NO IT WON’T MAKE YOU STERILE

ULTRAVIOLET DISINFECTION FROM AN OPERATIONAL PRESPECTIVE

SAFE DRINKING WATER WORKSHOP
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TOPICS

- Basic UV
- - Theory
  - Dosage
  - Disinfection Properties
- Types of UV systems
- Considerations
  - Why
  - Why Not
- Validation
- Operation
- Maintenance
- Summary

OLYMPIC GOLD

BASIC UV

Theory

- UV Disinfection is in the wavelength range of 220 to 320 nanometers (nm) compared to say sun tanning which is in the 315 to 340 nm range.

Dosage

- Dosage like any other disinfectant relies on intensity (strength) and time.
- Dosage is described as mJ/cm^2 (milli joules/square centimeter). Although you may see J/m^2 or $mW.sec/cm^2$ (milli watts/sec/square centimeter). So a dose of 400 J/m^2 = 40 $mW.sec/cm^2$ or 40mJ/cm^2

BASIC UV con't.

- In most Canadian jurisdictions the Regulators have adopted the European standard of 40 mJ/ cm^2 as the required dose

Disinfection Properties

- **UV does not Kill organisms it Inactivates them by altering their DNA so they cannot reproduce.**
- **Disinfection is measured by "log removal" for example Ontario Regulations call for the treatment process to remove**
  - **2 log Cryptosporidium (99%)**
  - **3 log Giardia (99.9%)**
  - **4 log Viruses (99.99%)**

BASIC UV (con’t)

- LOG REMOVAL – Short form for saying %.

- Is easier to say 4 log than 99.99%

BASIC UV (con't)

DISINFECTION PROPERTIES

- CRYPTOSPORIDIUM (4 LOG REMOVAL)
  - LP – 8 mJ/cm^2 (Clancy et al 2000)
  - MP – 3 mJ/cm^2 (Clancy et al 2000)
  - MP – Filter backwash water @ 11NTU – 3 mJ/cm^2 (Clancy et al 2000)

BASIC UV (con't)

- BACTERIA – 4 log removal

  - 3 – 15 mJ/cm^2 (Chang et al 1985, Wilson et al 1992, Tosa, Hirata 1998)

- VIRUSES – 4 log removal

  - 20-30 mJ/cm^2 (Wilson et al 1992)

BASIC UV con’t.

- **As you can see from the previous slide UV differs in hierarchy of micro-organisms it attacks from other disinfectants with Protozoa followed by Bacteria followed by Viruses - chlorine is the reverse.**

BASIC UV (con't)

- For surface water supplies UV is normally used to target Cryptosporidium and Giardia

BASIC UV con’t.

And thankfully for everyone's sake it is very accurate in hitting it’s target.

TYPES OF UV SYSTEMS

- There are 3 main types of UV units:
  - Low Pressure (LP)
  - Low Pressure/High Output (LPHO)
  - Medium Pressure (MP)

TYPES OF UV SYSTEMS con't.

- Low Pressure (LP)
  - LP units have the least energy, least amount of mercury and least amount of heat produced.
  - They require more space than MP units.

