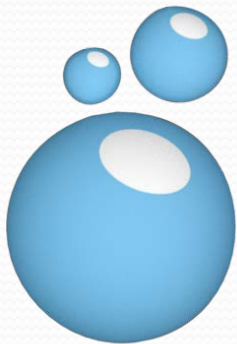


PRACTICAL APPLICATION OF UV AND OZONE IN RESIDENTIAL POOLS



PORTABLE SPAS

- Both UV and Ozone gained initial use in the Portable Spa Market in our industry.
- Spas are small bodies of water (< 500 gallons) compared to residential pools.
- The application of UV and Ozone are different in high volume water vessels like pools.



POOLS

- Spurred by consumer desire for low chemical/low chlorine pools, alternative technologies are coming into the market.
- So far, no technology has been developed that can completely eliminate chlorine.
- With alternative technologies like UV and Ozone, a chlorine residual is required, usually 0.5 - 1.0ppm.
- Properly applied, UV and Ozone provide safer, cleaner water. Fast acting and effective.



CHLORINE



WHAT IS OXIDATION?

Chemically converting or “burning up” organic matter into less harmful compounds

- Chlorine is an oxidizer
- Ozone is an oxidizer
- UV is not an oxidizer

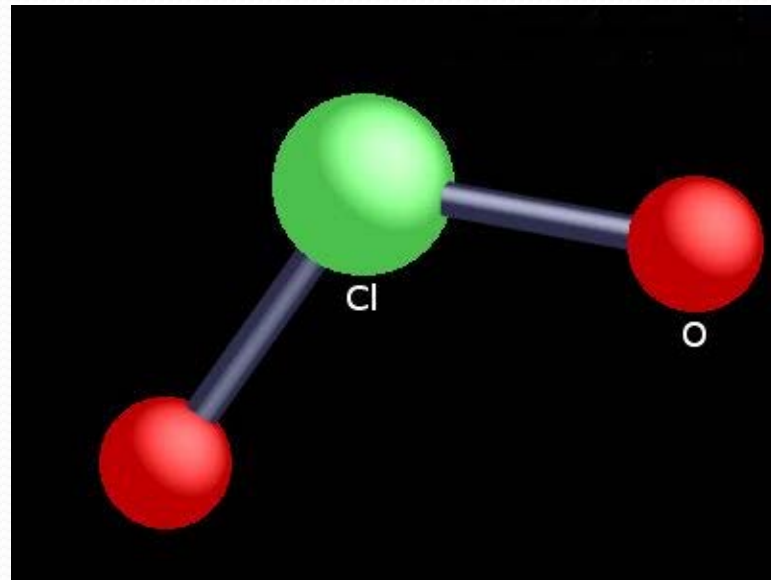


CHLORINE AS AN OXIDIZER

Chlorine is slow acting but stable in water if protected by cyanuric acid

PRO

1. Widely Available
2. Relatively Low Cost
3. Easy to Monitor



CON

1. Creates Harmful By Products: Chloramines and Trihalomethane
2. Irritating to Human Respiratory System and to Epidural (Skin)
3. Unstable in Sunlight – Requires Stabilization

WHEN CHLORINE IS INTRODUCED INTO WATER IT FORMS INTO HYPOCHLOROUS ACID AND HYPOCHLORITE IONS

Oxidant	Oxidation Potential
Ozone (O₃)	2.07
Hydrogen Peroxide	1.78
Hypochlorous Acid	1.49
Hypochlorite Ion	< .95

