A Laboratory Method For Measuring The Ozone Emission From In-duct Air Cleaners.

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1 Introduction

Indoor sources of ozone can lead to serious health effects through both direct exposures to ozone itself and to ozone byproducts. Currently there are standards and regulations that limit ozone emissions from portable indoor air cleaning devices. (e.g., Underwriters Laboratory 867, California Code of Regulations Title 17 Subchapter 8.7). However, in-duct air cleaners including electronic air cleaners, electrostatic precipitators, ozone generators and several other technologies, which can emit much more ozone than portable air cleaners (i.e., Viner et al., 1992), are generally exempt from standards and regulations because no suitable test methods for ozone emission currently exist. The purpose of this paper is to describe a test method for measuring ozone emissions from in-duct air cleaners. This method will be developed under a range of conditions including flow rate, humidity, temperature, dust loading and ozone removal. The result will be an emission rate methodology that is applicable to any electrically-connected in-duct air cleaner.

2 Proposed Methodology

The apparatus used for testing is shown in Figure 1. The air in the test duct, powered by two variable speed fans, travels through HEPA and activated carbon filters before passing through the test section containing the air cleaner. Ozone concentrations are measured both upstream and downstream of the air cleaner and multiplied by the airflow rate to determine the ozone emission rate of the air cleaner:

$$E=(C_{out}-C_{in})Q \qquad (1)$$

where

E ozone emission rate (μg/hr)
C_{out} downstream ozone concentration (μg/m^3)
C_{in} upstream ozone concentration (μg/m^3)
Q volumetric flow rate (m^3/hr)

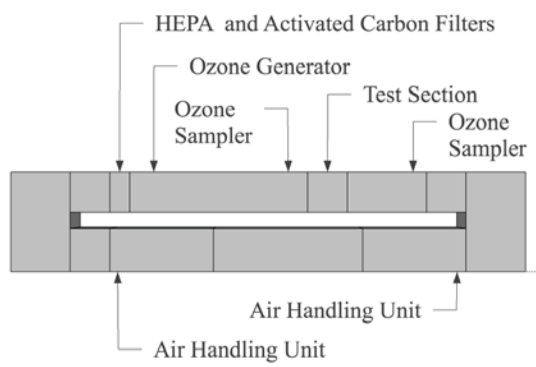

Figure 1. Apparatus

Uncertainty in the emission rate can be assessed by propagating the instrument uncertainty for all of the terms on the right side of Eqn 1.

Despite the simplicity of the approach, there are several limitations with actually using it to test many air cleaners. These issues include dilution of the emitted ozone to concentrations near the detection limit of typical ozone analyzers, ozone reactions with the air cleaners or deposited material, and sensitivity of ozone emissions to other parameters. Each of these concerns, and strategies for addressing them, are discussed below.

At large flow rates that are typical of HVAC systems, the ozone concentration rise can be much smaller than the measurement uncertainty of an ozone analyzer. Viner et al. (1992) studied commercial in-duct electrostatic precipitators and observed ozone emission rates ranging from 20-30 mg/h. At typical maximum air flow rates for large residential air conditioning system, 3330 m^3/h, the ozone concentration will only rise approximately 4 ppb. Good ozone monitors have an accuracy of ±1 ppb, at best, and thus there is a great level of uncertainty in reading such a small ozone concentration rise. This is especially true for air cleaners that emit even less ozone.

To address this limitation, variable speed fans are used to decrease the flow and increase the concentration difference to a much larger value. Successive tests at lower flow rates produce larger concentration changes, and the relationship between emission rate and flow rate can be used to extrapolate to the emission rate at the manufacturers recommended flow. To minimize uncertainty associated with extrapolation, we will only decrease flow enough to see a measurable ozone concentration rise across the air cleaner. We anticipate that emission rate will be independent of flow rate, but this can easily be confirmed.

For some air cleaners, ozone may react with air cleaner surfaces and thus serve to artificially lower the measured emission rate and produce reaction byproducts. To address this, a set of tests will be conducted with air cleaner turned off and a known emission of ozone will be generated by a secondary ozone generator upstream of the air cleaner to achieve the same downstream ozone concentration as was measured with the air cleaner turned on. The ozone loss rate through the air cleaner will be added to the emission rate to get a corrected emission rate. We anticipate that this correction will generally be small, except for a device that has an activated carbon filter, ozone catalyst or other ozone removal device. This correction will also generally be a function of air flow rate which may necessitate reporting the ozone emission rate at a standard air flow rate, similar to what is done for filter efficiency testing.

Other parameters that could cause challenges include relative humidity, temperature and dust loading of the air cleaner. One investigation observed that ozone emission rates from electrostatic air cleaners decreased by about 30% as relative humidity increased from 30% to 70% (Mason et al., 2000). Ozone emissions were also found to increase with temperature increase, although there was a much smaller effect (Liu et al. 2000). A much stronger effect on ozone production was found due to dust accumulation. The impact of soiling on ozone generation was found as a function of amount and composition of soiling particles, as well as how the corona voltage is regulated (Huang and Chen, 2001).

To address these concerns a series of parametric tests will be conducted on the air cleaners. Tests at high (70-80%) and low (20-30%) relative humidity, at high (50ºC) and low (10ºC) temperatures, and when the air cleaner has been naturally loaded and artificially loaded with test dust will be run. These parameters were selected to cover the range of conditions likely to be encountered in a typical home.

3 Conclusions and Outcomes

The proposed methodology produces an ozone emission rate for in-duct air cleaners that is widely applicable and can be used in risk assessments and indoor modelling. Application of this methodology will provide a suitable test method for measuring ozone emission, which is applicable to any electrically-connected in-duct air cleaner.

4 References

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