

Know Before You Flow: Basics of UV

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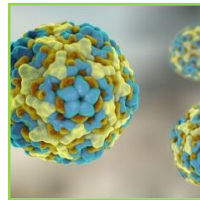
Basics of UV

- The “bugs” in the water
- UV Technology Basics

“The Bugs” in our water



Bacteria



Viruses



Protozoa

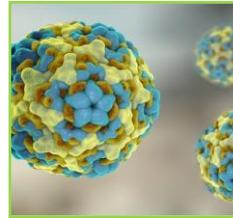
Bacteria

Bacteria will almost always be in the water; the question is which ones, and should we be concerned?...

Pathogenic	Opportunistic	Nuisance	Harmless
Known to cause infection	Does not typically cause infection, but can in the right conditions	Typically causes aesthetic issues but not illness	Just doing their thing..
<i>Salmonella</i>	<i>Legionella</i>	<i>IRB/SRB/Slime</i>	<i>...most others</i>

Viruses & Protozoa

Viruses and Protozoa are not as common/abundant in water as bacteria but are a significant cause of concern.



Norovirus

Can be highly infectious

Limitations in testing availability



Cryptosporidium

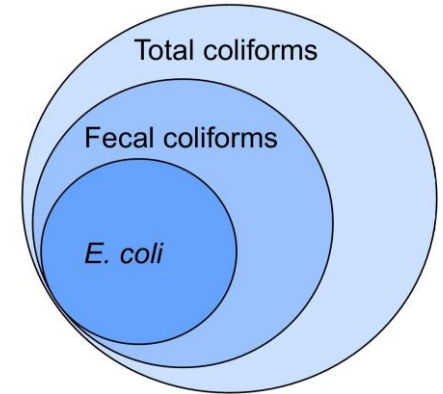
Sign of fecal contamination

Testing

It's unrealistic to test specifically for pathogenic organisms on every source (cost, technology).

Indicators are relied upon to “tell a story” about potential **sources** of contamination and potential **pathways**

Typical indicators: Total Coliform, E. Coli, Nitrate



How do they get in the well water?

Source and a pathway...

(poop)



How do they get in the stored rainwater?

Sources

- Rooftops
- Birds and other critters
- Storage issues – pathways into the tank
- Contaminated collection system – first flush/etc

WHY RAINWATER NEEDS TO BE TESTED AND PURIFIED

RAINWATER CAN CARRY BACTERIA, PARASITES, VIRUSES, AND CHEMICALS



UV Water Treatment

What is UV and how does it work?



UV Is...

1. Proven

The first full-scale, UV system for water treatment was used in France in **1910**.

Today, UV is trusted by cities like New York, Paris, and Vancouver to **treat water delivered to millions of homes**.

2. Recognized by health authorities

3. Eco-Friendly

4. Simple



Where is UV being used today?

Microelectronics



The pioneer in introducing UV into the microelectronics industry for TOC reduction. Today, the Microelectronics industry still remains our largest segment by revenue.

Food & Beverage



Our products are widely used in the F&B industry to guarantee the final product quality & safety.

Life Science (Pharmaceuticals)



The Life Sciences industry requires high performance and high stability equipment to guarantee the manufacturing process and product safety.

Aquaculture



We provide an end-to-end solution from hatchery and well boat water processing to waste/bleed water disinfection, guaranteeing that our customers meet regulatory requirements.

