IMPERIALS BINGO HALL, RENTON, WASHINGTON, USA

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ABSTRACT

Most of the application of ozone has been for the treatment of water. Recently, ozone increasingly is being employed commercially for air treatment odour control (removal of VOC's from the air). This is conveniently and practically achieved by integrating the ozone generator system into the HVAC system. Ozone sensors are installed to maintain ozone concentrations at an optimum level.
The majority of projects so far are for the gaming and hospitality industries, where there is a high return on investment in systems, which create and maintain high quality air. It has been found that ozone works well with particulate filters. It eliminates the need for costly carbon VOC filters and reduces the makeup air required which is costly to condition. Paybacks for ozone systems are typically about one year, and facilities customers and managements are very pleased with the noticeably higher air quality. This paper will present data from a bingo hall in Washington.

INTRODUCTION

Ozone has been used for about a century to treat water for pathogens, minerals, volatile organic compounds (VOC's) and other impurities. Only in the last decade or so, however, has ozone been applied on a large scale to heating, ventilating, and air conditioning (HVAC) systems. Major reasons for this surge of interest in ozone treatment of indoor air include:

- Heightened public awareness that something can be done about indoor air quality (IAQ).
- ·Increased IAQ problems due to sealed buildings and less makeup (outside) air metered into HVAC systems.
- Increased public intolerance for smoking and the realization that many common chemicals contribute to poor IAQ.
- New ozone generator and ozone monitor designs that make system control a reality.
- Attractive payback economics due to savings in energy and in replenishments for car-bon filters, which have been eliminated.

The large majority of projects so far are for gaming facilities (casinos, bingo halls, card rooms) and larger hospitality businesses including restaurants, showrooms, and bowling centres. Why these industries? Because they have found that there is a high return on investment in systems, which create and maintain high air quality. Many projects, often much smaller in scale, have been completed for cocktail lounges, taverns, airport smoking areas, and even for advanced technology facilities for animal raising on a large commercial scale.

Both air and water treatment, with ozone requires two basic steps: filtration for removal of particulates, and various methods to remove chemicals and pathogens. Chlorine is widely used for this purpose in water, but it is being replaced by ozone in water treatment plants because chlorine itself can be a health problem and because it is not effective against some pathogens. In air treatment systems carbon filters have been used to remove airborne chemicals and micropore filters have been used to block the passage of pathogens. These filters are now just beginning to be replaced by ozone because the filters have high periodic replenishment costs, and overcoming the pressure drop they cause consumes costly energy.
The major objection to ozone is safety. Its concentration in public areas must be kept below harmful levels. This is accomplished by new technology ozone generation and monitoring equipment combined as a self-controlling system. There is disagreement among cognizant agencies about what are safe levels and suitable guidelines for ozone concentrations. Safe concentrations generally are listed over the range 0.05-0.10 ppm. 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's significantly. Furthermore, the ozone concentrations are much higher in the supply ducts, where the ozone generators feed in (typically 0.3-0.5 ppm). Bacteria, mold, mildew, and VOC's are greatly reduced in those ducts, and thus eventually in the entire HVAC system (Ozone drops in concentration by a factor of 10 or so due to these reactions as well as due to normal "half life" reversion back to oxygen).

Important differences between systems where ozone treats water and ozone treats air are:

- Flow rates between system input and output. Water takes hours between entering a treatment plant and exiting at a customer's home. Airflow rates in HVAC systems can be thousands of feet per minute, and the residence time between the supply duct and the return duct is measured in minutes.
- Water systems do not have the equivalent of "makeup air" in air systems. When carbon dioxide, VOC's or other contributors to poor air quality exceed set points, increased make-up air (air from the outside) is metered into the building HVAC system. This seemingly simple solution leads to two problems: the energy required to heat or cool the additional make-up air can add significantly to the system operating cost, and the make-up air can bring in more contaminants such as dust and VOC's.

Ozone for air treatment is a relatively new area and as an engineering discipline is still evolving. Still, we have to start somewhere. To illustrate practical results from these ideas, we will present a case study of an ozonated, HVAC system at a large bingo gaming hall. Conclusions will be offered based on this and other installations we have done.

IMPERIALS BINGO HALL, RENTON, WASHINGTON, USA

The Imperials Bingo Hall is a 20,000 square foot structure built five years ago in Renton, Washington, USA, by Imperials Music and Youth Association. The building is 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, kitchens, restrooms, and loading- and storage areas. A floor-to-ceiling partition wall separates the smoking and non-smoking areas. The suspended ceiling is 14 feet from the floor.

Figure 1
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 smoking 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 non-smoking area.