THE EFFECTIVENESS OF CHLORINE IS GREATLY REDUCED AS PH LEVEL RISES



Effect of pH on Hypochlorous Acid

pH	% of HOCl in FAC
6.0	97
7.0	6.75
7.5	49
8.0	3

This is a downside of Salt systems where pH run high

TREATING WATER WITH OZONE



TWO METHODS OF PRODUCING OZONE

1. Ultraviolet Light

- Lower Output
- Less Expensive

2. Corona Discharge

- Higher Output and Efficiency
- More Expensive

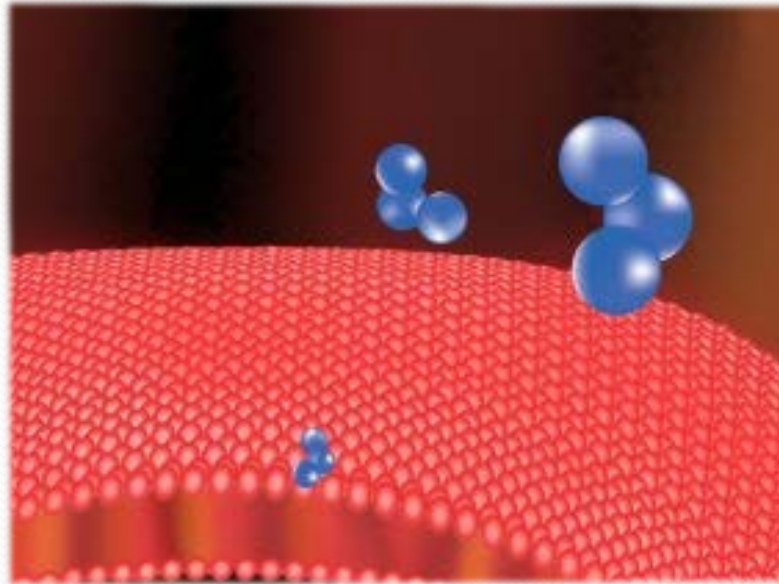


HOW DOES OZONE KILL BACTERIA?



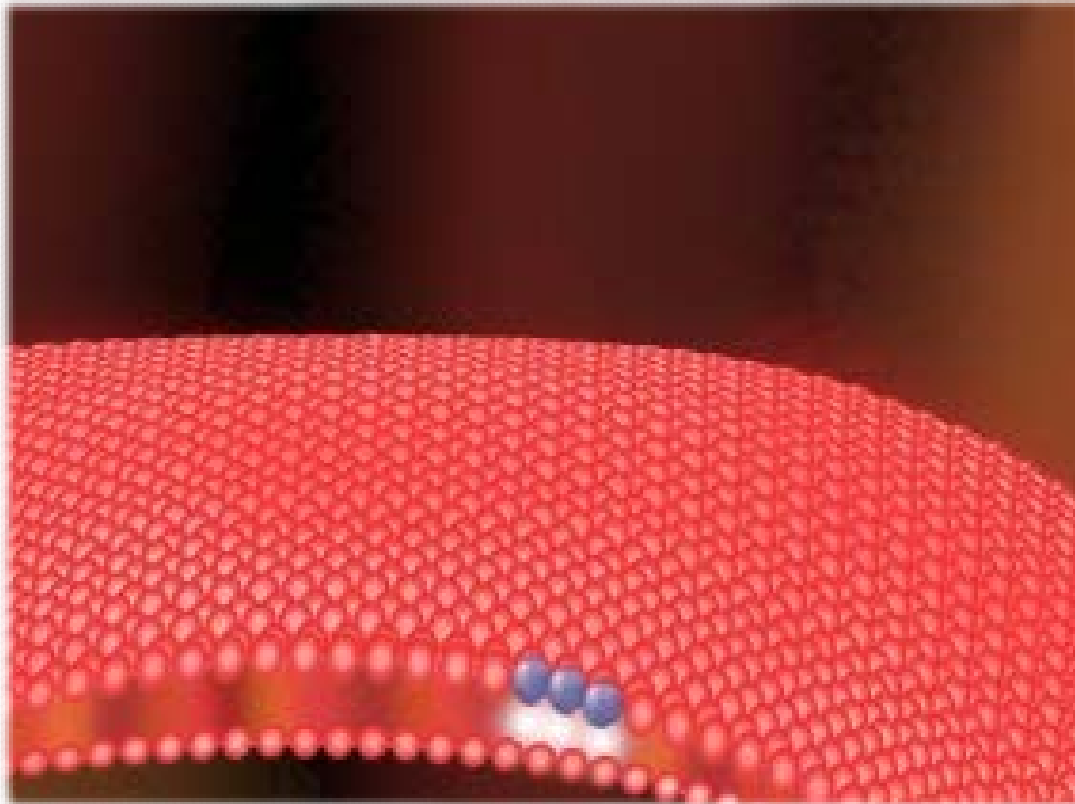
A healthy bacillus bacterial cell (waiting to ruin your day).

Ozone comes into contact with the cell wall which is vital to the bacteria because it ensures the organism can maintain its shape.



