Best Practices for Ozone Remediation Services

By the National Ozone Association

This material is the result of many contributions, studies, and years of experience working with ozone as a tool used in many facets of remediation services. We have synthesized available information that has been established as reliable, to create a set of standards and protocols for the use of ozone to be used in a safe and effective manner.

Mission: Our goal is to establish a set of standards for the use of ozone generation for any remediation process. In order to gain respect as a professional tool or service, the use of ozone should be well understood and meet certain guidelines for safety, effectiveness, and target goal.

Peer Review: The National Ozone Association worked with a variety of experienced and trained ozone professionals to review, comment, and share in the process of standards and protocols for the use of ozone.

Premise for This Project: Ozone suffers from poor public education, ill-informed critics, and some misapplied splash-over from environmental concerns for pollution. As a stand-alone concept, ozone is a principle of science with known properties that can be applied to real-world problems as a sustainable and environmentally-friendly process.

Our goals it to properly present the "Best Practices" for the professional application of ozone as a legitimate remediation tool. Like many cleaning and remediation products or processes, ozone can be abused and misused.

We refer to the many uses of ozone as a "Remediation" process, because ozone is a treatment that can resolve a wide variety of environmental challenges. This remediation can be proactive as in food processing, or it can be reactive as in mold remediation.

Ozone remediation by amateurs is sure to cause complaints and failures. The reputation and appreciation for ozone as a legitimate process can be harmed by untrained service providers. To that end, the need for a training and certification process should be encouraged by the public and any concerned agency.

Best Practices: Ozone is in the process of being rediscovered as a tool that can be used in a myriad of applications. This has opened the door to criticism, misguided comments, and public scrutiny. Therefore, we have the burden to properly present ozone as a legitimate treatment that has benefits and limitations. This presentation should be viewed as the "Best Practices" for the professional use of ozone that has value to commercial and non-commercial use of ozone to remediate, clean, and sanitize problematic environmental applications.

Ozone is found in nature, and in each case, it is a critical part of a healthy world. When created in the upper atmosphere, it reduces the amount of ultraviolet light that reaches the earth. In the lower atmosphere, ozone is a natural cleanser and oxidizer produced in lightning storms or sunlight to counteract pollution in our world.

While high levels of ozone can be a respiratory irritant and impact the ecology of any area, this is a natural phenomenon that is intended for our long-term good. Even high levels of ozone will quickly dissipate without a trace. This is because it simply an enriched form of oxygen known as O3 that goes back of normal oxygen in about 20-30 minutes.

Ozone is created in nature on an as needed basis, and returns to nature without any pollution or residue. As such, there can be no criticism of ozone unless it is misunderstood. We may as well criticize the rain for floods, erosion, or drought. Rain is a gift of nature that can be harnessed for good or allowed to impact our world in a random manner.

Critics of ozone tend to follow an environmental preoccupation, thinking that we (mankind) are in control of the world. We play a miniscule part in the immense scope of environmental concerns, but we can do little more than improve our use of resources rather than alter the course of nature.

Ozone generators are measured in grams or milligrams. An ozone generator producing 20 grams (20,000 milligrams) seems an innocuous event in any extrapolation. Remember that the average lightning storm produces 209 tons of ozone. The sun sustains about 0.10 or 0.075 ppm around the world. While a minor gas, worldwide there is always a lot of ozone in our world when considered globally.

So, a 20 gram ozone generator must run 24 hours to fill up a pint jar. Ozone generators pose a negligible volume of ozone while in operation that dissipates back to ozone shortly after creation. Fortunately, it only takes a small volume of ozone to remediate a very large area. In perspective, ozone uses to sanitize an area must be immensely preferred to the amount of chemicals to do the same work.

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SECTION 100 STANDARDS FOR THE USE OF OZONE GENERATORS

101- DEFINITION:

Ozone is a gas created corona spark in normal oxygen-rich atmosphere or created by ultraviolet light passing through oxygen-rich air. The fundamental value of ozone is that it is a non-polluting oxidizer that is also created in nature.

To be fully declared, ozone is a known respiratory irritant and high levels of ozone are offensive and potentially harmful to humans or animals.

Ozone (O3) is an oxidizer made from oxygen (O2) that reverts to normal oxygen in about twenty to thirty minutes depending upon temperature

Ozone is reactive, meaning the third oxygen atom will discharge from the O3 structure to bond and oxidize other elements. This oxidation process is helpful in several remediation circumstances and potentially harmful when improperly used.

102- ENVIRONMENTAL IMPACT:

The use of ozone generators should not be confused with concerns for the ozone layer or low-level pollution. In that ozone has proven to revert back to oxygen in about thirty minutes, isolated applications are too small and too short-term to produce a negative impact on the ozone levels of any community.

Sustainability: The use of ozone may be preferred as an alternative to chemical applications that require consumption of natural resources, may cause residual pollution or toxicity, or add to the waste management of other programs.

Pollution Control: Ozone is a known natural antidote to pollution. While concerns exist for the byproducts of ozone and certain pollutants, the basic action of ozone is to cleanse and detoxify air, water, and surfaces. Ozone is not a pollutant, but will combine with pollutants in the air during days of intense sunlight. Ozone in nature tends to clean, sanitize, and neutralize environmental threats, however, during the process byproducts of pollutants and ozone may be hurtful to people and the environment.

By contrast to chemical cleaning products ozone as a solution does not deplete natural resources, add to the landfill problem, not pollute our waterways. Since it dissipates back to oxygen or combines with pollutants as an

oxidized form the the original elements or compounds, ozone would seem to be a neutral treatment concept that is under-appreciated in the public realm.

103- APPLICATIONS:

Ozone is used in ambient air or in aqueous mixtures to perform a variety of services.

Notably:

1. Odor Elimination for a wide variety of odor problems
2. Sanitizing and purification to bill bacteria and virus
3. Mold and Mildew Remediation
4. Neutralizing of Pollutants
5. Pest elimination
6. Medical or Therapeutic Treatments
7. Aquaculture, water sanitizing, and cleaning processes
8. Commercial application including food processing, treatment of manufactured goods, aquariums, cooling towers, and swimming pool sanitizing.
9. Laundry systems, cleaning services, and water treatment systems
10. Post fire remediation services

104- OZONE AIR PURIFIERS VS OZONE GENERATORS

- **Ozone air purifiers**, by definition, are ozone generators that produce low levels of ozone that will not exceed more than .050 to 0.10 ppm in a normal setting. This means that air purifiers may be operated with people or pet in the area with the exception of small areas lacking adequate ventilation.
- **Ozone generators** are purposely intended to greatly exceed the 0.10 ppm levels for designated periods in order to provide remediation of microbial threats.
- As such ozone generators purposely exceed EPA and OSHA levels and require that ozone treatments for habited buildings and must only be applied in vacated rooms or buildings.
- It is, therefore, the **first protocol** for any ozone treatment exceeding .050 and/or 0.10 ppm that the treat areas must be applied only in vacated building using the guidelines for safe ozone remediation found in this document.
- A "**Vacated Building**" is understood to be a building absent any person or pet, and only workers with training and proper PPE may enter. Proper PPE is explained in Section 303 of this document.

