



INDOOR AIR QUALITY

Applying AAON Equipment for Resilient Mitigation of Infectious Aerosols

APPLYING AAON EQUIPMENT FOR RESILIENT MITIGATION OF INFECTIOUS AEROSOLS

There is a great deal of concern over best practices in the design and operation of building HVAC systems in light of the recent worldwide COVID-19 pandemic. AAON shares these concerns and recommends following WHO, CDC and ASHRAE guidance on operation of commercial buildings during this time. The need for healthy buildings has changed HVAC system design and operation going forward.

As an Essential Business, AAON has operated through the pandemic and provided the critical equipment needed to help deal with the outbreak. Over 5,000 tons of AAON HVAC equipment have shipped to projects related to the pandemic, such as temporary hospitals, isolation units and medical equipment production facilities. Using the tools, features and options available with AAON equipment, an effective and efficient HVAC system can be designed that can help to mitigate the risks of transmission.

In order to mitigate the spread of COVID-19, influenza and other similar type respiratory diseases, one must understand what affects transmission of the disease. The coronavirus is a whole family of viruses including SARS, MERS and some strains of the common cold. These viruses can spread through airborne droplets. Sneezing, coughing, singing or even talking expels moisture droplets and an infected individual will spread viruses in this moisture. Larger droplets will fall quickly due to gravity, thus the effectiveness of 6 feet of physical separation. Some droplets shrink and desiccate to reach a moisture equilibrium within the air in the space. Any viruses in those very tiny droplets becomes an infectious aerosol within the space and can remain suspended in the air. These aerosols can travel on the air currents within the space and even enter the HVAC system. This is the concern with spread through the HVAC system. There are several recommendations by the ASHRAE Epidemic Task Force to help mitigate the spread of the virus including humidity control, air filtration, increased outdoor air ventilation, and air disinfection.



- Operating as an Essential Business, AAON implemented measures throughout the manufacturing facilities to prevent the spread of COVID-19.

HUMIDITY CONTROL

Dr. Stephanie Taylor, MD, M. Arch, FRSPH(UK), CABE, ASHRAE Distinguished Lecturer, and member of the ASHRAE Epidemic Task Force stated, "Ten years ago we learned that viruses studied as surrogates for Coronavirus, the family of SARS and Wuhan, were INACTIVATED on surfaces when the ambient relative humidity (RH) was 40-60%. Conversely, when RH was either below 40% or above 60%, the viruses remained virulent and infectious. The opportunity to inactivate viruses in the air and on surfaces by maintaining this range of indoor humidity, which happens to also be the range best for human health, is Mother Nature's gift to us."¹

AAON Recommendations:

- Ensure that the leaving coil temperature in the HVAC system is lower than 60°F to aid in controlling the humidity below 60%. The use of modulating hot gas reheat to control humidity, especially when coupled with variable capacity compressors, in a well-designed VAV system can be extremely effective in a commercial building that has relative high internal latent loads. Return Air Bypass can be used to aid in dehumidification.
- Control building humidity levels during occupied and even unoccupied periods to keep the space relative humidity always below 60% and above 40%.
- AAON equipment is available with modulating hot gas reheat humidity control, which provides precise dehumidification control, even with low sensible heat loads, without the temperature swings common with on/off reheat systems.



- AAON equipment is available with modulating hot gas reheat humidity control, which provides energy efficient dehumidification, even with low sensible heat loads, without the temperature swings common with on/off reheat systems.

OUTDOOR AIR VENTILATION

The ASHRAE Task Groups recommend disabling demand control ventilation and increasing outdoor air within the limits of controlling temperature and humidity in the space. They also recommend the building be flushed with outside air for a period before occupancy.

