BSR/ASHRAE Standard 241P

Public Review Draft

Control of Infectious Aerosols

First Public Review (April 2025)
(Draft Shows Complete Proposed New Standard)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at https://www.ashrae.org/technical-resources/standards-and-guidelines/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

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FOREWORD

This standard is ASHRAE's first in more than a century to set requirements for control of airborne disease transmission in non-health care facilities. It addresses requirements for minimum clean airflow, air distribution, use of filters and air cleaners, and the assessment, planning, and implementation process for all types of occupiable space, including residential and health care spaces. It is complementary to standards that specify requirements for acceptable indoor air quality. It is intended to be used to enable systems to exceed the requirements of these standards when necessary. One of the main advances of Standard 241 is that it sets requirements for Equivalent Clean Airflow per person for Infection Control (ECAi), permitting air that is filtered or treated by air cleaners to be used on an equal footing with outdoor air. In support of this approach, it sets extensive requirements for effectiveness and safety testing of filtration and air cleaning systems.

Ventilation has been prescribed to reduce the risk of transmission of airborne infectious diseases since the 19th century. Early advocates included Florence Nightingale, John Billings, and Carl Flügge. Following the recommendations of such experts, ASHRAE's predecessor society ASHVE first adopted a recommendation of 30 cfm (14 L/s) of outdoor air per person in 1895 and included it in a model law published in 1914. This requirement was included in 22 state codes in the United States by 1922. In the 1930s and 1940s, the purpose of ventilation standards shifted away from control of disease transmission to control of odors to achieve occupant satisfaction and control of contaminants (particles and gases) with adverse health effects. ASHRAE's current ventilation standards for non-health care facilities continue to adopt this definition of acceptable indoor air quality. Health care standards focus on mitigation of infection transmission risk in specialized spaces such as airborne infection isolation rooms and operating rooms.

The COVID-19 pandemic that emerged late in 2019 and engulfed the world by early 2020 renewed interest in using ventilation to reduce indoor transmission. This standard was written to meet that demand. In response to an urgent request from the US White House COVID-19 Response Team in November 2022, ASHRAE developed and published ASHRAE Standard 241-2023 in less than six months. To the extent possible, ANSI procedures were followed in the development of Standard 241-2023, but the compressed time frame precluded conducting full public review. Nevertheless, an Advisory Public Review was conducted that garnered more than 1000 comments, all of which were considered by the project committee. In addition to serving as the basis for ANSI designation, this version of Standard 241 incorporates significant additions and improvements to non-ANSI 241-2023. These include expansion of the list of space types for which ECAi is specified, multiple updates to requirements for filtration and air cleaning systems, and requirements for toilet exhaust.

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. 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

c. May not substantially reduce transmission risk in all situations due to the diversity of infectious agents and

personal susceptibility

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

2.3 No requirement of 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], ANSI/ASHRAE/ASHE Standard 170 [3], or other referenced standards, 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 ordinarily 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 non-engineering 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 a volume of interest, 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 near a susceptible occupant.

mechanical fibrous filters: air filters that employ an air permeable media such as a fibrous fabric or porous membrane to capture particles from the air, inclusive of those filters that contain an initial one-time electrical charge (known as electret filters), as well as filters containing additives for antimicrobial or other performance purposes, but not inclusive of those filters relying on external power other than that used to move air through the filter.

3.3 Acronyms and Abbreviations

ACCA	Air Conditioning Contractors 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)
m-CADR	microbial clean air delivery rate
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 occupiable space 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
$V_{ACS,sys}$	multizone *air cleaning* system *equivalent clean airflow* rate
V_{ECAi}	minimum *equivalent clean airflow* rate required to mitigate *long-range transmission* risk in *IRMM*
V_{NV}	outdoor airflow rate from natural ventilation system
$V_{OA,sys}$	the outdoor air intake flow rate
V_{RC}	recirculated airflow rate cleaned by the *air cleaning* system
v_f	air handling system fraction

4. COMPLIANCE

4.1 Prerequisites

4.1.1 Occupiable spaces 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 approve the use of an equivalent standard as an alternate.

4.2 Requirements

4.2.1 All occupiable spaces, except as noted, shall comply with the requirements below.

4.2.1.1 Compliance with Sections 5 and 6 shall be required for all spaces.

4.2.1.2 Compliance with Section 7 shall be required for all equipment and devices that contribute towards *equivalent clean airflow*, except those that do so exclusively by supplying outdoor air or exhausting indoor air.

4.2.1.3 Compliance with Section 8 and Section 9 shall be required for all spaces except for those required to comply with Section 10.

4.2.1.4 Compliance with Section 10 shall be required for all non-institutional, non-transient residential occupancies, such as those within the scope of ANSI/ASHRAE Standard 62.2 [2].

4.2.2 Application and installation of systems or equipment shall be carried out in accordance with the manufacturer's installation, operation, and maintenance instructions.

5. EQUIVALENT CLEAN AIRFLOW FOR INFECTION RISK MITIGATION

5.1 Minimum Equivalent Clean Airflow Rate

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

$$V_{ECAi} = \text{ECAi} \times P_{Z,IRMM} \quad (5\text{-}1)$$

where

V_{ECAi} = minimum *equivalent clean airflow* rate required in the occupiable space to mitigate *long-range transmission* risk in *IRMM*, cfm (L/s)

ECAi = *equivalent clean airflow* rate required per person in *IRMM* from Table 5-1, cfm (L/s) per person

$P_{Z,IRMM}$ = number of people in the occupiable space during *IRMM*. Unless the *Building Readiness Plan* (*BRP*) specifies a lower occupancy limit, the following defaults shall apply. $P_{Z,IRMM}$ shall default to the number of occupants used to calculate the ventilation rate per the applicable standard (see Section 4.1.1) or the design occupancy. For multi-stall restrooms, the number of people shall be calculated as the total count of plumbing fixtures, including water closets, urinals, and sinks, present in the space.

5.1.2 Where the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density and activities shall be used.

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

5.1.4 For public toilets, the minimum *equivalent clean airflow* rate shall be met using one or a combination of exhaust airflow and in-room *air cleaning* systems.

5.1.5 For spaces (other than those complying with Section 10) where occupants known to be infected are permitted during *IRMM*, the *equivalent clean airflow* rate required per person shall be 100 cfm (50 L/s) per infected person.

Table 5-1 Minimum Equivalent Clean Airflow per Person 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
Toilets		
Toilets – Public[a]	70	35

a. Rate is for a multi-stall restroom intended to be occupied by more than one person at a time.

6. AIR DISTRIBUTION AND NATURAL VENTILATION

6.1 Critical Volume. The occupied space within a building shall be divided into one or more critical volumes. Each critical volume containing occupants to be protected shall be identified subject to Sections 6.1.1, 6.1.2, and 6.1.3.

6.1.1 The critical volume shall be a single volume of air that is contiguous or connected to the same air handling system(s).

6.1.2 The equivalent clean air supplied to the critical volume shall be equally shared amongst the occupants.

6.1.3 The entire critical volume shall have one occupancy category from Table 5-1.

6.2 Clean Airflow Rate. The clean airflow rate to each critical volume within a building shall be greater than or

equal to the minimum *equivalent clean airflow* required, as expressed by Equation 6-1.

$$\Sigma[v_f \times (V_{OA,sys} + V_{ACS,sys})] + \Sigma V_{ACS} + V_{NV} \geq V_{ECAi} \quad (6\text{-}1)$$

where

v_f = the fraction of air supplied by an air handling system to the critical volume, calculated as the airflow rate supplied to the critical volume divided by the total airflow rate supplied by the air handling system

$V_{OA,sys}$ = the outdoor airflow rate supplied by an air handling system, cfm (L/s)

$V_{ACS,sys}$ = the *air cleaning* system *equivalent clean airflow* rate, computed per Section 7 for an *air cleaning* system whose output is distributed by an air handling system, cfm (L/s)

V_{ACS} = the *air cleaning* system *equivalent clean airflow* rate for a system supplying clean air to the critical volume, determined per Section 7, cfm (L/s)

V_{NV} = The total outdoor airflow rate from all natural ventilation systems, determined per Section 6.4, cfm (L/s)

V_{ECAi} = the minimum *equivalent clean airflow* rate required in the critical volume, determined per Section 5, cfm (L/s)

6.3 Air Distribution Category. Each critical volume shall be assigned an air distribution category as described in Table 6-1.

6.4 Natural Ventilation. Natural Ventilation systems shall be designed in accordance with the methods described in ANSI/ASHRAE Standard 62.1 [1], ANSI/ASHRAE/ASHE Standard 170 [3], or an engineering analysis approved by the *AHJ*.

