Dechlorination and membrane protection by UV

PDA Israel
New Developments in Water Systems
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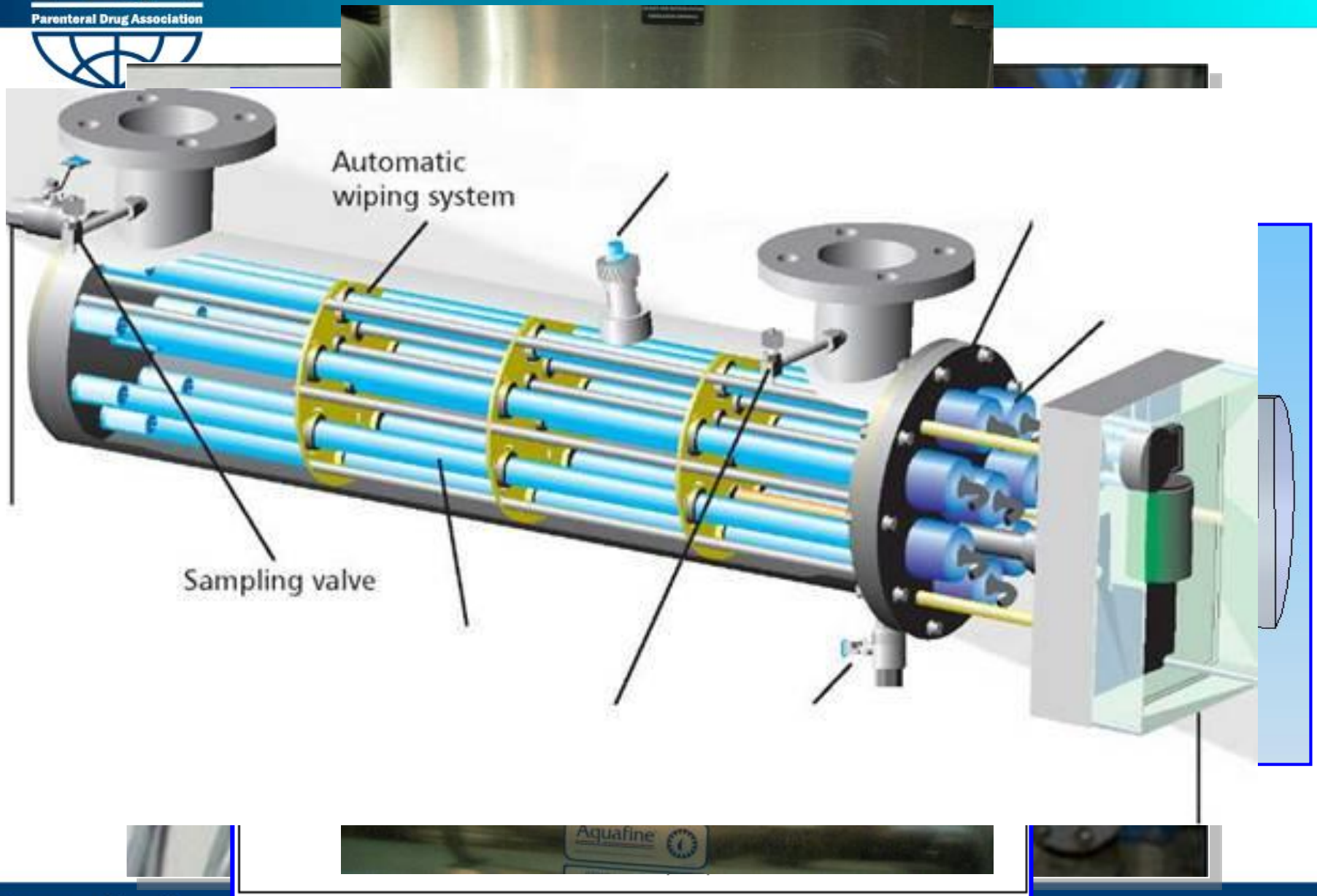
Efficient, Clean Dechlorination

