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UL Remote Air Quality Monitoring

CEC is pleased to receive copy of UL testing of the in cab air quality of Sterilyft in comparison side by side to a standard exhaust fan ventilated elevator during a one month trial period utilizing two actively used passenger elevators in an occupied building.

CEC is very thankful for the cooperation and coordination of this test in conjunction with an installation performed by ELCON Enterprises, Inc in Virginia.

For the test results below, Car 12 represents passenger elevator with Sterilyft and car 13 represents passenger elevator with only typical type exhaust fan.

Following is our takeaway of the attached UL results:

PARTICULATE MATTER (PM10) – Particles less than 10 microns

UL REL = 50 ug/m3 [World Health Organization (WHO) respirable particles (24-Hour mean)]

Car 13 = 13.1 ug/m3 avg
Car 12 = 0.59 ug/m3 avg

Sterilyft represents 95.5% less contamination than exhaust fan only. It should be noted that viral carriers (sneeze, cough or expelled particulate) falls within about 75% approximately 10 microns and less than 25% 1-5 microns.

PARTICULATE MATTER (PM2.5) – Particles less than .5 microns

UL REL = 35 ug/m3 [EPA (NAAQS) (24-Hour mean)]

Car 13 = 12.6 ug/m3 avg
Car 12 = 0.53 ug/m3 avg

Sterilyft represents 95.79% less contamination than exhaust fan only. It should be noted that viral carriers (sneeze, cough or expelled particulate) falls within about 75% approximately 10 microns and less than 25% 1-5 microns.

PARTICULATE MATTER (PM1) – Particles less than 1 micron

Car 13 = 9.86 ug/m3 avg
Car 12 = 0.25 ug/m3 avg

Sterilyft represents 97.46% less contamination than exhaust fan only. It should be noted that bacteria measures approximately .4 microns and virus range from .02 to .25 microns. Corona virus in particular is approximately .125 microns

CEC ELEVATOR CAB CORP.

PARTICULATE MATTER (PM>0.3) – Particles less than .3 microns

Car 13 = 2197 particles avg
Car 12 = 237 particles avg

Sterilyft represents 89.21% less contamination than exhaust fan only. It should be noted that bacteria measures approximately .4 microns and virus range from .02 to .25 microns. Corona virus in particular is approximately .125 microns

VOLTILE ORGANIC COMPOUNDS (VOC)

UL REL = 500 ug/m3 (300 ppb) [US Green Building Council]

Car 13 = 422 ug/m3 avg
Car 12 = 284 ug/m3 avg

Sterilyft represents 32.7% less contamination than exhaust fan only. As car 13 is at the threshold for Green Building standards, car 12 is at slightly over half of the standard.

SIGNIFICANCE

As we are all reminded by CDC, WHO and NIH, the spread of Corona virus (as well as many other infectious contagion, is transmitted via viral carriers be it sneezing, coughing or other expelled droplet particles from human to human. This being said, it is abundantly clear that by the reductions of these particles in excess of 95% as in the case of a typical elevator will substantially reduce the exposure of passengers in the elevator to these transmission vehicles. In addition, as to free floating bacterial or viral pathogens, the further reduction of particles in the sub micron area clearly shows further risk mitigation of bacterial or viral transmission by the reasonable result in reduction of particles less than 0.3 microns by over 89%.

Further efficacy testing will be conducted on bacterial and viral inactivation however, with UV-C 254nm irradiation trials widely tested and accepted, the added result of the efficacies in the area of 99.97% success is substantial be it as the carriers of infectious particulates and infectious particulates themselves are removed from the passenger cab enclosure in excess of 89-97% as determined above.

ATTACHED: UL remote air quality monitoring test results dated 8/20/20, data collection from 7/20/20 through 8/20/20. Building and building owner name has been redacted for privacy.

