Impacts of Ventilation and Building Airflows on Indoor Aerosol Transport

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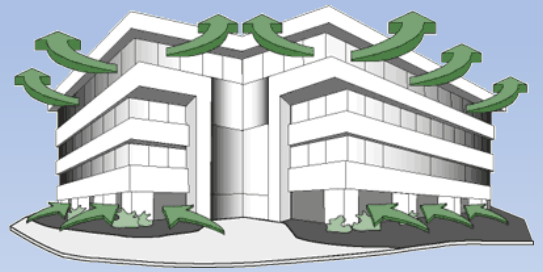
U.S. Department of Commerce



Outline

Which airflows and their magnitudes

- Buildings and systems
- Characterizing ventilation

Reducing exposure with airflow, including some current suggestions to reduce viral exposure

Summary

Some Key Concepts

Ventilation (ASHRAE Standard 62.1) the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space

Every building is different

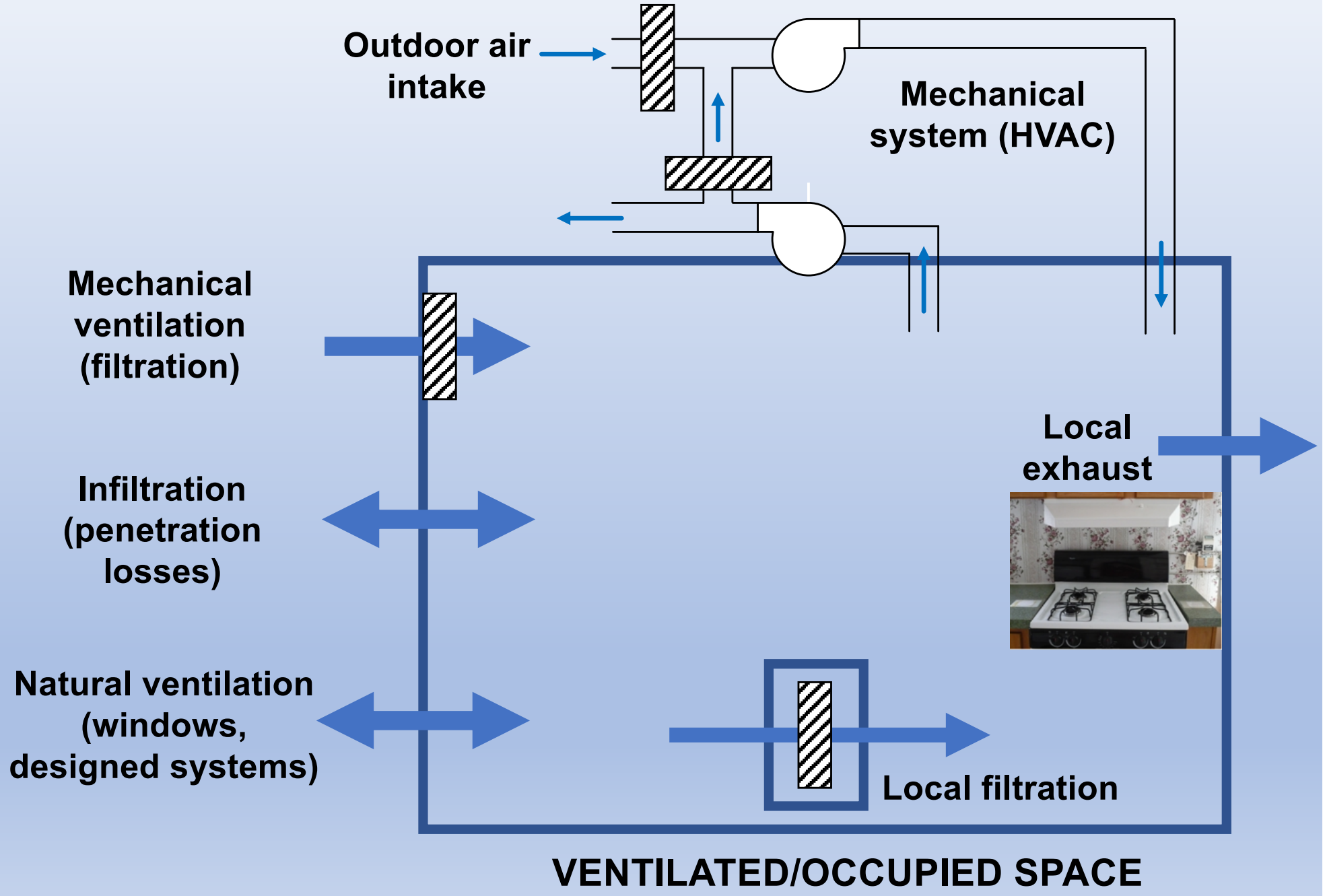
Buildings not tight unless built that way