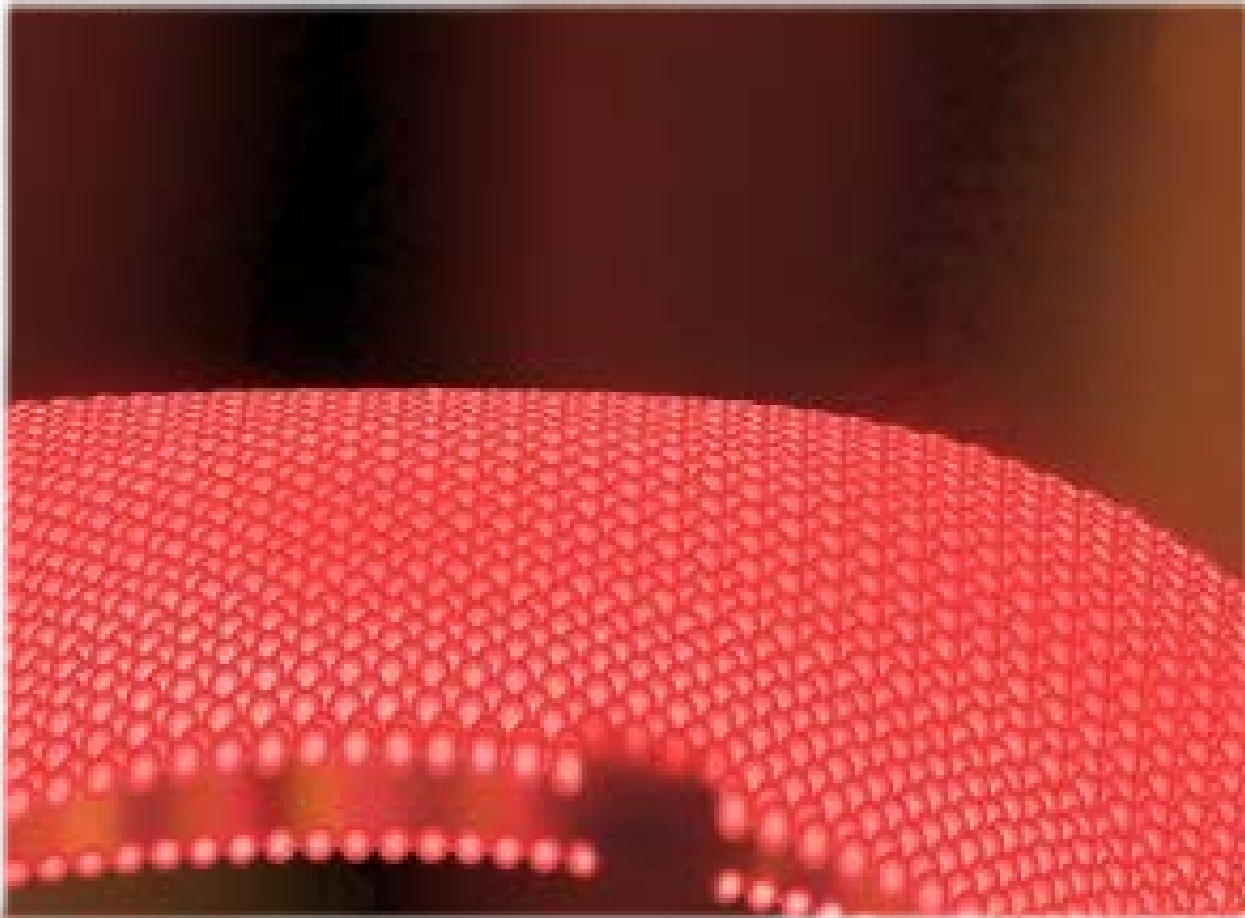
Ozone (O₃) carries an extra oxygen atom that aggressively attacks the cell wall. Whatever O₃ is not used in oxidation will eventually convert to oxygen (O₂).

As Ozone molecules make contact with the cell wall



A reaction called an oxidative burst occurs which literally creates a tiny hole in the cell wall.

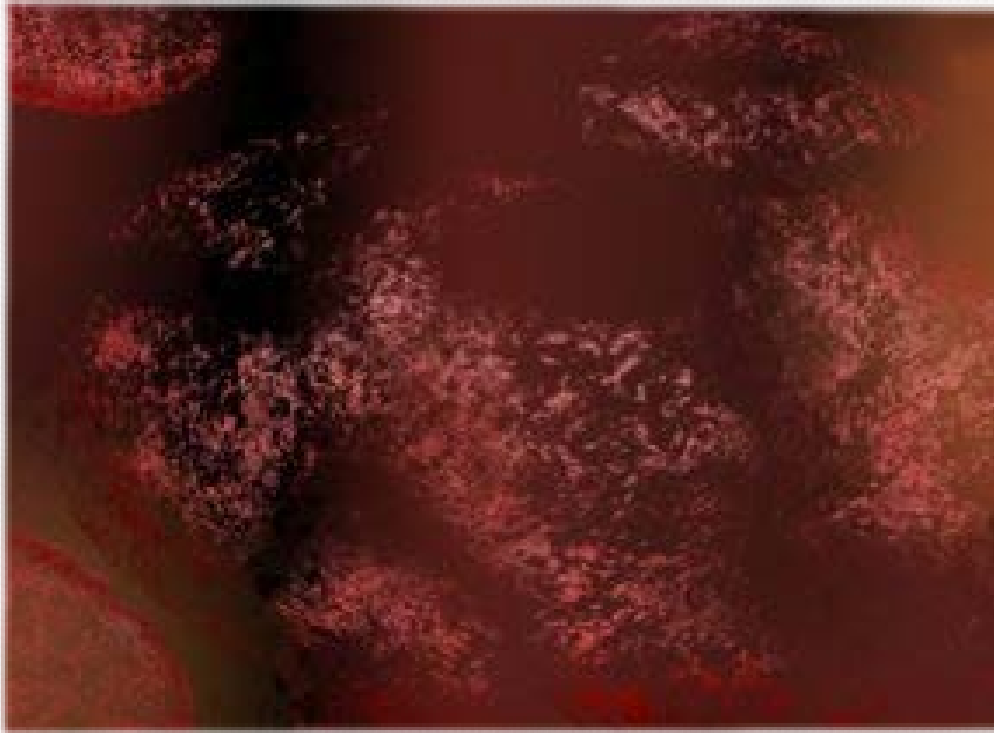
A newly created hole in the cell wall has injured the bacterium.



