Occupational Health Clinics for Ontario Workers Inc.

OHCOW

Centres de santé des travailleurs (ses) de l'Ontario Inc. .on.ca

Prevention Through Intervention • Prévention par l'intervention

Ventilation Checklist

A Pandemic-based Guide to Maintaining Your Building Ventilation System

March 2022

[Version 2.1 Beta]

Prepared for

March 2022

I M P O R T A N T

OHCOW Ventilation Checklist (v2.0) is being released as a beta checklist. In other words we value your feedback and can adjust this guidance after it has been applied to assess and improve ventilation in your workplace.

Please provide your feedback about modifications / improvements to Kevin Hedges (khedges@ohcow.on.ca) so that improvements can be made, and that the guidance is both iterative and practical with continuous improvement.

THE BASICS

Five Things You Can Do About Ventilation

1 Maximize fresh air by boosting intake and limiting recirculation levels

It is important to engage with occupants as well as the Heating, Ventilation, and Air Conditioning (HVAC) technician – or another person who knows the system.

2 Clean any recirculated air through a MERV 13 or higher filter

Minimum Efficiency Reporting Value (MERV) 13 or higher MERV rated filters, clean the air of exhaled aerosols containing the virus that can be inhaled. These particles can linger and accumulate in the air.

3 Determine how many air changes per hour (ACH) each room has and post on the outside of the room

It is important to maximize outside (or sufficiently cleaned / filtered) air to achieve the goal of >6 ACH or 10l/s fresh air per person, whichever is higher.

4 Manage room occupancy and portable air cleaning

Reduce occupancy and activity level where possible. Where needed, boost ACH with appropriately sized portable air purifiers. Refer to CBC Marketplace and Clean Air Crew.

5 Monitor and optimize using carbon dioxide as an indicator

Maintain CO_2 below 800ppm and preferably below 600ppm. If CO_2 is higher, any recirculated air should pass through a (minimum) MERV 13 filter to achieve effective ACH ≥ 6.

Seize opportunities to boost fresh air by opening windows and doors, using fans to assist flow as needed.

Room air filtration may need to be supplemented with appropriately-sized standalone air purifiers.

In addition to the above, OHCOW has a Ventilation Calculation Tool which provides 6 steps to assess and manage the ventilation. These include:

Step 1: Type of Ventilation and Room Setting
Step 2: Room Ventilation Rate and Proportion of Outdoor Air
Step 3: Determining Filters Used and Proper Fit
Step 4: Portable Air Filters and CADR Numbers and Noise Levels
Step 5: Supplementary Fan(s) and Typical Noise Patterns
Step 6: Final Results for Posting Outside Door

Introduction

"The most common way COVID-19 is transmitted from one person to another is through tiny airborne particles of the virus hanging in indoor air for minutes or hours after an infected person has been there. While there are various strategies for avoiding breathing that air – from remote work to masking – we can and should talk more about how to make indoor environments safer by filtering or cleaning air."

Dr. Alondra Nelson, Head of the White House Office of Science and Technology Policy and Deputy Assistant to the President

From Let's Clear the Air on COVID (35)

The following **Ventilation Checklist** can be used as a guide to assess and improve ventilation in rooms and buildings. It is recommended for Joint Health and Safety Committee members, Health and Safety Representatives, Managers, Supervisors and Workers since everyone has an interest in clean air as a part of a healthy workplace.

Pertinent questions are suggested that can be used to assess the suitability of ventilation in the workspace/building that is to be occupied. It follows the traditional health and safety R.A.C.E. framework:

Recognize • **A**ssess • **C**ontrol • **E**valuate

Ventilation Review Checklist (COVID-19)

Indicate: ✓ Complete ✗ Incomplete

1. RECOGNIZE

1.1 Occupant Knowledge

Have you spoken with occupants to find out if there are perceptions of stagnant air and/or odours, and if there are any issues around indoor discomfort?

GUIDANCE:

- If odours are present in a space (or in the building as a whole), facility management or a consultant should be asked to check into it.
- Typical odour sources might include: garbage or trash, rodents or insect nests, stagnant water collected somewhere (e.g., in a wet carpet), rotting plants, spoiled food, mould growths in carpets or walls, dirty ductwork, and dirty kitchens or break rooms. Remove or control such sources.
- Where there is stagnant air – improve air mixing / circulation where possible.
- Regularly check with occupants of the space to see if they feel comfortable with the environment and are not feeling ill in any way.
- Always follow up on any complaints or reported feelings of being ill or irritated while present in the building.