Air moves based on physics, not design intent

Airflow has been studied in very, very few buildings

Outdoor air isn't necessarily fresh air

Which Airflows



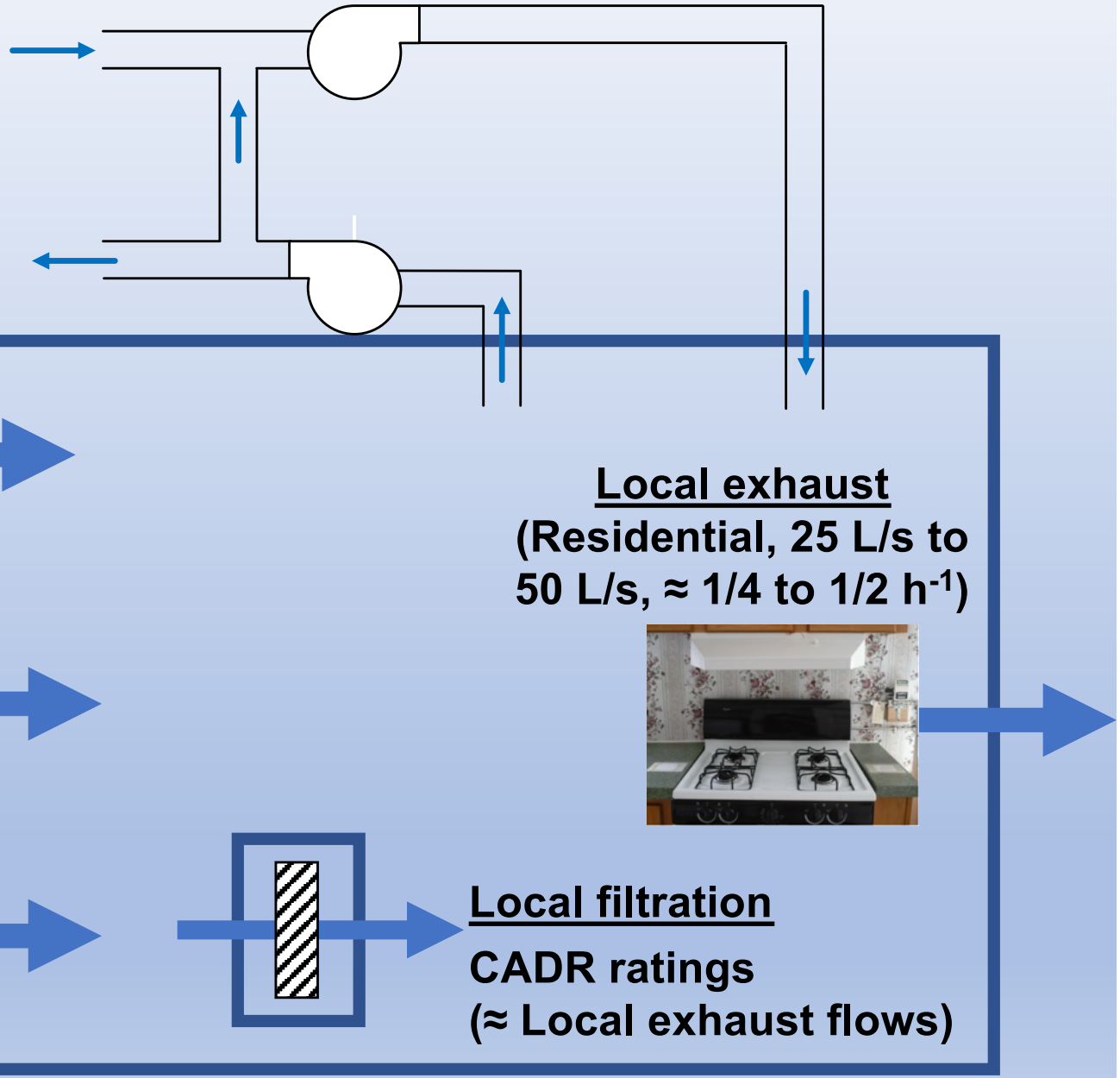
Magnitudes

Mechanical/Commercial
Outdoor air: ≈ 1 h^{-1}, highly variable, up to ≈ 5 h^{-1}
Supply air: ≈ 3 to 5 h^{-1}, higher in healthcare