6.4.1 Fans. In-room fan-assisted natural ventilation systems shall determine the equivalent outdoor airflow rate through engineering analysis.

6.4.2 Openings. Natural ventilation openings shall

a. Be separated by a minimum of 3 ft (1 m) from openings serving different rooms
b. Not be located within sheltered, recessed or enclosed areas

6.5 Mixed-Mode Ventilation. Mixed mode natural ventilation systems shall be evaluated independently under all operating conditions. The systems shall be designed in accordance with the natural ventilation and mechanical ventilation methods described in ANSI/ASHRAE Standard 62.1 [1], ANSI/ASHRAE/ASHE Standard 170 [3], or an engineering analysis approved by the *AHJ*.

6.5.1 Zoned Mixed-Mode Ventilation. In zoned or spatial mixed-mode systems, where the ventilation mode varies among different parts of the critical volume, satisfaction of Equation 6-1 shall be demonstrated for natural ventilation systems in naturally ventilated parts of the critical volume and for mechanical ventilation systems in mechanically ventilated parts of the critical volume.

6.5.2 Changeover Mixed-Mode Ventilation. In changeover or temporal mixed-mode systems, where the ventilation mode for the whole critical volume alternates according to space needs, satisfaction of Equation 6-1 shall be demonstrated individually for natural and mechanical ventilation systems.

6.5.3 Concurrent Mixed-Mode Ventilation. In concurrent mixed-mode systems, where both ventilation modes are used simultaneously, satisfaction of Equation 6-1 shall be demonstrated with combined effect of natural and mechanical ventilation systems.

6.6 Air Cleaning Systems

6.6.1 *Air cleaning* systems shall not inhibit the development of the intended flow regime of the ventilation system as described in Sections 6.6.1.1 and Section 6.6.1.2.

6.6.1.1 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.

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

Table 6-1 Clean Air Distribution Category

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

Table 6-2 Air Cleaning System Categories

	Discharge Orientation			
Location	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 m) 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 an downward direction.

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

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

7. AIR CLEANING SYSTEMS

7.1 General. The effectiveness and safety of *air cleaning* systems that contribute towards meeting zone minimum *equivalent clean airflow* requirements of Section 6 shall be determined in accordance with this section and Normative Appendix A. The requirements listed in this standard shall take precedence over specific requirements listed in the consensus standards referenced in this section and Normative Appendix A.

7.2 Air Cleaning System Effectiveness

The *equivalent clean airflow* rate, V_{ACS}, from *air cleaning* systems used in Section 6 to determine total zone *equivalent clean airflow* shall be determined in accordance with this section.

7.2.1 Air Cleaning Systems with Single-Pass Efficiency. *Air cleaning* systems with an effectiveness that is characterized by the manufacturer with a single-pass efficiency shall have an effectiveness reported as an

infectious aerosol reduction efficiency (ε_{PR}) as determined in accordance with this section and Normative Appendix A. The *equivalent clean airflow* rate shall be calculated in accordance with Equation 7-1.

$$V_{ACS} = \left[\frac{\varepsilon_{PR}}{100}\right] \times V_{RC} \quad (7\text{-}1)$$

where

V_{ACS} = *air cleaning* system *equivalent clean airflow* rate due to the *air cleaning* system, cfm (L/s)

ε_{PR} = infectious aerosol reduction efficiency, determined in accordance with Section 7.2.1.2 through Section 7.2.1.4, %

V_{RC} = recirculated airflow rate cleaned by the *air cleaning* system, cfm (L/s)

7.2.1.1 Where multiple *air cleaning* systems with a single-pass reduction efficiency are installed in series within the same airflow path, the infectious aerosol reduction efficiency (ε_{PR}) shall be determined in accordance with the appropriate version of Equation 7-2.

One System

$$\varepsilon_{PR} = \varepsilon_{PR,1} \quad (7\text{-}2a)$$

Two Systems

$$\varepsilon_{PR} = \left\{1 - \left[1 - \left(\frac{\varepsilon_{PR,1}}{100}\right)\right] \times \left[1 - \left(\frac{\varepsilon_{PR,2}}{100}\right)\right]\right\} \times 100 \quad (7\text{-}2b)$$

Three Systems

$$\varepsilon_{PR} = \left\{1 - \left[1 - \left(\frac{\varepsilon_{PR,1}}{100}\right)\right] \times \left[1 - \left(\frac{\varepsilon_{PR,2}}{100}\right)\right] \times \left[1 - \left(\frac{\varepsilon_{PR,3}}{100}\right)\right]\right\} \times 100 \quad (7\text{-}2c)$$

***N* Systems**

$$\varepsilon_{PR} = \left\{1 - \prod_{j=1}^{N}\left[1 - \left(\frac{\varepsilon_{PR,j}}{100}\right)\right]\right\} \times 100 \quad (7\text{-}2c)$$

where $\varepsilon_{PR,j}$ is the infectious aerosol reduction efficiency of the j^{th} *air cleaning* system determined in accordance with Section 7.2.1.3 or Section 7.2.1.4.

7.2.1.2 Single-Pass Particle Reduction Testing. *Air cleaning* system equipment with an effectiveness that is characterized by the manufacturer by a single-pass particle efficiency test shall be tested in accordance with one of the following applicable consensus standards:

a. ANSI/ASHRAE Standard 52.2 [5] with Appendix J

b. ISO 16890-1 [6]

Testing shall be conducted at the maximum face velocity that will be used with the *air cleaning* system in the application setting.

The infectious aerosol reduction efficiency (ε_{PR}) of *air cleaning* systems shall be determined in accordance with Equation 7-3 or Table 7-1.

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

where

ε_{PR} = infectious aerosol reduction 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 µm particle size range, dimensionless

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

ε_{E1} = particle removal efficiency in the 0.3 to 1.0 µm particle size range, %

ε_{E2} = particle removal efficiency in the 1.0 to 3.0 µm particle size range, %

ε_{E3} = particle removal efficiency in the 3.0 to 10.0 µm particle size range, %

The weighting fractions for use in Equation 7-3 shall be $W_{E1} = 0.30$, $W_{E2} = 0.30$, and $W_{E3} = 0.40$.

Exception to Section 7.2.1.2: For high efficiency particulate air (HEPA) filters tested under ISO 29463-1 [7], the infectious aerosol reduction efficiency (ε_{PR}) shall be in accordance with Table 7-2. For HEPA filters tested under standards from the Institute of Environmental Sciences and Technology (IEST) [8] or the U.S. Department of Defense [9], ε_{PR} shall be 99%.

Table 7-1 Infectious Aerosol Removal Efficiency (ε_{PR}) for Mechanical Fibrous Filters Tested in Accordance with ANSI/ASHRAE Standard 52.2 [5] with Appendix J or with ISO 16890-1 [6]

MERV-A	ISO 16890-1 [6] ePM	Weighted ε_{PR}
<8-A	<ePM10 50%	0%
8-A	ePM10 50%	34%
9-A	ePM10 60%	41%
10-A	ePM10 70%	47%
11-A	ePM2.5 50%	60%
12-A	ePM2.5 65%	71%
13-A	ePM1 50%	77%
14-A	ePM1 70%	88%
15-A	ePM1 85%	91%
16-A	ePM1 95%	95%

Table 7-2 Infectious Aerosol Removal Efficiency (ε_{PR}) for Mechanical Fibrous Filters Tested in Accordance with ISO 29463-1 [7]

Filter Class and Group	ε_{PR}
ISO 05 E	85%
ISO 10 E	90%
ISO 15 E	95%
ISO 20 E through ISO 75 H	99%

7.2.1.3 Single-Pass Bioaerosol Reduction Testing. *Air cleaning* systems that do not contain their own air moving equipment and have a performance that is characterized by the manufacturer with a single-pass efficiency test for viable bioaerosol reduction shall be tested in accordance with the methodology of ANSI/ASHRAE Standard 52.2 [5] with Appendix L (found in Addendum c to ANSI/ASHRAE 52.2-2017). In-duct germicidal ultraviolet (also called ultraviolet germicidal irradiation) systems shall be tested for single-pass efficiency using the methodology of ANSI/ASHRAE Standard 185.1 [10]. For *air cleaning* systems tested in accordance with this section, the resulting viable bioaerosol reduction as determined by the single-pass tests shall be equivalent to the *air cleaning* system's infectious aerosol reduction efficiency (ε_{PR}).

7.2.2 Air Cleaning Systems with an Equivalent Clean Airflow Rate Performance. The effectiveness of *air cleaning* systems characterized by the manufacturer with an *equivalent clean airflow* rate (V_{ACS}, cfm [L/s]) shall be determined in accordance with this section and Normative Appendix A.

