Welcome to Webinar Wednesday

Varitec Technical Institute - 2024

Presenter: Dan Hahne
(Varitec: Director of High-Performance HVAC Solutions)

Program Coordinator: Kellie Huff
(Varitec: Marketing Manager)

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Mission:

(New Horizons Launch, January 9, 2006)

To provide an educational platform for continued learning in the HVAC industry with a focus on high performance buildings and innovative technologies for a better built environment.

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March 30th, 2024 – Guest Presenter: Dr. Stephanie Taylor

April – 100% OSA Systems Importance of Ventilation

May - Psychrometrics 101

June 5th, 2024 – Guest Presenter: Janice Means, PE, LEED AP

July –Controls Fundamentals

Sept – 100% OSA & VRV

Oct – Psychrometrics 201

Nov – 100% OSA w Underfloor

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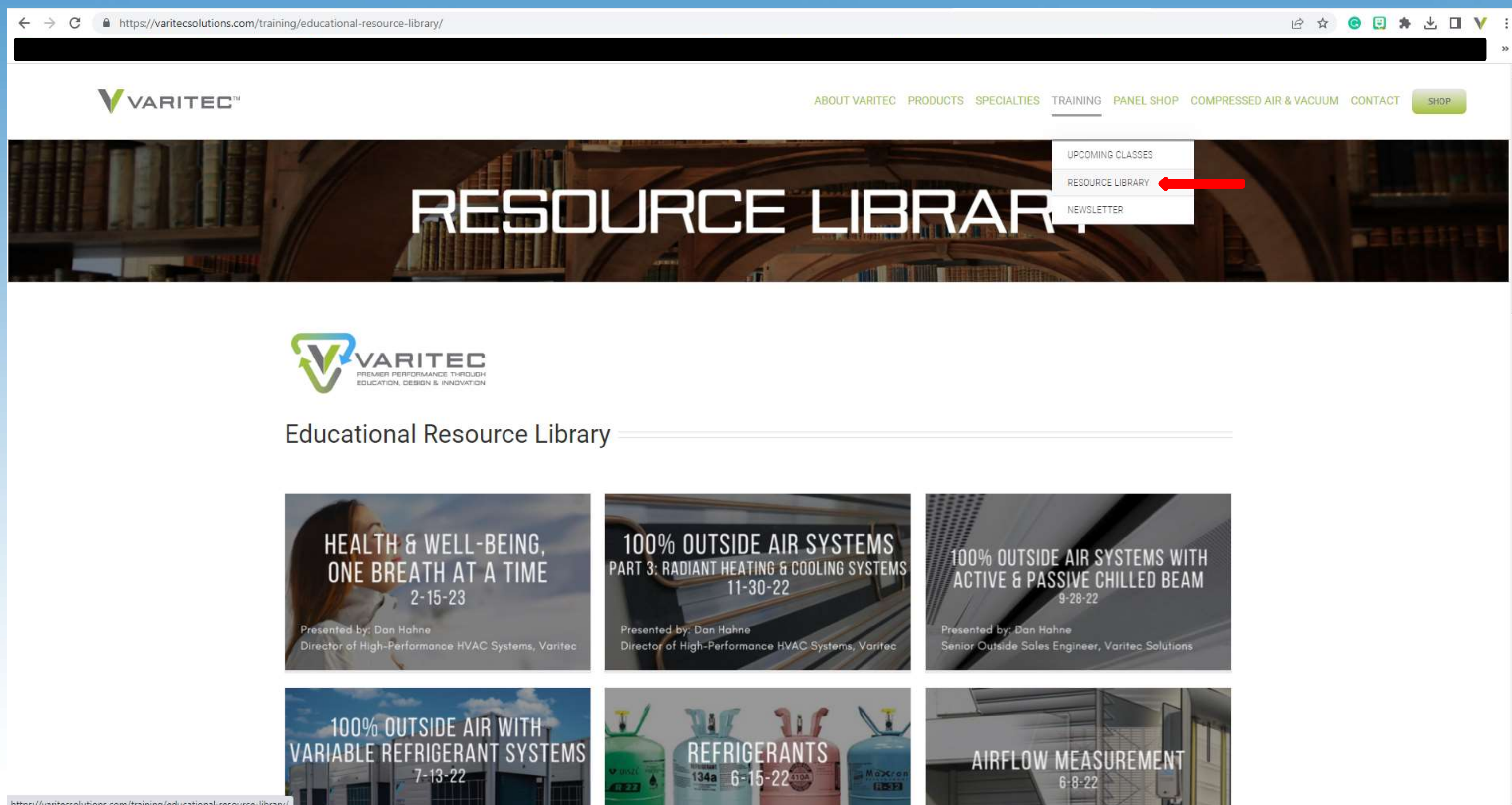

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Housekeeping Items:

- We are recording this session
- Please ask questions in the chat
- If you need PDH or AIA credit, make sure your name is displayed correctly. If you are calling in, send me an email to let me know you attended.

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ASHRAE Standard 241

Control of Infectious Aerosols

Presented by: Dan Hahne
Varitec: Director of High-Performance HVAC Solutions

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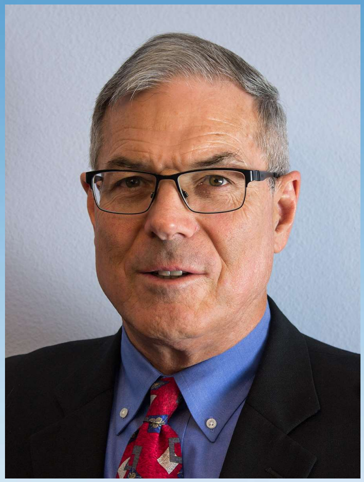
Introduction

- **Education:**
  - University of Arizona – Chemical Engineering
    - 1974 thru 1976
  - University College London – BFA Degree (Sculpture)
    - 1978 thru 1983
  - Boston University – MFA Degree (Sculpture)
    - 1983 thru 1985



- **Industry:**
  - **Norman S. Wright SW:** Estimator/Sales
    - 1985 thru 1999
  - **Air Specialty Products:** Outside Sales
    - 2000 thru 2008
  - **Air Specialty Products/ThermAir Systems:** Engineering Sales
    - 2009 thru 2016
  - **Varitec Solutions:**
    - Senior Sales Engineer
      - 2016 - 2022
    - Director of High-Performance HVAC Solutions/Educator
      - 2022 thru present

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Today’s Agenda:

- The COVID-19 Pandemic: CDC Timeline & Statistics
- Modes of Transmission: Infectious Aerosols
- ASHRAE Standard 241: Foreword, Purpose & Scope
- ASHRAE Standard 241: Definitions
- ASHRAE Standard 241: Compliance
    - Standard 52.2: Informative Appendix J
- Equivalent Clean Airflow for Infection Risk Mitigation
- Air Distribution and Natural Ventilation
- Air Cleanings
- Assessment, Planning, and Implementation
- Operations and Maintenance
- Concluding Remarks

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The COVID-19 Pandemic: CDC Timeline & Statistics

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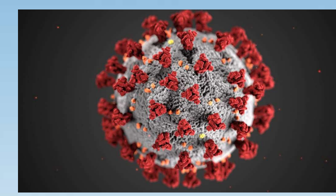
The COVID-19 Pandemic: CDC Timeline & Statistics

CDC: COVID-19 Origin & Initial Cases

- **December 12, 2019:** *"A cluster of patients in China's Hubei Province, in the city of Wuhan, begin to experience the symptoms of an atypical pneumonia-like illness that does not respond well to standard treatments."*



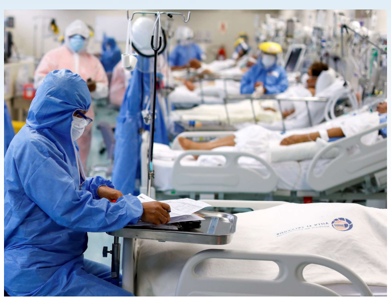
- **CDC: Timeline**
- **January 7, 2020:** *"Public health officials in China identify a novel coronavirus as the causative agent of the outbreak."*
- **January 19, 2020:** *"Worldwide,* ***282 laboratory-confirmed cases*** *of the 2019 Novel Coronavirus have been reported in four countries: China (278), Thailand (2), Japan (1), Republic of Korea (1)*

The COVID-19 Pandemic: CDC Timeline & Statistics

CDC: COVID-19 Initial Cases & Infection Rate

CENTERS FOR DISEASE CONTROL AND PREVENTION

- **January 24, 2020:** *"CDC confirms a travel-related infection of the **SARS-CoV-2 virus in Illinois, bringing the total number of cased in the U.S. to two**."*
- **January 30, 2020:** *"CDC confirms that the **SARS-C0V-2 virus has now spread between two people in Illinois with no history of recent travel.** This is the first recorded instance of person-to-person spread of the 2019 Novel Coronavirus in the U.S. and brings the total number of cases up to seven."*



- **February 10, 2020:** *"**Worldwide deaths** from the 2019 Novel Coronavirus **reach 1,013**. The SARS-C0V-2 virus has **now killed more people than the severe acute respiratory syndrome (SARS-CoV-1) outbreak**, which claimed 774 lives…"*

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The COVID-19 Pandemic: CDC Timeline & Statistics

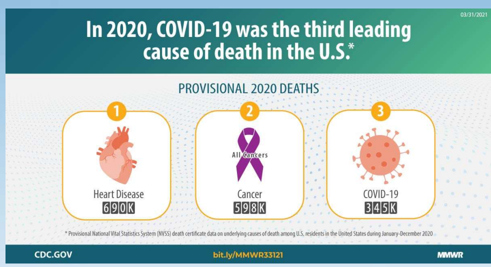
CDC: COVID-19 First Year Infection Rate

- **April 4, 2020:** *“More than* ***1 million cases of COVID-19 had been confirmed worldwide****, a more than ten-fold increase in less than a month.*
- **April 10, 2020:** *“With* ***over 18,600 confirmed deaths*** *and* ***more than 500,000 confirmed cases*** *in* ***under four months****, the U.S. is the country with the most reported COVID-19 cases and deaths…”*
- **May 9, 2020:** ***“The unemployment rate in the U.S. is 14.7% - the highest since the Great Depression.*** *With* ***20.5 million people out of work****, the hospitality, leisure, and healthcare industries take the greatest hits overall…”*
- **May 28, 2020:** *“The* ***recorded death toll*** *from COVID-19 in the U.S. surpasses* ***100,000****.”*