Mechanical/ Residential
OA: ≈ 0.1 to 0.5 h^{-1}

Infiltration
≈ 0.1 to 1.0 h^{-1}
≈ 5 to 1 variation in individual building

Natural ventilation
>1 h^{-1}, hard to measure and predict



Local exhaust
(Residential, 25 L/s to 50 L/s, ≈ 1/4 to 1/2 h^{-1})

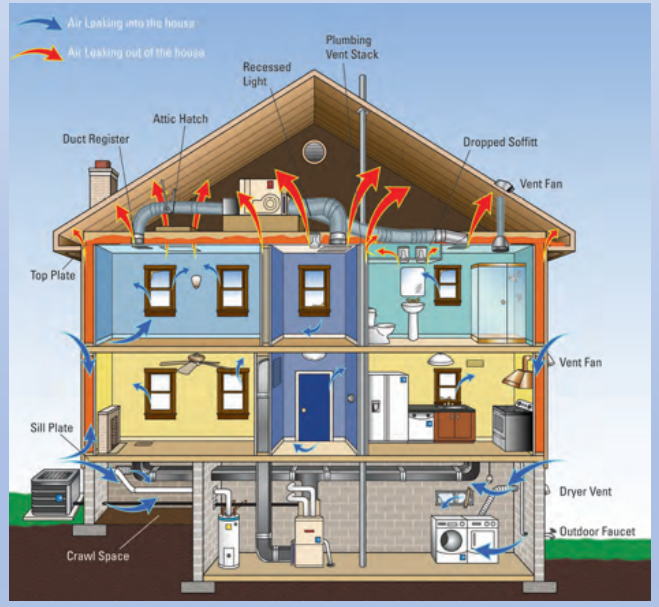
Local filtration
CADR ratings
(≈ Local exhaust flows)

Interzone airflows

Magnitudes similar to airflows from outdoors

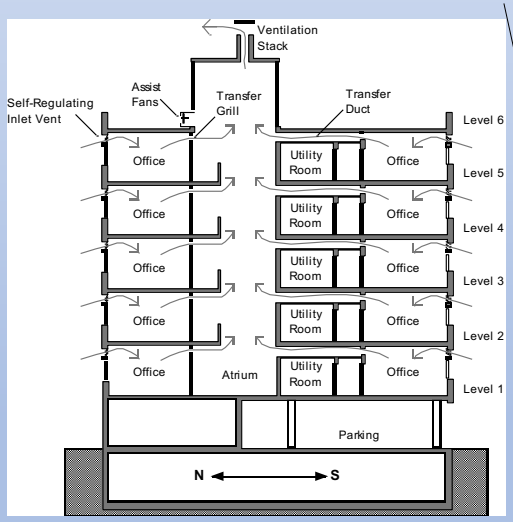
Residential

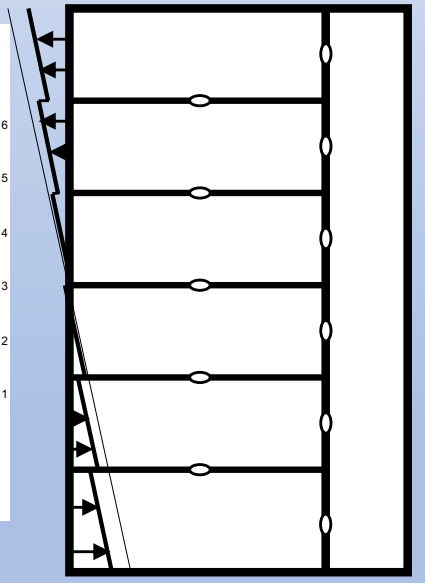
Crawl spaces, basements, attics, ...



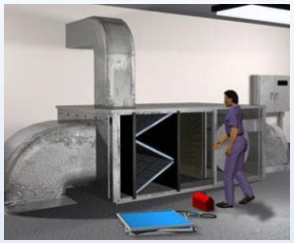
Commercial

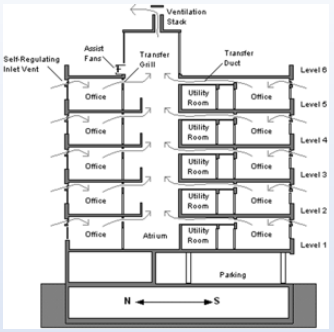
Return air plenums, plumbing chases, mechanical rooms, ...











