Ozone Water Treatment Application and Design

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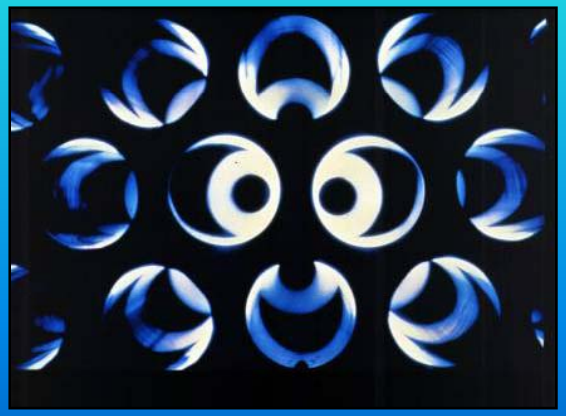


Ozone Water Treatment - Application and Design: Topics for Today's Talk

- Spartan Environmental Technologies
- Ozone Basics
- Ozone Applications
- Ozone Water Treatment System Design Considerations

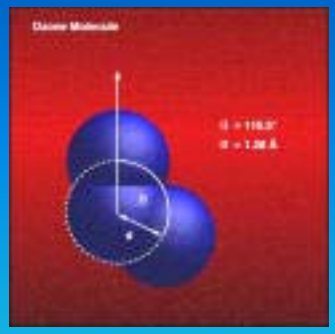
Spartan Environmental Technologies, LLC

- Spartan is a Distributor and Systems Integrator for Ozone Water Treatment Systems Serving North America
  - Spartan utilizes ozone systems from Ozono Elettronica Internazionale of Milan Italy (larger systems) and Absolute Systems Edmonton, Canada (smaller systems)
  - Spartan supplies oxygen concentrators from AirSep Systems of Buffalo, NY
  - Spartan assembles complete ozone water treatment systems at its shop in Mansfield, OH
  - Corporate members of the International Ozone Association

Spartan Supplies a Broad Range of Ozone Generator Systems, Components and Services

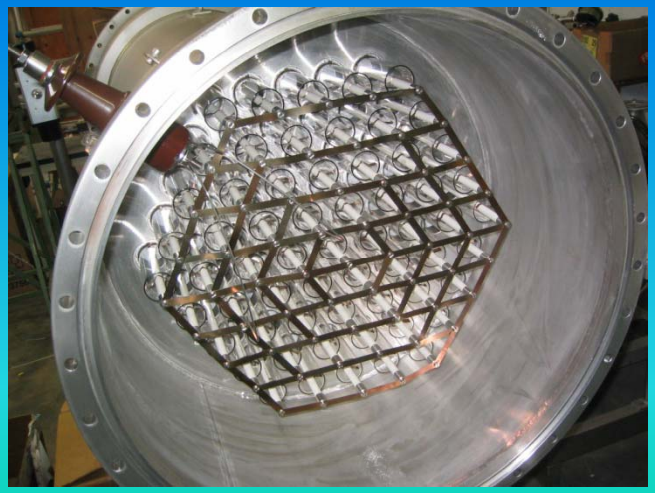
- Ozone Generators
- Instruments
- Mixers
- Ozone Destroyers
- Odor Control Systems
- Integrated Turn Key Ozone Water Treatment Systems

What is Ozone

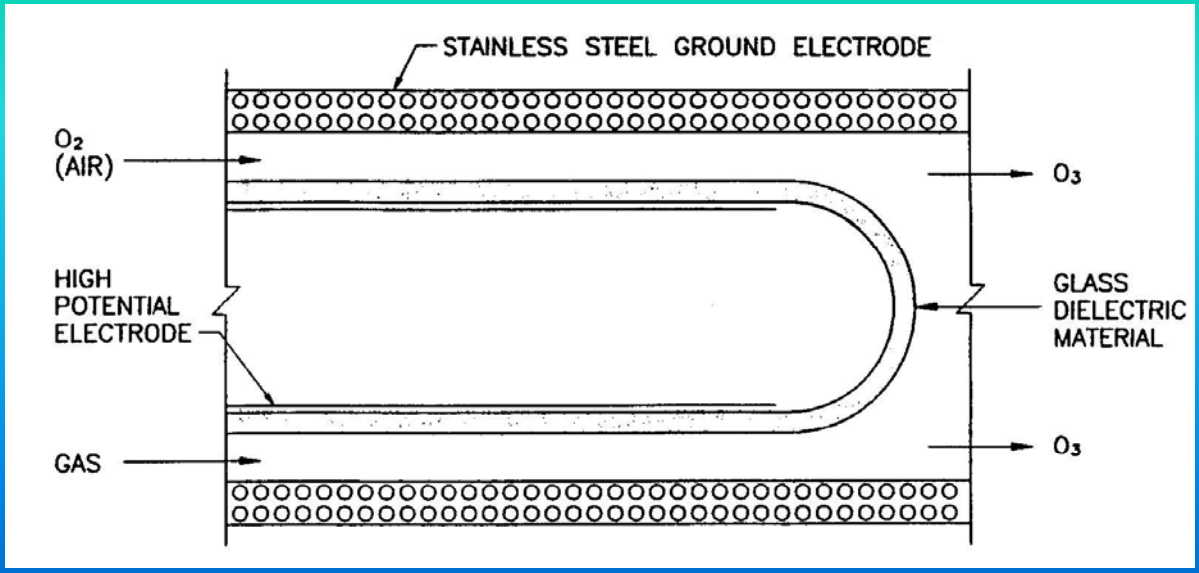


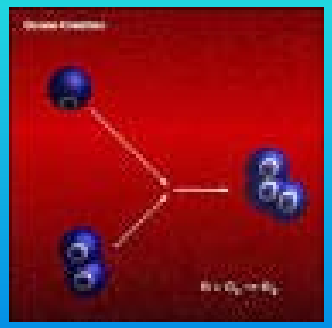
- Ozone is a light blue gas at room temperature and has a characteristic pungent odor.
- Ozone is triatomic oxygen with the chemical formula O3.
- It was discovered by Christian Friedrich Schonbein in 1840. It derives its name from the Greek word ozein or ogeiv, “to smell or smell.”

How is ozone made?