UL
3251 Old Lee Hwy #100
Fairfax, VA 22030
o: (703) 323-4400
f: (703) 323-4440

August 20, 2020

[redacted]

Dear [redacted]:

Remote Air Quality Monitoring
[redacted]

As requested by [redacted], UL is conducting screening level air quality monitoring in the above listed address in McLean, Virginia. Remote air quality monitoring units were installed July 20, 2020 through August 20, 2020. This interim letter style report records our measurements, conclusions and recommendations.

Screening Locations

Monitoring was conducted in the following areas:

- Elevator 12 Cab
- Elevator 13 Cab (control)

Description

Monitoring in Elevator 12 and 13 Cab was conducted as part of a comparative study performed over a month to determine the effectiveness of an air purifier system installed within the cab. The CEC cab sanitizing unit was installed in Elevator 12 Cab. The Elevator 13 Cab served as the control location with no system installed for comparison. The CEC system is equipped with a dual pleated HEPA filter, UVC germicidal lamp, and 4.5-watt UVC germicidal fluorescent lamp.

Monitoring Hardware Specifications

The Senseware IAQ Indoor Air Package Modules remote monitors were deployed with the following sensors: Temperature, Particulate Matter less than 2.5 microns ($PM_{2.5}$), Particulate Matter less than 10 microns (PM_{10}), Carbon Monoxide (CO), Carbon Dioxide (Calculated Equivalency), Volatiles Organic Compounds (VOCs), Nitrogen Dioxide (NO_2) and Noise.

Sensor	Resolution	Measurement Range	Accuracy
Nitrogen dioxide (NO_2)	20 ppb	0 to 5 ppm	+/-15%
Particulate Matter ≤2.5 microns ($PM_{2.5}$)	1 µg/m^3	0-500 µg/m^3	N/A
Particulate Matter ≤10 microns (PM_{10})	1 µg/m^3	0-500 µg/m^3	N/A
Volatile Organic Compounds (VOCs)	1 ppb (0-2008) 6 ppb (2008-11110)	0 to 60000 ppb	N/A

	32 ppb (11110 -60000)		
Temperature (degrees Fahrenheit [°F])	0.1 °F	-40 to 257 °F	0.5 °F

Recommended Standards

In this report, UL has included various standards, threshold limit values, time weighted averages, or other recommended acceptable standards for various indoor air pollutants based on the findings and publications of several U.S. government agencies, independent industrial hygiene organizations, and other bodies. Furthermore, based on our professional opinion, we have selected the most appropriate guidelines in interpreting the data gathered during this screening. If further information is required in appreciating the guidelines used by UL, please feel free to request such information.

UL has selected the standards listed in Table below to be used as comparative levels for the air quality screening. The standards below reflect the most stringent standard available where more than one exists. It should be noted that standards from the ACGIH reflect personal exposure levels which cannot be derived from the screening data in the tables below.

Table Key	Name	Recommended Exposure Limit (REL)	Regulatory Agency
CO	Carbon Dioxide	9 ppm	ASHRAE Std 62.1-2016 Selected EPA NAAQS
CO_2 Equivalency	Carbon Dioxide	Outdoors plus 700	ASHRAE Std 62.1-2016
NO_2	Nitrogen dioxide	200 ppb	ACGIH TLV (8-hour TWA)
$PM_{2.5}$	Particulate Matter 2.5 microns	35 µg/m^3 (24 hours)	EPA (NAAQS) (24-hr mean)
PM_{10}	Particulate Matter 10 microns	50 µg/m^3	World Health Organization (WHO) (PM_{10}) respirable particles (24-hr mean)
VOC	Volatile Organic Compounds	500 ug/m^3 (300 ppb)	US Green Building Council *See additional information regarding this standard in Attachment B
Temperature	Temperature	Summer: 73-79°F Winter: 68-75°F	ASHRAE Std 62.1-2016
Humidity	Humidity	Summer: 30-65% Winter: 20-65%	ASHRAE Std 62.1-2016

Results and Conclusions

UL conducted continuous air monitoring from July 20, 2020 through August 20, 2020 in the Elevator 12 Cab and Elevator 13 Cab.