Buildings are diverse

USA: 100 million dwellings; 6 million commercial

Building systems matter and vary

Layout, design intent, occupant activities, operation, maintenance, …

Ventilation has been well-studied in few buildings

Impacts of HVAC & ventilation on aerosol transport in even less





Characterizing Ventilation

System Design

- Outdoor air intake rates; Supply flow rates;
- Local exhaust airflows, e.g. toilets, clothes dryers
- Operating schedule; Control strategies

Airflow rates

- System status: on/off, mode of operation, …
- Whole building outdoor air change rates (Rooms)
- Ventilation system airflows: Supply, outdoor air, exhaust
- Envelope infiltration

Pressure differences: Indoor-to-outdoor and interzone

Important considerations

Why are you measuring?

Weather, system operation

<u>One measurement doesn't tell you much!</u>

Reducing Aerosol Exposure with Airflow

Build tight, ventilate (filter) right

Overpressure buildings (careful with moisture)

Airflow/pressure from clean spaces to dirty

Commissioning, Operations & Maintenance

Ventilation limited for strong, local sources

“Primum non nocere”

First, do no harm!

- Hippocrates

Some current suggestions on ventilation to reduce viral exposure

Increase outdoor air ventilation rates

System capacity
Outdoor air quality
Moisture management
Assuming good HVAC control

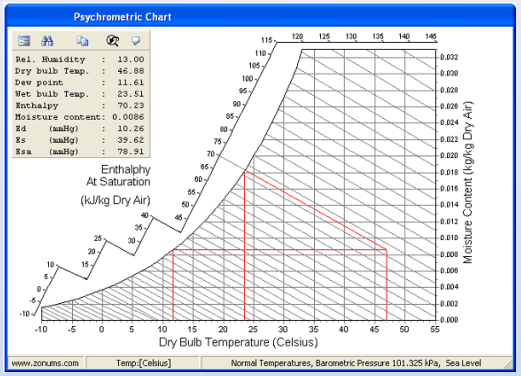
More efficient filtration

System capacity
Sealing
Maintenance
Safety when changing?

Some current suggestions on ventilation to reduce viral exposure

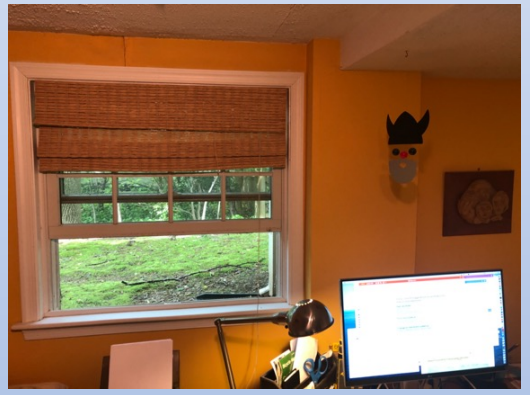
Change relative humidity

Do we know the right number?
System capacity
Condensation potential/microbial growth



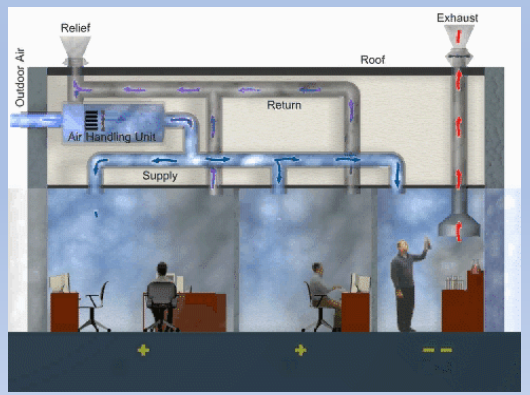
Open windows

Outdoor air quality
Moisture
Direction, magnitude, distribution



Change air distribution

System configuration
Options may be limited



Summary

Good ventilation is good practice

Do no harm

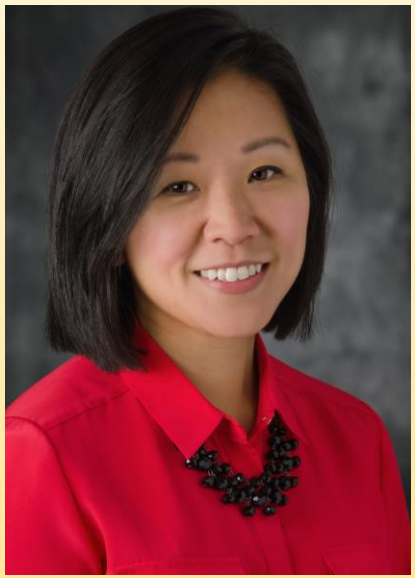
Excellent time to check system, review O&M practice (Schoen 2020 and ASHRAE guidance)