7.2.2.1 Particle Reduction Chamber Testing. *Air cleaning* systems with a performance that is characterized

by the manufacturer with a particle chamber test (systems that consist of only *mechanical fibrous filter* components and air moving equipment) shall be rated in accordance with the methodology of ANSI/AHAM AC-1 [11]. For *air cleaning* systems with a $CADR_s$ > 500 cfm, $CADR_d$ > 600 cfm, or $CADR_p$ > 450 cfm, the ANSI/AHAM AC-1 [11] method shall be used with a chamber having a ratio of test chamber volume to the *air cleaning* system *equivalent clean airflow* rate greater than 1.7 ft^3/cfm (0.101 m^3/[L/s]).

The *equivalent clean airflow* rate shall be determined using the results from this performance test in accordance with Equation 7-4.

$$V_{ACS} = (W_s \times CADR_s) + (W_d \times CADR_d) + (W_p \times CADR_p) \quad (7\text{-}4)$$

where

V_{ACS} = *air cleaning* system *equivalent clean airflow* rate, cfm (L/s)
W_s = weighting factor for tobacco smoke, dimensionless
W_d = weighting factor for dust, dimensionless
W_p = weighting factor for pollen, dimensionless
$CADR_s$ = clean air delivery rate for tobacco smoke, cfm (L/s)
$CADR_d$ = clean air delivery rate for dust, cfm (L/s)
$CADR_p$ = clean air delivery rate for pollen, cfm (L/s)

The weighting fractions for use in Equation 7-4 shall be W_s = 0.30, W_d = 0.30, and W_p = 0.40. If the CADR is not reported for any of the challenge aerosols, the CADR value to be used in Equation 7-4 for that aerosol shall be zero.

7.2.2.2 Bioaerosol Reduction Chamber Testing. *Air cleaning* systems with a performance that is characterized by the manufacturer with a bioaerosol chamber test shall be rated in accordance with Normative Appendix A and the methodology of one of the following consensus standards:

a. ANSI/AHAM AC-5 [12]
b. ANSI/ASHRAE Standard 185.3 [13]

For *air cleaning* systems tested using ANSI/AHAM AC-5 [12], the reported m-CADR shall be the *equivalent clean airflow* rate (V_{ACS}). For *air cleaning* systems tested in accordance with ANSI/ASHRAE Standard 185.3 [13], the CADR shall be the *equivalent clean airflow* rate (V_{ACS}).

V_{ACS} shall be calculated using data collected from a test lasting at least one hour (following the bioaerosol nebulization period) or until a minimum of 2 log10 (99%) bioaerosol reduction is achieved (comparing the time-matched bioaerosol sampling recoveries from the average of *air cleaning* system ON and *air cleaning* system OFF test replicates).

7.3 Air Cleaning System Safety

7.3.1 Air Cleaning System Installation. Some *air cleaning* systems have specific requirements to help ensure a safe installation. When applicable, the following requirements in this section shall apply.

7.3.1.1 Ultraviolet Radiation. In-room *air cleaning* systems that generate electromagnetic radiation into the room with a wavelength between 100 and 400 nm shall be installed and operated in accordance with ANSI/IES RP-44-21 [14]. These systems shall not result in exposures to room occupants that exceed the threshold limit values (TLVs) in the 2024 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) [15] for the wavelength(s) emitted by the system. The ultraviolet TLVs shall not be exceeded in the space served by the system at a height of 6 ft (1.8 m) or below. Conformance with the TLVs shall be confirmed by measurements as described in ANSI/IES RP-27.1-22 [16] and ANSI/IES RP-44-21 [14]. The UV system installer shall provide documentation that these requirements have been met.

7.3.1.2 Combustion Byproducts. *Air cleaning* systems that utilize any form of combustion, or heat surfaces in contact with the airflow greater than 2240°F (1500 K), shall not increase the concentration of nitrogen

oxides and carbon monoxide by more than 20% over baseline concentrations with the *air cleaning* system not running. The manufacturer shall provide specific documentation that these requirements have been met.

7.3.2 Safety Testing Requirements. Safety testing requirements for *air cleaning* systems shall be in accordance with Normative Appendix A.

7.4 Air Cleaning Systems with Air Moving Equipment. *Air cleaning* systems that include factory-installed air moving equipment shall be tested for sound power level. An average A-weight sound power level (unit: dB re 1 pW) shall be determined from sound pressure level measurements at a distance of 3.3 ft (1.0 m) from the *air cleaning* system per ANSI/AHAM AC-2 [17]. The sound power level shall be included in the test report.

Informative Note: Information on acceptable noise levels in occupied building spaces may be found in the 2023 ASHRAE Handbook—HVAC Applications [I1], Chapter 49, "Noise and Vibration Control."

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 non-engineering controls that the facility's systems will use to achieve its target *equivalent clean airflow* for infection control ($V_{ECAi,target}$). The *BRP* shall be either a standalone document or a section of an existing emergency operations planning document. The *BRP* shall be reviewed annually or when there are changes to the engineering controls or a modification to the $V_{ECAi,target}$ used by the facility and its systems, whichever is more frequent.

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, and any changes made to the system for *infection risk management mode* (*IRMM*) as opposed to normal mode of operation (which is how the system is operating when it is not in *IRMM*). The *BRP* shall also include a zone-level ventilation matrix that specifies the V_{ECAi} target for *IRMM*. If V_{ECAi} is to be provided by standalone systems (e.g., in-room air filters), then the *BRP* must also include O&M schedules for all such systems. The *BRP* shall include any testing or safety documents required by this standard.
b. The non-engineering controls section shall include any requirements for allowed changes in building occupancy levels ($P_{z,IRMM}$), personal protection equipment use, physical distancing, and cleaning.
c. The *BRP* shall include a process for managing known or potentially infected occupants, either in a separation area or by relocation to another facility.

Informative Note: See Informative Appendix E, "Building Readiness Plan Template."

8.2 Existing Buildings Assessment, Planning, and Implementation

8.2.1 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 processes in Section 8.2 shall be followed for an existing building or system to be deemed to comply with 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}. In the planning phase, potential engineering controls shall be evaluated, selected, and implemented. In the commissioning phase, the systems shall be verified as operational. All information shall be documented in the *BRP*. Detailed requirements for components of the assessment, planning and implementation for existing buildings are listed in Normative Appendix B.

8.2.2 Building Alterations or Change of Use. The systems contributing to V_{ECAi} shall be reevaluated as necessary when any of the following occur:

a. Buildings or systems are altered
b. Changes are made to building use or space occupancy category
c. A significant change in occupancy density occurs

d. Other changes are made that are inconsistent with system design assumptions

8.2.3 Existing Building Assessment. The existing building and its systems shall be assessed through document review and site observations to determine how the spaces are currently used and how the facility, equipment, and systems are currently operating, and to identify potential engineering controls that contribute to the required V_{ECAi}.

8.2.3.1 Data Gathering

a. The following documents, if available, shall be obtained and reviewed:
   1. Record or as-built documents for the mechanical, electrical, and plumbing systems
   2. Most recent design documents for the current configuration, and the original design documents used for construction.
   3. Commissioning documents that include the functional performance tests (FPTs), commissioning report, and systems manual
   4. Building automation systems (BAS) sequences of operation and control diagrams
   5. Testing, adjusting, and balancing (TAB) reports

b. The following information shall be discussed with the owner and operator in a meeting:
   1. Operating issues with the systems as identified by the facility staff or service contractors
   2. Ongoing renovation projects
   3. Planned renovation projects
   4. BAS trending that is available or that can be made available

8.2.3.2 Site Observations

a. Walk the facility and determine what HVAC systems are installed, and observe how the systems are operating.
b. Evaluation of the air-side and water-side systems shall be completed.

8.2.3.3 Occupied Space Inventory. Each occupied space shall be categorized as one of the nonresidential occupancy categories in Table 5-1 of this standard and one of the following:

a. A nonresidential occupancy category in ANSI/ASHRAE Standard 62.1 [1], Table 6-1
b. A dwelling unit
c. For health care, the appropriate function of space from ANSI/ASHRAE/ASHE Standard 170 [3] Table 7-1 (inpatient), Table 8-1 (specialized outpatient), Table 8-2 (general outpatient), and Table 9-1 (support spaces)

8.2.3.4 Equipment Inventory. The type and size of the HVAC systems that serve the occupied spaces shall be inventoried.

8.2.3.5 Multifamily Residential Buildings, Including Dorms and Hotels. In multi-unit residential buildings, including dormitories and hotels, transfer air between corridors and dwelling units, corridors and stairwells or elevator shafts, common areas and dwelling units, and utility or mechanical areas and dwelling units shall be assessed in accordance with Section B4.4.

