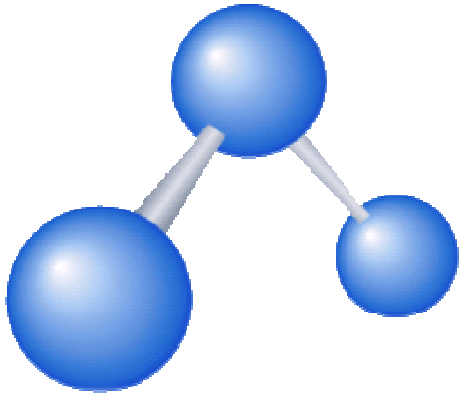
Ozone Technology for Commercial Pools

presented by

DEL Ozone



Ozone History

1840 **Identified by German Scientists**

1906 **Ozone Drinking Water Purification Plant in Nice, France**

1937 **Commercial Pool Installs Ozone, Mohawk Cruiser, Bryam, NJ**

1940 **Ozone Used to Purify the Indoor Pool Water at the U.S. Naval Academy in Annapolis, MD**

1984 **Olympic Games Competition Pools Began Ozone Purification**

Ozone History, continued

1976 EPA Approves Ozone as an Antimicrobial

1982 IBWA Bottled Water Specifications Approve Ozone as an Antimicrobial for Product and Disinfectant for Filler Lines

1999 EPA Lists Ozone as Safe for Surface and Ground Water

2001 FDA/USDA Approve Ozone as an Antimicrobial Food Additive

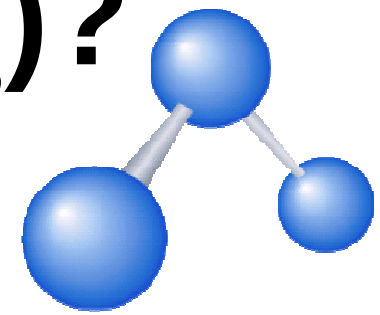
2001 FDA/USDA Approve Ozone as a Food Contact Surface Disinfectant

2002 USDA National Organic Program Allows Ozone as an Antimicrobial Food Additive and Food Surface Disinfectant

Ozone Regulatory/Safety

- **EPA approved**
  - **As a pesticide, ozone equipment must be registered by the EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). DEL Ozone is an EPA registered establishment (EPA Estab. No. 071472-CA-001).**
- **OSHA Regulations for Ozone (Gaseous Only)**
  - **Health Hazard Data**
    - **Inhalation /Respiratory System, Eyes, Blood**
  - **PEL (Permissible Exposure Limit)**
    - **8 hour Time Weighted Average 0.1 PPM Vol.**
  - **STEL (Short Term Exposure Limit)**
    - **15 Minute 0.3 PPM Vol.**
  - **IDLH (Immediately Dangerous to Life and Health)**
    - **5 PPM**
- **No OSHA Regulations apply to Aqueous Ozone**
- **Properly sized and applied Aqueous Ozone systems control the release of ozone off-gas**

What is Ozone (O_3)?

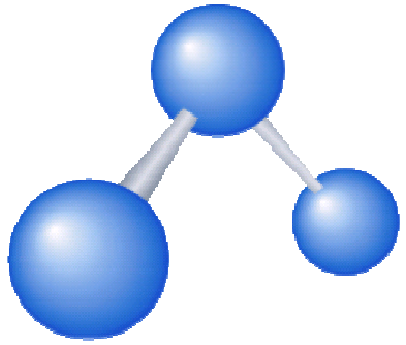


- Ozone (O_3) is a ***powerful*** oxidizer
- It occurs naturally in Earth's atmosphere
  - Light Energy from the Sun
  - Electrical Energy from Lightning
- Each ozone molecule consists of three oxygen atoms (O_3)
- Ozone has a clean, fresh scent at low levels
- Aqueous Ozone is Gaseous Ozone dissolved in water
- Aqueous Ozone is a ***very effective*** micro-flocculent
- Aqueous Ozone is a ***very effective*** antimicrobial agent
- 1 PPM Aqueous Ozone is equal to 200 PPM Cl
- Ozone is compatible with Br and Cl in Swimming Pools
- Ozone reduces Br or Cl by 80% with applied O_3 dose of 1.6 PPM

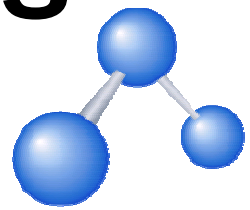
O_3 for Commercial Pools

Benefits of Ozone Use in Commercial Pools

- Reduces Chlorine or Bromine use up to 80%
- Eliminates Chloramines, Bromamines, & their off-gas odor
- Improves Air Quality
- Reduces Chemical Structural Corrosion
- Improves Water Quality and Clarity
- Enhances Swimmer Comfort
  - Eliminates Red Eyes/Irritation; Dry Skin & Hair
  - Reduces “Swimmer’s Asthma”
- Reduces RWI (Recreational Water Illness) which can potentially lead to facility shutdown



O_3 for Commercial Pools



RWI (Recreational Water Illness)

- **Common causes of RWI's include dirty or ill bathers, poor poolside hygiene, poor pool hygiene**
- **The Centers for Disease Control and Prevention in Atlanta (CDC) states that in 2002 there were 2,536 RWI related illnesses (the largest number reported since CDC started tracking them in 1978)**
- ***Pseudomonas aeruginosa (causing "Hot Tub Rash")* is determined to be the most common of all reported RWI's**
- ***E. coli* is the second most common cause of RWI's**
- **Latest RWI development is *Cryptosporidium* (3,000 infections in one outbreak in one swimming venue 2005)**

O_3 for Commercial Pools

Anti-Microbial Validation under NSF Standard 50, Annex H

Pass compliance requires a 3-log (99.9%) reduction of *Pseudomonas aeruginosa and Enterococcus faecium* in 30 minutes