AAON Recommendations:

- During any period of concern with airborne viral transmission, disable any demand control ventilation and ventilate with outside air in accordance with ASHRAE 62.1.
- In new AAON equipment, select modulating hot gas reheat for humidity control to meet the demands of ventilating to ASHRAE 62.1 and any building flush cycle.
- Variable speed, Digital scroll or multiple stages of compressors to precisely match the variable loads associated with high amounts of outside air.
- If occupancy is less than 24/7, initiate an early morning flush for two hours prior to occupancy of 100% outside air. Then run an evening flush of 100% outside air for two hours post occupancy. Terminate the flush if relative humidity in the space drops below 40% or rises above 60%.
- VAV systems may require a minimum amount of outside air to satisfy the requirements of ASHRAE 62.1. AAON can provide airflow monitoring stations to measure the outside air cfm and adjust the economizer as necessary to provide the required outside air cfm. All AAON economizers are designed to allow for 100% outside air.

- AAON equipment is available with AMCA Certified Low Leakage Gear Driven Economizer Dampers that allow operation with up to 100% Outside Air.



- Variable Speed Compressors are available to provide precise control with extremely high efficiency

ENERGY RECOVERY

The energy required to operate a unit with 100% outside air can increase substantially compared to a unit operating with the minimum volume of outside air require to meet ASHRAE 62.1. Implementing energy recovery will reduce this energy increase by recovering energy that would otherwise be exhausted out of the building.



- AAON Aluminum Energy Recovery Wheel

AAON offers both energy recovery wheels and energy recovery plates. Energy recovery wheels allow some leakage between the outside air and exhaust air streams. However, this leakage can be forced from the outside air to the exhaust air stream (preventing recirculation of building exhaust into the fresh outside air) by maintaining a higher static pressure in the outside air stream relative to the exhaust air stream. Most applications will have return duct pressure losses, which force the outside air stream to have a higher static pressure than the exhaust air stream. All leakage will go from the outside air stream to the exhaust air stream if there is at least 0.5 in. wc. return duct loss ensuring that building exhaust air is not recirculated back into the building through the energy recovery wheel. Exhaust air filters upstream of the energy recovery wheel reduce the static pressure further, which ensures leakage from the outside air to the exhaust air stream.

AAON Recommendations:

- Specify energy recovery with ventilation HVAC equipment to save energy while providing increased ventilation.
- Specify energy recovery wheels with 1% purge option to reduce air leakage.

FILTRATION

ASHRAE states “Research has shown that the particle size of the SARS-CoV-2 (COVID-19) virus is around 0.1 μm (micrometer). However, the virus does not travel through the air by itself. The virus is trapped in respiratory droplets and droplet nuclei (dried respiratory droplets) that are predominantly 1 μm in size and larger. . . ASHRAE currently recommends using a minimum MERV 13 filter, which is at least 85% efficient at capturing particles in 1 μm to 3 μm size range.”²

AAON Recommendations:

- Specify new AAON equipment with a minimum of MERV 13 filtration. Install MERV 13 filtration in existing AAON equipment if fan selection can safely operate at the increased pressure drop.
- Follow ASHRAE recommendations for personal protective equipment for maintenance personnel changing filters of a minimum of N95 filtering face-piece respirators, eye protection, disposable gloves, and disposable coveralls. After maintenance activities, wash hands with soap and water or use an alcohol-based hand sanitizer. Change clothes if soiled.



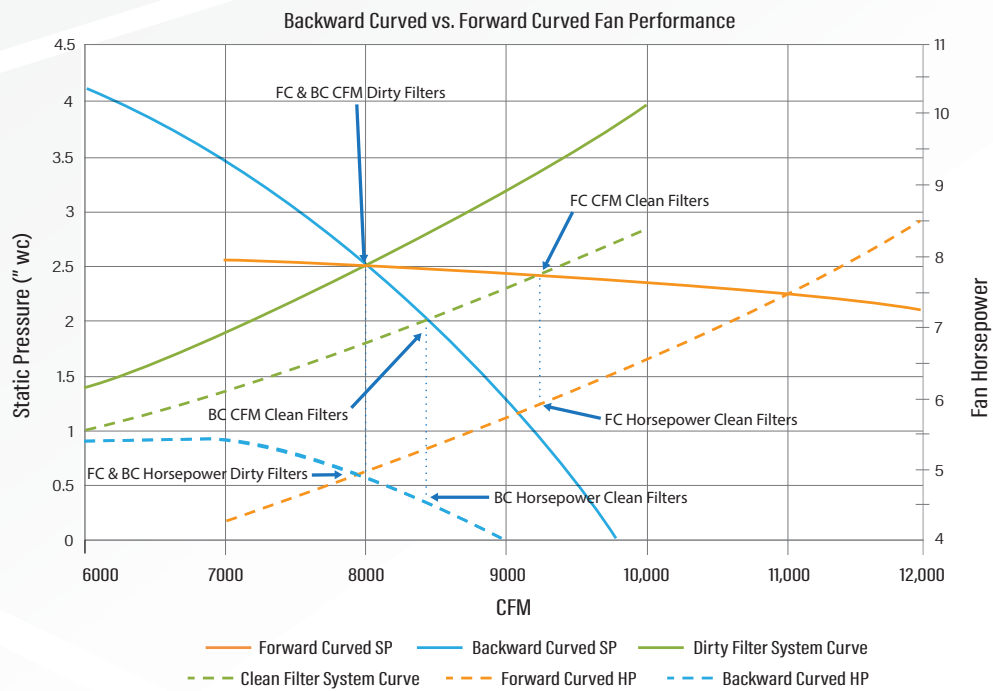
- Multiple High Efficiency Filtration options are available to meet application requirements.

