Revised on 06 Apr 2023

UPDATED GUIDANCE NOTE ON IMPROVING VENTILATION AND INDOOR AIR QUALITY IN BUILDINGS FOR A HEALTHY INDOOR ENVIRONMENT

1. Introduction

1.1. Poor indoor air quality can have direct and significant impact on the health of occupants in a building. The risk of airborne infectious disease transmission is higher in poorly ventilated spaces, and exposure to particulate or chemical pollutants can lead to short and long-term health effects, including irritation of the eyes, nose, and throat, and respiratory and cardiac diseases. Maintaining good ventilation and indoor air quality in buildings continues to be important beyond the COVID-19 pandemic.

1.2. This updated Guidance Note provides building owners and facilities managers with recommended measures to enhance ventilation and air quality in indoor spaces to maintain a healthy indoor environment, through the proper operations and maintenance of air-conditioning and mechanical ventilation (ACMV)[1] systems. Earlier versions of this document, focused on measures appropriate for the acute phase of the pandemic, were issued on 26 Sept 2021, 25 May 2021 and 29 May 2020.

1.3. This Guidance Note applies to all non-residential premises where air-conditioning is used intermittently or continuously, as well as to naturally ventilated premises, with the exception of specialised premises[2] such as certain factory production areas, hospitals, polyclinics, and laboratories. Advice from subject matter experts and specialists should be sought for these specialised premises to improve ventilation.

1.4. Occupants of residential homes may improve home ventilation by opening doors and windows. Fans can be used to promote air circulation when needed.

1.5. A comprehensive plan for commercial and public area should be developed and reviewed regularly to improve ventilation and indoor air quality to mitigate the risk of transmission of airborne pathogens, as well as reduce risk of exposure to airborne chemical pollutants and particulate matter. Facilities managers should tailor the measures to each space, ensuring adequate ventilation while taking factors such as the type of ventilation system in the indoor space, number of people relative to the area of the indoor space, occupants' thermal comfort, and relative humidity into consideration. Indoor air quality should be closely monitored and maintained according to Singapore Standard SS554:2016 Code of Practice for Indoor Air Quality for Air-Conditioned Buildings.

2. Measures for air-conditioned premises with mechanical ventilation provision (e.g. centralised air-conditioning system)

2.1. Ensure that ventilation systems are in good working condition:

a. Check ACMV systems to ensure adequate ventilation in all occupied spaces, based on the minimum outdoor air supply rates specified in Singapore Standard SS553:2016 Code of Practice for Air Conditioning and Mechanical Ventilation in Buildings[3]. Use of sensors and systems for monitoring outdoor air supply rate should be considered.

b. Check AHUs/FCUs/PAUs/FAFs/EAFs[4] daily to ensure proper operation, especially in occupied spaces.

c. Check all supply air diffusers and exhaust grilles to ensure airflow movement is in the correct direction.

d. Maintain ACMV systems regularly. This includes inspecting and cleaning supply fans and exhaust fans to ensure optimal operation, checking air ducts and dampers to ensure no air leakages or blockages, and checking filter seals to avoid air bypass. Recommended maintenance frequencies are specified in SS554:2016 Annex H. Replacement of filters should be done during non-operational periods, with the ACMV system turned off. Used filters should be properly disposed of in sealed bags. Maintenance staff should wear the appropriate PPE, comprising at least N95 masks, eye protection, and gloves, especially when replacing filters.

e. Check other systems to ensure there is no undesired air leakage into occupied spaces, including water seals in the sanitary system, cracks in pipes and ducts, and wall gaps. Rectify faults detected.

f. The air distribution system should be balanced to ensure outdoor air provision to all intended spaces.

2.2. Air-purging can rapidly remove pollutants from a space:

a. Consider air purging before each occupancy especially for spaces with high airborne disease transmission risk[5] or when there is a need to rapidly remove pollutants.

b. For buildings without air purging systems, consider extending operation of ACMV systems with outdoor air intake before each occupancy.