Pseudomonas aeruginosa	**6.6 log (>99.9999%)**
Enterococcus faecium	**6.7 log (>99.9999%)**

Test Parameters

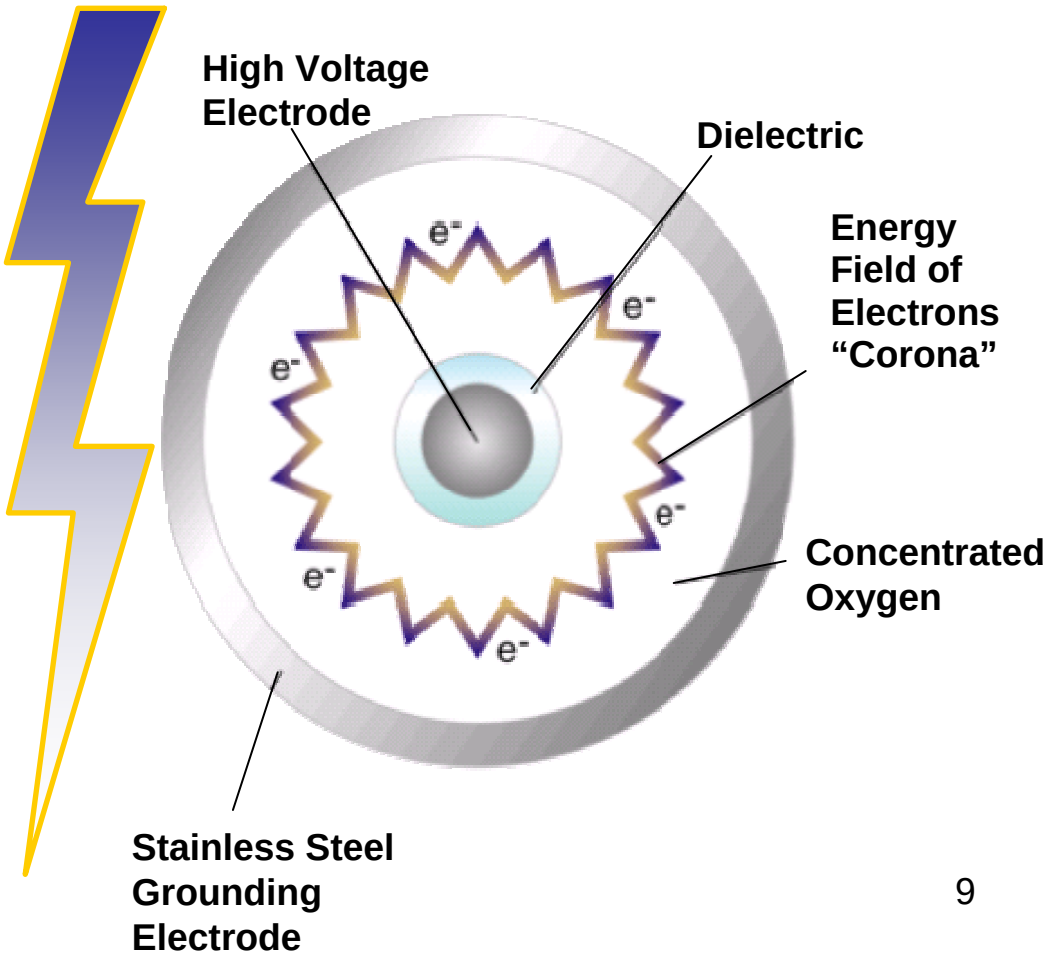
- **165 gallon recirculating potable water test system; water temperature @ 70° F**
- **20 PPM baby oil added to water to represent grease and oil (bather load)**
- **9 PPM Urea added to water to represent bather contamination**
- **1.6 PPM applied ozone dose**