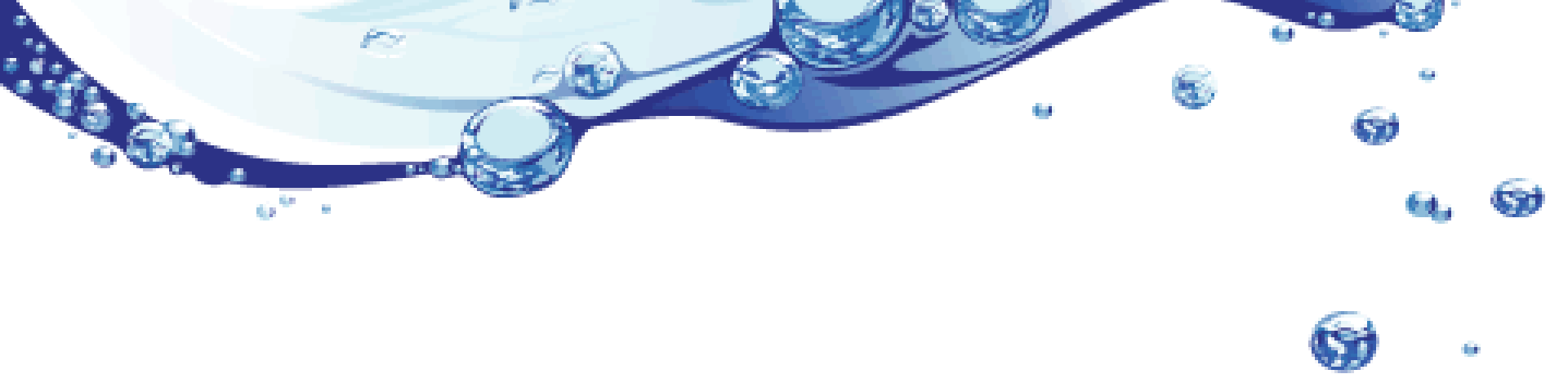


The bacterium begins to lose its shape while ozone molecules continue creating holes in the cell wall.

After thousands of ozone collisions over only a few seconds, the bacterial wall can no longer maintain its shape and the cell dies.



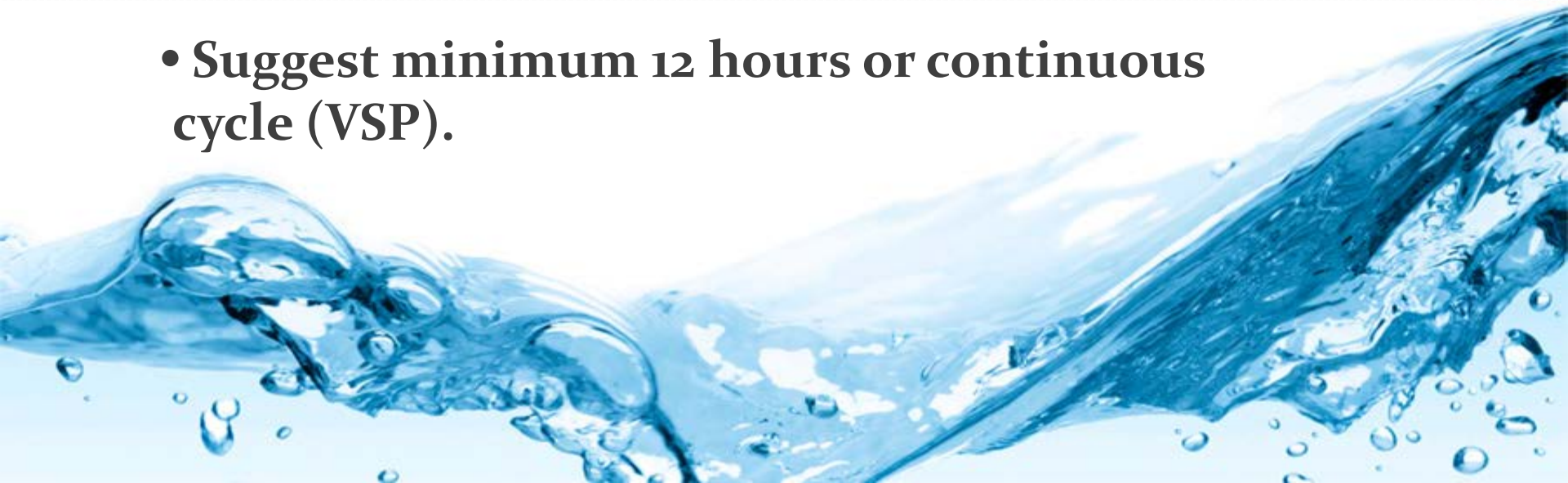
- Filtration cycle time is important to continually ozonate the water and to filter out dead material
- VSP work extremely well in this application.