FAN AND AIRFLOW PERFORMANCE WITH MERV 13 FILTERS

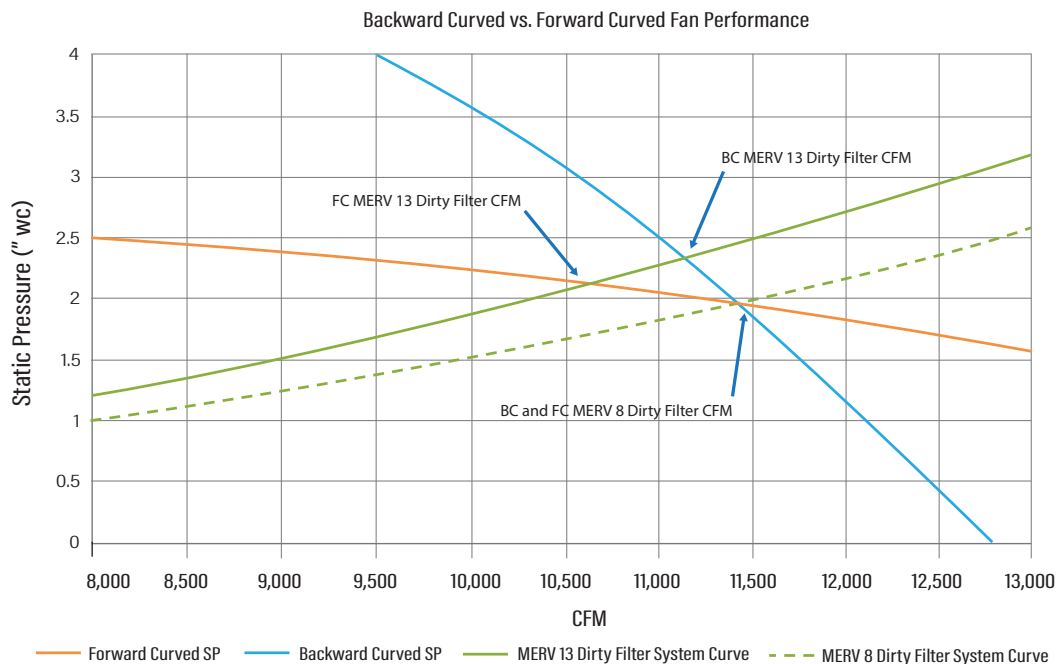
Most rooftop air conditioners use forward curved fans while AAON uses backward curved fans. Fans will operate at the intersection of the constant speed fan pressure curve and the unit & duct system pressure loss curve (the system curve). If the pressure drop changes due to filter loading or the use of different pressure drop filters, the system curve will change. There are significant differences between the application of forward and backward curved fans. Forward curved fans have a flatter static pressure vs cfm curve as compared to a backward curved fan. This is very important when considering the use of MERV 13 filters.