ALL COMMERCIAL OZONE SYSTEMS MUST BE NSF LISTED

Corona Discharge (CD) Ozone Production

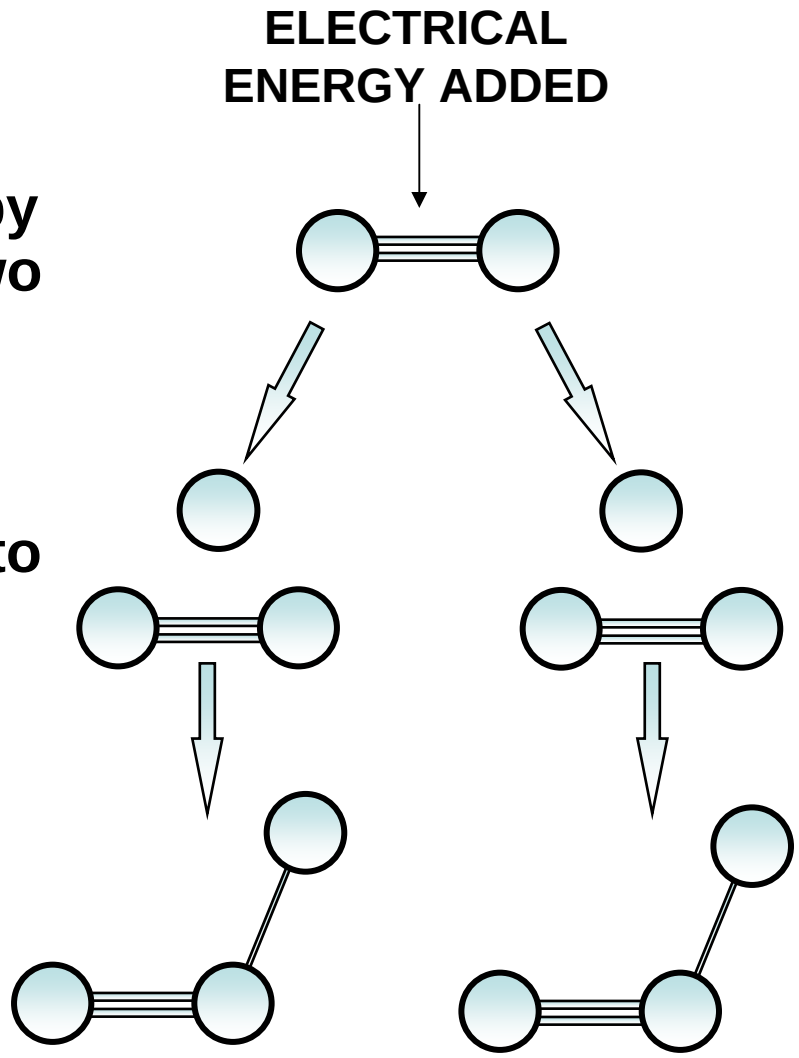
High Voltage Electrical Energy

- **Electrically efficient to operate**
- **Typical Ozone concentration output 36,000 PPM (gaseous)**
- **Consistent ozone output**



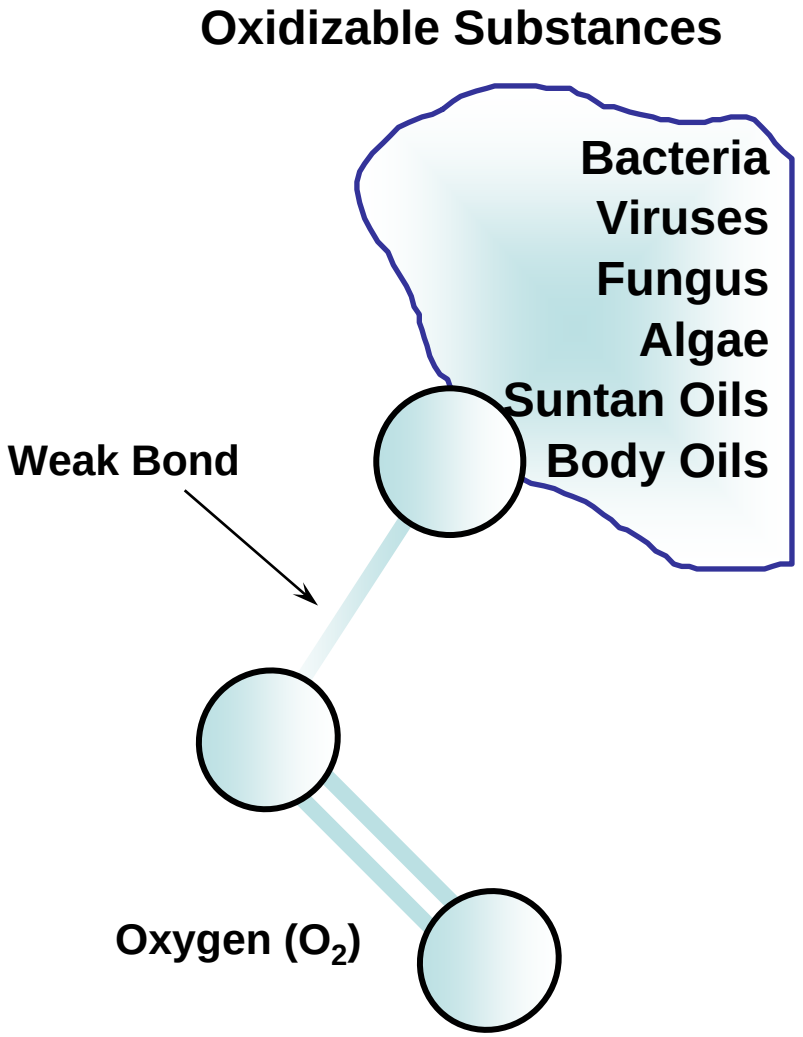
How is Ozone Made?

- **Oxygen molecules (O_2) split by adding energy, resulting in two individual oxygen atoms (O_1).**
- **Oxygen atoms (O_1) unite with other oxygen molecules (O_2) to produce Ozone (O_3).**
- **(O_1) + (O_2) = (O_3)**