105- OZONE SHOCK LEVELS

Ozone shock levels are a popular term that refers to an ozone saturation that creates rapid reaction/remediation of the pollutant. Ideally, the ppm will neutralize the target problem in the minimal amount of time. Hence, ozone shock is the **optimum level of ozone** concentration in the **shortest period possible**, or maximum reactivity per the target problem.

Ozone shock is believed to occur at 12 ppm or higher and will be requires fans to move the air because ozone is slightly heavier than ambient air. Concentrations of ozone will be slightly more elevated at low-lying levels than the higher levels of the room(s). EPA has indicated a 12 ppm is shock level and requires caution for such applications to protect the health of workers, visitors, or residents when ozone levels exceed maximum EPA safety standards.

As a reactive gas, mild ozone application will not be as effective in the remediation process as it is at high concentrations. Therefore, the creation of high ozone saturation (ozone shock) is desirable to remediate the area more quickly and more completely.

The standard of time for shock level ozone is relatively brief, and should not exceed an eight hour cycle. When ozone is applied for an extended period, it may cause impact vulnerable products referenced in Section 309 of this document.

Notably, prolonged ozone shock lasting 24 hours or more could cause embrittlement of elastomers and certain plastics. This is a rare event that happens with prolonged exposure to elevated ozone levels.

Ozone generators making claims of shock level ozone often ignore the 12 PPM threshold suggesting that 4-6 PPM may be considered shock level ozone. This is a mistake in the Best Practices since low level ozone PPM forces application times beyond eight hours to achieve the same results of more powerful ozone generators that will do the task in eight hours or less.

Less than shock level ozone will still neutralize some odors, kill bacteria, and may kill mold if the area of treatment is limited in scope. Ozone is a basic concept of oxidizing of threats which will still work, to some extent, in lower than shock level applications. This distinction may be lost on the public due to the over-promotion of small output ozone machine promotion and self-serving Internet hype.

106- SAFETY CONCERNS FOR SHOCK LEVEL OZONE

As stated in Section 104, there is a difference between small ozone generators that are not intended to reach ozone shock level and those that developed to reach or exceed ozone shock levels. While a loose estimation, ozone air purifiers are often 1000 mg/hr or less and may be as small as 100 mg/hr. Therefore, warnings for ozone irritation are deemed a small concern for ozone-type air purifiers.

However, ozone generators in excess of 1000 mg/hr should be taken more seriously because they are capable of raising the ozone levels above the EPA or OSHA safe levels, depending on the cubic feet within the treatment area. Anyone entering an ozone treatment area should wear recommended personal protection equipment.

The proper **personal protection equipment** (PPE) for high ozone levels is a carbon filter mask that must cover the mouth and nose. Carbon filters may eventually loose their filtering ability over time and must be replaced as needed. One of the first indications of excessive ozone in the air is a "**Tickle Cough**" that will last for 5-20 minutes. Longer exposures can also cause a "Tired Lung" symptom that will also pass. These symptoms are the result of irritation of the mucus membranes of nose, throat, and lungs.

This brings us to a consideration of the amateur and professional use of ozone equipment. Any ozone generator that is capable of exceeding the EPA or OSHA limits for ozone exposure should be considered a professional piece of equipment and operated by those who have training in the proper operation and safe operation of large output ozone generators.

It would seem wise that any ozone generator capable of exceeding ozone levels beyond the EPA or OSHA levels should display a warning for the operator to wear a carbon filter mask during operation.

The requirement of communities or states to regulate or license the use of ozone equipment should follow a basic standard that gaseous ozone generators in excess of 5000 mg/hr should be limited to trained or certified persons from a bona fide national organization.

Aqueous ozone, by comparison, does not offgas like gaseous ozone, but would likely be a safe application as long as the output of the equipment does not exceed 1000 mg/hr, depending in the area treated and ventilation supply.

107 - AGENCY STANDARDS FOR OZONE[1]

For reference, there are agencies that have established healthy levels of ozone for inhabited and workplace areas. These are included by reference, but are not applicable to the professional use of ozone remediation because the **10 Ozone Protocols** include a mandate to only use ozone remediation for uninhabited facilities.

1. FDA states no more than 0.05 ppm
2. OSHA states no more than an average of 0.10 ppm
3. EPA states no more than 0.08 ppm average over an eight hour period

Per section 105, the loose definition for ozone air purifiers require that the size of the ozone generator/ozone purifier not exceed posted limits for an average room. However, there are no specifics for room size.

Therefore, low-ozone output units of 100 to 1000 mg/hr may be classified as air purifiers rather than ozone generators. Manufacturers of ozone-type air purifiers endeavor to represent themselves as ozone generators capable of solving problems similar to larger ozone generators, such as odor elimination, sanitizing, and mold treatment.

[1] http://www.epa.gov/iaq/pubs/ozonegen.html#table_1

200 - OZONE MEASUREMENTS

201 - OZONE GENERATORS OUTPUT:

Ozone generators are often measured for the volume of ozone they produce. This is measured in milligrams (mg) or grams (g) per hour

- **Oxygen Supply**: Medical grade ozone is typically generated from a 90% pure oxygen source.
- **Ambient Air Supply**: Commercial ozone generators may use ambient air to produce ozone.
- **Desiccated Air Systems** reduce the moisture content, and thereby allow ozone generators to produce higher levels of ozone than ambient air.
- Most ratings for ozone generators are measured by a 90% **oxygen supply**. So, a 3.5 or 5 gram ozone corona plate will produce at the suggested level if supplied with 90% oxygen.

202 - TYPES OF OZONE GENERATORS:

There are basically two types of ozone generators although the actual construction may differ.

