advanced building solutions

# ARTS NETWORK OTTAWA
# HVAC and Indoor Air Quality Guidelines Study

## Final Report

2021-08-26
Project: 8021-023

**ARTS NETWORK OTTAWA**

**245 CENTRUM BOULEVARD**

**ORLEANS (ONTARIO)**

**K1E 0A1**

**ARTS NETWORK OTTAWA**

**HVAC AND INDOOR AIR QUALITY GUIDELINES STUDY**

Prepared by: Ayman Kassan

Reviewed by: Pedja Corluka, P.Eng.
(PEO no. 100196901)

**TABLE OF CONTENTS**

1. **OBJECTIVE**

1.1 The objective of this study is to review existing HVAC systems serving and Indoor Air Quality (IAQ) guidelines applicable to the five selected Ottawa venues, and provide recommendations to owners on how to mitigate the risk of COVID-19 exposure in view of reopening their spaces to the public.

2. **MANDATE**

2.1 BPA Inc. was engaged by Arts Network Ottawa to complete a study on the existing HVAC systems and IAQ guidelines for five (5) different venues and provide recommendations on mitigating the risk of COVID-19 exposure to the occupants and public having access to those venues.

3. **PROBLEM**

3.1 Coronavirus disease 2019 (COVID-19) is a respiratory illness caused by a new coronavirus. Scientists and researchers are continually gathering new evidence about this disease, including routes of transmission. The virus that causes COVID-19 is spread by respiratory droplets and aerosols that are produced when an infected person breathes, speaks, sings, laughs, sneezes or coughs *(Toronto Public Health, May 2021)*.

3.2 As per the CDC (Centers for Disease Control and Prevention): “Research shows that the particle size of SARS-CoV-2 is around 0.1 micrometer (µm). However, the virus generally does not travel through the air by itself. These viral particles are human-generated, so the virus is trapped in respiratory droplets and droplet nuclei (dried respiratory droplets) that are larger. Most of the respiratory droplets and particles exhaled during talking, singing, breathing, and coughing are less than 5 µm in size.”

3.3 Data suggests that COVID-19 can more easily spread through the air when there are a higher number of people indoors, for a long period of time, with poor airflow or ventilation *(Toronto Public Health, May 2021)*.

4. **CODES AND STANDARDS**

4.1 The following codes, guides and standards were used:

4.1.1 Ontario Building Code (OBC) – 2012 & all revisions.

4.1.2 Ventilation for Acceptable Indoor Air Quality – ASHRAE 62.1-2019.

4.1.3 ASHRAE Fundamentals Handbook - 2017.

4.1.4 ASHRAE Epidemic Task Force (Building Readiness) – 2021.

4.1.5 ASHRAE Epidemic Task Force (Commercial Buildings) – 2021.

4.1.6 Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems Authorized by ASHRAE TC 5.5 – 2020.

4.1.7 In-Room Air Cleaner Guidance for Reducing COVID-19 in Air in Your Space/Room – ASHRAE 2021.

4.1.8 Heating, Ventilation and Air Conditioning (HVAC) Systems in Buildings and COVID-19 – Public Health Ontario 2021.

4.1.9 "Guidance for Building Operations During the COVID-19 Pandemic" – ASHRAE Journal, May 2020.

4.2 Indoor air quality (IAQ) has long been a critical issue for ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) and its members because of the connection to ventilation and other HVAC systems in buildings. ASHRAE's Standards 62.1 (applicable for commercial and institutional buildings) and 62.2 (applicable for residential buildings) intended to support acceptable IAQ and have been the benchmarks for ASHRAE's members and others involved with IAQ (e.g., practitioners; contractors; industrial hygienists) since 1973. ASHRAE has been concerned with all aspects of IAQ through its position documents, other standards and guidelines, conferences, and other similar efforts.

4.3 History of building ventilation:

4.3.1 Recommendations for minimum outdoor air date back to early 19th century when Thomas Tredgold published an estimate of 4 cubic feet per minute per person.

4.3.2 In 1895, the American Society of Heating and Ventilating Engineers, now ASHRAE, adopted a minimum recommendation of 30 cfm per person. In 1914, ASHVE proposed a model code requiring 30 cfm per person as the minimum. By 1925, 22 states had adopted the requirement. The first ASHRAE Standard 62 appeared in 1973. In 1981, the standard was updated and reduced the outdoor air in response to the oil crises and energy conservation concerns. In the 1989, ASHRAE Standard 62.1 was updated, the minimum acceptable ventilation rate increased from 5 cfm per person to 15 cfm/person.