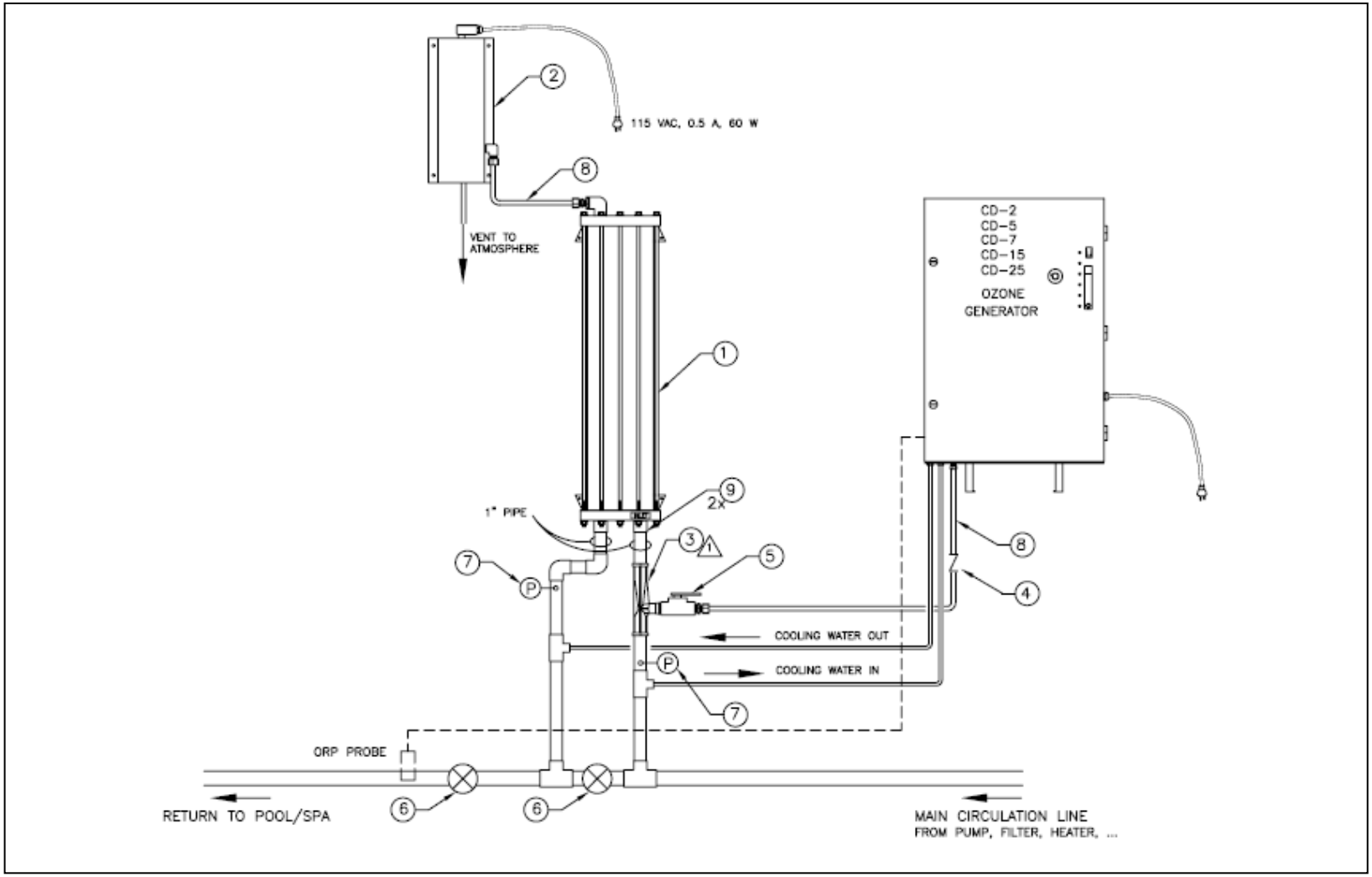
How Ozone Works

- The third oxygen atom is held by a weak single bond
- An oxidation reaction occurs upon any collision between an ozone molecule and a molecule of an Oxidizable substance
- The weak bond splits off leaving oxygen as a by-product
- During an oxidation reaction, organic molecules are changed or destroyed and dissolved metals are no longer soluble



