

## What is UV disinfection and how does it work?

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## Why use UV disinfection?

- Advantages
  - Very effective against protozoans such as *Cryptosporidium* & *Giardia*
    - Protozoans are relatively resistant to chlorine
  - Is relatively safe to use
    - Operator safety (risk / harm of UV exposure relatively low)
    - No Disinfection Bi-products (such as Tri-Halo Methanes or “THMs”)
  - Nothing “added” to the water
    - No taste or odour
    - Low public health concerns
    - No environmental residue (E.G. discharge to waterways, reuse)



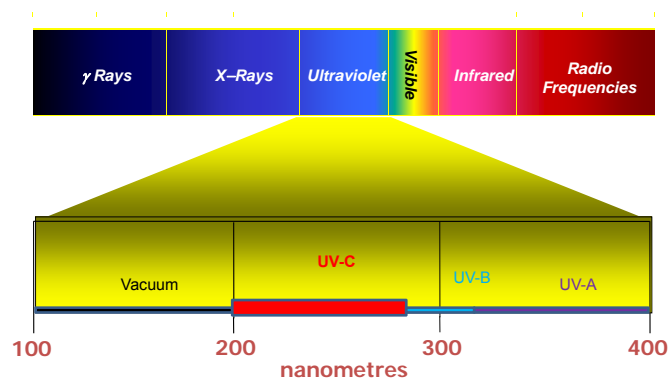
## Why use UV disinfection?

- Disadvantages
  - No residual disinfection
    - Chlorine-based disinfectants can remain in the water to continue disinfection in reticulation systems
  - Relatively high power usage
    - When compared to chlorine
    - But not when compared to Reverse Osmosis (RO) or ozone
  - UV lamps contain tiny amounts of Mercury
    - Should the lamp break, very small amounts of Mercury (a few milligrams) may contaminate the water being treated

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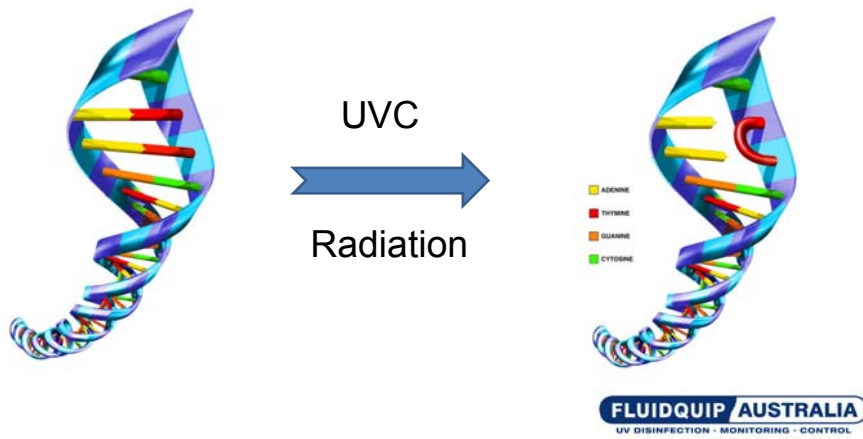
## What is UV light?

A section of the Electromagnetic Spectrum



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## How Does UVC light inactivate pathogens? UVC light denatures DNA