- No carbon filters
- No chemicals

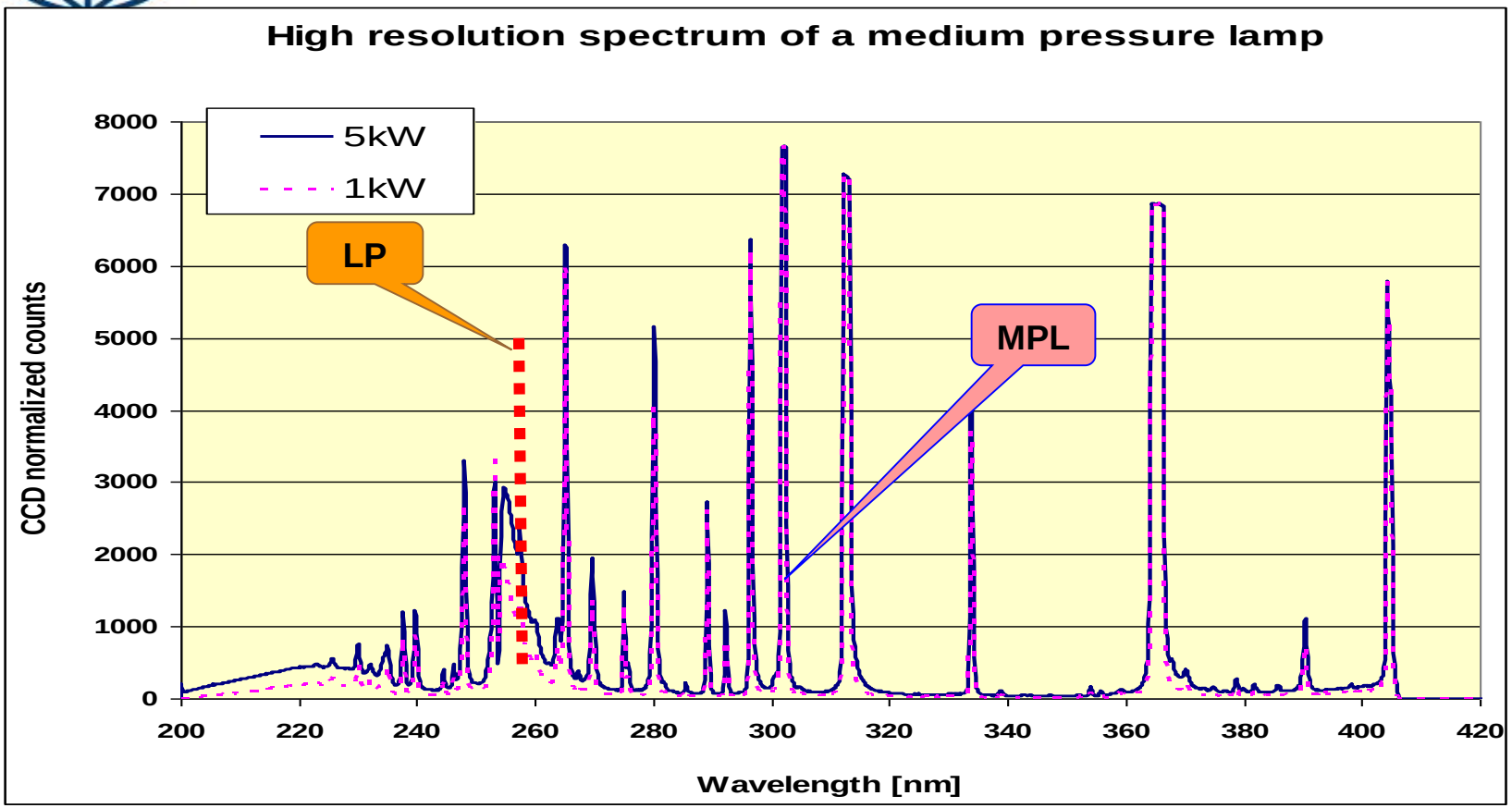
High-Level Disinfection

Complies with PW, WFI, USP, EP, JP and WHO Standards

Conventional UV Systems



Medium Pressure vs Low Pressure UV Lamps



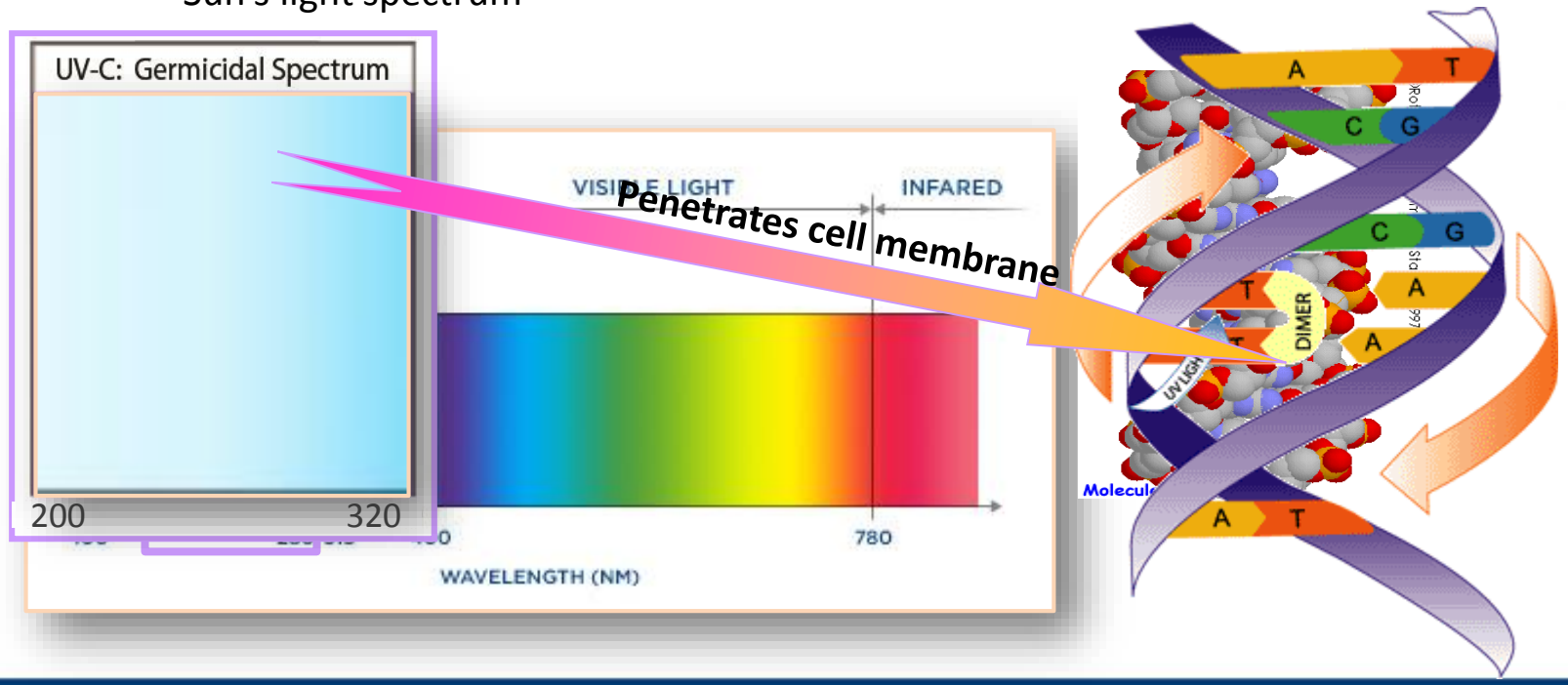
Low Pressure (LP UV)
Mercury vapor
Monochromatic (253.7 nm)
Inactivates pathogens by damaging their DNA/RNA

Medium Pressure (MP UV)
Mercury vapor - Polychromatic
Inactivates pathogens by damaging DNA and additional macromolecules (proteins) via polychromatic

Medium Pressure Lamps are Better

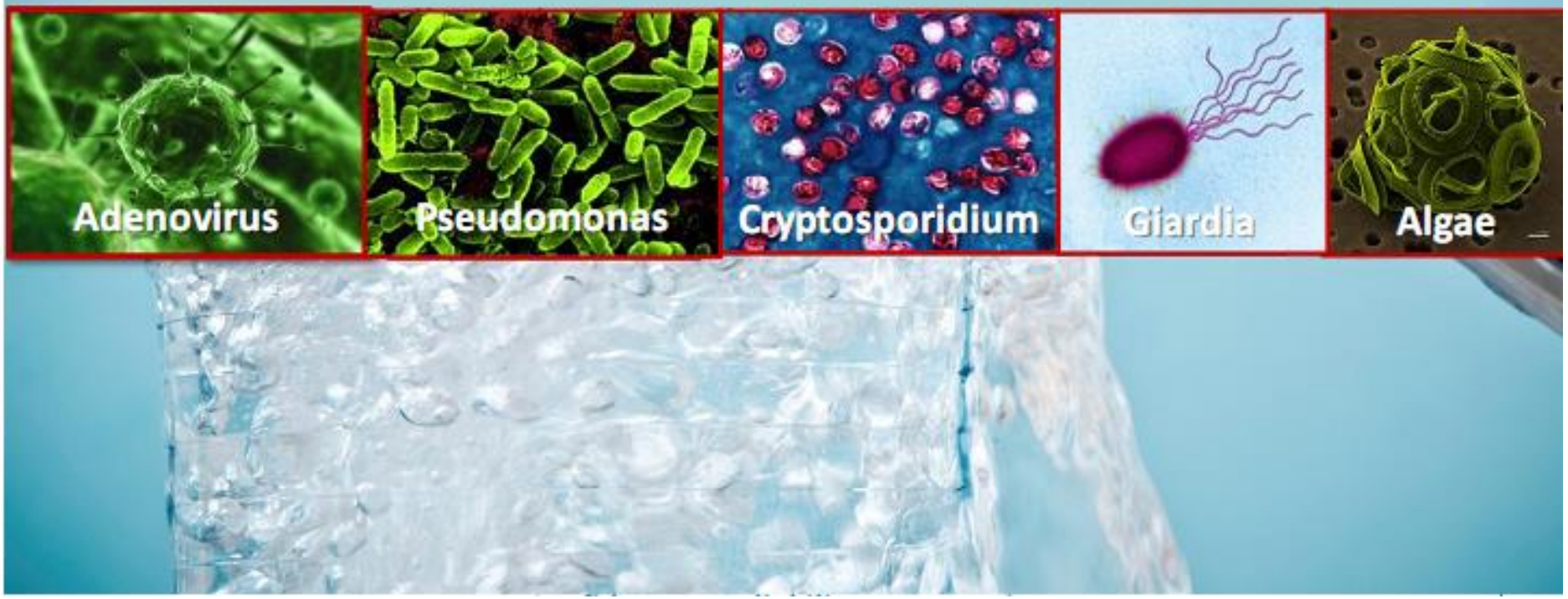
- Uses entire germicidal spectrum for much better efficiency (200 - 320nm)
- Totally inactivates cells by damaging their repair mechanism
- Creates Thymine Dimers to inhibit DNA replication
- Adenoviruses are 2-3 times more sensitive to Medium Pressure UV

Sun's light spectrum

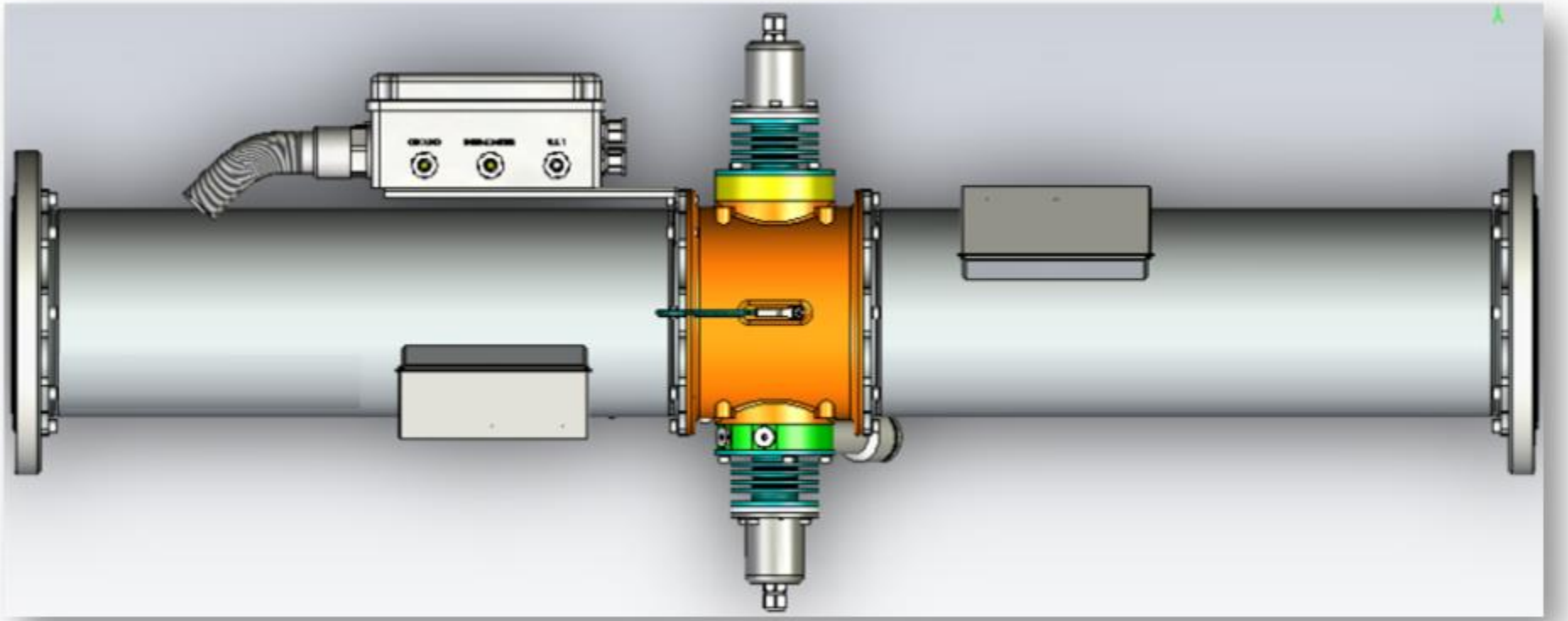


Medium Pressure UV Broad Spectrum

- Broad spectrum action: easily inactivates chlorine-resistant viruses, pseudomonas, cryptosporidium and giardia, as well as algae.