Other Industries

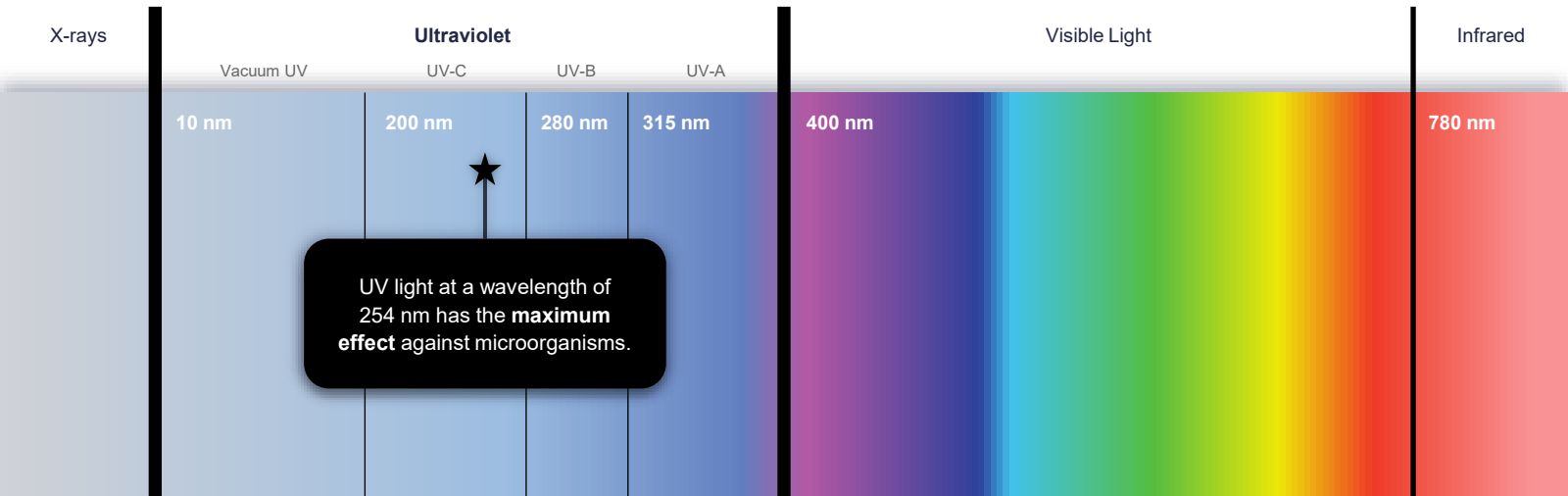


We serve the Cooling and Boiler Water, Oil and Gas, Power Generation, Recreational Water, and Marine customer base, offering a variety of products and solutions.

UV Light Is Part of the Electromagnetic Spectrum

UV light can:

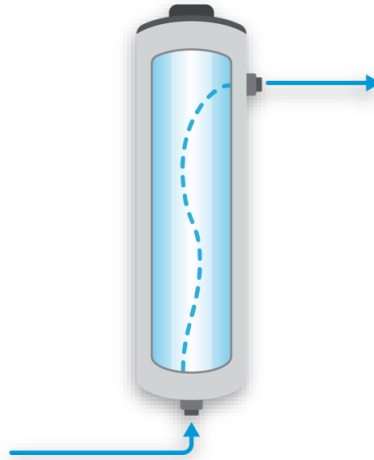
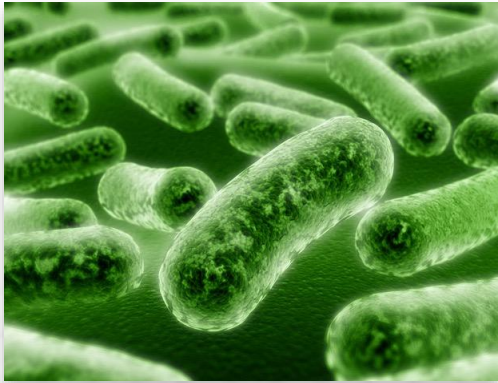
- Inactivate Microorganisms



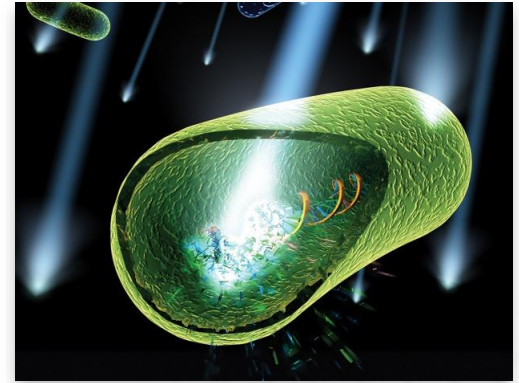
UV Penetrates the Cell Wall, Permanently Altering DNA Structure

No replication means no infection and no illness!