The COVID-19 Pandemic: CDC Timeline & Statistics

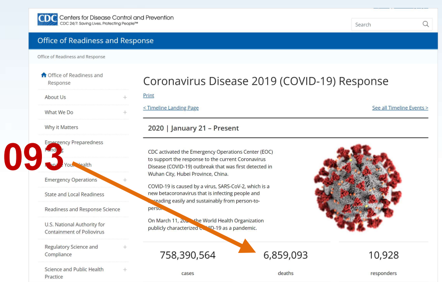
CDC: COVID-19 First Year Infection Rate

- **July 7, 2020:** *“The **number of confirmed COVID-19 cases in the U.S. surpasses 3 million.”***



- **August 17, 2020:** *“COVID-19 becomes the **3rd leading cause of death in the U.S.** Deaths from COVID-19 now **exceed 1,000 per day** and **nationwide cases exceed 5.4 million.”***
- **September 30, 2020:** *The reported **death toll** from COVID-19 reaches **more than 1 million worldwide – in just 10 months.”***

March 29th, 2023:
Total Global Deaths: 6,859,093

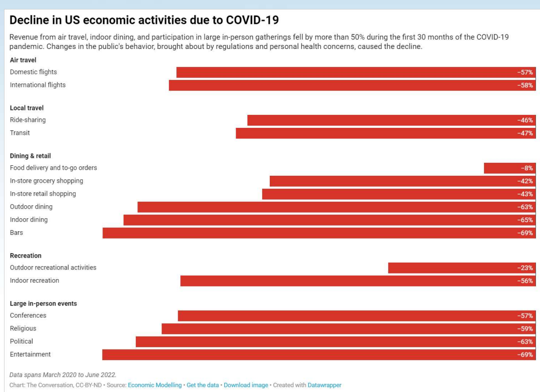


The COVID-19 Pandemic: CDC Timeline & Statistics

COVID-19 Pandemic: Economics

- **June 8, 2020:** *"The **World Bank states** that the COVID-19 pandemic will **plunge the global economy into the worst recession since World War II**."*

USC Schaeffer
Leonard D. Schaeffer Center for Health Policy & Economics
The Future of American Healthcare



- **USC Schaeffer / Perspective: May 16, 2023**
  - *COVID-19's **Total Cost to the U.S. Economy Will Reach $14 trillion (US) by End of 2023***
  - **2nd Quarter of 2020:** International & Domestic flights fell by nearly 60%, indoor dining 65% and in-store shopping by 43%
  - **Total U.S. Death toll** through May 16, 2023: **1,172,266**

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The COVID-19 Pandemic: CDC Timeline & Statistics

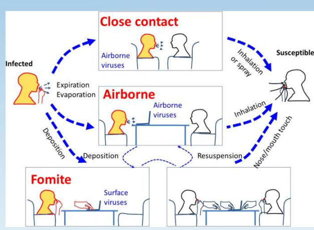
COVID-19 Pandemic: Modes of Transmission

CDC — Centers for Disease Control and Prevention

SARS-CoV-2 Infection Pathways (Original 2020 Statements)

- **Fomite Transmission:** Surface to Surface
- **Large Droplets:**
  - Social Distancing Guidelines of 6 Feet

World Health Organization



Time ARTICLE: Published August 25th, 2020

TIME

By: Jose-Luis Jimenez

(Professor of Chemistry and a Fellow of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado-Boulder)

"COVID-19 Is Transmitted Through Aerosols. We Have Enough Evidence, Now It Is Time to Act"

- "Contrary to public health messaging, I, together with many other scientists, believe that a substantial share of COVID-19 cases are the result of transmission through aerosols."

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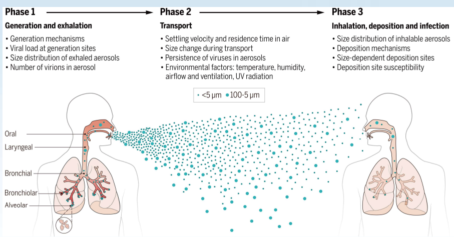
The COVID-19 Pandemic: CDC Timeline & Statistics

COVID-19 Pandemic: Modes of Transmission

TIME

- "**Fomites and droplets** have dominated our everyday understanding of COVID-19 transmission.
- While **the WHO and CDC both state that aerosols *could* lead to transmission** under highly specific situations, **both organizations maintain that they are less important.**



- "I believe **this is a significant mistake** and on **July 6 I, along with 239 scientists, appealed to the WHO** to reevaluate their stance. WHO updated their position in response, **but the agency's language continues to express skepticism of the importance of this pathway."**

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The COVID-19 Pandemic: CDC Timeline & Statistics

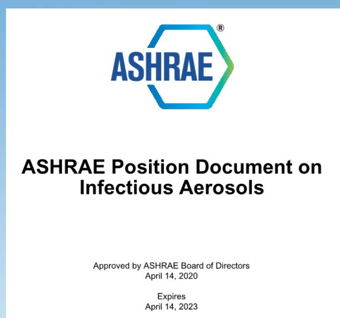
CDC: COVID-19 Infectious Aerosol Statement
(October 2nd, 2020)

- **"COVID-19 can sometimes be spread by airborne transmission."**
- "Some infections can be spread by **exposure in small droplets and particles that can linger in the air for minutes or hours**."

- "These viruses **may be able** to infect people who are further than 6 feet away from the person who is infected….
- This kind of spread is referred to as **airborne transmission**…"

The COVID-19 Pandemic: CDC Timeline & Statistics

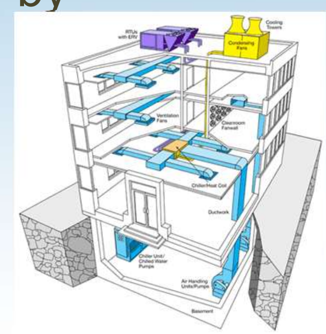
CDC: COVID-19 Infectious Aerosol Statement


ASHRAE Position Document on Infectious Aerosols

Approved by ASHRAE Board of Directors
April 14, 2020

Expires
April 14, 2023

- **ASHRAE's** Position Document on Infectious Aerosols
  - **Published: April 14, 2020**
  - **Abstract:**
    - "Some diseases are known to spread by infectious aerosols."



- The **risk of pathogen spread** … **can be affected** both positively and negatively **by the airflow patterns in the space and by heating and ventilating, and air-conditioning (HVAC)** and local exhaust ventilation (LEV) systems.

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Modes of Transmission: Infectious Aerosols

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Modes of Transmission: Infectious Aerosols

Expiration Events: Velocity, Momentum & Distance

- **Expiratory Event:**
  - **Breathing**
  - **Talking**
  - Coughing
  - Sneezing

Sandia National Laboratories

- **Talking & Breathing:**
  - **Droplet Sizes: several to several tens of microns**
  - **Discharge Velocities:**
    - **2.2 mph**
  - Droplet count: 100's to 1000's droplets
  - **Laminar flow discharge**

- **Talking: 10 times more droplets than breathing**

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Modes of Transmission: Infectious Aerosols

Expiration Events: Velocity, Momentum & Distance

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  - Breathing
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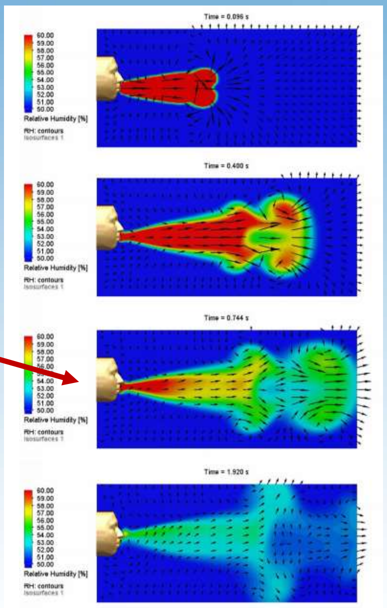
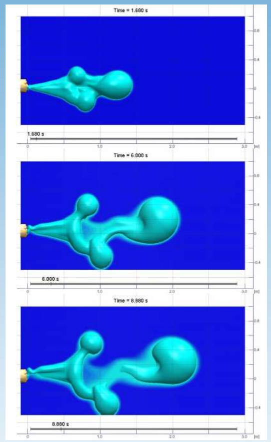
  - **Coughing**
  - Sneezing

Ballistic Trajectory





- **Coughing:**
  - Droplet Sizes: <10 - ~20 microns
  - Droplet Count: ~ 3,000 droplets
  - **Discharge Velocities: 21.5 mph**
  - **Bifurcated plume**

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Modes of Transmission: Infectious Aerosols

Expiration Events: Velocity, Momentum & Distance

- **Expiratory Event:**
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  - Coughing
  - **Sneezing**

Ballistic Trajectory

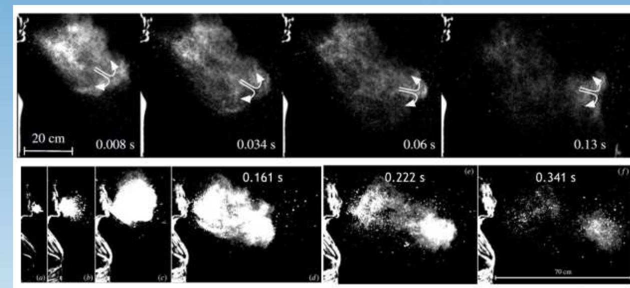

Figure 7. High-speed camera images of a sneeze illustrating salient processes of counter-rotating flow at the leading edge and bifurcation of the droplet plume (Bourouiba et al. [6]).

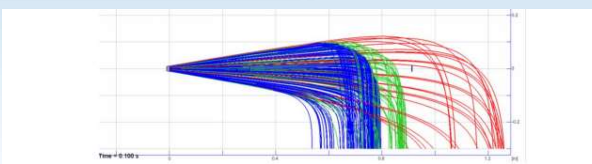

Figure 9. Top: Droplet trajectories observed using high-speed imaging during a sneeze [6]. Bottom: Simulated droplet trajectories at 0.1 s for different water droplet sizes (blue = 100 microns, green = 200 microns, red = 300 microns). Both images are scaled to the same size.