Please note the following findings:

- The data collected indicate that the indoor air quality in the monitored locations are within the selected recommended regulatory air quality standards. Measurements were collected for dusts (PM_{10} and $PM_{2.5}$), VOCs, and carbon dioxide. While fluctuations were observed, no sustained exceedances in contaminant levels were identified. VOC levels were briefly elevated likely due to cleaning and sanitizing products used during the scheduled times of janitorial operations in the building.

- Temperature and relative humidity were within the ASHRAE thermal comfort envelope during normal office hours.

See details in graphical form in Attachment C for each constituent.

For UL,

Kristen Rogers

Kristen Rogers
Senior Client Services Specialist
Environment and Sustainability
UL

Attachments:

Glossary of Technical Terms
Attachment A. Senseware Module Technical Information
Attachment B. Description of Recommended Volatile Organic Compound (VOC) Concentrations
Attachment C. Monitoring Data Results Graphs

Glossary of Technical Terms	
ASHRAE Std 62.1-2016	American Society of Heating, Refrigerating and Air Conditioning Engineers standard – Ventilation for Acceptable Indoor Air Quality. Standard selected from Table C-1 of the standard, which is based upon the EPA NAAQS for Carbon Monoxide (not to be exceeded more than once per year).
ACGIH TLV (8-hour TWA)	American Conference of Industrial Hygienist – Threshold Limit Value, Time-Weighted Average – average exposure limit based upon a 8 hour work day
EPA (NAAQS) (24-hr mean)	Environmental Protection Agency, National Ambient Air Quality Standard, 24 hour averaging time.
Carbon dioxide (CO_2)	A byproduct of respiration and normal constituent of the atmosphere. Measurement of carbon dioxide can provide an indication of ventilation rates in a building and/or a threshold of comfort
Carbon monoxide (CO)	A toxic byproduct of fuel combustion. While odorless, carbon monoxide gas is often accompanied by other odorous combustion products (aldehydes, oxides of nitrogen, etc.)
Counts per cubic meter of air (count/m^3)	A calculated unit of measurement for quantifying airborne mold spores per unit volume of air
Formaldehyde (HCHO)	A pungent, organic compound associated with certain new furnishings, glues, pressed woods, vehicle exhaust and tobacco smoke. Reacts in the atmosphere to become a component of smog
Hydrogen Sulfide (H_2S)	Or sewer gas. A toxic and flammable gas associated with rotten egg odor from the bacterial breakdown or organic matter. Detectable by the human sense of smell at extremely low concentration.
Micrograms per cubic meter (µg/m^3)	A unit of concentration common to particles and gases which describes the weight or mass of the contaminant per unit volume of air. A microgram is 1/1,000,000th of a gram.
Micrometer (µm)	A common unit of measurement for microscopic particles. Unit of measure that is 1/1,000,000th the length of a meter
Nitrogen Dioxide (NO_2)	A toxic and pungent gas common to internal combustion engines and power plants. Reaction products include ozone.
Relative humidity	The amount of water vapor that exists in a gaseous mixture of air and water relative to temperature. Measured in %.
Respirable Suspended Particulate	A classification of dust which describes a particle size range averaging less than 10 micrometers (µm) in diameter. Excessive particles in the respirable range are more likely to be implicated in respiratory distress
Sulfur Dioxide (SO_2)	A toxic gas associated common to coal burning, power plants, and the incomplete combustion of lower grade fuels.
Temperature	A physical property of air describing heat or cold measured in degrees Fahrenheit
Total Volatile Organic Compounds (TVOCs)	An aggregate measure of volatile organic compounds in air expressed in ppm or µg/m^3.
Ultrafine Particles	A classification of airborne particles with diameters in the range of 0.02 – 1.0 micrometers characterized by their ability to reach the gas exchange regions of the lung; under considerable investigation as a trigger for respiratory distress
Volatile Organic Compounds	Classes of organic chemical compounds (containing carbon) with high enough vapor pressures to exist as gases under normal temperature and pressure conditions. Odors common to fuels, paints, new furnishings, etc.