**Microorganisms enter via
untreated water**



**UV destroys DNA so they
can't replicate**



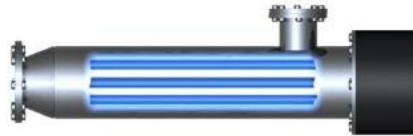
UV Dose

UV DOSE



=

UV Intensity
(Quantity of UV light per unit area)



X

Residence Time
(contact time in the reaction chamber)



UV Dose is expressed in:

- mJ/cm² (Millijoules/cm²)
- μWsec/cm² (Microwatt seconds/cm²)

Depends on:

- UV lamp type & output
- Number of lamps
- Lamp & reactor geometry
- Quartz sleeve & water UV absorbance

Depends on:

- Effective reactor volume
- Water flow rate
- Hydraulics

Common UV Dose measurements

UV dosage rates are expressed in a **mJ/cm²** format. Some common Target UV Dosage Rates referred to in UV technology include:

- 16mJ/cm² - Suited to general rainwater applications with a clean reticulation and catchment area
- 30 mJ/cm² - This is a good Target UV Dosage to aim for when sizing process applications
- 40 mJ/cm² - Used for critical applications in healthcare, waste water and chlorine deactivation

The Amount of UV Light Needed Depends on the Target Organism



UV Efficacy Chart

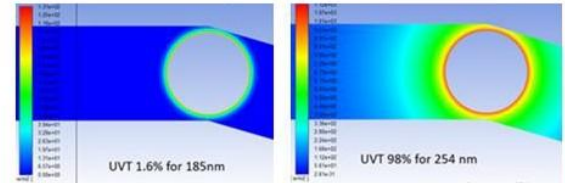
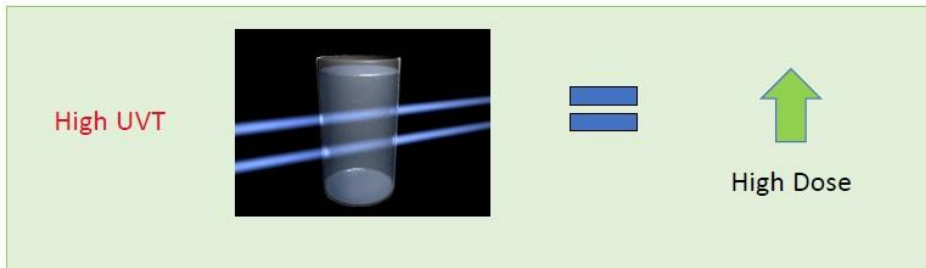
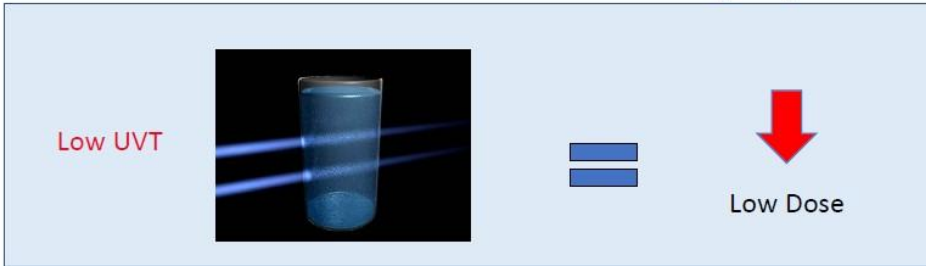
UV Systems have been challenged through microbial testing. Through this testing, performance data has been generated for delivering the UV dose to inactivate:

Bacteria	<i>Vibrio cholerae</i>
	<i>Shigella dysenteriae</i>
	<i>Escherichia coli</i> 0 157:H7
	<i>Salmonella typhi</i>
	<i>Shigella sonnei</i>
	<i>Salmonella enteritidis</i>
Protozoan Cysts	<i>Cryptosporidium parvum</i> oocysts
	<i>Giardia lamblia</i> cysts
Viruses	<i>Hepatitis A virus</i>
	<i>Poliovirus</i> Type 1
	<i>Coxsackie B5 virus</i>
	<i>Rotavirus</i> SA 11

The industry standard (30 mJ/cm²) achieves a 99.9% reduction of many common waterborne pathogens.

UVT vs. Dose

UV Transmittance (UVT)



What is UVT exactly?