NOTES:

1.2 HVAC System Status (preliminary check)

Through discussion with an HVAC technician:

- ❑ ***Is it running properly?***
- ❑ ***What service does it need?***
- ❑ ***Does anything need to be done to make the system work more effectively?***
- ❑ ***Are the Plans and Specifications available for review, just in case?***

GUIDANCE:

- Check in with the person* in charge of the day-to-day operation of the heating, ventilating and air conditioning (HVAC) system.
- As a minimum, refer to Core Recommendations (2) by ASHRAE.
- See also Coronavirus (COVID-19) Response Resources (3) from ASHRAE and others.

- Where possible engage with an Occupational Hygienist (Registered or Certified) or Ventilation Engineer (P.Eng.), depending on the scale of operation:
  - Occupational Hygiene Association of Ontario (OHAO) list of consultants (4)
  - Canadian Registration Board of Occupational Hygienists (CRBOH) consultants directory (5)

* building owner and/or property manager, etc.

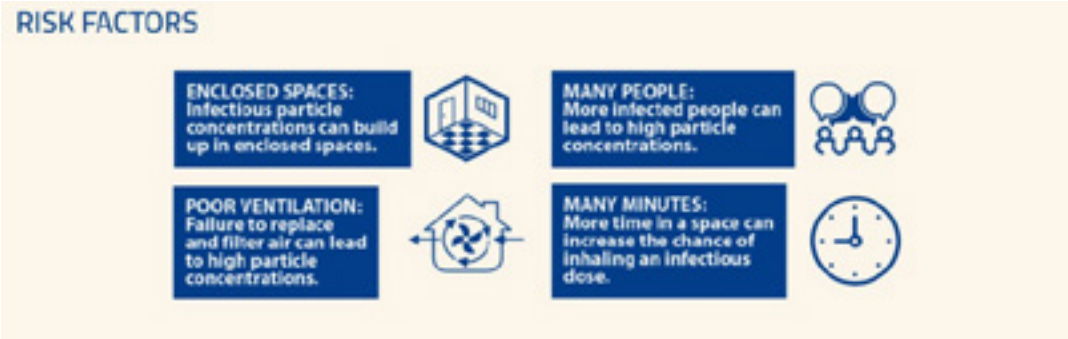
NOTES:

1.3 Need / Risk Assessment

Have you carried out a risk assessment of the different workspaces to determine where more improvements to ventilation are needed?

GUIDANCE:

Identify spaces of concern based on # people, stuffiness/enclosure, activity level, operational demands/"need"



Think about duration (time spent in locations) and activity (such as heavy exercise – gyms).

Community transmission is important to help inform about the level of risk.
See OHCOW's Regional Risk Tool.

NOTES:

1.4 Review Tool

Have you found a review tool that works for you?

GUIDANCE:

- The WHO Roadmap can be consulted for advice on "how to improve ventilation":

  a) There are straightforward process flow diagrams that cover:
  - Health care settings including quarantine facilities
  - Non-residential settings
  - Residential settings including homes and self-quarantine at home

  b) Series of **Yes / No** questions are asked.

  c) Includes a technical document to help users analyze building HVAC systems in order to implement, if required, the different strategies proposed to improve HVAC's ability to mitigate and reduce the risk of COVID-19 transmission

- The British Occupational Hygiene Society, and the Chartered Society for Worker Health Protection have developed a free, online Ventilation Tool – Breathe Freely (6) to help limit the transmission of COVID-19 in workplaces.
- Also: ACGIH COVID-19: The Virus is in the Air and ACGIH COVID-19 Resources (7)
- A useful way to stratify and control the risk is by using a process known as control banding. The fact sheet provided by the ACGIH about Control Banding explains a qualitative approach to risk and exposure assessment that can be used to determine the degree of risk (control band) associated with a particular job, workplace or activity. The band describes a control hierarchy that prioritizes source and pathway over receiver controls.

NOTES:

2. ASSESS

Maintenance

2.1 Health and Safety Procedures

In advance of an investigation determine if there are proper health and safety procedures in place for contractual / maintenance personnel working on HVAC systems, including an operational and situational risk assessment?

GUIDANCE:

- Refer to Building Engineering Services Association (BESA). Technical Bulletin TB / 048 / 2: COVID-19 and air-conditioning systems. 2 April 2020. (29)

NOTES:

2.2 Grills and Registers

Have you checked all of the supply and return grilles and registers to be sure they are open, operating properly and that air is flowing through them when the system fan is on?

GUIDANCE:

- Check outdoor air intakes to assure that they are clean, open and not blocked by bushes, defective louvres, etc.
- If reviewing drawings, make sure room divisions and walls plus diffusers and returns are located on drawings.

