

Boston University
COVID-19 Response
Mechanical Ventilation (HVAC) Systems
July 28, 2020

There is limited scientific data concerning the spread of SARS-CoV-2 (COVID-19) through building heating, ventilating and air conditioning (HVAC) systems. The Centers for Disease Control (CDC) describes SARS-CoV-2 infection as occurring primarily from exposure to respiratory droplets from an infected person. Larger droplets from coughing and sneezing are believed to contain more virus than smaller aerosol particles that may be generated by talking, and large droplets settle rapidly before they might enter HVAC systems.

The CDC recommends increasing HVAC system ventilation and filtration to reduce the airborne concentration of SARS-CoV-2 if present in smaller droplets in the air as part of a comprehensive program to control the spread of COVID-19 including frequent hands washing, good respiratory etiquette, appropriate social distancing, face coverings, cleaning and disinfecting surfaces, and staying home if sick. CDC guidance for HVAC system operations and maintenance is based on American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommendations.

BU Heating Ventilating and Air Conditioning (HVAC) COVID-19 Precautions

Based on CDC and ASHRAE guidance, Boston University Facilities Management and Operations (FMO) has implemented enhanced maintenance protocols for mechanical and plumbing systems in campus buildings. There are 318 buildings on the Charles River, Fenway and Medical Campuses of which 120 have mechanical ventilation systems and 198 are naturally ventilated using operable windows. Each of the 120 buildings with mechanical ventilation systems is unique in terms of HVAC system design and operation.

HVAC systems are designed to meet the state building code and follow American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) standards. ASHRAE is a professional organization that develops standards for the engineering industry based on a rigorous peer review process. ASHRAE standards are considered state of the art and regularly incorporated into building codes. The Centers for Disease Control and Prevention (CDC) relies upon ASHRAE guidance for many of their recommendations regarding managing HVAC systems during the COVID-19 pandemic. ASHRAE Standard 62.1 "Ventilation for Acceptable Indoor Air Quality" provides standards for the recommended quantity of ventilation air and non-recirculated outdoor air based on the type of space and occupancy in a building.

Ventilation rates for offices, classrooms, residence halls, and general purpose space is measured in Cubic Feet per Minute (CFM) per occupant. Ventilation rates in Boston University buildings are 5 CFM per occupant for offices and dormitory bedrooms. 7.5 CFM per person for residential building common areas, and 10 CFM per occupant in classrooms, conference rooms, and dry laboratories. These CFM rates are consistent with ASHRAE standards.

Special purpose spaces such as laboratories are designed to standards in addition to ASHRAE 62.1 that are specific to these types of spaces, including those provided by the American Industrial Hygiene Association (ACGIH), National Fire Protection Agency (NFPA), and the Occupational Safety and Health Organization (OSHA). Laboratory systems are designed with minimum air changes per hour (ACH), a measure how many times the volume of air within a space is exhausted and replenished in one hour.

For example, chemistry and biological laboratories at Boston University are ventilated at a minimum of 6 ACH.

To illustrate, an HVAC system supplies a typical 10 foot by 10 foot office with 9 foot high ceilings with 75 CFM of air, with 5 CFM being outdoor air and 70 CFM being filtered indoor (recirculated) air. The outdoor air exchange rate for this office is 0.33 ACH while the total effective exchange rate is 5 ACH, taking into account the filtered recirculated air. Similarly a typical classroom that is 20 by 32 feet with 11 foot high ceilings is supplied with 750 CFM of air, of which 350 CFM is outdoor air. The outdoor air exchange rate for this space is 3 ACH, with a total effective exchange rate of 6.4 ACH taking into account the filtered recirculated air. These air change rates meet or exceed ASHRAE standards.

Laboratory buildings are required to have ventilation systems with single pass air, meaning there is no recirculation of air from inside the lab space. Non laboratory occupancies, such as offices and classrooms, rely on some percentage of re-circulated air from within the building. Boston University is following Centers for Disease Control (CDC) and ASHRAE guidance to upgrade air recirculation system filters to a minimum MERV 13. The combination of additional filtration and increased outdoor air ventilation is intended to mitigate the risk of airborne transmission of COVID-19 virus in buildings with mechanical ventilation systems. Airborne transmission risk in naturally ventilated buildings is mitigated by increasing fresh from open windows.