Atlantium Hydro-Optic Operation Principles
Over 60 protected patents



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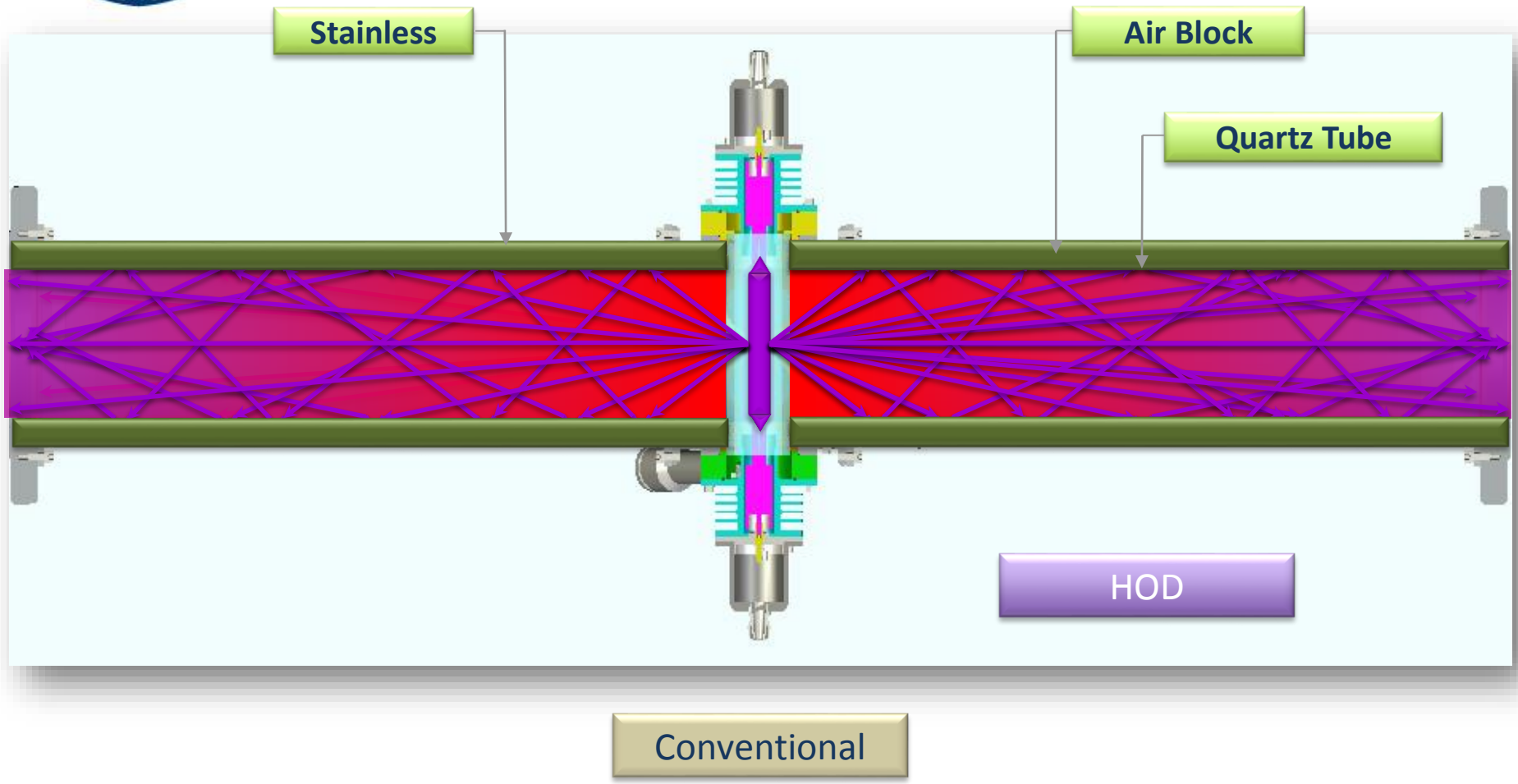
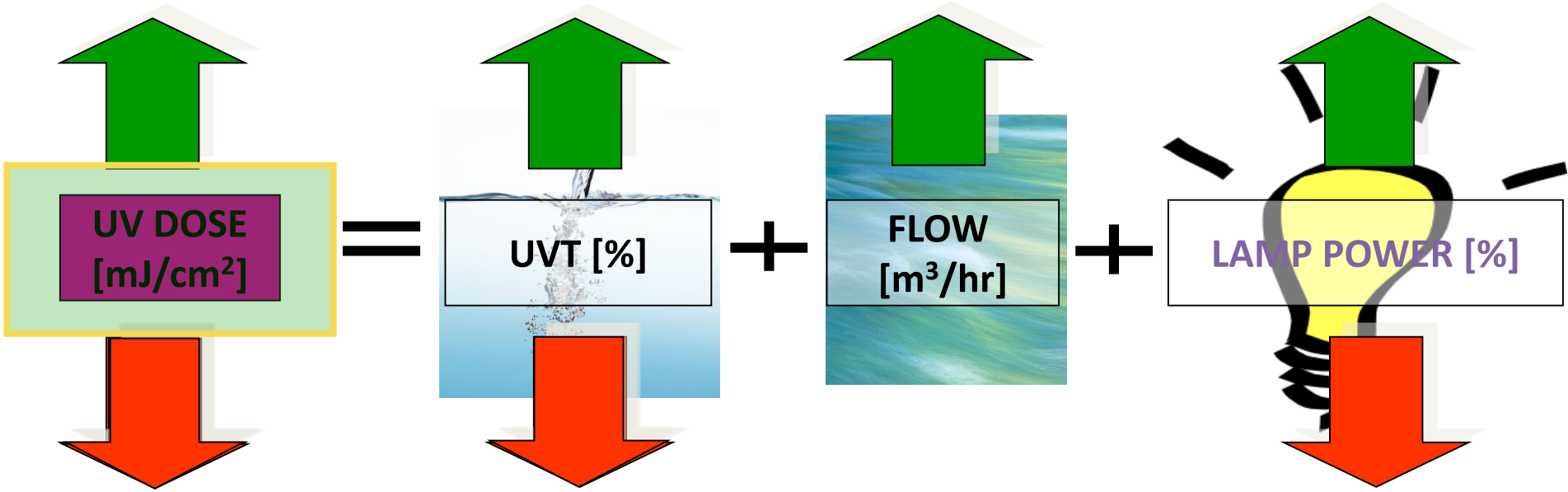


