The Ozonation of Swimming Pool Water: Process Selection and Material Requirements

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Ozone is an excellent oxidant and disinfectant that is used in a wide variety of commercial and industrial applications, among them water, waste water and swimming pool water treatment, pulp and kaolin bleaching, water reclamation and food processing. The ozonation of pool water is a relatively new technology in the U.S.A., so special attention must be given to the design of the ozonation process and to the selection of ozone-resistant materials for all affected components. The presentation will review different pool water ozonation processes, from the European ozonation with dual filtration to the post-filter side stream ozonation common in the U.S.A. Because of the high reactivity and corrosiveness of both gaseous and aqueous ozone, pool water ozonation imposes material requirements and constraints not normally encountered in pool construction and operation. The impact of ozonation on treatment components will be discussed, and recommendations for material selection will be listed.

Note: These Lists, Figures and Tables are reproductions or extractions from Dr. Hartwig's handout, which was distributed at the symposium. They are best understood in conjunction with the audiocassette recording of the presentation. Please see page 6 for order information.

About the Author

Wolfram Hartwig, Ph.D. has been involved in ozone applications for drinking water, industrial bleaching processes and pool water treatment since 1984. He holds a Physik Diplom (eq. to Masters in Physics) from the Justus Liebig University in Giessen, Germany, and recieved a Ph.D. in physics from Kansas State University. Dr. Hartwig is a past president of the Pan American Group of the International Ozone Association. As manager of Engineered Treatment Systems, he is responsible for the design and installation of customized ozone treatment systems for pools and spas, as well as being responsible for a number of ozonation systems for single and multiple indoor pools.

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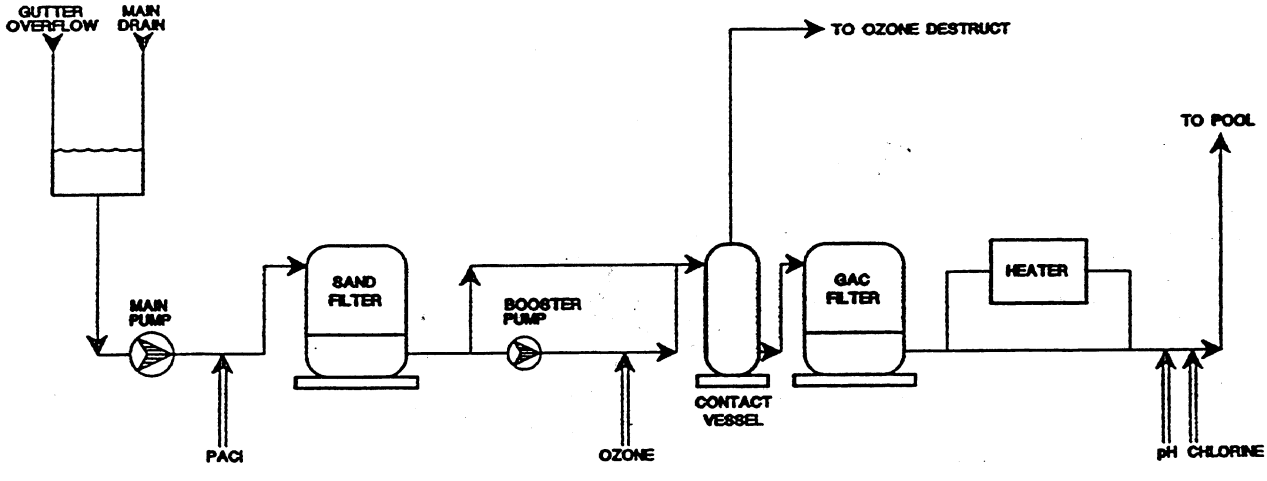
Process Variations (1)

- **DIN 19643: Dual Filtration**
  - Coagulation and PAC
  - Filtration
  - Full Flow Ozonation
  - Long Contacting: >2 min
  - Offgassing; Gas 0_3 Destruct
  - GAC; Aqueous 0_3 Destruct
  - Chlorination