4.3.3 A new methodology for determining ventilation requirements was developed and first included in the 2004 standard. The per person ventilation requirements were selected to control contaminant sources associated with the number of occupants, including but not limited to body odor. The floor area requirements were based on contaminant sources associated with the size of space, such as materials and furnishings.

4.4 ASHRAE's positions are that:

4.4.1 IAQ impacts people's health, comfort, well-being, learning outcomes and work performance. Improved IAQ brings substantial health and economic benefits from a broad public health perspective, as well as to individual building owners and occupants.

4.4.2 The provision of acceptable IAQ is an essential building service and central to ASHRAE's purpose.

4.4.3 Achieving and maintaining good IAQ should be included in all decisions that affect the design and operation of buildings and HVAC systems, including efforts to improve building energy efficiency, sustainability and resiliency.

4.5 Ventilation (outdoor air) requirements and code compliance:

4.5.1 ASHRAE's IAQ standards noted above have been adopted by building codes and regulations, and as such, form part of building code requirements. The OBC (Ontario Building Code) specifically requires that outdoor air rates supplied in buildings by ventilation systems shall not be less than the rates required by ASHRAE 62.1. a

4.5.2 As can be seen from the evolution of the ventilation standard, ventilation system design would vary between existing building depending on the codes and standards applicable at that time. As such, it should not come as a surprise that certain existing buildings and ventilation systems do not meet current codes and standards. Another reason for existing systems not meeting current standards may stem from changes undergone within the buildings, anywhere from extensions, fit-ups, or vocational changes.

4.5.3 Although not obliged to comply with current applicable ventilation standards due to grandfathered laws and due to buildings not undergoing any modifications/renovations, it is highly recommended that building owners and building operators review the existing systems and spaces served, to ensure adequate IAQ for their occupants.

## 5. **IAQ IMPROVEMENT TECHNOLOGIES-METHODS**

5.1 The following guidelines are meant to provide practical information and checklists for how the building should be operating and how to practically check its operation. Actual conditions at any specific building will vary, and the adjustments that should be made will depend on many factors such as local climate, complexity of systems involved and the use, occupancy and activities that occur in and around the building.

5.2 Increase the introduction of air flow and outdoor (fresh) air.

5.2.1 For central air handling units at a building level or serving multiple zones, avoiding recirculation is ideal, e.g., operating on outdoor-fresh air supply as much as possible. Open outdoor air dampers beyond minimum settings to reduce or eliminate HVAC air recirculation. In mild weather, this will not affect thermal comfort or humidity. However, this may be difficult to do in cold, hot, or humid weather.

5.2.2 Rebalance or adjust HVAC systems to increase total airflow to occupied spaces when possible.

5.2.3 Turn off any demand-controlled ventilation (DCV) controls that reduce air supply based on occupancy or temperature during occupied hours. In buildings where the HVAC fan operation can be controlled at the thermostat, set the fan to the “on” position instead of “auto”, which will operate the fan continuously, even when heating or air-conditioning is not required.

5.2.4 ASHRAE recommends operating the HVAC system in occupied mode when people are present in the building, including periods when the building is occupied at partial occupancy. ASHRAE also recommends continuing to run the HVAC system in occupied mode for additional periods pre- and post-occupancy before switching to unoccupied mode; ASHRAE provides a more detailed guidance on determining the duration. ASHRAE and REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations) recommend maintaining normal temperature and humidity setpoints without any night or unoccupied setpoint setbacks.

5.2.5 Recommended inspection and maintenance measures for air-handling systems (including inspection and replacement of filters if applicable) are critical to the optimal operation of ventilation systems. Adjustments to ventilation (e.g., increased outdoor air) may require more frequent inspections and filter changes. System humidifiers should be inspected to ensure they are cleaned, maintained and operating properly.

5.3 Air Filtration

5.3.1 Increase air filtration as high as possible without significantly reducing design airflow. Increased filtration efficiency is especially helpful when enhanced outdoor air delivery options are limited.

5.3.2 ASHRAE recommends that mechanical filter efficiency be at least MERV 13 and preferably MERV 14 or better to help mitigate the transmission of infectious aerosols. Many existing HVAC systems were designed and installed to operate using MERV 6 to MERV 8 filters. MERV 13 and greater filters are better at removing particles in the 0.3 micron to 1-micron diameter size (the size of many virus particles). Higher efficiency filters may require greater air pressures to drive or force air through the filter. To have a clear idea on the system cost, replacing the existing filters for a single roof top unit to MERV 14 filters can cost within the range of $ 700 – $ 1,000 including labor charges.