NOTES:

2.3 Ventilation System Filters

A) Intake Filters:

- ❑ ***Are the filters clean?***
- ❑ ***Are they rated at the highest efficiency the system is capable of handling?***
- ❑ ***Are the filters within their service life?***
- ❑ ***Are the filters appropriately installed?***
- ❑ ***Has a check been carried out to make sure there is a seal around the edge of the filters to ensure that there is no by-pass (short-circuit) of air?***

GUIDANCE:

- Air will take the path of least resistance, so ensuring no leakage around or through the filter remains critical.
- See Prof. Jeffrey Siegel, University of Toronto, in OHCOW webinar: Infection Control – Air Cleaning and Filtration in the Age of COVID-19 (22)
- See also More Important than Ever: Air Treatment in the Age of COVID-19 (36).

NOTES:

B) Recirculation Air Filters

- ❑ ***Are the filters clean?***
- ❑ ***Are they rated at the highest efficiency the system is capable of handling?***
- ❑ ***Are the filters within their service life?***
- ❑ ***Are the filters appropriately installed?***
- ❑ ***Has a check been carried out to make sure there is a seal around the edge of the filters to ensure that there is no by-pass (short-circuit) of air?***
- ❑ ***Can (recirculation air) filters be upgraded to MERV 13 or higher filter rating?***

GUIDANCE:

- See National Air Filtration Association (NAFA) COVID-19 (Corona Virus) and Air Filtration Frequently Asked Questions (FAQs) (20)

NOTES:

2.4 Maintenance, Inspection and Duct Cleaning

Is there a program of duct cleaning, inspection and maintenance?

GUIDANCE:

- The standard ANSI/ASHRAE 180-2018, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems (26) covers good practices for inspecting and maintaining HVAC systems for the purpose of providing good air quality. The standard can help determine whether cleaning should be performed. It also includes a required inspection and maintenance tasks section (5) and table 5.1 (Air Distribution Systems) and table 5.2 (Air Handlers) checklist.
- Check to be sure there are no water leaks.
- Check if complying with codes (e.g. ANSI/ASHRAE).
- Detailed information on the ductwork cleaning work planning and equipment is available in REHVA Guidebook 8. (28)

NOTES:

Air Flow

2.5 A) Air Changes / Hour (ACH)

Are the air changes per hour (ACH) for each room determined and adequate? Aim for at least 6 ACH (or higher with more people or activity) – 10l/s fresh air at minimum.

GUIDANCE:

Refer to OHCOW Ventilation Calculator (17) – An Excel-based tool to assist you in determining the adequacy of the ventilation in your workspace. Can be used to evaluate classrooms, single offices and small meeting rooms. The levels in this tool are based on classroom occupancies.

NOTES:

B) Ventilation Estimate

Can an estimate of ventilation be carried out, if the required information isn't readily available?

GUIDANCE:

- Refer to AIHA Six Ways to Approximate Airflow (1)

NOTES:

2.6 Fresh Air Changes / Hour (ACH)

Can outdoor air ventilation be increased (disable demand-controlled ventilation and open outdoor air dampers to 100% when indoor and outdoor conditions permit)?

GUIDANCE:

- Refer to Burton, J. 2022, A Ventilation Checklist – Helping Control Airborne Disease Transmission in Non-Healthcare Facilities (18)

NOTES:

3. CONTROLS

Operational

3.1 Ventilation Rate

- ❑ ***Can the ventilation rate be increased by providing more air to highly or continuously occupied rooms?***
- ❑ ***Where practical, can the system be run for longer hours (e.g. 24/7) to enhance air changes in the building space?***

GUIDANCE:

- Where not possible, reduce occupancy.
- Be sure the HVAC system is on and running whenever someone is present in the building.
- If necessary, set the fan to “On” or “Circulate” at the thermostat if the HVAC system does not provide a constant airflow all the time people are present.
- Set the outdoor air (OA) intakes or controls to the maximum level of fresh outdoor air the system is capable of handling or providing. (This usually depends on weather, season, operating costs, etc.)
- For Variable Air Volume (VAV) systems, be sure the minimum airflow is set to the highest possible setting.
- Provide more fresh outside air where the risk is greater (see question 2, also note above question 7).

NOTES:

3.2 Airflow Direction

Can the airflow direction be transferred from less occupied spaces to more occupied spaces?

GUIDANCE:

- Refer to REHVA Federation of European Heating Ventilation and Air Conditioning Associations. (27)

NOTES:

3.3 Humidity

Is the Relative Humidity (RH) at least 30% and preferably between 35% and 60%?

GUIDANCE:

- Check system humidifiers to be sure they are clean, operating properly and providing an in-room relative humidity of about 35-60%. Aim for at least 30% RH if 35% is difficult to achieve.
- Humidifiers may be necessary.