Typically, a MERV 8 filter is used and it usually has a clean pressure drop of about 0.25". MERV 8 filters are relatively inexpensive so they are usually changed as the filter becomes dirty and the pressure drop reaches 0.5". MERV 13 filters usually have a clean pressure drop closer to 0.3" and are considerably more expensive than MERV 8 filters. MERV 13 filters are currently in high demand and are more difficult to obtain so it may be common to change the filters when the pressure drop reaches 1". ASHRAE also recommends fewer filter changes to reduce the exposure of dirty and potentially contaminated filters to maintenance personnel. The media used in some MERV 13 filters are also used in facemasks further reducing the supply of MERV 13 filters.

Consider the following example in which the blue curve is a backward curved fan and the orange curve is a forward curve fan. The unit is designed to deliver 8,000 cfm with MERV 13 filters and a dirty filter pressure drop of 1" for a total fan static pressure (TSP) of 2.5". The fan system curve with 8,000 cfm and a TSP of 2.5" is represented with the solid green curve. With clean filters, the system curve is represented by the dashed green curve since the clean filters have a pressure drop of 0.7" less at 8,000 cfm compared to the dirty filters. The backward curve fan would provide 8,430 cfm on the clean filter system curve but the forward curve fan would provide 9,220 cfm. The forward curve fan would move about 15.3% more airflow than design, which could make the duct diffusers significantly louder. Increasing the airflow also raises the leaving air temperature from the unit, which reduces the latent capacity of the unit and therefore raises the humidity in the space. The fan power also increases significantly with the forward curved fan. The dashed blue curve is the backward curve fan power. The dashed orange curve is the forward curve fan power. On the clean filter system curve, the backward curved fan uses 4.6 BHP (decrease from design of about 6%) but the forward curve fan uses 6 BHP (increase from design of about 15%). The forward curve fan would use 30% more power than the backward curve fan with clean filters, which would reduce the unit efficiency.



The converse of this example can be a problem as well. Simply replacing a MERV 8 filter with a MERV 13 filter without resetting the fan can cause significantly less airflow with a forward curved fan. Consider the following example in which the blue curve is a backward curved fan and the orange curve is a forward curve fan. In this example, the unit is designed to provide 11,450 cfm at 2\" TSP with MERV 8 filters loaded to 0.5\" when dirty. Replacing the MERV 8 filter with a MERV 13 filter will add an additional 0.5\" TSP. At 2.5\" TSP the backward curve fan will produce 11,150 cfm but the forward curve fan will only produce 10,650 cfm. The backward curve fan is about 2.6% less airflow than design but the forward curve fan is about 7% less airflow than design simply by changing the filters from MERV 8 to MERV 13. This could affect building pressurization and could cause a positive pressure space to become a negative pressure space. There could be other problems depending on the unit and ductwork design. The forward curved fan unit may need to use more hot gas bypass (if equipped) to prevent the evaporator coil from freezing as the suction temperature will be lower with less airflow. More operating time with hot gas bypass reduces the unit efficiency. The evaporator coil could freeze if it is not equipped with hot gas bypass. The lower suction temperature could also significantly increase compressor power and reduce unit efficiency. The unit leaving air temperature will also be lower with less airflow and could cause condensation to form on the duct registers in the space.



COOLING COIL CLEANING AND AIR DISINFECTION—UV LIGHTS

ASHRAE states . . . “Ultraviolet energy inactivates viral, bacterial, and fungal organisms so they are unable to replicate and potentially cause disease. The entire UV spectrum is capable of inactivating microorganisms, but UV-C energy (wavelengths of 100 – 280 nm) provides the most germicidal effect, with 265 nm being the optimum wavelength. The majority of modern UVGI lamps create UV-C energy with an electrical discharge through a low-pressure gas (including mercury vapor) enclosed in a quartz tube, similar to fluorescent lamps. Roughly 95% of the energy produced by these lamps is radiated at a near-optimal wavelength of 253.7 nm.”³

UV lights can be used to inactivate pathogens in the airstream of an air handling unit. This is referred to as Single Pass Air Disinfection. Different pathogens require different intensity of UV light to inactivate them. Intensity is a combination of exposure time and the amount of UV light produced. It may take significantly more UV lights to kill pathogens in the airstream vs. pathogens on a coil surface as the exposure time to UV lights is significantly less than the exposure time on a cooling coil.