1- **Corona Ozone Generators**: Ozone generators that rely on a spark, corona, or electrical discharge to create ozone are all corona type ozone generators.
2- **UV Ozone Generators**: Ozone generators that use some sort of ultraviolet light source are UV ozone generators.
3- **Cold Fusion Ozone Generators**: Cold fusion refers to a glass shielded spark system that produces ozone surrounding the glass elements. This type of ozone generator is more commonly used in medical applications.
4- **Aqueous Ozone Generators**: Regardless of the type of ozone generation, ozone may be dissolved into water for a variety of purposes.

203 - HYDROXYL GENERATORS:

Hydroxyl generators are not truly ozone generators. They mostly resemble the UV ozone generators because they rely on an ultraviolet light source that irradiates a surface treated with titanium oxide to produce the hydroxyl radicals.

Hydroxyl generators differ from ozone generators as follows:

1. Hydroxyl generators may be used in buildings where people and pets are present.
2. The system usually requires a fan capable of large volumes of air flow, because the hydroxyl reaction happens in a fraction of a second within the hydroxyl generator.
3. Ozone permeates the air of the whole facility, reaching areas that a hydroxyl may not affect.
4. Both hydroxyl and ozone generators will sanitize the air by killing virus and bacteria.

204 - MEASURING THE OUTPUT OF OZONE GENERATORS

By Volume: Ozone generators are measured by the volume of ozone they will output. As already stated in 201, these ratings are calculated with an oxygen supply. Therefore, ozone generators will not produce at the oxygen-rated levels if used in ambient air situations.

By Saturation: When any gas is mixed into the air, it is measured by parts per million (ppm) or parts per billion (ppb). PPM or PPB are levels of saturation, not of volume. Therefore, the more grams (volume) of ozone being introduced into a fixed area will influence the PPM levels. If the goal is to reach a "Shock Level" of at least 12 PPM, the larger the volume of ozone produced, the more likely shock level ozone will occur.

Ozone production is not the only variable when using an ozone generator. The PPM levels are also affected by:

1. **Cubic volume** of the room(s) being treated.
2. **Humidity**: High humidity (above 60-7-%) will adversely affect ozone production. Does not apply to UV ozone generators and hydroxyl generators.
3. **Temperature**: High temperatures will adversely affect the creation of ozone. Cold temperatures will delay the decay of ozone.

PPM Meter: Ozone saturation levels may be measured by a PPM meter if there is an interest in determining the value of the ozone in the treatment area.

ORP Meter: ORG (Oxidation Reduction Potential) meter measures the high and low levels of water. High ORP is preferred for disinfection and purifying of water, including waste water. This test system can test for ozone by measuring the relative ORP characteristics.

205 - SHOCK LEVEL OZONE

There has been little information about the necessary PPM for certain applications. The reference to zone shock is most often an indeterminate reference by promoters. Claims of shock level ozone by ozone generation vendors tend to be ambiguous and speculative.

As stated, the formula for achieving shock level has several variable, such as: ozone output, cubic size of the treated area, humidity, and temperature. The direct method to determine the value of the ozone treatment would be the ability to monitor the ozone PPM levels.

Ozone, however, is still effective at less than 12 PPM. For example, ozone will kill bacteria and virus, neutralize some odors, or impact mold growth though supplied in less-than shock level treatments:

- Sanitizing … 2-4 ppm
- Odor Removal … 2-6 PPM
- Mold Kill … 8-12 ppm
- Insect Kill … 12-18 PPM

Another variable is the type of threat encountered. Severe challenges like massive mold infestations, post-death odors, trauma scenes, drug house recovery, and foul odors of all types will change the dynamics of the ozone treatment.

Extreme conditions will require multiple cleaning task, removal of goods and even tear out of spoiled materials in addition to multiple and extensive ozone treatments. While the Best Practices protocols herein are intended for common remediation treatments, ozone treatments in disaster situations (provided that the property is fully vacated) will likely exceed the protocols of this set of ozone treatment standards.

206 - AQUEOUS OZONE

Ozone is readily dissolved in water. The common methods of putting ozone in water is by bubbling ozone through water or the use of a venturi in the water pumped into the reservoir.

The size of the bubbles produced into the water is a factor in the total dissolved ozone and the impact of the ozonated water. Essentially, the larger the bubble, the less ozone will migrate into the water. Smaller bubbles will dissolve better, producing a higher ORP reading and providing a more effective treatment.

Venturi systems must deal with the amount of water flow, the cleanliness of the water in the ozone treatment cycle, the reservoir being treated, and the end result of the ozone levels to achieve intended results.

The most common measurement of dissolved ozone in water is the ORP meter. This electronic measure of water addressed the oxidation reduction potential. Scales are -999 as the least oxidizing and 1000 as the most oxidizing solution.

High ORP levels are necessary for sanitizing and disinfection of the solution.

Aqueous ozone is used in cleaning and sanitizing processes in:

- kennels, restaurants, and bathrooms where water can be applied
- sanitizing meat, fish, and vegetables during processing
- sanitizing and purification of drinking water and pools
- waste water recovery or remediation of polluted water
- sanitizing augment for aquariums
- Algae and mold kill on exterior surfaces

Aqueous ozone is becoming more accepted as a cleaning/sanitizing service that is also environmentally preferable because there are no chemicals added to the waste water. It oxygenates water, which is beneficial to any runoff.

207 – OZONE CREATION AND DECAY

Ozone can be quickly created by an ozone generator. The ozone creation of 5000 mg/hr will cause a Bell curve where the ppm will plateau. This plateauing affect can be less than the best level for the problem as shown in 205.

The decay of ozone is immediate as well as delayed. If ozone reaches the pollutant, the third atom is immediately discharged, leaving freshly available oxygen for the ozone generator to recycle.

Otherwise, the unstable ozone molecule will fall apart in about 20 minutes, reverting to O2 oxygen. Thus there is a constant decay of ozone in any application (ambient air or water).

Smaller ozone generators may plateau under the necessary shock level, meaning that the treatment is only partially successful. If the ozone generator plateaus above the desired shock level, the potential for a more complete remediation is improved.

208 – LENGTH OF OZONE SHOCK APPLICATION

Length of application is yet another variable. Many elements go into the estimation of the amount of ozone introduced as well as the length of time for the treatment. Some factors are:

1- Cubic volume of the room
2- Humidity and temperature
3- The effectiveness of the cleaning process prior to ozone treatment
4- Nature of the problem
5- Intensity of the problem

The best practice for ozone application is high ozone concentration (ppm) in the shortest period possible. Therefore, the more mg/hr introduced to the treatment area, the faster the desired ozone shock will occur. Sustaining the ozone shock level applies maximum remediation for the prescribed period.

Cycles of ozone remediation of one to six hours are optimum, with potential of secondary treatments when necessary.