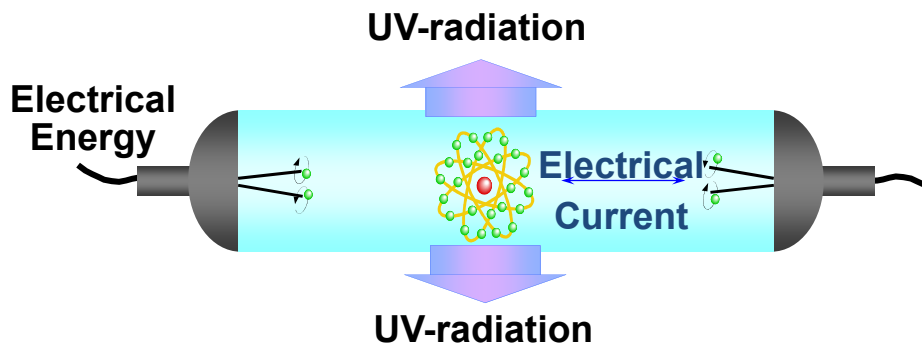


## What does a UV lamp look like? Mercury visible at right-hand end of lamp



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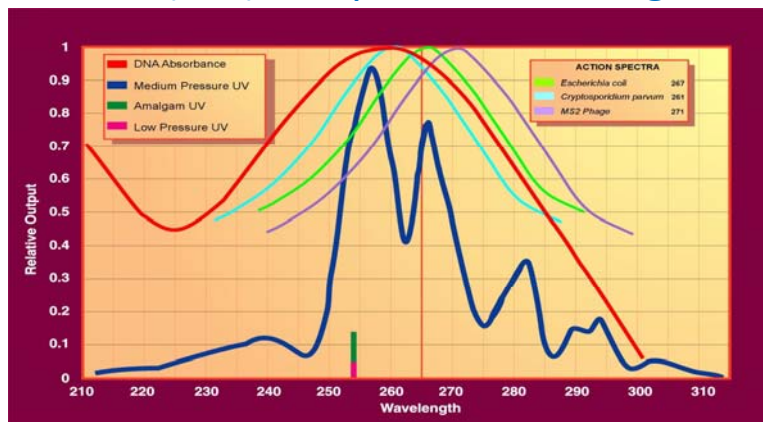
## How does a UV lamp work?



- Electrical interacts with mercury atoms causing 'excitation'
- Mercury Atoms release UV light energy as photons with wavelengths at or around 254 nm

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## What is the difference between Low Pressure High Output (LPHO) & Medium Pressure (MP) Lamps in denaturing DNA?



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## MP lamps Vs LPHO lamps - Comparison

	Medium Pressure	LPHO (Amalgam)
Power efficiency (to UVC)	Low (18%)	High (35%)
Lamp Life (hrs)	Low (4000-8000 )	High (12,000-16,000)
No. lamps per system	Low (1X)	High (3-4x)
Germicidal effectiveness	High	High



## Selecting a UV system

### What three parameters need to be considered?

1. Water Quality
  - UV Transmissivity (UVT) – how well will UV light penetrate through the water.
  - Suspended Solids less than 20 mg/l – “Shielding”
2. Water Flow Rate
  - Governs exposure time of pathogens to UV light
  - Peak instantaneous flow rate most important
3. Pathogens to be inactivated & by what amount
  - Each pathogen requires a different UV “dose” to be inactivated.
  - Generally, the more UV “dose”, the greater the “log inactivation”.



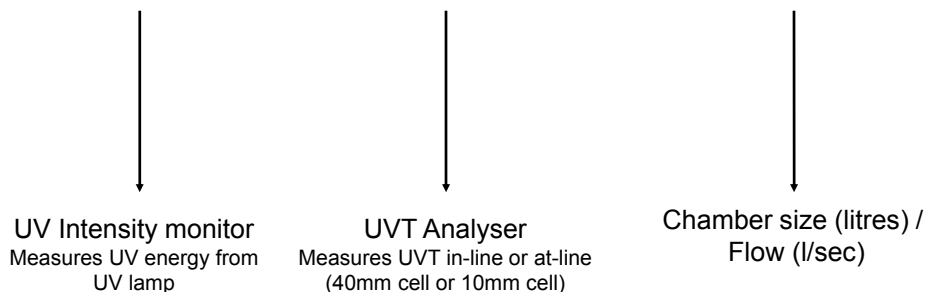
## What does log reduction (“inactivation”) of pathogens mean?

- Log reduction principle
  - 1 log = 90% inactivation
  - 2 log = 99% “
  - 3 log = 99.9% “
  - Etc...
- All disinfection media (including chlorine) adhere to this principle

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## What is UV dose and how is it calculated?

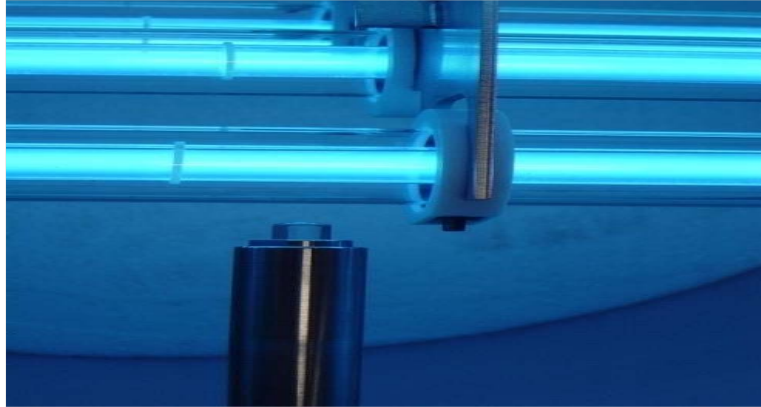
$$\text{Average UV Dose (Fluence) (mJ/cm}^2\text{)} =$$
$$[\text{Intensity (mW /cm}^2\text{)} / \text{UV Transmittance of fluid (\%)}] \times \text{Residence Time (sec)}$$