- ④ The primary difference between chlorine oxidation and ozone oxidation is the speed of the reaction. Ozone is 100% faster and a much better virucide than chlorine, does not affect pH and is not dependent on pH level for effectiveness.
- ④ However, the half life of ozone in water is less than 20 minutes whereas stabilized chlorine will last for days. Continuous run cycle will keep a continuous residue of ozone in the water.

KEYS TO OZONE EFFECTIVENESS

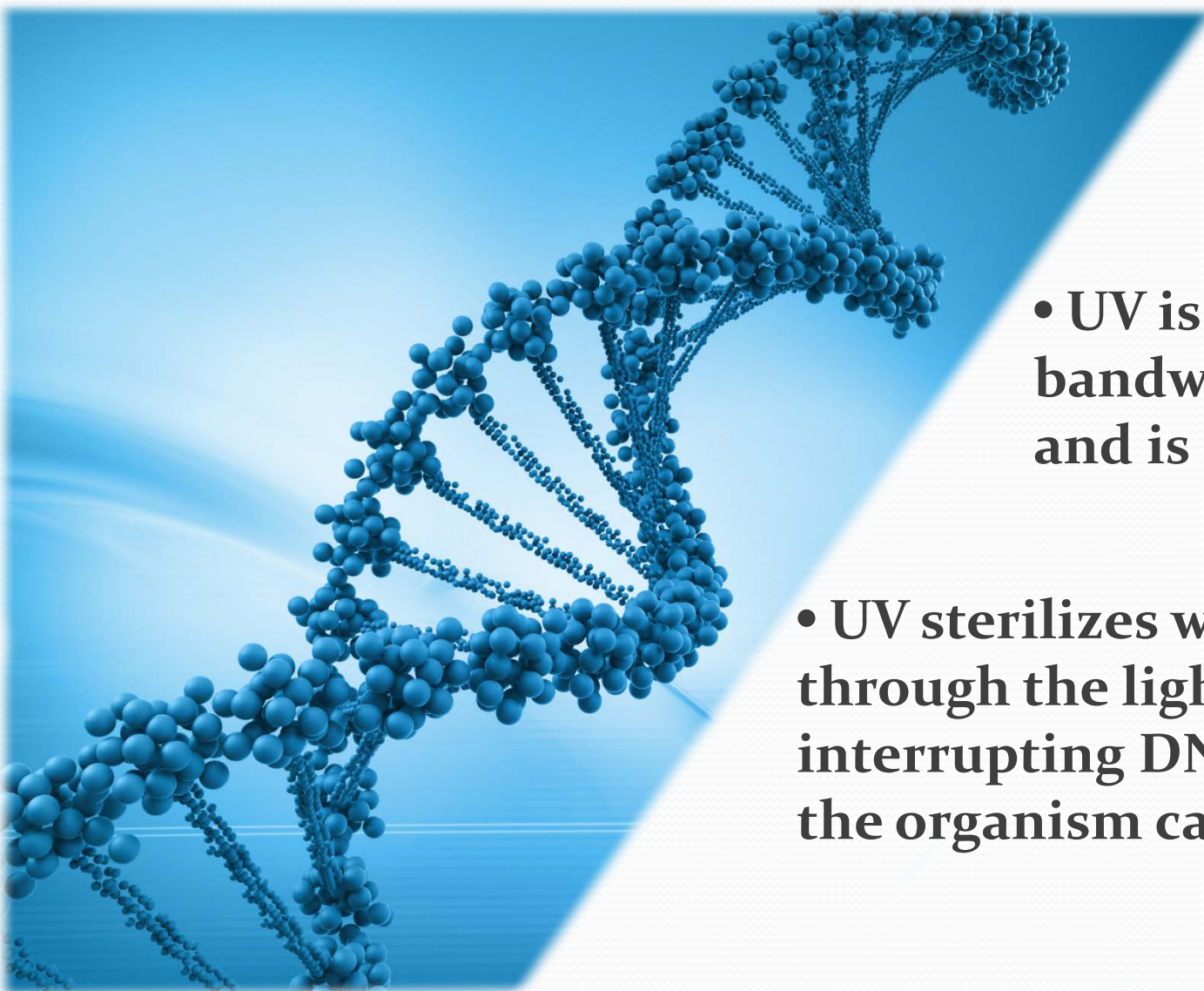
- **Bypass usually required or some type of flow control.**
- **Small bubbles provide greater contact time.**
- **Extend pump/filter cycle time to continually inject ozone into water for longer periods of time.**
- **Suggest minimum 12 hours or continuous cycle (VSP).**