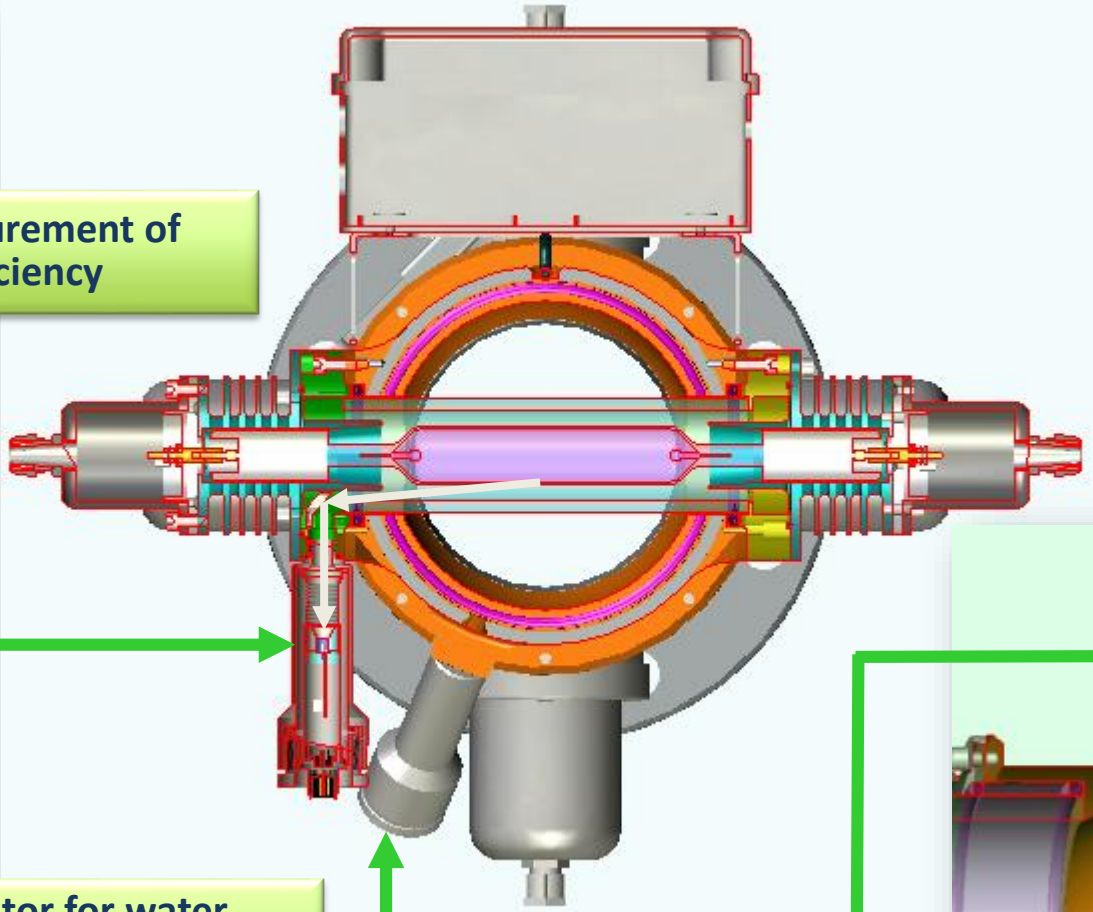
The Dose Function and monitoring

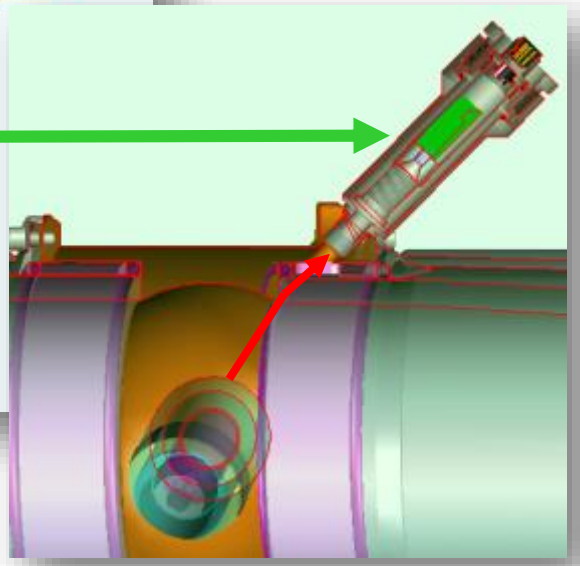


Sustained Performance

Dual sensors configuration provides actual dose measurement

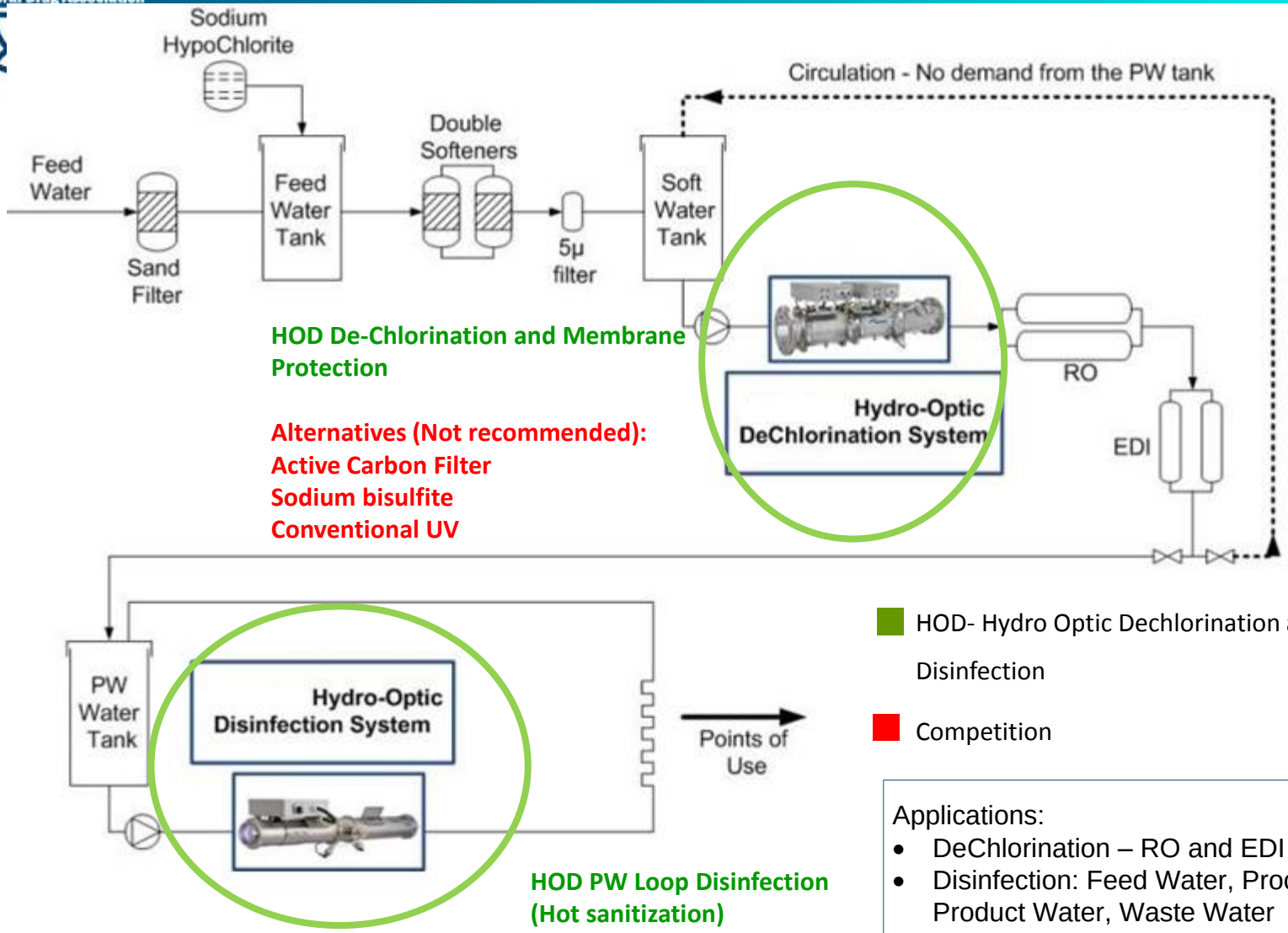
Direct measurement of UV lamp efficiency





Built-in monitor for water Transmittance (UVT)

Recommended UV In a Pharmaceutical Plant



HOD- Hydro Optic Dechlorination and Disinfection

Competition

Applications:

- DeChlorination – RO and EDI protection
- Disinfection: Feed Water, Process Water, Product Water, Waste Water
- Ozone Reduction

Dechlorination:
Protects RO Membranes and EDI

Chlorine Reduction Unit

Reverse Osmosis

Hydro-Optic UV Dual Effect:
1. **DeChlorination – RO Protection**
2. **Powerful Disinfection – Reducing Biofouling**

Activated carbon
Maintenance intensive
Microbe-nursery

Sodium bisulfite
Chemical injection
Chemicals removal

Hydro-Optic UV
Very clean
Low-maintenance

All 3 Methods: Free Chlorine to Chloride ions

ACF

SBS / SMBS

UV Photons

→ Chloride ions (Cl^-)

Activated carbon

- Active Carbon filter is replaced between 1 – 3 years
- High Risk of Microorganism Contamination
- Gracious host for bacterial growth
- Organics it filters from the water provide food
- Has negative effect on RO Membranes (bio-fouling)

Activated carbon

- Operating Costs (OPEX) and Maintenance Burden
- ACF has no flexibility to flow rate changes
- Steam sterilization or hot water sanitation (once/twice a week)
- Backwash (several times a week) – can't treat water, downtime
- Disposal of Carbon can be expensive

Sodium Bi-Sulfite

- SBS is a source of food to microbes, and creates anaerobic conditions on the membrane
- Difficult to control, therefore the injection level is higher than needed, this will create a rapid bio-fouling buildup
- As consequence, increase in the cost of energy needed for producing the RO water, more CIP, shorter membrane lifetime, downtime.

Sodium Bi-Sulfite

- Highly corrosive
- May crystallize at room temperatures (on dosing pump)
- Necessity of storage space

In general – industry is leaving chemical solution

Medium Pressure UV

- UV converts Free Chlorine to chloride by use of photon radicals:

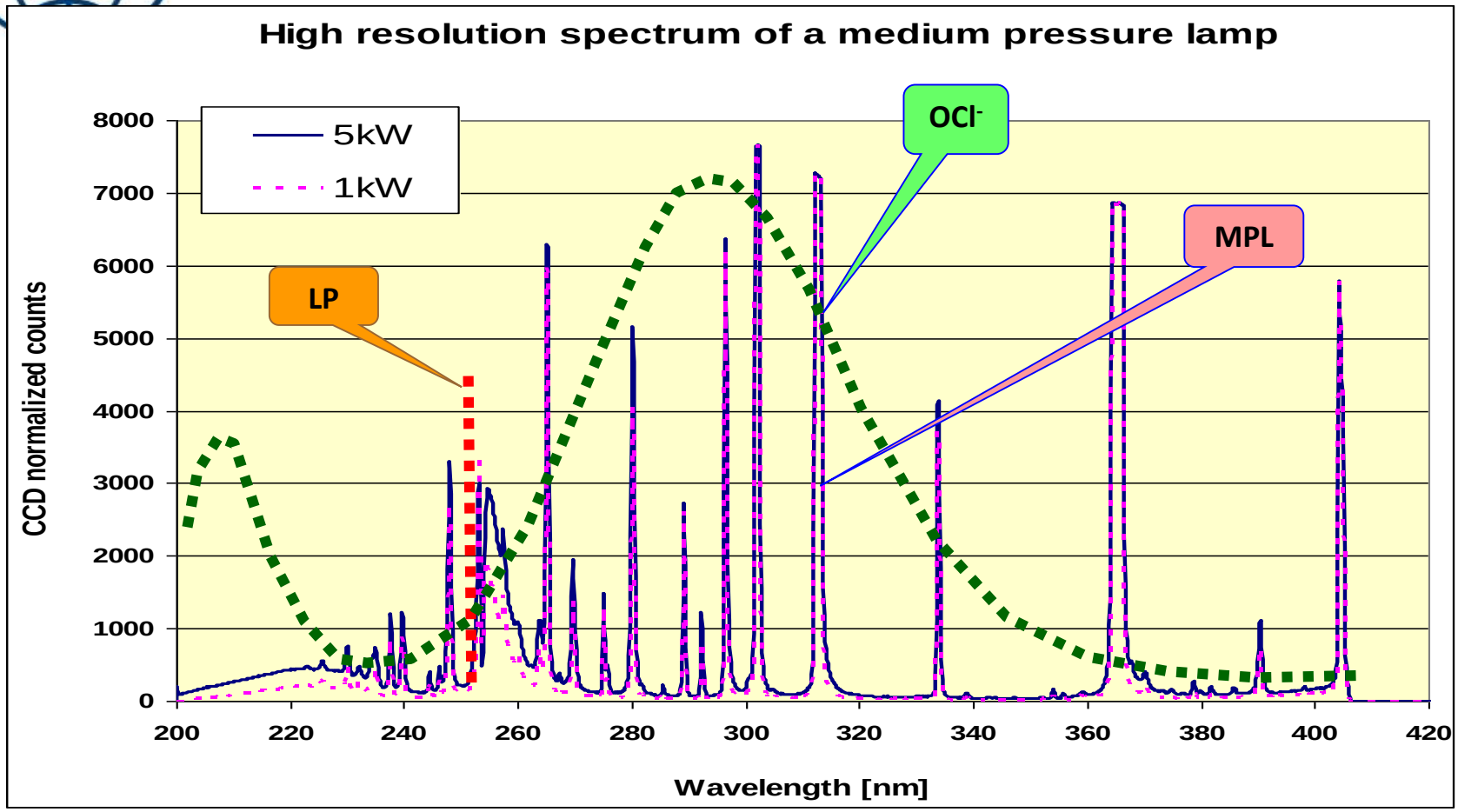
  $OCl^- + UV = O_2 + Cl^-$

- No residual effects (pH, chemicals, conductivity, etc.)
- RO Membrane and EDI unit protection
- User friendly software and reliable real-time monitoring
- Measured and validated UV dose for guaranteed results, using exact minimal dosage required (saving power)

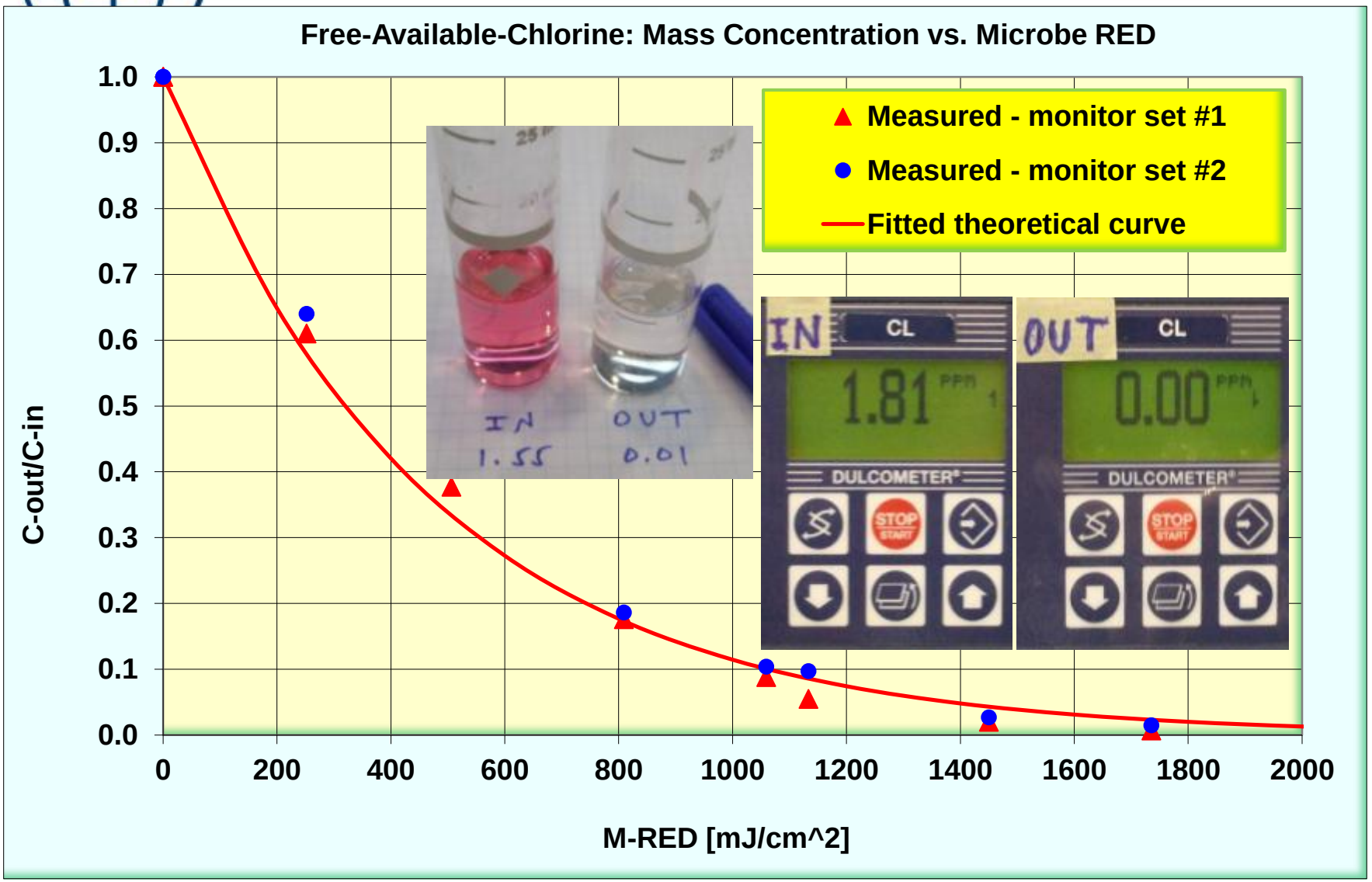
Medium Pressure UV

- No bacterial escape routes (5-log min reduction in bacteria, 4-log min reduction in virus)
- Energy and space are utilized with Total Internal Reflection concept
- Can be positioned Vertically or horizontally to save space
- Easy maintenance, Lamp replacement takes 5 mins, No need to empty unit to replace lamp

How It Works!

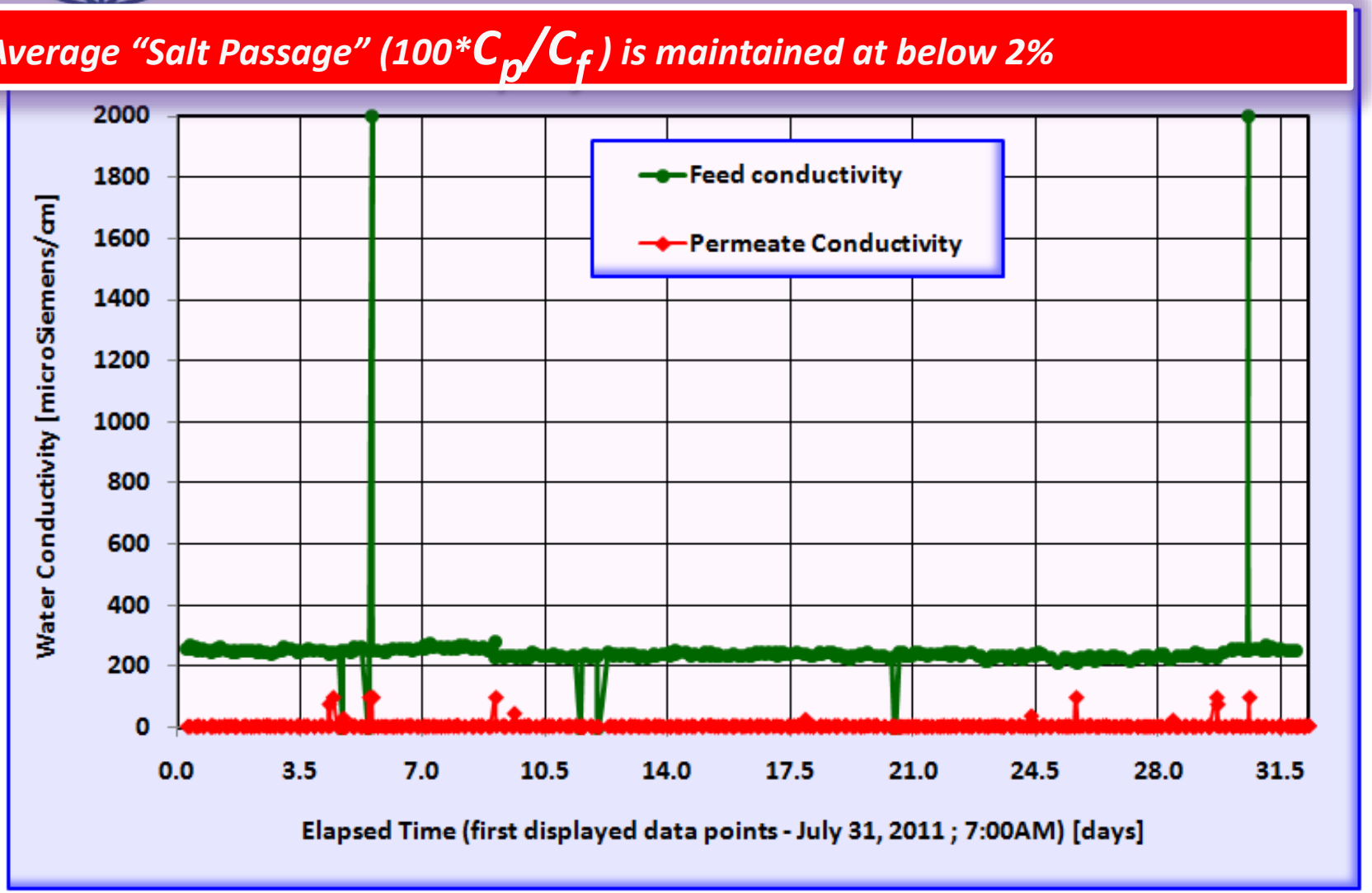

High resolution spectrum of a medium pressure lamp
5kW
1kW
OCl-
MPL
LP
CCD normalized counts
Wavelength [nm]
8000
7000
6000
5000
4000
3000
2000
1000
0
200
220
240
260
280
300
320
340
360
380
400
420