  - **High Applied Ozone Dosage**
  - **Slow, Deep Bed Filtration**
  - **Long Contact Times**
  - **Control of Chemical and Microbial Water Parameters**
  - **Excellent Water Quality**

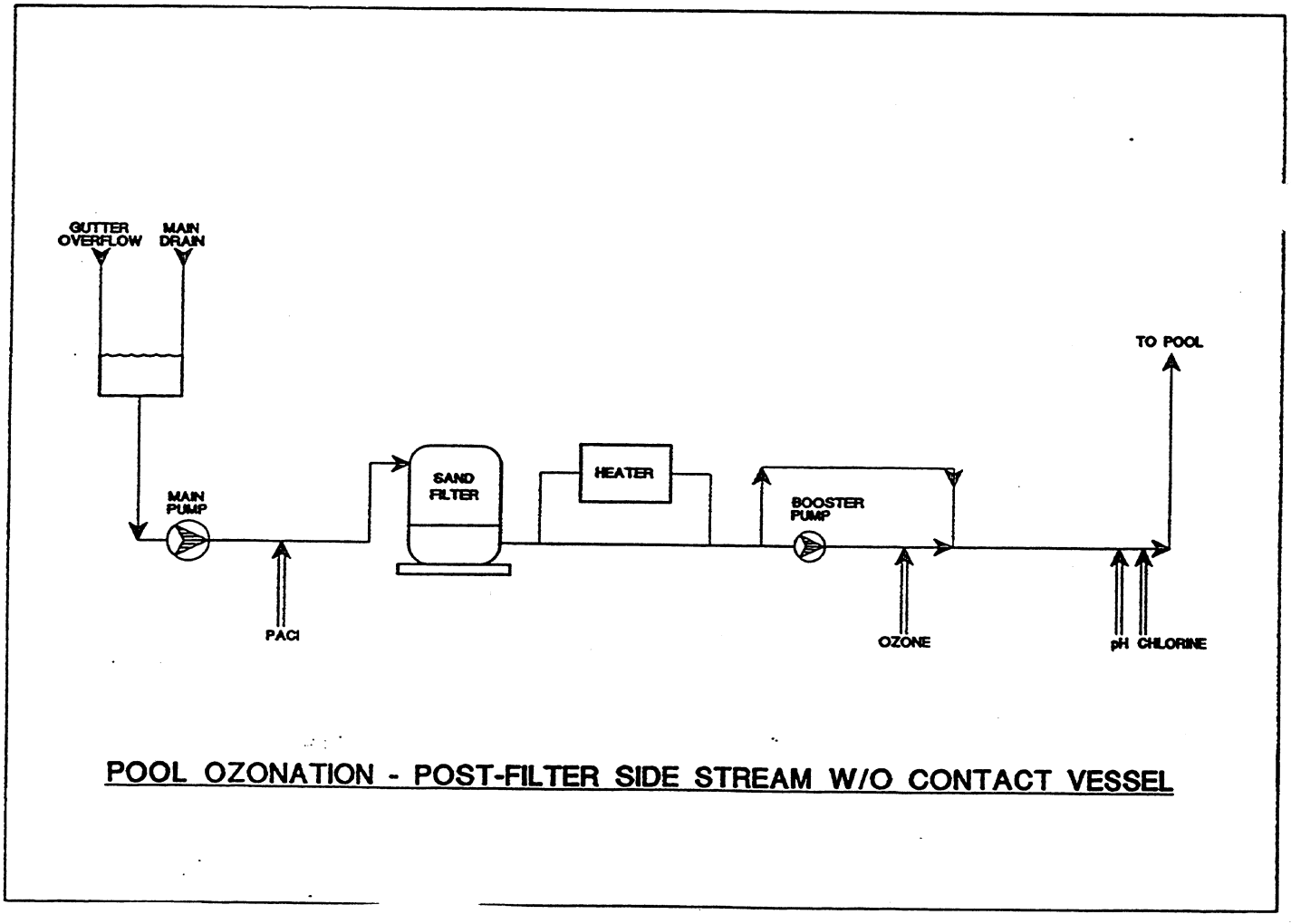


POOL OZONATION PROCESS - DIN 19643

Process Variations (2)