NOTES:

3.4 Ventilation Modifications

Have you worked with building maintenance staff to determine if the ventilation system can be modified to increase ventilation rates or the percentage of outdoor air that circulates into the system?

GUIDANCE:

- Ensure ventilation systems operate properly and provide acceptable indoor air quality for the current occupancy level for each space.
- In buildings where the HVAC fan operation can be controlled at the thermostat, set the fan to the "on" position instead of "auto," to operate the fan continuously, even when heating or air-conditioning is not required.
- Turn off any demand-controlled ventilation (DCV) controls that reduce air supply based on occupancy or temperature during occupied hours.
- Extend operating times In buildings with mechanical ventilation systems
- Preferably keep the ventilation on 24/7, with lowered (but not switched off) ventilation rates when people are absent.
- Start ventilation at nominal speed at least 2 hours before the building usage time and switch to lower speed 2 hours after the building usage time.
- Where in-demand ventilation systems cannot be converted: change CO_2 set point to lower, 400 ppm value
- Use fans judiciously to increase the effectiveness of open windows. Avoid placing fans in a way that could potentially cause contaminated air to flow directly from one person to another. Ideally, use a securely placed window fan, to exhaust room air to the outdoors drawing outdoor air into the room via other open
- Windows and doors, without generating strong room air currents.

NOTES:

Special Ventilation – Kitchens

- Inspect and maintain exhaust ventilation systems in areas such as kitchens, cooking areas, etc. Check kitchen exhaust hood ventilation systems to be sure they are operating properly and exhausting air to the outside. Operate whenever occupied or more frequently as able. (If kitchen exhaust systems recirculate, ensure that have very good filters.)
- Where feasible, generate clean-to-less-clean air movement.

NOTES:

Special Ventilation – Washrooms

- Keep washroom exhaust ventilation systems on 24/7, and make sure that negative-pressure is created, especially to avoid the faecal-oral transmission.
- Avoid any open windows in washrooms with mechanical exhaust systems which may cause a contaminated airflow back to other rooms.
- If there is no adequate exhaust ventilation from washrooms and window airing in washrooms cannot be avoided, it is important to keep windows open also in other spaces in order to achieve cross flows throughout the building.
- Increase outdoor air. Even a slightly open window can be beneficial – except in washrooms or if ventilation balancing does not permit it.

NOTES:

3.5 Shutdown

Can the HVAC system be maintained and continue to be operated even during periods of "shut down" where there is a likelihood of intermittent occupancy (during shutdown) or occupancy in the future?

NOTES:

3.6 Integrity of Water Supply

Have you ensured the integrity of the water supply system after a prolonged shutdown since standing water may lead to microbial contamination of the HVAC system?

GUIDANCE:

- Legionella and Legionellosis (Legionnaires disease and Pontiac fever)
- Stagnant or standing water in a plumbing system can increase the risk for growth and spread of Legionella and other biofilm-associated bacteria. When water is stagnant, hot water temperatures can decrease to the Legionella growth range (77-113°F, or 25-45°C). Stagnant water can also lead to low or undetectable levels of disinfectant, such as chlorine. Ensure that your water system is safe to use after a prolonged shutdown to minimize the risk of Legionellosis and other diseases associated with water.

NOTES:

3.7 Portable Room Air Cleaners

Can portable room air cleaners be added with HEPA or MERV13 or 13+ filters based on room size and clean air delivery rate (CADR)?

GUIDANCE:

- Portable air cleaners can be very effective at cleaning virus particles from room air.
- Match to room size and activity level; measure room volume to account for height as well as length and width.
- Look for validated CADR by Association of Home Appliance Manufacturers (AHAM) (38). Note based on operating on high which can be noisy.
- Avoid add on devices such as ionizers.
- Filters need to be changed at reasonable intervals ~6m) depending on use and environmental conditions.
- Corsi-Rosenthal DIY filter/fan boxes (39) have been reviewed by UL and 3M (40) and determined to be safe and effective.
- Good review by Dr. Jeff Siegel on CBC Marketplace in February 2021. Is an $800 purifier best to clean your home's air? Marketplace tested 5 top brands and their claims (23)
- See the presentation and slides by Jim Rosenthal, Tex-Air Filters. Using Ventilation and Filtration to Help Fight SARS-Cov-2 (25)
- Collection of tips & tools for an airborne pandemic, #CleanAirCrew, #COVIDisAirborne (24)
- A do-it-yourself (DIY) box fan air filter is effective (44)

NOTES:

Administrative

3.8 Occupancy

Where possible can you ensure that offices are not occupied by more than one person at a time, with a gap between users?