ATTACHMENT A

Senseware Module Technical Information

IAQ Sensor Package - T/RH, VOC, PM, CO_2, and more, all in one place

Written by Nathan Sacks:

Senseware's Indoor Air Quality (IAQ) Sensor Package makes it easy to monitor a variety of environmental conditions. The sensor can provide the following sensor data depending on your ordered configuration: Temperature, Relative Humidity, Total Volatile Organic Compounds (TVOC), Particulate Matter ($PM_{1.0}$, $PM_{2.5}$, PM_{10}, and total number of counted particle sizes), CO_2, and additional gases.

Installation:

Plug the IAQ Sensor Package into a wall outlet using the provided wall power adapter. The CO_2 and VOC sensors automatically calibrate and will reach full operational accuracy within 24-48 hours, although readings will be available before this time.

ATTACHMENT B

Description of Recommended Volatile Organic Compound (VOC) Concentrations

Volatile Organic Compounds (VOCs) – Background Information

Organic chemicals that may be emitted as gases or "volatilize" at room temperatures are described as volatile organic compounds. These compounds are released by "off-gassing" from diverse sources, such as occupants, pests, manufactured building products, furnishings, paints, cleaners, etc. In commercial buildings, it is not uncommon to find VOC levels two to ten times higher than outdoor levels since there are multiple sources in buildings. However, they are normally present in very dilute concentrations in the air, usually measurable in parts per billion (ppb) or micrograms per cubic meter of air (ug/m3). In assessing these compounds there are three factors of concern: odors, irritation and potential health effects to toxic effects. No federal agency has set permissible exposure levels for mixtures of these compounds in the indoor air. The Molhave Dose Response scale is generally accepted as a guideline for interpreting TVOC exposure in commercial environments. Molhave developed a classification of four grades of TVOC concentrations and Healthy Buildings has adopted that classification with the slight modification that extends the "comfort range" for TVOCs from undetectable to 500 μg/m3 (300 ppb). This reflects the standard adopted by the US Green Building Council in their Leadership in Energy and Environmental Design (LEED™) rating system for "Green," or "environmentally friendly" buildings. This was in turn based on the standard adopted by the State of Washington and is still the most stringent standard for TVOCs in the United States.

Tentative Dose Response to TVOCs			
Grade	**Airborne TVOC* concentration ($\mu g/m^3$)**	**Symptoms**	**Effects**
A	<500 (<300 ppb)	No irritation or discomfort expected	The comfort range
B	500-3,000 (300 – 1,800 ppb)	Irritation and discomfort possible if other exposures interact	The multi-factorial exposure range
C	3,000-25,000 (1,800 – 15,000 ppb)	Exposure effect and probable headache possible if other exposures interact	The discomfort range
D	>25,000 (25,000 ppb)	Additional neurotoxic effects other than headache may occur	The toxic range

*Via photoionization measurement, equivalent to isobutylene.