5.3.3 Outdoor air is free of viral particles. HVAC filters that only filter outdoor air do not need to be upgraded.

5.3.4 Make sure air filters are properly sized and within their recommended service life.

5.3.5 Inspect filter housing and racks to ensure appropriate filter fit and minimize air that flows around, instead of through the filter.

5.3.6 High Efficiency Particulate Air (HEPA) Filters: By definition, HEPA filters are at least 99.97% efficient at filtering 0.3 μm mass medium diameter (MMD) particles in standard tests. HEPA filter efficiency is higher than MERV 16. It is usually not feasible to retrofit existing HVAC systems with HEPA filters due to high pressure drops and the likelihood that systems will need new filter racks to allow sufficient sealing to prevent filter bypass. Adding HEPA filters to systems that are not designed for them may cause significant pressure drops and affects the overall system capacity.

## 5.4 Portable Air-Purification

5.4.1 A dedicated and in-room air cleaner is installed within occupied space rather than in an HVAC system. Presently, there is no evidence to show that air purifiers on their own are effective in reducing the spread of COVID-19 transmission. Portable air cleaners or air purifiers may be useful as a supplement to HVAC ventilation or if there is no outdoor-fresh air supply to the spaces. Ensure the exhaust air of the air purifier is not blowing directly at a person.

5.4.2 Air purifiers or in-room air cleaners should be used when HVAC equipment does not meet ASHRAE recommendations for ventilation and filtration, when removal of contaminants near a source is needed, or where risk activities occur such as health clinics, workout rooms, or public areas.

5.4.3 In-room air cleaners may contain one or more technologies designed to remove or inactivate air contaminants. Media filters, including high efficiency particulate air (HEPA) filters, can remove particles, including those containing viruses and other microorganisms. UV-C (ultraviolet light in the germicidal wavelengths) integrated modules kill or inactivate viruses and microorganisms to make them non-infectious but does not remove them from the air. Technologies such as ionizers, UV-PCO, and many called by other names may claim to remove or destroy multiple types of contaminants but may convert them to other compounds that might be harmful. These technologies are designated by CDC (Centers for Disease Control and Prevention) as emerging technologies without an established body of evidence reflecting proven efficiency under used conditions.

5.4.4 Selection and Sizing Process

- The table below provides a simplified method to select the proper size of air purifier, depending on the room size (square footage = length x width of the room), ceiling height, occupancy density, and the severity of air contamination within the space. Moreover, ASHRAE provides some recommendations to consider during the selection process:

  - Space layout: how is the space arranged? Is there power access? Are there safety issues?

- Noise: check for noise/sound levels (decibel or dBa). The unit may have a high speed and lower speed options. In order to address potential noise issues, running the unit at lower speed may address this concern.

- Confirm that you can locate the unit in your space without the air inlet or outlet being blocked or causing gusts of air that may reintroduce previously settled duct from surfaces or cause discomfort.

- Check for additional technologies you do not want or need. Avoid added technologies that may cause problems or cost more to maintain.

- Particles removal or virus' inactivation: A HEPA air cleaner or higher MERV (Minimum Efficiency Reporting Value) of 13 or more is recommended.

- Prices and availability: be sure to check on the prices and expected lifetimes for replacement filters. The price of a portable air purifier can range from $ 500 to $ 1,500, depending on the manufacturer, size and capacity, used technologies, and features and accessories.

**Air Quality Sizing Guide**

| Severity of Air Contamination | Typical Environment | Maximum Coverage (Square Feet) Based on 8 ft. Ceiling | | |
|---|---|---|---|---|
| | | AirMedic Pro 4 | AirMedic Pro 5 | AirMedic Pro 6 |
| **LIGHT:** occasional pollutants; low population | Residences & Home Offices | 1200 sq. ft. | 1500 sq. ft. | 1800 sq. ft. |
| **MODERATE:** populated; increasing sources of pollutants | Commercial Offices, Waiting Rooms | 400 sq. ft. | 500 sq. ft. | 600 sq. ft. |
| **HEAVY:** constant source of pollutants | Commercial & Industrial | 250 sq. ft. | 300 sq. ft. | 400 sq. ft. |
| **CRITICAL:** constant source of difficult to remove pollutants | Commercial & Industrial with difficult to remove contaminants | 125 sq. ft. | 150 sq. ft. | 200 sq. ft. |

## 5.5 Ultraviolet Germicidal Irradiation (UVGI) Devices

5.5.1 Upper-room UVGI: upper-room (or upper-air) UVGI uses specially designed UVGI fixtures mounted on walls or ceilings to create a disinfection zone of ultraviolet (UV) energy that is focused up and away from people. These fixtures disinfect air as it circulates from mechanical ventilation, ceiling fans, or through natural air movement. The advantage of upper-room UVGI is that it disinfects the air closer to and above people who are in the room. Based on data from other human coronaviruses, a UVGI system designed to protect against the spread of TB should be effective at inactivating SARS-CoV-2 and therefore prevent spread.