The typical filter specification in Boston University HVAC systems is MERV 8. MERV stands for Minimum Efficiency Reporting Value. A MERV 8 filters capture particles larger than 3 Microns which includes contaminants such as dust and pollen. ASHRAE's COVID-19 recommendations include upgrading to MERV 13 in existing HVAC systems. MERV 13 filters are rated to capture contaminants as small as 0.3 microns, similar to a High Efficiency Particulate Air (HEPA) filter. For those systems that cannot support MERV 13 filters due to air flow or pressure limitations, BU Facilities is evaluating the installation of standalone, HEPA-grade air purification to provide a result comparable to ASHRAE recommended filtration.

Status of Boston University HVAC Evaluation

As of Monday, July 20, 2020, in preparation for the return of faculty, staff and students to campus Facilities Management and Operations (FMO) has inspected 223 buildings of which:

- 120 buildings have centralized HVAC systems
 - 400+ air handlers (some facilities have multiple units) have been upgraded to a minimum of MERV13 filtration when air is recirculated or 100% outside air
 - All air handlers were able to support the change to MERV13 filtration
- Demand Control Ventilation (DCV) settings have been disabled
 - DCV modulates air flow in rooms based on occupancy and CO2
 - Disabling DCV allows for full ventilation 24/7
- 50 buildings have building automation systems (BAS) with runtime schedules
 - All 50 buildings have been rescheduled to run 24/7 providing full ventilation
- 73 buildings contain classrooms
 - Approximately 800 classrooms are being inspected to confirm they have the equivalent of 3 to 7 air changes per hour based upon a mathematical extrapolation of the ASHRAE recommended exchange rate of 10 cubic feet per minute per person

Summary

BU Facilities has implemented a comprehensive process to review all HVAC systems on campus to ensure they meet COVID-19 public health and safety guidelines. The following table summarizes the type of changes being made to the mechanical ventilation systems:

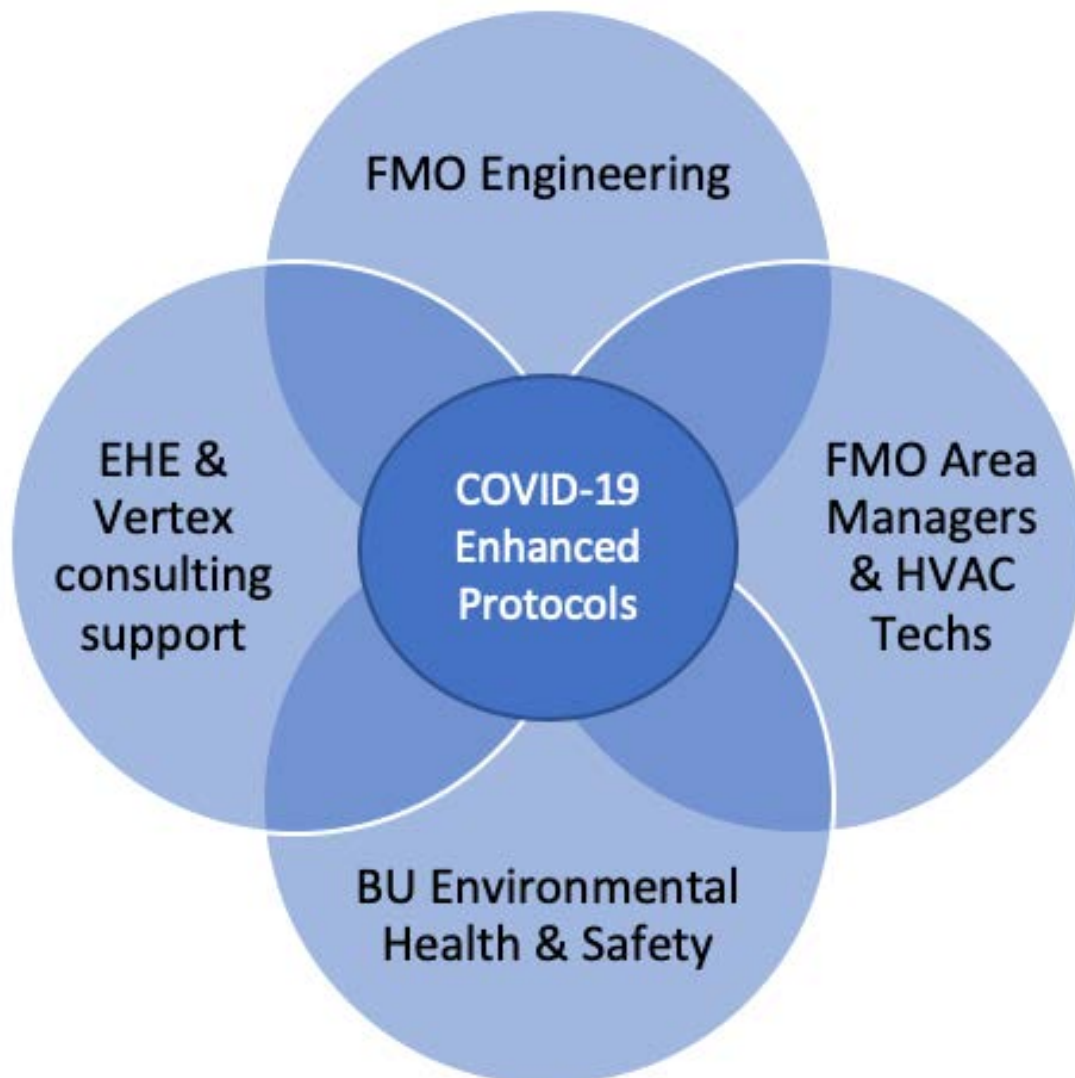
	PRE-COVID-19 BUILDING HVAC CONDITION	COVID-19 BUILDING HVAC CONDITION ^(a)
HVAC Maintenance Schedule	Seasonal Quarterly Maintenance	HVAC System Inspection, Verification, Enhancement, Ongoing Maintenance
HVAC Filtration	MERV-8 Filters 3 to >10 micron particles	MERV-13 ^(b) Filters 0.3 to >10 micron particles
HVAC Runtime Schedule	12-16 Hour Runtime	24/7
Demand Control Ventilation (DCV)	Enabled	Full-Time Ventilation
Outside Air Setting	Minimum Outside Air Required by Code	Increase Outside Air while maintaining control ^(c)
Outside Air/Person	Ventilation Designed for Maximum Occupancy	Lower building occupancy = more outside air per person
Air Changes per Hour	Laboratories 6 ACH Offices, Classrooms 0.3 to 7 ACH	Laboratories 6 ACH Offices, Classrooms 3 to 7 ACH ^(d)
<p>^(a) ASHRAE recommends ensuring HVAC systems can handle filter and ventilation upgrades without negative impacts to pressure differentials and/or air flow rates.</p> <p>^(b) HEPA rated filters capture a similar size particle range as MERV-13.</p> <p>^(c) For systems that provide recirculated air, adjust controls, both automatic and manual, to increase the amount of outside air volume consistent with individual building design specifications, where possible, without adversely impacting performance, pressurization, or temperature control.</p> <p>^(d) Effective ACH considering MERV-13 filtration</p>		

Frequently Asked Questions

What are the steps BU is taking to review the proper functioning of HVAC systems?

Although there is limited scientific data on HVAC systems being conduits for the spread of the SARS-CoV-2 virus, BU Facilities Maintenance and Operations (FMO) is taking additional steps to ensure HVAC systems are operating per their design specifications and increasing fresh air, air changes per hour, and filtration consistent with CDC and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) guidance.

FMO has created an integrated, multi-disciplinary team composed of University Engineering and Building Systems staff, HVAC technicians, external COVID-19 HVAC consultants, building area managers, and Environmental Health and Safety (EH&S) staff to review and monitor building HVAC system performance and maintenance on a continuous basis. The University has hired Environmental Health and Engineering (EHE / www.eheinc.com), an engineering and consulting firm with expertise in HVAC system design and operation, to assist both FMO and EH&S staff with this work.