ULTRAVIOLET WATER TREATMENT

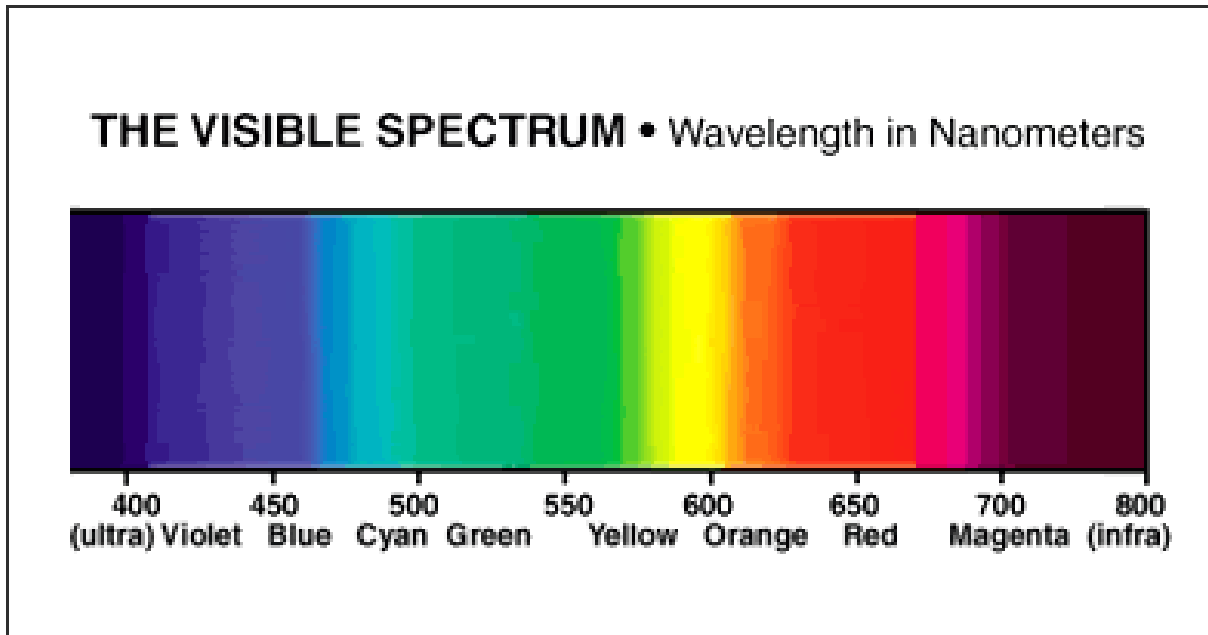


HOW DOES UV STERILIZE WATER?



- UV is a specific bandwidth of light and is not an oxidizer.
- UV sterilizes water passing through the light field by interrupting DNA connectors so the organism cannot reproduce