- Potential application: can be used in any indoor environment; most useful in spaces highly occupied with people who are or may be sick.

The upper-room UVGI system is sized based on the fixture area coverage. A fixture can cover an area of 150 ft² to 320 ft², depending on the brand and model. The manufacturer or specialist can provide the best options and configurations for your space. Moreover, the cost of an upper-room UVGI system starts from $ 1,000. It will vary by space, square footage and the amount of coverage.

5.5.2 Air disinfection UVGI systems: effective at applying intense UV energy to inactivate airborne pathogens as they flow within the HVAC duct. HVAC air disinfection UVGI systems generally require more powerful UV lamps or a greater number of lamps, or both, to provide the necessary UVGI required to inactivate pathogens in a short period of time. Air disinfection systems are often placed downstream of the HVAC coils. This location keeps the coil, drain pan, and wetted surfaces free of microbial growth while disinfecting the moving air. Adding UV light inside the air handling equipment costs around $ 7,500, including labor charges.

- Potential application: can be used inside any HVAC system to disinfect infectious airborne pathogens.

5.5.3 Ceiling fans with UV-C light: the fan with its UV-C light fixture is a multi-stage clean air system for eliminating airborne viruses and bacteria. In the first stage, a disinfection zone is created above the fan by its UV-C light. As the fans runs, the air is circulated through this zone. In the second stage, as air enters the zone, the constant UV-C rays kill viruses, bacteria, and more while neutralizing odors. The number of UV fixtures, use of mixing fan, and air exchange rate can significantly affect the UV effectiveness. The cost of a fan with the UV-C light technology starts at $ 2,000, depending on the fan manufacturer, model and fan diameter size.

## 6. SUMMARY OF TYPICAL RECOMMENDATIONS

6.1 The owner should consider evaluating their building systems to check that they are operating properly (per design conditions or current operational strategies), are capable of being modified to align with HVAC mitigation strategies, and to identify deficiencies that should be repaired. This could be viewed as tactical commissioning of the systems to determine risk areas for the building operating in epidemic conditions.

6.2 The following recommendations are the basis for the detailed guidance issued by ASHRAE. They are based on the concept that within limits, ventilation, filtration and air cleaners can be deployed flexibly to achieve exposure reduction goals subject to constraints that may include comfort, energy use, and costs. This is done by setting targets for equivalent clean air supply rate and expressing the performance of filters, air cleaners, and other removal mechanisms in these terms.

6.2.1 Ventilation, Filtration, Air Cleaning: for buildings fitted with air conditioning systems:

- Provide and maintain at least the minimum outdoor airflow rates required, specified by applicable codes and standards.
- Use combinations of filters and air cleaners that achieve MERV 13 performance for air recirculated by HVAC systems.

6.2.2 Ventilated spaces with shortage of outdoor airflow: the optimal solution would be to introduce more fresh airflow to the spaces through dedicated outdoor air systems or heat/energy recovery ventilators to overcome the shortage of outdoor air based on the local codes and ASHRAE 62.1 requirements. Whenever it is not possible to add more fresh air, other options can still be considered to improve the air quality during the epidemic:

- Large gathering spaces: consider providing upper-room UVGI systems or ceiling fans with UV-C fixtures.
- Small spaces and office rooms: the best option would be to provide in-room air cleaners or purifiers.
- Spaces with no ventilation: installing ceiling fans with UV-C fixtures can prevent stagnant air and provide air movement to maximize the elimination of pathogens through the UV-C light.

## 7. CONCLUSION

7.1 Airborne transmission of SARS-CoV-2 is significant and should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures. Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. In general, ventilation is improved by more air changes with outdoor air. As stated earlier, ASHRAE standard 62.1 provides minimum ventilation rates for acceptable indoor air quality according to the type of setting, occupancy and area. For optimal solution, enhancing outside air ventilation and/or enhancing filtration where possible, and a well-functioning HVAC system can remove and dilute virus from indoor air, thereby lowering exposure to COVID-19. On the other hand, unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus. Therefore, ASHRAE has provided some complimentary measures based on assessments for specific buildings conditions that are most appropriate and feasible to reduce the risk of viral spread through the air.