As a part of its COVID-19 HVAC monitoring program, FMO, EH&S and the consulting firm of EH&E will:

- a. *Inspect All HVAC Systems*
Ensure all primary air delivery systems and their components are operating as designed.
- b. *Optimize Filtration*
Review the maintenance and effectiveness of all air filtration systems, maximize filtration within the limits of each individual building's design specification to a minimum of MERV-13.
- c. *Evaluate Increases in Outside Air Volume*
For systems that provide recirculated air, adjust controls, both automatic and manual, to increase the amount of outside air volume consistent with individual building design specifications, where possible, without adversely impacting performance, pressurization, or temperature control.
- d. *External Third-Party Review*
FMO will utilize outside HVAC consultants to review and confirm the University's mechanical system protocol are best practice and have incorporate evolving guidance from government and industry groups.

Has replacing the filters in the air handling systems to the highest efficiency level possible been considered?

Yes, in response to COVID-19, FMO has been reviewing the air filtration in all 124 University properties with mechanical ventilation systems. Each building is being evaluated based on the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards. ASHRAE recommends the installation of [MERV 13](#) filters (most office and laboratory systems use MERV 8 or lower) unless the reduced airflow from increased filtration would adversely affect the performance of the system. MERV (Minimum Efficiency Reporting Value) is a measure of how effective an air filter is at catching particles of varying sizes.

A High Efficiency Particulate Air filter (HEPA filter) is a filter that removes 99.97% of airborne particulate contaminants as measured at 0.3 Microns. HEPA filters require specialty housings and HVAC system designs to overcome the pressure drop required to maintain airflow through the filter media. Because of these design specifications, HEPA filters cannot typically be installed in non-laboratory buildings.

According to ASHRAE, MERV 13 filters are efficient at capturing airborne viruses, including SARS-CoV-2, the virus that causes COVID-19. SARS-CoV-2 virus is around 0.1 µm (micron). However, the virus does not travel through the air by itself. Since it is human generated, 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. MERV-13 captures a similar particle size range as HEPA filters (.3µm) and have been retrofitted into all HVAC systems on campus.

See <https://www.ashrae.org/technical-resources/filtration-and-disinfection-faq> for additional information.

If occupants in offices and classrooms open windows/doors, what will be the impact on moving air into common spaces?

Ventilation by opening windows is an acceptable ventilating option. However, the use of windows creates uncontrolled air movement within the spaces and airflow will vary throughout the course of the day. FMO and EHS recommend not opening windows in buildings with mechanical ventilation provided by HVAC systems.

Did BU completely shut down HVAC systems during the stay at home advisory, and are there plans to check for mold growth and Legionella in the water systems?

While the majority of BU faculty, staff, and students were learning and working remotely, all BU properties were operational and being maintained by FMO during the COVID-19 stay at home period.

In preparation for Back2BU, all HVAC, plumbing and other mechanical systems have been maintained in accordance with CDC and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommendations.

What is the ventilation rate in my space?

Buildings ventilation is determined by the building code and varies by the type of space and the number of people expected to occupancy each building. Below are typical examples of spaces on campus with mechanical ventilation (HVAC) systems:

- **Classroom, Office, and Common spaces:** ASHRAE design standard is 10 cubic feet per minute of fresh air per person for classrooms and 5 cubic feet per minute of fresh air per person for office space. De-densification increases fresh air available per person depending on the ratio of reduction. As discussed above, increased filtration in combination with outdoor air ventilation being employed on campus increases the effective total air exchange rate in these spaces. Typical offices and classrooms on campus with upgraded filters will have total effective air exchange rates of approximately 3 to 7 ACH. As discussed, BU Facilities is recommending installing portable HEPA-filters in some spaces to increase the effective air exchange rate.
- **Residential buildings:** The University follows ASHRASE recommended ventilation guidelines for dormitory and other residential buildings. ASHRAE standard for dorms is 5 CFM per person in bedrooms and 7.5 CFM for public spaces.
- **Lab spaces:** Typical biology and chemistry laboratories at Boston University have a minimum six (6) Air Changes per Hour (ACH). These laboratory buildings are required by code to have ventilation systems with single pass air, i.e., no recirculation of air from inside the lab space. Dry laboratories that do not use major chemicals or other hazardous materials are ventilated similarly to office and assembly spaces with a minimum ventilation rate of 5 cubic feet per minute per person of outdoor air based on occupancy design load. These laboratories have total effective air exchange rates of approximately 3 to 7 ACH.

Should I do anything differently with my window unit to circulate outside air?