Due to the real concern for embedding the “Ozone Smell” in a home or building, we strongly suggest that no ozone treatment should last more than 8 hours. It is better to apply multiple cycles and evaluate results than overtreat a building.

Reports of damage to delicate goods (plastic, rubber, paint, varnish, and oil based goods) are most often the result of prolonged ozone treatments lasting more than 12 hours in duration.

In certain industrial ozone applications (air or water) the ozone supply is constant or semi-constant. When applied to farm or sewer application, odor elimination requires a steady flow of ozone. Pools and water remediation also require constant flow of ozone to accomplish the task.

In cases of constant or semi-constant use of ozone inside a building, ozone monitoring is suggested per the controlling agency noted in section 106.

SECTION III
300 - OZONE APPLICATION PRECAUTIONS

In order to create consistency in the application of ozone, the following protocols are suggested as the Best Practices for professional ozone application that have been reviewed and approved by the National Ozone Association as proper guidance for residential and commercial remediation by an ozone application.

301 - PREPARATIONS PRIOR TO OZONE APPLICATIONS

Ozone is a tool or application for the applicator. It is not a singular treatment concept, but to be used intelligently as part of an overall service agenda. For best practices it is best to consider additional safety, job specific challenges, and practical protocols prior to the use of an ozone treatment.

1. Cleaning is always the starting point when dirt, debris, soot, animal waste, or trash of any sort is present.
2. Partitioning of the treatment area may be required
3. Sealing ventilation or air sharing pathways
4. Removing water, water-soaked goods, and furniture
5. Removal of mold-damaged material

It is a classic mistake of amateurs to use an ozone generator as the tool for nearly all forms of remediation. Professionals need to assess the problem and the true source of the environmental threat. This means a reasonable investigation of the area and building to understand the numerous concerns to be addressed during the remediation process.

While ozone may be applied early in the treatment cycle to halt the spread of mold, reduce the problem of strong powerful odors, or resolve minor odor threats; the extent and complexity of the job generally suggest that ozone will follow the basic cleaning and preparation of the problem area, including the associated concerns for the building and workers.

302 - CALCULATIONS AND MEASUREMENTS

The following are the findings of the National Ozone Association. To establish some kind of norm for the use of ozone, we have measure the ppm for a 1000 cubic foot room using different ozone rated output using ambient air at a fixed temperature and humidity levels.

This simple approach may allow for reasonable calculation of “On the Job” ozone treatments. The intent is to provide a simple calculation for professional applicators to assure the appropriate level of ozone for efficient application of ozone.

Any level of ozone will have an impact on microbial kill, odor elimination, and mold kill. However, the comparison would be the difference between a cup of red dye or a bucket of red dye added to a pool of water.

The saturation level impacts the length of time of the application and the effectiveness of the treatment. This saturation level is typically referred to as parts per million or ppm. As in the illustration of red dye in the pool, the volume of ozone introduced (measured in grams or milligrams) will influence the intensity of the red color in the pool.

Therefore, the most important variables for an ozone application are:

A- Size or volume of the room(s)
B- Size of the ozone generator (grams or milligrams)
C- Length of time of the application
D- Temperature and humidity of the rooms/building

303 - PPE FOR OZONE TREATMENTS

High ozone levels will adversely impact the mucus membranes of the throat and lungs, even in short period of ozone exposure. OHSA warns that levels above .050 PPM are a health concern as a respiratory irritant.

Ozone shock levels greatly exceed OSHA safe levels, and the required personal protection equipment (PPE) is either:

1. A face mask that utilizes charcoal filtration
2. A fresh air supply for breathing

Exposure to high ozone levels will cause a spasmodic cough that will pass once the person is in fresh air. If the person remains in an area with elevated ozone levels, they may also experience the “Tired Lung” symptom that is also temporary.

Prolonged or repeated exposure to ozone is not healthy outside the guided assistance of a medical or wellness ozone treatment using accepted practices per treatment guidelines. In industrial or commercial applications, ozone meters and protocols are intended to avoid over-exposure to ozone by workers.

304 - PUBLIC WARNING AND BARRIERS

When ozone is applied to a room or building, the applicator should take measures to prevent the accidental entrance of people and pets. Enter the treatment area only with proper safety equipment.

Yellow caution tape would be a sufficient warning of entry areas. Yellow cones in front of doors with warning signs would also be sufficient.

Generally, a statement of "Caution, Ozone Treatment in Progress. Do Not Enter" would be a proper warning.

305 - POSITIVE AIR PRESSURE

Positive air pressure in an ozone application would mean placing an ozone generator outside the room/building and pushing ozone into the room with an air-tight hose arrangement.

Positive air pressure for ozone would be used for pest control, mold treatments, and extreme odor problems embedded into the facility. Positive air pressure is rarely used in normal ozone treatment.

Note, however, that ozone under pressure decreases the effectiveness of the treatment. So, the idea of pumping in ozone from the outside is not as effective as using equipment in a sealed area. Bringing in ozone from the outside is an arguable concept.

When treating for insects, positive pressure can force the ozone into the hard-to-reach areas of the building.

306 - INFILTRATION AND EXFILTRATION

It is a well-known standard for any ozone treatment that the building/room/area must be vacated during an ozone application. Even if the treatment areas is sealed from the rest of the building, it is the duty of the applicator to assure that the ozone generated does not accidently spread into other areas where people or pets may be located.

Be mindful of ways that ozone may inadvertently invade non-treatment areas:

1. Vents and air ducts
2. False ceiling, like a hanging ceiling that may hide walls that allow air flow above the walls between rooms.
3. Doors with gaps at the bottom
4. Holes, pipes, and holes in the wall

Infiltrations means the air that comes into the room/building from outside sources. Air is introduced by cracks, crevices, and holes in the facility. It can also be through the air handling system if it uses a fresh air supply.

The infiltration of fresh air has actually been promoted by some misguided ozone promoters as a way to supply fresh oxygen to the ozone generator. If we understand that an ozone treatment is intended to radically raise the Parts per Million (PPM) of ozone in the room, it makes no sense to dilute the treatment area with fresh air that would tend to lower the PPM of the ozone.

Exfiltration refers to the air that escapes from the treatment area from within the building to non-treatment areas. Exfiltration allows air to escape through cracks, crevices, and holes in the facility.

Exfiltration has a more specific meaning when the ozone application is in a limited area of the building, but ducts, barrier walls, doorways, or holes exist that allow the ozone to move into areas not intended for ozone treatment.