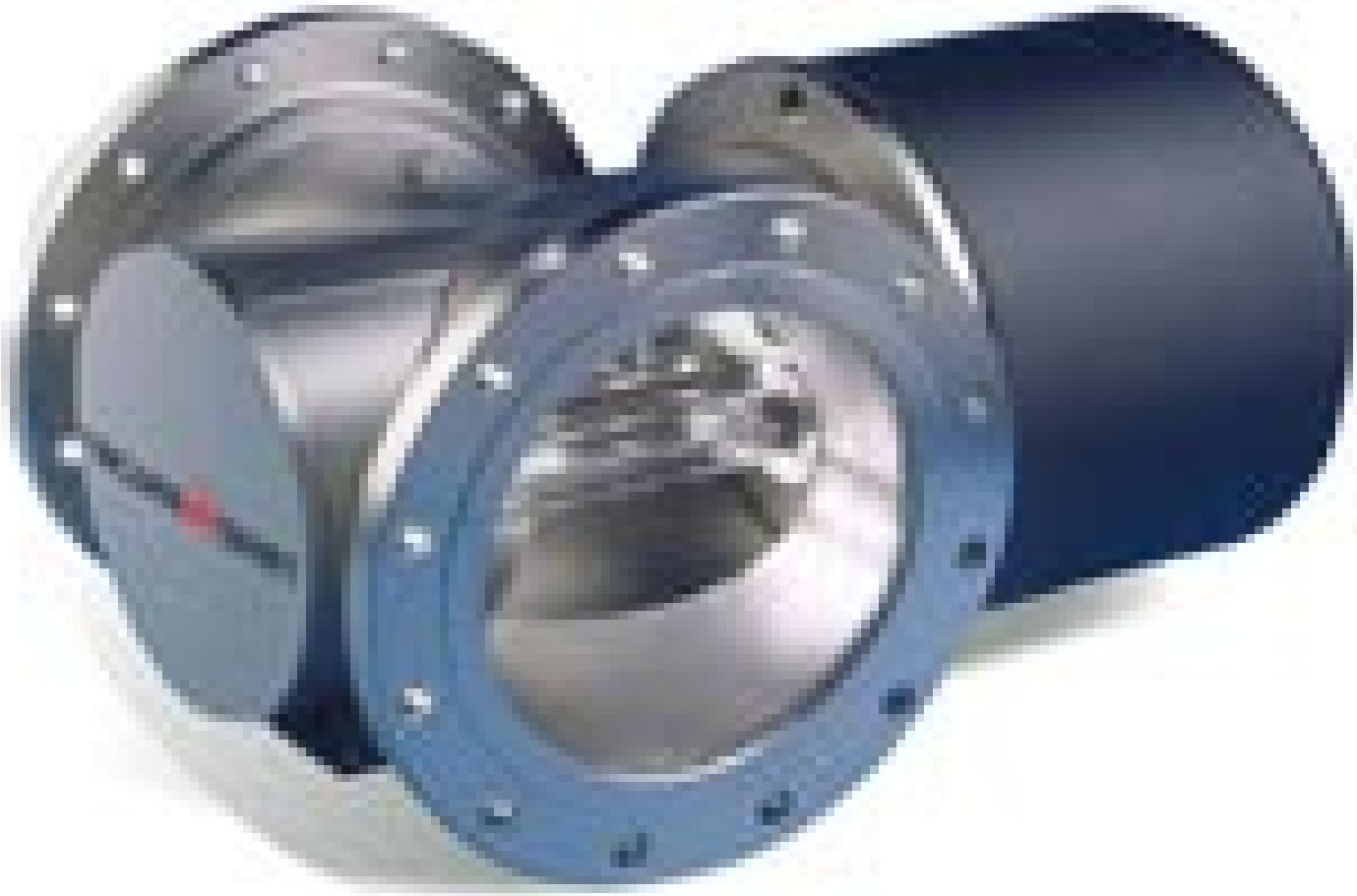
TYPES OF UV SYSTEMS con't.

- Medium Pressure

  - MP units are smaller than LP units but generate much more energy and thus more heat. (i.e. 40^0C for LP vs. 800^0C for MP).

  - Very good for areas with limited space.

  - Shorter lamp life than LP.



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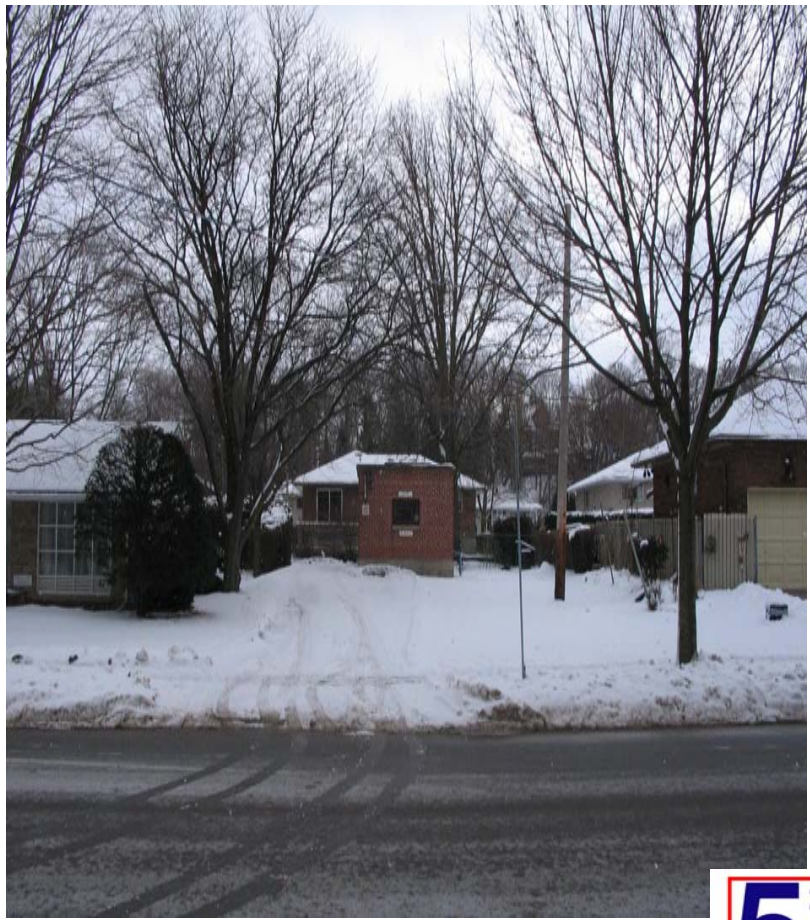
CONSIDERATIONS

