WELCOME TO THE IOA/PAG AIR TREATMENT TASK FORCE WEB SITE

This web site contains the following items of information, all dealing with the use of ozone for the treatment of air for one or multiple purposes.

Statements by the International Ozone Association Concerning Air Treatment with Ozone

Uses for Ozone in Treating Air

Roles for Ozone in Air Treatment

Criteria for Evaluating Case Studies

Case Studies of Installed, Commercial Applications of Ozone for the Treatment of Air.

STATEMENTS BY THE IOA CONCERNING AIR TREATMENT WITH OZONE

The following statements represent the positions of the International Ozone Association with respect to the treatment of air with ozone for any purpose. These statements were adopted by the IOA International Board of Directors in 2004.

A. IOA supports the applications of ozone for the treatment of air, as long as such applications are made under conditions that are protective of workers involved and of the safety of humans and their possessions in facilities being treated with ozone.

B. IOA will NOT support the indiscriminate application of ozone in any manner that endangers the health of workers or recipients of air treated with ozone or containing ozone.

C. IOA will provide space on its web site(s) and will sanction publication of IOA documents to present information on known procedures of applying ozone to treat air for purposes of improving its quality under conditions stated in A and B above.

D. IOA is a U.S. Internal Revenue Service-recognized not-for-profit association under Section 501(c)(3) of the U.S. Internal Revenue Code. As such, IOA will provide an organizational umbrella under which industrial representatives in the ozone and air treatment industries can meet to discuss technical, safety and regulatory issues and to advance the causes of ozone without fear of anti-trust suits, as long as pricing and similar issues are not discussed.

USES FOR OZONE IN TREATING AIR

Air exists everywhere on our planet Earth. It is present outdoors in natural environments, as well as indoors. It is man's responsibility to ensure that air that becomes contaminated is cleaned so that it may be reused by the organization or next person needing it.

Ambient outdoor air can become fouled with odorants, contaminants discharged from industrial plants, exhausts from power plants, automobiles, buses, trucks, trains, aircraft, tractors, etc. Indoor air in homes can be contaminated by normal household activities such as cooking, washing laundry, cleaning, burning wood in fireplaces, painting, and the like. However, indoor air also can become contaminated by smoking odors, mold and mildew, and volatile organic compounds that slowly evaporate from modern plastics and glues used in building and furniture-making materials. Many food processing facilities and areas of wholesale and retail grocery stores and supermarkets face control of odors and bacteria throughout their establishments constantly. Air in hospitals, medical laboratories and nursing homes can be contaminated by all of the above-mentioned contaminants, as well as by volatile medicinal compounds. Air conditioning ducting and mechanical systems need to be kept free of microorganisms. Casinos, night clubs, bars, etc., where smoking is allowed, have a need to cope with smoke odors and volatile organic compounds.

ROLES FOR OZONE IN AIR TREATMENT

Ozone is both a strong oxidizing agent as well as a strong disinfectant. Because of this, both benefits (oxidation and disinfection) can be achieved during the single step of ozonation. When considering oxidation, however, one must also recognize that not all oxidizable substances can be totally destroyed even by ozone, the strongest oxidant and disinfectant commercially available, e.g., mineralized in the case of organic substances, to produce carbon dioxide and water. In most cases, oxidation reactions proceed through intermediate stages, arriving at CO_2 and water only when the pollutant is provided with a sufficient concentration of ozone for a sufficient period of time to allow complete oxidation (mineralization).

Therefore, when considering ozone for treating contaminated air, one also should consider the partial oxidation products from ozonation of` organic contaminants. This situation is not unique to ozone. All oxidants do their work through multiple intermediate stages, thus forming byproducts. Ozone however, consisting of nothing but oxygen, forms intermediates by the mechanisms of increasing incorporation of oxygen atoms into the intermediate structures. Usually, this results in decreasing toxicological effects compared to those of the starting compound.

It is not healthful to breathe ozone, in any concentration. Thus treatment of air with ozone is never recommended when humans or pets are present to breathe the air during treatment.

CASE STUDIES OF SUCCESSFUL OZONE USES FOR AIR TREATMENT

The Task Force believes that it is instructive to provide specific examples of the many applications of ozone for treating air on this web site. That being said, the question next arises as to what constitutes an appropriate Case Study of Air Treatment with Ozone.

The literature is replete with publications describing ozone treatment of contaminated air. However, the Air Treatment Task Force believes that Case Studies to be listed on this web site must be complete to rather rigid standards. It is not sufficient to say only that ozone will accomplish some air treatment task without providing all of the procedures for generating and applying ozone, and without reporting data to support the claims made. Conditions should be described that will allow the reader to duplicate the procedure and to develop his/her own data.