Vapor barriers, like those used during a mold remediation process, may be a method of sealing an ozone treatment area as long as the barriers are well sealed to prevent the infiltration of ozone. In addition, seal all air vents in the treatment area.

In the event of a closed area where people may be within proximity of the ozone treatment area and vapor barriers are in place, it is the applicator's duty to assure that the non-treated areas do not permit ozone levels above .050 PPM per OSHA standards.

307 - PROBIOTICS AND ENZYMES

Ozone is a tool that may be used as a part of treatments that include other products such as probiotics or enzymes. Ozone is a sanitizing agent that will kill microbial life. So, avoid treating an area with probiotics or enzymes prior to an ozone treatment is not recommended as ozone will destroy probiotics and enzymes.

Since probiotics and enzymes are biological processes that are referred to as “Digesters”, the use of ozone while using probiotics or enzymes is not wise.

Probiotics and enzymes require time to digest the solids and films that can cause odors or harbor bacteria and virus. Therefore, probiotics and enzyme should allow 24 hours of digestion before ozone is used. However, probiotics and enzymes would be of greater use as a post-treatment once the ozone has dissipated.

308 - OZONE FOR PRE-TREATMENT AND POST-TREATMENT APPLICATIONS

Ozone can be used in mold, odor, drug house decontamination, and infection control as a pre-treatment to mitigate the impact of a wide-spread, powerful remediation threat.

Examples like hoarder homes, bacteria or virus sanitizing, large mold infestations, and death scenes may apply ozone as a pre-treatment to quickly mitigate the threat and reduce health concerns for workers.

Ozone will reduce odors prior to full cleanup, kill mold and damage mold spores, neutralize chemical threats, and kill virus and bacterial threats before or after the remediation work begins. To prevent premature fouling of the ozone equipment, consider very thin fabric at the air intake that will not hinder the air flow through the ozone generator.

Using ozone as a pre-treatment is intended to reduce the health threats and hardships on the workers who will do the gross cleanup.

Using ozone as a post-treatment is used as a safe-guard against any missed residue that may remain in the building.

309 - POTENTIAL DAMAGE TO GOODS

There has been speculation about the impact of ozone on items in the room during an ozone application. Since ozone is an oxidizer, it will affect a few types of products. Any deterioration of vulnerable items generally requires a prolonged exposure to ozone rather than a short exposure.

Ozone is always present in our atmosphere. Ultraviolet light and ozone may affect certain items in normal exposures. During high-saturation ozone, the deterioration will accelerate. The longer the exposure, the more deterioration there will be.

ABS Plastic	B
Acrylic (Perspex)	B
Aluminum	C (Wet Ozone) B (Dry Ozone_
Brass	B
Bronze	B
Butyl	A
Cast Iron	C
Copper	B
Cast Iron	C
CPVC	A Does get Brittle
Copper	B
Cross Lined Polyethylene (PEX)	A
EDPM (Synthetic rubber)	B (Dry Ozone) C (Wet Ozone)
EPR Plastic	A
Ethylene Propylene	A
FRD - Fiber Reinforce Plastic	D
Galvanized Steel	C
Glass	A
HDPE – High Density Polyethylene	A
LDPE – Low Density Polyethylene	B
Magnesium	D
Natural Rubber	D
Neoprene	C
Nylon	D
Polyethene	B
PVC	A (Wet Ozone) B (Dry Ozone) Does get brittle
Silicon	A
Stainless Steel	A
Steel	D
Titanium	A
Zinc	D

A = No Effect, B = Minor Effect, C = Break down with weeks of use, D = Break Down within days of use. Note: Chart reference embrittlement or corrosion. Steel will rust more quickly in ozone-rich environments than normal exposure to elements.

Chart taken from “The Definitive Guide to Understanding Ozone” by Ozone Solutions

The ozone applicator should be aware of the time limitations for ozone treatments.

Basically, an ozone treatment means that the application will provide sufficient ozone generation to radically raise ozone levels above the 12 PPM level known as “Ozone Shock”. While ozone may treat an area at PPM levels lower than 12 PPM, the length of time needed to do the job is extended, which presents other problems.

To prevent potential harm to household or building goods that may be harmed by prolonged ozone exposure, we suggest that eight hours is the maximum treatment time that would prevent damage to soft goods like rubber or soft plastic goods.

- Mild treatment might be 1-2 hours in durations
- Medium treatments might be 3-4 hours in duration
- Serious treatments might be 5-8 hours in duration

As a rule, it is better to treat the area with high PPM levels for shorter periods than longer (protracted) periods at lower PPM.

During the initial evaluation, the applicator may take note of goods referencing the chart above to prevent damage to goods. The classic example is the rubber seal around the refrigerator door.

If anything might be harmed during the ozone treatment, the product should be bagged, sealed, or removed during the ozone process.

Experience has shown that “Quick and Hard”, rather than “Slow and and Low” ozone treatments are most effective with no damage to household goods.

When in doubt, either remove or bag any item that might be adversely affected. Keep large, air-tight bags on hand for anytime such protective measures are needed.

Since the garage does not usually share the vent system of the house, an alternative would be to move any items of concern into the garage or a building nearby.

SECTION IV – FORMULAS FOR OZONE APPLICATION

401 - THE SIZE OF THE ROOM

The size of the room can be measured in square feet or cubic feet. Since ozone is heavier than air, it will tend to be more concentrated in the lower 3-4 feet of the room rather than near the ceiling. Therefore, cubic foot calculation can be somewhat misleading depending on the height of the measuring device.

If we average all ceilings at 10 foot high for a simple average, that means we may want to base our system on 100 or 1000 sq foot standards.

Our premise, then would be to create a "Rule of Thumb" (10,000 mg/hr per 1000 sq ft of the treatment area) for ozone shock levels that can be quickly applied to any type of application, knowing that a rule of thumb is modestly inaccurate but generally effective for most ozone applications.

That means a 32,000 mg/hr ozone generator will treat 3000-3500 sq ft, but be mindful that the type and intensity of the problem will changes ozone volume to achieve success.

Based on the assumptions of **205- Shock Level Ozone**, we have tested various milligram ozone output in a controlled environment, to determine the relation between ozone output in milligrams to the ppm of the test rooms.

402 - Calculation of Ozone Output of an Ozone Generator

5 liters/min x 120 g/m3 x (1 m3/1,000 liters) = 0.060 g/min x 60 min = 36 g/min

Basically, the concept is the amount of ozone gas produced (measured in milligrams or grams) is introduced into a room or building measured in square feet or meters. The more the output, the greater the ppm levels; and the greater the building volume, the less the ppm levels.