- Methods of manufacture
  - Corona Discharge
  - Photochemical (UV)
  - Electrolytic
  - Radiochemical
- Corona Discharge is the main commercial method





Ozone Generators

500 lb/day Ozone Generator
Water Cooled

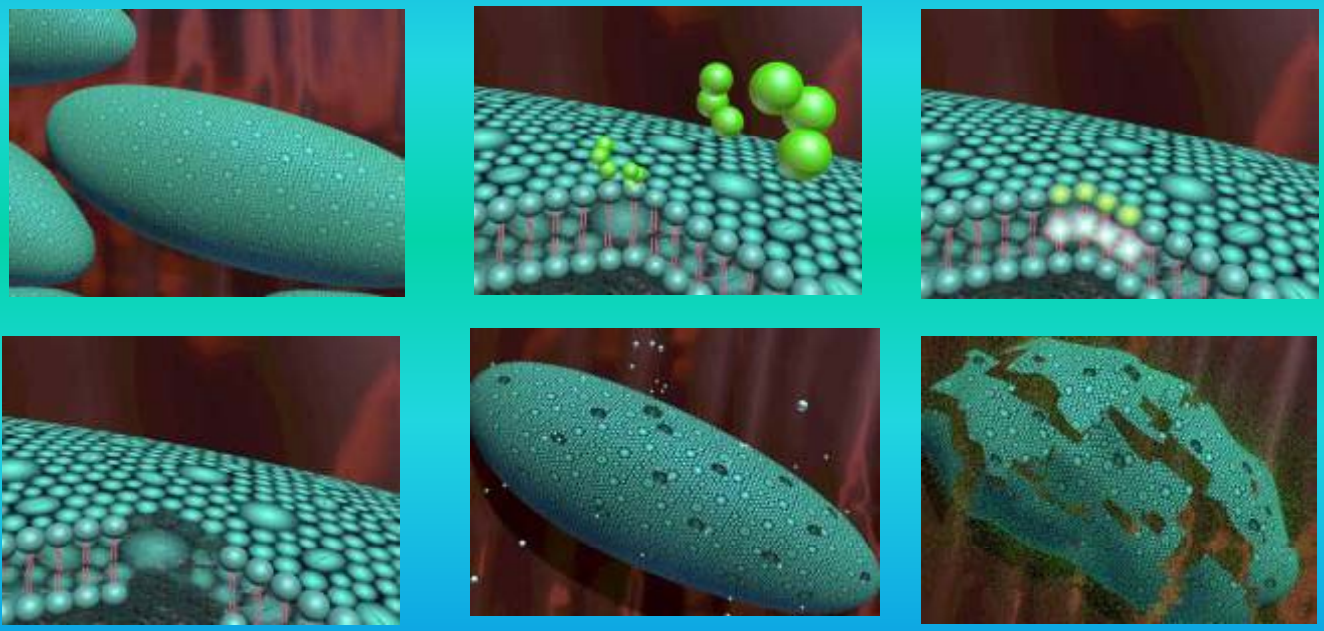
5 lb/day Air Cooled
Ozone Generator

Ozone's properties provides multiple benefits in water treatment:

- **Oxidation**
  - **COD/TOC**
  - **Fe/Mn**
  - **Hydrogen Sulfide**
  - **Taste & Odor**
  - **Color**
  - **Specific Chemicals**
- **Disinfection**
  - **Bacteria**
  - **Virus**
  - **Parasites**
- **Flocculation**
  - **Less Chemical Coagulant**
  - **Lower solids Handling**
  - **Lower Turbidity & Particles**
  - **Longer Run time**
  - **Less Backwashing**

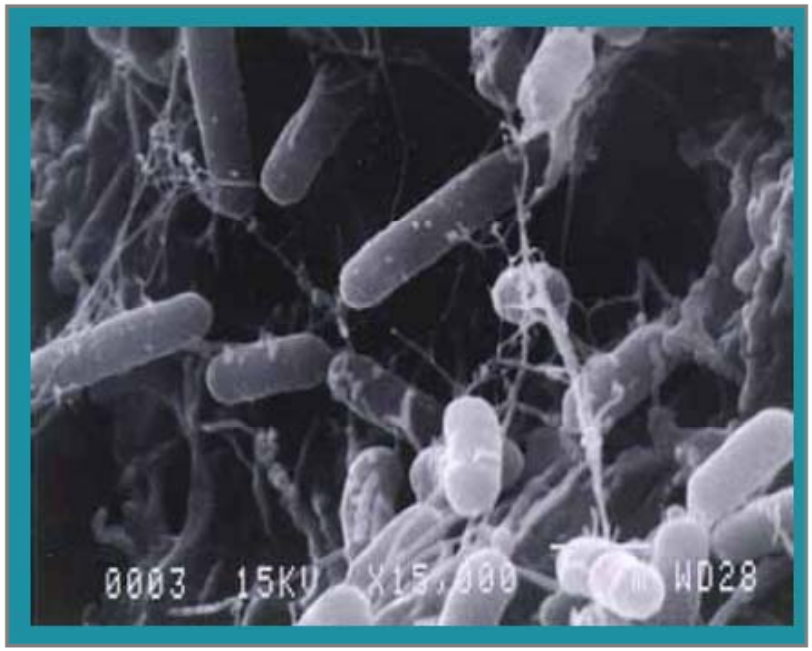
Photo Courtesy of SNWA

Ozone disinfects by destroying cell structure of bacteria, viruses, cysts and parasites:



Ozone Biocidal Behavior

Before ozone treatment



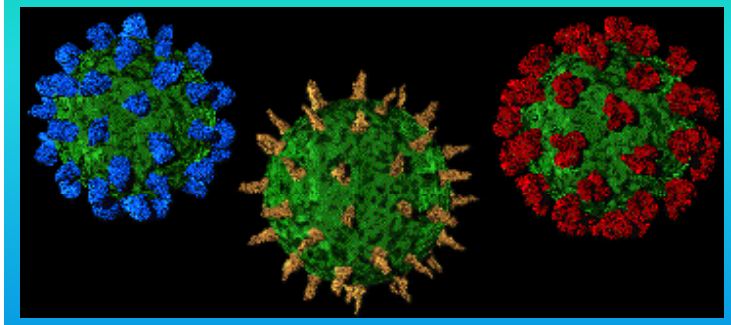
After ozone treatment

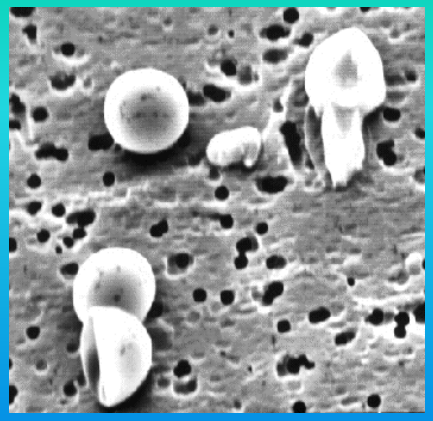
1. Ozone oxidizes cell membrane, causing osmotic bursting
2. Ozone continues to oxidize enzymes and DNA

Air Liquide America Corp., Chicago Research Center, James T.C. Yuan, Ph.D., year 2000

Ct Values (mg x min./L) For 99.9 % Inactivation of Giardia and 99.99% Virus

				Data for 5°C	
	Free Chlorine	Chloramine	Chlorine Dioxide	Ozone	
	(pH 6 to 7)	(pH 8 to 9)	(pH 6 to 7)	(pH 6 to 7)	
Giardia	122	2200	26.0	1.9	
Virus	8	1988	33.4	1.2	





Taken from: "Optimizing Water Treatment Plant Performance Using Composite Correction Program." prepared by Process Applications, Inc., for the U.S. EPA, Office of Drinking Water, Cincinnati, Ohio.

