STANDARD

ASHRAE Standard 241-2023

Control of Infectious Aerosols

Approved by the ASHRAE Standards Committee on June 24, 2023.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 180 Technology Parkway, Peachtree Corners, GA 30092. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1041-2336B

This standard includes links to online supporting files.

SPECIAL NOTE

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Senior Manager of Standards of ASHRAE should be contacted for

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

CONTENTS
ASHRAE Standard 241-2023
Control of Infectious Aerosols

Access to Online Supporting Files is available with purchase of ASHRAE Standard 241-2023. Visit www.ashrae.org/bookstore.

NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ASHRAE requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE.)

FOREWORD

Airborne transmission of communicable diseases occurs when a susceptible person inhales a sufficient number of active pathogens to cause an infection, i.e., an infectious dose. Engineering controls—dilution ventilation, filtration, and air disinfection—can reduce the concentration of active pathogens in the air, which tends to reduce risk of infection. Engineering controls are only one element of a well-designed risk management plan. They cannot eliminate risk and may not be as effective as other risk mitigation measures. However, inadequate control of indoor exposures has been demonstrated to contribute to elevated risk, so it is important to strike a balance between levels of control that create high risk and those that are beyond the point of diminishing returns.

Explicit requirements for airborne infection risk management have been absent for a century from indoor air quality (IAQ) standards with the exception of those written for health care facilities and laboratories. ASHRAE's predecessor society, the American Society of Heating and Ventilating Engineers (ASHVE), published ventilation recommendations in 1895 intended to reduce disease transmission, which were incorporated in a proposed 1914 model law and included in 22 U.S. state codes by 1922. In the 1930s, IAQ standards began adopting definitions of acceptable IAQ that focused on perceived air quality and control of typical chemical and particulate contaminants and that reset minimum ventilation rates to values generally much lower than the original ASHVE values. Since then, there has been growing awareness that indoor environments play a significant role in disease transmission. ASHRAE's early contributions on this topic include the 2009 "ASHRAE Position Document on Airborne Infectious Diseases," revised in 2022 as "ASHRAE Positions on Infectious Aerosols. Unfortunately, that awareness has not, until now, resulted in significant changes to standards and codes, despite concern that a large-scale, historical infectious event on the scale of the 1918 influenza pandemic was highly likely. Many smaller epidemics over the past several decades involving influenza and coronaviruses generated momentary concern and then faded from memory.

The COVID-19 pandemic caused enormous personal, societal, and economic damage, much of which resulted from the closure of public buildings due to widespread perception (supported by considerable evidence) that they were high-risk environments for infection transmission. This experience intensified discussion about the adequacy of existing IAQ standards, including code-basis standards such as ANSI/ASHRAE Standard 62.1, and added renewed urgency to calls for improved guidance. Recognizing that indoor environments were not well-prepared to mitigate the risk of COVID-19 transmission, ASHRAE formed its Epidemic Task Force (ETF) early in 2020. In a matter of months, the ETF produced a large body of guidance that has been well received and widely used. It addressed ventilation, filtration and air cleaning, air distribution, HVAC system operation, and commissioning for multiple building types, and presented a framework for planning effective upgrades. This guidance was not intended to set new enforceable minimum requirements, but it laid the groundwork for their development, which was envisioned as a logical next step.

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 was encouraged to take the lead in developing a new standard for control of airborne pathogens. On December 6, 2022, the ASHRAE Board of Directors authorized development of a standard with the goal of publishing in six months, and authorized the use of special procedures to make that possible. The project scope approved by the 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. The Project Committee roster and the title, purpose, and scope of the standard were approved at the ASHRAE 2023 winter meeting, and the committee began its work in February. A draft was approved for advisory public review on May 11, 2023, that received over 1000 comments. The revised draft was approved for publication by the Project Committee on June 15, 2023, and the ASHRAE Standards Committee gave final approval on June 24, 2023. As was the case with the Epidemic Task Force, the work of SPC 241 was accomplished almost exclusively through frequent virtual meetings. The full Project Committee and Executive Committee held bi-weekly meetings, and the six working groups met no less than weekly throughout the development period. The two-day Executive Committee meeting on June 9–10, 2023, at ASHRAE headquarters to assemble the publication review draft was the sole in-person meeting during development of the standard.

The requirements of the standard apply to a wide range of building and space types. Key features include the following:

- *A requirement that systems comply with the requirements of the applicable ventilation and indoor air quality standards (e.g., ANSI/ASHRAE Standards 62.1 and 62.2 or ANSI/ASHE/ASHRAE Standard 170), including minimum ventilation rates. Standard 241 provides additional requirements 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 based on public health data.*
- *Requirements for infection risk management given in terms of equivalent clean airflow rate in units of flow per occupant in a space (ECAi). The equivalent clean airflow requirement for a space or system can be met not only by outdoor air but also by filtered recirculated air and air disinfected by various other technologies. This allows flexibility for compliance using combinations of controls that optimize factors such as cost and energy use. ECAi requirements are based on extensive risk modeling, using inputs supported by peer-reviewed literature wherever possible. This analysis found flow rate per person to be the most useful and scalable way to represent requirements. To assist users in calculation of equivalent clean airflow, an updated version of the ETF equivalent outdoor air calculator spreadsheet is provided.*
- *Requirements for air distribution in mechanically ventilated, naturally ventilated, and mixed-mode buildings, and requirements for application of in-room air cleaners.*
- *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, documented in a building readiness plan that is modeled after the document of the same name developed by the ETF. These requirements address commissioning of installed systems to verify compliance.*
- *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, including requirements for separation areas to be used by infected residents and additional ventilation when there are vulnerable occupants.*