NOTES:

3.9 Windows

Can more windows be opened allowing natural and fresh outside air without impeding relative humidity and temperature? (with the exception of washrooms where exhaust fans are operating)?

GUIDANCE:

- Ventilation can still be improved by assigning a "**COVID Guardian**" to open windows for ten minutes every hour.
- When using free-standing fan (e.g., pedestal fans, floor fans, wall fans, desk fans) to cool a person or to help mix the air in the space, try to avoid having the fan blow from one person directly past another. These standalone fans can be placed adjacent to open windows to help draw more fresh air in through the windows.
- Fans inserted into windows (exhausting out) will also assist with the provision of more fresh air.

NOTES:

3.10 Lunch and Break Rooms

Is special attention being given to improve ventilation in lunch rooms, break rooms and other common areas where people mix and congregate both socially and in meetings?

GUIDANCE:

- Special ventilation in congregate settings where people mix.
- Depending on the level of mechanical ventilation additional air purifiers should be considered to supplement the ventilation. Consider maximum occupancy when deciding where to improve ventilation.

NOTES:

3.11 Design

Have you reviewed system and room design for the possibility of ultraviolet germicidal irradiation (UVGI) disinfection which can provide effective air cleaning within occupied spaces with sufficient exposure time?

GUIDANCE:

- Before installing UV systems ensure that the use and maintenance does not pose a risk to health. See Considerations on the Safe use of UVC Radiation for Surface and Air Disinfection (41).
- Far-UVC (222 nm) efficiently inactivates an airborne pathogen in a room-sized chamber (43).

NOTES:

4. EVALUATION

4.1 Carbon Dioxide (CO_2)

Can carbon dioxide (CO_2) be utilized as another tool to assess the adequacy of ventilation and indicate where improvements are required?

GUIDANCE:

- For background information including limitations for CO_2 monitoring, refer to:
  - UK: Scientific Advisory Group for Emergencies (SAGE) (30)
  - EMG and SPI-B: Application of CO_2 monitoring as an approach to managing ventilation to mitigate SARS-CoV-2 transmission, 27 May 2021 (31)
  - ASHRAE Position Document on Indoor Carbon Dioxide (42)

NOTES:

4.2 Respiratory Protection

Has a systematic / risk based / objective approach been taken to determine workplaces and activities that require properly selected respiratory protection and the implementation of a respiratory protection equipment program (RPE) in accordance with CAN/CSA-Z94.4-18 Selection, use, and care of respirators*?

GUIDANCE:

- Consult CAN/CSA-Z94.4-18 Selection, use, and care of respirators* to determine the level of respiratory protection that is required.
- Generally, across most place workplaces, filtering facepiece respirators (FFR) with N95 filters or better are needed where there is a risk of exposure.
- **Note** – *Elastomeric Half Mask Respirators (EHMR) are better. In some situations (high risk) powered air purifying respirators (PAPR) will be required.*
- Refer to the tool provided by IRSST – Support Tool for Choosing Respiratory Protection against Bioaerosols in the Workplace (33)
- See also Brosseau, LM 2020, Are Powered Air Purifying Respirators a Solution for Protecting Healthcare Workers from Emerging Aerosol-Transmissible Diseases? Annals of Work Exposures and Health, Volume 64, Issue 4, May 2020, (p.339–341)(34)

  * view access is available in Canada.

NOTES:

Appendix 1

General Recommendations for Ventilating

1. Clean HVAC unit and ensure proper maintenance and filter changes regularly.
2. Ensure building and exhaust fans run continuously (e.g. thermostat setting at “ON” instead of “AUTO”) to maximize the amount of fresh and filtered air.
3. Boost washroom ventilation and air changes.
4. Keep windows open whenever possible if it doesn’t interfere significantly with HVAC’s operation.
5. Review **Ventilation Checklist** with JHSC/HSR & HVAC technician / P.Eng.
6. Maintain relative humidity between 35-60% where feasible.
7. Adjust the ventilation system to optimal outdoor air supply (adjust thermostat to allow for less temperature control during weather extremes) – to ensure occupant originating CO_2 levels are 500-800 ppm (lower better).
8. Install minimum of MERV 13 or 14 filters – check to ensure air volume is not significantly compromised.
9. Use one or more portable MERV 13, 14 or HEPA air filters if ventilation can’t be increased, they are suitably sized and adequately maintained.
10. Organize washroom break schedules to allow distancing and leave time between users to allow air movement.
11. Consider UV disinfection in air handling units with appropriate safety precautions.
12. Keep ventilation in building running on low even when unoccupied and/or several days before re-entry.
13. Provide suitably sized and placed air purifiers.