Small Commercial Ozone Systems

Generate ⟶ Dissolve ⟶ React ⟶ Separate ⟶ Destroy



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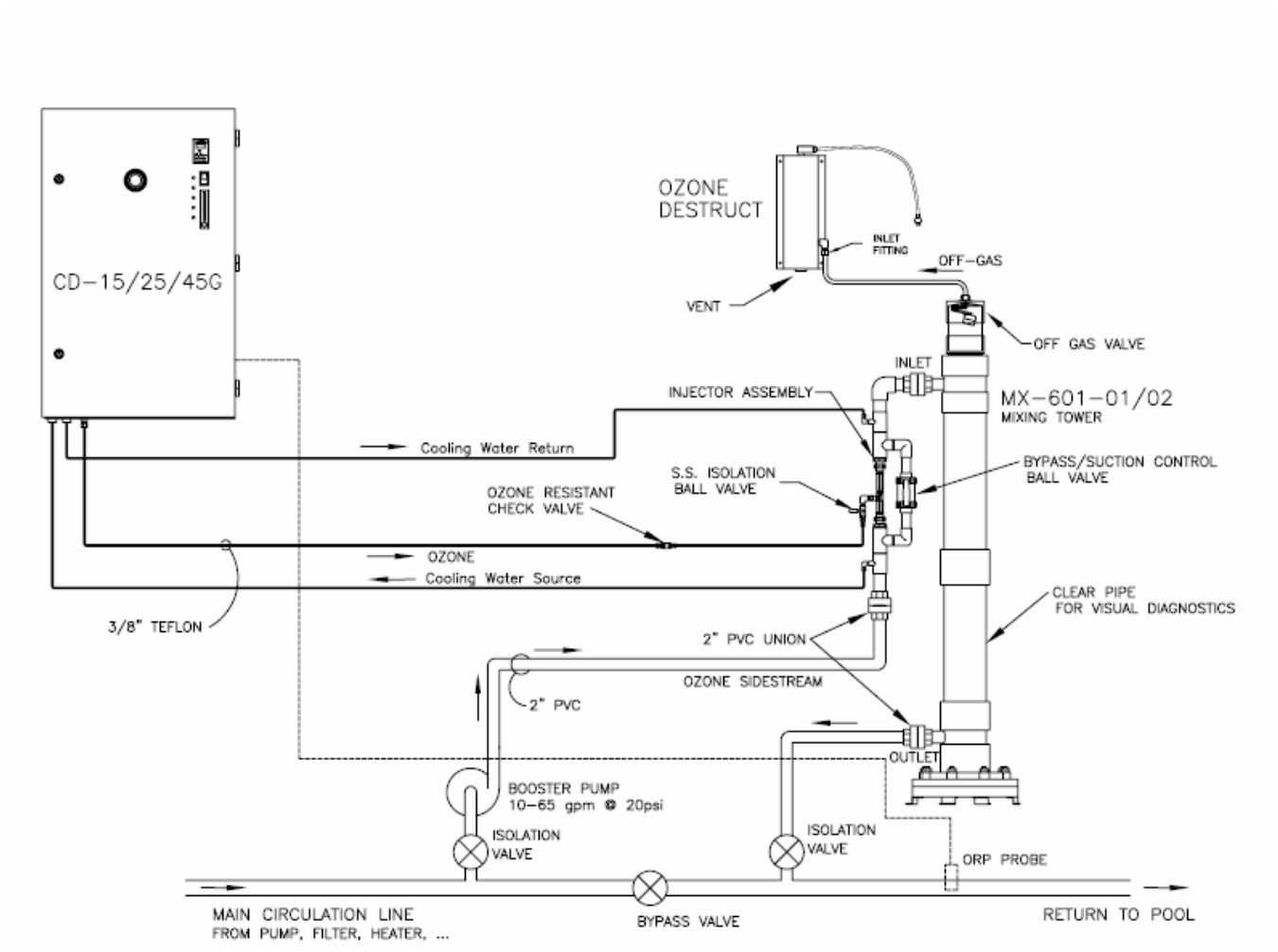
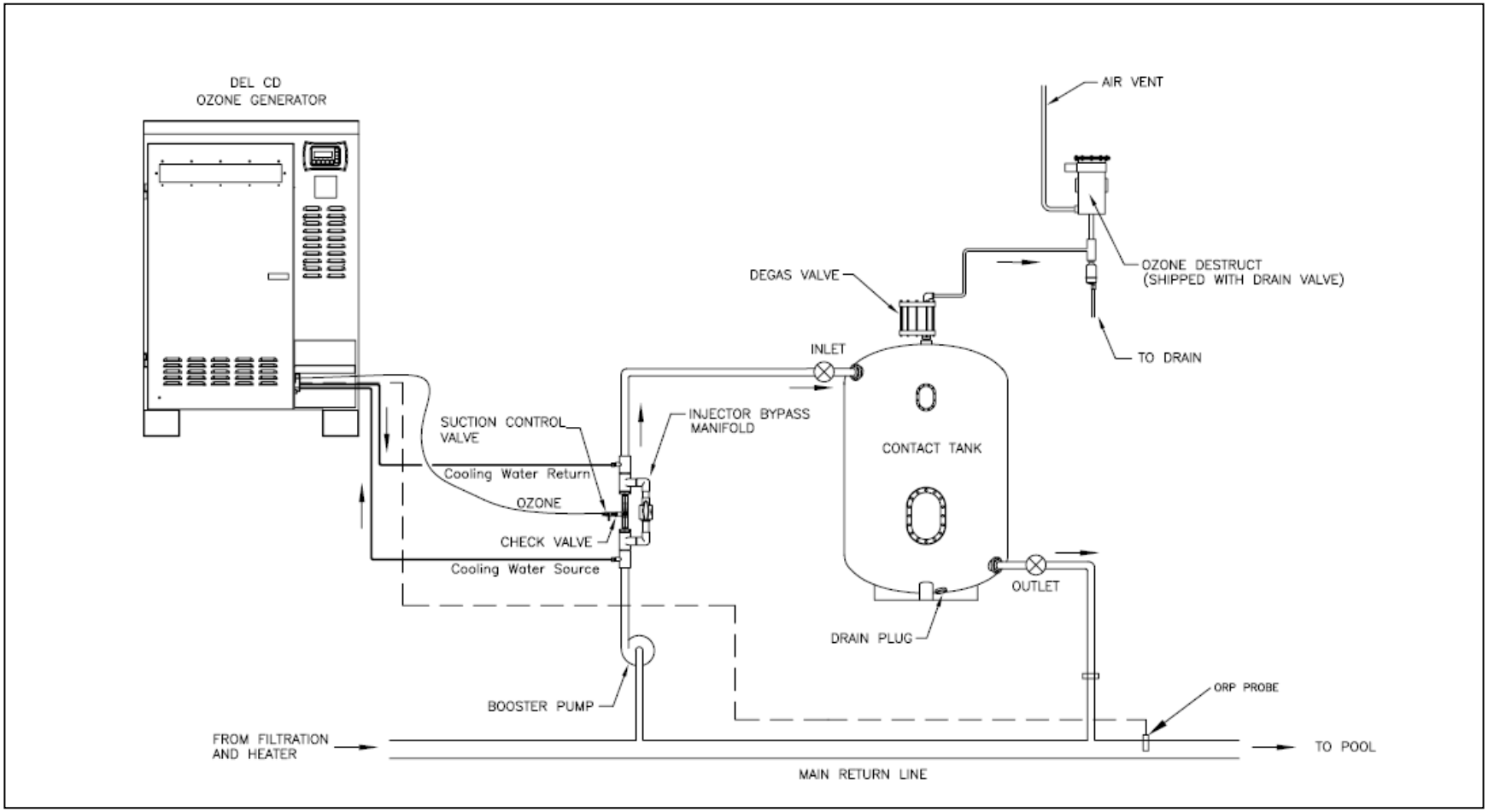