Knowing that few in the ozone services will accurately measure or calculate the output of the ozone generators versus the building volume, we suggest a Rule of Thumb that would provide general guidance to the sizing of ozone generators to the size of the building.

To achieve a level of ozone ppm, the following chart may be helpful:

	1000 sq ft - 10 ft ht	10,000 sq ft – 10 Ft ht	50,000 sg ft – 10 ft ht
6 ppm			
8 ppm			
10 ppm			
12 ppm			
14 ppm			
16 ppm			
18 ppm			

By default, it has been suggested that a simple "**Rule of Thumb**" can be substituted for average ozone treatments. That Rule of Thumb is "10,000 mg/hr for ever 1500 sq ft of floor space.

This Rule of Thumbs makes no accommodation for room height, potential infiltration or exfiltration of air, type of remediation problem, and other variables that may be involved.

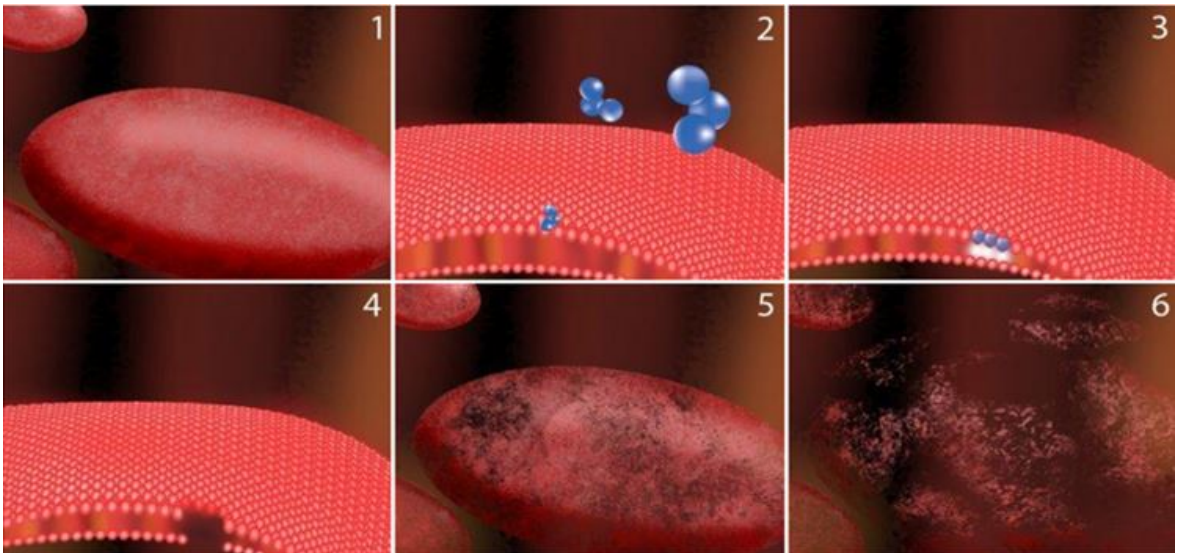
As you might quickly realize, the boasts of many ozone generator companies are often misleading. Smaller ozone generators may claim to treat 4000-5000 sq ft, but they do so in a marginal fashion because PPM levels of 4-8 PPM will have an effect, but they also require a much longer treatment period than properly sizing the equipment for a limited period of ozone shock above 12 PPM.

409 Sanitizing with Ozone

Ozone is well recognized as an effective sanitizing agent. What it lacks is a method of testing for effectiveness. The oxidizing power of ozone actually burns holes in the outer membrane of bacteria and virus. And, ozone does not take long to kill bacteria and virus.

What we lack is the methodology to properly sanitize with ozone and the ability to test the results. An ATP can be used to test surfaces, but the ATP meter only tests small areas throughout the building.

We find that ozone is a good follow-up to a cleaning sanitizing program. In addition, it may be hard to treat areas that have infirmed people in the building.



Generally, you will not find ozone used for sanitizing purposes because it is a respiratory irritant. You will find it used in alternative healing. Other than unique lab applications, ozone sanitizing is not a popular or convenient service.

Ozone is used in wellness applications called insuffation where medical-grade ozone is taken in small amounts into a body orifice. Externally, saunas, spas, and bagging has been used for treatments.

Such health applications are not in our scope of review except by brief mention.

SECTION V – PROTOCOLS FOR OZONE APPLICATIONS

501 - Ozone Protocols for Vehicles

Assumptions made for comparison:

Small Car cubic feet ……. 40 cu.ft.
Medium car cubic feet …….. 60 cu.ft.
Large Car cubic feet ……. 80 cu.ft.
SUV cubic feet ……. 100 cu.ft.
Van cubic feet …… 240 cu.ft

During ozone application, the AC or heat system has the fan running at top speed and the temperature is set approximately 60-70 degree Fahrenheit.

The debate is over whether to pump ozone into the vehicle from an outside source versus placing the unit inside the vehicle. Both methods will work, so the question is which one if preferred.

Argument for Ozone Generator Location (Exterior or Interior)

Pro: The **exterior placement** of the ozone unit is fed a more oxygen rich air supply.
Con: Outside humidity may reduce ozone output unless units are UV generators.

Pro: The **interior placement** of the ozone unit works in a controlled environment, making temperature and humidity a non-issue.

Con: Oxygen supply is limited as the ozone saturation builds.

Since the goal is to raise the ppm (saturation) level, the interior placement of the unit may make more sense. As oxygen is used up, the ppm is raised. Therefore, it would appear from the theory side, that interior placement is preferred. Further, the decay of the ozone back to oxygen is immediately available to the ozone generator.

502 – Ozone Application for Mold Remediation

The use of ozone in mold remediation is effective, but comes with a precaution that ozone is not a stand alone treatment, but may be included as part of the overall remediation process.

Criticisms against the use of ozone for mold treat raise these objections:

1- Ozone generators that are within EPA of OSHA limitations for habitable building is not effective.
2- The physical cleaning, removal of spoiled goods, and post-cleaning treatments cannot be ignored by ozone applicators.
3- Shock level ozone treatments are dangerous for human health.

We agree with each of these objections. Building on the premise that ozone is a tool to be used as part of the more complete mold remediation, the cleanup and post-treatment issues are equally important for a full-scale mold remediation project.

Per item 1 and 3 above, the ozone generator should not be limited by EPA or OSHA limits, and the first protocol for shock ozone treatments is to treat with shock level ozone ONLY in vacated buildings.