Some window air conditioning units can be configured to pull in outside air rather than solely recirculate indoor air. Please contact your area manager for more specific instructions on reconfiguring your window unit as necessary.

The building I occupy does not have central HVAC and airflow is provided solely by opening windows, is there anything I should be mindful of?

For naturally ventilated buildings, the CDC recommends increasing circulation of outdoor air as much as possible by opening windows and doors if possible, and using fans. Do not open windows and doors if doing so poses a safety or health risk for occupants, including children (e.g., a risk of falling or of breathing outdoor environmental contaminants such as carbon monoxide, molds, or pollens). <https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html>

Has the University considered putting UV lights or extra HEPA filters in the return air plenums?

FMO and EHS are evaluating HEPA air purification and UV disinfection systems. Unlike HVAC system performance, filtration and ventilation, neither CDC nor ASHRAE have issued specific suggestions for the addition of UV or HEPA filtration to building-wide HVAC systems. FMO and EHS are evaluating the suitability of these systems on a building by building basis and will continue to monitor and evaluate guidance issued by CDC and other recognized authorities. Given the efficacy of UV disinfection for COVID-19 is not certain, UV systems are not expected to be used widely on campus at this time.

What is FMO doing to evaluate drinking water & plumbing systems?

In consultation with EHS, FMO has reviewed all building water systems including domestic hot water heaters, hot and cold-water piping systems, sinks, water fountains, bottle filling stations, toilets, as well as of building systems.

In accordance with CDC and ASHRAE guidance, the following additional actions have been taken by FMO to mitigate the risk of viral and bacterial exposure following a prolonged period of minimal building use:

- Implemented a plan to regularly flush hot and cold-water systems.
- Regularly monitor domestic hot water heaters for proper operation and ensuring set points that are consistent with the Commonwealth of Massachusetts plumbing code.
- Disabled water fountains where the potential transmission of COVID-19 is higher. Where possible, water bottle filling stations remain operational.
- For more information on Boston's water quality, please consult the [MWRA 2019 Drinking Water Test Results](#).

Does flushing a toilet spread the transmission of COVID-19?

According to the CDC, there have been no reports to date of fecal-related transmission of COVID-19. Also, it is unclear whether the virus found in feces may be capable of causing COVID-19 or what the risk is that the virus could be spread from the feces of an infected person to another individual. The CDC and WHO consider the risk of fecal-related transmission of COVID-19 low based on data from previous outbreaks of diseases caused by coronaviruses, such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS).

See <https://www.cdc.gov/coronavirus/2019-ncov/faq.html#Spread>

Where can I find more information on BU COVID-19 building maintenance and operation?

The University's [Campus Planning and Operations](#) web site has detailed information on building maintenance and operational changes in response to COVID-19. The [Return to Campus Advisory Services](#) page includes links to [Building Operations](#) where you can find detailed information on cleaning and disinfection protocols, and a list of [Building Coordinators](#) you can contact with questions. You can also [submit a question using an on line form](#) available on the website. Some sections of the website and forms require a BU Kerberos password to access.

Construction Activities

In addition to members of the BU community in our buildings, there are several spaces on campus that will see construction activity. BU construction project managers have developed strategies to ensure the safe conduct of construction activities.

What should I be aware if construction is occurring in my building?

Contractors in our buildings and spaces must follow University guidelines and all projects must develop a project-specific Safety Plan for COVID-19 that addresses the CDC, OSHA, and Commonwealth of Massachusetts guidelines and best practices. The City of Boston and Town of Brookline require contractors to provide written plans outlining their site-specific safety plan and protocols before any work can begin on site.

In addition, the CPO project management team will share with the Building Coordinator the approved COVID- 19 Site Specific Construction Safety and Logistics Plan and CPO project management will communicate on a regular basis, or as needed, with the Building Coordinator as questions might arise.

Contractors will be providing their workers in our buildings with COVID-19 safety training, will limit the number of workers in small workspace areas such as job site elevators and interior spaces under renovation, limit tool sharing, access to handwashing and sanitizing stations, modify work schedules to stagger work, clean and disinfect frequently touched surfaces, designate a safety and health officer to be responsible for responding to COVID-19 concerns at every jobsite, and will inform the University immediately if a worker tests positive. BU Occupational Health will work with the contractor on contact tracing to properly inform BU community members of any potential transmissions.