



"Solving the World's Water Problems"

ADVANCED OXIDATION PROCESSES (A.O.P.)

Advanced Oxidation Processing is the generation and implementation of hydroxyl radicals (HO⁻) to oxidize contaminants in air and water. Hybrid ozone (ozone + free radical hydroxyl ions) is considered one of the most powerful oxidants readily available, and it minimizes the production of harmful by-products.

Hydroxyl Radicals are generated by two means: (1) by the breakdown of hydrogen peroxide (H₂O₂) by irradiating water with germicidal U.V., or (2) combining ozone and water at the wavelength of germicidal U.V. -(254 nanometers).

The A.O.P. that DO₂E utilizes will be from the second process for generating hydroxyl radicals in the presence of germicidal U.V. Our system is compact and produces a concentrated product and a more effective oxidation process when applied through the DO₂E wastewater process.

Ozone Chemistry

Ozone is a form of energized oxygen containing three oxygen atoms (O₃) rather than the normally encountered oxygen (O₂) Ozone naturally occurs in the atmosphere after a lightning storm and is one of Mother Nature's most powerful, readily available disinfectant and

oxidants. Ozone does not produce harmful by-products and can be generated on-site.

Oxygen = O₂

Ozone = O₃

Oxidation

When ozone reacts with B.O.D. compounds, C.O.D. compounds, F.O.G. compounds, and combined halogen compounds, ozone reduces contaminants to inert compounds, carbon dioxide, and water. Inert compounds may be saline, silicon dioxide, or various other compounds.

Ozone removes many soluble heavy metal ions and compounds - iron, manganese, zinc, and copper, for example, by means of advanced oxidation processing. This process breaks down (oxidizes, actually) pharmaceuticals, kills many bacteria (*E. coli*) and viruses (the three types of hepatitis, for example). Ozone is also able to oxidize hydrogen sulfide(H₂S) to:

(1) sulfur dioxide, SO₂, (2) sulfites, SO₃⁼, (3) *sulfates*, SO₄⁼

Advanced Oxidation Process for H₂S:

H₂S + O₃

= (1) Sulfur dioxide SO₂

= (2) Sulfites SO₃⁼

= (3) Sulfates SO₄⁼

This is why A.O.P. is effective for air quality and odor control.

A.O.P. utilizing hybrid ozone (or ozone combined with hydroxyl radicals), is reported to be 100 to 200 times more effective when properly injected directly into the water column where the hydrogen sulfide is produced. This hybrid ozone exhibits a half-life of up to 15 minutes (depending on ambient conditions).

Most ozone is applied as a fogging agent; this does not reach the

source of the hydrogen sulfide. The method of fogging ozone is ineffective at destroying the source of the problem, and often creates a severe corrosion problem. This fogging approach only reacts with H_2S as it is released from the water column. To effectively eliminate H_2S , one must properly inject the ozone directly into the water column where the H_2S originates.

The most efficient and therefore effective method of injecting ozone or concentrated oxygen into a fluid column requires a unique combination of coarse and fine bubble diffusion, released in a confined space or vessel under minimal pressure, (>2.5 p.s.i.) Air under pressure generates heat, and heat can reduce oxygen transfer by as much as 80%. This can be achieved by means of a low- pressure, high-volume regenerative air blower.

Ozone and Advanced Oxidation Combined

Ozone generated by vacuum ultraviolet (V.U.V.) or coronal discharge ozone generators is exposed to ultraviolet light creating hydroxyl radicals ($OH\cdot$).

Hydroxyl radicals are more potent and powerful oxidizers than ozone alone is. The combination of ozone and hydroxyl radicals provides one of the most powerful oxidation products and will substantially reduce organic loading and microorganisms in wastewater.

This patented hybrid ozone allows us to:

- (1) Reduce the amount of ozone normally required.
- (2) Improve the reaction time (200X).
- (3) Address more complicated applications particularly in very large commercial, industrial and municipal wastewater cleanup projects.

A.O.P. combined with the patented DO_2E delivery technology, can now be used on varying scales to address a wide variety of difficult and previously impossible cleanup applications in wastewater treatment and environmental issues.

Patented Hybrid Ozone Technology

Unlike regular UV lamps for ozone generation, this patented UV Hybrid lamp is combined with a high- energy electromagnetic field. These tubes exhibit lifetimes of 15 – 20,000 operating hours and can be easily changed out.

This hybrid ozone technology uses a modified V.U.V. ozone tube as an electrode. This is accomplished by placing a high voltage helical field around the tube to generate this high energy electromagnetic field. The results are an ozone generator which produces ozone using a modified coronal discharge in conjunction with different ultraviolet frequencies (wavelengths).

This combination produces pure ozone in addition to the Advanced Oxidation Process, (A.O.P.), utilizing free radical hydroxyl ions to add another level of effectiveness in terms of oxidation, disinfection, and sanitation.

This patented hybrid ozone system produces ozone with the absence of toxic nitrous compounds as found in many standard coronal discharge ozone generators. The output is constant and is not negatively affected by temperature or humidity as is often the case with standard coronal discharge generators.