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## UV Intensity Monitor

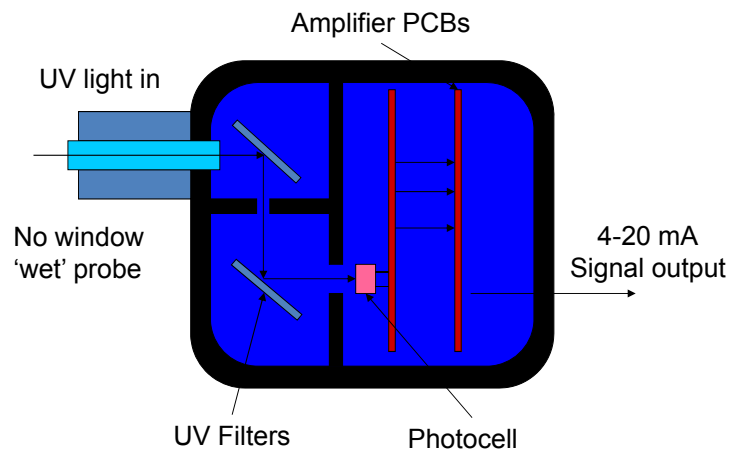
Transmits to the UV system controller how much UV light is being put into the water



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## UV Intensity Monitor Design

Should measure only UVC light by filtering out all other UV wavelengths



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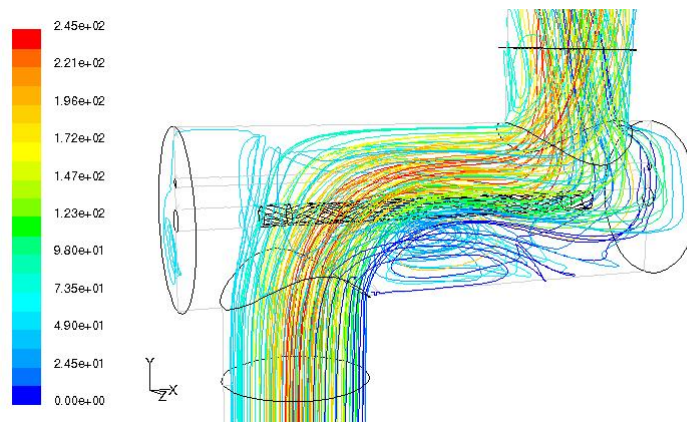
## UVT Monitor

Transmits to the UV system controller how well the UVC light will penetrate the water



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Computational Fluid Dynamic (CFD) water flow plot  
-Showing water pathways through a parallel flow UV chamber.  
- Used to calculate minimum chamber residence times.

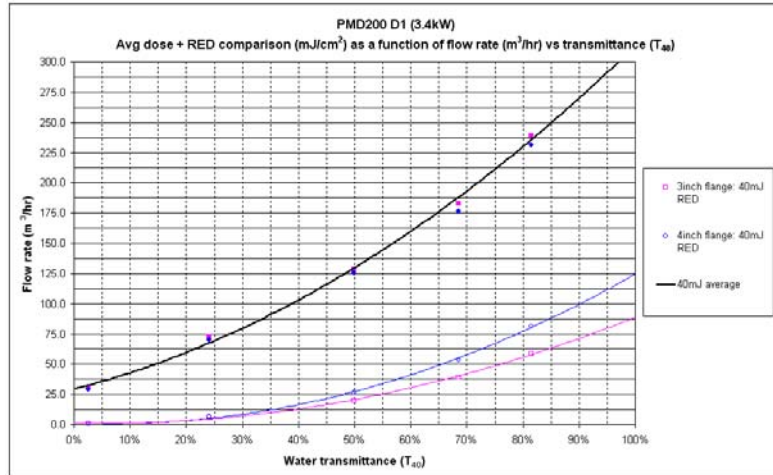


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# UV Dose

## Average Dose Vs Reduction Equivalent Dose (RED)



# UV Dose Requirements

## UV dose required for 1 log inactivation (mJ/cm<sup>2</sup>)

### BACTERIA:

<i>E. coli</i>	5.4
<i>Bacillus subtilis</i> (spores)	5.8
<i>Streptococcus faecalis</i>	4.5