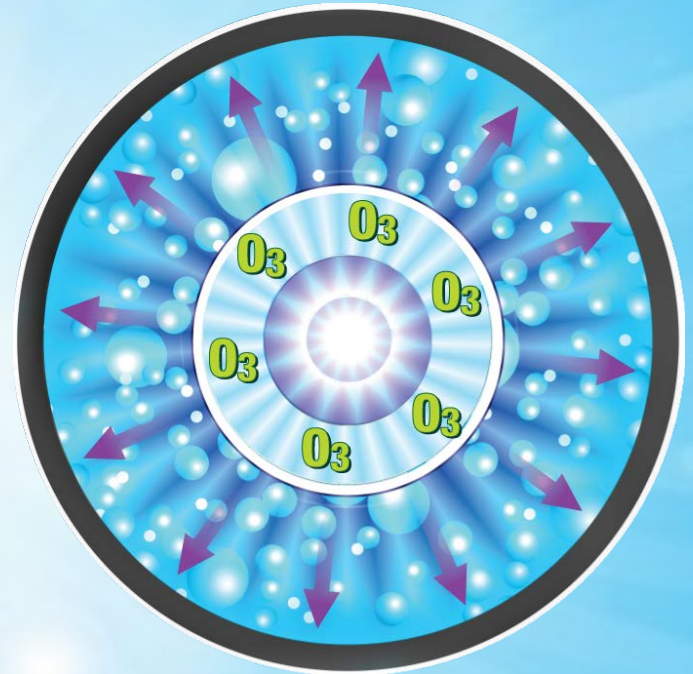
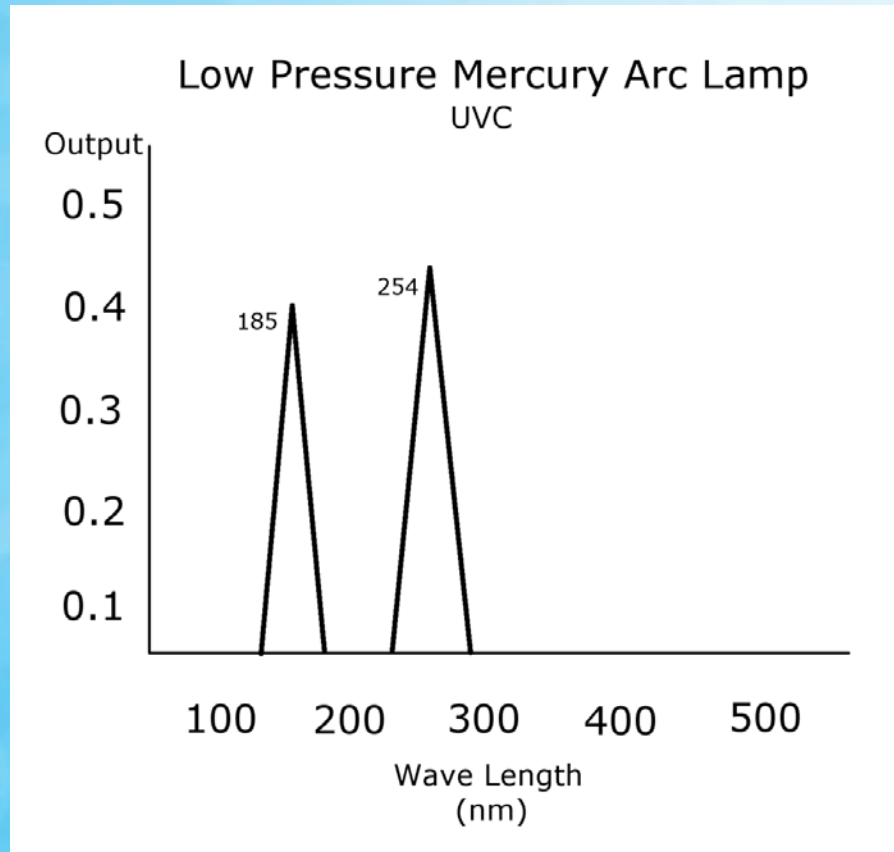
THE ULTRAVIOLET LIGHT SPECTRUM



UV FROM SUN

UVA	315-400 nm	Not absorbed by atmosphere - reaches earth
UVB	280-315 nm	Mostly absorbed by atmosphere - little to Earth
UVC	100-280 nm	Completely absorbed - 254 is what we use