WHY PICK UV OVER SOME OTHR FORM OF DISINFECTION?

WHY - EASE OF INSTALLATION

WHY (con’t)

- Have Cryptosporidium or Giardia in the source water (Surface Water)_
- LOT SIZE – Lot size too small to install a reservoir (Groundwater)

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WHY (con't)

- THM Issues

- CHLORINE TASTE – complaints in distribution system due to dosage

- COST EFFECTIVE – cost effective compared to other technologies such as membranes or ozone.

WHY (con’t)

- Ease of operation.
- Little maintenance
- Small foot print.
- Very effective in producing safe water

WHY **NOT** TO SELECT UV OVER OTHER FORMS OF DISINFECTION

WHY NOT (con't)

- WATER QUALITY

  - High Turbidity

    – If a surface water supply then pretreatment will be necessary.

    - If a groundwater supply this is normally caused on start-up with sand "kicking – up", if cause by iron or manganese precipitation then pretreatment is necessary.

WHY NOT (con't)

- HIGH DISSOLVED ORGANIC CARBON – (DOC). (Should be less than 5.0 mg/l)
- Dissolved organic carbon is part of the Total Organic Carbon (TOC) in the water. DOC is the dissolved organics which can occur naturally or be manmade. TOC includes the DOC plus the fine suspended particles in water.
- IF HIGH DOC – Pretreatment is necessary.

WHY NOT (con't)

- High UV Transmittance (UVT)
- UVT is the % of light emitted at 254 nm that can pass through 1 cm of water.
- Your light source = 100% and it passes through 1 cm of water. Depending how "clear" the water is the detector will read anywhere between 100% and downward.
- 95% UVT and above is the most desirable however a range between 95 – 80% is satisfactory – anything lower than 75% requires pretreatment.

WHY NOT (con't)

- The implications of this (high/low UVT) is important for several reasons: -

  - For every 5% decrease in the UVT you get roughly 50% less UV available disinfection.

- This increases the cost since you need: -

  - a larger unit.
  - larger footprint to install the UV unit.
  - more lamps and thus more power
  - more maintenance, more spare parts etc.

OTHER CONSIDERATIONS

- Availability of spare parts.
- Availability of service rep.
- Availability installation of a modem to connect to supplier troubleshooting hot line.
- Staff capability – capable of troubleshooting system.
- It is electronic equipment and the larger the unit the more complex.
- On site storage i.e. reservoirs.
- Operating costs including hydro.

OTHER CONSIDERATIONS (con't)

- Reliability of hydro supply and hydro fluxuations.
- UPS/diesel standby power
- Cooling water
- Automatic clean in-place system
- Do you require redundancy unit.
- Lamp cleaning system

OTHER CONSIDERATIONS (con't)

- Lamp breakage

- Lamp replacement: -
  - LP – approx. 14,000 hr.
  - LPHO – approx. 11,000 hr.
  - MP – approx. 8,000 hr.

OTHER CONSIDERATIONS (con't)