UV Transmittance (UVT)

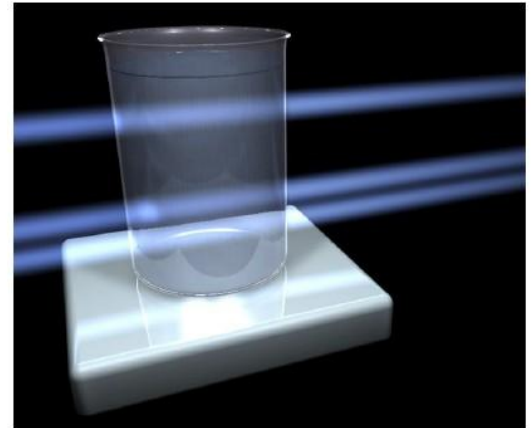
The ratio of light entering the water to that exiting the water – usually reported for a path length of 1 cm. UVT is often represented as a percentage and is related to the UV absorbance by the following equation:

$$\%UVT = 100 \times 10^{-A}$$

As the UV absorbance increases, the UV transmittance decreases.

Examples:

DI/RO Water	= 99% UVT
Fresh Water (Post AGC)	= 95% UVT
Municipal Tap Water	= 85-95% UVT



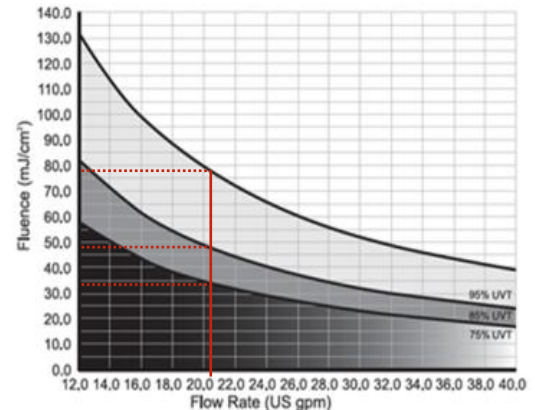
UVT of source water can significantly impact dose at different flow rates

At a given flow rate, dose can vary greatly due to UVT.

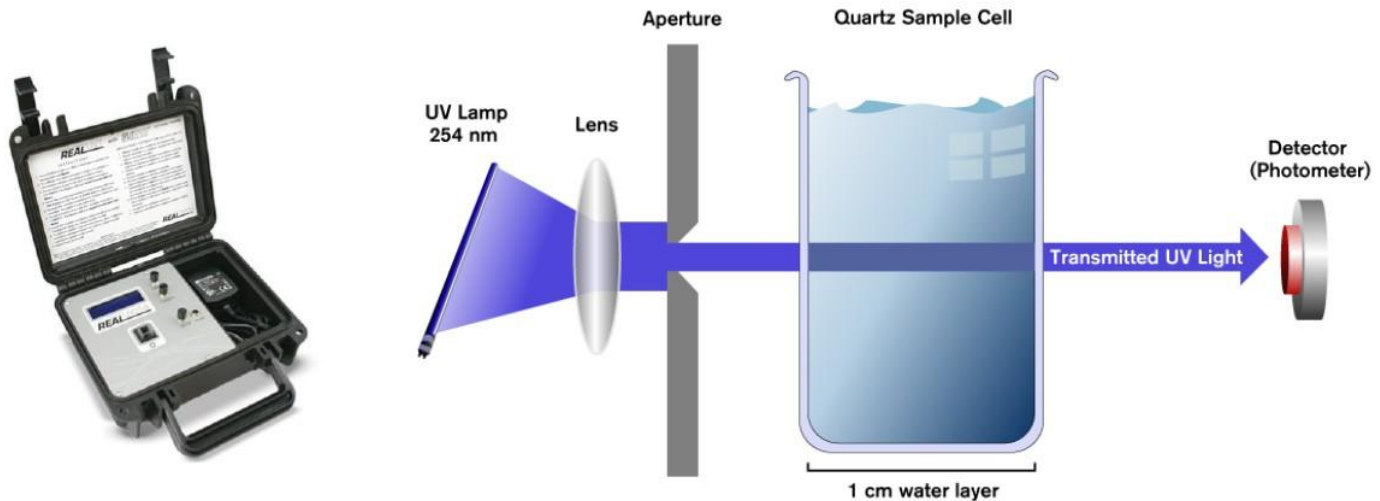
If flowrate is **20 gpm**, for example

- **UVT @ 95%** → UV dose is 80 mJ/cm²
- **UVT @ 85%** → UV dose is 50 mJ/cm²
- **UVT @ 75%** → UV dose is 35 mJ/cm²

Dose Curve



Measuring UVT



Low UVT cannot always be seen

Water Quality Influences Dose

Objective: Maximum UV penetration through total volume of water in the chamber.