- **Sneezing:**
  - Droplet Sizes: ~1 – 100 microns
  - Droplet Count: ~40,000 droplets
  - **Discharge Velocities: 44 mph @ 0.25 seconds**
  - **Enhanced bifurcated plume**

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Modes of Transmission: Infectious Aerosols

Particle Sizes: Size References and Float Time

- **Relative Particle Sizes:**

Everyday References

- Human Hair: 50 – 180 microns
- Fine Beach Sand: ~90 microns
- Grain of Pollen: ~15 microns
- Red Blood Cell: 7 – 8 microns
- Respiratory Droplets: ~5 – 10 microns
- Dust Particle: ~2.5 microns
- **Coronavirus: ~0.01 – 0.5 microns**

Steady State Environment (i.e. No Air Movement)

Particle size and air resistance between the falling object and ground impact particle float time

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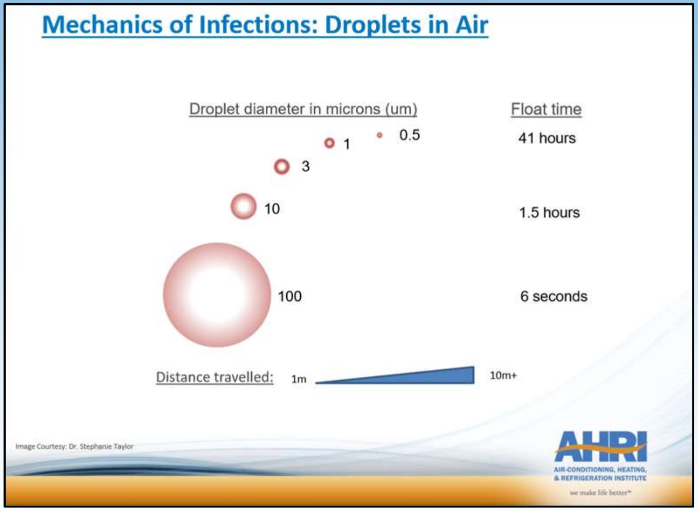
Modes of Transmission: Infectious Aerosols

Particle Size & Buoyancy

- **Buoyancy affects Float Time**

- **Large Droplets:** by definition larger than **100 microns – (6) Seconds**
- **Medium Droplets:** by definition larger than **20 to 100 microns**
- **Small droplets and aerosols:** range from **10-20 microns – 1.5 hours**
- **Droplet nuclei:** Below 10 microns (may be **0.5 microns or smaller**) **– 1.5 to 41 hours**



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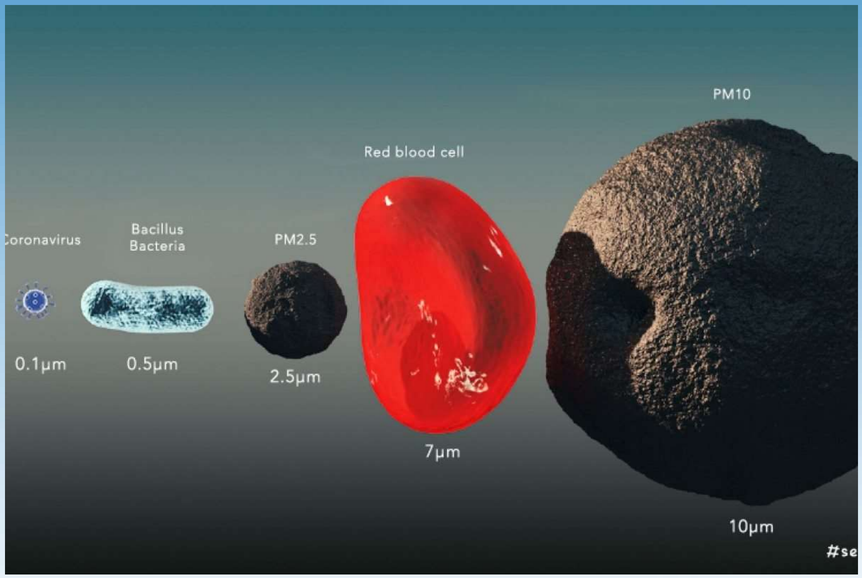
Modes of Transmission: Infectious Aerosols

The Physics of Falling Objects

Droplet Size, Buoyancy & Float Time

SARS-CoV-2 = ~0.125 microns

- Smaller size (Mass) = greater buoyancy and particle float time



Desiccated (anhydrous) virus can remain airborne 72 hours, perhaps longer.

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Modes of Transmission: Infectious Aerosols

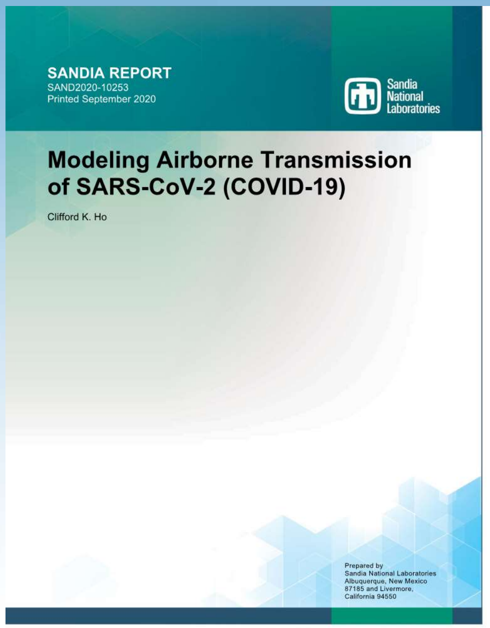
Expiration: Tidal Breathing

Dr. Clifford Ho:

(Senior Scientist Sandia Labs)

Sandia Report:

Modeling Airborne Transmission of SARS-CoV-2 (Covid-19)


SANDIA REPORT
SAND2020-10253
Printed September 2020

Sandia National Laboratories

Modeling Airborne Transmission of SARS-CoV-2 (COVID-19)

Clifford K. Ho

Prepared by Sandia National Laboratories Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia National Laboratories

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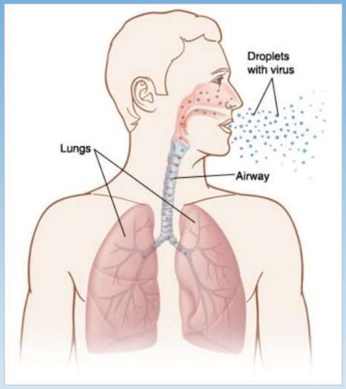
Modes of Transmission: Infectious Aerosols

Expiration: Tidal Breathing

Sandia National Laboratories

- Expiratory Event:
  - Dr. Clifford Ho (2020):
    - "…because the size of the droplets that are emitted during tidal breathing are small, the exhaled aerosol plume can remain suspended for long periods."



"Thus, despite the lower viral load per exhalation event relative to coughs or sneezes, the persistence of the small aerosolized droplets and continuous nature of breathing and/or talking can increase the potential for transmission, especially in enclosed spaces with low fresh-air exchange."

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ASHRAE Standard 241:
Foreword, Purpose & Scope

ASHRAE Standard 241: Foreword, Purpose & Scope

Standard 241: Foreword

- **Statements:**
  - *"Airborne transmission of communicable diseases occurs…*
  - *Engineering controls – **dilution ventilation, filtration, and air disinfection** – can reduce the concentration of active pathogens in the air…*
  - *"…The COVID-19 pandemic caused **enormous personal, societal, and economic damage…***

- *This experience intensified discussion about **the adequacy of existing IAQ standards**, including **code-basis standards such as ANI/ASHRAE Standard 62.1…***
- *The catalyst for the development of Standard 241 was **discussion between ASHRAE and the White House COVID-19 Response Team** about **the need for new and better IAQ standards**…*

ASHRAE Standard 241: Foreword, Purpose & Scope

Standard 241: Foreword

- **Statements:**
  - *The project scope approved by the (ASHRAE) Board also stated the intention to "**work to incorporate similar provisions into existing ASHRAE IAQ standards, specifically ANSI/ASHRAE Standards 62.1 and 62.2**, perhaps as optional requirements."*

- *On December 6, 2022, the ASHRAE Board of Directors authorized development of a standard with the goal of publishing in six months…*
- ***The revised draft was approved for publication by the Project Committee on June 15, 2023***

ASHRAE Standard 241: Foreword, Purpose & Scope

Standard 241: Foreword

- **Requirements:**
  - (HVAC) systems **comply with the requirements of …ventilation and indoor air quality standards (e.g., ANSI/ASHRAE Standards 62.1 and 62.2 or ANSI/ASHRE/ASHRAE Standard 170, including minimum ventilation rates**
  - **A requirement** for an **infection risk management mode of operation (IRMM)** that applies during periods when **higher levels of infection risk mitigation are desired or are required by authorities**…
  - Requirements for **infection risk management** given in terms of **equivalent clean airflow rate** in units of flow per occupant in a space **(ECAi)**.
  - Requirements for air distribution in mechanically ventilated, naturally ventilated, and mixed-mode buildings
  - **Requirements for application of in-room air cleaners**

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ASHRAE Standard 241: Foreword

Requirements:

- Requirements for **filtration and air cleaning** that **include laboratory testing requirements for performance and safety** and **calculation procedures** for determining the **contribution of filters and air cleaners to equivalent clean airflow requirements**.
- Requirements for **assessment, planning and implementation of airborne infection risk reduction measures** in existing buildings
- Requirements for **operation and maintenance**. Operational requirements also owe much to guidance developed by the ETF*, while maintenance requirements are adapted from ANSI/ASHRAE Standard 62.1
- **Special requirements for residential and health care facilities which may house infected persons**…

*ASHRAE's Epidemic Task Force (ETF)

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ASHRAE Standard 241: Foreword

Groundbreaking:

- By **creating a special operating mode** for use when conditions warrant ***(IRMM),*** it **introduces the concept of resilience** into indoor air quality standards.
  - A similar approach could be taken to developing requirements for systems to **mitigate wildfire smoke**
- Expressing **control requirements** in terms of **a quantity (*ECAi*)** that integrates the impact of multiple controls.
  - This concept could also be adapted and applied to other indoor air quality standards.
- They are **a major step in the direction of creating uniform and effective technology-agnostic criteria for characterizing filter and air-cleaner performance and safety**.

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ASHRAE Standard 241: Foreword

1. Purpose:

1.1 The purpose of this standard is to **establish minimum requirements for control of infectious aerosols to reduce risk of disease transmission** in the occupiable space in new buildings, existing buildings, and major renovations to existing buildings, including requirements for …air cleaning system design, installation, commissioning, operation, and maintenance.

1.2 **This standard defines the amount of *equivalent clean airflow* necessary to substantially reduce the risk of disease** transmission during ***infection risk management mode***.