- **Post Filter Side Stream Ozonation w/o Contacting**
  - ◆ Filtration
  - ◆ Side Stream Ozonation
  - ◆ No Contact Vessel
  - ◆ Chlorination

  - ■ Low Applied Ozone Dosage
  - ■ Usually Small Side Stream
  - ■ UV or CD Generators
  - ■ Offgassing into Pool Area
  - ■ Possible Damage from 0_3
  - ■ Health Risks
  - ■ Bromide as "Scavenger"

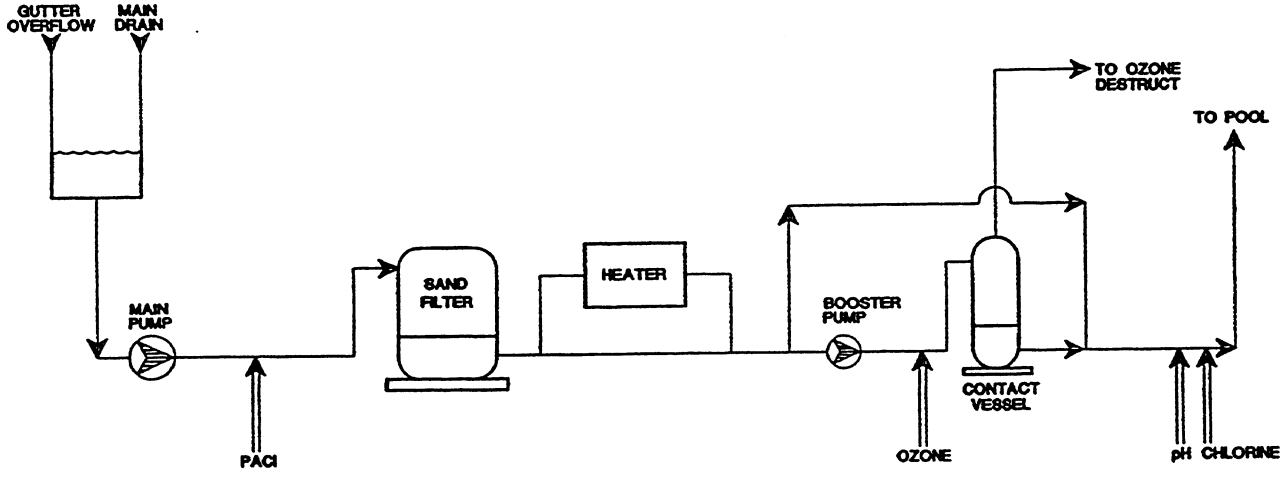


POOL OZONATION - POST-FILTER SIDE STREAM W/O CONTACT VESSEL

Process Variations (3)

- **Post-Filter Side Stream Ozonation with Contacting**
  - **Filtration**
  - **Side Stream Ozonation**
  - **Contact Vessel**
  - **Offgassing; 0_3 Destruction or Re-injection**
  - **Chlorination**

  - **Wide Variations of Applied Ozone Dosage**
  - **Wide Variations of Side Stream Fractions and Contact Times**
  - **Needs No 0_3 Resistant Filter**
  - **Best Option for Retrofitting**