Transmission studies in buildings need to characterize ventilation (Persily & Wargocki 2016)

Schoen, L.J. (2020) Guidance for Building Operations During COVID-19 Pandemic, *ASHRAE Journal*, 62 (5), 72-74.

Persily, A. and Wargocki, P. (2016) How to Evaluate Ventilation in IAQ Studies, *14th International Conference on Indoor Air Quality and Climate, Indoor Air 2016*, Ghent.

Summary of Current HVAC Recommendations for Re-Opening Buildings



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Updated 9/3/2020

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Outline

- To be or not to be
- Transmission routes (as far as they know)
- List of resources
- Specific guidance made available
- Summary

To be or not to be

What this talk is

- Summary of available guidance provided by reputable organizations
- Focused on commercial buildings (e.g., offices but applicable to schools)
- Focused on HVAC-related O & M

What this talk isn't

- Guidance for disinfecting buildings, social distancing, etc
- Transmission of infectious diseases
- Comprehensive, mandatory guidance

Transmission routes of SARS-CoV-2

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

Updated August 3, 2020

"three transmission routes are dominant:

(1) combined droplet and airborne transmission in 1-2 m close contact region arising from droplets and aerosols emitted when sneezing, coughing, singing, shouting, talking and breathing;

(2) long-range airborne (aerosol-based) transmission

(3) surface (fomite) contact through hand-hand, handsurface, etc. contacts"

Position Document on Infectious Aerosols

"*Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures*."

Updated April 14, 2020

Letter to WHO

It is Time to Address Airborne Transmission of COVID-19

Lidia Morawska, Donald Milton
+ 239 scientists

Studies by the signatories and other scientists have demonstrated beyond any reasonable doubt that viruses are released during exhalation, talking, and coughing in microdroplets small enough to remain aloft in air and pose a risk of exposure at distances beyond 1 to 2 m from an infected individual.

Resources

Ventilation

ASHRAE

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

Health & Safety

AIHA
Protecting Worker Health

CDC
Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

UNITED STATES DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Broad coverage