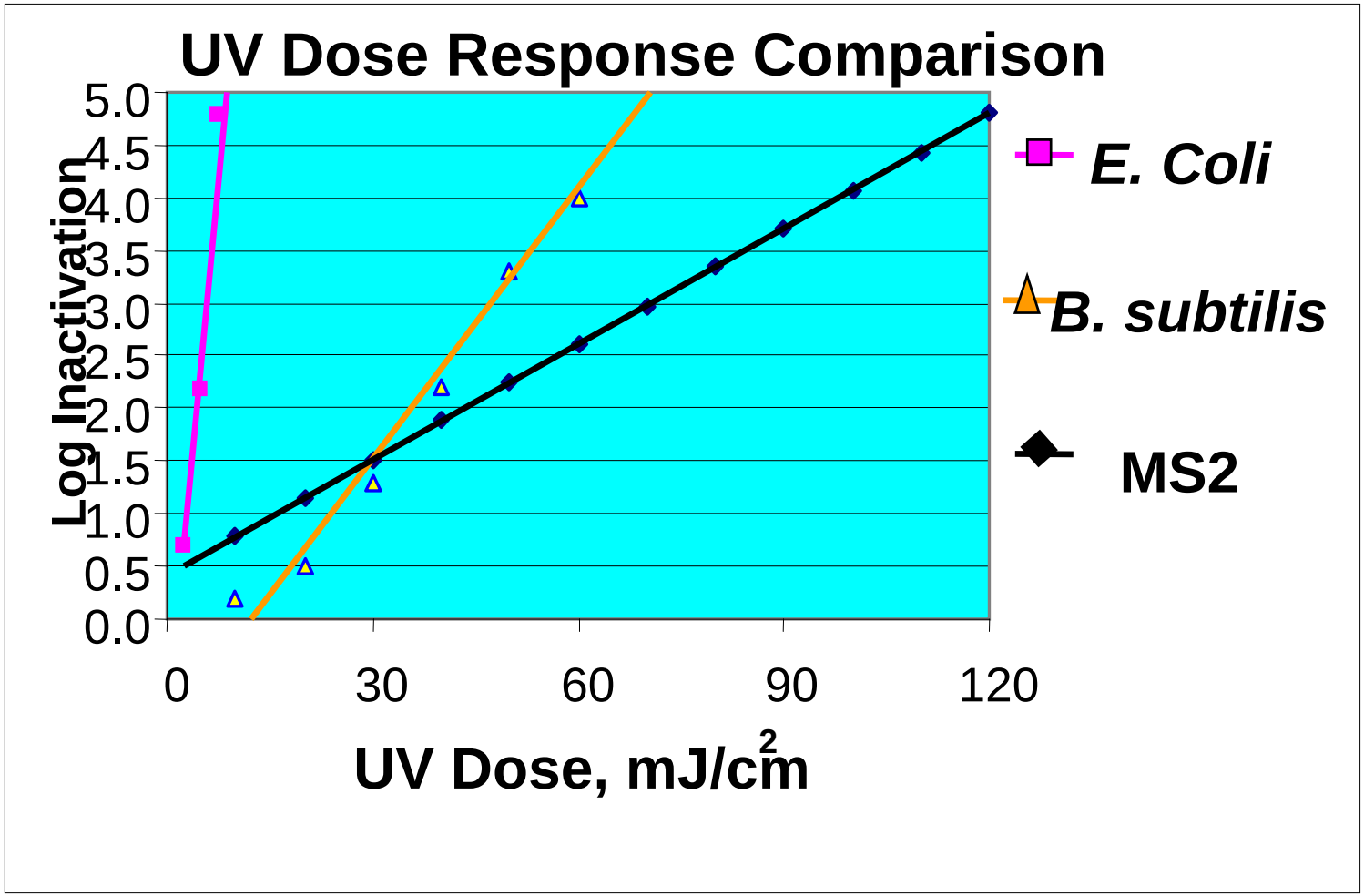
- The Atlantic Canada Guidelines for the Supply, Treatment , Storage, Distribution and Operation of Drinking Water Supply Systems, Section 4.6.2.2 outlines design considerations for UV systems which contains a lot more information on areas to consider when choosing a system.
- (www.gov.ns.ca/enla/water/docs/watersupplyguidelines)

VALIDATION

- Why do I want to make sure my UV reactor has been validated?
- UV is a physical disinfetion with no measurable residual
- Complex interaction between dose delivery and monitoring
- Must ensure dose monitoring is robust

VALIDATION

- Measure full-scale response send dispersed indicators through reactor
- Evaluate effect on indicators
- Measure inactivation used to determine Reduction Equivalent Dosage (RED)
- Process referred to as – BIOASSAY or BIODOSIMETRY


UV Dose Response Comparison
Log Inactivation
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
30
60
90
120
UV Dose, mJ/cm2
E. Coli
B. subtilis
MS2

OPERATION & MAINTENANCE

OPERATION & MAINTENANCE (con't)

- Commissioning of unit

  - may have to run to waste through the UV system extensively – depends on WQ

  - after flushing put UV in test mode to determine if intensity is acceptable.

  - if not clean sleeves and sensor then try again – if okay do a remote start.