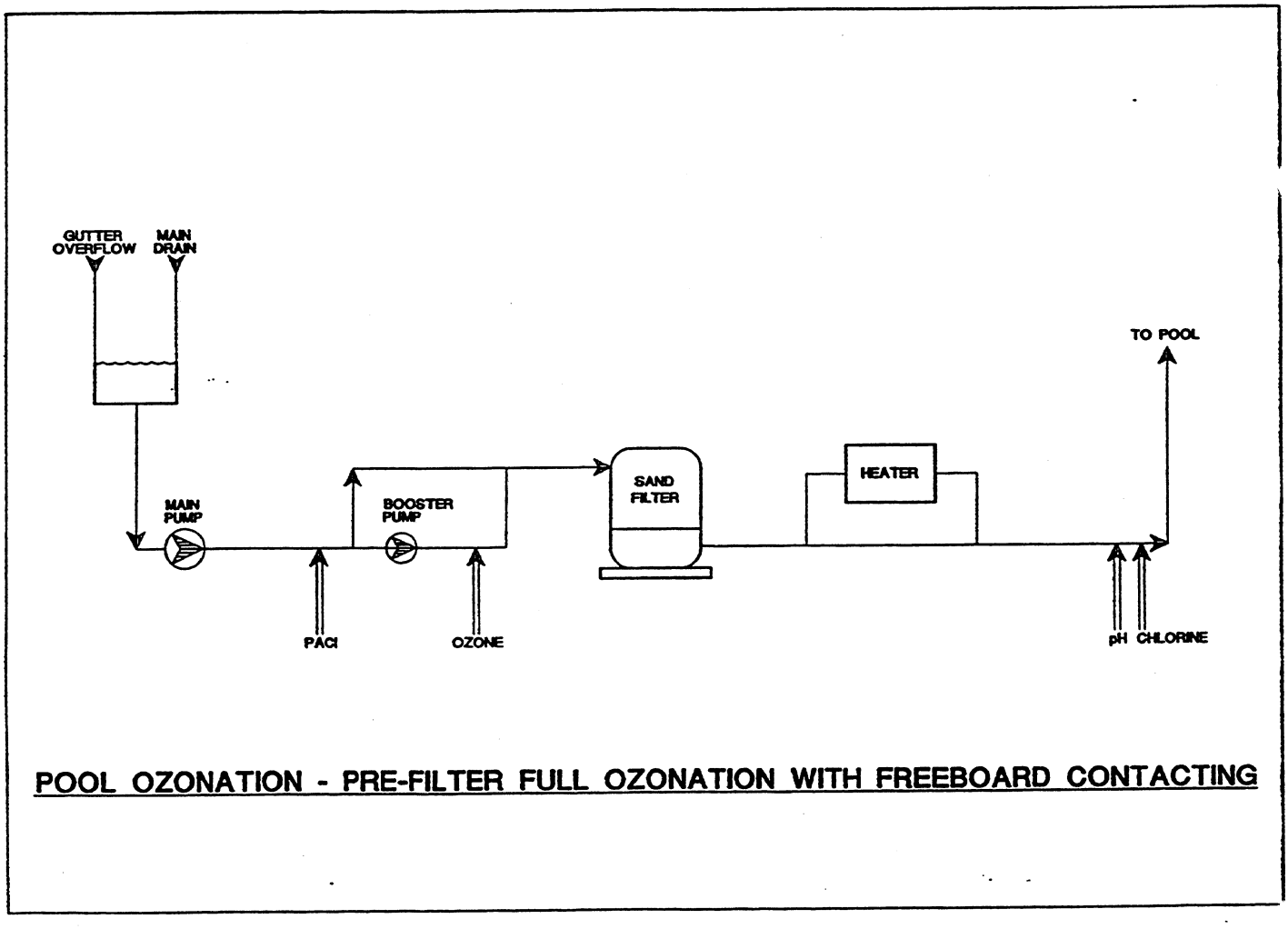


POOL OZONATION - POST-FILTER SIDE STREAM WITH CONTACT VESSEL

Process Variations (4)

- **Pre-Filter Ozonation with Free-Board Contacting**
  - ◆ **Side Stream Injection with Full Flow Ozonation**
  - ◆ **Freeboard Contacting**
  - ◆ **Filtration; Carbon Cap**
  - ◆ **Offgassing; 0_3 Destruction**
  - ◆ **Chlorination**

