Executive Summary

Colorimetric Real-Time Measurement of Airborne Ozone and Hydrogen Peroxide Produced by Hydroxyl Generating Air Cleaners

Odorox Environmental LLC

By:

Rod Handy, Ph.D., CIH & Cory Allen

Date:

12/21/09

Introduction

Hydroxyl generating air cleaners use multiple UV wavelength ranges that, when combined with water vapor in the air, create hydroxyls which help to eliminate bacteria, mold, mildew and odors in the indoor and outdoor air. During the air cleaning process, it is thought that certain oxidants such as ozone and hydrogen peroxide may be produced at concentrations that may need to be quantified. This is due to the health and safety issues associated with breathing such airborne contaminants in potentially significant concentrations.

HGI Industries, Inc. produces and distributes several of these types of units under the Odorox brand name for both industrial as well as light-duty usage. Specific models within the Odorox line include the Slimline, Oasis, and Boss. While each of these units basically operate upon the same premise and technology, there are differences that exist. The purpose of this paper is to elucidate the results from a series of test runs aimed at characterizing several different types of hydroxyl generating air cleaners for two common airborne oxidants – ozone and hydrogen peroxide.

Methods

The testing was conducted on 12/14/09 and 12/15/09 in two different rooms within the same complex of the Purdue campus. There were five different units tested during the event: Slimline, Boss XL3 w/fan, Oasis, Boss (basic), and MDU. Each of these units were run for a total of 2 hours, with samples being taken for ozone at both the one-hour and two-hour time intervals. Hydrogen peroxide was only measured at the end of the 2-hour duration in each of the test runs. One of the rooms (aka Rm 1) was 20' X 20.5' with a 9' drop ceiling (V = 3690 ft^3) while the other (aka Rm 2) was 44' X 15.5' with a 14' rafter ceiling (V = 9548 ft^3).

The ozone and hydrogen peroxide concentrations were measured with a Draeger CMS direct-reading instrument and appropriate detector chip. This instrument is capable of taking measurements of ozone at a sensitivity of 25 parts per billion (ppb) and hydrogen peroxide at a sensitivity of 0.2 parts per million (ppm). In addition to the two oxidant concentrations, temperature, relative humidity, and average air velocity between the CMS and hydroxyl generator were measured and recorded with a VelociCalc. Also, a qualitative observation was made during each test run for the presence of ozone, based upon odor detected by smell. While the odor threshold varies from person-to-person, a good approximation of this value is between 5 and 10 ppb.

The CMS was used to measure the concentrations approximately in the breathing zone of an adult human. The hydroxyl unit was placed approximately 5' from the CMS and at ground level. Due to the sampling time required for the CMS, each test ran just a little over 2 hours in duration. Approximately 5 minutes was allocated between each unit changeover in order to allow for the room(s) to "air out" between the test runs.

Data and Results

Table I provides the results from the test runs. The table shows the concentrations measured for both hydrogen peroxide and ozone for all of the units tested. However, due to a chip error, ozone was not sampled in Rm 2 (i.e., larger room) for the MDU unit or at the end of the 2^{nd} hour for the Boss (basic) unit. Table I also indicates the relative presence of ozone concentrations based on the ability of the sampler to smell the familiar odor and at what intensity (e.g., strong, moderate, faint, etc.). The temperature ranged from 69.3 – 71.2 degrees F in Rm 1 while the range was from 60.4 – 63.6 degrees F in Rm 2. The relative humidity for the test runs ranged from approximately 30% - 45% over the course of the two testing days while average velocity between the units and the CMS averaged approximately 25 ft/min.

