Changes in IAQ Caused By Corona Discharge Air Cleaner

In the December 2018 column "Changes in IAQ Caused By Corona Discharge Air Cleaner," an in situ test done in a high school classroom formed the basis for the column. On reviewing this column, AtmosAir saw several inconsistencies and data presented in such a way that could bias the reader into an uninformed conclusion. This letter is written to help readers of this column better understand those inconsistencies and better educate the reader.

The column concludes that operation of the corona discharge air cleaner degraded air quality as there were increased levels of ozone, aldehydes and ultra-fine particles on days when the air cleaner was in operation. In the testing described, lemon essence, containing d-limonene, was evaporated into the subject classroom during the four separate phases of tests, as described in the column. It is well known that limonene when introduced to an environment with any ozone level, regardless of the source of the ozone, will precipitate an increase to aldehydes and ultra-fine particles. Many studies have concluded this (Weschler, C. J., and Shields, H. C. 1999. "Indoor Ozone/Terpene Reactions as a Source of Indoor Particles." *Atmos. Environ.* 33(15):2301–2312). The column would seem to suggest that the corona discharge air cleaner operation was solely responsible for these increases, but in fact ambient ozone levels in the classroom, which cannot be definitively traced to solely the operation of the air cleaner, were a causal link to any levels of aldehydes and ultra-fine particles measured.

Also as we well know, ozone is a natural element of air and can be found in varying levels in both outdoor and indoor air. Indoor ozone levels have been found to track to outdoor ozone levels closely (Weschler, C.J. 2001. "Ozone in Indoor Environments: Concentration and Chemistry." *Indoor Air* 10(4):269–288). The measured increases in indoor ozone the test cites had no corresponding outdoor ozone measurements taken, so the increase in any indoor ozone level cannot be definitively traced to solely an indoor source or the corona discharge air cleaner.

Average outdoor ozone levels for the upstate New York region in 2013 averaged 64 ppb (New York State Department of Environmental Conservation). The testing cites indoor levels ranging from 16.3 ppb to 34.8 ppb. Since ambient indoor ozone levels can be 10% to 50% of outdoor levels (*Estimating Mortality Risk Reduction and Economic Benefit From Controlling Ozone Air Pollution*. 2008. The National Academies Press, Washington D.C.), it stands to reason indoor levels in the ranges measured could be attributed to the concentrations found outdoors.

The column makes reference to various measured levels of contaminants sampled in the space. However, the column does not reference what the acceptable exposure limits are for the various compounds measured. See *Table 1* for a comparison.

TABLE 1 Comparison of contaminant levels.

CONTAMINANT	HIGH MEASURED VALUE	STANDARD	OTHER GUIDELINE
Ozone	34.8 ppb	100 ppb (NIOSH)	50 ppb (CARB)
Formaldehyde	3.74 ppb	16 ppb (NIOSH)	27 ppb (USGBC)
Acetaldehyde	1.71 ppb	200,000 ppb (OSHA)	25,000 ppb (ACGIH)
Propionaldehyde	.44 ppb	N/A	20,000 ppb (ACGIH)
Butyraldehyde	.31 ppb	N/A	N/A
Valeraldehyde	.27 ppb	N/A	N/A
Hexaldehyde	.37 ppb	N/A	N/A
Acetone	8.22 ppb	250,000 ppb (NIOSH)	250,000 ppb (ACGIH)

NIOSH = National Institute for Occupational Safety and Health
OSHA = Occupational Safety and Health Administration
USGBC = United States Green Building Council
ACGIH = American Conference of Governmental Industrial Hygienists
CARB = California Air Resources Board

As you can see the contaminant levels measured were significantly lower than any published standard or guideline, and some contaminants were so obscure that no published permissible exposure limits could be found. These levels do not show that bad air quality was found in the tested space in any of the test conditions.

The same can be attributed to the measurements of ultra-fine particles. Since no baseline was established nor outdoor levels measured, they cannot be definitively traced to an indoor source or the corona discharge air cleaner. Ultra-fine particles lack any indoor standards or guidelines or permissible exposure limits, so a comparison table cannot be provided.

The column also implies that the findings of this test were a factor in the New York State Education Department determining corona discharge air cleaner systems cannot be used to apply the 403.2 exception, which allows for reduction of outside air from standard ventilation rates. The fact is prior to and subsequent to this testing; the 403.2 exception has not been allowed in New York State Education Department.

Corona discharge is just one form of an ionization process and one type of an electronic air cleaner. There are many types of these technologies, and they have been used in literally 10,000-plus applications in schools across the U.S. over the past 20 where the 403.2 exception was applied. No IAQ issues have ever been reported from any of these applications, and these schools have benefitted from lower HVAC equipment and conditioning costs plus good IAQ in those treated spaces. Many studies with findings of improved IAQ using electronic air cleaning products have been done.

It is our position that the testing the column was based on was poorly constructed. It lacked an adequate baseline and an outdoor air comparison. The column then makes statements based on this flawed test. This column would leave the reader with more questions than answers.

Anthony M. Abate, Member ASHRAE, Fairfield, Conn.

The Authors Respond

Thank you for asking New York State Department of Health (Department) to respond to the most recent letter regarding our column in the December 2018 issue of *ASHRAE Journal*.

The Department determined that increases in concentrations of aldehydes and ultra-fine particles resulted from operating the corona discharge air cleaner in the classroom by comparing the concentrations during periods when the corona discharge was turned on to periods when it was turned off. The data, summarized in Table 1 and Figure 2 in the column, show that the concentrations of aldehydes and ultra-fine particles were consistently higher when the corona discharge was operating.