  - ■ **High Applied Ozone Dosage**
  - ■ **Needs 0_3 Resistant Filter**
  - ■ **Relatively Short Contacting**
  - ■ **Sand, GAC or Anthracite for Aqueous 0_3 Destruction**
  - ■ **Works Well with PACI**

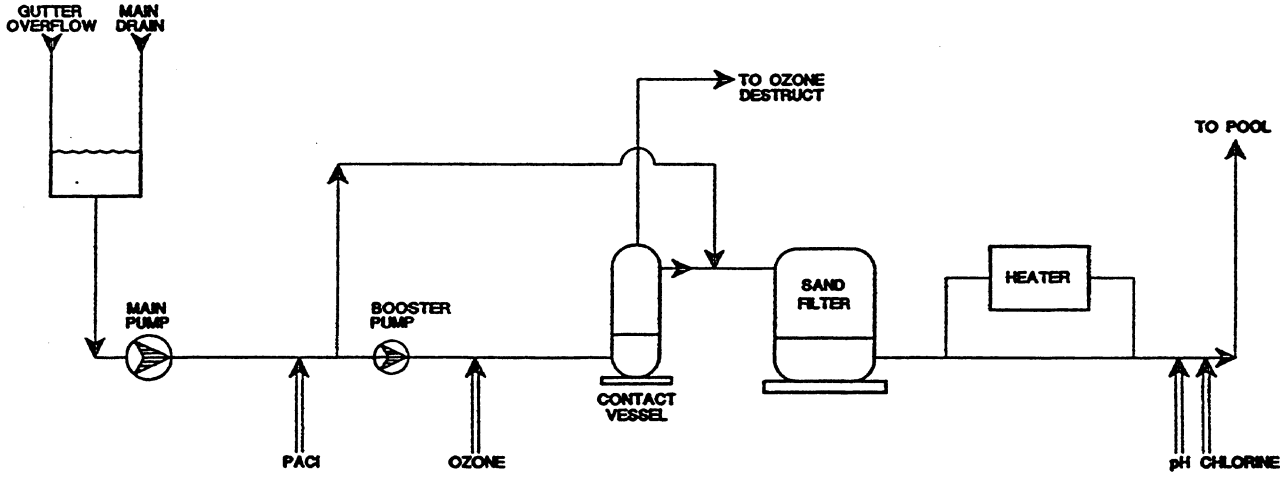


POOL OZONATION - PRE-FILTER FULL OZONATION WITH FREEBOARD CONTACTING

Process Variations (5)

- **Pre-Filter Ozonation into a Contact Vessel**
  - **Both Side Stream and Full Flow Ozonation**
  - **Contact Vessel; Offgassing**
  - **Additional Freeboard Contacting**
  - **Filtration; Carbon Cap**
  - **Chlorination**

  - **High Dosage to Side Stream**
  - **Efficient Mixing**
  - **Extended Contact Time**
  - **Extended Contact Time**
  - **Needs 0_3 Resistant Filter**
  - **Sand, GAC or Anthracite for Aqueous 0_3 Destruction**