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ASHRAE Standard 241: Foreword

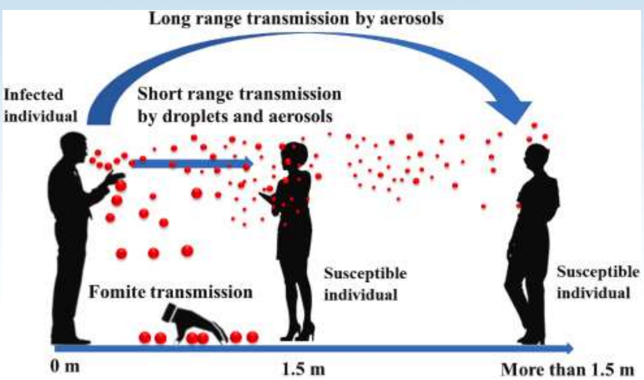
2. Scope:

2.1 This standard:

a. Does not address requirements for maintaining acceptable indoor air quality

b. **May not substantially reduce transmission risk** in all situations due to the diversity of infectious agents and personal susceptibility

c. **Addresses only indoor *long-range transmission*** resulting **from inhalation of infectious aerosol…**



2.2 This standard **does not determine** the conditions under which infection risk management mode should be invoked

2.3 No requirement in this standard shall be used to circumvent any health, safety or comfort regulations required by the ***authority having jurisdiction (AHJ)***.

ASHRAE Standard 241: Definitions

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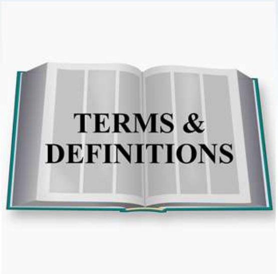
ASHRAE Standard 241: Foreword

ASHRAE Standard 241: Definitions

- ***Air cleaning:* *reducing the concentration of infectious aerosols*** *in the air through infectious aerosol capture and removal or by infectious aerosol inactivation"*
- ***Authority having jurisdiction*:** the agency or agent responsible for determining compliance with this standard.
- ***Building readiness plan (BRP):*** a plan that documents the engineering and non-engineering controls that the facility systems will use for the facility to achieve its goals.



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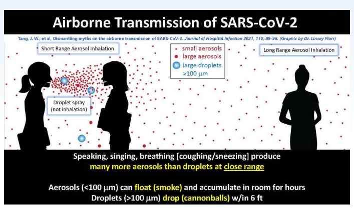
ASHRAE Standard 241: Foreword

ASHRAE Standard 241: Definitions

- ***Equivalent clean airflow:*** the **theoretical flow rate of pathogen-free air** that, if distributed uniformly within the breathing zone, would have the same effect on infectious aerosol concentration as **the sum of actual outdoor airflow, filtered airflow, and inactivation of infectious aerosols**
- ***Infection risk management mode (IRMM);*** the mode of operation in which **measures to reduce infectious aerosol exposure documented in a *building readiness plan*** *are active*



- ***Long-range transmission:*** disease transmission that is due to aerosols emitted by an infector who is not in close proximity to (within approximately 3 ft of) a susceptible occupant.

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ASHRAE Standard 241: Compliance

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ASHRAE Standard 241: Compliance

ASHRAE Standard 241-2023

- **4.1 Prerequisites**
  - 4.1.1 The building shall **meet the requirements of the applicable version of ANSI/ASHRAE Standard 62.1, ANSI/ASHRAE Standard 62.2, or ANSI/ASHRAE/ASHE Standard 170**

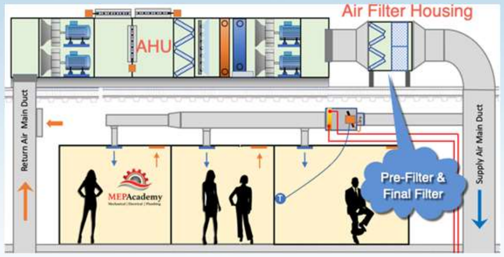
- **4.2 Requirements:**
  - 4.2.3 The **infectious aerosol removal efficiency (ε_{PR})** of mechanical fibrous filters shall be assigned **a value of zero unless rated MERV-A 11 or higher** when **tested in accordance with ANSI/ASHRAE Standard 52.2, Informative Appendix J**. Any filter with an ePM2.5 50% rating from ISO Standard 16890-1 or certified by the manufacturer to be a high-efficiency particulate air (HEPA) filter is deemed to meet this requirement
  - **Exception to 4.2.3** Compliance prior to January 1, 2025, **does not require** use of **ANSI/ASHRAE Standard 52.2, Informative Appendix J**

ASHRAE Standard 241: Compliance

ASHRAE Standard 52.2-2017: Foreword

Passive Electrostatic Fibrous Media Air Filters:

- *“**Some fibrous media air filters have electrostatic charges** that may be either natural or imposed on the media during manufacturing.”*
- *“**Such filters may demonstrate high efficiency when clean and a drop in efficiency during their actual use cycle.***



- *“Therefore, **the minimum efficiency observed during testing may be higher than that achieved during actual use.**”*

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ASHRAE Standard 241: Compliance

ASHRAE Standard 52.2: Camfil Website

camfil
AIR POLLUTION CONTROL

What are MERV Ratings? MERV vs MERV-A Filter Ratings Explained

ASHRAE Standard 52.2-2017			
Minimum **E**fficiency **R**eporting **V**alue	Composite Average Particles Size Efficiency		
	Range 1 (µm)	Range 2 (µm)	Range 3 (µm)
MERV	0.3 - 1.0	1.0 - 3.0	3.0 - 10.0
7			$E_3 \geq 50$
8		$E_2 \geq 20$	$E_3 \geq 70$
9		$E_2 \geq 35$	$E_3 \geq 75$
10		$E_2 \geq 50$	$E_3 \geq 80$
11	$E_1 \geq 20$	$E_2 \geq 65$	$E_3 \geq 85$
12	$E_1 \geq 35$	$E_2 \geq 80$	$E_3 \geq 90$
13	$E_1 \geq 50$	$E_2 \geq 85$	$E_3 \geq 90$
14	$E_1 \geq 75$	$E_2 \geq 90$	$E_3 \geq 95$
15	$E_1 \geq 85$	$E_2 \geq 90$	$E_3 \geq 95$
16	$E_1 \geq 95$	$E_2 \geq 95$	$E_3 \geq 95$

The final MERV value is the highest value where the filter meets all the requirements of that MERV.

Is a Higher MERV Rating Always Better?

- *"…there is **a critical component of MERV that is not being discussed** nearly enough…"*
- ***"Air filters can be produced with an electrostatic charge** which acts much like a magnet and **temporarily increases the particle capture efficiency** on the three size ranges (i.e.: E1, E1, E3)"*
- *"A **MERV-13 filter**, for example, **can drop to a particle capture efficiency equivalent to that of a MERV-8 filter** within a short period of time…"*

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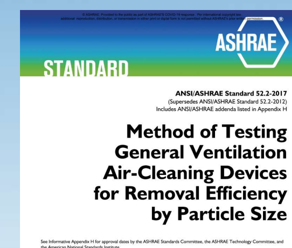
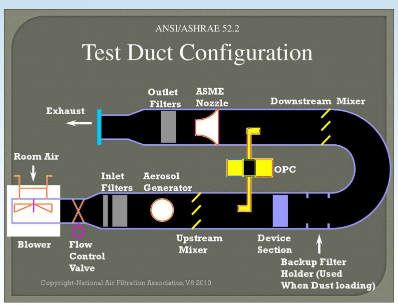
ASHRAE Standard 241: Compliance

ASHRAE Standard 52.2: Informative Appendix J

- **J1. Purpose of Optional Test:**
  - *Appendix J presents a conditioning procedure to determine the **magnitude of the efficiency loss** a filter may realize in field applications.*
  - ***This procedure is a separate test from that described in Section 10.7.1.2 (b).***





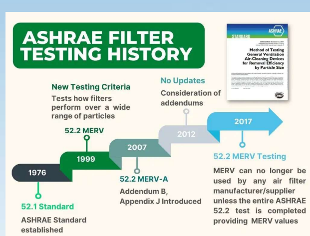
(Copyright: National Air-Filtration Assoc. V6 2010)

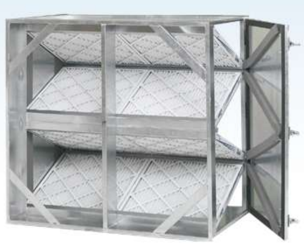
- *"When the **Appendix J** test is used, the data output obtained from the efficiency test procedure **after the KCL (Section 10.7.1.2(b))** conditioning step **is referred to as MERV-A**, as defined in Section J2.2."*

ASHRAE Standard 241: Compliance

ASHRAE Standard 52.2: Informative Appendix J

- **J1. Purpose of Optional Test:**
  - ***"…When the test in Appendix J is used, the data output*** *value* ***(from the conditioning test)*** *is thus* ***differentiated from the MERV value*** *…"*





- ***The conditioning step****… is representative of the best available knowledge of* ***real-life filter efficiency degradation*** *at the time of the publication of this procedure.*
- ***Changes in filtration performance are environment dependent*** *and, therefore,* ***filters may or may not degrade*** *to the conditioned efficiencies…*
- Test Purpose: "*…so that those concerned about a* ***possible drop in filtration efficiency*** *have a recognized test method* ***to predict the magnitude of the efficiency loss…"***

ASHRAE Standard 241: Compliance

ASHRAE Standard 52.2: HPAC Engineering Article

Updated Standard for Air-Filter Testing (August 1, 2008)

HPAC Engineering

- *"The conditioning step in Appendix J will allow manufacturers to show* ***results from two test procedures (e.g., MERV 14 and MERV11-A)…,***
- ***"…it is safe to assume that MERV-A is closer to the efficiency of the filter in real-life application."***

What to Look For?:

- *"When comparing air filters,* ***look at both the MERVs and MERV-As****."*
- *"…the most common particle size is about 0.4 micron.*
- *"To protect building occupants,* ***choose a filter that is highly efficient in capturing particles of that size****."*
- ***"For a commercial building****, that would be a* ***MERV13/MERV-13-A filter…"***

ASHRAE Standard 241:
Equivalent Clean Airflow for Infection Risk Mitigation

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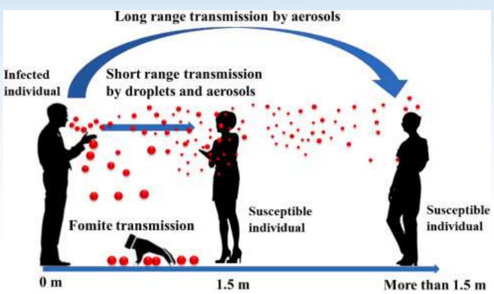
Equivalent Clean Airflow for Infection Risk Mitigation