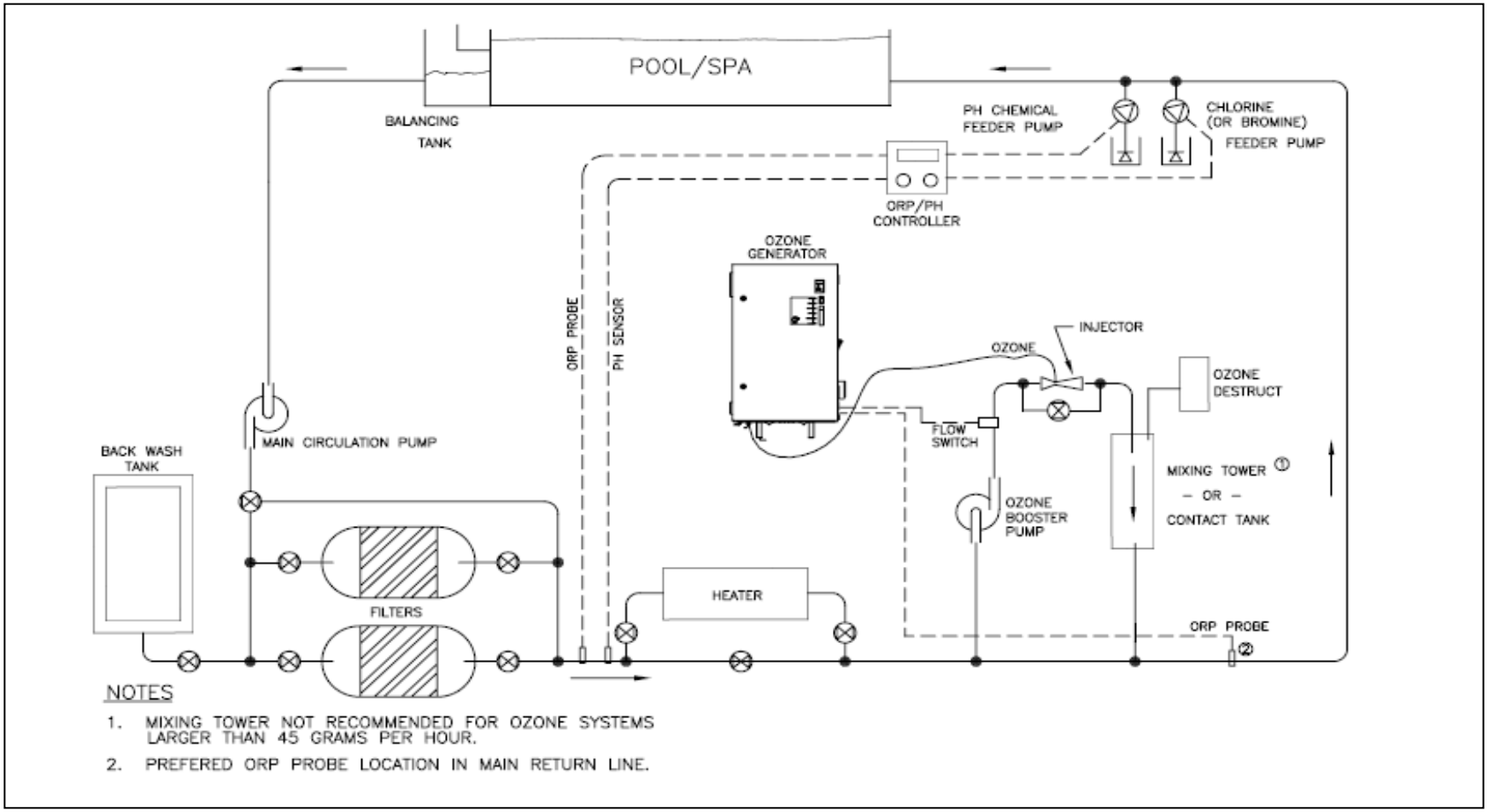
Large Commercial Ozone Systems

Generate ⟶ Dissolve ⟶ React ⟶ Separate ⟶ Destroy



Basic Commercial Ozone Systems

Generate ⟶ Dissolve ⟶ React ⟶ Separate ⟶ Destroy



Ozone System Sizing U.S.

- **Ozone Systems are sized according to the pool water volume, bather load and water temperature; always assuming 24 hour operation**
- **For optimum water quality, use the following ozone sizing formulas (applied ozone dose 1.6 PPM/Minimum 0.06 PPM 60 min.)**
  - **Total gallons X 1.6 X 0.227 / 120 = Grams/hr O_3 Spa (94-104°F)**
  - **Total gallons X 1.6 X 0.227 / 240 = Grams/hr O_3 Wading Pool (80-88°F)**
  - **Total gallons X 1.6 X 0.227 / 720 = Grams/hr O_3 Therapy Pool (86-94°F)**
  - **Total gallons X 1.6 X 0.227 / 1440 = Grams/hr O_3 Lap/Main Pool (78-85°F)**
- **Example Pool**
  - **125,000 Gallon Main Pool**
    - **125,000 X 1.6 X 0.227 / 1440 = 31.5 grams/hour (round to nearest available system)**
- ***Other situations may need to be taken into consideration when sizing ozone for individual pools***

Ozone System Requirements

Generate → Dissolve → React → Separate → Destroy

PLC/Diagnostics/ORP

Oxygen Concentrator

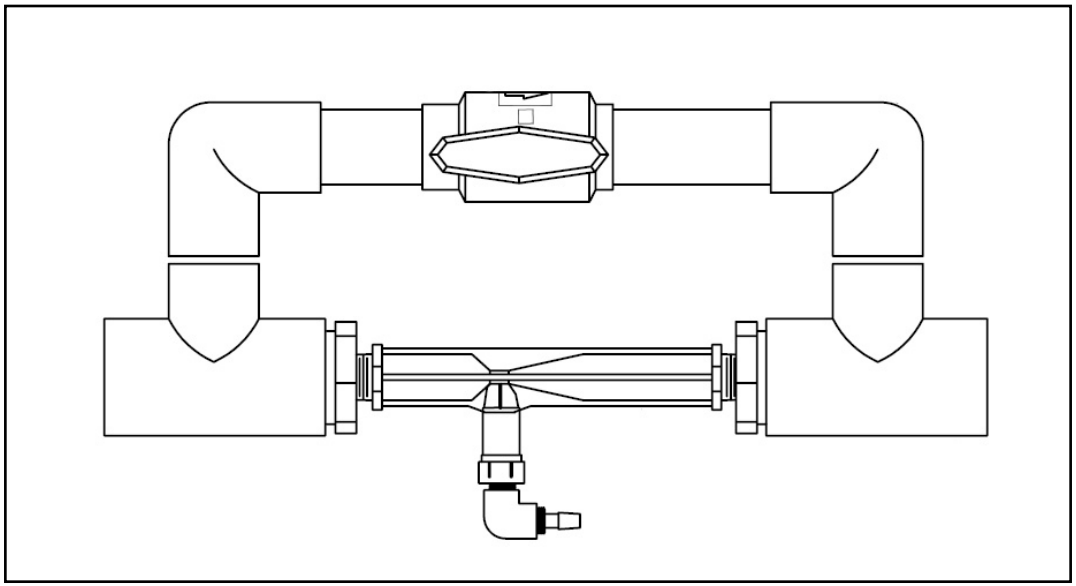
Ozone Generator

Compressor

Ozone System Requirements

Generate → Dissolve → React → Separate → Destroy

- ***Generation***
- ***Injector***
- ***Venturi Injection provides greater than 95% MT***