2.3. Air filters help to reduce indoor air pollution by trapping microscopic particles like dust, mold spores and other airborne pollutants:

a. Consider using efficient filters (at least MERV14, F8, or ePM1 70-80% is recommended) in AHUs to treat both outdoor and recirculated air. Alternatively, consider ensuring that the ACMV system is able to accommodate such filters when needed, e.g. during an epidemic or haze episode. Filters should be properly installed and maintained according to manufacturers' recommendation.

2.4. Ventilation can help dilute the concentration of pollutants and airborne microorganisms and reduce transmission risk. For premises with limited ventilation and air filtration provision (e.g. meeting rooms with only FCU), consider below measures to increase ventilation:

a. Open operable windows and doors as frequently as possible, unless outdoor/outside air quality is poor. Air-conditioning should be reduced or turned off when doors and/or windows are opened to conserve energy.

b. Consider positioning fans to blow air out of windows to increase air exchange.

c. Add dedicated outdoor air supply and/or exhaust[6].

d. Where there is a high risk of airborne disease transmission[5], localised air cleaning may be considered as an interim measure, in line with the recommendation for spaces without mechanical ventilation (please see sections 3.3 and 3.4).

3. Measures for enclosed air-conditioned premises without mechanical ventilation provision (e.g. split-unit air-conditioners or FCUs without fresh air supply)

3.1. Increase ventilation and enhance air exchange:

a. Open operable windows and doors as frequently as possible, unless outdoor air quality is poor. Air-conditioning should be reduced or turned off when doors and/or windows are opened.

b. Consider adding dedicated outdoor air supply and/or exhaust[6]**Error! Bookmark not defined.**.

c. Operate exhaust fans (e.g. in toilets, kitchens) at full capacity to expel air from indoor spaces.

3.2. Consider installing window-mounted exhaust fans to enhance ventilation:

a. The fan systems should at least provide the minimum air changes specified in SS553:2016.

b. Air supply and exhaust system can be aligned to provide uni-directional airflow in a poorly ventilated space.

c. To cater for occasions of poor outdoor air quality (e.g. haze), consider getting fans with coverings that can cover up the fans when needed. As a longer-term solution, supply air fans fitted with efficient filters (at least MERV14, F8, or ePM1 70-80% is recommended) can also be considered to maintain good ventilation during haze episodes. Such systems should be installed by professionals to ensure good filtration and supply air distribution.

3.3. In enclosed spaces with high risk of airborne disease transmission[5], portable air cleaners for localised air cleaning may be considered as an interim measure:

a. Portable air cleaners should be equipped with high-efficiency air filters such as HEPA filters, which are effective at removing virus aerosols.

b. The clean air delivery rate (CADR) or equivalent of a portable air purifier should be used to determine the size and number of portable air cleaner devices needed in a space.

c. If present, the portable air cleaner's ozone generation function should be turned off to avoid potential exposure to excessive levels of ozone and undesirable by-products, which may be hazardous to health.

d. The use of portable air cleaners should be considered an interim measure. **Air cleaning does not replace the need for adequate ventilation**. Regular surface cleaning and disinfection[Error! Bookmark not defined.] should also continue, as portable air cleaners do not remove surface contamination.

e. Please refer to NEA's List of Portable Air Cleaners Against COVID-19 Virus Aerosols for more information on the use of portable air cleaners.

3.4. Where ceiling height allows, upper-room UVGI may be considered for air cleaning. As viral disinfection efficacy and safety (UV-C radiation can cause injury to the eyes and skin) are greatly dependent on the system and how it is installed and maintained, professional services must be used. Please refer to NEA's Technical Advisory on Use of Air-Cleaning Technologies to Mitigate COVID-19 Aerosol Transmission Risk for more information.

3.5. Check other systems to ensure there is no undesired air leakage into occupied spaces, including water seals in the sanitary system, cracks in pipes and ducts, and wall gaps. Rectify faults detected.