National Institute of BUILDING SCIENCES™

APPA Leadership in Educational Facilities

U.S. DEPARTMENT OF ENERGY

BOMA International

Maintenance personnel

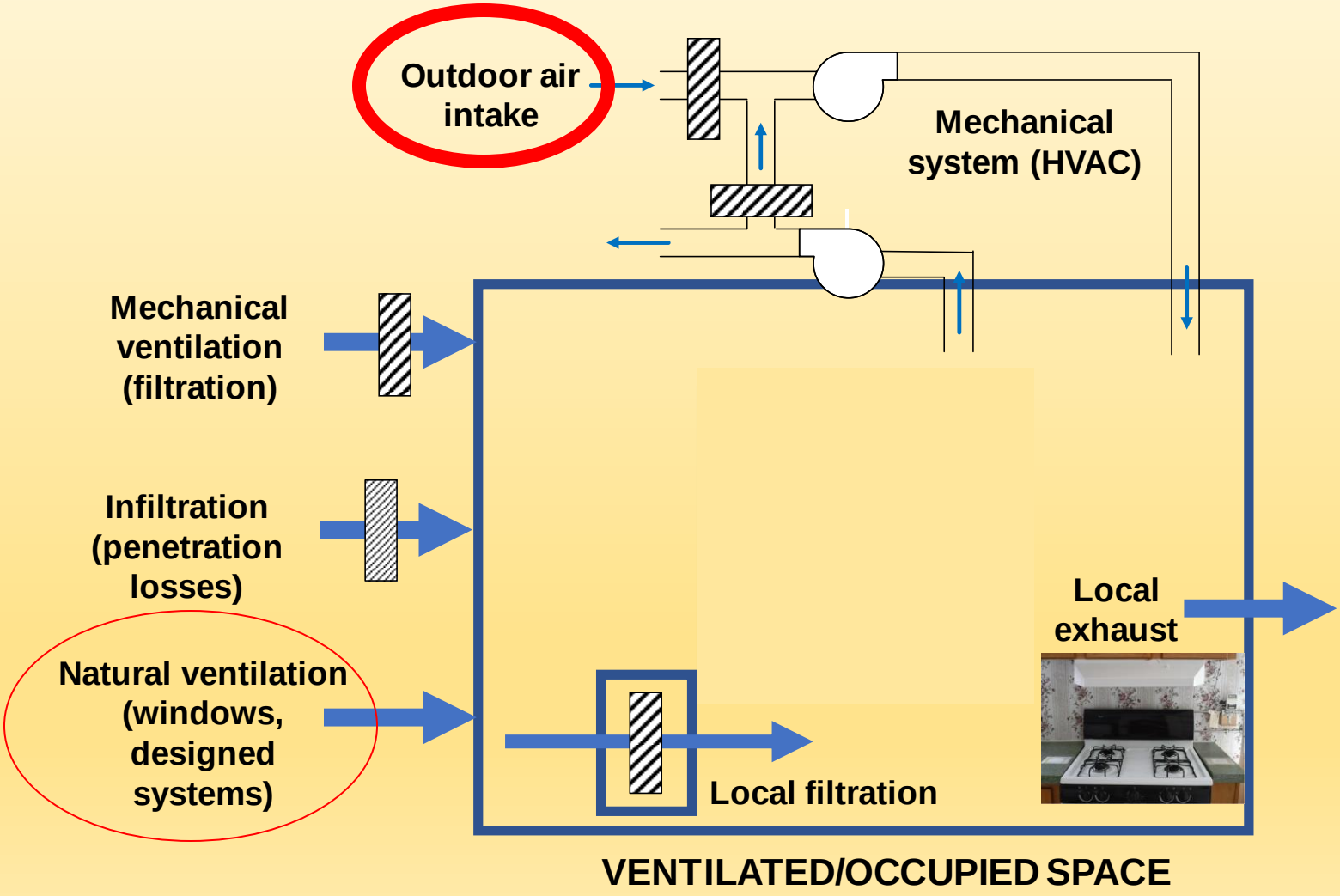
PLUMBERS • UNION • PIPEFITTERS • SERVICE TECHS • STEAM FITTERS • SPRINKLERFITTERS

the NEWS

Available guidance

- Outdoor ventilation
- Filtration
- Relative humidity
- Toilet areas
- UV-C and air cleaners
- Maintenance personnel

Outdoor ventilation



Outdoor ventilation

Increase ventilation

Reduce recirculation

Outdoor ventilation

Maintain 24/7 outdoor ventilation

- Perhaps lower rates during unoccupied hours

- Ventilation at “occupied rates” 2 h prior to and after occupied hours

Flush with 3 “clean” air changes

Disable or increase setpoints for demand controlled systems (DCV)

Outdoor ventilation

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Check heat recovery devices for leaks

- Possible re-contamination of supply air stream

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Check airflow directions and pressures

- Especially for critical spaces

AIHA®
Protecting Worker Health

Clean/disinfect intakes and returns

Filtration

Ensure proper filtration

- Install high efficiency filters

AIHA Protecting Worker Health

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Continue routine maintenance

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REHVA
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Filtration

MERV-13 minimum

- MERV-14 preferred
- HEPA better
- Must consider equipment and operating conditions

Dispose of existing filters

HEPA filters

[T]he peak concentration of SARS-CoV-2 aerosols appears in two distinct size ranges, one in the submicron region with aerodynamic diameter dominant between 0.25 and 1.0 μm, and the other peak in supermicron region with diameter larger than 2.5 μm… According to our previous measurements, the efficiencies of HEPA are more than 95% for aerosols of diameter between 0.25 and 1.0 μm and nearly 100% for those with diameter larger than 2.5 μm.

Building and Environment 177 (2020) 106918

Contents lists available at ScienceDirect

Building and Environment

journal homepage: http://www.elsevier.com/locate/buildenv

Check for updates

Air purifiers: A supplementary measure to remove airborne SARS-CoV-2

Relative humidity

Maintain between 40 % and 60 % RH

Relative humidity

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

The evidence does not support that moderate humidity (RH 40-60%) will be beneficial in reducing viability of SARS-CoV-2, thus the humidification is NOT a method to reduce the viability of SARS-CoV-2.

