Application Note AT-103

Ozone and Its Measurement in Fire Restoration

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Ozone is rapidly becoming a treatment method of choice for odor removal in fire restoration. Simple but effective monitoring equipment must be used, however, to gauge if the applied ozone is doing its job in odor removal and if human safety standards are not exceeded. What is this ozone we're talking about?

[See Figure 1 below showing ozone molecules and reactions]

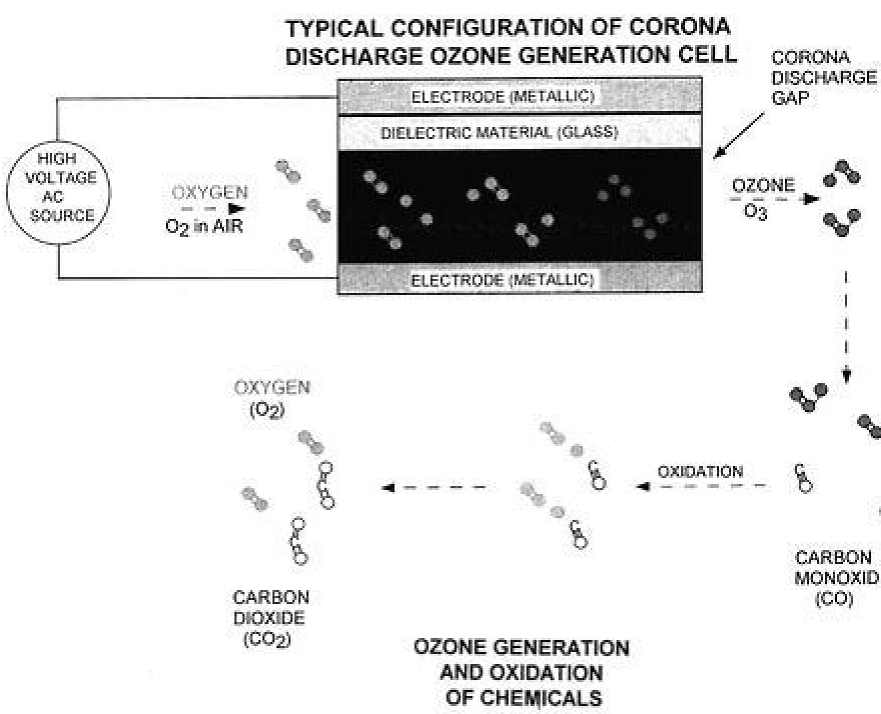

Figure 1

It's the same stuff that was in the ozone hole and is in smog, and it is the same stuff which gives the fresh clean smell after lightning, but because it rapidly decomposes it must be generated electrically on-site. Ozone is the trivalent form of oxygen, which in chemical terms is an oxidizing agent. This means that it neutralizes most chemicals which are reducing agents, and these include virtually all odors, volatile hydrocarbons, and the like. It also attacks microorganisms including virus, bacteria, mold, fungus, and mildew. In other words, it is very similar in effect to a gaseous form of Chlorox, which is effective because it is an oxidizing agent. Ozone, however, is a more powerful oxidizing agent than any chlorine compound and it doesn't leave residuals. It naturally reverts back to oxygen with a half-life of 2-20 minutes.

To be effective yet safe, ozone must be measured on-site to see if it is concentrated enough to do any good, and later on, weak enough to allow human re-entry into the building. Excessive ozone concentrations damage the lungs and other tissues, and various government agencies have definite limits on concentrations and exposure.

During the phase of the restoration project where ozone is being used, restoration contractors face some basic questions. One is how much and how long ozone should be used to effectively remove odors. As a starting point, contractors can use charts showing the ozone generator output (usually in grams per hour) recommended for basic treatment for a given building volume (usually in cubic feet).

[See Figure 2 below showing ozone requirements and typical generators]

GENERATOR SIZING
Guidelines

FIRE RESTORATION ROOM SIZE (Cu Feet) For concentrated treatment of clothing, furniture, etc.	1,700	7,500	37,500
ON-SITE BUILDING VOLUME (Cu Feet)	2,500-15,000	6,000-150,000	15,000-750,000
OZONE OUTPUT (Grams/hour)	2	4	8
GENERATOR WEIGHT (lbs)	34	60	90
POWER CONSUMPTION (watts) at 115 VAC	70	125	260

Fire restoration room treatment is typically 12 hours and on-site building 24-48 hours.