Chlorine (FAC) Photodecomposition by MPLs'



Conductivity vs. Time

Average "Salt Passage" ($100*C_p/C_f$) is maintained at below 2%



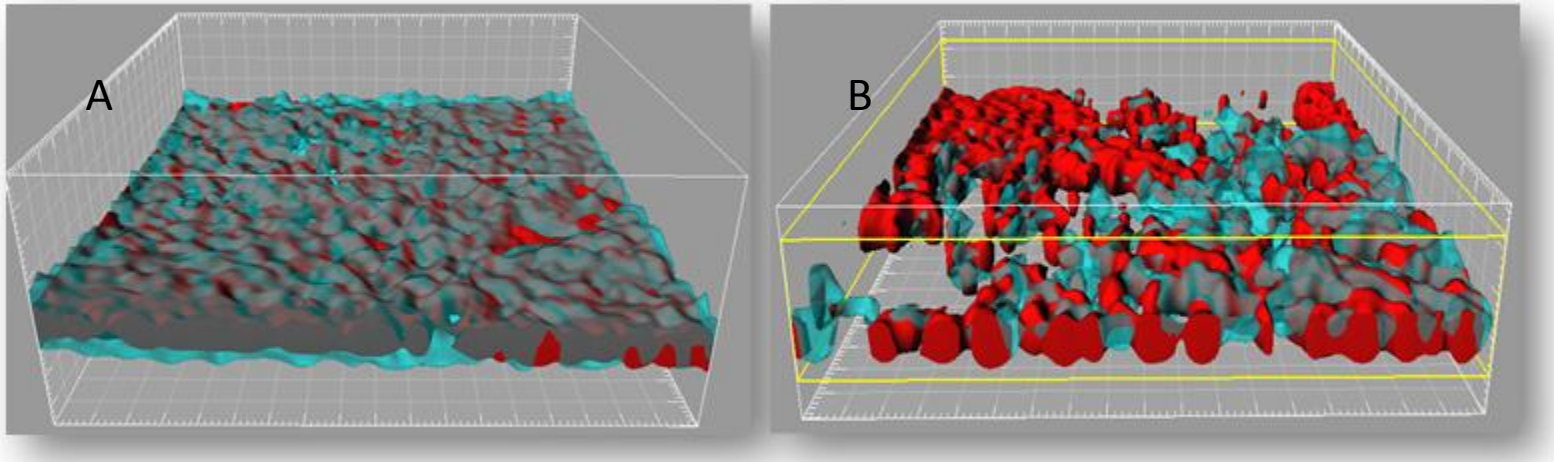
Installation Attributes

- In-Line configuration
- NO “Dead Legs” design
- Horizontal or Vertical Installation possible
- Complying with cGMP
- Easy and quick Validation process (IQ, OQ)
- “Birth” certificates for all critical parts

Medium Pressure UV in Action

Membrane Biofilm Analysis – Laser Microscopy

- (A) Biofouling layer without HOD UV pretreatment
- (B) Biofouling layer with HOD UV pretreatment
- Total biomass of EPS- **E**xtracellular **P**olymeric **S**ubstances (transparent light blue) and microorganisms (red)

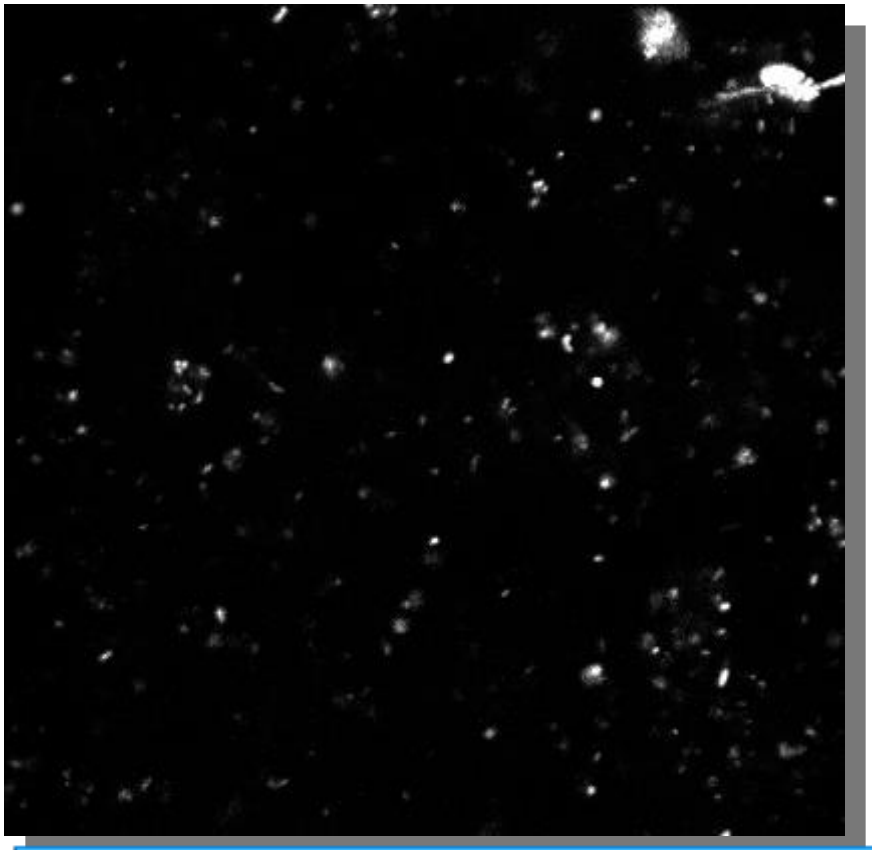


The EPS content in the biofilm on the membrane that received HOD UV pre-treated water was far lower than the biofilm on the membrane that did not

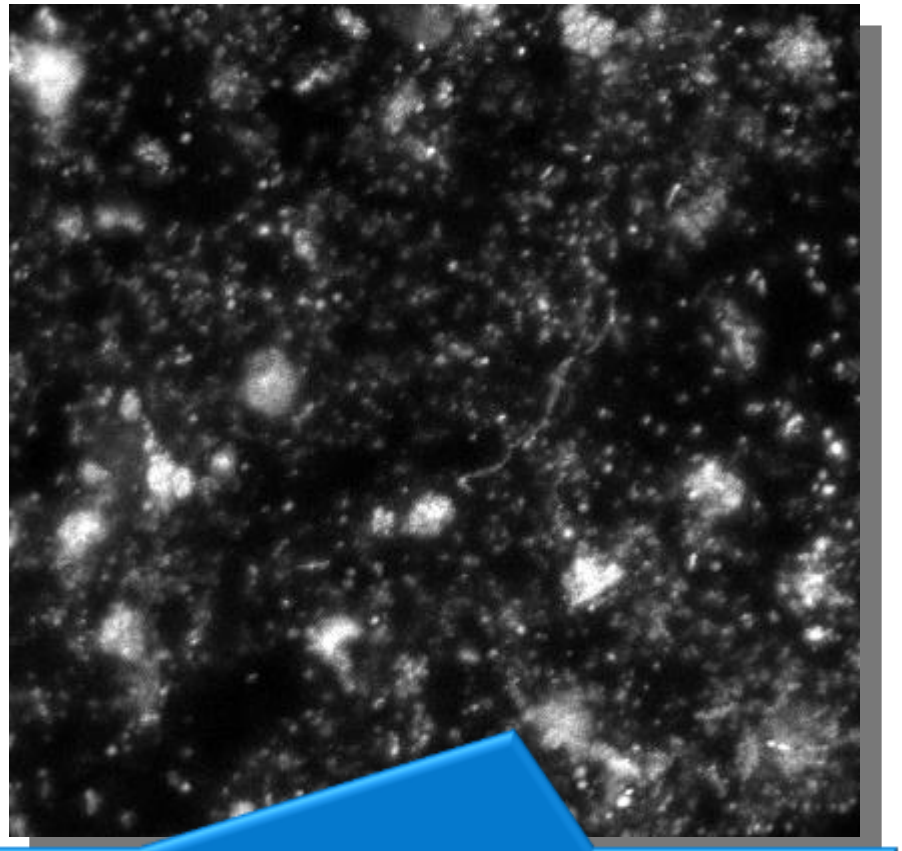
Membrane Surface Analysis
Confocal Scanning Laser Microscopy