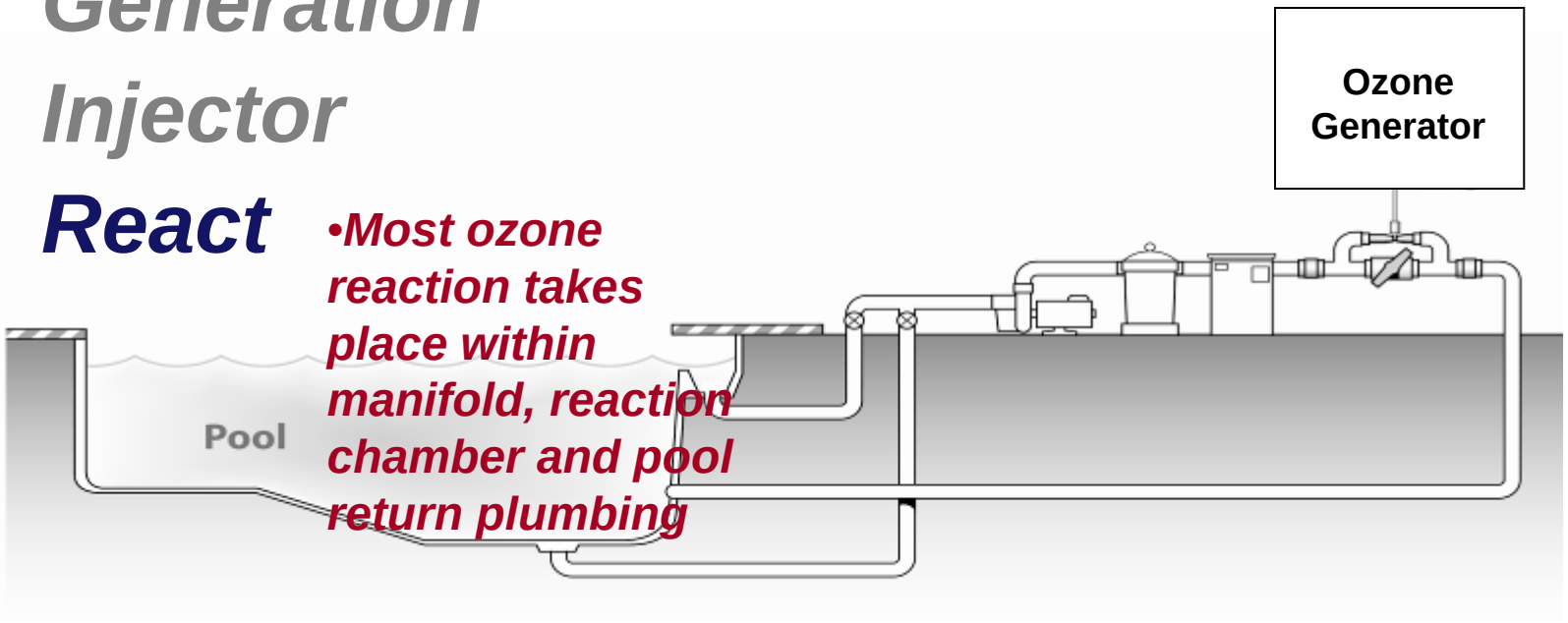


Ozone System Requirements

Generate → Dissolve → React → Separate → Destroy

- *Generation*
- *Injector*
- ***React***

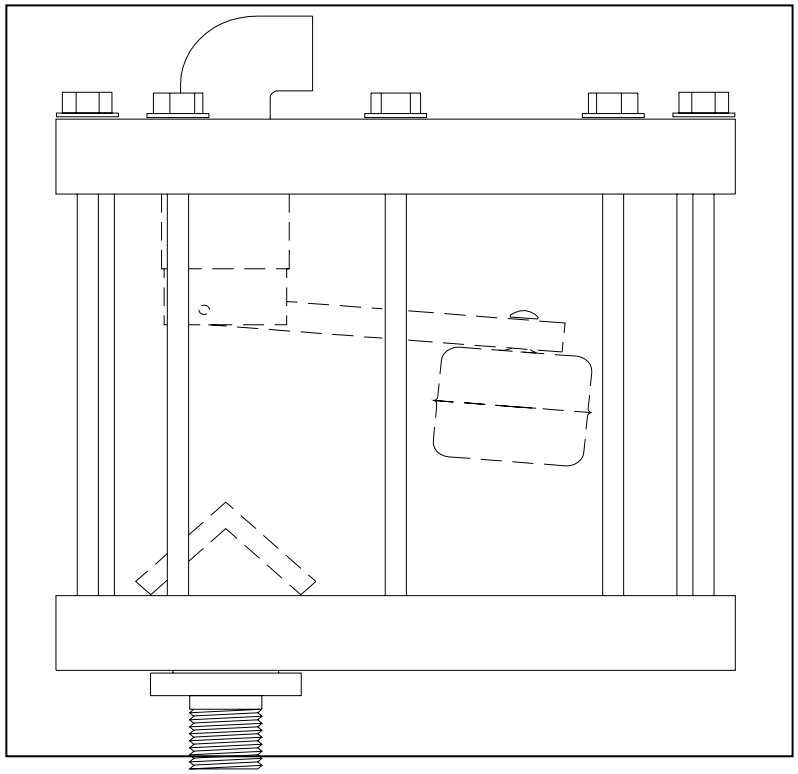
•Most ozone reaction takes place within manifold, reaction chamber and pool return plumbing