OPERATION & MAINTENANCE (con't)

- On start up intensity may drop below acceptable limit

  - poor WQ

  - air entrapment – air entrapment is a concern – it confuses the sensors very easily.

  - if start up is masked may observe may observe a drop in UV for a couple of seconds – but not enough to shut unit down.

  - when not masked and intensity is okay it can drop and invoke a shutdown

OPERATION & MAINTENANCE (con't)

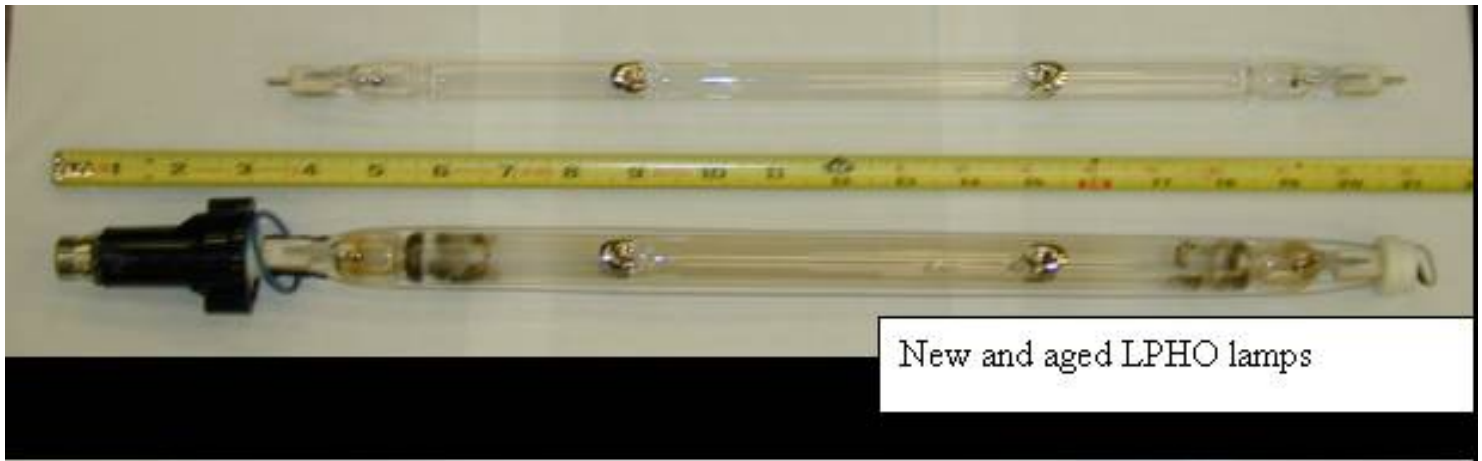
- In general once the UV system is "up and running" there are few operational issues with it.
- Like any other piece of sophisticated equipment is does require routine maintenance.
- Each installation will have it's own operation and maintenance issues depending on the UVT.
- Issues like lamp and sensor fouling may occur more often in waters with low UVT's, high hardness levels.

OPERATION & MAINTENANCE (con't)

- Until staff are familiar with the system regular draining of the reactor to remove and inspect bulbs and quartz sleeves and intensity housing will be required
- When handling the lamps gloves and safety eye wear must be worn.
- Any build-up can be removed by acetic acid or mild (10%) hydrochloric acid wash.
- When carrying out any maintenance record the condition and if possible take a picture

OPERATION & MAINTENANCE (con't)

- Severe discolouration indicates throwaway
- Depending on whether it is a LP or MP the warranted run-time will differ
- Return to supplier if run-time is significantly less.
- Reset run-hours when bulb is replaced



New and aged LPHO lamps

New and aged MP lamps

OPERATION & MAINTENANCE (con't)

- The inspection should be monthly initially to build understanding of system performance
- Once staff get familiar with the system and a comfort level develops the inspection can be moved to quarterly or semi-annually.

OPERATION & MAINTENANCE (con't)

- Regular calibration of the UV intensity monitors has to be carried out

- Request a spare sensor. When recalibration is necessary you install the spare and send other one back to the supplier for calibration

OPERATION & MAINTENANCE (con't)

- Lamp failure indicated by low amperage or over-voltage alarm
- Could also mean failure of another component:
  - Ballast
  - Capacitor
  - DC Control Card

SUMMARY

In summary UV certainly has taken it’s place in providing reliable primary disinfection for surface and groundwater supplies.

I personally think it has revolutionized the treatment of potable water both on a municipal and residential level.

QUESTIONS