In hotels, dormitories, and other public residential buildings, dwelling-to-dwelling transfer air shall be assessed in accordance with Section B4.4.

In pressurized corridor systems, the ventilation system assessment shall include corridor supply airflow rates sampled on at least three individual floors: above, below, and at the neutral pressure plane, along with a qualitative assessment of corridor positive pressurization relative to dwelling units.

8.2.3.6 Potential Separation Areas. Potential separation spaces shall be evaluated as follows:

a. In non-health-care facilities, evaluate any spaces identified by the owner that could be repurposed to a designated temporary space for infected or potentially infected occupants during *IRMM*.
b. In health care facilities and spaces, the owner shall identify temporary isolation rooms during *IRMM* to be evaluated.

8.2.3.7 Ventilation. Ventilation systems shall be assessed for compliance with the applicable version of the relevant indoor air quality (IAQ) standard per Section 4.1.1 and adjusted if not currently compliant. The assessment shall result in measurement of current system outdoor air delivery rates, and determination of the maximum potential outdoor airflow rates and conditions for their delivery.

8.2.3.8 Airflow Measurement. The outdoor air and supply air rate from each air handler, and the supply air rate to each ventilation zone, that is intended to contribute to the V_{ECAi} shall be measured, estimated, or identified by any of the following methods:

a. Using airflow measuring sensors that have been calibrated within the calibration interval recommended by the manufacturer
b. Testing, adjusting, and balancing (TAB report within three years of assessment, along with site observation of supply, return, and outdoor airflow at the system)
c. Methods in ANSI/ASHRAE Standard 111 [18] or equivalent as allowed by the *AHJ* to determine supply, return, and outdoor airflow.
d. A tracer gas dilution evaluation in accordance with ASTM E741 [19] to determine outdoor airflow

8.2.3.9 Minimum Outdoor Airflow Requirements. The minimum outdoor airflow required for each ventilation zone and for each air handler shall be calculated using the applicable IAQ standard.

8.2.3.10 Measured Outdoor Airflow Rates. Measured outdoor airflow rates for HVAC systems that do not comply with the applicable IAQ standard shall be identified on the issues log and be addressed in the planning and implementation phase.

8.2.3.11 Coil Condition and Capacity. Cooling or heating coils that treat outdoor air, for systems expected to condition (cool, heat, dehumidify or humidify) outdoor airflow above design rates in *IRMM*, shall be evaluated.

8.2.3.12 Energy Recovery Ventilators (ERVs). Energy recovery ventilators, if present, shall be assessed for proper airflow measurements and fan locations to determine if the ERV shall remain operational or require maintenance and upgrades to operate in *IRMM*. Assessment shall include evaluation of whether higher-than-design airflows can be achieved within the capacity of the HVAC system to maintain control of supply air conditions.

Informative Note: See Informative Appendix G, "Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems."

8.2.3.13 Ventilation System Controls. Control capabilities shall be verified for proper operation to deliver the required quantity of outdoor air continuously throughout occupied periods.

8.2.3.14 Filtration. The following filtration system characteristics shall be documented for each system:

a. Location of filters in the system (air path), including prefilters
b. Size of existing filter rack
c. Quantity and size of filters
d. MERV-A rating of existing filters (see Section 7) for conversion to pathogen removal efficiency
e. Fan's design allowable pressure drops for both clean and dirty filters
f. Evaluation of filter installation quality, including use of spacers or tape or the presence of air gaps

8.2.3.15 Exhaust. Exhaust equipment shall be confirmed to be operating as scheduled. Pressure relationships between non-health-care spaces that are intended to have a pressure differential according to design documents or an accepted TAB report shall be qualitatively assessed. Health care space pressure differential shall be quantitatively assessed. The potential for exhaust air re-entrainment into outdoor air intakes shall be assessed.

Informative Note: See Informative Appendix H, "Exhaust Re-entrainment Guide."

8.2.3.16 Air Cleaners. All *air cleaning* systems that contribute to $V_{ECAi,existing}$ shall be assessed for effectiveness and safety according to Section 7 and Normative Appendix A, and for allowable placement per Section 6.6.

8.2.3.17 Controlling Sensors. The controlling sensors on air delivery systems that will be adjusted to achieve target V_{ECAi} shall be assessed for the need for calibration.

8.2.3.18 Control Strategies and Sequences of Operation. The assessment shall document the existing control strategies and sequences of operation for HVAC systems that could be affected by additional engineering controls.

8.2.3.19 Existing Engineering Controls. If any additional engineering controls are already in use, assess their capacity and control according to Section 6 and Section 7 of this standard or an accepted method approved by the *AHJ*.

8.2.4 Existing Building Planning and Implementation. Existing building systems shall meet minimum operating requirements and be evaluated for their contribution to V_{ECAi}. The need for additional engineering controls to meet the $V_{ECAi,target}$ shall be determined, and potential engineering controls shall be evaluated, selected, and implemented according to the requirements of this section.

8.2.4.1 Minimum Operating Requirements. Use the information obtained during the assessment to determine if any adjustments according to the requirements of this section.

a. HVAC systems for which measured outdoor air did not meet the calculated required minimum rates under the applicable IAQ standard shall be corrected in the planning and implementation phase to provide code minimum outdoor air in both normal mode and *IRMM*.

b. Control devices or HVAC components that were deemed to be out of calibration or not functioning per the intended sequence of operations shall be corrected in the planning and implementation phase.

8.2.4.2 Determine Target. Determine the required $V_{ECAi,target}$ for each ventilation zone, where $V_{ECAi,target}$ is equal to V_{ECAi} as determined by Equation 5-1 using the $P_{z,IRMM}$ accepted by the owner. Determine the current system $V_{ECAi,existing}$ that is the combination of the following:

a. Outdoor air quantity introduced to the building as identified in the assessment phase

b. Recirculated air that is subjected to existing, functioning air cleaners and calculated based on the assessment phase

8.2.4.3 Determine if Additional V_{ECAi} Is Required. Equation 8-1 shall be used to determine if additional engineering controls are necessary:

$$V_{ECAi,differential} = V_{ECAi,target} - V_{ECAi,existing} \quad (8\text{-}1)$$

where $V_{ECAi,existing}$ is determined by Equation 8-2, with terms as defined for Equation 6-1, for each ventilation zone as found.

$$V_{ECAi,existing} = \Sigma[vf \times (V_{OA,sys} + V_{ACS,sys}))] + \Sigma V_{ACS} + V_{NV} \quad (8\text{-}2)$$

If $V_{ECAi,differential}$ is less than or equal to zero, then the assessment, planning, and commissioning shall be complete. No modifications are required.

If $V_{ECAi,differential}$ is greater than zero, then the planning phase needs to be completed to determine the engineering controls combination to have the modified system meet or exceed the target performance.

An alternative method for determining $V_{ECAi,existing}$ based on the impact of the ventilation, filtration, and filter-based air cleaners shall be the particle tracer decay methods of determining *equivalent clean airflow* for infection risk mitigation as described in Normative Appendix C.

8.2.4.4 Select Engineering Controls. Potential options to increase $V_{ECAi,existing}$ shall be determined based on

a. Physical constraints

b. Predicted $V_{ECAi,existing}$ (See Informative Appendix F, "Equivalent Clean Airflow Calculator.")

8.2.4.5 Control Limitations. Fan speed and outdoor air control shall impact the quantity of supply, return, and outdoor air used in calculating V_{ECAi} as follows:

a. If demand-control ventilation (DCV) is deactivated in *IRMM*, the design or measured outdoor air shall be used to calculate $V_{ECAi,existing}$.

b. If DCV is activated in *IRMM*, only the minimum outdoor airflow set point to achieve the building

component of the ventilation rate, plus airflow to maintain the building pressure relationship to outdoors, shall be used to calculated $V_{ECAi,\ existing}$.

c. If fan speed is set to constant during *IRMM*, then the measured or resulting airflows shall be used to calculate $V_{ECAi,existing}$.

d. If fan speed is allowed to modulate, then the minimum airflow set point shall be used to calculate $V_{ECAi,existing}$.

8.2.4.6 Implement Engineering Controls. Existing systems shall be modified or supplemented with the selected engineering controls, as agreed upon by owner and operator, that provide the occupied space with $V_{ECAi,target}$.

8.2.4.7 The *BRP* shall be updated to include the existing and implemented engineering controls, their intended sequences of operation for *IRMM*, and any modifications to the existing system operations in normal mode.