To this end the Air Treatment Task Force has developed the following criteria for case studies to be reviewed and posted on this web site:

- Title of Case Study
- Description of Problem
- Description of Plant or Process
- Details of Ozone System and Application
- Case Study Information
    - Cost savings / Return on Investment
    - Improvement in air quality attained
    - Other synergies/additional benefits
- Employee Health & Safety Issues
- Submitter—Job title – contact details
- Reference – original article(s), if applicable

In practice, whenever a proposed Case Study is submitted to the Task Force for posting on this web site, a systematic evaluation/review procedure is followed. Selected members of the Task Force review the submission and compare the content to the criteria listed above. If all criteria are met, the submission is circulated to Task Force members for review and comment. Upon receipt of these comments, the document is revised and returned to the submitter for review, comment and approval. The cycle repeats until the Task Force and the submitter agree, and the document then is approved for posting on this web site.

CASE STUDY EXAMPLES OF AIR TREATMENT WITH OZONE

Please review the following USR and contact the IOA at info@io3a.org with any questions or comments:

- BINGO HALL HVAC SYSTEM

Other Case Studies of air treatment with ozone are under review and will be posted on this web site as they are approved.

IOA/PAG AIR TREATMENT TASK FORCE

USER SUCCESS REPORT

TITLE: **BINGO HALL HVAC SYSTEM** – Air Treatment with Ozone

ABSTRACT:

A 20,000 sq ft bingo hall opened in 1994 and included a traditional HVAC system. Almost immediately, complaints were received by management from visitors about tobacco odors. Installation of exhaust fans did not rectify the problem nor were complaints reduced. Ozone was installed to treat in-duct air with great success. Not only were tobacco odors eliminated, but total VOC levels also were reduced. An alternative technology, granular activated carbon, which would have cost $25,000 annually in replacement carbon, did not have to be installed. Ozone costs were $22,000 and resulted in less maintenance, less makeup air, and energy savings of $250/month.

A. DESCRIPTION OF THE PROBLEM

The Imperials Bingo Hall is a 20,000 square foot structure built in 1994 in Renton, Washington, USA, by Imperials Music and Youth Association. Although significantly remodeled in 2004, the building was originally divided into two bingo rooms, one non-smoking and an 8,000 square foot smoking section for up to 400 bingo players. There are also administrative offices, kitchen, restrooms, loading and storage areas. A floor-to-ceiling partition wall separates the bingo hall, which is all smoking, and the new "mini-casino" and restaurant. The suspended ceiling is 14 feet from the floor.

20,000 sq ft Imperials Bingo Hall, Renton, Washington

The building was constructed with a conventional heating, ventilating, and air conditioning (HVAC) system designed for a high occupancy structure. The bingo area is served by four 7.5 ton, rooftop packaged HVAC units, which have gas heat and electrical cooling with thermal economizers. Positive air pressure is maintained in the overall structure, with negative pressure in the smoking area relative to the nonsmoking area.

When the new facility opened in 1994, there were immediate complaints from players and employees in the smoking section about strong odors and physical discomfort associated with exposure to excessive levels of tobacco smoke, volatile organic compounds (VOCs – see Section G – Discussion of VOCs), burning and itchy eyes, dry throat, headaches, nausea, etc. Furthermore, Imperials received numerous complaints from non-smokers due to communication of tobacco smoke into the non-smoking section. Strong tobacco odors were present in the entry area, generating further complaints and player dissatisfaction.

During peak load conditions, it was difficult to see from one end of the smoking area to the other. Strong tobacco odors were present, and high levels of VOCs were determined to be present by analytical measurement. Total VOC concentrations ranged from 0.8 ppm at light load conditions, to as high as 2.6 ppm during peak loads.

In attempts to overcome these problems, Imperials began a series of changes to the HVAC system. The economizer dampers were opened to the point where the HVAC units could not keep up with the heating/cooling load at temperature extremes. Two 3,500 cfm exhaust fans were added to the smoking section to evacuate the smoke and further enhance the pressure differential between the smoking and nonsmoking sections, and barometric pressure dampers provided up to 4,000 cfm of make-up air.

The exhaust fans produced a noticeable reduction in the tobacco odors in the entry area, but no observable difference in the odors and VOCs in the rest of the building. The energy cost of exhausting 7,000 cfm of conditioned air ran in excess of $350 per month and caused the internal temperature to fluctuate beyond acceptable norms during extremes of temperature. The make-up air grills were located in the center of the smoking area, therefore, due to their chilly drafts, the center of the smoking area seating section was empty during all games. Player and employee complaints of odors and physical symptoms continued unabated.