When the new facility opened, there were immediate complaints from players and employees in the smoking section about strong odours and physical discomfort associated with exposure to excessive levels of tobacco smoke, volatile organic compounds (VOC's) - 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 odours were present in the entry area, generating further complaints and player dissatisfaction.

After consultations with its mechanical engineer and contractor, 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 non-smoking 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 odours in the entry area, but no observable difference in the odours and VOC's 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 centre of the smoking area, so due to their chilly drafts, the centre of the smoking area seating section was empty during all games. Player and employee complaints of odours and physical symptoms continued unabated.

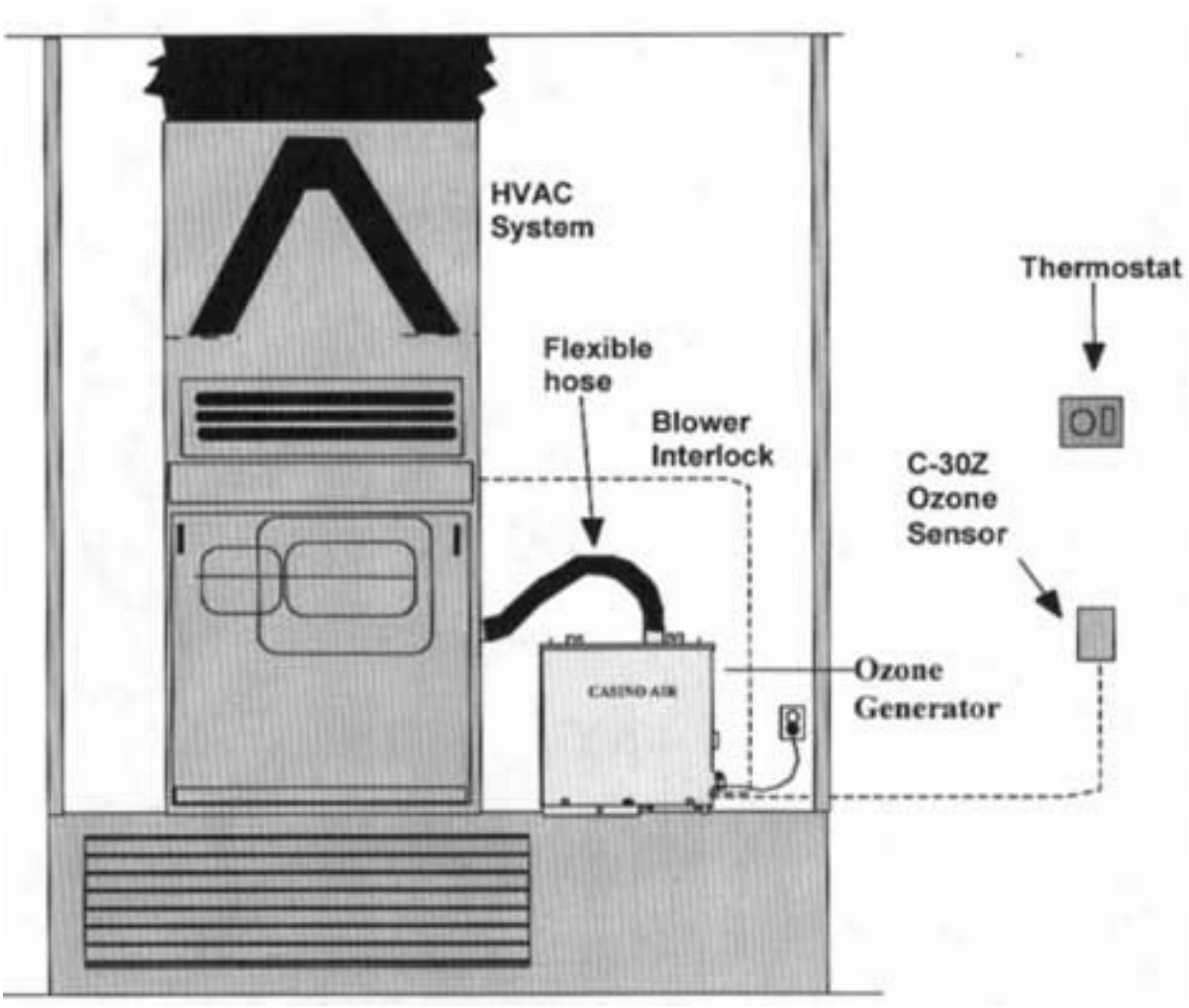
After investing more than $50,000 in consulting fees and mechanical alterations without solving its problems, Imperials Bingo retained Clean Air Systems, Inc. of Bellevue, Washington. In conjunction with Airtronics Environmental, Inc. of Hazel Crest, Illinois, they are the leaders in the implementation of ozone in commercial HVAC systems in gaming, hospitality and recreation applications.