Hardness minerals and iron deposits coat quartz surfaces.

Reduces treatment dose and blocks UV light.

Turbidity in source water blocks UV rays.

Particles “shield” pathogens from UV light, reducing treatment.

Tannins absorb UV rays.

Lessening the intensity of UV light that can be absorbed by microbes.

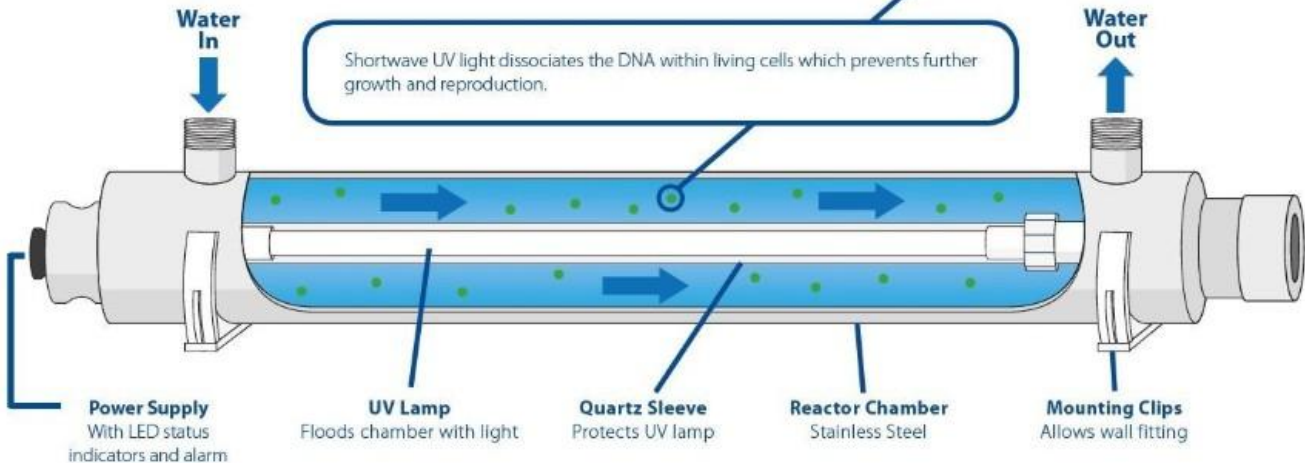
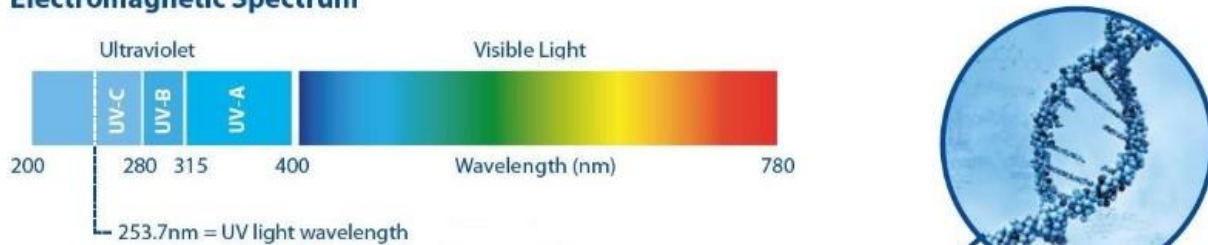
Recommended Water Quality

Parameter	Influence / Effect	Limits	Treatment Options
UV transmittance	Measure of absorption of UV light; UVT can affect system sizing requirements	> 75% UVT @ 254nm	
Iron	Affects UVT and sleeve fouling	< 0.3 ppm (0.3 mg/L)	Softening (low levels only) Oxidation / filtration
Hardness	Affects rate of sleeve fouling	< 120 ppm (7 grains per gallon)	Softening
Turbidity	Can shield pathogens; post UV contamination	< 1 NTU	5-micron filter
Tannins	Affects UVT and performance	< 0.1 ppm (0.1 mg/L)	GAC filter (low levels only) Anion exchange

Proper pretreatment is key to optimizing dose and ensuring system performance.