Microflocculation

- Improved Floc/Clarification & Filtration
- TOC Reduction
- Dosage Influenced by pH, TOC
- Extends Filter Runs
- Reduces Solid Handling

Microflocculation

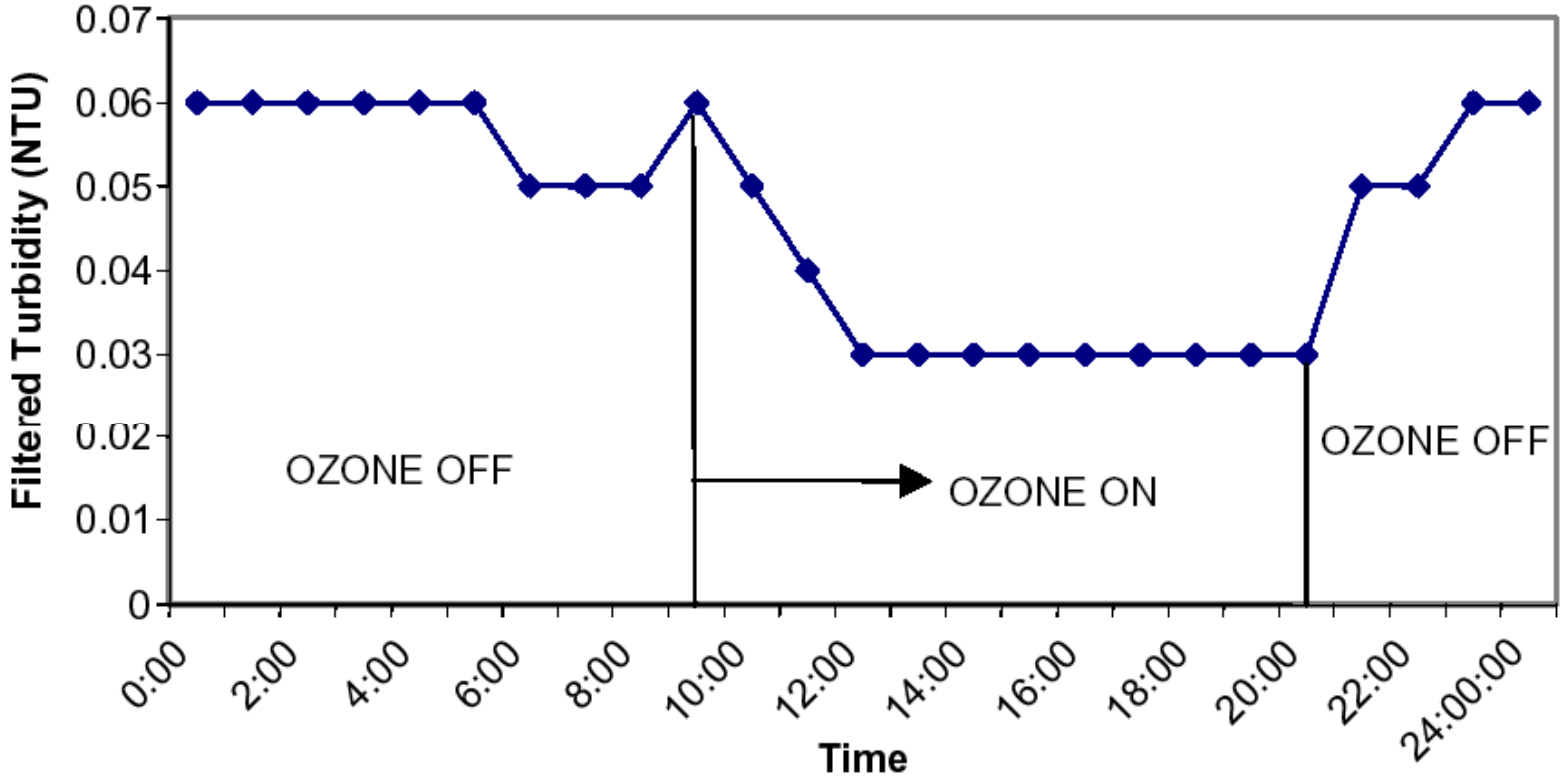


Figure 2-11. Pre-coagulation ozonation effect on turbidity during startup (Mazloum, 2004)

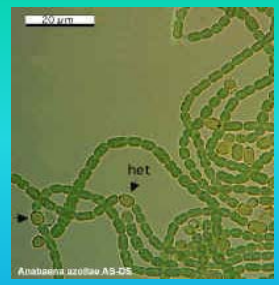
Organic Color Reduction

- Ozone is an Excellent Bleaching Agent
  - Textile Processing
  - Paper Mills
  - Drinking Water

Textile Mill Wastewater Treated with Ozone

Taste & Odor

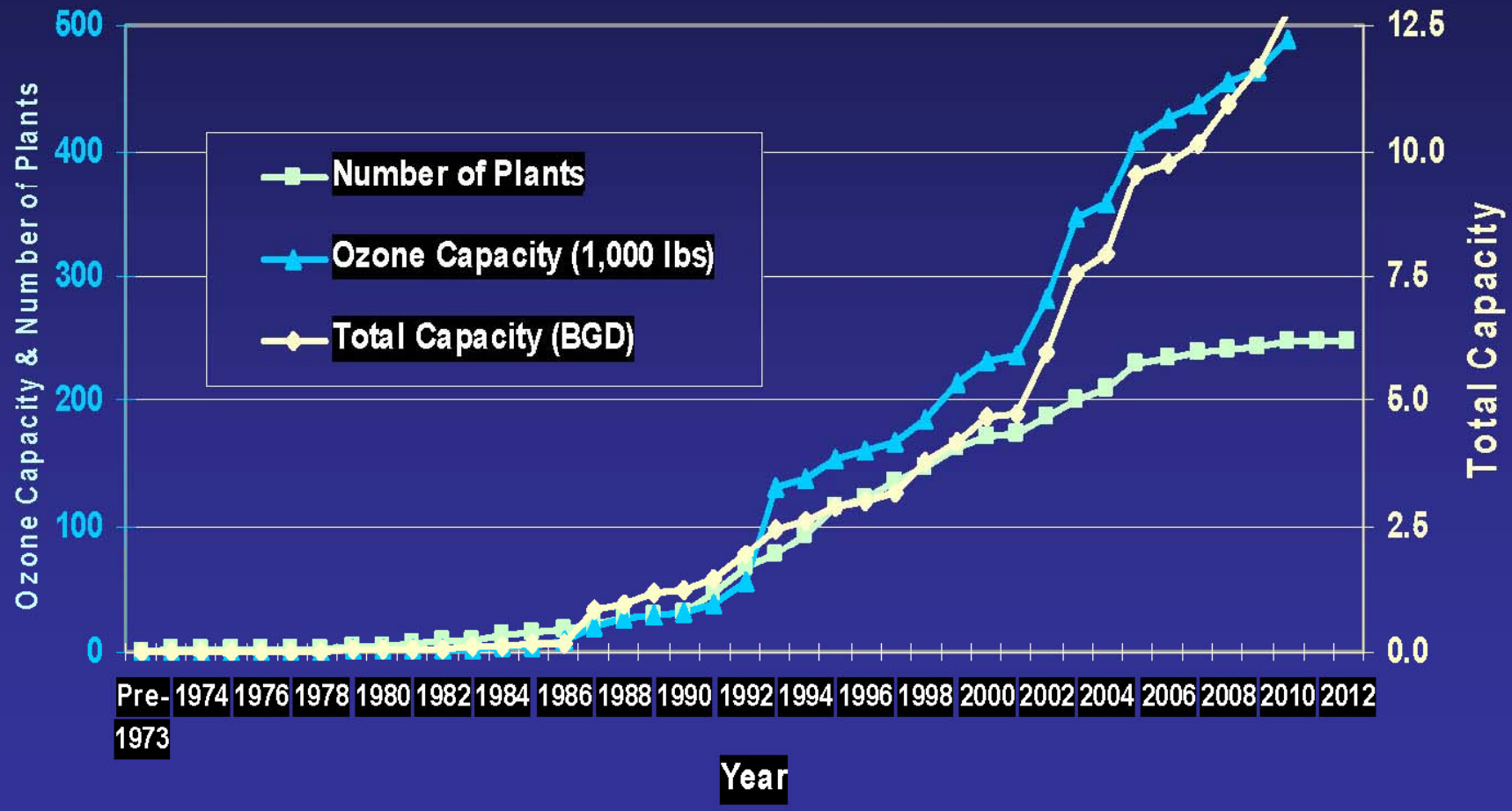
- Algal Sources in Surface Water
  - Methyl Isoborneal (MIB)
  - Geosmin
- Recycled Water Systems
- Sumps
- Condensate with VOC