Commercial Ozone Systems

Generate → Dissolve → React → Separate → Destroy

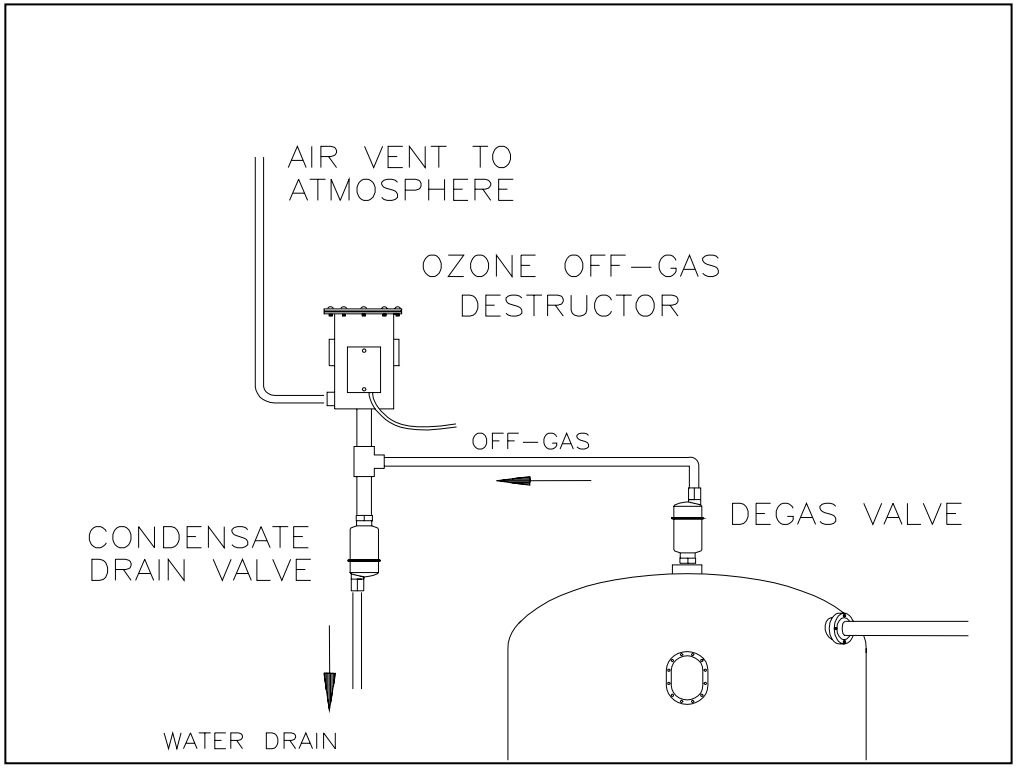
- *Generator*
- *Injection*
- *Reaction*
- ***De-gas***
  - ***Undissolved gasses***
  - ***Gas/Water separation***
  - ***Unused ozone (~5%)***



Commercial Ozone Systems

Generate → Dissolve → React → Separate → Destroy

- *Generator*
- *Injection*
- *Reaction*
- *De-gas*
- ***Destruction***
  - ***Unused ozone***
  - ***Heat/Catalyst***



Ozone/Br & Cl Compatibility

- **Ozone/Bromine (Br)**
  - **Ozone converts "spent" Bromine (Sodium Bromide) back to useful Bromine while eliminating Bromamines**
    - **<u>This Process reduces Ozone</u>**
- **Ozone/Chlorine (Cl)**
  - **Ozone converts Chlorine to Chloride Ion while eliminating Chloramines and its off-gas**
    - **<u>This Process reduces Chlorine</u>**
- **Ozone provides the main oxidation and disinfection in the pool while the residual halogen (Chlorine or Bromine) provides a chemical residual**
- **Proper installation of an Ozone system suggests distancing the ozone feed location from the halogen feed location in an effort not to reduce either of the sanitizing capabilities**
- **The Ozone is installed first with a contact/degas vessel; or on a separate return line**
- **Ideal Chlorine level is 0.3 – 1.0 PPM; Over-sizing residual Cl level may result in higher chlorine losses due to reaction with Ozone (increased probability of contact)**
- **Ideal Bromine level is 1.0 – 2.0 PPM; Over-sizing the residual Br level may result in reduced Ozone oxidation effectiveness in the pool**

Ozone vs. UV Sterilizers

Both Ozone and UV provide very effective anti-microbial action as documented by NSF Standard 50, Annex H

Ozone Destruction of Chloramines

- ***Ozone breaks down Chloramines by oxidation in two ways***
  - ***By breaking down the N-Cl bonds of the Chloramine molecules through oxidation by ozone (this process occurs at the point of ozone injection and continues the oxidation process as it passes at low levels into the pool)***
  - ***Ozone also forms hydroxyl radicals, adding to the Chloramine oxidation process***
- ***Ozone reduction of Chloramines is known to reach zero***

UV Destruction of Chloramines

- ***UV can break down Chloramines in two ways***
  - ***By breaking the N-Cl bonds of the Chloramine molecules with UV light energy (this process occurs in the UV chamber only)***
  - ***By forming small numbers of hydroxyl radicals with UV light energy, which oxidize Chloramines (this process occurs within nanoseconds, effectively occurring only in, or very near the UV chamber)***
- ***UV reduction of Chloramines has been documented to reach near zero***

Commercial Pool with Ozone

Summary

- **Advances in Ozone Technology have provided the means for affordable and effective ozone systems for commercial pool applications**
- **Commercial pools will benefit from safer, cleaner and more manageable water, completely free of chloramines and noticeably clearer**
- **Pool water sanitized with Ozone provides a very healthy and pleasant swimming experience**