8.2.5 Existing Building Commissioning. All modifications to the existing system shall be verified to be working to their intent through a commissioning process that includes functional performance testing.

8.2.5.1 Commissioning FPTs shall be performed for any sequence of operations modified for *IRMM*. FPTs shall include the information and checks outlined in ANSI/ASHRAE Standard 230 [20] in addition to the following:

a. Test all modes of operation.
   1. Normal mode: occupied and unoccupied
   2. *IRMM*: occupied and unoccupied

b. Test all adjustments to outdoor air control and delivery.

c. Central filtration shall include a visual check of filter bank and spacer installation by observing whether light from a source on one side of the filter bank can be seen on the other, which will make bypass paths visible.

d. Confirm air cleaner effectiveness and safety per Section 7 and Normative Appendix A.

e. Provide an issues log to the owner and contractors so that any necessary adjustments or changes can be made to ensure the systems contributing to V_{ECAi} are operating as intended.

8.2.5.2 Systems Evaluation. The modified systems shall be evaluated for compliance according to Section 8.2.4.3.

8.2.5.3 Building Readiness Plan. All results from the previous sections shall be documented in the *BRP*.

8.3 New Construction and Major Renovations. The requirements of this section apply to new buildings and systems and renovations to existing buildings and systems. Planning and implementation of engineering controls to achieve V_{ECAi} in new construction and major renovations to existing buildings shall be incorporated into the design, construction, and commissioning processes of the facility for permanently installed engineering controls. Temporary *air cleaning* systems, if used, shall be identified in the *BRP*. Detailed requirements for components of the assessment, planning and implementation for new construction and major renovations are listed in Normative Appendix B.

8.3.1 Alterations to Existing Buildings. Substantial alterations to existing buildings, as defined in ANSI/ASHRAE/IES Standard 90.1 [21], Section 11.1.4.1, shall follow the requirements of Section 8.3.

8.3.2 Owner's Project Requirements. Assist in the development of the Owner's Project Requirements (OPR). In addition to the items noted in ANSI/ASHRAE/IES Standard 202 [22], Section 6, the OPR shall include potential engineering and non-engineering controls for *IRMM*.

8.3.3 Design Review. The review shall determine if the expected engineering controls have been evaluated by the design team and documented in the Basis of Design, drawings, and specifications. The commissioning provider (CxP) shall perform a review of systems and assemblies in the design documents to evaluate compliance with the OPR *IRMM* systems and information and provide an issues log for the design professional to adjust the design documents to align with the OPR.

8.3.4 Submittals. The CxP and designers of record shall review the infection control equipment and systems submittals concurrently. The CxP shall review the system sequences of operation submittals closely to verify

that the *IRMM* operation is clearly defined with set points, enable and disable actions, and expected control devices.

8.3.5 Site Observations. The CxP and designers of record shall perform site observations through the construction phase and include on the project issues log any items that do not comply with the design intent for systems to achieve the $V_{ECAi,target}$.

8.3.6 Equipment Checklists. The CxP shall include on the equipment checklist information about the control devices and equipment required to achieve the $V_{ECAi,target}$.

8.3.7 Functional Performance Tests

8.3.7.1 CxP shall create FPTs that are project specific and test the system's ability to transition between normal mode to *IRMM* and verify that V_{ECAi} is achieved.

8.3.7.2 An alternative method for determining V_{ECAi} based on the impact of the ventilation, filtration, and filter-based air cleaners shall be the particle tracer decay methods of determining *equivalent clean airflow* for infection risk mitigation described in Normative Appendix C.

8.3.7.3 The designers of record shall review the FPTs to confirm the *IRMM* is being tested to meet the design intent.

8.3.7.4 The CxP shall identify issues that prevent the systems from operating as intended in *IRMM* and during transition from normal mode to *IRMM*. The designers of record shall work with the project team to resolve any issues.

8.3.8 Training. The CxP and designers of record shall verify that the project specification for training includes appropriate time to train the facility staff on the equipment and sequences of operation required for *IRMM*.

8.3.9 Systems Manual. The CxP shall provide the owner a systems manual that includes the equipment, functions, and sequences for HVAC system operation in *IRMM*.

Informative Note: See ASHRAE Guideline 1.4 [23] for additional information required for the development of a systems manual.

8.3.10 Building Readiness Plan. The *BRP* shall be created and included as an appendix to the systems manual, Current Facility Requirements, and O&M manual.

9. OPERATIONS AND MAINTENANCE

9.1 Operations

9.1.1 Building Readiness Plan (BRP). The *BRP*, in either hard copy or electronic format, shall be maintained on site or in a centrally accessible location for the working life of the applicable ventilation system equipment or components. This plan shall be updated as necessary.

9.1.2 Essential Facility Supplies for Operations. The operator shall review the operations and maintenance (O&M) manual to understand the ongoing activities and materials required to make systems work, including spare parts. The building operator shall maintain a critical asset inventory management plan that includes storage (on site or off site) or supply chain arrangements.

9.1.3 Modes. The occupant, operator, and building owner, *AHJ*, or public health official shall determine which mode of operation shall be used for the system or space. 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

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 operating schedule shall be controlled by one or more of the following:

a. Time of day scheduling shall be inclusive of all times that spaces are occupied, including by support staff and vendors.
b. Occupancy sensors shall be used in accordance with ANSI/ASHRAE Standard 62.1 [1], Section 6.2.6.1.4.

Ventilation that is switched to an occupied standby mode zone if the HVAC system is in normal mode shall be turned on if occupancy is detected. The ventilation systems shall turn on if occupancy is detected during unoccupied hours.

c. During *IRMM*, intermittent ventilation (such as fans that supply primary air cycling ON/OFF with heating/cooling) shall not be permitted when the space is occupied.

d. Demand-control ventilation (DCV) shall operate as noted in the *BRP*.

9.1.5 Flush Between Occupied Periods. For systems achieving V_{ECAi} targets, flushing shall not be required between occupied periods.

9.1.6 Occupant Count During IRMM. If the occupant count exceeds $P_{z,IRMM}$, during *IRMM*, V_{ECAi} calculations shall be updated to determine if changes to engineering controls and non-engineering controls must be implemented to achieve the revised $V_{ECAi,target}$.

9.1.7 Operation at Varying Fan Speeds. Systems with variable speed fan control shall have it confirmed that their fan speed control aligns with the *BRP* and resulting $V_{ECAi,existing}$.

9.1.8 Temperature and Humidity. Maintain temperature and relative humidity set points during all occupied modes, as indicated in design documents.

9.1.9 Air Distribution. Operator shall confirm that air distribution used in the spaces aligns with the zone air distribution category, and with the *BRP* as noted, per Table 6-1. If any form of variable-air-volume or demand-controlled ventilation system is used for energy conservation, it shall not compromise pressure balancing and control.

9.1.10 Separation Area. If the building has a designated separation area for potentially infected or infected individuals, this temporary area shall remain separated by doors and kept under negative pressure, relative to all adjoining rooms, whenever a potentially infected or infected individual is present.

9.1.11 Operator Training. Operators shall receive training on the following topics:

a. Ventilation requirements during normal mode and *IRMM*

b. Requirements for the facility, spaces, equipment, and systems as noted in the *BRP*

9.1.12 Occupant Communication. Information about the current and possible operating modes and building occupancy limits when in *IRMM* shall be posted in a public location near the entrance to the building or space. Equipment used to achieve V_{ECAi} that can be adjusted by the occupants shall have signage indicating required settings. The *BRP*, which shall include mode, intended target V_{ECAi} by system, current operating schedules, and any occupancy limits, shall be made available to all occupants of the building.

9.2 Maintenance

9.2.1 Maintenance. Systems shall be maintained in accordance with the requirements of this section while the systems are operating in *IRMM*.

9.2.2 Tasks and Frequency. Maintenance tasks and frequencies for all occupancies and system types shall follow ASHRAE/ACCA Standard 180 [24] as well as any system-specific requirements listed below. Upon transition to *IRMM*, tasks shall be performed that have not been performed within the intervals indicated in Table 9-1 and Table 9-2.

9.2.2.1 Ventilation Equipment. Maintenance tasks and frequencies for all ventilation equipment shall follow Table 9-1. Exceptions for small systems are not applicable to this standard.

Informative Note: These tasks and frequencies are based on ANSI/ASHRAE Standard 62.1 [1], Table 8-1.

9.2.2.2 Air Cleaning Equipment

a. **In Use.** Maintenance tasks and frequencies for all *air cleaning* equipment shall follow the manufacturer's instructions and any tasks listed in Table 9-2 while in use.

b. **Testing While Not in Use.** All *IRMM* engineering controls that are disabled in normal mode shall be tested semiannually.