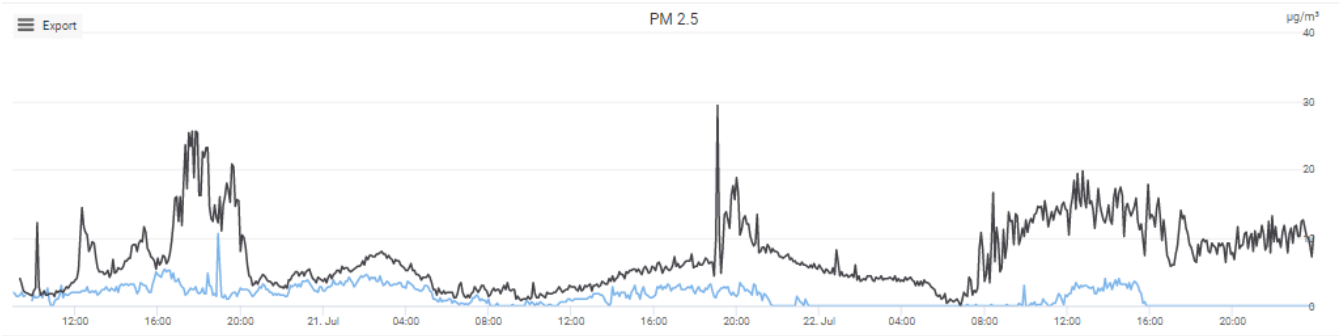
ATTACHMENT C

Monitoring Data Results Graphs

Blue: Elevator 12

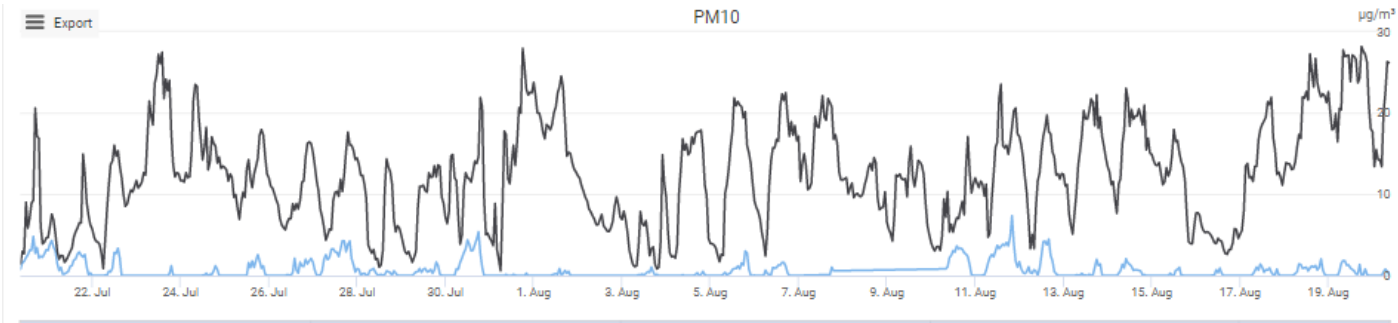
Black = Elevator 13

Particulate Matter ($PM_{2.5}$)



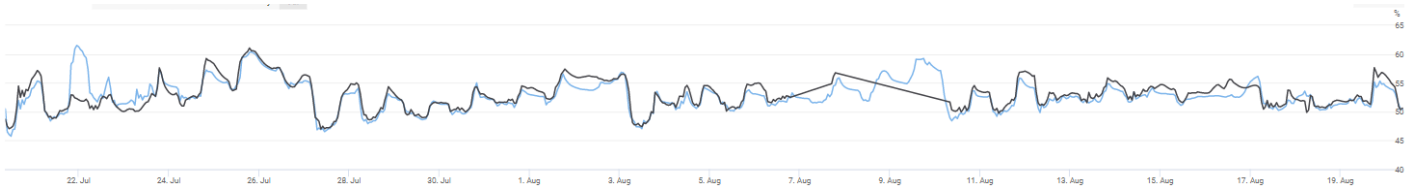
$PM_{2.5}$ levels were noted to average higher in Elevator 13. All peaks fell below 30 µg/m^3.

Particulate Matter (PM_{10})



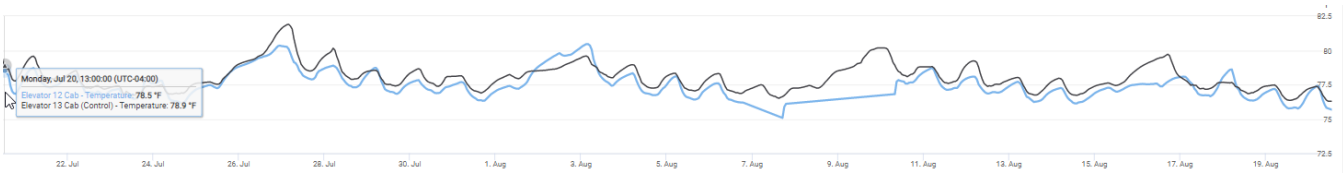
PM_{10} levels were noted higher in Elevator 13. All levels averaged below our recommended limit of 50 µg/m^3.