* Where additional ventilation is required the ventilation can be supplemented by air purifiers. Refer to “marketplace” for selecting air purifiers https://www.cbc.ca/news/business/portable-air-purifier-tests-marketplace-1.5900782. The Clean Air Crew is another useful resource which includes a Portable Air Cleaner (HEPA filter) buying guide.

Alternatively, a Corsi-Rosenthal box, the DIY method of building your own air filter with MERV13 furnace filters and a box fan are an easy and cost-effective way to help clear indoor air from airborne virus particles!

Appendix 2

Additional Resources and Recommendations

See also Engineering Controls for Bioaerosols in Non-Industrial/ Non-Healthcare Settings (ACGIH, 2021).

The Government of Canada (Public Health Agency of Canada (PHAC)) has developed a guide to inform Canadians about how indoor ventilation, in combination with other recommended public health measures, can reduce the spread of COVID-19. See: COVID-19: Guidance on indoor ventilation during the pandemic.

Each location will have its own unique building system ventilation requirements. There will also be varied recommendations based on the relative risk of COVID-19 transmission within the region/community. The following recommendations should be considered a starting point for assessment and discussion with location facility management as well as staff that work in the office or office environment.

More stringent control measures including priority to upgrade existing ventilation, should also consider local community transmission. OHCOW's Regional Risk Tool should be referred to first along with OHCOW's Ventilation Checklist.

Also incorporated into the OHCOW Ventilation Checklist is the OHCOW Ventilation Calculator which provides a tool which is an excel-based tool to assist in determining the adequacy of the ventilation in a workspace.

More detailed information is provided as follows:

American Conference of Governmental Industrial Hygienists (ACGIH)

The American Conference of Governmental Industrial Hygienists (ACGIH) has a 1) White Paper on Engineering Controls for Bioaerosols in Non-Industrial/Non-Healthcare Settings and 2) White paper on Ventilation for Industrial Settings during the COVID-19 Pandemic. APPENDIX A DECISION MATRIX FOR CONTROL MEASURES (1) provides a useful risk control matrix that can be used to guide towards what controls are required.

American Society for Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

The American Society for Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) has formed an Epidemic Task Force to follow the COVID-19 pandemic situation and produce position statements and documents related to recommendations for ventilation systems with the intent to mitigate viral transmission. Their guidance documentation may be found on ASHRAE's technical resource page.

World Health Organization (WHO)

More recently the World Health Organization (WHO) has developed "Roadmap to improve and ensure good indoor ventilation in the context of COVID-19" (WHO, 2021). Each clinic should go through the process flow diagram in section 6.1 to look for opportunities to improve ventilation.

Basic guidance on how to protect workers can be found in:

The Ontario Federation of Labour (OFL) Follow the science. Enforce the law. Protect workers [https://ofl.ca/wp-content/uploads/2021.06.04-FollowTheScience-COPE.pdf]

Refer to the risk factors – Five C's of Airborne COVID-19:

1. **C**rowded places,
2. **C**lose contact,
3. **C**ontinuous or repetitive spaces,
4. **C**losed spaces,
5. **C**old indoor air temperatures.

Ventilation is one layer in a multi-layered approach. Improved ventilation will help break the path of transmission. A risk matrix has been developed by the British Occupational Hygiene Society (BOHS) to help guide control options. A simple tool provided by the British Occupational Hygiene Society (BOHS) will help prioritize where improvements should be made to ventilation. See: BOHS Simple Ventilation Self-Help Guide for Workplaces During the Coronavirus Pandemic.

Another useful, qualitative, simple to use tool is the US Harvard Healthy Buildings COVID-19 Risk Calculator.

This tool is primarily designed to provide insight into the effectiveness of various control strategies and impacts of human behaviors on infection risks in indoor environments rather than providing exact estimates of absolute risk. It is based on several super-spreading events, which may result in overestimates of the risk that people face in typical indoor environments.

More recently the COVID-19 International Research Team in partnership with others, including The Integrated Bioscience and Built Environment Consortium (IBEC), AIHA, and CDC under the global Commit to C.A.R.E. public education initiative have released the SARS-CoV-2 Exposure Assessment Tool.

Factors Assessed by Tool include:

- the emission rate of virus,
- viral aerosol degradation and removal,
- duration of activity/exposure,
- inhalation rates,
- ventilation rates (indoors and outdoors),
- volume of indoor space,
- HVAC filtration removal efficiency,
- mask use and effectiveness,
- distance between people,
- group population's adherence to public health guidance,
- size of the group, and
- prevalence of infection (including variants) and immunity in the population.

