Retro Fitting Ventilation Systems for COVID-19

White Paper

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0.0 The 8 MAIN STEPS

1. Gather Information: Client criteria, existing system spec's & specific goals need to be detailed
2. Control or influence the travel of the airborne virus (AKA: Emission, contaminant, etc.) therefore limiting the "Person to Person" transmission
3. Capture the contaminant and introduce it to the duct system
4. Transport the contaminant to the existing air handler
5. Filtration of the emission
6. Introduction of additional fresh air and energy recovery
7. Return the air to the Facility
8. Maintenance plan

As offices, shopping malls, and schools start to open, evaluation of existing HVAC systems may be necessary. This white paper has been written to help you navigate and consider additional engineering controls to limit the exposure of respirable aerosols (COVID-19 virus). Use this white paper to guide stakeholders through some of the steps that can be taken to limit COVID-19 exposure to building occupants.

For example, New York State's mandatory rules and recommended guidelines relating to "Air filtration and building systems in shopping malls" for regions that have reached phase 4 are as follows:

Mandatory Rules:

- *Pre-Return checks, tasks, and assessments of all building systems*
- *HVAC systems to be outfitted with minimum MERV 13 filtration*

Best Practices:

- *Increasing ventilation rates and outdoor air ventilation to the best extent possible*
- *Keeping systems running for more extended hours (e.g., 24/7 if possible)*
- *Disabling demand-controlled ventilation, where reasonable, but still maintaining systems that increase fresh air supply (e.g., conference or meeting rooms)*
- *Opening outdoor air dampers to reduce or eliminate recirculation to the best extent possible*
- *Considering the installation of appropriately designed and deployed ultraviolet germicidal irradiation (UVGI) to deactivate airborne virus particles*
- *Sealing edges of the filter to limit by-pass*
- *Regularly inspecting systems and filters to ensure they are correctly installed and operating*
- *Maintaining regular maintenance during the system's service life.*

1.0 Gather Information

To begin the process of a COVID-19 retrofit on an HVAC system, start by gathering the following information:

- 1.1 Voltage?
- 1.2 Amperage (FLA and actual)?
- 1.3 Flow rate?
- 1.4 Percentage of recirculated air?
- 1.5 MERV Rating of Existing filters?
- 1.6 Equipment details (MFG, Serial number, H.P., amperage, flowrate, etc.)
- 1.7 Air distribution drawings (duct layout, location of existing grills and diffusers)
- 1.8 Type of filter currently installed in the HVAC system
- 1.9 What are the maximum MERV rated filters that can put into my air handler?
- 1.10 A recent balancing report
- 1.11 Is there additional electrical capacity available to run booster fans or packaged "inline" air cleaners?
- 1.12 Budget available
- 1.13 Resources available to install (e.g., facility staff, outside mechanical contractor)
- 1.14 With what ventilation method am I going to control the contamination (Source capture, Dilution ventilation, etc.)?
- 1.15 Any additional client criteria

2.0 Influence the Travel of the Airborne Virus

- 2.1 Understanding that the virus is heavier than air, it is best to use the existing overhead supply air to "PUSH" the emission down towards a low-level point of capture.
- 2.2 Additionally, you will want to take into consideration the velocity and direction of the emission whenever possible.
  - 2.2.1 For example, if a person is sitting at a desk for 50+% of the day, the best direction of the supply air would be from a +/- 45-degree angle behind their head and capture the air behind the computer monitor. For more information, **refer to section 4.3 of the ACHIG Industrial Ventilation Manual**.
- 2.3 Be aware of eddy currents caused by higher speeds.
  - 2.3.1 For example, a pedestrian walking near a source at normal speeds will create a moving wake behind them that can easily draw the contaminant air from the source towards them [1].
- 2.4 When possible, use CFD to identify designs to the highest potential [2].
- 2.5 Refer to Section 7.0 for more detail as the return air is used as the influencing air source.

3.0 Capture

For contaminant control, there are two types of ventilation systems: “dilution” and “local exhaust”;

3.1 Local exhaust is preferred in applications where the person is stationary (e.g., where the contaminant is captured between 2-4 feet in front of them).

3.2 Dilution ventilation is best suited when Local Exhaust is not possible (e.g., when people are walking around). In these cases, the capture points should be installed systematically in several locations and designed to have the lowest mixing factor**. Refer to chapter/figure 4-9 of the ACGIH manual 26th ed**.

4.0 Transport of the Air to the Filter System

4.1 Due to small particle size and mass, additional ductwork should be sized according to typical ASHRAE design standards and transport velocities.

4.2 As some of these ducts may be near a person, keep noise level in mind. Acoustically insulated capture hoods and ductwork are recommended.

4.3 Additional ducts typically require the fan to overcome additional pressure losses. This could adversely affect your existing HVAC system. You will want to consider a booster fan or a VFD powered fan filtration unit.

5.0 Filtration of the Emission

The desired level of filtration must be known. Your existing HVAC units will be rated to house up to a specific MERV rated filter. Decide whether you need to upgrade your current filters or add a new filter housing and associated filters.