Standard 241: Definitions Review

- ***Equivalent clean airflow***: the **theoretical flow rate of pathogen-free air** that, if distributed uniformly within the breathing zone, would have **the same effect on infectious aerosol concentration as the sum of actual outdoor airflow, filtered airflow, and inactivation of infectious aerosols**

5.1 Minimum Equivalent Clean Airflow Rate



- **5.1.1 Minimum *equivalent clean airflow* rate required** in the breathing zone for each occupiable space **to mitigate *long-range transmission* risk in *IRMM* (V_{ECAi}) *shall be determined in accordance with Equation 5-1.***

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Equivalent Clean Airflow for Infection Risk Mitigation

5.1 Minimum Equivalent Clean Airflow Rate

- ***Occupied Space Equivalent Clean Airflow Calculation***
  - $V_{ECAi} = ECAi \times P_{Z,IRMM}$ ***(Equation 5-1)***

Table 5-1 Minimum Equivalent Clean Airflow per Person in Breathing Zone in IRMM

Occupancy Category	ECAi cfm/person	ECAi L/s/person
Correctional Facilities		
Cell	30	15
Dayroom	40	20
Commercial/Retail		
Food and beverage facilities	60	30
Gym	80	40
Office	30	15
Retail	40	20
Transportation waiting	60	30
Educational Facilities		
Classroom	40	20
Lecture hall	50	25
Industrial		
Manufacturing	50	25
Sorting, packing, light assembly	20	10
Warehouse	20	10
Health Care		
Exam room	40	20
Group treatment area	70	35
Patient room	70	35
Resident room	50	25
Waiting room	90	45
Public Assembly/Sports and Entertainment		
Auditorium	50	25
Place of religious worship	50	25
Museum	60	30
Convention	60	30
Spectator area	50	25
Lobbies	50	25
Residential		
Common space	50	25
Dwelling unit	30	15

(Table 5-1)

- V_{ECAi} ***= minimum equivalent clean airflow rate*** *required in the breathing zone to mitigate long-range transmission risk in IRMM, CFM*
- ***ECAi =*** *Equivalent clean airflow rate required per person* ***in IRMM*** *from* ***Table 5-1****, CFM per person*
- $P_{Z,IRMM}$ *= number of people in the breathing zone in IRMM (CFM per person)**

**(Note: PZ,IRMM shall default to the number of occupants used to calculate the ventilation rate per the applicable standard (i.e. Standard 62.1, 170…or) design occupancy or lower number of occupants during IRMM accepted by the owner)*

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Equivalent Clean Airflow for Infection Risk Mitigation

5.1 Minimum Equivalent Clean Airflow Rate

- *Occupied Space Equivalent Clean Airflow Calculation*
  - *V_{ECAi} = ECAi x $P_{Z,IRMM}$ (Equation 5-1)*

Table 5-1 Minimum Equivalent Clean Airflow per Person in Breathing Zone in IRMM

	ECAi	
Occupancy Category	**cfm/person**	**L/s/person**
Correctional Facilities		
Cell	30	15
Dayroom	40	20
Commercial/Retail		
Food and beverage facilities	60	30
Gym	80	40
Office	30	15
Retail	40	20
Transportation waiting	60	30
Educational Facilities		
Classroom	40	20
Lecture hall	50	25
Industrial		
Manufacturing	50	25
Sorting, packing, light assembly	20	10
Warehouse	20	10
Health Care		
Exam room	40	20
Group treatment area	70	35
Patient room	70	35
Resident room	50	25
Waiting room	90	45
Public Assembly/Sports and Entertainment		
Auditorium	50	25
Place of religious worship	50	25
Museum	60	30
Convention	60	30
Spectator area	50	25
Lobbies	50	25
Residential		
Common space	50	25
Dwelling unit	30	15

- **V_{ECAi} Calculation: Sample**
  - **Commercial / Retail Building:**
    - *V_{ECAi} = ECAi x $P_{Z,IRMM}$*: **Applied**
    - *Occupants: 10*
    - *Office ECAi Factor: 30 CFM per person*
    - *Total V_{ECAi} = 30 CFM x 10 (occupants) = 300 CFM ECAI*

Informative Note: See Informative Appendix D

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Equivalent Clean Airflow for Infection Risk Mitigation

5.1 Minimum Equivalent Clean Airflow Rate

- ***5.1.3: Where the occupancy category*** *for a proposed space or zone* ***involves group vocalization above conversational level,*** *the equivalent clean airflow rate require per person in IRMM shall be multiplied by a factor of 2.*

- **Commercial / Retail Building: Office Singing**
  - **V_{ECAi} = ECAi x $P_{Z,IRMM}$: Applied**
  - **Occupants: 10**
  - **Office ECAi Factor: 30 CFM per person**
  - **Total V_{ECAi} = 30 CFM x 10 = 300 CFM ECAI**
  - **300 CFM ECAI x 2 = 600 CFM ECAi**

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ASHRAE Standard 241:
Air Distribution and Natural Ventilation

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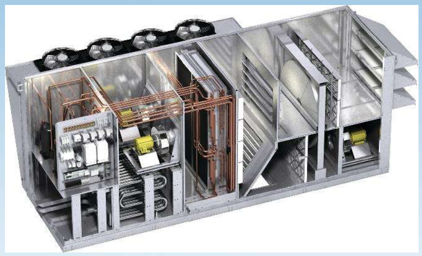
Air Distribution and Natural Ventilation

Equivalent Clean Airflow: Standard Definitions

- **Clean Air:** "…theoretical flow rate of pathogen free air, if distributed uniformly within the breathing zone, that would have the same effect on infectious aerosol concentration as the **SUM of**:
  - **Actual Outdoor Airflow**
  - **Filtered Airflow**
  - **Inactivation of infectious aerosols**



- **Clean Airflow Rate to each zone is the total volume of air supplied to each zone to provide the required occupant ECAi cfm at the breathing zone**

Air Distribution and Natural Ventilation

6.1 Clean Airflow Rate: (e.g. Multizone Air Handler)

- The **clean airflow rate to each zone**, as **shown in Figure 6-1**, shall be greater than or equal to the **minimum *equivalent clean airflow*** required, as **expressed by Equation 6-1**

Equation 6-1: $V_{ECAi} \geq \Sigma[Z_f \times (V_{OT} + V_{MVS})] + \Sigma V_{ACS} + V_{NV}$

- V_{ECAi} = ***the minimum clean airflow rate*** *required at the breathing zone, cfm*
- Z_f = the **zone air fraction**, calculated as the supply airflow rate to the zone divided by the total supply airflow rate to all zones
- V_{OT} = the **outdoor air intake flow rate**, cfm
- V_{MVS} = **multizone *air cleaning* system *equivalent clean airflow rate***, computed as **V_{ACS} from Section 7** for **an *air cleaning system*** **whose output is shared amongst zones, cfm**.
- V_{ACS} = ***air cleaning* system *equivalent clean airflow* rate**, determined per Section 7 typically as **a function of the recirculated airflow rate** to be treated **(V_{RC}), cfm**.
- V_{NV} = ***outdoor airflow rate from natural ventilation, cfm***

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Air Distribution and Natural Ventilation

6.1 Clean Airflow Rate: Air Cleaning System Applications

- **Clean Airflow Rate: Source Illustrations (Section 7.2 Calculated Effectiveness of Air Cleaning Systems)**

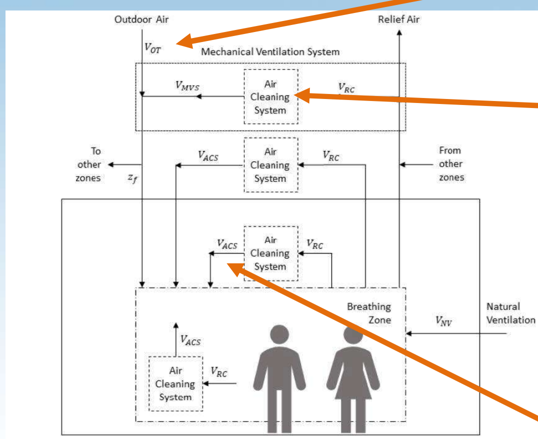

Figure 6-1 Sources of outdoor and clean air (for V_{RC}, see Section 7).

- **V_{OT} = Outdoor air intake flow rate (multizone unit)**
- **V_{MVS} = In-Duct Air cleaning Systems** that Clean Air in the **Air-Handling Unit, Ductwork, or Plenum**
- **V_{ACS} = In-Duct Air Cleaning Systems** that Clean Air **in the Occupied Zone**
- **V_{ACS} = In-Room Air Cleaning Systems** located in the occupied zone

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Air Distribution and Natural Ventilation

6.2 Zone Air Distribution Category

- Each ventilation zone shall be assigned a **zone air distribution category** as described in **Table 6-1**

Table 6-1 Zone Clean Air Distribution Category

Zone Air Distribution Category	Description	Typical System Types
Well-mixed	Airflow pattern characterized by recirculation within the breathing zone	Overhead mixing, underfloor mixing
Natural	Airflow pattern characterized by buoyant updraft within the breathing zone	Natural ventilation, horizontal displacement
Cross flow	Airflow pattern characterized by lateral movement of air throughout the breathing zone	Toilet room, kitchen transfer air
Downflow	Airflow pattern characterized by downward movement of air throughout the breathing zone	Clean room
Upflow	Airflow pattern characterized by upward movement of air throughout the breathing zone	Underfloor or sidewall displacement

Zone Air Distribution Categories:

- **Well-Mixed:** Overhead mixing, UFAD mixing
- **Natural:** Natural ventilation, horizontal displacement
- **Cross Flow:** Toilet room, kitchen transfer
- **Downflow:** Clean room
- **Upflow:** UFAD or sidewall displacement

6.3 Natural Ventilation:

- Natural Ventilation systems shall be designed **in accordance with** the methods described in **ANSI/ASHRAE Standard 62.1**…

6.4 Mixed-Mode ventilation: Well-Mixed plus Natural Ventilation

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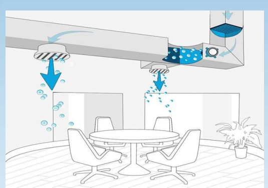
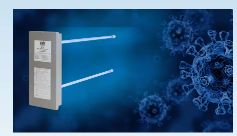
Air Distribution and Natural Ventilation

6.5 Air Cleaning Systems: Applications

- **6.5.1 Air Cleaning Systems shall not** inhibit the development of the intended flow regime of the ventilation system as described in Section 6.5.1.1 and Section 6.5.1.2
  - **6.5.1.1 In-Room Air Cleaning System Categorization.**
    - **In-room air cleaning systems** shall be **categorized** in accordance with **Table 6-2**. All categories for which the system meets the requirement shall apply.