The nomogram model (in this tool) can be broadly applied to many situations (i.e., worker safety, public events, and schools). The model's results are aligned with the United States Occupational Safety and Health Administration (US OSHA) classifications of exposure risks, by benchmarking the exposure calculations to a baseline scenario that is considered high risk by US OSHA. The baseline scenario represents a person (i.e., medical worker) who is exposed in close proximity to a COVID-19 infected person.

References

1. Refer to Six Ways to Approximate Airflow (aiha.org) [https://synergist.aiha.org/201807-six-ways-to-approximate-airflow]
2. Core recommendations [https://www.ashrae.org/file library/technical resources/covid-19/core-recommendations-for-reducing-airborne-infectious-aerosol-exposure.pdf] by ASHRAE.
3. Coronavirus (COVID-19) Response Resources from ASHRAE and others.
4. Occupational Hygiene Association of Ontario (OHAO) List of Consultants [https://www.ohao.org/index.php/consultantdirectory/consultants-listing]
5. Canadian Registration Board of Occupational Hygienists (CRBOH) Consultants Directory [https://crboh.ca/consultant-directory/]
6. Health and Safety Executive (HSE) BOHS Simple Ventilation Self-Help Guide for Workplaces During the Coronavirus Pandemic [https://breathefreely.org.uk/ventilation-tool/]
7. ACGIH COVID-19 Resources [https://www.acgih.org/covid19/], The Virus is in the Air [https://www.acgih.org/covid-19-fact-sheet-virus-in-air/], and:
    a. Ventilation for Industrial Settings During the COVID-19 Pandemic (revised June 2021)[https://1lnfej4c7wie44voctzq1r57-wpengine.netdna-ssl.com/wp-content/uploads/2021/07/ASHRAE-ACGIH-COVID-19-White-Paper_2021-07-26.pdf]
    b. Engineering Controls for Bioaerosols in Non-Industrial/ Non-Healthcare Settings (revised June 2021) [https://1lnfej4c7wie44voctzq1r57-wpengine.netdna-ssl.com/wp-content/uploads/2021/07/ACGIH-COVID-19-Engineering-Controls-White-Paper_2021-07-13a.pdf]
8. AIHA COVID-19 Resources [https://www.aiha.org/public-resources/consumer-resources/aiha-covid-19-pandemic-efforts]
9. OHCOW Ontario COVID-19 Regional Risk Tool [https://www.ohcow.on.ca/covid-19/regional-risk-tool-tips/#ventilating]
10. ACGIH COVID-19: Control Banding Can Identify Infection Risks and Interventions [https://www.acgih.org/covid-19-fact-sheet-control-banding/]
11. WHO Roadmap in how to improve ventilation [https://www.who.int/publications/i/item/9789240021280].
12. CDC Ventilation in Buildings and tools to improve ventilation [https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html#:~:text=Open%20windows%20and%20doors%2C%20when,can%20introduce%20beneficial%20outdoor%20air.]
13. CDC Ventilation FAQs. What is a HEPA filter and why use a portable air cleaner [https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html#refphf]
14. CDC FAQ on Directional Airflow [https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html]
15. CDC Upper-room UVGI systems [https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html]
16. CDC Reopening Buildings After Prolonged Shutdown or Reduced Operation [https://www.cdc.gov/nceh/ehs/water/legionella/building-water-system.html]
17. OHCOW Ventilation Calculation Tool [https://www.ohcow.on.ca/covid-19/ventilation-calculation-tool/#1636726803734-5e447b6e-34ec]
18. Burton, J 2022, A Ventilation Checklist Helping Control Airborne Disease Transmission in Non-Healthcare Facilities [https://synergist.aiha.org/202012-a-ventilation-checklist]
19. Federation of European Heating Ventilation and Air Conditioning Associations. REHVA Covid 19 Guidance [https://www.rehva.eu/activities/covid-19-guidance]
20. National Air Filtration Association (NAFA). COVID-19 (Corona Virus) and Air Filtration Frequently Asked Questions (FAQs) [https://www.nafahq.org/covid-19-corona-virus-and-air-filtration-frequently-asked-questions-faqs/#Doesn%E2%80%99t%20filtration%20require%20that%20the%20droplets%20that%20cause%20COVID-19%20be%20airborne?;%20I%20have%20heard%20that%20it%20is%20large%20droplets.]
21. World Health Network [https://www.worldhealthnetwork.global/holiday-flyer/]
22. Siegel, J. OHCOW Webinar: Infection control – Air cleaning and Filtration in the Age of COVID-19 [https://www.ohcow.on.ca/events/occ-covid-webinar-series/]
23. CBC Marketplace tested 5 top brands and their claims: Is an $800 purifier best to clean your home's air? [https://www.cbc.ca/news/business/portable-air-purifier-tests-marketplace-1.5900782]