Table 1

Concentrations of Ozone (O_3) & Hydrogen Peroxide (H_2O_2) During Test Runs

Unit/Location	H_2O_2 ppm @ 1 hour	H_2O_2 ppm @ 2 hours	O_3 ppb @ 1 hour	O_3 ppb @ 2 hours	O_3-like odor present?
Slimline/Rm 1	<0.2 ppm	<0.2 ppm	<25 ppb	<25 ppb	No
Slimline/Rm 2	<0.2 ppm	<0.2 ppm	<25 ppb	<25 ppb	No
Boss XL3 with fan/Rm 1	<0.2 ppm	<0.2 ppm	<25 ppb	<25 ppb	Yes
Boss XL3 with fan/Rm 2	<0.2 ppm	<0.2 ppm	<25 ppb	<25 ppb	Yes
Oasis/Rm 1	<0.2 ppm	<0.2 ppm	<25 ppb	<25 ppb	Yes (faint)
Oasis/Rm 2	<0.2 ppm	<0.2 ppm	<25 ppb	<25 ppb	Yes (faint)
Boss (basic)/ Rm 1	<0.2 ppm	<0.2 ppm	40 ppb	39 ppb	Yes (strong)
Boss (basic)/ Rm 2	<0.2 ppm	<0.2 ppm	45 ppb	Chip error	Yes (strong)
MDU/Rm 1	<0.2 ppm	<0.2 ppm	<25 ppb	<25 ppb	Yes (faint)
MDU/Rm 2	<0.2 ppm	<0.2 ppm	N/A	N/A	Yes (faint)

The only unit that tested above the detection limit of 25 ppb for ozone was the Boss (basic) unit. The three values taken for this unit ranged from 39 ppb to 45 ppb. None of the concentration measurements for hydrogen peroxide resulted in values over the 0.2 ppm sensitivity of the detector chip. Samples were taken at both the one-hour and two-hour time intervals to compare the units on potential contaminant build-up, elimination, or steady state conditions. From the Boss (basic) data, inference can be made that the ozone levels reach their steady state level at or before one-hour in operation and hold approximately steady thenceforth.

Another concern is that at least some of the measured value for ozone concentrations is from a 'false positive' condition as the result of interferences from other oxidants produced in the air by the process. This is certainly a possibility. One of the limitations of the colorimetric technique is the possibility of other contaminants causing "interference" in the measurement process, and thus, an inaccuracy (or bias) in the data collected.

While the results from this test must not be used for OSHA employee exposure compliance, a comparison with the OSHA permissible exposure limit (PEL) for ozone and the data collected during the sampling event provides some interesting insight on the issue. The OSHA PEL for ozone happens to currently be 100 ppb for 8-hour workplace exposures. The highest value measured during the test runs was 45 ppb. This is less than one-half of the mandated workplace exposure limit to the contaminant and was only measured for one of the test units - the Boss (basic) model; all of the other units were less than 25 ppb or less than one-fourth of the workplace PEL.

Conclusions

The results from a series of test runs used to measure potential concentrations of ozone and other oxidants during the operation of hydroxyl generating air cleaners were presented. While the majority of the units did not produce quantifiable levels of ozone or hydrogen peroxide, it was evident that most of the units did produce ozone levels above the human odor threshold. Only one unit, the Boss (basic), produced measurable levels above the 25 ppb detection limit of the technique while no measurable levels of hydrogen peroxide were detected in any of the runs.

While not definitive, it is likely that the Slimline unit is producing ozone concentrations from 0 - 5 ppb, the Oasis and MDU units from 10 – 15 ppb, and the Boss units from 25-45 ppb. On a related note, it is expected that the Boss XL3 w/ fan unit was dispersing the higher oxidant concentrations due to the turbulent flow produced by the fan required during its operation.

The testing for the presence of ozone and hydrogen peroxide in this project does not provide for any judgments or conclusions to the overall safety and effectiveness of the equipment. Determining the overall safety of the product was beyond the scope of this project.

References

1. www.draeger.com, retrieved 12/16/09.
2. www.hgiind.com, retrieved 12/16/09.
3. www.osha.gov, retrieved 12/17/09.
4. www.tsi.com, retrieved 12/17/09.