POOL OZONATION - PRE-FILTER FULL OZONATION W/ADDITIONAL CONTACT VESSEL

MATERIAL SELECTION FOR OZONE SERVICE			
Process Component	**Acceptable and/or Recommended**	**Not Acceptable or Not Recommended**	**Additional Notes**
Gaseous O_3 Tubing/Piping	Teflon Tubing SS Tubing or Pipe	PVC Pipe, Except for Offgas	Swagelok Fittings for Tubing Weld Pipe. Minimize Threaded Connections
Aqueous O_3 Piping	PVC (Sch.80), SS Pipe		
Gaseous O_3 Valves	SS Ball Valve, Teflon Seat		Offgas: PVC Ball Valves O.K.
Process Water Valves	**PVC Ball Valves**: Teflon Seat, Viton O-Rings; **Butterfly Valves**: SS Stem & Disc, Viton Seat, Epoxy Coated Body		
Venturi Injectors	Kynar; Stainless Steel	PVC Machined	Must Have Checkvalve. Additional Backflow Preventer between O_3 Generator and Injector
Offgassing Valves	SS Body, SS Internals, SS or Viton Needle	PVC Body	Water Trap
Filter and Contact Vessels: Shell & Liner	O_3 Resistant Fiberglass, SS; Hypalon-, Epoxy- or PVC-Liner	Not Ozone-Resistant Fiberglass	Check Manufacturer's Guarantee. Check NSF 50 Compliance
Ozone Destructor	PVC Sch. 80 or SS Shell. GAC or Catalyst as Destruct Material		Preheat Offgas when Using Catalyst
Gaskets & O-Rings	Teflon, Viton, Hypalon, EPDM, Red Silicone	Rubber, Buna-N, Neoprene	No Test Data for Long Term Resistance to High O_3 Concentrations

OZONE DESTRUCT MATERIAL

- Granular Activated Carbon (GAC) or Special Catalyst
- GAC Must Be Installed w/o Touching any Metal (Battery); Well Suited for PVC
- Offgas to Catalyst Must Be Preheated to Prevent Catalyst Poisoning or Failure
- Vent Offgas to Outside above Maximum Snow Level
- Install Moisture Trap; Prevent Condensation
-

FLOWMETERS AND PRESSURE GAUGES

- O_3 Resistant Flowmeter Body
  - Acrylic
  - Borosilicate Glass
- Stainless Steel Internals
- Pressure Gauges May Incorporate Materials Not Resistant to Ozone (Brass)

GASKETS & O-RINGS

- For Gaseous Ozone:
  - Viton (FKM)
  - Hypalon (CSM) (Chlorosulfonated Polyethylene)
  - EPDM (Ethylene Propylene Diene Terpolymer)
  - Red Silicone
  - Teflon (TFE) (Tetrafluoroethylene)
- For Aqueous Ozone:
  - Teflon
  - Hypalon
  - Viton
- DuPont Has NOT Established Data for Resistance to High Ozone Concentrations

COATINGS

- Epoxy Coating Recommended for Butterfly Valve Bodies and Pump Volutes
- Epoxy Coating May also Be Sufficient for Vessel Interiors (Need More Data)
- State Codes May Require NSF Approval of the Coating
- All Coatings Should Carry Non-Prorated Guarantee
- Some Manufacturers Give Guarantee only if Periodic Inspections Are Permitted (May Require Sand Removal)

GASEOUS OZONE VALVES

- **For Ozone Product Gas: Stainless Steel Ball Valves with Teflon Seat**
- **For Offgas: PVC Ball Valves with Teflon Seat and Viton O-Rings Acceptable**

PROCESS WATER VALVES

- **Up to 2": PVC Ball Valves with Teflon Seat, Viton O-Rings**
- **3" and Greater:**
  - **For Ozonated Water: Butterfly Valves with Stainless Steel Disc and Stem, Epoxy Coated Body, Viton Seat, Lever or Gear Operator**
  - **For Non-Ozonated Water: Standard Process Butterfly Valves**

VENTURI INJECTORS

- **Kynar or Stainless Steel**
- **PVC Injectors May Implode or Break from Embrittlement**
- **Need Checkvalve (Integral or Added) and Second Backflow Preventer, Such as U-Tube, Stand Tube, Float-Actuated Solenoid etc.**
- **For Large Injection Flows: Dual Injectors May Be Less Expensive than One Single Large Injector**

OFFGASSING VALVES

- **Stainless Steel Body, with Stainless Steel Linkage and Stainless Steel, Hypalon or Viton Needle.**
- **Top-Mounted or Spraying Valves Require Trap for Moisture Separation**
- **Mount with Isolation Valves for Maintenance.**