Information courtesy of
Sonozaire Div. of
Howe-Baker Engineers
Tyler, Texas

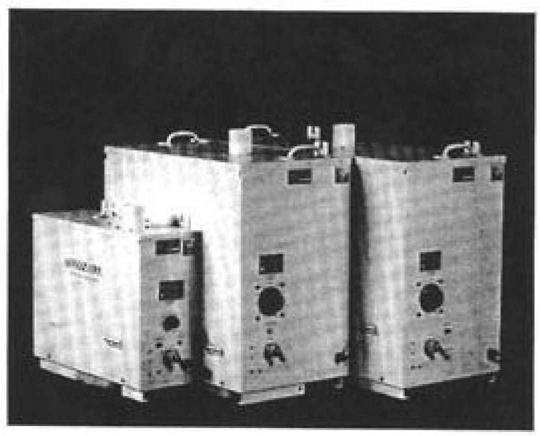

Figure 2

A typical chart is shown here courtesy of an industry leader in ozone generators, Howe-Baker Engineers. In actual practice, the questions to ask are:

1. What is the volume of treatment area in the building or home? How much is it in various areas which can and should be isolated separately?
2. What are the odors to be removed? In treating for fire, are they organic, chemical, protein, etc.?
3. What is the degree or amount of odor? This may be measured by a VOC monitor or other

sampling equipment or may be subjective (the nose!).

4. Will ozone effectively remove the odor? Ozone will treat most odors, but check with sources such as your equipment distributor, ASCR or ozone equipment manufacturers.
5. How much ozone is to be used? Most contractors will have one or more ozone generators and should be familiar with their output. Get sizing charts or guidelines from the generator manufacturers. 2-8 grams per hour should be adequate for most jobs.
6. How long should ozone be used for each project? Some contractors use manufacturers' guidelines, and some contractors have developed their own charts and formulas. 12-48 hours are typical application times.

How can a restoration contractor consistently determine the answer to the above questions, particularly 5 and 6? Even the most experienced contractors are occasionally forced to make guestimates. All restoration contractors should be interested in a better, more economical way to complete the task: some method that would prevent excessive ozonation and would allow the residents or owner to return to the building sooner.

Such a method of determining that the odors are gone is by measuring the amount of residual ozone in the air using a small hand-held electronic monitor or meter. This allows multiple readings easily and quickly.

The ozone levels will pass through several phases. At the start of the treatment for fire, more odors are present and when ozone is introduced, the reaction is extensive, resulting in a low initial level of ozone.

[See Figure 3 below showing the time dynamic of the ozone reacting with the VOCs]

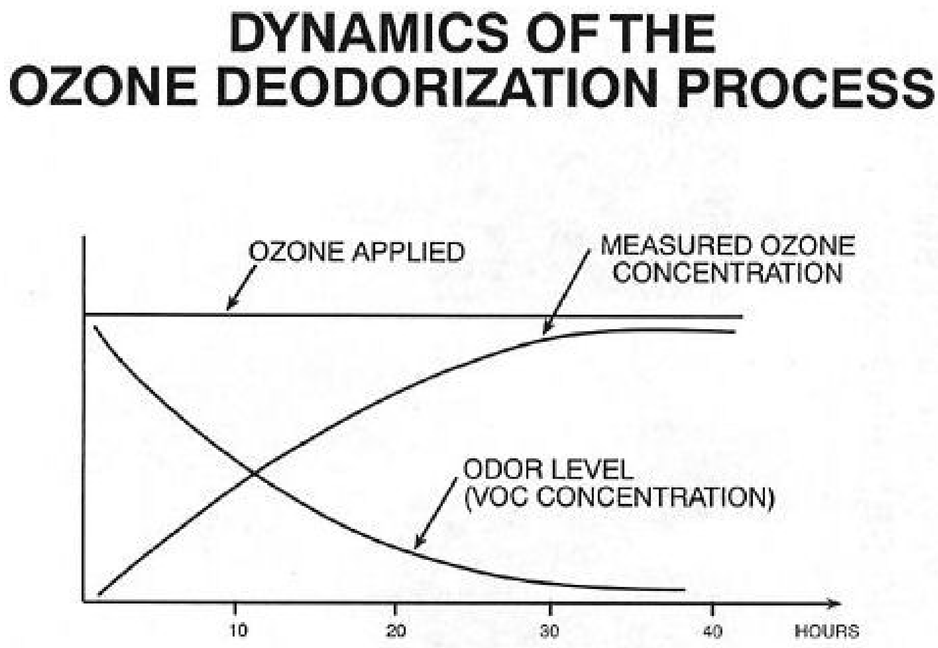

Figure 3

As the treatment progresses, the ozone level will begin to increase because there are fewer odor molecules to oxidize and the odor level will decrease. After a period of hours, the ozone level will reach its maximum value. After this point is reached, the ozone treatment should be continued for a period of time to destroy lingering odors, the time depending on the contractor's experience or it could be determined from research. All of these ozone level measurements are being done with the ozone monitor.