The UV system components

Electromagnetic Spectrum



UV System Components

1

The **lamp** is the “heart” of the UV system.

2

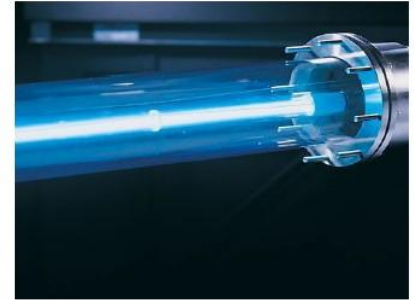
The **sleeve** helps ensure optimal lamp performance.



Standard output High output Amalgam

How the lamp works

1. Power is applied to the lamp electrodes
2. Electrical arc is generated from ionized gas or gas mixtures, which conduct electricity
3. Current is limited from the power source to protect the lamp and supply wiring
4. As the arc temperature rises, mercury in the lamp converts to a gaseous vapor state
5. Mercury vapor conducts electricity, completing the circuit
6. Lamp output in the UV range depends on the amount of mercury and vapor pressure of mercury in the lamp

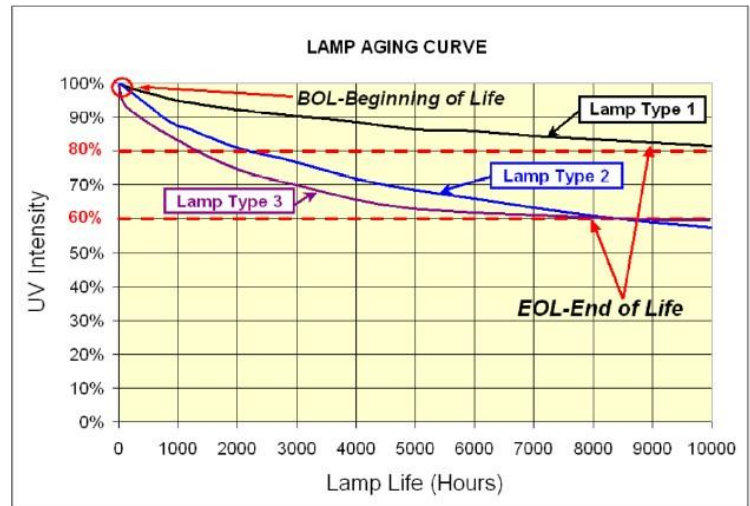


Lamp degradation over a year

Lamp Degradation (Aging) of Lamps: figure gives a typical example of the aging characteristics of low-pressure Hg lamps. The lamp life is measured relative to the intensity at **100 h** of operation.

The causes of aging:

- solarization of the lamp wall material (the phenomenon is faster for optical glass than for quartz)
- blackening due to deposits of sputtered oxides from the electrodes



3

The **controller** powers the lamp.



Constant current



End-of-life timer

4

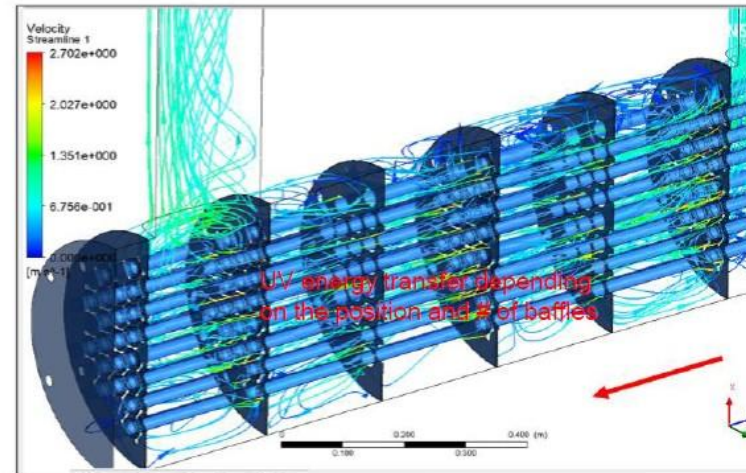
The **chamber** design determines contact time.