Humidity



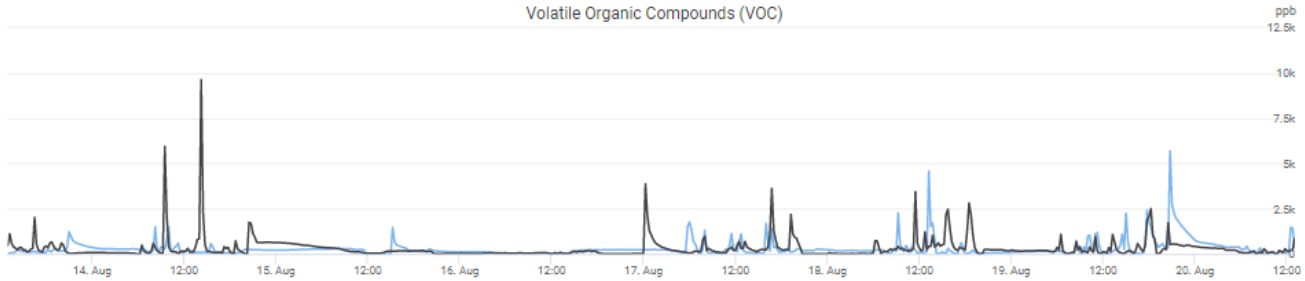
Humidity was noted to be tightly controlled and well within seasonal norms in both sample areas.

Temperature



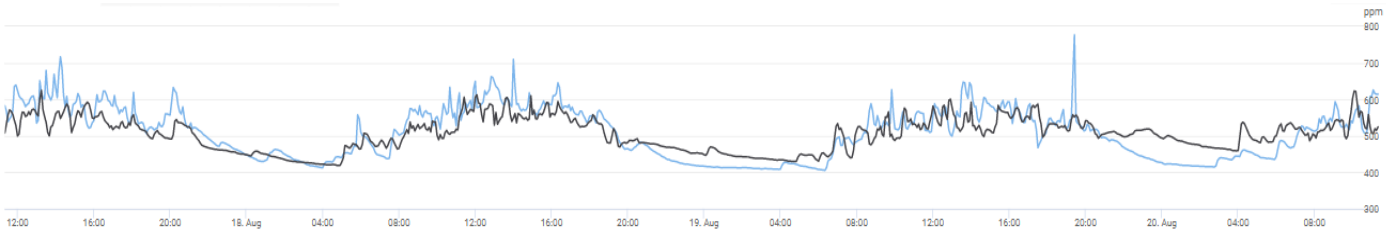
Temperatures were noted to be within seasonal norms during occupied periods.

Volatile Organic Compounds



VOC levels averaged 284 ug/m^3 in Elevator 12 and 422 ug/m^3 in Elevator 13 with several peaks that coincided with janitorial operations in the Elevator Lobby.