While understanding the COVID-19 virus can have a particle size of 0.125 Micron, the virus typically attaches to a larger particle, such as a water droplet, summing up to 1.000 Micron.

5.1 Some of the filter choices are as follows:

a. MERV 11 - 65% @ 1.0 Micron (Lowest efficiency level allowed for shopping malls in N.Y. state. However, a letter from an engineer is required).

b. MERV 13 - 95% @ 1.0 Micron (Lowest efficiency level allowed for shopping malls in N.Y. state).

c. MERV 16 - 95% @ 0.3 Micron (Similar to an N95 Mask).

d. MERV 17 - 99% @ 0.3 Micron (HEPA filter as defined by ASHRAE).

5.2 It is best to consult a mechanical engineer with experience in contaminant filtration and HVAC design when selecting air filters to be used in a retrofitted system.

5.3 Filter housings: As research into the mass median diameter of the particles hosting COVID-19 virus is still unclear, it is recommended that all filter housings are rated up to a MERV 17 filter.

5.4 Adding a filter with a higher degree of filtration can adversely affect the performance of your existing HVAC system. You will want to consider a booster fan, or a VFD powered fan filtration unit with differential pressure controls.

5.5 Adding ultraviolet germicidal irradiation (UVGI) to deactivate airborne virus particles.

6.0 Introduction of Additional Fresh Air and Energy Recovery

6.1 Adding fresh air increases the overall air quality by diluting the contaminated indoor air.
6.2 Making sure the indoor air is pulled through a filter system. Whether it be; a power air filter system or the filters in the existing HVAC. Ducts should be well thermally insulated.
6.3 An equal amount of air should be exhausted to the atmosphere, assuming the HVAC system is well balanced.
6.4 Consider the impact of the fresh air on the heating and cooling systems. A qualified HVAC engineer should complete this evaluation.
6.5 Consider a heat recovery or energy recovery ventilator (ERV) to precondition fresh outdoor air and meet ASHRAE standards.

7.0 Return the Air to the Facility

7.1 For a local ventilation installation, the supply is to be re-oriented to PUSH the contaminated air towards the capture hood in a manner that does not overload the capture with contaminated air.
7.2 For a dilution ventilation installation, HVAC diffusers usually are well suited to supply air in a manner that dilutes the contaminant.
7.3 On-Demand ventilation systems are typically not recommended as an increased run time is preferred to maintain a well-filtered environment.
7.4 As always, CFD is recommended when possible.

8.0 Maintenance Plan

8.1 Allow filters to load more than usual without disrupting room pressures or filter by-pass.
8.2 Wear proper PPE when changing filters [such as Properly fitted N95 mask (or greater), face shield, disposable gloves].
8.3 Confirm filters are sealed tightly in their frames.
8.4 When feasible, filters can be disinfected with a 10% bleach solution or other appropriate disinfectants.
8.5 Treat filters as toxic and handle accordingly.
8.6 Wash hands with soap and water or hand sanitizer:
    a. Make sure your maintenance plan meets the latest ASHRAE technical resources relating to filtration/disinfection [3].

9.0 Conclusion

As with any complex engineering project, the solution is within the finer details. This is extremely important to consider when dealing with a high-risk contaminant. You will need experienced support staff from both the world of HVAC (supported by the ASHRAE org.) and LEV (supported by ACGIH org.). It is best to treat these retrofit projects by forming a team of individuals that are well versed in both these subjects. This team may include a: Mechanical Engineer, Industrial Hygienist, Electrical Engineer, Maintenance Planner, sheet metal workers, or subject matter expert (SME) in the field of capturing airborne contaminants. It is best to follow local regulations for retrofitting and reopening based upon your location.

10.0 References

[1] ACGIH manual, INDUSTRIAL VENTILATION, A MANUAL OF RECOMMENDED PRACTICE AND DESIGN, 29th ed., 2016. ch. 4-5

[2] ACGIH manual, INDUSTRIAL VENTILATION, A MANUAL OF RECOMMENDED PRACTICE AND DESIGN, 29th ed., 2016. ch. 5-37

[3] ASHRAE, "FILTRATION/DISINFECTION: Facilities/Maintenance – PPE Basics." 2020. Available: https://www.ashrae.org/technical-resources/filtration-disinfection=

Useful links:

https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf

U.S. Department of Labor: COVID-19 - Control and Prevention: Dentistry Workers and Employers

ASHRAE: Health Care Facilities

BPE: Indoor Air Flow and COVID-19

Bassett Mechanical: COVID-19 Educational Series- Part 1: Indoor Air Quality

ScienceDirect: How can airborne transmission of COVID-19 indoors be minimised?

ASHRAE: ASHRAE Position Document on Infectious Aerosols

CDC: Interim Guidance for Businesses and Employers Responding to Coronavirus Disease 2019 (COVID-19), May 2020

U.S. Department of Labor: Guidance on Preparing Workplaces for COVID-19

Jamda: Practical Steps to Improve Air Flow in Long-Term Care Resident Rooms to Reduce COVID-19 Infection Risk

CDC: COVID-19 Employer Information for Office Buildings

AIHA: Reopening: Guidance for General Office Settings

The American Institute for Architects: Re-occupancy Assessment Tool V1.0