9.2.2.3 Test Areas in Compliance with Normative Appendix C

9.2.2.3.1 Every 12 months, testing shall be completed for a new set of randomly selected spaces from the

previous test locations.

9.2.2.4 Control Systems. Remote or off-site access to building control systems, if present, shall be tested for successful control on a quarterly basis.

9.2.2.4.1 Control system transition between normal mode and *IRMM* shall be tested on a semiannual basis.

9.2.3 Cleaning. Review and document the custodial program for the facility. Pay particular attention to roles and responsibilities for staff and external contractors related to HVAC equipment and other equipment used to comply with this standard. (See ISSA 0415 [25], Section 3.)

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
Verify the accuracy of permanently mounted sensors whose primary function is outdoor air delivery monitoring, outdoor air delivery verification, or dynamic minimum outdoor air control, such as flow stations at an air handler, flow stations at ventilation zones, and those used for demand-controlled ventilation, including CO_2 sensors, and handheld CO_2 sensors. A sensor failing to meet the accuracy specified in the O&M manual shall be recalibrated or replaced. Performance verification shall include output comparison to a measurement reference standard consistent with those specified for similar devices in ASHRAE Standard 41.2 [26] or ASHRAE Standard 111 [18].	As recommended by the sensor manufacturer, but not less frequently than every three years.

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

Inspection/Maintenance Task	IRMM Maintenance Interval
Verify the total quantity of outdoor air delivered by air handlers set to minimum outdoor air mode. If measured minimum airflow rates are less than the design minimum rate documented in the O&M manual, ±10% balancing tolerance, (a) confirm the measured rate does not conform with the provisions of this standard and (b) adjust or modify the air handler components to correct the airflow deficiency. Ventilation systems shall be balanced in accordance with ASHRAE Standard 111 [18] or its equivalent, at least to the extent necessary to verify conformance with the total outdoor airflow and space supply airflow requirements of this standard. (Note: No systems are exempt from this requirement based on size.)	Every three years

Table 9-2 Minimum Maintenance Activity and Frequency for Additional Engineering Controls and Associated Components While in Use

Engineering Control	Inspection/Maintenance Task	Frequency
In-room air cleaners	Verify unit is in appropriate location and operating as intended per the *BRP*. Confirm that the air cleaner is operating at the speed or setting assumed in the V_{ECAi} calculation. Maintain systems and equipment and verify performance per manufacturer's instructions. Visually inspect intake for debris and clean as necessary.	Monthly
Ultraviolet (UV) germicidal irradiation	Maintain systems and verify performance and safety per manufacturer's instructions and in accordance with ANSI/IES RP-44-21 [14] and ANSI/IES RP-27.1-22 [16] or equivalent. Adjust, clean, and replace equipment as needed.	Assess quarterly or per manufacturer's recommended interval
All *air cleaning* systems and equipment (including in-room, in-duct, and UV air cleaners)	Maintain systems and equipment and verify performance per manufacturer's instructions. Adjust, clean, and replace equipment as needed. If equipment cannot be repaired, remove equipment from service and use a substitute engineering control to maintain V_{ECAi} in occupied space.	Assess quarterly or per manufacturer's recommended interval
Separation space	The designated temporary separation areas shall be tested for negative pressure whenever an infected individual is present.	As used

10. DWELLING UNITS—ADDITIONAL REQUIREMENTS

10.1 General Requirements

10.1.1 All toilets shall be provided with lids.

10.1.2 All plumbing traps shall be filled with water.

10.1.3 Fans used to meet the requirements of this standard that are connected to ductwork shall have their flows measured in accordance with either Section 4.3 or Section 5.4 of ANSI/ASHRAE Standard 62.2 [2] or equivalent.

10.2 Building Readiness Plan (BRP). A *BRP* shall be created to describe the engineering and non-engineering

controls that will be used to achieve its total target *equivalent clean airflow* for infection control (V_{ECAi}) during *IRMM*. The *BRP* shall be included in a section of the operations and maintenance manual required by ANSI/ASHRAE Standard 62.2 [2], Section 8. The *BRP* shall require that local exhaust ventilation be operated in bathrooms and toilets when in use and shall indicate that toilet lids are to be closed when flushing.

10.3 Multifamily Dwellings

Buildings with forced-air HVAC systems supplying air that is returned through ductwork from more than one dwelling unit shall have at least MERV-13A filtration or ePM1 of 50% per Table 7-1 filtration or equivalent. In existing buildings that do not meet this requirement, the HVAC systems shall be blocked off, and portable HVAC and air filtration/*air cleaning* units shall be provided.

10.4 Separation Areas

When a dwelling unit has infected or vulnerable occupants, a separate fully-enclosed space shall be used as a separation area. A single space may be used to comply with either Section 10.4.1 or Section 10.4.2, provided operation and any reconfiguration is described in the *BRP*. The *BRP* shall specify what protections caregivers shall take when entering a separation area. When the separation area does not have toilet or bathroom facilities, the *BRP* shall document how occupants of that area will access toilet or bathroom facilities outside the area while minimizing infection risk.

Exception to Section 10.4: Dwelling units having a single habitable zone combining all sleeping and living functions shall have a required *equivalent clean airflow* rate V_{ECAi} per Equation 5-1 using ECAi of 100 cfm (50 L/s) per person.

10.4.1 Separation Area for Infected Occupants. The separation area for infected occupants shall meet either Section 10.4.1.1 or Section 10.4.1.2.

10.4.1.1 Unsealed transfer grilles or jump ducts shall have a damper that operates during *IRMM* to prevent flow from the separation space to other parts of the dwelling unit. An exhaust ventilation system capable of a minimum of 200 cfm (100 L/s), shall be operated. A fan installed in a window or other opening shall be permitted. Any supply registers and return grilles in the room that are part of the dwelling's central conditioning systems shall be sealed, with temporary space conditioning provided as needed.

10.4.1.2 The separation area shall contain an exhaust ventilation system that can maintain a measured negative pressure of 5 Pa (0.02 in. H_2O) with respect to the rest of the dwelling unit.

10.4.2 Separation Area for Vulnerable Occupants. The separation area for vulnerable occupants shall meet either Section 10.4.2.1 or Section 10.4.2.2. Air that is mechanically recirculated from other parts of the dwelling unit into the separation area, such as via supply registers, shall meet the requirements of Section 10.3.

Exception to Section 10.4.2: No separation area for vulnerable occupants is required when the dwelling unit *equivalent clean airflow* meets or exceeds required *equivalent clean airflow* V_{ECAi} per Equation 5-1 using ECAi of 100 cfm (50 L/s) per person. For attached dwelling units, exhaust ventilation shall not exceed V_{tot} from ANSI/ASHRAE Standard 62.2 [2], Section 4.1.1, or the dwelling unit ventilation rate if complying with another equivalent standard.

10.4.2.1 Unsealed transfer grilles or jump ducts shall have a damper that operates during *IRMM* to prevent flow to the separation space from other parts of the dwelling unit. A supply ventilation system capable of a minimum of 200 cfm (100 L/s) shall be operated to supply *equivalent clean air* to the separation area. A fan is installed in a window or other opening shall be permitted.

10.4.2.2 The separation area shall contain a supply system that can maintain a measured positive pressure of 5 Pa (0.02 in. H_2O) with respect to other parts of the dwelling unit is required.

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(This appendix is part of this standard. It contains requirements necessary for conformance to the standard.)

NORMATIVE APPENDIX A—DETERMINING AIR CLEANING SYSTEM EFFECTIVENESS AND SAFETY

A1. GENERAL

A responsible party designated by the *authority having jurisdiction* (*AHJ*) shall certify the *air cleaning* system operational, performance, and safety equivalence. If acceptable to the *AHJ*, the responsible party may be the manufacturer of the *air cleaning* system. Alternatively, administration and certification bodies that are accredited in accordance with ISO/IEC 17065 [27] with respect to application of the standards and test procedures referenced in Sections 7.2 and 7.3 and accredited by an accreditation body operating in accordance with ISO/IEC 17011 [28] shall certify the air cleaner operational, performance, and safety equivalence.

The manufacturer shall review final test reports for accurate documentation of effectiveness and safety. The manufacturer shall make documentation of the effectiveness and safety test results publicly available for *air cleaning* systems under the requirements of this standard.

A1.1 Parity. Testing for effectiveness and safety shall be performed using identical operating conditions of the *air cleaning* system equipment, but the testing shall be performed separately. The environmental and airflow conditions (external to the *air cleaning* system) in the effectiveness and safety test environments shall be equivalent. The environmental, airflow, installation and operating conditions used in testing shall correspond to the intended application and use of the *air cleaning* system equipment for contributing ECAi under this standard.