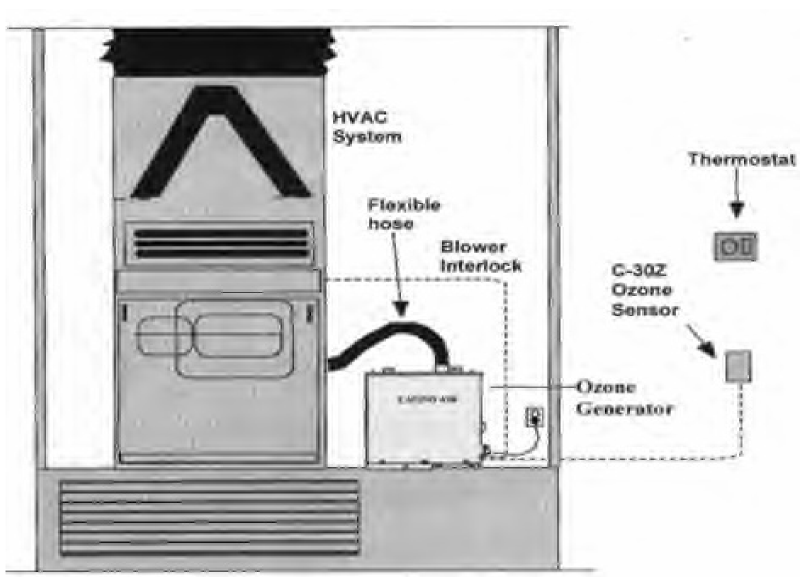
In combination with self-contained particulate control technology to eliminate visible tobacco smoke, ozone technology was applied, with great success, to overcome the tobacco odor and VOC problems.

B. DESCRIPTION OF PLANT OR PROCESS

Typical HVAC Connection for Indoor Air Quality Control. In this configuration, the ozone is injected into the mixing plenum in the air handling unit, the chamber in which the return air coming back from the bingo hall is mixed with the outside air used for ventilation. Sampling is achieved within the occupied space, and the monitors are hard-wired to the ozone generators to ensure maintenance of appropriate and safe levels.

C. DETAILS OF OZONE SYSTEM AND APPLICATION

The ozone treatment system consists of four 10-grams per hour corona discharge ozone generators, model Casino Air CA-1000 (manufactured by CB & I Howe Baker to Clean Air Systems' specification), fed with ambient air. These units are controlled by ozone sensors, very much like thermostats control furnaces or air conditioners. Eco Sensors (Santa Fe, N. Mexico) C-30Z ozone monitors are programmed to shut off the ozone generators at 0.04 ppm, which is 0.01 ppm below the Food and Drug Administration's 24-hour, seven-day ozone exposure limit of 0.05 ppm. The ozone generators are installed above the drop ceiling, one per HVAC unit, with the ozone flowing directly into the HVAC return air duct.



Typical HVAC Connection for Indoor Air Quality Control

Blower motors in the air handling units are set for constant fan. This means that regardless of demand for heating or cooling, the air handling unit fans run constantly while the space is occupied. The ozone generators are set up to run constantly (though not at maximum output) while the space is occupied.

The four ozone generators are installed at the top of the occupied space (14 feet altitude from floor) and the bingo customers are at the floor level. Each ozone generator is linked via hard-wire to a monitor. All four monitors are attached to the wall at an altitude from the floor of six feet (the top of the breathing zone) and control the four generators independently. The monitors are set to terminate ozone output at 40-50 ppb (0.040-0.050 ppm).

D. CASE STUDY INFORMATION

1. IMPROVEMENT IN AIR QUALITY

The benefits of using ozone were obvious from the moment the system was commissioned. Customer and employee complaints about the "smoke problem" ceased. Tobacco odors are no longer present in the entry area or in the nonsmoking section. Even inside the smoking section under peak load conditions, tobacco odors are barely past the odor threshold, and none of the physical symptoms of exposure have been noted. Total VOC levels dropped to 0.25 ppm maximum at peak load levels, or about 10% of what they were previously.

2. COSTS / ROI

The installed price of the ozone part of the two-tiered system was $22,000, roughly the same as a recommended activated carbon system. The comparative "payback" was one year, since the carbon system would have carried an annual replenishment expense of $25,000, whereas the ozone system requires only quarterly cleanings and annual monitor calibration. Imperials also experienced energy savings of more than $250 per month due to reduced demand for outside air and reduced operation of the 7,000 cfm exhaust system.