PDA Parenteral Drug Association

With HOD UV



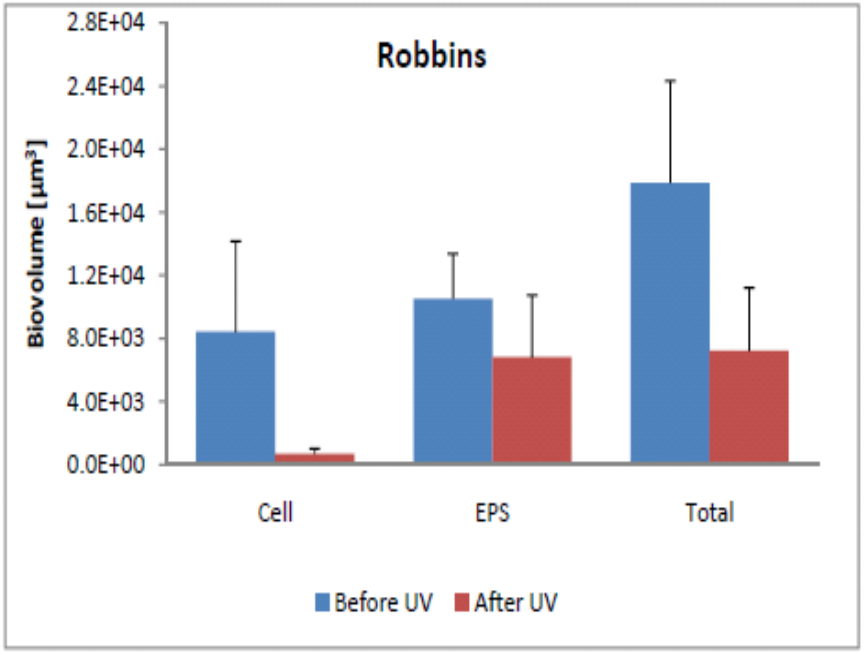
Without HOD UV

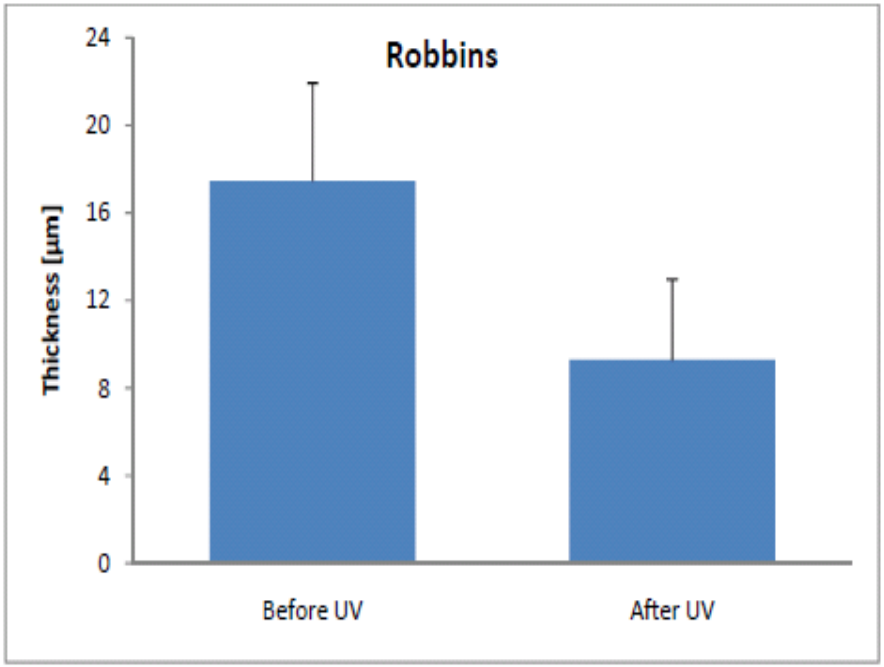


The white patches are particles which “stuck” to the biofilm – due to the increased amount of EPS

Biofilm Reduction - Results

Based on analysis of Robbins Devices at a pilot site





Membrane Protection – Value Proposition

- Extend the period between consecutive CIPs
  Reduction of chemical use

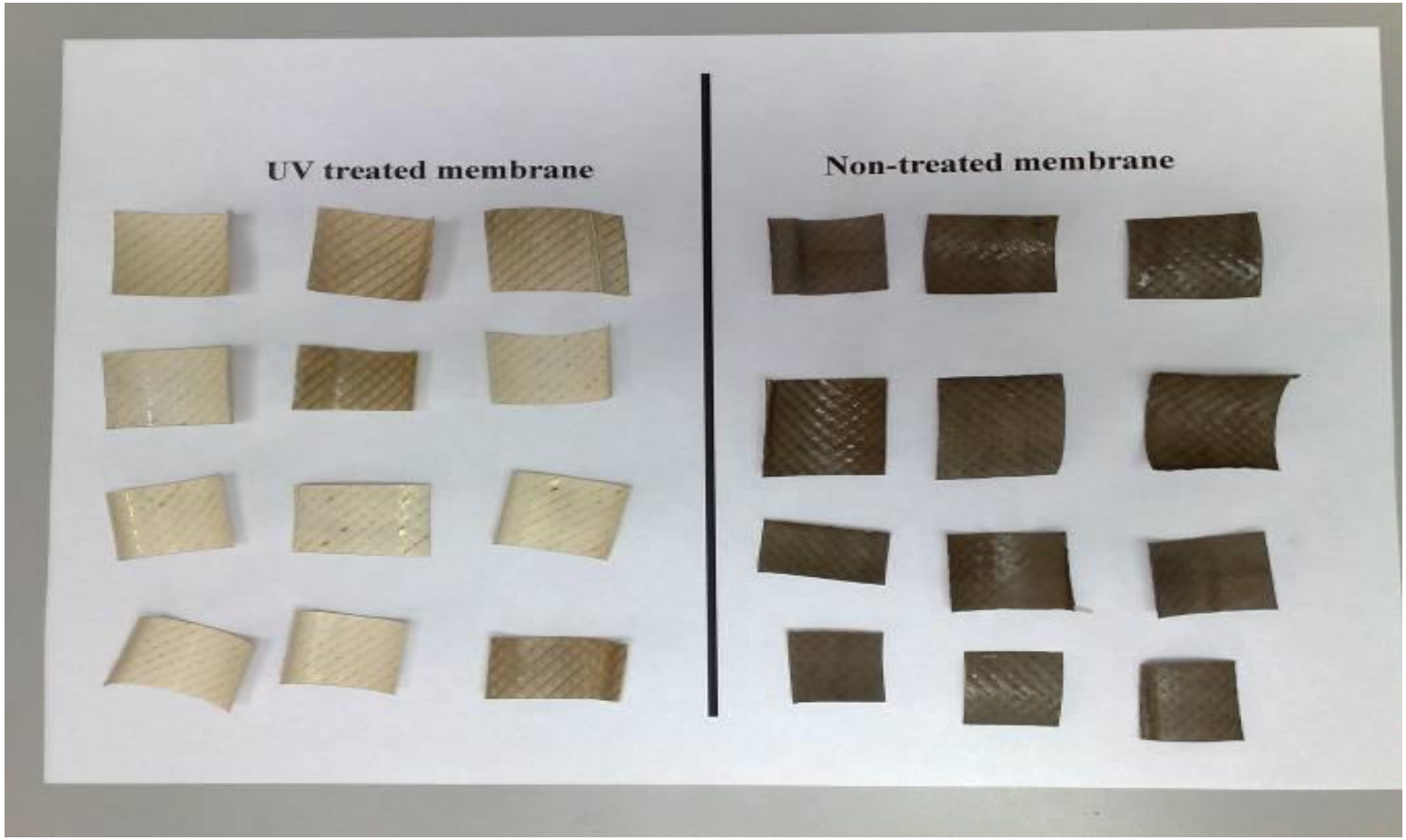
- Maintain flux rate at lower Net Driving Pressure
  Less energy & more product water

- Enable less aggressive CIP regimes and improve membrane recovery properties post CIP
  Less chemicals, shorter downtime, less energy & more product water

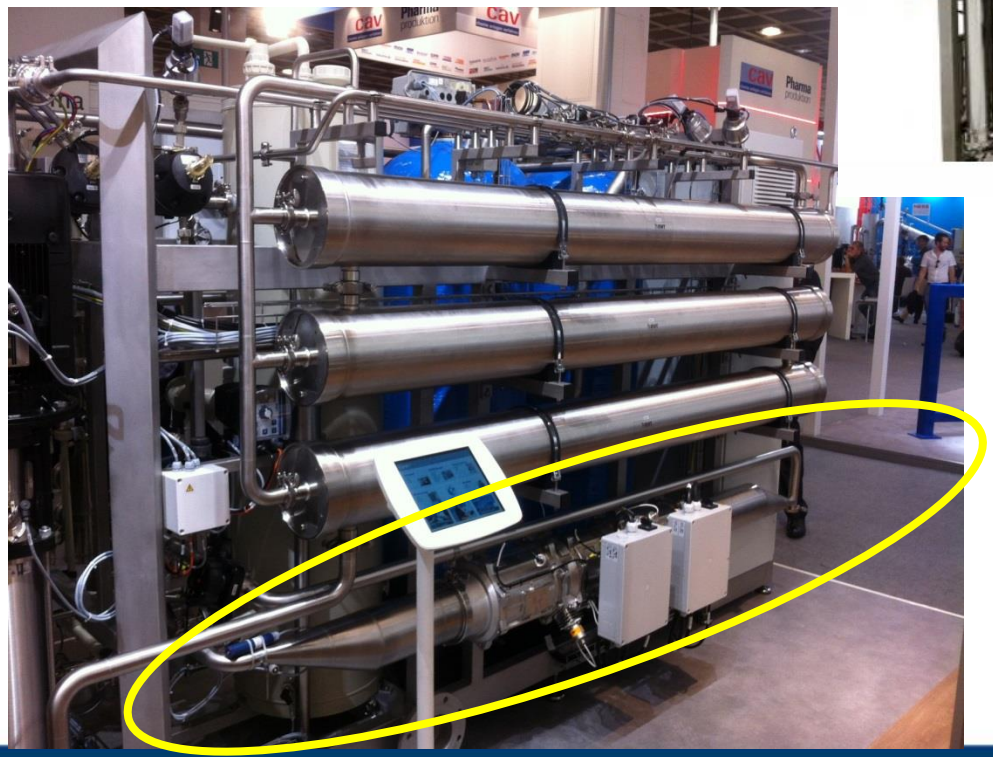
- Extend membrane life-time
  Less membrane replacement costs