It is otherwise a well-established fact that shock level ozone treatments will kill mold and mildew, damage mold spores, but will not prevent mold returning to vulnerable areas.

In short, ozone may be used to pre-treat building to prevent further mold growth, lower worker exposure, and at a later point to kill mold after debridement of the area.

Ozone shock in a post-flood situation may hinder mold growth until the real work of remediation can be conducted.

503 – Ozone treatment Time Duration

The duration of the treatment depends on the strength and type of odor, the temperature and humidity of the work area, and the size of the vehicle.

In light of improvements in ozone generator systems, we have observed a constant increase in ozone output by more modern equipment. This has changed the dynamics of typical ozone treatment. There is an inverse factor when considering the length of time

for a typical application and the ozone output power, which is denominated in grams per hour or milligrams per hour.

- To control temperature and humidity, the vehicle should have the fans and AC running as needed. The blowers will force the ozone through the air vent system.

- Be mindful that some vehicles have a cabin filter that may be clogged or full of debris. Clean or change the cabin filter as needed.

- Typical time for treating a car or SUV would be about an hour assuming that the ozone equipment can raise the level of the ozone sufficiently for sustained ozone shock.

- Vehicle should have been cleaned as well as possible before an ozone treatment.

- Check for wet or damp carpet which could create a mold or mildew problem.

- Digesters (enzymes and probiotics) should not be used before or during ozone treatment. Pre-treatment with probiotics should be done 2-24 hours prior to ozone treatment or after the ozone treatment is over and the vehicle is fully aired out.

In light of the increased power of ozone generators, we suggest that the optimum time for a building ozone application is somewhere between two to eight hours depending on the power of the ozone unit(s), the environmental issues, and the type of problem that is being treated.

Applications that exceed eight hours should bring extra precautions and practices. If a treatment exceeds eight hour, the following steps should be applied:

1- Apply ozone treatments in cycles of no more than eight hours until the intended results are achieved.
2- Remove any items that may be adversely affected by prolonged ozone exposure.
3- If removal is not possible, non-treatment areas or items should be bagged, taped, or placed behind a vapor barrier that prevents exposure to the ozone treatment.

The exception to this rule may apply to those who are treating radical remediation threats such as infection control, mold remediation, death scenes, hoarder home, and similar major remediation threats.

Even with the exception made above, the issue of potential damage from ozone may be something to consider. Although, in these examples, damage and/or costs may forfeit any concern for further damage to the goods in the building.

In addition, pre-treatment by ozone may be applied pre-emptively to mitigate massive odor, disease concerns, and to halt the spread of mold after flooding. Such pre-emptive treatment should not be considered as the proper treatment of these environmental threats.

504 – Ozone Protocols for Buildings

The factors influencing ozone treatments for buildings are:

1. Multi-floor facilities
2. Potential Ozone Exfiltration
3. Temperature and Humidity
4. Air Flow Restrictions
5. Type and Strength of Odors or Contamination
6. Size and placement of ozone generators

One of the first and foremost precautions for shock level ozone applications is the requirement that people and pets are not permitted in any treated areas of the building. People and pets should not be permitted in the building until the treated areas are aired-out or about twenty to thirty minutes for the ozone to dissipate below OSHA limits for normal occupation.

Questions arise about plants in the treated areas. Actual experience in the field shows that plants are not adversely affected by short-term ozone treatments, but long term exposure can cause plants to yellow and potentially die.

Fish and aquariums are also not affected by short-term ozone treatments.

Ozone applicators should post warnings at the entries of ozone treatment areas to prevent accidental entry by people if the area is not otherwise supervised.

Be mindful of exfiltration or cross-ventilation that would allow the ozone in a treated area to flow into a non-intended area. This happens when there are shared heating and ventilation in various parts of the building, barrier walls do not reach to the roof, or holes allow ozone to cross into unintended areas.

Ozone application in buildings with humidity above 60% and temperatures above 90 degrees reduces ozone production with decreasing ozone outputs as the humidity moves higher. To improve performance of the ozone generator:

1. Use dehumidifiers prior to and during ozone application
2. Measure and monitor humidity levels
3. Run air conditioners when possible to reduce humidity

Temperature affects the length of time ozone will remain in the O3 state before turning back into O2. As a rule, the colder the environment, the longer ozone will remain. The

higher the temperature, the shorter ozone will remain in the ozone state. This rule applies to ozone in the air or in water.

The length of time the “Ozone Smell” will remain is roughly gauged as non-health-impacting after 20-30 minutes of air-out time. The ozone smell may be noticeable for 12-48 hours depending on the sensitivity of smell of the customer and the duration of the ozone application.

The ozone that remains is referred to as Residual ozone. "Residual" ozone created will return to oxygen usually within 30 minutes, in amounts equal to half its level. What this means, is that after each subsequent 30 minute period there would be half as much residual ozone left at the end of the period as was present at the beginning of the period. This is similar to a geometric progression of 16; 8; 4; 2; 1.

Ozone is used to treat a building for the following:

1- Unwanted odors
2- Destroy bacteria and virus
3- Kill mold and neutralize mold spores
4- Destroy the biofilm on surfaces
5- Kill dust mites
6- Kill certain insects
7- Counteract volatile organic compounds

Prolonged ozone shock levels can deteriorate elastomers such as rubber and latex. Prolonged exposure is defined herein as periods longer than 8 hours. Hence, ozone treatments of shock level ozone of 24, 48, or 72 hours are not recommended.

Should an odor problem exist after a normal treatment, a secondary treatment could be applied at a later time in what we refer to as “cycles” allowing time for the building to breath and possible release embedded odors.

Small output ozone generators (such as air purifiers) may suggest prolonged ozone application in excess of the two to eight hour time frame. We disagree with this practice as detailed elsewhere in this document.

505 - SIZING THE OZONE SYSTEM FOR THE BUILDING

There are no two jobs alike unless you are working in apartments, hotels, or complexes. In most cases, the ozone applicator must be concerned with the common issues for ozone treatments.

1- Ozone is heavier than normal air and lethargic, but only slightly so. Provisions to move the ozone may require external fans or air movers can be helpful.
2- Multi-level buildings may require units on each level.
3- Monitoring of ozone levels insure the success of the job.
4- It would be beneficial to allow the furnace fan to run during an ozone treatment to help distribute the ozone throughout the building. This would also allow for air duct to benefit from the ozone treatment.

An ozone meter capable of measuring parts per million can determine is the prefer 12 PPM or higher has been reached within the allotted time.

Another indicator of saturation level ozone is the “Blue Haze” that may be observed in low light.