Because of its various biocide and oxidation properties ozone has many applications in water treatment:

- Municipal Drinking Water Treatment
- Municipal Wastewater Treatment
- Bottled Water Production
- Industrial Wastewater Treatment
  - Color Removal in Textile and Paper Industries\
  - TOC/COD Reduction
  - Water Reclaim
  - Destruction of Toxic Compounds
- Clean In Place Systems
- Ultrapure Water Systems (e.g. Micro Electronics)
- Food Processing (e.g. Vegetable Washing)
- Aquatics (Pools, Aquariums, etc.)
- Cooling Water Systems
- Rain Water Harvesting
- Ground Water Remediation
- Grey Water Recycling

Ozone Use at WTPs in United States



Ozonation of Bottled Water

- Most Bottled Water is Ozonated
  - Improves Shelf Life
  - Disinfects without impacting taste
  - Allows for disinfection of cap and gas space in bottle

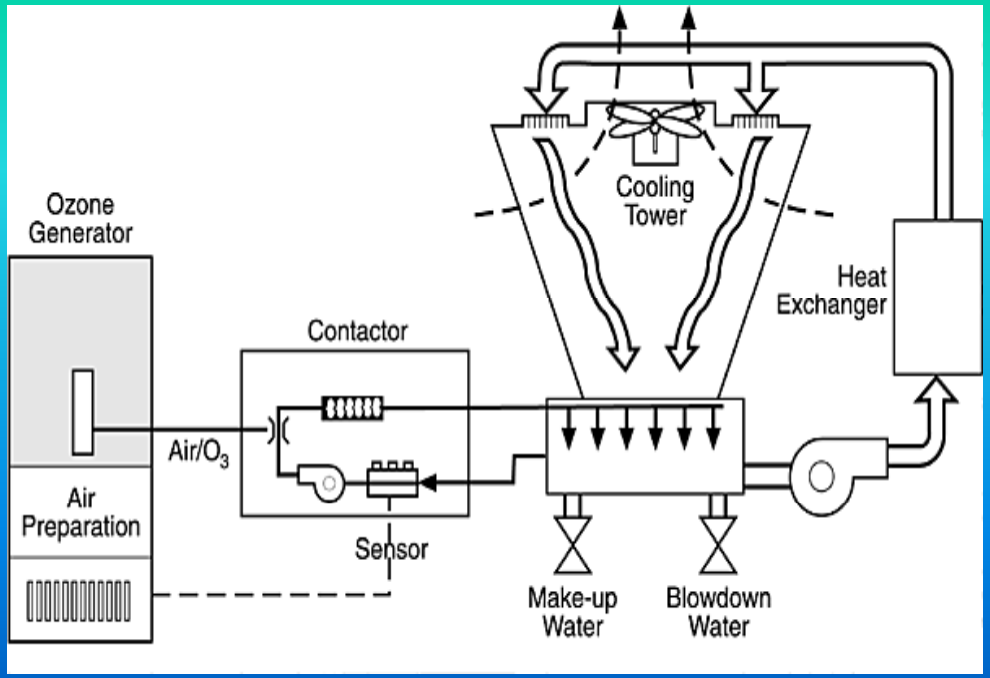
Champaign Springs Water Company

Industrial Wastewater Treatment

- Reduction of COD/TOC to meet discharge permits or lower sewer surcharges
- Removal of specific toxic organics compounds
- Removal of color
- Reclaim/Reuse of wastewater

Cooling Water Treatment

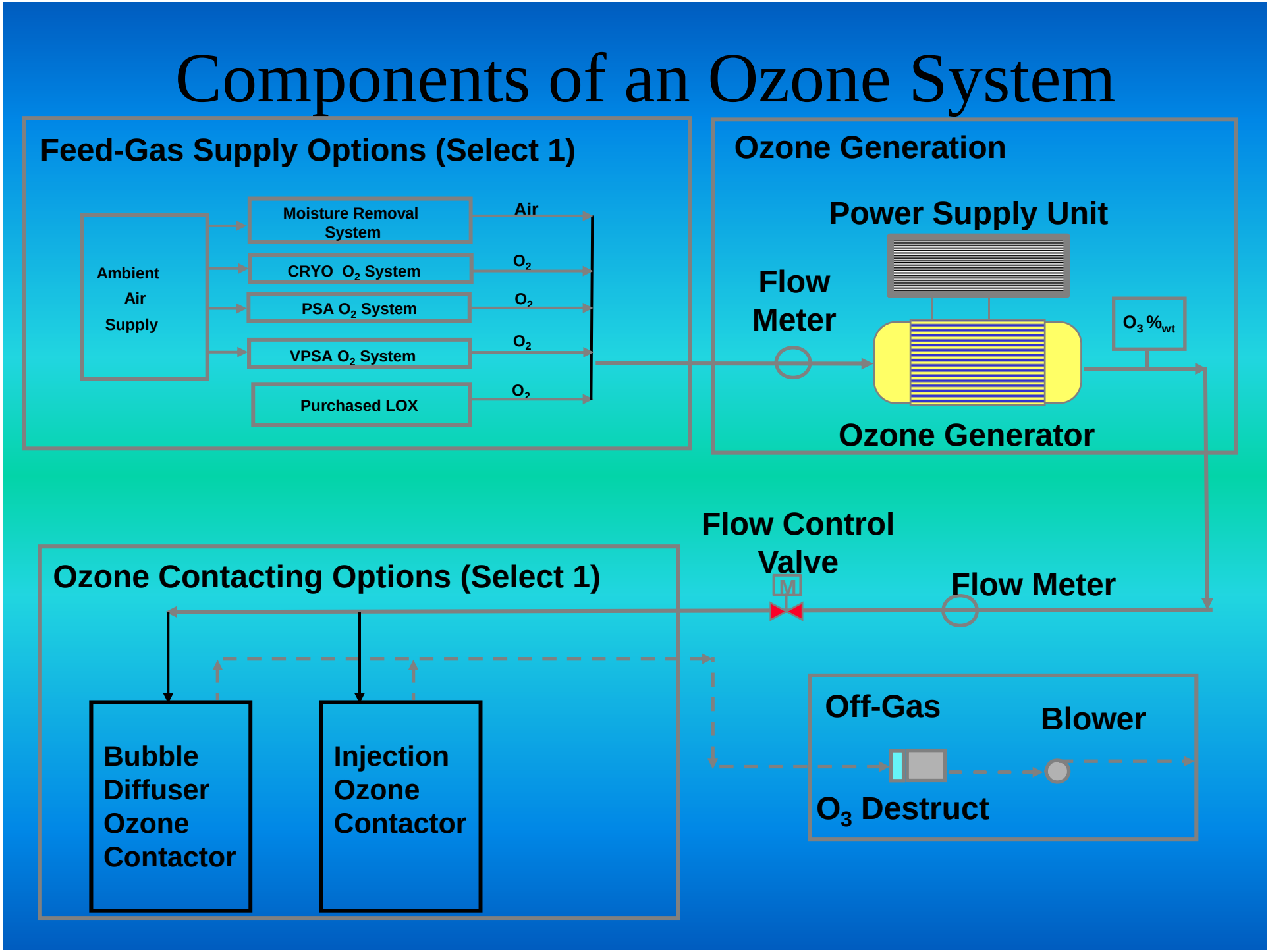
- Ozone is a proven biocide for cooling towers that has been used in over a thousand cooling towers.
- Benefits Include:
  - Lower bacteria counts
  - No salt build-up
  - Greener/lower blow down