### PROTOZOA:

<i>Cryptosporidium parvum</i>	2.5
<i>Giardia lamblia</i>	2.1

### BACTERIOPHAGE:

MS-2 Coliphage	40.0
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### VIRUSES:

Adenovirus (Type 40)	58.0
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# UV Dose Requirements

## USEPA UV Disinfection Guidance Manual (UVDGM)



**Table 1.4. UV Dose Requirements – millijoules per centimeter squared (mJ/cm<sup>2</sup>)<sup>1</sup>**

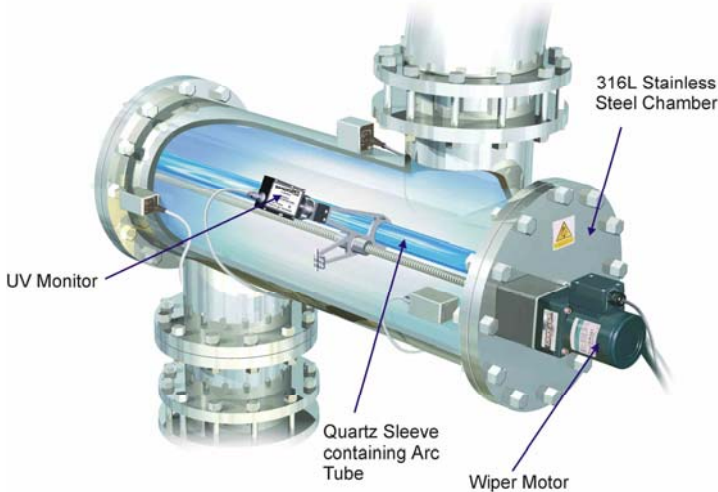
Target Pathogens	Log Inactivation							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
<i>Cryptosporidium</i>	1.6	2.5	3.9	5.8	8.5	12	15	22
<i>Giardia</i>	1.5	2.1	3.0	5.2	7.7	11	15	22
Virus	39	58	79	100	121	143	163	186

<sup>1</sup> 40 CFR 141.720(d)(1)



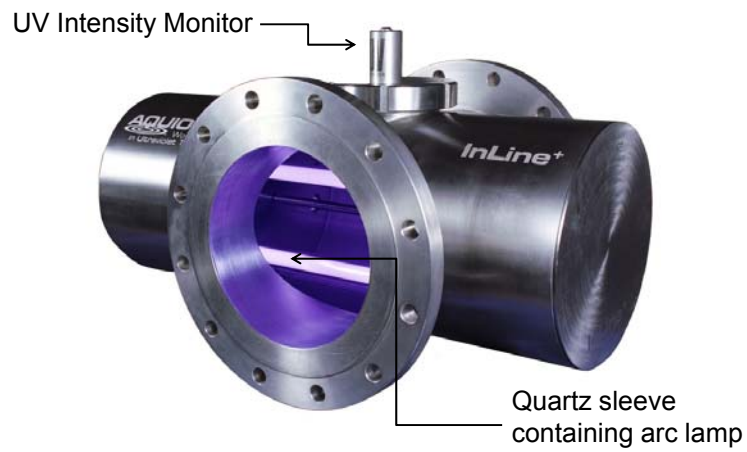
## Examples of UV system types

### Parallel flow chamber



## Examples of UV system types

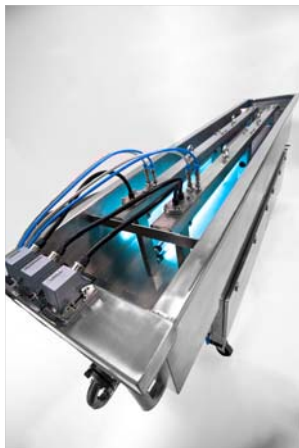
### Cross flow chamber



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## Examples of UV system types

### UV channel



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## Questions?

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