Visual Differences

Results from HOD UV installation using municipal tap water Pre - RO membranes

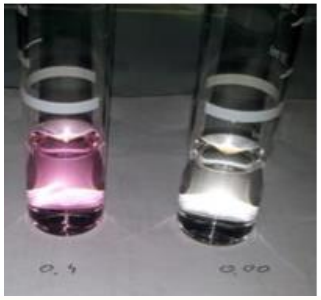


Hydro-Optic Installation for Dechlorination



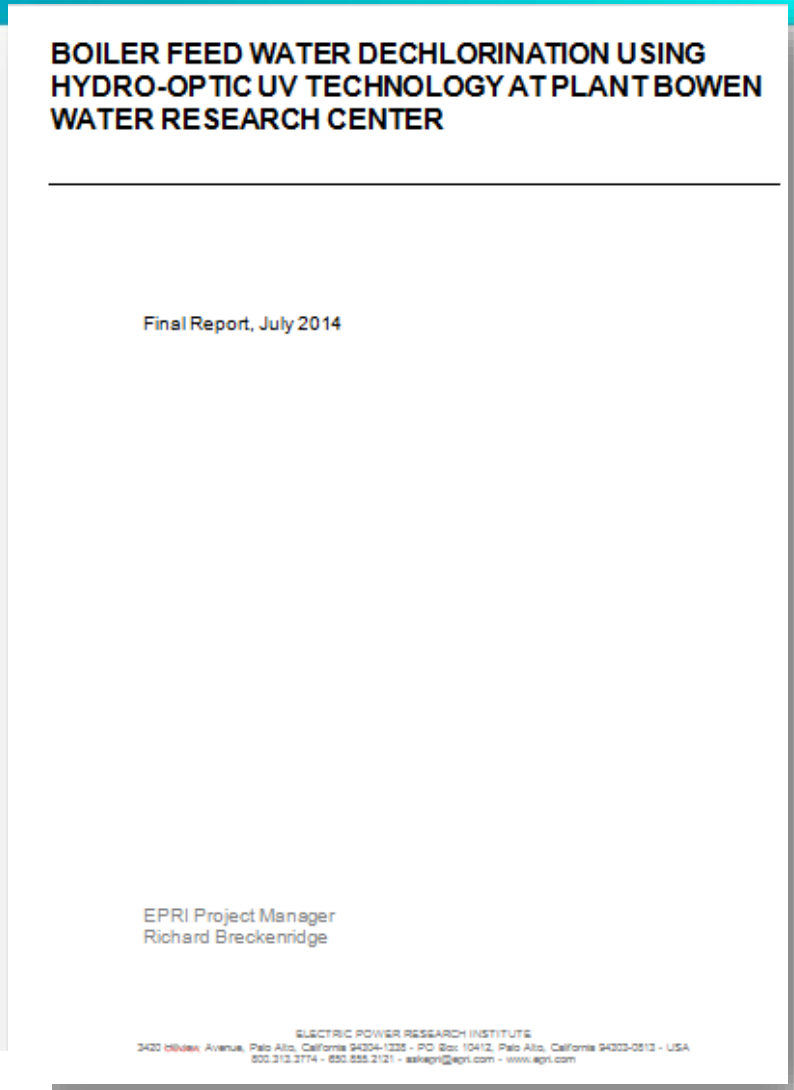
Thermal Power Plant ,USA
Dechlorination in boiler feed water pre RO

- Surface water
- pretreatment including chlorine injection
- Flow rate – 154 m^3/h
- Inlet free chlorine level – up to 0.7ppm
- Required outlet free chlorine (≤0.02ppm)
- Previous treatment – SBS



Thermal Power Plant ,USA
Dechlorination in boiler feed water pre RO

"…the HOD UV technology effectively removed free and total chlorine from boiler feed water to undetectable levels from levels above 0.7 mg/L at the inlet. Bacteria levels were also reduced to an average of 3.8 organisms per 100/mL"



BOILER FEED WATER DECHLORINATION USING HYDRO-OPTIC UV TECHNOLOGY AT PLANT BOWEN WATER RESEARCH CENTER

Final Report, July 2014

EPRI Project Manager
Richard Breckenridge

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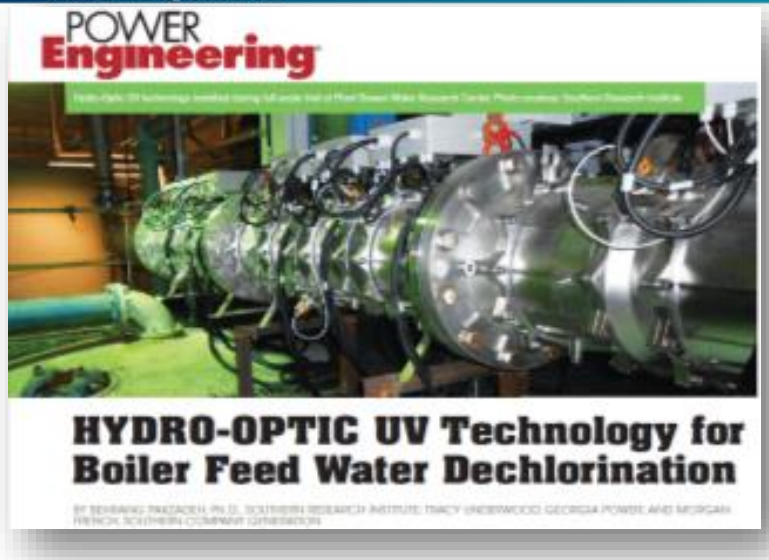
Dechlorination in boiler feed water pre RO



- *The TOC reduction while De-Chlorinating the water*

EPRI study concluded in 2014. Membrane performance was further monitored from August 2014 – August 2017.

The membranes are performing as new, even after three years of operation.

CONCLUSION

Following the successful full-scale demonstration of the HOD UV technology, the Plant Bowen WRC is finalizing the justification necessary to incorporate the system into full-scale operations at the plant. Based on the savings in chemical elimination, benefits of reduced CIP, extended life of the membranes, and reduced organic loading leading to fewer regeneration cycles of the demineralizers, the HOD UV technology will be a favorable addition to dechlorination treatment efforts at Plant Bowen WRC.

Membrane Performance- ROI

Differential pressure

- New membrane - 28 psi
- Membrane 4 years old WO HOD UV - 50psi
- Membrane 4 years old with HOD UV - 34psi

Annual saving on electricity – 5K-USD

Annual Saving on chemicals – 5K USD

Since 2014 saving on micron filtration replacement – 240K USD

Increased life time of membrane – 100K USD

Total ROI recognized by the plant – **2 years** [WO extended membrane life time]

Dechlorination Methods: Comparison, Summary

	Carbon Filter	Sodium Bisulfite	Medium Pressure UV HOD
Bacteria Proliferation & Contamination	Yes. Intensive	Yes Anaerobic, including sulfur-reducing bacteria	No The very high UV-Dose "kills" ALL micro-organisms
Effect on RO Membranes	Negative Bio-fouling	Negative Bio-fouling and Scaling	Positive (high) Greatly reduces Biofouling and Scaling
Effect on pH and Conductivity	No	Yes	No
Water On Demand, availability	Not Always Intensive maintenance, risk of filter breakthrough	Yes Occasional chemicals contact time	Yes
Chemicals in the Water	No	Yes Must be removed	No
Maintenance Cost	Yes Ongoing routine	Yes Ongoing routine	No
Footprint &Space	Large	Small	Small Can also be mounted vertically
Price (CAPEX)	Relatively Expensive (high)	Inexpensive	Relatively Expensive (low)
OPEX	Expensive (high)	Expensive (average)	Moderate
TCO	High (excellent)	High (fair)	Medium

HOD DeChlorination - Summary

- Clean, field proven and reliable superior solution
- Best protection for RO membranes and other costly chlorine-sensitive equipment
- Safe and sustainable
- Appealing Low Total Cost of Ownership
- True in-line system with very small footprint
- No chemicals
- On-demand availability
- Reduced maintenance burden
- Reduced operating costs
- Full control with real time monitoring

Thank you for your attention

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