Standard 241 is groundbreaking in a number of ways:

- *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.*
- *The requirements for filter and air cleaner testing incorporated in this standard go well beyond what is found in current 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. Ultimately, this should enable more widespread and confident application of these technologies when method-of-test standards currently under development are published and available for reference.*

While the initial publication of Standard 241 provides a complete framework for planning, design, operation, and maintenance of systems that reduce risk of airborne infection transmission, there are ways in which it can be improved in the future with the benefit of needed research. Areas of need include the following:

- *A risk calculator implementing the methodology used to develop prescriptive equivalent clean airflow requirements that will support development of custom targets*
- *Refined air distribution guidance that accounts for contaminant removal effectiveness*
- *Guidance on use of computational fluid dynamics in complying with air distribution requirements*

The Project Committee will take up these and other issues in the next publication cycle.

The publication of Standard 241 is a notable achievement in terms of both its content and the speed with which it was produced. Both are due to the expertise of volunteers and staff, and their commitment to meet an ambitious schedule, along with the strong support of the ASHRAE Standards Committee and ASHRAE Board of Directors. It is their hope that the standard will be widely used to save many lives and help minimize the disruption to society of airborne diseases in the future.

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 both outdoor air system and 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*.

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 emitted by an infector who is not in close proximity to a susceptible occupant

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*.

3. DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

3.1 General. Certain terms, abbreviations, and acronyms are defined in this section of the standard. When the tense or number of the term differs from the defined terms, the defined term still applies. These definitions are applicable to all sections of the standard except where specified.

3.1.1 Coordination. Terms not defined in this standard that are defined in ANSI/ASHRAE Standard 62.1 [1], ANSI/ASHRAE Standard 62.2 [2], or ANSI/ASHRAE/ASHE Standard 170 [3], shall have the meanings assigned to them in those standards. Where terms are not defined in those documents or this standard, they shall have their ordinary accepted meanings within the context in which they are used. Ordinarily accepted meaning shall be based on standard American English language usage as documented in an unabridged dictionary accepted by the authority having jurisdiction.

3.2 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 (AHJ): the agency or agent responsible for determining compliance with this standard.

building readiness plan (BRP): a plan that documents the engineering and nonengineering controls that the facility systems will use for the facility to achieve its goals.

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 [1 m] of) a susceptible occupant.

3.3 Abbreviations and Acronyms

ACCA	Air Conditioning Contractor of America Association, Inc.
ACH_T	target air changes per hour
AD	aerosol detector
AHAM	Association of Home Appliance Manufacturers
AHJ	*authority having jurisdiction*
AHU	air-handling unit
ASTM	ASTM International
BAS	building automation system
BRP	*building readiness plan*
CADR	clean air delivery rate
cfm	cubic feet per minute
CxP	commissioning provider

DCV	demand-controlled ventilation
ECAi	required *equivalent clean airflow* per person for infection risk mitigation.
EPA	U.S. Environmental Protection Agency
ePM	particulate matter efficiency
ε_{PR}	infectious aerosol reduction efficiency
ERV	energy recovery ventilation
FPT	functional performance test
ft	foot or feet
HCHO	formaldehyde
HEPA	high-efficiency particulate air
IAQ	indoor air quality
IES	Illuminating Engineering Society
IRMM	*infection risk management mode*
ISO	International Organization for Standardization
L/s	liters per second
k_{nd}	infectious microorganism decay rate without *air cleaning* system operating
k_{td}	infectious microorganism decay rate with *air cleaning* system operating
L_{off}	first-order loss rate for the chemical that includes both air change and surface losses
m	meter(s)
MERV	minimum efficiency reporting value
O_3	ozone
O&M	operations and maintenance
OPR	owner's project requirements
$P_{Z,IRMM}$	number of people in the breathing zone in *IRMM*
TAB	testing, adjusting, and balancing
UL	Underwriters Laboratory
UV	ultraviolet
V	test chamber volume
V_{ACS}	*air cleaning* system *equivalent clean airflow* rate
V_{ECAi}	minimum *equivalent clean airflow* rate required in the breathing zone to mitigate *long-range transmission* risk in *IRMM*
V_{MVS}	multizone *air cleaning* system *equivalent clean airflow* rate
V_{NV}	outdoor airflow rate from natural ventilation system
V_{OT}	the outdoor air intake flow rate, cfm (L/s)
V_{RC}	recirculated airflow rate cleaned by the *air cleaning* system
VSC	ventilation system controls
z_f	zone air fraction

4. COMPLIANCE

4.1 Prerequisites

4.1.1 The building shall meet the requirements of the applicable version of ANSI/ASHRAE Standard 62.1 [1,4], ANSI/ASHRAE Standard 62.2 [2,4], or ANSI/ASHRAE/ASHE Standard 170 [3,4], as determined by its occupancy and date of construction or major renovation, or as determined by the *authority having jurisdiction* (*AHJ*). The *AHJ* may also approve the use of an equivalent standard as an alternative.

4.2 Requirements

4.2.1 All occupiable spaces, except as noted, shall comply with requirements of Sections 5 through 9.

4.2.2 All occupancies within the scope of ANSI/ASHRAE Standard 62.2 [2] shall also comply with Section 10.

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 [5], Informative Appendix J. Any filter with an ePM2.5 50% rating from ISO Standard 16890-1 [6]