AAON Recommendations:

- Select UV-C down stream of cooling coil option on new AAON equipment. This will keep the coil clean and free of viruses and other microorganisms. A clean coil also has less airside pressure drop than a dirty coil. A unit with a dirty coil uses more fan power than one with a clean coil. This also keeps the coil drain pan clean.
- AAON can provide single pass air disinfection with UV lights.
- Replace bulbs as recommend in installation, operation and maintenance manual, typically annually.

- UV Light options are available factory installed for both keeping the cooling coil clean and for single pass air disinfection



AIR DISINFECTION—BIPOLAR IONIZATION

Bipolar ionization uses an electronic charge to create a plasma field filled with a high concentration of positive and negative ions. As these ions travel with the air stream, they attach to particles, pathogens and gas molecules. The ions help to agglomerate fine submicron particles together, which allows the HVAC filters to trap them more effectively. Fine submicron particles can remain suspended in the air and not moved by air currents. Larger agglomerated particles are moved by the air currents and return to the HVAC unit.

The ions surround the surface membrane of airborne viruses. Ions are transformed into very reactive OH groups called hydroxyl radicals on the virus membrane surface through a chemical reaction. Hydroxyl radicals steal hydrogen from the surface of the virus membrane, opening holes in the virus membrane. The ions destroy the virus surface structure on the molecular level. As a result, the virus cannot infect even if it enters the body.

The ions also break down harmful VOCs with an Electron Volt Potential under twelve ($eV < 12$) into harmless compounds like O_2 , CO_2 , N_2 and H_2O . The ions produced travel with the air stream into the occupied spaces, cleaning the air everywhere the ions travel, even in unseen spaces.

An ion is a molecule or atom that is positively or negatively charged, meaning that it has electrons to give or needs electrons to become uncharged, thus becoming stable. In nature, lightning, waterfalls and ocean waves create ions. It is nature's way of cleansing the air naturally and creating a healthy environment. Some ionization products create ozone, which is harmful to humans. However, the bipolar ionization solutions that AAON can provide do not create ozone.

AAON Recommendations:

- AAON can factory install bipolar ionization for applications that require it.

CONTACT YOUR LOCAL SALES REPRESENTATIVE FOR HELP SELECTING YOUR AAON EQUIPMENT.

INDOOR AIR QUALITY AND COVID-19 REFERENCES

AAON recommends following WHO, CDC and ASHRAE guidance on operation of commercial buildings.

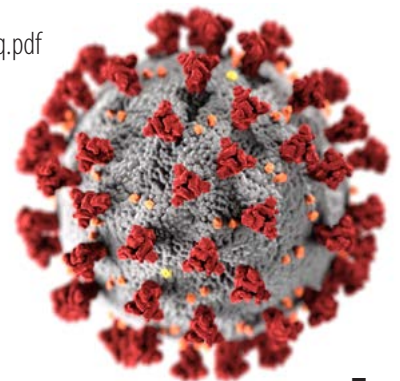
ASHRAE COVID-19 Resources

<https://www.ashrae.org/technical-resources/resources>

¹ Feb. 2nd post on LinkedIn by Dr. Stephanie Taylor, MD, MArch, FRSPH(UK), CABE, ASHRAE D.L. and member ASHRAE Epidemic Task Force
<https://www.hpac.com/industry-perspectives/article/21125154/editors-notes-iaq-ieq-public-health-humidity-controls>

² <https://www.ashrae.org/file%20library/technical%20resources/covid-19/filtration-and-disinfection-faq.pdf>

³ <https://www.ashrae.org/technical-resources/filtration-disinfection>



Temporary Hospital in New York with AAON HVAC Systems



United We Stand

AAON is ready to respond to your critical project needs. We have shipped over 5,000 tons of essential HVAC systems to critical infrastructure projects related to the pandemic, such as temporary hospitals, isolation units and medical equipment production facilities. Our manufacturing capacity and streamlined processes ensure essential demands are met rapidly. We are also manufacturing solutions to meet the current Indoor Air Quality concerns.

AAON Units Shipped Out to this Job in 10 days



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