ULTRAVIOLET WAVELENGTH USED IN UV/OZONE SYSTEMS



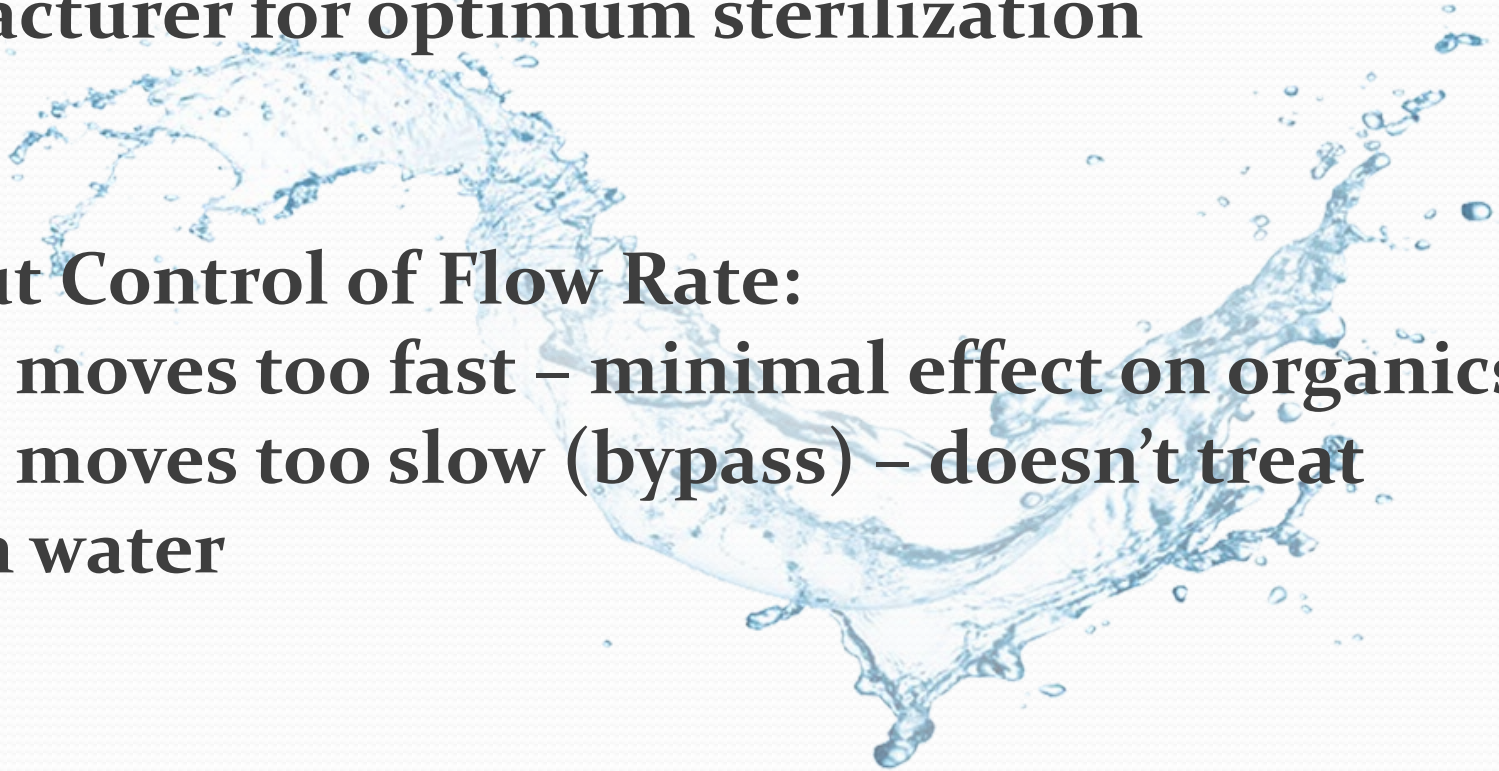
RESIDENT TIME IN UV CHAMBER

Flow Rate vs. UV Effectiveness

- **Varies by Bulb Wattage**
- **Resident Time Established by manufacturer for optimum sterilization**

Without Control of Flow Rate:

- **Water moves too fast – minimal effect on organics**
- **Water moves too slow (bypass) – doesn't treat enough water**



UV EFFECTIVENESS IS MEASURED IN MILLIJOULES

Micro-Organisms	Log Reduction		Micro-Organisms	Log Reduction	
	1	2		1	2
Bacteria					
Bacillus anthracis	4.5	8.7	Fecal coliforms	3.4	6.8
Bacillus subtilis, spores	12	22	Salmonella enteritidis	4	7.6
Clostridium tetani	12	22	Shigella dysenteriae	2.2	4.2
Mycobacterium tuberculosis	6	10	Staphylococcus aureus	5	6.6
Viruses			Algae		
Hepatitis A	7.3	14	Chlorella vulgaris	12	22

- 30 MJ/ CM² is standard for drinking water
- 99.99% elimination of bacteria, algae and viruses



Swimming Pools Can Be Effectively Sterilized at 99%

KEYS TO UV EFFECTIVENESS

- **Bypass usually required or some type of flow control**
- **Resident Time in Chamber (not too fast)**
- **Enough gpm to make a difference in turnover**
- **Extend Pump/Filter Cycle Time to sterilize the water and to remove dead organics from water**
- **Suggest minimum 12 hours or continuous cycle (VSP)**



ADVANCED OXIDATION PROCESS



COMBINING UV AND OZONE

- **Known as Advanced Oxidation Process (AOP)**
- **Creates Hydroxyl Free Radicals**
- **Strongest oxidants that can be supplied in water**
- **Reacts non selectively and aggressively**
- **AOP can also be achieved using UV and Hydrogen Peroxide**
- **Extended cycle time produces best results**



SUMMARY

LOW CHEMICAL POOLS

- Using UV and Ozone separately but especially together, allows chlorine residual < 1 ppm safely and effectively in residential pools
- Neither technology affects pH
- Ozone oxidizes
- UV sterilizes
- UV/Ozone combined increase effectiveness exponentially
- Consumer demand driving alternative sanitizers