Data collected by the New York State Department of Environmental Conservation (data available upon request) shows hourly, average ozone concentrations ranged from 21 to 38 parts per billion (ppb) at the outdoor ozone monitor nearest the school during the study period, Feb. 18– 22, 2013, considerably lower than the 64 ppb concentration cited in the letter. In fact, that value was the fourth highest eight-hour average ozone concentration in 2013 and was recorded on May 2, 2013, during the ozone season.

As shown in Figure 1 of the column, the indoor ozone concentrations fluctuated between 2 and 25 ppb when the corona discharge was turned off and 25 to 40 ppb when it was turned on. The observed changes in indoor ozone were clearly associated with operating the corona discharge air cleaner.

The measurements were made in an unoccupied classroom during the school winter vacation, and the normal ventilation cycles were modified to maintain uniform outdoor air supply rates during the study. There were no interferences from changes in room or building occupancy, outside traffic patterns or from cleaning or maintenance activities in the classroom during the study.

The study was designed to evaluate changes in the indoor air quality of a classroom while operating a corona discharge air cleaner with a reduced fresh air flow rate provided by the ventilation system. The Department found that the concentrations of ozone, ultra-fine particles and aldehydes increased under these conditions. The study was not designed to determine the health effects of these air pollutants, but instead was intended to test the claims that the amount of fresh air brought into a classroom can be reduced without adverse impacts on air quality. Since corona discharge air cleaners are marketed as potentially beneficial to health, it is appropriate to investigate those claims.

Todd Crawford, Patricia Fritz, Member ASHRAE, and Thomas Wainman, New York State Department of Health, Albany, N.Y.

Editor's Note: The authors' response to a June 2019 letter regarding this column can be found at www.ashrae.org/June2019Letters.

Improving the Performance of Steam Turbine Chiller Plants

"Saving Energy: Improving the Performance of Steam Turbine Chiller Plants" by Charles G. Copeland in August 2019 highlights the importance of combined heat and power-based steam power plants, which could provide an economical electrical energy source as well as thermal energy for cooling/heating for an overall efficient solution.

There are two factors which further need the author's attention and comments:

1. Fuel Options. The advantages of a steam system-based energy solution should be highlighted in terms

of fuel options, especially because oil and natural gas are becoming more expensive in developing countries, increasing costs of operating such plants substantially. Biomass options should be highlighted, as in Pakistan and other agro-based economies a large number of high-pressure steam boilers are fired by biomass (mostly bagasse, sugarcane waste) in combined heat and power mode, providing both economical process steam and electrical energy, some even exporting to the national grid and making good money.

2. Solar Option. There is a big opportunity for concentrated solar power (CSP)-based thermal energy to supplement boiler feed water heating, which could considerably reduce boiler fuel costs. I am not aware of any industrial or large commercial installation of this option, but technically this is feasible if roof or open space allows this.

Mr. Copeland's comments could clear the above options for possible implementation.

Ainul Abedin, P.E., Fellow ASHRAE, Karachi, Pakistan

The Author Responds

Comments as follows:

1. Biomass is certainly an option as the primary form of heating for boilers where oil and gas in parts of the world are becoming more expensive.

2. I'm not familiar with concentrated solar power (CSP) to produce heat; usually solar panels these days produce electricity. In the 1970s we worked on an early thermal solar collector on New York's lower east side to heat domestic hot water. The building later installed a windmill on the roof, which produced electricity, exporting some of it to the grid. When the local utility objected, the former attorney general Ramsey Clark defended it with the Public Service Commission, which gave rise to the Public Utilities Regulation Policies Act, which recently celebrated its 40th anniversary. This permits the export of electricity from localized generation such as cogeneration along with proper safeguards to be exported into the grid.

Charles C Copeland, P.E., Fellow/Life Member ASHRAE, New York, N.Y.

Desiccant Dehumidification Process for Energy Efficient AC

The August 2019 article "Desiccant Dehumidification Process For Energy Efficient Air Conditioning" details a first-generation device consisting of a desiccant belt, aimed at reducing energy consumption for HVAC. Though the article is well-written and well-presented, it represents a substantial "step backward" in desiccant technology, using a methodology of a poorly sealed desiccant laden belt, and insufficient desiccant mass for the application.

In comparison, multiple manufacturers use a similar, though patented and proven, approach in this very same application—minimizing HVAC energy consumption using desiccant technology. I am baffled as to why *ASHRAE Journal* would publish an article on an unproven, "step backward," single example of a technology which is already sold commercially and is already saving energy cost in use.

I request that *ASHRAE Journal* clarify for its readers that the method presented in the article is a single example experimental device, and that there are multiple equipment offerings incorporating desiccant technology that are currently used to reduce HVAC energy consumption.

Spencer Goland, Baton Rouge, La.

The Authors Respond

Thank you to Mr. Goland for the interest taken in our article. We fully acknowledge that desiccant is widely used and effective in commercially packaged and well-proven desiccant systems, such as the desiccant wheel discussed in the article. The belt design from our article is absolutely a first-generation experimental model. That being said, we saw design benefits in the belt that are not present in other commercially available desiccant technologies, including the use of low-cost silica beads and operation at low regeneration temperatures.

Our article illustrated a limited example including application of a relatively small system (i.e., not much desiccant) to a building with low outdoor airflow located in a climate with comparatively low humidity, and yet potential for energy savings was still observed.

Using a commercial product with optimized design and size, being in high humidity climate, and/or requiring a higher amount of outdoor air would greatly increase the potential of the desiccant technology for energy saving. We recommend that anyone interested in reducing system latent loads contact a local commercial HVAC supplier or representative to see all the options and have them assist in the selection.

Tom B. Cremonte, Associate Member ASHRAE, Troy, Mich., and Jonathan Maisonneuve, Ph.D., Auburn Hills, Mich.