When the ozonation begins, an initial measurement of ozone should be made within an hour, and then measurements should be made every few hours. When the ozone level reaches the saturation point, it should be maintained for several hours before stopping the ozone treatment.

During ozone treatment of a building, portable air blowers or air handlers are required to keep the ozone circulating to all areas. (Ozone is about 66% heavier than air and has a low vapor pressure, so left to itself, it stays in a glob on the floor). Ozone is started in the areas of greatest odors and then moved to areas of lesser odors. All of this can be efficiently managed with the help of electronic ozone monitors to determine where the ozone really is and at what levels.

As a safety precaution, any measurements of ozone above .1 ppm should be made while wearing a respirator approved for ozone. In most countries, including the United States, the limits are .05 ppm for continuous exposure, .1 ppm for short term exposure, and the NIOSH value for IDLH immediately dangerous to life and health is 5 ppm. This concentration of ozone is easily reached in smaller rooms with larger generators, so ozone approved respirators are to be used.

Many who work with ozone say that the sniff test is sufficient due to ozone's distinct odor, but this is not responsible industrial safety practice. People who work around ozone often lose their sensitivity to its odor, at least at low levels. Ozone's damage to the person is not immediately apparent: it mainly attacks the lung and other respiratory tissues leading to progressive tissue erosion and encouragement of various respiratory and lung diseases.

Why haven't ozone monitors been used more up to now? Ozone has been a surprisingly difficult gas to measure. First there were chemiluminescent systems. The reaction gas cylinders often exploded (there was more fire restoration work!). Then there are UV absorption analyzers. These are very accurate but weigh at least 10 pounds and cost about $6,000. Then there are gas tubes. They look like a fever thermometer. You break one glass end for a one-time measurement. Expensive and limited accuracy. There are also badges that change color. Limited range and slow reacting among other negatives.

Just in the last few years have simple, low cost electronic monitors been developed.

[See Figure 4 below showing typical low cost instruments]

LOW COST AND SIMPLE OZONE SENSING INSTRUMENTS

MODEL A-21Z X
DIGITAL READOUT
0-10 PPM
AC LINE OR BATTERY

MODEL EZ-1X
MULTICOLOR BARGRAPH
0-.15 PPM
AC LINE OR BATTERY
LOWER COST

VOC SENSING INSTRUMENTS ALSO AVAILABLE

Eco Sensors, Inc.
Santa Fe, New Mexico

Figure 4

For sensors these use either heated metal oxide semiconductors (HMOS), or electrochemical cells. Both approaches have their pros and cons that we need not go into here because both work satisfactorily under suitable conditions. I will note here the general precautions that should be used with all the small electronic ozone monitors:

1. Allow adequate warm-up time. 10 minutes is usually safe. Allow 30 minutes the first time of the day if the time is available.

2. Do not block any air flow in or out of the instrument.
3. Make all measurements in essentially still air.
4. Do not let dust, water, or oils into the instrument.
5. Keep the instrument away from your body while making measurements.
6. Make all measurements indoors.
7. Avoid making measurements in heavy concentrations of chlorine or acid fumes.
8. Do not use the instrument to try to measure the output of the ozone generator.
9. Do not enter an area where the concentration measures:

   - .1 ppm for more for more than a few minutes occupation
   - More than .05 ppm for continuous occupation

10. Bring a spare instrument

While all these do's and don'ts may sound complicated, after a short while they will seem like common sense and there should be no problems.

Hand-held ozone monitors are available from several suppliers. [See Figure 4, above, showing Eco Sensors recommended ozone instruments.] Our popular model A-21ZX will measure from .02 to 10 ppm, although readings above .1 ppm should be only for short times. It is economically priced at about $750 and is available through major distributors of safety equipment, instruments, and ozone equipment, including many ozone generator manufacturers.

We also make other instruments and accessories. One of the most popular is a battery-operated, pocket-size ozone calibrator. It is a tiny .1 ppm ozone generator that allows field checking of the calibration of ozone instruments. Until now, ozone instruments had to be returned to the manufacturer for calibration checking and recalibration.

I would like to acknowledge here the input I have received from Curtis Nipp at Howe-Baker Engineers, Tyler, Texas, pioneers and leaders in ozone generator design and manufacturing, for his guidance in the use of ozone in fire restoration and for the data and photos from his company.