

## IOA/PAG AIR TREATMENT TASK FORCE CASE STUDY DATA REPORT

### TITLE: BINGO HALL HVAC SYSTEM – Air treatment with ozone



#### 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, rest rooms, 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.

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) -- burning and itchy eyes, dry throat, headaches, nausea, etc. Furthermore, Imperials received numerous complaints

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.

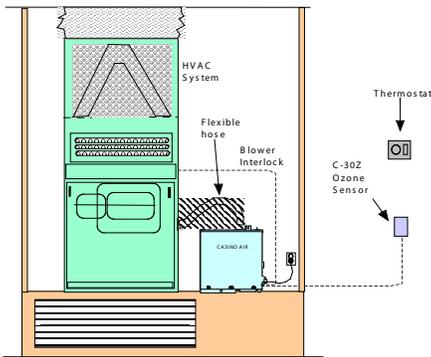
During peak load conditions, it was difficult to see from one end of the smoking area to the other. Strong tobacco odors were observed, as well as very high levels of VOCs (volatile organic compounds). Total VOC concentrations ranged from 0.8 ppm at light load conditions, to as high as 2.6 ppm during 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 (cubic feet per minute) 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, so 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. 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 ozone generators, model Casino Air CA-1000. These units being controlled by ozone sensors, very much like thermostats control furnaces or air conditioners. 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 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.

## 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 half-life, much of the ozone is lost by reacting with 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, mildew, and VOCs 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).

## 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.

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References and Articles:  
L.B. Kilham and R.M. Dodd, "Case Study of a Bingo Hall HVAC System"



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