Carbon Dioxide

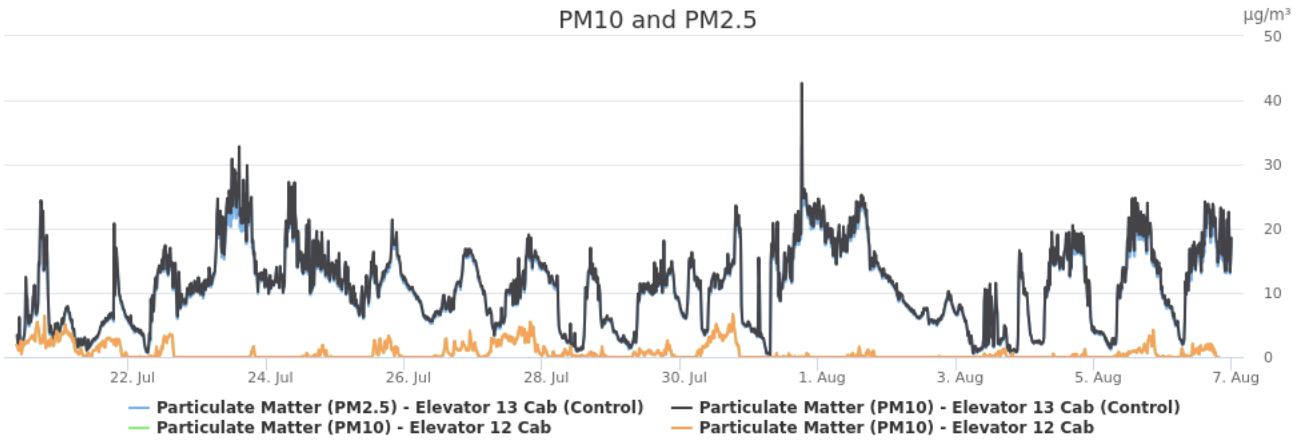


Carbon Dioxide levels were well below our recommended limit of outdoors plus 700 ppm.

[redacted]

2007057DC

Elevator 12 is equipped with a CEC Cab Sanitizing Unit System



Particulate Matter (PM10) - Elevator 13 Cab (Control)
13.1 µg/m³
Average

Particulate Matter (PM10) - Elevator 12 Cab
0.59 µg/m³
Average

Particulate Matter (PM2.5) - Elevator 13 Cab (Control)
12.6 µg/m³
Average

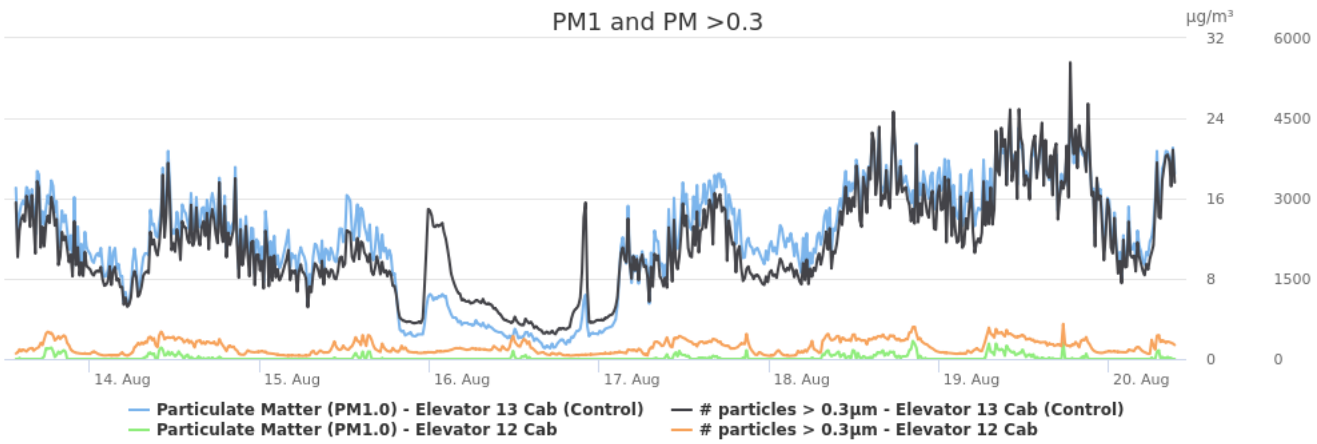
Particulate Matter (PM2.5) - Elevator 12 Cab
0.53 µg/m³
Average

Time	Particulate Matter (PM10) - Elevator 13 Cab (Control) µg/m³	Particulate Matter (PM10) - Elevator 12 Cab µg/m³
07/20/20 12:00 AM	8.41	2.67
07/21/20 12:00 AM	5.49	1.80
07/22/20 12:00 AM	9.07	0.55
07/23/20 12:00 AM	18.2	0.06
07/24/20 12:00 AM	15.4	0.14
07/25/20 12:00 AM	12.3	0.58
07/26/20 12:00 AM	9.88	0.63
07/27/20 12:00 AM	10.9	2.22
07/28/20 12:00 AM	7.60	0.33
07/29/20 12:00 AM	8.20	0.42