Duct Mounted Bipolar Ionization



Duct Mounted UVGI UV-C Lighting

Table 6-2 Air Cleaning System Categories

Location	Discharge Orientation: Horizontal (H) [d]	Up (U) [e]	Down (D) [f]	No Air Discharge (X)
Floor (F) [a]	FH	FU	FD	FX
Wall (W) [b]	WH	WU	WD	WX
Ceiling (C) [c]	CH	CU	CD	CX

a. Air inlet is at or below 6 ft (1.8 m) from the floor.
b. Air inlet is within 18 in. (0.5 m) of a wall.
c. Air inlet is above 6 ft (1.8) from the floor.
d. Air discharges within ±45 degrees of a plane parallel with the floor.
e. Air discharges within ±45 degrees of a plane perpendicular to the floor in an upward direction.
f. Air discharges within ±45 degrees of a plane perpendicular to the floor in a downward direction.

Table 6.2: Air Cleaning System Categories

- **Air Cleaning System Categories**
  - Each type of device will be assigned a **discharge orientation** depending on its location in a zone; i.e. floor, wall or ceiling

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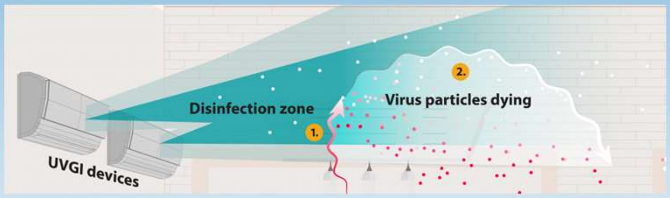
Air Distribution and Natural Ventilation

6.5 Air Cleaning Systems

- **6.5.1.2 Permitted In-Room Air Cleaning System Applications.**
  - **In-room air cleaning** systems shall only be applied in accordance with Table 6-3



Upper-Room Mounted UVGI UV-C Lighting

Ceiling Mounted Bipolar Ionization

Table 6-3 Permitted In-Room Air Cleaning System by Air Distribution Category

Zone Air Distribution Category	Permitted Air Cleaning System Categories
Well-mixed	CD, CH, CU, CX, FD, FH, FU, FX, WD, WH, WU, WX
Natural	CH, CU, CX, FU, FX, WU, WX
Cross flow	CU, CX, FD, FH, FX, WH, WU, WD, WX
Downflow	CD, CX, WD, WX
Upflow	FU, FX, WU, WX

Table 6-3: Permitted In-Room Air Cleaning System by Air Distribution Category

- Provides **guidance** on **air cleaner type**, **its discharge pattern** and the **room's Zone Air Distribution Category**

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ASHRAE Standard 241:
Air Cleaning

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Air Cleaning

7.2 Calculated Effectiveness of Air Cleaning Systems.

- The **effectiveness and safety of cleaning systems** shall be determined by **testing an *air cleaning* system** or equivalent system **in accordance with Section 7**.
- A responsible party designated by the ***authority having jurisdiction (AHJ)*** shall certify air cleaner operational, performance, and safety equivalence…

- **The manufacturer** shall certify that ***air cleaning*** systems are **effective and safe** for use under the requirements of ASHRAE Standard 241.

Air Cleaning

7.2 Calculated Effectiveness of Air Cleaning Systems.

- **7.2.1 In-Duct Air Cleaning Systems that Clean Air in the Air-Handling Unit, Ductwork, or Plenum.**
  - Each ***air cleaning* system** located **inside an air-handling unit (AHU), ductwork, or plenum** that cleans air inside the AHU, ductwork, or plenum shall have an effectiveness reported as an **infectious aerosol reduction efficiency *(ƐPR)*.**

$$V_{ACS}{}^{*} = [\varepsilon_{PR}/100] \times V_{RC}$$

- The ***(ƐPR)*** shall be determined by **a single-pass test in accordance with Section 7 and Normative Appendix A**. The ***equivalent clean airflow*** rate shall be calculated in accordance with **Equation 7-1**.

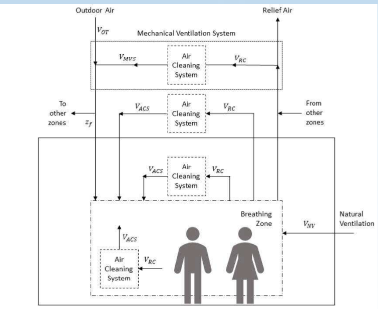

Figure 6-1 Sources of outdoor and clean air (for V_{RC}, see Section 7).

* **V_{ACS} = *air cleaning* system *equivalent clean airflow* rate**…as **a function of the recirculated airflow rate** to be treated **(V_{RC}), cfm**.

Air Cleaning

7.2 Calculated Effectiveness of Air Cleaning Systems.

- **7.2.1 In-Duct Air Cleaning Systems that Clean Air in the Air-Handling Unit, Ductwork, or Plenum.**

$$V_{ACS} = [\varepsilon_{PR} / 100] \times V_{RC}$$

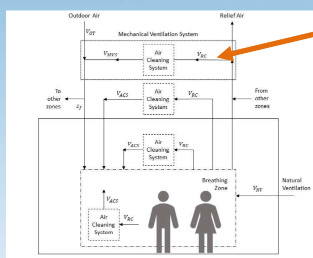

Figure 6-1 Sources of outdoor and clean air (for V_{RC}, see Section 7).

Equation 7.1 Variables Defined

- V_{ACS} = ***air cleaning* system *equivalent clean airflow* rate** due to the in-duct *air cleaning* system, cfm
- ε_{PR} = **infectious aerosol reduction efficiency**, determined in accordance with **Section 7.3.1, Section 7.4.1.1**, or **Normative Appendix A**
- V_{RC} = recirculated airflow rate **cleaned by the *air cleaning* system**, cfm

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Air Cleaning

7.2 Calculated Effectiveness of Air Cleaning Systems.

- **7.2.1 In-Duct Air Cleaning Systems that Clean Air in the Air-Handling Unit, Ductwork, or Plenum.**
  - **7.2.1.1** Where **multiple in-duct *air cleaning* systems** with a single-pass reduction efficiency **are installed in series within the same HVAC airflow path**, the infectious aerosol reduction efficiency *($\mathcal{E}PR$)* shall be determined in accordance with the appropriate version of Equation 7-2.

One System: $\mathcal{E}_{PR} = \mathcal{E}_{PR,1}$

Two System: $\mathcal{E}_{PR} = \left\{1 - [1 - (\mathcal{E}_{PR,1} / 100)] \times [1 - (\mathcal{E}_{PR,2} / 100)]\right\} \times 100$

Three System: $\mathcal{E}_{PR} = \left\{1 - [1 - (\mathcal{E}_{PR,1} / 100)] \times [1 - (\mathcal{E}_{PR,2} / 100)] \times [1 - (\mathcal{E}_{PR,3} / 100)]\right\} \times 100$

***N* Systems:**

$$\varepsilon_{PR} = \left\{1 - \prod_{j=1}^{N} \left[1 - \left(\frac{\varepsilon_{PR,j}}{100}\right)\right] \times 100\right\}$$

- Where $\mathcal{E}_{PR,j}$ is the *infectious aerosol reduction efficiency* of the Jth *air cleaning* system determined in accordance with Section 7 or **Normative Appendix A**

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Air Cleaning

7.3 Mechanical Fibrous Air Cleaning Systems.

- **7.3.1 Infectious Aerosol Removal Efficiency for Mechanical Fibrous Filters Installed In-Duct.** The infectious aerosol removal efficiency (*ε_{PR}*) *of* ***mechanical fibrous filters installed within AHUs, ductwork, or plenums***

$$\text{(Equation 7-3)}\ \varepsilon_{PR} = W_{E1}\varepsilon_{E1} + W_{E2}\varepsilon_{E1} + W_{E3}\varepsilon_{E3}$$

ε_{PR} = ***infectious aerosol removal efficiency, %***

W_{E1} = *fraction of the infectious aerosol in the 0.3 to 1.0 micrometer (µm) particle size range, dimensionless*

W_{E2} = *fraction of the infectious aerosol in the 1.0 to 3.0 micrometer particle size range, dimensionless*

W_{E3} = *fraction of the infectious aerosol in the 3.0 to 10.0 micrometer (µm) particle size range, dimensionless*

$\varepsilon_{E1, E2, E3}$ = ***particle removal efficiency*** *in the 0.3 (1.0 to 3.0, 3.0 to 10.0 respectively) to 1.0 micrometer (µm) particle size range, dimensionless**

* *See Table 7-1 Infectious Aerosol Removal Efficiency for Mechanical Fibrous Filters*

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Air Cleaning

7.3 Mechanical Fibrous Air Cleaning Systems.

- **Table 7-1 Infectious Aerosol Removal Efficiency (ε_{PR}) for Mechanical Fibrous Filters**

$$\text{(Equation 7-3)}\ \varepsilon_{PR} = W_{E1}\varepsilon_{E1} + W_{E2}\varepsilon_{E1} + W_{E3}\varepsilon_{E3}$$

Table 7-1 Infectious Aerosol Removal Efficiency (ε_{PR}) for Mechanical Fibrous Filters

ANSI/ASHRAE Standard 52.2 MERV (Prior to 1/1/2025) MERV-A (After 1/1/2025)	ISO 16890 ePM	Weighted ε_{PR}
<11		0%
11	ePM2.5 50%	60%
12	ePM2.5 65%	71%
13	ePM1 50%	77%
14	ePM1 70%	88%
15	ePM1 85%	91%
16	ePM1 95%	95%
HEPA [a]	ISO 20E [b]	99%

a. High-efficiency particulate air (HEPA) filters are not tested under ANSI/ASHRAE Standard 52.2 [5] or ISO 16890-1 [6]. However, HEPA filters are included here for completeness.
b. Tested in accordance with ISO 29463 [7].