National Institute of BUILDING SCIENCES™

Humidity kept in the 40% to 60% range may be ideal

U.S. DEPARTMENT OF ENERGY

Several recent studies recommend 40 % – 60 % RH for disease-specific infection risk

Toilet areas

Close lid when flushing

Maintain underpressure

- **Exhaust fans 24/7**
- **Keep windows/doors closed**

UV-C & Air cleaners

“Consider” as supplementary

Maintenance personnel

No PPE recommended

APPA Leadership in Educational Facilities

UNITED STATES DEPARTMENT OF LABOR
Occupational Safety and Health Administration

*

**Most in-home services workers are unlikely to need PPE beyond what they use to protect themselves during routine job tasks. However, employers should consider whether their hazard and risk assessments warrant the use of more protective PPE ensembles.*

"Common protective measures"

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Maintenance personnel

PPE recommended

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N95* **vs** **Surgical masks or face coverings**

the NEWS

* ASHRAE: For HVAC systems suspected to be contaminated with SARS-CoV-2, workers performing maintenance should wear appropriate PPE, including a properly-fitted respirator (N95 or higher)

* TUA: PPE is recommended for HVAC workers working near plumbing vents and rooftop HVAC equipment, specifically exhaust fans, including N95 facemask or half-face respirator with HEPA filters to protect from inhalation of aerosol transmission

Maintenance personnel

PPE recommended

Face shield **vs** **Eye protection (e.g., goggles)**

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theNEWS

Maintenance personnel

PPE recommended

Gloves

Booties

Summary

Increase ventilation, reduce recirculation

- Specific recommendations available

Filtration

- Higher efficiencies with practical limitations

Relative humidity

- 40 % - 60 %

Toilet areas

- Maintain underpressure, e.g., 24/7 operation

UV-C and air cleaners

- Supplementary

Maintenance personnel

- PPE level depends on circumstances

Links to school-specific guidance

AIHA - Schools (K-12) Reopening Guidelines (July 10, 2020)

APPA – Reopening Guidance for Campus Facilities by School Type

ASHRAE – ASHRAE Epidemic Task Force – Schools and Universities (July 17, 2020)

Harvard T.H. Chan School of Public Health – Risk Reduction Strategies for Reopening Schools (June 2020)

Johns Hopkins Center for Health Security – Filling in the Blanks: National Research Needs to Guide Decisions about Reopening Schools in the United States (May 15, 2020)

The National Academies of Sciences Engineering Medicine (NASEM) – Reopening K-12 Schools During the COVID-19 Pandemic: Prioritizing Health, Equity, and Communities (July 2020)

WHO Considerations for school-related public health measures in the context of COVID-19 (May 10, 2020)

Links to resources

ACHR News – Comprehensive Guide: HVAC Service Calls During COVID-19 (March 24, 2020)

AIHA: American Industrial Hygiene Association – Reopening: Guidance for General Office Settings (June 22, 2020) and Recovering from COVID-19 Building Closures

APPA – Leadership in Educational Facilities (FAQs)

ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers Epidemic Task Force (August 2020)

BOMA: Building Owners and Managers Association International – Getting Back to Work: Preparing Buildings for Re-Entry Amid COVID-19 (May 1, 2020)

CDC: Centers for Disease Control and Prevention – CDC Activities and Initiatives Supporting the COVID-19 Response and the President's Plan for Opening America Up Again (May 2020)

DOE: U. S. Department of Energy – Webinar: Managing HVAC Systems to Reduce Infectious Disease Transmission (May 2, 2020)

NIBS: National Institute of Building Sciences – COVID-19 Virtual Town Hall: Preparing for Re-entering Buildings (May 7, 2020)

NIBS: National Institute of Building Sciences – Whole Building Design Guide

OSHA: Occupational Safety and Health Association – Guidance on Preparing Workplaces for COVID-19 (March 9, 2020)

REHVA: Federation of European Heating, Ventilation, and Air Conditioning Associations – How to operate and use building services in order to prevent the spread of the coronavirus disease (COVID-19) virus (SARS-CoV-2) in workplaces (August 3, 2020)

TUA: The United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada – Guidelines to Protect Workers Related to Coronavirus (COVID-19) and Other Potential Infectious Materials (OPIM) in Plumbing and HVAC Systems (March 25, 2020)

Thanks!

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