4. Measures for naturally ventilated premises

4.1. Natural ventilation is weather dependent. It could be limited to the areas around windows and doors (perimeter zones), with little air exchange in the inner portion of the space (internal zones). Cross ventilation is significantly more effective than single-sided ventilation (e.g. when the opening exists only at one side of the space).

4.2. Increase natural ventilation with enhancement:

a. Keep windows and/or doors open at all times, unless outdoor air quality is poor or the weather condition does not allow.

b. Consider positioning fans to blow air out of windows to increase air exchange.

4.3. Consider installing window-mounted exhaust fans to enhance ventilation:

a. The fan system should at least provide the minimum air changes specified in SS553:2016.

b. Air supply and exhaust system can be aligned to provide uni-directional airflow in a poorly ventilated space.

4.4. Check other systems to ensure there is no undesired air leakage into occupied spaces, including water seals in the sanitary system, cracks in pipes and ducts, and wall gaps. Rectify faults detected.

5. Carbon dioxide (CO_2) levels as a proxy for ventilation

5.1. To assess the adequacy of ventilation, measurement of ventilation rate is required. If this is not possible or difficult to determine, CO_2 levels in occupied areas may be used as a proxy for ventilation adequacy.

5.2. Managers may use CO_2 readings to identify pockets of under-ventilated spaces or overcrowding, so that prompt action can be taken to improve the situation. Quick assessment can be done by taking readings over a period of at least 5 minutes per sampling location, in occupied areas at breathing zones. In spaces with a dynamic crowd, managers could implement constant monitoring by installing CO_2 sensors with visible displays in occupied areas or take spot measurements especially during high occupancy.

5.3. SS554:2016 recommends an indoor CO_2 limit of not more than 700 ppm in excess of outdoor levels. With ambient outdoor CO_2 levels at about 400 ppm, the limit is therefore approximately 1100 ppm.

5.4. To reduce risk of transmission of airborne infectious diseases, including possible new COVID-19 variants, managers should consider aiming for CO_2 levels below 800 ppm over the measurement period as recommended by Centers for Disease Control and Prevention (CDC)[7], Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA)[8] and SS554:2016 Annex K[9]. Alternatively, consider having a plan in place (e.g. increasing ventilation and/or reducing occupancy) to achieve CO_2 levels below 800 ppm when needed, e.g. during an epidemic.

5.5. While high CO_2 levels indicate poor ventilation and/or overcrowding, CO_2 levels may not be directly correlated to risk of exposure to infectious pathogens, as other risk factors may be involved.

Notes and references

[1] ACMV systems include air handling units and fan coil units such as cassette- or wall-mounted types.

[2] Specialised premises refer to those with ACMV systems that fall outside the scope of SS553:2016 Code of Practice for Air Conditioning and Mechanical Ventilation in Buildings.

[3] For building/occupancy types not listed in SS553:2016, ASHRAE 62.1 should be used as reference.

[4] AHU: air handling unit; FCU: fan coil unit; PAU: primary/pre-cool air handling unit; FAF: fresh air fan; EAF: exhaust air fan.

[5] Such spaces include those where bioaerosol-generating procedures are performed on people (e.g. nasopharyngeal swab taking and dental procedures), where infectious patients may be present

[6] To avoid mould growth due to condensation caused by introduction of excessive humid outdoor air, outdoor air may be treated by a dedicated outdoor air processing system. The outdoor air system can be designed such that efficient filters (at least MERV14, F8, or ePM1 70-80% is recommended) can be fitted when necessary. The filters will be useful during times when windows cannot be opened due to poor outdoor air quality.

[7] Centers for Disease Control and Prevention - Ventilation in Buildings. https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

[8] Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) - REHVA COVID 19 Guidance version 4.1: How to operate HVAC and other building service systems to prevent the spread of the coronavirus (SARS-CoV-2) disease (COVID-19) in workplaces. https://www.rehva.eu/activities/covid-19-guidance/rehva-covid-19-guidance

[9] Draft Amendment No. 1 to SS554: 2016. https://www.enterprisesg.gov.sg/-/media/37324ECF5FF7448F9C43021E69EE0D78.ashx