Rainwater harvesting prevents the loss of a valuable natural resource:

- Rainwater is collected from the roof of a building and treated for applications like toilet flushing and landscape irrigation.
- New buildings being design with rain water capture systems include Thursgood Marshall Federal Courthouse and 51 Astor Place, both in NYC
- Ozone is chosen because
  - It is safer than chlorine in buildings
  - And unlike UV can project it disinfection beyond the UV reactor to the storage tank
  - The flocculation effect enhances filter operation

Components of an Ozone System



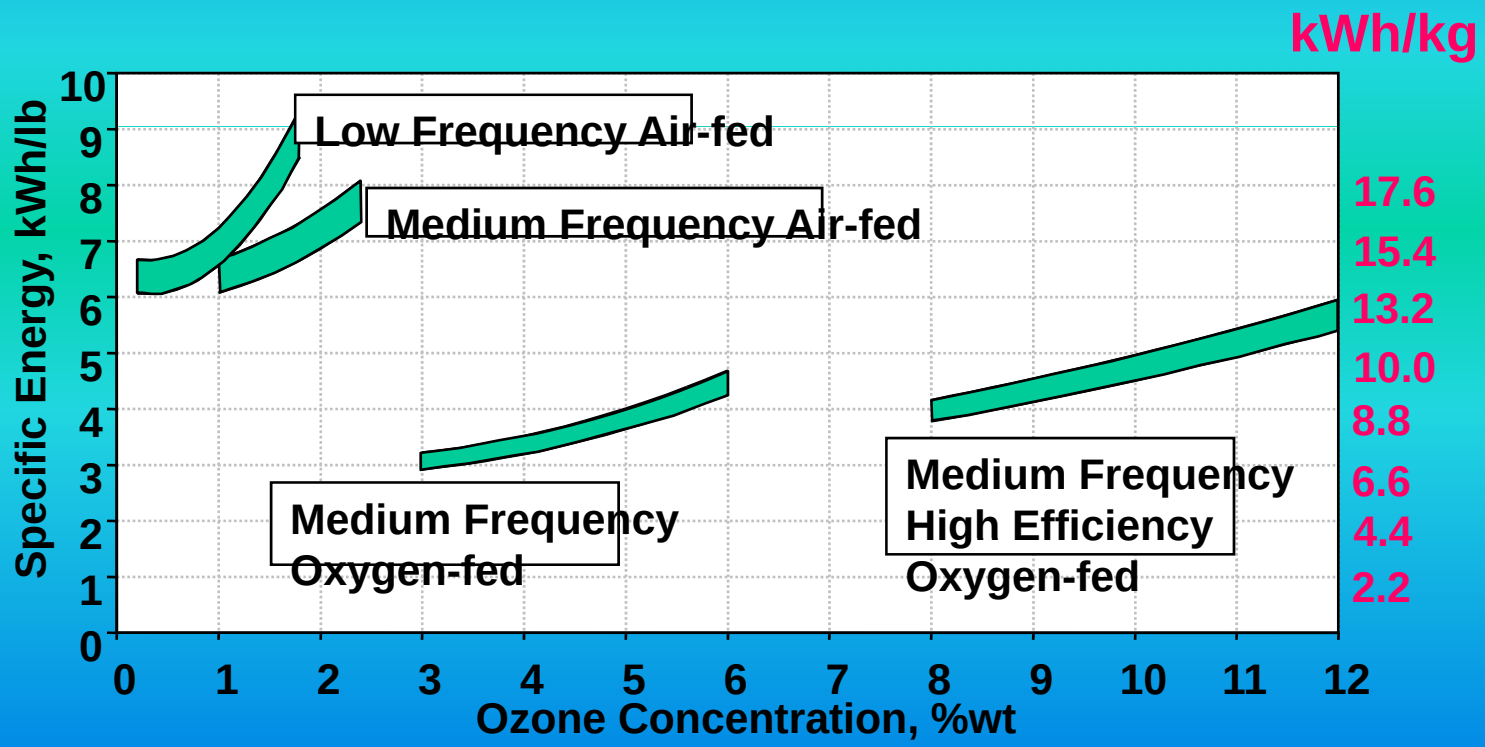
Design considerations for ozone water treatment systems:

- Generator Reliability
- Oxygen Versus Air
- Ozone Transfer Efficiency
  - Fine Bubble Diffusers
  - Venturi Injectors
- Back Flow Prevention
- Controls
- Materials of Construction
  - Gas Phase
  - Liquid Phase

Ozone generator elements that promote reliability:

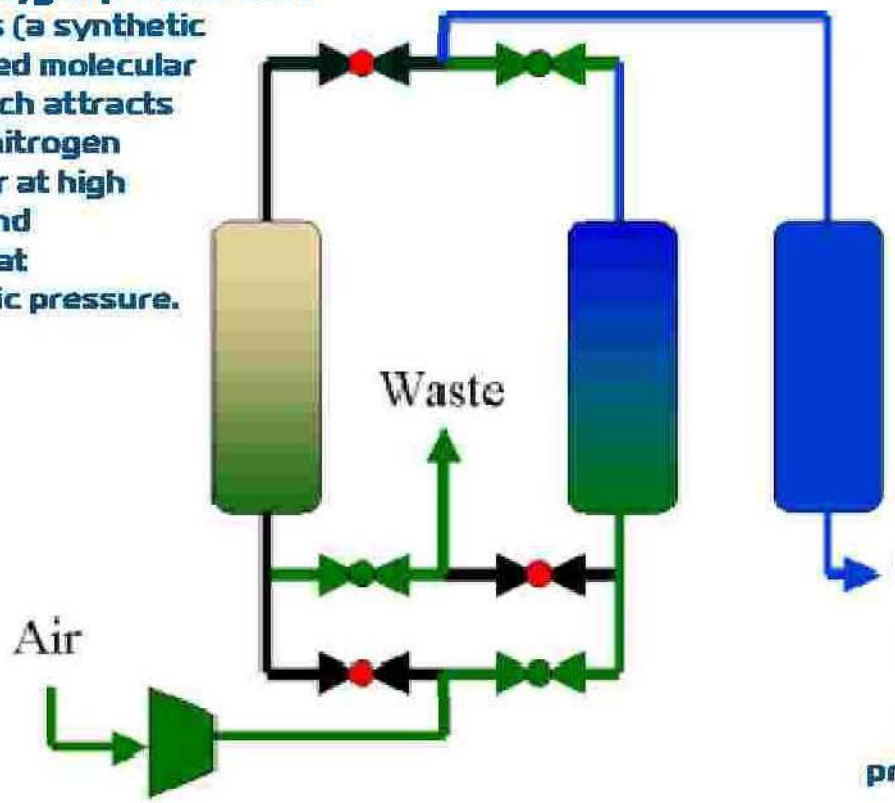
- PLC Controller to Automatically Monitor Faults, Alert Operator and Shut Down System
- Dielectrics Individually Fused, Failure of a Dielectric Will Not Shut Down the Generator
- Flow Switch on Gas Line
- Outlet Gas Temperature Monitoring: Early Warning of Problems with Dirt Collecting on the Dielectrics or Cooling Water issues
- Cooling Water Monitoring and Control:
  - Temperature Measured Before and After the Generator with High Temperature Shutdown
  - Cooling Water Flow Measured and Controlled by Automatic Valve and Low flow Switch
- Gas Pressure Safety Valve Versus Rupture Disk
- High Quality Components and Proper Materials of Construction

From Air to Oxygen: Pre-1987, 1987 to 1993 and Post 1993



PSA: How Does It Work?

The PSA oxygen process uses adsorbents (a synthetic **zeolite called** molecular **sieve), which attracts (adsorbs)** nitrogen **from the air** at high **pressure and releases it at atmospheric** pressure.



Adsorption Step

-Nitrogen is adsorbed at elevated pressure and oxygen is produced

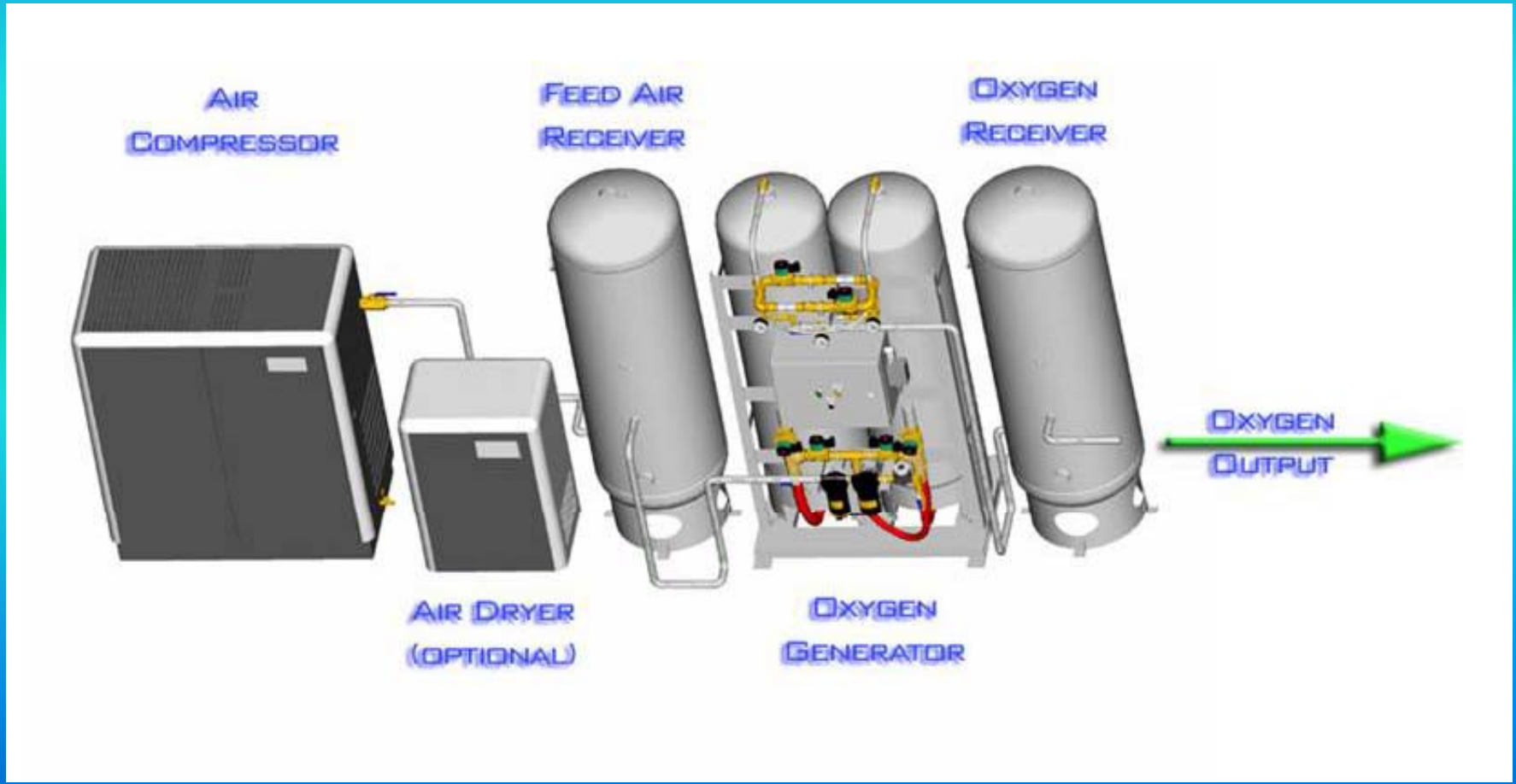
Regeneration Step

-Nitrogen is desorbed via depressurization so the adsorbent is regenerated

Two adsorbent beds transform the PSA Process from a batch process into a continuous process