- **MERV-11 and Lower are given a "ZERO" weighting factor**
- **Note:** After **January 2025**, **MERV-A ratings only** will be applied

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Air Cleaning

7.3 Mechanical Fibrous Air Cleaning Systems.

- **7.3.2 Equivalent Clean Airflow Rate for In-Room Air Cleaning Systems Using only Mechanical Fibrous Filters**
  - **7.3.2.1 Residential In-Room Air Cleaners Using Only Mechanical Fibrous Filters**

(Equation 7-4)

$$V_{ACS} = (W_s \times CADR^*_s) + W_d \times CADR_d) + W_p \times CADR_p)$$

- **7.3.2.2 Commercial and Industrial In-Room Air Cleaners Using Only Mechanical Fibrous Filters**
  - The *equivalent clean airflow* rate (VACS) of commercial and industrial in-room air cleaners…
- **7.3.3 Safety Requirements for Air Cleaning Systems Using Only Mechanical Fibrous Filters**

** CADR = Clean Air Delivery Rate, cfm: smoke, dust, pollen*

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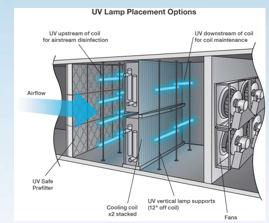
Air Cleaning

7.4 Air Cleaning Systems that Inactivate Infectious Aerosols.:

- The effectiveness and safety of air cleaners **of** **air cleaners** **with technologies that** **inactivate infectious aerosols** **shall be determined in accordance with Section 7.4.** This applies to **all *air cleaning* technologies that provide** **microorganism inactivation** or enhanced removal from the airstream, acting alone or in combination with mechanical fibrous filters, including ultraviolet, electrostatic, photocatalytic, and ionizing *air cleaning* systems.



- **7.4.1 In-Duct Air Cleaning Systems.**
  - **7.4.1.1 In-Duct Ultraviolet Germicidal Irradiation**
  - **7.4.1.2 Other in-Duct Air Cleaning Systems**
- **7.4.2 In-Room Air Cleaning Systems**
  - **7.4.2.1 Upper-Room Ultraviolet Germicidal Irradiation**
  - **7.2.2.2 Other In-Room Air Cleaning Systems**

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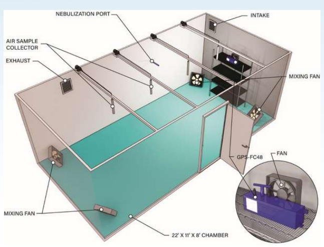
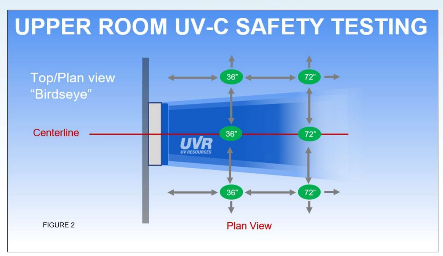
Air Cleaning

Normative Appendix A: Determining Air Cleaning System Effectiveness and Safety

- **A1. Testing Procedure**
  - Where **testing of the effectiveness or safety elements of *air cleaning* systems** fall within the scope of a national consensus standard approved by the AHU, these elements **of the systems shall be tested in accordance with the applicable standard per the requirements of Section 7.**





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Air Cleaning

Normative Appendix A: Determining Air Cleaning System Effectiveness and Safety

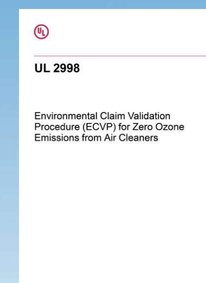
- **Referenced Standards:**
  - The consensus standards that shall be used for **determining effectiveness** are as follows:
    - A. **ANSI/ASHRAE Standard 52.2** (**Informative Note: After January 1, 2025, MERV-A ratings using Appendix J shall be required.**
    - ISO 16890-1
    - ANSI/AHAM AC-1 *
    - ANSI/AHAM AC-5 * *
    - ANSI/ASHRAE 185.1

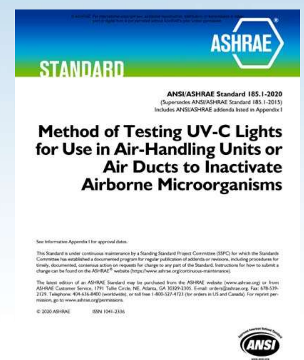
* AHAM AC-1 – Method for Measuring Performance of Portable Household Electric Room Air Cleaners
* * AHAM AC-5 – Method for Assessing the Reduction Rate of Key Bioaerosols by Portable Air Cleaners Using An Werobiology Test Chamber

Air Cleaning

Normative Appendix A: Determining Air Cleaning System Effectiveness and Safety

- **Referenced Standards:**
  - The **consensus standards** that shall be used for determining **safety** are as follows:
    - UL2998
    - ASTM D8407
    - ISO 14644





- Where the effectiveness and/or performance of an air cleaning system is not covered by any of the above consensus standards, **custom tests shall be performed by a third-party, independent laboratory in accordance with the conditions in Normative Appendix A**.

* ASTM D8407 – Standard Guide for Measurement Techniques for Formaldehyde in Air
* * ISO 14644 – Cleanrooms and associated controlled environments – Part 1: Classification of air cleanliness by particle concentration

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Air Cleaning

Informative Appendix F: Equivalent Clean Airflow Calculator

- The **Equivalent Clean Airflow Calculator** can help determine the existing system's ***equivalent clean airflow*** for infection controls as well as the modifications that achieve the target V_{ECAi} set by ASHRAE Standard 241.

Phase of the Process		Assessment	Planning	Planning	Planning	Planning	Implement
Name of Space / AHU / Building	Units	EXISTING	Option 1	Option 2	Option 3	Option 4	FINAL SYSTEM
Description of system or Option		AHU with X,Y,Z	Description	Description	Description	Description	Description
Space Type from Standard 241	Type	Office	Office	Office	Office	Office	Office
Target ECAi from Standard 241 (See Instructions for Table)	CFM / Person	30	30	30	30	30	40.0
Area	Sq Ft	2,000	2,000	2,000	2,000	2,000	2,400
Average Ceiling Height	Ft	9	9	9	9	9	9
Volume	Cu Ft	18,000	18,000	18,000	18,000	18,000	21600
Total Supply Air	CFM	1,800	1,800	1,800	1,800	1,800	1800
Total Outdoor Air	CFM	240	240	240	240	240	272
Occupancy - Design (Pz)	Quantity	12	12	12	12	12	12
Occupancy - IRMM Target ($P_{z,IRMM}$)	Quantity	8	8	8	8	8	12
$V_{ECAi,t,Des}$ Airflow Target - Design Occupancy	CFM	360	360	360	360	360	480
$V_{ECAi,t,IRMM}$ Airflow Target - IRMM Target Occ.	CFM	240	240	240	240	240	480
Central AHU Filter MERV Rating	MERV	12	13	13	13	13	13
Method for Rating Filter	241 or DNFE	241	241	DNFE	241	241	241
Filter Pathogen Removal Efficiency	εPR	71.0%	77.0%	67.0%	77.0%	77.0%	77.0%
UV in HVAC - Single Pass Inactivation	%	0.0%	35.00%	50.00%	0.00%	0.00%	0.00%
Air Treatment in HVAC (Impacts Space)	CFM	400	100	0	0	0	0
Air Treatment Device in Space	CADR	0	4	0	0	0	0
Number of Air Treatment Devices in Space	Quantity	0	1	0	0	0	0

Figure F-2 Equivalent Clean Airflow Calculator interface.

- The goal is to be able to **evaluate new designs as well as existing building HVAC systems** to help **determine the equivalent clean airflow** for infection control

- **The calculator can be downloaded at www.ashrae.org/241-2023**

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ASHRAE Standard 241-2023

Assessment, Planning and Implementation

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Assessment, Planning and Implementation

8. Assessment, Planning, and Implementation

- **8.1 Building Readiness Plan (BRP)**, The BRP shall be created after the assessment, planning, and implementation phases to describe the engineering and nonengineering controls that the facility's systems will use to achieve its target *equivalent clean airflow* for infection control ***($V_{ECAi,target}$).***

Informative Appendix E:
Building Readiness Plan Template

- ASHRAE Standard 241 requires the development of a ***building readiness plan (BRP)* to document sequences of operations,** specifically the added engineering controls to the HVAC&R system to operate in ***infection risk management mode (IRMM)*** in lieu of normal mode.

Contents

Introduction 3
HVAC Mitigation Strategies by Building 3
  Building Description 4
    Occupied Hours 4
    Building Occupancy (Normal Mode and IRMM) 4
    Outside Air 4
    Filters 4
    Air Cleaners—In HVAC 4
    Air Cleaners—In Room 5
    In-Room Fan Filter Units 5
    Assessment and Planning 5
    Non-HVAC Mitigation Strategies 5
Attachments 6
  Attachment A—Owner's HVAC IRMM Operations Guide 6
  Attachment B—Critical Asset Inventory Management Plan 6
  Attachment C—Testing Documentation 19

Figure E-1 Sample table of contents for a building readiness plan.
(Courtesy of Hanson Professional Services, Inc.)

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Assessment, Planning and Implementation

8. Assessment, Planning, and Implementation

- **8.1(a)** The engineering controls section shall include:
  - The **operations and maintenance (O&M)** procedures (including **operating schedules**),
  - **Ventilation system operating schedules** and airflow values
  - ***Air cleaning* technologies used** with
    - Included locations, filtration MERV rating and rack sizing
    - Final design drawings
    - Critical asset inventory management plan
    - Maintenance schedules based on manufacturer instructions, the maintenance requirements and frequencies provided in Section 9.2.2…

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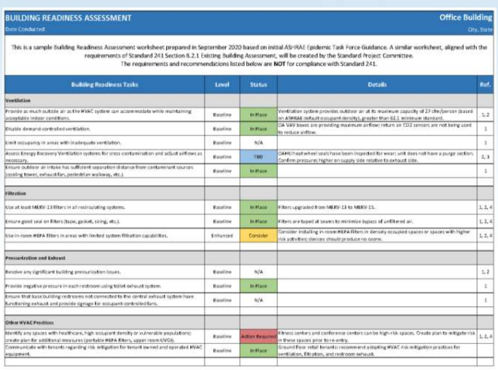
Assessment, Planning and Implementation

8. Assessment, Planning, and Implementation

- **8.2 Existing Buildings**
  - The requirements of this section apply to buildings and their systems that were constructed or renovated before the adoption of this standard.
  - The existing building and its system shall be assessed for current operation and feasibility of potential engineering controls that contribute to the required ***V_{ECAi}.***



BUILDING READINESS ASSESSMENT — **Office Building**

Date Conducted — City, State

This is a sample Building Readiness Assessment worksheet prepared in September 2020 based on initial ASHRAE Epidemic Task Force Guidance. A similar worksheet, aligned with the requirements of Standard 241 Section 8.2.1 Existing Building Assessment, will be created by the Standard Project Committee.
The requirements and recommendations listed below are **NOT** for compliance with Standard 241.