Clean Air Systems found that Imperials' HVAC system is only capable of meeting the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

standards for heavy smoking environments at peak occupant load with the economizer dampers in the 100% open position. Ambient temperature in this area of the Northwest is suitable for 100% outside air less than 20% of the time. Additional HVAC units could not be added due to the saturated load bearing capacity of the roof. Furthermore, Imperials Bingo is situated on a heavily travelled thruway with very high levels of dust and pollutants from automobiles.

During peak load conditions, it was difficult to see from one end of the smoking area to the other. Strong tobacco odours were observed, as well as very high levels of VOC's. Total VOC concentrations ranged from 0.8 ppm at light load conditions, to as high as 2.6 ppm during peak loads.

Clean Air Systems set as its goal the integration of both particulate and VOC control into the existing HVAC system to achieve maximum cost efficiency. Due to inadequate airflow, the introduction of higher efficiency filters with the corresponding pressure drop would have worsened, not improved, the situation. Particulate removal was achieved through the implementation of seven 2,000 cfm, Casino Air Spyder air cleaners.



To deal with continuing complaints about odours and VOC's, Imperials' mechanical consultants recommended inline activated carbon filtration. Clean Air Systems, with over 20 years' experience in activated carbon systems, ran a model which demonstrated that replenishment of expended carbon would represent a minimum $25,000 per year expense. Also, due to the configuration of the HVAC system, only nominal amounts of gas-phase pollutants would be drawn through the inline carbon system for VOC removal.

With all traditional approaches for gas, odour and VOC control ruled out, Clean Air Systems and Airtronics Environmental recommended ozone air treatment.
The system consists of four 10 grams per hour ozone generators model Casino Air CA-1000. These units being controlled by ozone sensors, very much like thermostats control furnaces or air conditioners. Eco Sensors C-30Z ozone monitors were selected, and they are programmed to shut the ozone generators off at 0.04 ppm, which is 0.01 ppm below the Food and Drug Administration's 24-hour, seven-day 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.
The benefits of using ozone were obvious from the moment the system was commissioned. Customer and employee complaints about the "smoke problem" ceased. Tobacco odours are no longer present in the entry area or in the non-smoking section. Even inside the smoking section under peak load conditions, tobacco odours are barely past the odour 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.

Figure 2
Typical HVAC Connection for Indoor Air Quality Control

The installed price of the ozone part of the two-tiered system was $22,000, roughly the same as the recommended activated carbon system. The comparative "payback" was one year, since the carbon system 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.
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.

CONCLUSIONS

Filtration will remove particulates and the small percentage of the gas-phase pollutants that have adsorbed to the surface of the dust. But particulate filters don't remove the majority of gas phase pollutants, and the high-efficiency filters required for tobacco smoke particulate have a very considerable impact on airflow.
High ventilation-rate systems, including even 100% make-up air systems with no re-circulation, will reduce particulates through dilution, but are only nominally effective at reducing VOC's and have no impact on VOC's, which adsorb to porous finish surfaces. High ventilation-rate systems also waste tremendous amounts of energy, even when energy recovery ventilators (an extremely maintenance-intensive device in a heavy smoke application) are implemented.
Carbon is effective at removing the VOC's from the air that flows through the carbon, but with a huge replenishment expense in heavy smoking environments. Carbon reduces VOC's only in the air that is returned through the HVAC system, and most commercial HVAC systems don't produce the airflow patterns, which drive the contaminated air back through the HVAC system. Carbon does nothing to remove residual odours and VOC's from finish surfaces.
Ozone reduces VOC's more effectively than carbon, has no replenishment expense, oxidizes residual VOC's 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 ductwork.
The conditioned air residence time in occupied areas is typically 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 half-life, we see that much of the ozone has reacted with VOC's.

Sometimes reducing the VOC's by ozone eliminates the need to increase the makeup air when the area population increases. This in turn eliminates the additional energy otherwise required to heat or cool the additional make-up air.

Using ozone for IAQ problem requires extreme cautions when being implemented. Installations must cover a variety and complexity of commercial ventilation systems, along with a multitude of environmental and human factors. All of these need to be considered, and the negative potential of introducing a toxic gas into any occupied space. Only experienced, knowledgeable ozone suppliers, who have done numerous large, commercial, ozone systems, should be considered.

However, when implemented correctly, ozone offers superior performance to any other method currently in use for gas, odour, and VOC control; has benefits which none of the other strategies offers; and results in lower ownership costs due to lack of replenishment expense and decreased make-up air heating and cooling requirements.

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KEY WORDS

Ozone; Air Treatment; HVAC Systems; Odour Control; Gaming and Hospitality Industries; Automatic Maintenance of Ozone Concentration; Cost Considerations and System Savings

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