A Look At The PSA Process

PSA System Configuration

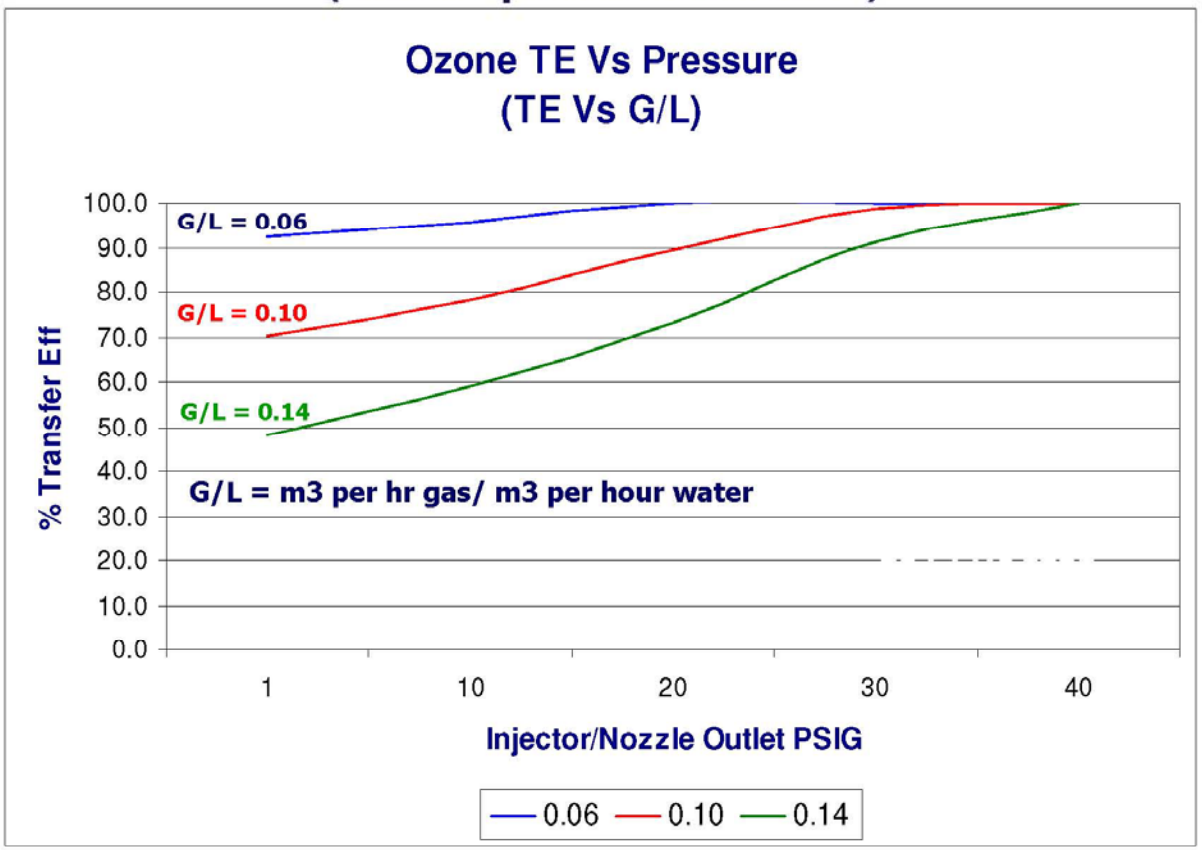


Ozone Transfer Efficiency: Getting ozone into solutions:

- The transfer efficiency is mainly affected by the following factors:
  - The ratio of gas volume to liquid volume (G/L ratio), lower ratio increases efficiency
  - Bubble size, smaller bubbles increase efficiency
  - Ozone demand of the water, higher demand increases efficiency
  - Ozone concentration, higher concentration increases efficiency
  - Pressure, higher pressure increases efficiency
  - Detention time, longer detention time increases efficiency
  - Temperature, lower temperature increases efficiency

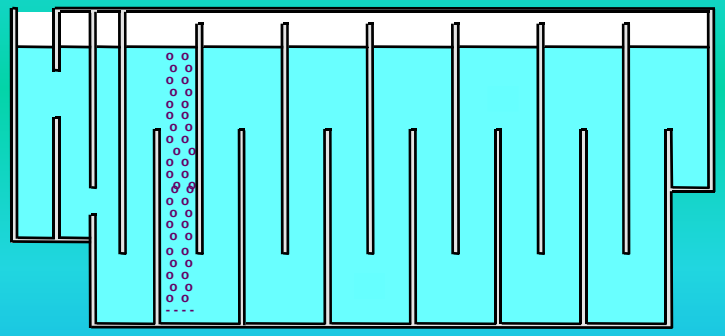
OZONE TRANSFER

(Gas/Liquid Vs Pressure)