Building Readiness Tasks	Level	Status	Details	Ref.
Ventilation				
Provide as much outside air as the HVAC system can accommodate while maintaining acceptable indoor conditions.	Baseline	In Place	Ventilation system provides outdoor air at its maximum capacity of 27 cfm/person (based on ASHRAE default occupant density), greater than 62.1 minimum standard.	1, 2
Disable demand-controlled ventilation.	Baseline	In Place	OA VAV boxes are providing maximum airflow; return air CO2 sensors are not being used to reduce airflow.	1
Limit occupancy in areas with inadequate ventilation.	Baseline	N/A		1
Assess Energy Recovery Ventilation systems for cross contamination and adjust airflows as necessary.	Baseline	TBD	OAHU heat wheel seals have been inspected for wear; unit does not have a purge section. Confirm pressures higher on supply side relative to exhaust side.	2, 3
Ensure outdoor air intake has sufficient separation distance from contaminant sources (cooling tower, exhaust fan, pedestrian walkway, etc.).	Baseline	In Place		1
Filtration				
Use at least MERV-13 filters in all recirculating systems.	Baseline	In Place	Filters upgraded from MERV-13 to MERV-15.	1, 2, 4
Ensure good seal on filters (tape, gasket, sizing, etc.).	Baseline	In Place	Filters are taped at seams to minimize bypass of unfiltered air.	1, 2, 4
Use in-room HEPA filters in areas with limited system filtration capabilities.	Enhanced	Consider	Consider installing in-room HEPA filters in densely occupied spaces or spaces with higher risk activities; devices should produce no ozone.	1, 2, 4
Pressurization and Exhaust				
Resolve any significant building pressurization issues.	Baseline	N/A		1, 2
Provide negative pressure in each restroom using toilet exhaust system.	Baseline	In Place		1
Ensure that base building restrooms not connected to the central exhaust system have functioning exhaust and provide signage for occupant-controlled fans.	Baseline	N/A		1
Other HVAC Practices				
Identify any spaces with healthcare, high occupant density or vulnerable populations; create plan for additional measures (portable HEPA filters, upper room UVGI).	Baseline	Action Required	Fitness centers and conference centers can be high-risk spaces. Create plan to mitigate risk in these spaces prior to re-entry.	1, 2, 4
Communicate with tenants regarding risk mitigation for tenant owned and operated HVAC equipment.	Baseline	In Place	Ground floor retail tenants: recommend adopting HVAC risk mitigation practices for ventilation, filtration, and restroom exhaust.	

- The existing building and its system shall be **assessed for current operation and feasibility** of potential engineering controls that contribute to the required ***V_{ECAi}.***

ASHRAE Standard 241-2023: Operation and Maintenance

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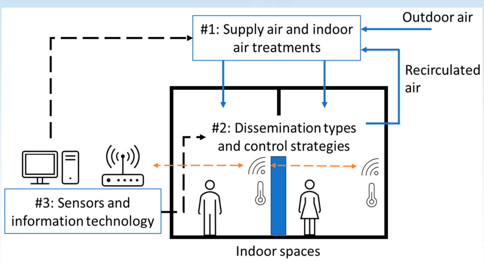
Assessment, Planning and Implementation

9. Operations and Maintenance

- **9.1 Operations:**
  - **9.1.1 Building Readiness Plan (BRP).** The *BRP*,…shall be maintained on site or in a centrally accessible location for the working life of the applicable ventilation system equipment and components



  - **9.1.3 Modes:** The operator and building owner, *AHJ*, or public health official shall determine which mode of operation shall be used for the facility. Modes of operation shall be identified as one of the following
    - **a. Normal mode: occupied and unoccupied**
    - **b. *IRMM*: occupied and unoccupied**
    - **c. Temporary shutdown**

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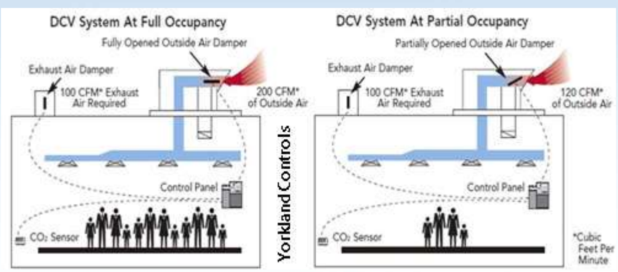
Assessment, Planning and Implementation

9. Operations and Maintenance

- **9.1 Operations:**
  - **9.1.4 Operating Schedule:** Engineering controls shall be operated whenever the space is occupied in ***IRMM*** to provide not less than the target V_{ECAi} for all load conditions or dynamic reset conditions



- **The operation schedule shall be controlled** by one or more of the following:
  - a. Time of day scheduling
  - b. Occupancy sensors shall be used in accordance with ANSI/ASHRAE Standard 62.1, Section 6.2.6.1.4.
  - c. During *IRMM*, intermittent ventilation…shall not be permitted when space is occupied
  - d. Demand-control ventilation (DCV) shall operate as noted in the *BRP.*

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Assessment, Planning and Implementation

9. Operations and Maintenance

- 9.1 Operations:
  - 9.1.5 Flush Between Occupied Periods.
  - 9.1.6 Occupant Count During IRMM
  - 9.1.7 Operation at Varying Fan Speeds
  - 9.1.8 Temperature and Humidity
  - 9.1.9 Air Distribution
  - 9.1.10 Separation Area
  - 9.1.11 Operator Training

Table 9-1 Minimum Maintenance Activity and Frequency for Ventilation System Equipment and Associated Components

Inspection/Maintenance Task	IRMM Maintenance Interval
Check pressure drop and scheduled replacement date of filters and *air cleaning* devices. Confirm that pressure drop readings do not exceed the maximum pressure drop of the filter or the maximum allowable for the fan based on the static pressure calculations. Clean or replace as necessary to ensure proper operation.	Quarterly or when replaced, whichever is more frequent
Check P-traps in premise plumbing and floor drains located in plenums or rooms that serve as air plenums. Prime as needed to ensure proper operation.	Monthly
Visually inspect outdoor air intake louvers, bird screens, natural ventilation openings, and adjacent areas for cleanliness and integrity; clean as needed. Remove all visible debris or visible biological material observed and repair visible damage to louvers or screens if such damage impairs the provision of outdoor air.	Monthly
Verify the operation of natural ventilation manual and automatic opening controls for proper operation; repair or replace as necessary.	Monthly
Verify the operation of the outdoor air ventilation system and any dynamic minimum outdoor air controls; repair or replace as necessary.	Quarterly
Check air filter fit and housing seal integrity. Correct as needed.	Annually or when replaced, whichever is more frequent
Check for proper damper operation. Clean, lubricate, repair, replace, or adjust as needed to ensure proper operation.	Quarterly

Table 9-1 Minimum Maintenance Activity and Frequency for Ventilation System Equipment and Associated Components

ASHRAE Standard 241:
Dwelling Units – Additional Requirements

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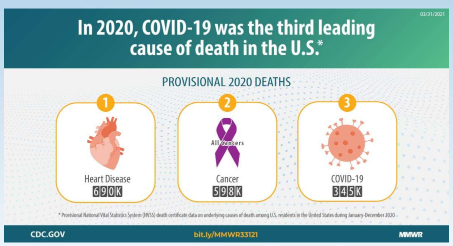
Concluding Remarks

Concluding Remarks

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

The Covid-19 Pandemic: The Rate of Infection

- **January 19, 2020: China** reports **282 laboratory-confirmed cases**
- **January 24, 2020:** USA – Illinois reports **two cases**
- **August 17, 2020:** USA – **COVID-19 becomes the 3rd leading cause of death in the U.S.**. Deaths from COVID-19 now exceed **1,000 per day**



USC Schaeffer
Leonard D. Schaeffer Center for Health Policy & Economics

The Future of American Healthcare

- **September 30, 2020:** The reported death toll from COVID-19 reaches more than **1 million worldwide – in just 10 months**
- **Total Economic Cost: "…to the U.S. economy…$14 trillion (US) by end of 2023**

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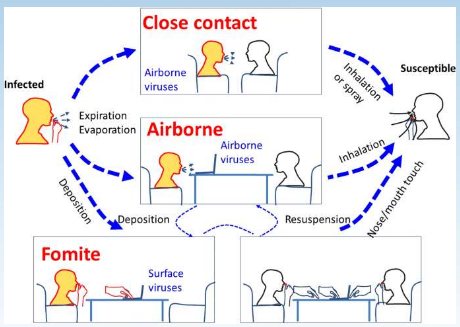
Concluding Remarks

The Covid-19 Pandemic: The Rate of Infection

- **Covid-19: Modes of Transmission**
  - **Fomic and Close Range Droplets**
  - **Sterilize surfaces and hands, social distancing**



- **April 14, 2020:** ASHRAE Epidemic Task Force
  - Properly design HVAC systems can reduce the risk of infection
- **August 25th, 2020:** Consortium of global scientists argue COVID-19 is transmitted as a long-range aerosol

Concluding Remarks

The Covid-19 Pandemic: The Rate of Infection

- **Covid-19: Modes of Transmission**
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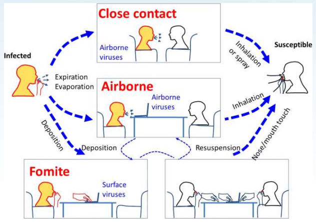
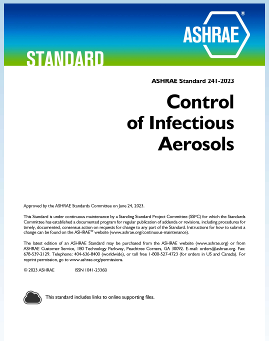


- **April 14, 2020:** ASHRAE Epidemic Task Force
  - Risk of transmission as an aerosol
  - HVAC systems can reduce the risk of infection
- **August 25th, 2020:** Consortium of global scientists argue COVID-19 is transmitted as a long-range aerosol

Concluding Remarks

ASHRAE Standard 241

- **December 2022: White House COVID-19 Task Force** approaches ASHRAE about the need for new and better indoor air quality standards



- **June 15, 2023: ASHRAE Project Committee published Standard 241-2023: Control of Infectious Aerosols**
- **New Standard's Objective: reduce long-range transmission of infectious aerosols** by designing **HVAC "resiliency** into mechanical systems that can operate in an ***infection risk management* mode (IRMM)** that supply a prescribed amount of ***clean air*** to occupant breathing zones to **reduce concentrations of aerosolized pathogens**

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Questions?

Thank you.

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