There is a calculation for the amount of ozone applied to a treatment area, it is needlessly complex and not applied by ozone applicators. We have suggested a generalized Rule of Thumb that recommends 10,000 mg/hr of output per every 1500 sq ft of treatment area. In lieu of no practical formulas and the constant misrepresentations of ozone generator promoters, it is believed this suggested Rule of Thumb can be a modestly helpful guide to normal ozone applications.

506 – AQUEOUS OZONE APPLICATIONS

The growth of the aqueous ozone cleaning and sanitizing is notable. By adding ozone to water, a new dimension of cleaning and sanitizing without chemicals is now available.

While the ozone generator still measures in mg/hr output, you will find that the amount of ozone required may be much less than typical air treatment. This is because the media of water is much smaller by volume than the cubic feet for a room.

Ozone saturation in water is measured in "Oxidizing Reduction Potential" (ORP) which is a scale from zero (no ozone saturation) to one thousands (maximum ozone saturation. Examples of ORP are:

- 0-150 --- No practical application
- 150-250 --- Aquaculture applications
- 250-350 --- Cooling tower applications
- 400-475 --- Swimming pool application
- 450-600 --- Hot Tub applications
- 600 --- Water disinfection applications
- 800 --- Water sterilization applications

In closed area, the ozone will still offgas, which may raise an issue of ozone levels that exceed the OSHA standard of no more than .050 PPM in the workplace. Because one might anticipate short-term ozonated water treatments, nominal ventilation may solve the concern for ozone accumulation in the room.

Ozone can be dissolved into water by:

1. **Bubbling systems** that use an outside ozone source to push ozonated air though a hose and diffuser, causing ozone bubbles to infiltrate the water.
2. **Venturi systems** do not use an air pump to inject ozone. A venture is an inline pipe with the water pipe that creates a vacuum to draw the ozone into the water stream. This allows for ozonated water on demand.

506 – Commercial Odor Elimination

507 - Farming

SECTION VI – REVIEW OF BASIC REMEDIATION PROTOCALS

THE TEN BASIC PROTOCOLS OF OZONE REMEDIATION

1- **Ozone applicators** and their workers should be trained and certified in the Best Practices of remediation service using ozone.

2- Elevated levels of ozone should only be applied to **vacated buildings**.

3- Be aware of **exfiltration** of ozone through ducts, lowered ceilings, and passage ways between treated areas and other areas where people or pets may be impacted.

4- Determine the **best level of ozone and duration period** for the threat.

5- **Cleaning is always the first step** to an effective remediation process.

6- Ozone is **slightly heavier than air**, so place ozone generators 3-5 foot off the floor and use fans to promote air movement throughout the treatment area.

7- **Avoid high humidity or high temperatures** which can affect ozone production

8- Use **carbon filter masks** if entering or working in high ozone areas

9- **Allow the room/building to air out** after ozone treatment for about thirty minutes before allowing people and pets back into the treated area.

10- **Set warning barriers** at entry areas to prevent accidental entry of ozone treated areas, and ventilate treated areas for 30 minute before public access.

11- **Inform the customer** of the lingering ozone smell that will eventually disappear.

SECTION VII – OZONE EQUIPMENT CERTIFCATION

Upon request, the National Ozone Association will approve ozone generation devices per the standards set out below. In a period of exaggerated claims, misrepresentations, and a need for credibility in the ozone remediation services, this approval represents an effort to standardize equipment and allow for third-party validation that serves the public interest.

701 – Type of Ozone System (10 Points)

The NOAI Approved® certification applies to corona or UV ozone generator, but also includes hydroxyl generators under similar standards of performance. Applicant will state the type of unit (corona, UV, aqueous, hydroxyl, or hybrid)

Certification may apply to similar units in a model line that vary in size or production.

702 – Specific Task for Application (10 Points)

Applicant will declare the intended applications of the unit, although it is likely that there will be undetermined or unanticipated use of the equipment.

We consider all ozone that generators are broadly used in remediation of some environmental threat regardless of the mundane or common uses of ozone generators. Air type or aqueous ozone should list intended applications that detail their primary markets.

Industrial applications should define the process and purpose of ozone use, the type of product/material the ozone is treating, and the intended purpose for the use of ozone in the application.

703 – Fair Advertising (0-10 Points)

Due to the abundance of misleading and overblown claims, be aware that the buying public needs to know that advertised claims are supported by some general or specific proof. We evaluate the advertising compared to proven support offered, or the general knowledge of such ozone applications.

The points awarded are based on the fairness of the representation rather than the brand, construction, or quality of the equipment.

In particular, statements of ozone production, fan output in CFM, ability to perform specific tasks mentioned in advertising, and unit specifications are part of this review.

704 – Safety of Construction (0 to 10 Points)

Safety is always important. We look for built-in safety features including:

1- Fused circuits
2- Proper grounding or shock protection
3- Aspects that may cause overheating or potential fires
4- Resistance to water intrusion
5- General concerns for sharp edges, system flaws, and wiring safety.

706 – Accurate Unit Specifications (0-10 Points)

With the emphasis on size, we expect that the claims for ozone production (if stated) be supported by an independent measurement.

In addition, if an ozone system is rated for an oxygen supply, this should be stated somewhere in proximity to the output volume. If rated for ambient air, there is no need to report oxygen supply ratings.

Ratings of grams/hr or milligrams/hr are generally ratings from the manufacturer of the ozone cells, plates, or units. It is sufficient to adopt the manufacturer's stated ratings.

PPM (parts per million) are the actual readings are performed on a given model to gain a working example of the actual ozone output

707 – Serviceability of Unit (5-10 Points)

Serviceability of the unit is somewhat tied to the construction of the unit, but actually focuses on: 1) the availability of parts for repair, and 2) the ease of repair by a non-technician operator.

If the unit must be returned for repairs, we assign a basic 5 points if there is a designated repair program in place.

If the unit can be repaired by an average person with basic instructions, we award 10 points.

To earn NOAI Approved® certification, a product must reach 50 out of 70 points according to items 501-507. The intent of this process is to encourage a higher standard among all ozone generator manufacturers regardless of brand, design, or type.

NOAI is not a complaint-handling organization. All complaints received by our office are forwarded to the manufacturer. Complaints should be addresses by the vendor. In the extreme, NOAI may terminate the NOAI approval if the complaints are ignored or issues go unresolved.

NOTICE

INDEX OF REFERENCES

Ozone Measurement in Water by Electric Review: http://pe.org.pl/articles/2012/9b/61.pdf