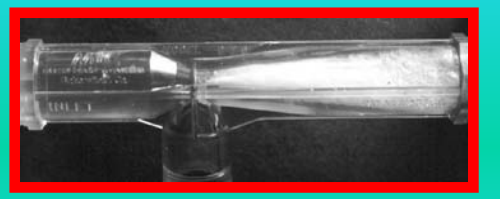
Ozone Dissolution Options

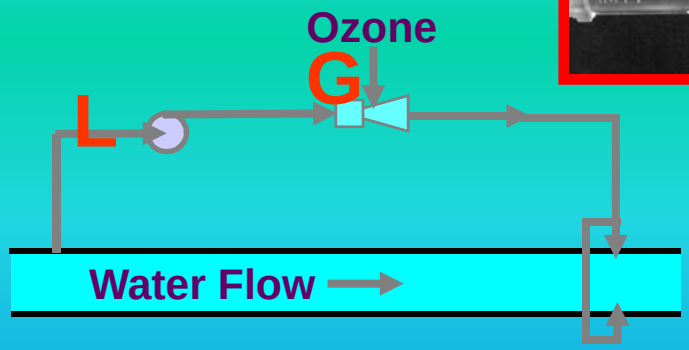
Bubble Diffuser



Historically, the most common ozone contacting option

Side Stream

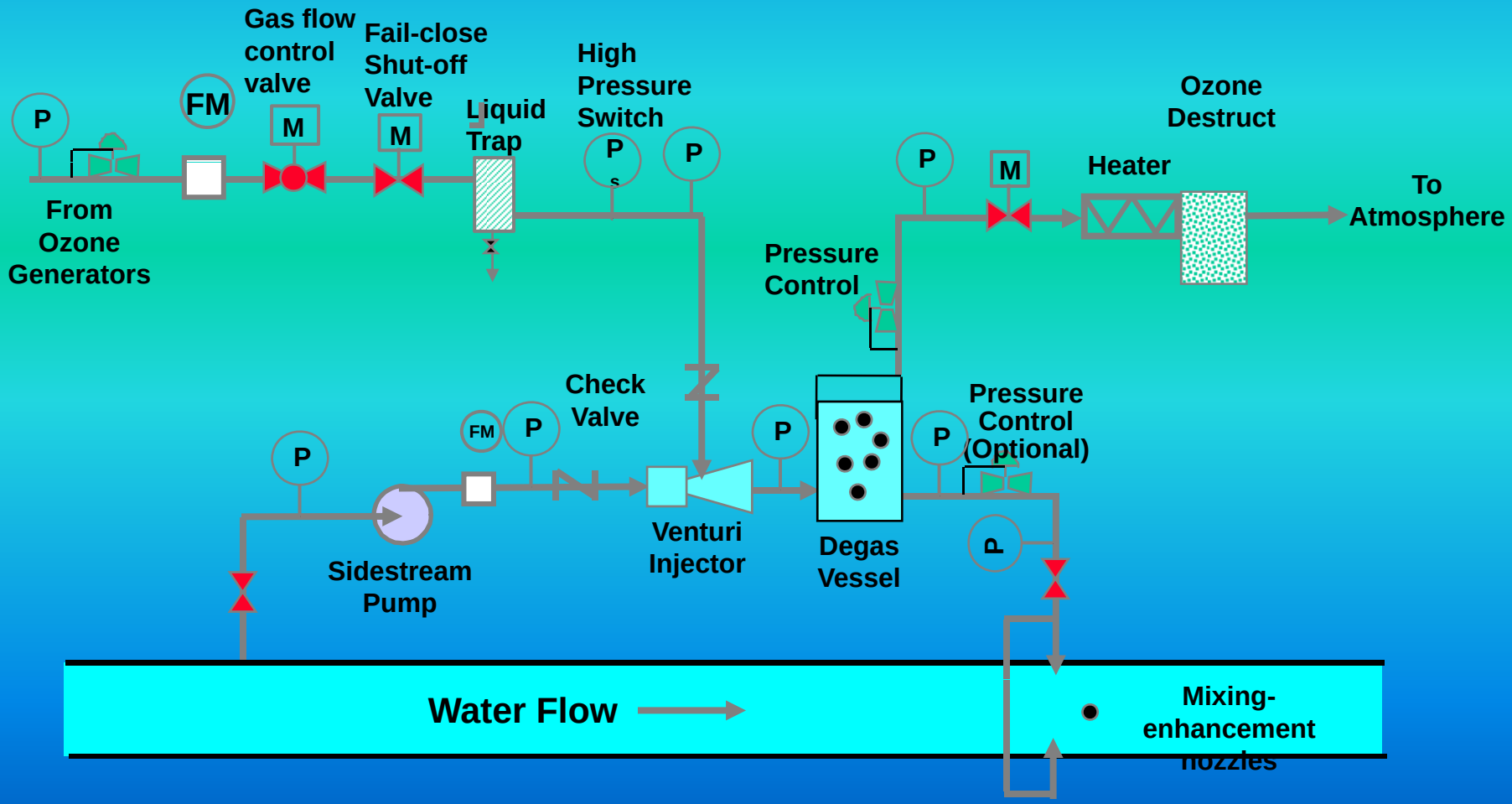




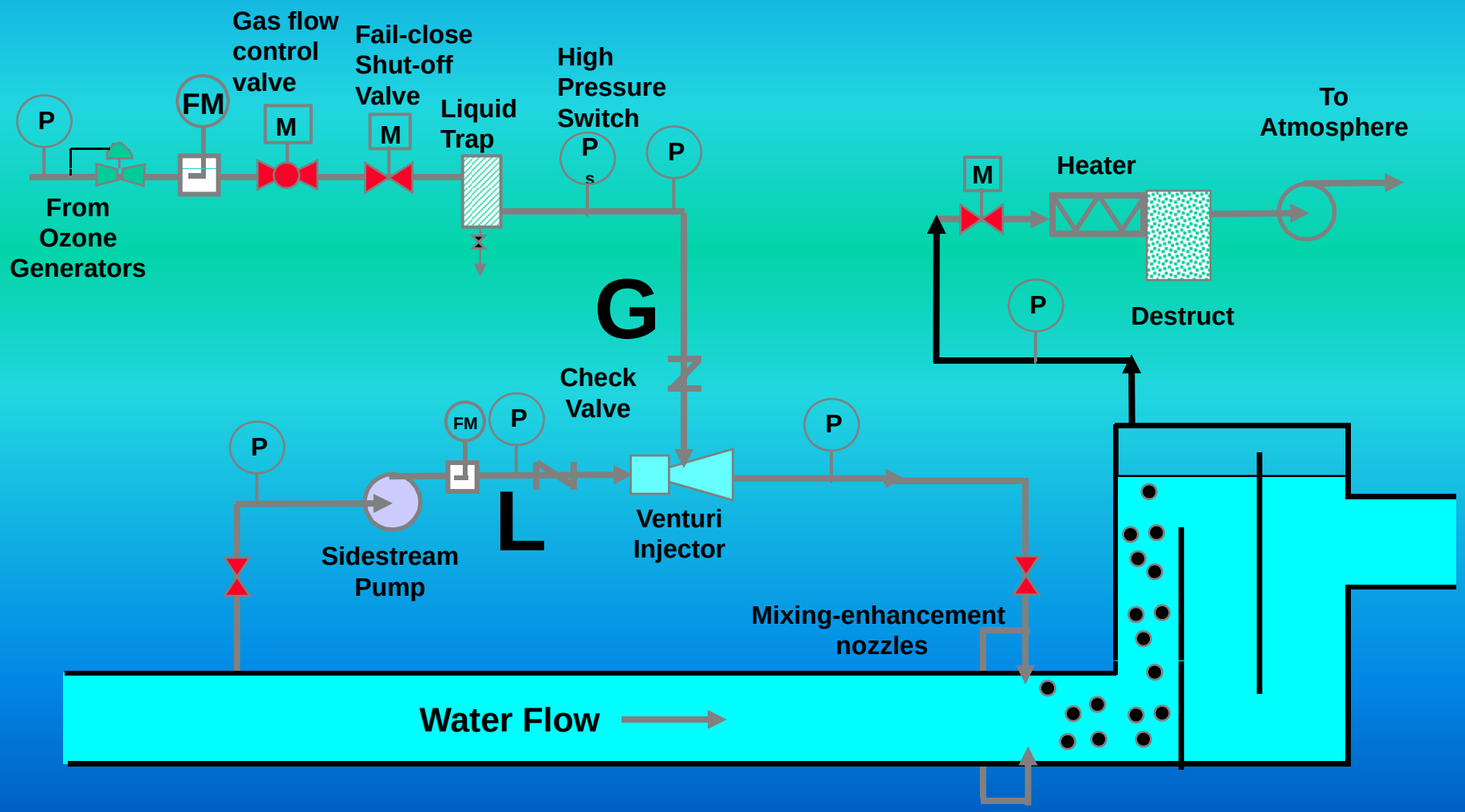
High Efficiency Venturi Injectors

For many reasons, the side stream option is becoming more popular today

Option 1 - Designed to maximize ozone transfer within the side stream flow



Option 2 - Designed to utilize ozone contactor for ozone transfer assistance



Ozone Generator Control Through Ozone Residual Monitoring:

- "Indigo Trisulfonate" Standard Method ozone residual test (Simple prepackaged ampoules with portable meters available)
- Trustworthy on-line residual analyzers and robust sampling systems

Display Range: 0-200.0 PPB, 0-2.000 PPM
Accuracy: ± 0.02 PPM or 0.5% of F.S.
Repeatability: ± 0.01 PPM or 0.3% of F.S.
Linearity: 0.1% of F.S.
Zero Drift: < 0.01 PPM per month

Materials of construction that provide excellent to good performance with ozone:

- Gas Side
  - 316 SS, Glass, Teflon, PVDF
- Liquid Side
  - Excellent:
    - CPVC, 316 SS, PVDF, Hypalon, Viton
  - Good:
    - PVC, LDPE, Tygon, Copper, Brass, 304 SS

International Ozone Association

www.io3a.org

Joint IOA & IUVA Conference
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