VESSELS: SHELL MATERIAL AND LINER

- **Post-Filter Ozonation:**
  - **Standard Fiberglass or Coated Carbon Steel Filters**
  - **Ozone Resistant Contact Vessel (Durakane)**
- **Pre-Filter Ozonation:**
  - **Filter Ozone Resistant; Fiberglass, Hypalon-Lined CS, Stainless Steel, Epoxy or PVC Coating (Guarantee!)**
  - **Contact Vessel (if Used): Ozone Resistant Fiberglass**
- **Ozone Destruct Vessel: Stainless Steel or PVC Sch. 80 Pipe; No Metal in Contact with GAC (Electrochemical Cell)**

OTHER CONSIDERATIONS

- Feed Gas Preparation
  - Heat Regenerated Dryer
  - PSA Dryer (Air or Oxygen)
  - Feed Gas Pressure
    - True Vacuum Throughout
    - Pressure Drying, but Vacuum O_3 Generation
    - Pressure O_3 Generation
- O_3 Generator Voltage and Type
  - Low, Medium or Variable Frequency
  - Tubular or Plate Dielectrics
  - Water or Air Cooling
  - UV Generators

MATERIALS SELECTION

- Gaseous Ozone: Tubing/Piping
- Aqueous Ozone: Process Water Piping
- Gaseous Ozone Valves
- Process Water Valves
- Venturi Injectors
- Offgassing Valves
- Vessels: Shell Material and Liners
- Ozone Destruct Material
- Flowmeters; Pressure Gauges
- Gaskets and O-Rings
- Coatings

GASEOUS O_3: TUBING/PIPING

- Teflon Tubing
- Stainless Steel Tubing
- Stainless Steel Pipe
- Compression Fittings for Tubing (Swagelok) or Welded Connections for Pipe
- Concentrated Dry Ozone Gas Embrittles PVC Pipe
- PVC Pipe Acceptable for Low Pressure Ozone Offgas
- No Copper or Brass Tubing or Fittings; no Rubber or Buna N
- Soap Test All Pressurized Connections

AQUEOUS OZONE: PROCESS WATER PIPING

- PVC Pipe (Preferably Sch. 80)
- Stainless Steel Pipe (Usually Only in Drinking Water Plants)
- Must Have Ozone Resistant Gaskets or O-Rings
- Special Attention at Transition Points (Valves, Gaskets, Vessels)

	DIN 19643	Post-Filter Ozonation w/o Contact Vessel	Post-Filter Ozonation w. Contact Vessel	Pre-Filter Ozonation; No Separate Contact Vessel	Pre-Filter Side Stream Plus Full Flow Ozonation; Side Stream Contact Vessel
Process Steps	Coagulation/PAC. Filtration. Ozonation. Contacting. GAC Filtration. Chlorination.	Filtration. Ozonation. Chlorination.	Filtration. Ozonation. Contacting. (GAC) Filtration. Chlorination.	Ozonation. Full Flow. Contacting. Filtration. Chlorination.	Ozonation. Side Stream and Full Flow Contacting. Filtration. Chlorination.
Advantages	Full (100%) Flow Is Ozonated. High Applied O_3. Long Contacting. No Residual O_3. Excellent Water.	Ozone Removed when Used with Bromine(?). Need No O_3 Resistant Filter.	Depending on Design: May Use Large Side Stream Fraction, Large O_3 Dosage, Good Contacting. Need No O_3 Resistant Filter. Ideal for Retrofits	Full (100%) Flow Ozonation. High O_3 Dosage. Synergy with PACl.	High Dose Side Stream & Low Dose Full Flow Ozonation. Synergy with PACl. Long Contact Time, Good Mixing.
Disadvantages	Expensive Additional Equipment. Larger Floor Space.	Small Side Streams. Low O_3 Dose. O_3 in Pool Area. Health Risk. EQ Damage.	Contact Vessel Must Operate as Filter.	Short Contact Time. Needs O_3 Resistant Filter.	Needs O_3 Resistant Filter.

Pool Water Ozonation: Process Evaluation