Time	Particulate Matter (PM10) - Elevator 13 Cab (Control) µg/m³	Particulate Matter (PM10) - Elevator 12 Cab µg/m³
07/30/20 12:00 AM	11.1	1.81
07/31/20 12:00 AM	14.1	0.03
08/01/20 12:00 AM	18.8	0.14
08/02/20 12:00 AM	7.98	0.00
08/03/20 12:00 AM	4.78	0.14
08/04/20 12:00 AM	11.5	0.06
08/05/20 12:00 AM	12.2	0.63
08/06/20 12:00 AM	13.9	0.59
08/07/20 12:00 AM	16.5	0.59
08/08/20 12:00 AM	11.0	
08/09/20 12:00 AM	10.5	
08/10/20 12:00 AM	7.48	2.27
08/11/20 12:00 AM	14.3	2.39
08/12/20 12:00 AM	12.7	1.33
08/13/20 12:00 AM	15.2	0.28
08/14/20 12:00 AM	16.3	0.54
08/15/20 12:00 AM	12.1	0.12
08/16/20 12:00 AM	4.85	0.10
08/17/20 12:00 AM	14.4	0.39
08/18/20 12:00 AM	19.5	0.67
08/19/20 12:00 AM	23.6	0.56
08/20/20 12:00 AM	15.7	0.09

Time	Particulate Matter (PM2.5) - Elevator 13 Cab (Control) µg/m³	Particulate Matter (PM2.5) - Elevator 12 Cab µg/m³
07/20/20 12:00 AM	8.09	2.45
07/21/20 12:00 AM	5.19	1.65
07/22/20 12:00 AM	8.78	0.49
07/23/20 12:00 AM	17.2	0.05
07/24/20 12:00 AM	15.0	0.11
07/25/20 12:00 AM	12.0	0.52
07/26/20 12:00 AM	9.55	0.58
07/27/20 12:00 AM	10.6	2.09
07/28/20 12:00 AM	7.34	0.27
07/29/20 12:00 AM	7.97	0.38
07/30/20 12:00 AM	10.8	1.72

Time	Particulate Matter (PM2.5) - Elevator 13 Cab (Control) µg/m³	Particulate Matter (PM2.5) - Elevator 12 Cab µg/m³
07/31/20 12:00 AM	13.5	0.02
08/01/20 12:00 AM	18.2	0.12
08/02/20 12:00 AM	7.76	0.00
08/03/20 12:00 AM	4.59	0.11
08/04/20 12:00 AM	11.2	0.05
08/05/20 12:00 AM	11.7	0.56
08/06/20 12:00 AM	13.2	0.51
08/07/20 12:00 AM	15.7	0.51
08/08/20 12:00 AM	10.8	
08/09/20 12:00 AM	10.1	
08/10/20 12:00 AM	7.13	2.12
08/11/20 12:00 AM	13.8	2.21
08/12/20 12:00 AM	12.4	1.18
08/13/20 12:00 AM	14.5	0.23
08/14/20 12:00 AM	15.5	0.45
08/15/20 12:00 AM	11.8	0.11
08/16/20 12:00 AM	4.63	0.08
08/17/20 12:00 AM	13.9	0.31
08/18/20 12:00 AM	18.7	0.60
08/19/20 12:00 AM	22.2	0.49
08/20/20 12:00 AM	15.0	0.04



particles > 0.3µm - Elevator 13 Cab (Control)

2197

Average

particles > 0.3µm - Elevator 12 Cab

237

Average

Particulate Matter (PM1.0) - Elevator 13 Cab (Control)

9.86 µg/m³

Average

Particulate Matter (PM1.0) - Elevator 12 Cab

0.25 µg/m³

Average