Developing and testing a product

Computational Fluid Dynamics (CFD)

- Reactor inlet/outlet and internal geometry design
- Fluid flow analysis (Navier-Stokes equation)
- UV intensity analysis (Discrete Ordinate model)
- Chemical reaction analysis (photolysis and radical reaction of water modeled with C++ and MATLAB code)



Key to Success – Choosing a system

1



Size of service line

2



House size / number
of bathrooms

3

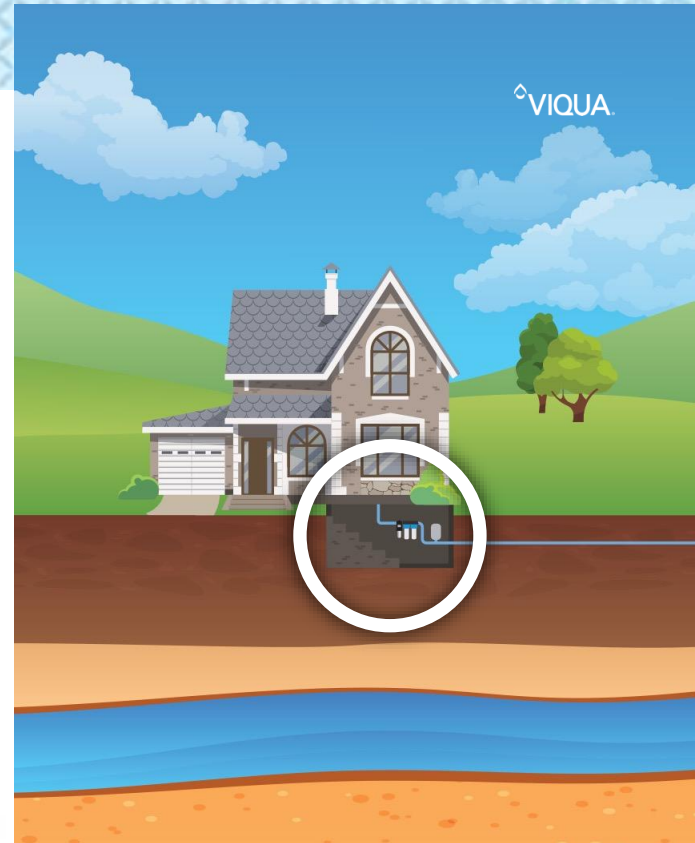


Water meter

You cannot overdose so don't undersize!

Point-of-Entry Systems

- Deliver treated water to every tap for drinking, cooking, bathing, brushing teeth, washing clothes, and more
- Prevent biofilm from forming on plumbing



Integrated Systems

Available with pre-mounted filter cartridges that remove contaminants before they can enter the UV chamber.

Types of filters:

5-micron sediment

Carbon

Spin-down sediment



It Takes Good Water to Make Great Water

Sediment filter 5-micron filter <0.5 NTU	Filter Iron <0.1 mg/L (Tannins <0.1 ppm)	Softener Softened <7 mg/L	VIQUA UV	Reverse osmosis (RO)
Homeowner benefits				
<ul style="list-style-type: none"> Removes sediments. Optimizes UV effectiveness. 	<ul style="list-style-type: none"> Eliminates rust staining on clothes and fixtures caused by iron, without adding chemicals. Eliminates objectionable color and odor caused by tannins. Optimizes UV effectiveness. Minimizes UV maintenance. 	<ul style="list-style-type: none"> Eliminates scale build-up. Makes glassware shine. Optimizes UV effectiveness. Minimizes UV maintenance. 	<ul style="list-style-type: none"> Inactivates disease-causing microorganisms. Offers 24/7 protection. Delivers quality, treated water to every tap. 	<ul style="list-style-type: none"> Purifies drinking water from heavy metals and other contaminants



Maintenance

- Lamp must be changed every 365 days
- Quartz sleeve should be cleaned yearly and replaced every two years
- Check for leaks and replace pre-filters

Thank You

Any questions?

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