24. Collection of tips & tools for an airborne pandemic:
    - cleanaircrew.org [https://cleanaircrew.org/]
    - #CleanAirCrew [http://twitter.com/search?q=%23CleanAirCrew], #COVIDisAirborne [http://twitter.com/search?q=%23].
25. Using Ventilation and Filtration to Help Fight SARS-Cov-2 [https://www.ohcow.on.ca/wp-content/uploads/2021/10/Using-Ventilation-and-Filtration-to-Help-Fight-SARS-Cov-2.pdf]. Presentation and slides by Jim Rosenthal, Tex-Air Filters.

    See also OCC-COVID Webinar Series: Science, Solutions and Success Stories [https://www.ohcow.on.ca/events/occ-covid-webinar-series/#1642444279114-dae5283b-4af4]
26. ANSI/ASHRAE 180-2018, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems [https://www.ashrae.org/technical-resources/bookstore/standards-180-and-211]
27. Federation of European Heating and Ventilation and Air Condition Associates (REHVA). Are there any additional precautions advisable when carrying out a routine ventilation ductwork cleaning? [https://www.rehva.eu/activities/covid-19-guidance/rehva-covid-19-faq]
28. Detailed information on the ductwork cleaning work planning and equipment is available in REHVA Guidebook 8. [https://www.rehva.eu/eshop/detail/cleanliness-of-ventilation-system]
29. Building Engineering Services Association (BESA). Technical Bulletin TB / 048 / 2: COVID-19 and Air Conditioning Systems. REFCOM Building Engineering Services Association, 2 April 2020, [https://www.thebesa.com/media/837542/technical-bulletin-tb-048-2-refcom-updated.pdf]
30. UK Scientific Advisory Group for Emergencies (SAGE) [https://www.gov.uk/government/organisations/scientific-advisory-group-for-emergencies]
31. EMG and SPI-B: Application of CO_2 monitoring as an approach to managing ventilation to mitigate SARS-CoV-2 transmission, 27 May 2021 [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/992966/S1256_EMG_SPI-B_Application_of_CO2_monitoring_as_an_approach_to_managing_ventilation_to_mitigate_SARS-CoV-2_transmission.pdf]
32. CAN/CSA-Z94.4-18: Selection, use, and care of respirators
    * view access is available in Canada
33. Support Tool for Choosing Respiratory Protection against Bioaerosols in the Workplace (IRSST). [https://www.irsst.qc.ca/en/institute/medias/news-releases/id/281/support-tool-for-choosing-respiratory-protection-against-bioaerosols-in-the-workplace]
34. Brosseau, LM 2020, Are Powered Air Purifying Respirators a Solution for Protecting Healthcare Workers from Emerging Aerosol-Transmissible Diseases? Annals of Work Exposures and Health, Volume 64, Issue 4, May 2020, Pages 339–341. [https://academic.oup.com/annweh/article/64/4/339/5802550]
35. Let's Clear the Air on COVID [https://www.whitehouse.gov/ostp/news-updates/2022/03/23/lets-clear-the-air-on-covid/]
36. More Important than Ever: Air Treatment in the Age of COVID-19 [https://www.ohcow.on.ca/posts/occ-covid-air-treatment/]
37. Infection Control – Air Cleaning and Filtration in the Age of COVID-19 [https://www.ohcow.on.ca/posts/occ-covid-infection-control/]
38. Association of Home Appliance Manufacturers (AHAM) [https://www.aham.org/]
39. Corsi-Rosenthal DIY filter/fan boxes [https://en.wikipedia.org/wiki/Corsi%E2%80%93Rosenthal_Box]
40. 3M [https://news.3m.com/2022-02-24-3M-scientists-This-Corsi-Rosenthal-box-movement-is-legit]
41. Considerations on the Safe use of UVC Radiation for Surface and Air Disinfection [https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/Public-Resources/UVC-RadiationInfographic_V6.pdf]
42. ASHRAE Position Document on Indoor Carbon Dioxide [https://www.ashrae.org/file%20library/about/position%20documents/pd_indoorcarbondioxide_2022.pdf]
43. Far-UVC (222 nm) efficiently inactivates an airborne pathogen in a room-sized chamber [https://www.nature.com/articles/s41598-022-08462-z]
44. A do-it-yourself (DIY) box fan air filter is effective [https://www.tandfonline.com/doi/full/10.1080/02786826.2022.2054674?journalCode=uast20]