A1.2 Testing Laboratories. Testing shall be performed by independent laboratories that meet OSHA Nationally Recognized Testing Laboratory requirements [29]. Testing for effectiveness and safety may be performed by a single laboratory or separate laboratories. All testing laboratories shall comply with the requirements of ISO/IEC 17025 [30].

A1.3 Air Cleaner System Installation. *Air cleaning* system equipment shall be installed for effectiveness and safety testing following the manufacturer's published specifications and in a manner that minimizes impacts on other testing procedures. The independent test laboratory shall certify that the installation meets these conditions or describe any potential impacts in the testing report.

A1.4 Quality Assurance and Quality Control Measures. To ensure the quality of testing, the following measures shall be taken:

a. All equipment used in testing shall be calibrated per manufacturer instructions.
b. All equipment and surfaces shall be decontaminated between tests as necessary to eliminate cross-contamination between tests.
c. The test equipment shall be placed within the chamber prior to testing, except for control tests with an in-duct *air cleaning* system where having the system in place would contribute to aerosol reduction.
d. Samples shall be collected, handled, and analyzed in the same manner for all test iterations.
e. Background samples for each sampling target during testing (particle, biological, or chemical analyte) shall be collected prior to each test.

A1.5 Reporting Requirements. The independent testing laboratory shall prepare a test report that contains sufficient information and detail to ensure repeatability of the tests and that, at a minimum, contains the following:

a. The name, address, and contact information of the laboratory performing the test, the names of test operators performing each test, and the names and affiliations of the authors, contributors, and reviewers of the report
b. The name, address, and contact information of the party requesting the test
c. A description of the *air cleaning* system being tested, including model number, size, and features
d. The manufacturer-recommended operational and environmental conditions of the *air cleaning* system equipment; a description of how the *air cleaning* system equipment is installed in the test chamber

e. A certification that the *air cleaning* equipment has been installed to minimize impacts on other equipment or testing methods, or a description of any potential interferences of the *air cleaning* equipment on testing processes
f. A description of the test chamber, including its dimensions, a description of its surfaces, and the location and orientation of equipment installed within (including *air cleaning* system, mixing, nebulization, and sampling equipment)
g. The date and time of the test
h. The make, model, minimum resolution, minimum limit of detection and quantitation, accuracy, precision, and date of last calibration for each piece of measuring equipment
i. A log of the environmental and airflow conditions of the test environment throughout the duration of each test
j. A log of the operating conditions of the tested equipment throughout the duration of each test
k. Quantitative sampling results from all samples collected during testing, including background samples
l. A quantification of uncertainty, based on replicate testing and methods detection limits

A1.6 Testing Certification Requirements. The independent laboratory shall prepare, review, and approve the test report.

A2. EFFECTIVENESS

A2.1 Air Cleaning System Effectiveness. Effectiveness testing for all *air cleaning* systems shall be performed following a consensus standard and in accordance with the additional requirements listed in this section. Where multiple test methods are applicable, the manufacturer shall select the most appropriate test method to rate performance in a manner that is aligned with the intended use and operation of the *air cleaning* system.

A2.1.1 Bioaerosol Effectiveness Testing Requirements. Effectiveness testing conducted using a bioaerosol challenge are subjected to the additional requirements stated in this section. The following requirements shall supersede the requirements stated in the respective referenced consensus standards.

A2.1.1.1 Biosafety Requirements. All biological testing and procedures shall be conducted in accordance with the current version of the CDC/NIH *Biosafety in Microbiological and Biomedical Laboratories* [31].

A2.1.1.2 Test Microorganism and Microbiological Procedures. All effectiveness testing using microorganisms shall be performed with the nonenveloped bacteriophage MS2 (host *Escherichia coli*). The test microorganism shall be suspended in an artificial saliva prepared using the recipe in Heimbuch et al. [32] and aerosolized to produce discrete particles. Addition of an antifoaming agent to the microbial suspension is permitted. Bioaerosol samples for chamber tests shall be collected between 48 and 50 in. (123 and 127 cm) above the floor and >2 ft (0.6 m) from walls or equipment. Samples shall be collected using impingers, impactors, or other sampling methods as determined by the testing laboratory. The test microorganism samples shall be collected, handled, and analyzed in the same manner for all test iterations. Each collected impinger sample shall be plated in triplicate.

A2.1.1.3 Test Controls and Replicates. For effectiveness testing using a biological challenge agent, a minimum of three test replicates for each test condition (*air cleaning* system OFF and *air cleaning* system ON) shall be performed, for a minimum of six total tests per *air cleaning* system. Each test replicate shall consist of a separate sequence of aerosolization, sampling, and chamber or duct reset procedures.

A2.1.1.4 Bioaerosol Reduction Effectiveness Calculations. The effectiveness calculations resulting from all bioaerosol testing shall

a. Account for background reduction of the test microorganism
b. Compare averages of time-matched sample recoveries from test replicates with the *air cleaning* system OFF to the averages of the replicates with the *air cleaning* system ON
c. For microorganism recoveries lower than the limit of detection, use the value of the limit of detection for effectiveness calculations

A2.1.1.5 Biological Effectiveness Testing Reporting Requirements. In addition to the reporting

requirements in Section A1.5, the independent testing laboratory shall include the following information in the report from all effectiveness testing utilizing bioaerosols:

a. A description of the aerosolization equipment, procedures (including the composition of the microbial suspension and concentrations of its constituents), and location(s) within the test chamber
b. A description of the sampling equipment and procedures, including the media used for sampling, sampling locations, sampling times, and the air volume extracted for each sample
c. A description of the microbiological assay and enumeration methods, including the limit of detection
d. The results from each test replicate, including propagated error for each sample collected based on replicate sampling and plating to demonstrate reproducibility and uncertainty
e. The calculations for effectiveness, including all values and equations used

A2.2 Chamber Testing with a Duct. For *air cleaning* systems with an effectiveness reported as an *equivalent clean airflow* delivery rate that require test chamber air to recirculate through a side duct or test duct within the test chamber, *air cleaning* system effectiveness shall be evaluated with a modified chamber to include the duct. The test duct shall maintain the same temperature and humidity as the test chamber throughout testing. Only the *air cleaning* system being tested shall be mounted in the recirculating duct. Airflow through the duct shall provide the most challenging (i.e., worst-case) test condition for the *air cleaning* system being tested, as determined by the laboratory from the range of operating conditions advertised by the system manufacturer.

A2.3 Average Air Cleaning System Performance. When the test method used to rate the efficiency or CADR of the air cleaner is based on initial performance, the performance shall be depreciated to manufacturer certified average performance to account for degradation over the lifetime of the air cleaner according to the manufacturer's instructions.

Exception to A2.3: *Mechanical fibrous filters* rated to ANSI/ASHRAE Standard 52.2 [5] with Appendix J (MERV-A) or to ISO 16890 [6] (ePM1, ePM2.5, and ePM10) in accordance with Section 7.2.1.3.

A3. SAFETY

A3.1 Required Tests. *Air cleaning* system safety shall be tested as required by this section.

Exception to A3.1: *Mechanical fibrous filters* tested using ANSI/ASHRAE Standard 52.2 [5] with Appendix J or ISO 16890 [6] and placed in an airstream do not have additional safety testing requirements.

A3.1.1 Chemical Analytes Released by Air Cleaning Systems or Resulting from Chemical Reactions in the Air. Air cleaners shall be tested for analytes according to Table A-1. An *air cleaning* system exceeding the target for any single analyte in Table A-1 shall be noted in the test report, and the *air cleaning* system shall not be used under the provisions of this standard.