E. HEALTH & SAFETY ISSUES

The conditioned air residence time in occupied areas typically is about 15 minutes, or about the half-life of ozone in such environments. Because the ozone concentration typically drops about 90% from supply ducts to return ducts (instead of about a 50% drop predicted by ozone half-life calculations), much of the ozone is assumed to be lost by reacting with the air contaminants (tobacco smoke and VOCs).

Most ozonated HVAC systems with automatic controls are programmed not to exceed concentrations ranging from 0.03 to 0.05 ppm. These concentrations are below naturally occurring outdoor levels in many regions, but are just high enough to reduce VOC levels significantly. Furthermore, the ozone concentrations are much higher in the supply ducts, where the ozone generators feed in (typically 0.3-0.5 ppm). Levels of bacteria, mold, and mildew were observed visually to be greatly reduced in those ducts, and VOC level reductions were determined analytically. Thus eventually the entire HVAC system becomes cleansed (ozone drops in concentration by a factor of 10 or so due to these reactions as well as due to normal reversion back to oxygen).

F. ADDITIONAL COMMENTS

Indoor air quality went from being a top complaint at Imperials Bingo to a source of positive customer comments. In fact, Imperials uses its air quality as a marketing tool, mentioning it in all its advertisements in general and trade publications.

Ozone reduces VOC levels more effectively than does activated carbon, has no replenishment expense, oxidizes residual VOCs from finish surfaces, reduces demand for outside air, and through the “stat” effect, eliminates the growth of microbial matter inside the condensate drip pans, coils and heat exchangers, and duct work.

G. DISCUSSION OF VOCS

VOCs are volatile organic compounds, exemplified by gasoline fumes, paint solvents, "air freshener," various construction chemicals such as volatiles from carpet adhesive, dry cleaning (perchloroethylene) fumes, the gaseous portion of cigarette smoke, most alcohol vapors, light petroleum distillates, and solvent vapors. Many of these are characterized by rapid dispersal throughout the room in which they are present, little gravitational settling or floating, and quick and definite response on VOC analytical instruments.

Heavy VOCs and those of lesser volatility consist of chlorinated hydrocarbons which generally are used as commercial solvents: perchloroethylene ("perc" dry cleaning fluid), methylene chloride, trichloroethylene, carbon tetrachloride, chloroform, and the like. If there is not much room air circulation, these VOCs will tend not to disperse throughout the room, but instead will tend to keep in one area and sink to the floor or table top. They also tend to cling to fabrics such as curtains. This is important to know in terms of placement of the VOC monitors and ozonated air supply duct outlet locations.

The Eco Sensor C-21 VOC sensor contains a heated (250°C) metal oxide semiconductor (HMOS) (–type, meaning electron-repelling) that reports the totality of volatile organics present. It is very good at early warning in semi-quantitative terms, and for follow-up leak tracking, but it is not designed or sold as a quantitative analyzer for any specific VOC.

When reducing gases (VOCs) contact the HMOS, electrons which have been trapped at the semiconductor surface are freed, leading to increased conductivity (decreased resistance). This change of resistance is measured by the instrument. Oxidizing gases such as ozone have the opposite effect, e.g., the resistance increases.

This process cannot be species-specific but can be species-emphasized by means of dopants. The most common gas-sensing semiconductor is tin oxide, SnO_2. The resistance change is essentially logarithmic. It is modified by temperature and humidity (water introduces hydroxide ions into the surface chemistry). For calibration, the sensitivity of the VOC response circuit is increased until it just zeros in zero air.

VOC sensors are used for alarms, not quantitative analyzers of the common VOCs that OSHA regulates in the workplace.

H. SUBMITTER – JOB TITLE – CONTACT DETAILS

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I. REFERENCE(S) – ARTICLE(S) – IF APPROPRIATE

L.B. Kilham and R.M. Dodd, "Case Study of a Bingo Hall HVAC System", paper available on EcoSensors, Inc. Web site, www.ecosensors.com.
Clean Air Systems web site: www.cleanairsystemsinc.net

J. DISCLAIMER

This report is based on information provided by commercial organizations and manufacturing firms that has been submitted to describe an application or applications for ozone that are based on data developed by the providers. IOA is not responsible for the accuracy of the information and data submitted.

R.G. Rice – 2 December 2005

Consensus approved for posting on IOA web sites by members of the IOA/PAG Air Treatment Task Force