All *air cleaning* systems shall be tested in-chamber for ozone, formaldehyde, and airborne particulate matter, as shown in Table A-1. Testing for formaldehyde and particulate matter may be done concurrently or independently. Formaldehyde testing shall be conducted in the presence of a single-pulse injection of limonene resulting in approximately 25 $\mu g/m^3$ (4.5 ppb_v) initial gas concentration in the chamber. When sorbent sampling methods are utilized during testing, these samples shall be collected in duplicate, at a minimum. The experiment shall last at least four hours to allow reactive chemistry to occur. Loss rates for the air cleaner OFF shall be determined according to the procedure described in Stephens et al [33]. The average emission rate for formaldehyde over the test period shall be determined using Equation A-1:

$$E = V\left(L_{off}C_{t=\Delta t} + \frac{C_{t=\Delta t} - C_{t=0}}{\Delta t}\right) \quad \text{(A-1)}$$

where

E = emission rate, µg/h
V = volume of the chamber, ft^3 (m^3)

L_{off} = first order loss rate for the chemical that includes both air changes and surface losses (see Stephens et al [33])

$C_{t=\Delta t}$ = concentration at the end of the test period, μg/m^3

$C_{t=0}$ = concentration at the beginning of the test, μg/m^3

Δt = total length of test in h; minimum = 4

Table A-1 Required Analytes for Safety Testing

Analyte of Concern	Abbreviation	Test Method	Target
Formaldehyde	HCHO	Formaldehyde shall be measured using any method described in ASTM D8407 [34] that has a detection limit better than 0.5 ppb_v (0.6 μg/m^3) for a 1-minute sample. Air change must be low enough to detect target emission rate with instrument detection limits.	Emission rate less than 50 μg/h
Ozone	O_3	UL 2998 [35]	<5 ppb
Particulate matter count concentration (#/m^3)	Particles greater than 20 nm	ISO 14644-14 [36] (duct testing requires isokinetic sampling)	Test results shall be at least one cleanliness class better (cleaner) than the empty test chamber or test duct as described in ISO 14644-14 [36], Table 1. Empty chamber shall not measure higher (dirtier) than Class 5.

A3.1.2 Test Chamber Requirements. The test chamber for safety testing shall comply with the following:

a. The volume shall be at least 800 ft^3 (22.7 m^3). For *air cleaning* systems with an operational volume greater than 800 ft^3 (22.7 m^3), the ratio of the test chamber volume to the *air cleaning* system *equivalent clean airflow* rate shall be greater than 1.7 for I-P units (ft^3/cfm) or 0.101 for SI units (m^3/[L/s]).

b. Surfaces shall be smooth, nonporous, produce minimal emissions, and react minimally with the *air cleaning* system.

c. Surfaces shall be electrically grounded.

d. The test chamber shall have fans to provide sufficient mixing, as defined by ASTM Standard D6670 [37], Section 8.4.

e. The test chamber shall be sufficiently airtight during testing (leakage of less than 0.05 ach).

f. The test chamber shall be capable of flushing or treating air between tests.

g. The test chamber shall maintain temperature throughout the duration of testing at 73°F ± 5°F (23°C ± 3°C).

h. The test chamber shall maintain relative humidity throughout the duration of testing at 50% ± 10%.

i. For *air cleaning* systems that require test chamber air to recirculate through a side duct or test duct within the test chamber, the chamber meeting all other requirements of this section shall be modified to include the duct. The test duct shall maintain the same temperature and humidity as the test chamber throughout testing. Only the *air cleaning* system being tested shall be mounted in the recirculating duct.

j. Air-handling systems associated with chamber ventilation shall be powered off during testing to minimize recirculation, unless testing with a side duct is necessary, in which case air-handling systems intended to clean the air before or after tests shall be powered off during the testing.

A3.2 Safety Testing Reporting Requirements. In addition to the general reporting requirements listed in Section A1.5, the independent testing laboratory shall include the following information in the test report:

a. A concentration log of any direct products intentionally introduced into the air by the *air cleaning* system during safety testing
b. Description of the test method and monitoring equipment (including limits of detection) used for formaldehyde
c. Description of monitoring equipment used for measurements of particulate matter
d. The amount of limonene introduced into the chamber during each test and the tests conducted with limonene present
e. A matched set of concentration data for duplicate testing with the *air cleaning* system off and with the *air cleaning* system on
f. Clear indication of whether a tested *air cleaning* system exceeded targets outlined in Table A-1 during testing.

(This appendix is part of this standard. It contains requirements necessary for conformance to the standard.)

NORMATIVE APPENDIX B—ASSESSMENT, PLANNING, AND IMPLEMENTATION

B1. OCCUPIED SPACE INVENTORY

In addition to the space category, the following items shall be documented for each space:

a. Geometry: floor area, ceiling height, and any partial-height walls within the space
b. Number of occupants indicated in the HVAC design, current occupant count, and occupants planned to be allowed during *IRMM* per Section 5.1.1
c. Space use, including categorization under the applicable IAQ standard and Table 5-1
d. Occupancy schedule
e. Space conditions that could impact the feasibility of in-room *air cleaning* devices
f. Locations, sizes, and control method for any openings to the outdoors
g. Locations and types of airflow inlets and outlets

B2. EQUIPMENT INVENTORY

The inventory or air delivery systems shall include

a. Space the equipment serves
b. Type of air delivery systems: variable or constant volume, single or multiple zones, 100% outdoor air or recirculating
c. Cooling source
d. Heating source
e. Type of ventilation (mechanical, natural, or hybrid) and how outdoor air is delivered to the space (system, path, openings)
f. Outdoor airflow measurement devices
g. Ventilation airflow control method, and, if variable, under what conditions
h. Associated exhaust fans
i. Method of control, whether manual, local (thermostat), or central (building automation system). The following information shall be identified if present:
    1. Controlling set points
    2. Controlling sensor types and locations
    3. Schedules
    4. Setbacks
    5. Trend reports and alarm logs
    6. Life safety interfaces with HVAC
    7. Access control interlocks, interfaces with HVAC
    8. Smoke control system interfaces with HVAC

B3. POTENTIAL RESPIRATORY SEPARATION AREA

The assessment for a repurposed space shall include evaluation of

a. Physical separation from the rest of the building by at least one door
b. Whether systems exist to create negative pressure relative to adjoining rooms
c. A path of egress for potentially infected or infected individuals

Informative Note: A building may have multiple designated isolations areas (e.g., a healthcare facility), and occupants may stay in these areas indefinitely if allowed by the building owner's response plan.

B4. VENTILATION

B4.1 Minimum Outdoor Airflow Requirements. Mechanical ventilation in nonresidential spaces shall use either of the following procedures to determine compliance for the current space use and occupancy:

a. Ventilation Rate Procedure (prescriptive). Determine outdoor air systems compliance per ANSI/ASHRAE Standard 62.1 [1], Section 6.2.
b. Indoor Air Quality Procedure (performance). Determine outdoor air and *air cleaning* systems compliance per ANSI/ASHRAE Standard 62.1 [1], Section 6.3.
c. Natural ventilation in nonresidential spaces shall use ANSI/ASHRAE Standard 62.1 [1], Section 6.4, to determine the required area of openings. Assessing engineers shall determine the outdoor conditions when natural ventilation will provide expected airflow and when mechanical ventilation will be used.
d. Residential spaces shall use ANSI/ASHRAE Standard 62.2 [2], Section 4 or Normative Appendix A, to determine the required ventilation rates.
e. Health care spaces shall use ANSI/ASHRAE/IES Standard 170 [3], Sections 7 through 9, to determine the required ventilation rates.

B4.2 Coil Condition and Capacity. The coils shall be evaluated as follows:

a. Assess coil capacity under the following conditions:
    1. Design cooling day
    2. Design heating day
b. Identify the last maintenance cleaning of the coils per ANSI/ASHRAE/ACCA Standard 180 [24]. Attach any coil cleaning reports to the *BRP*.
c. Confirm that the coil valves are operational and modulate as intended by the controlling signal.
d. Record the condensate line size.
e. Assess freeze protection controls and capacity.

B4.3 Ventilation System Controls. Ventilation systems controls shall be evaluated to check the following:

a. Control damper operation and control sequence
b. Fan speed adjustment capability, variable air volume, or constant air volume
c. Fan cycling
d. Demand-controlled ventilation (DCV) strategies (temperature, carbon dioxide, timed, or occupancy sensing) resulting in variable total air delivery

B4.4 Pressurization. Building and space pressurization shall be assessed, including:

a. Doors that will not close
b. Perceivable noise at entrance doors and between adjacent spaces
c. Reverse of the expected pressure relationship between spaces

B5. CONTROLLING SENSORS

Evaluate the controlling sensors or devices on air delivery systems that will be adjusted to achieve target V_{ECAi} by checking the calibration of the following:

a. Air temperatures
b. Air pressures
c. Air relative humidity
d. Airflow rate
e. Freeze protection
f. CO_2

B6. CONTROL STRATEGIES AND SEQUENCES OF OPERATION

Assess the control strategies and sequences of operation that may be adjusted to implement engineering controls, including:

a. Scheduling and temperature setbacks

b. Fan speed control, min and max
c. Outdoor air control
d. Minimum and maximum air quantities
e. Outdoor air control methods
f. Building and space pressure controls
g. Economizer sequencing
h. Existing *IRMM* sequences
i. Demand-controlled ventilation
j. Humidification control set points and upper limits
k. Dehumidification control and limits
l. Temperature, high and low, cutoffs for ventilation delivery
m. Cooling and heating availability
n. Energy recovery ventilation (ERV) operation
o. *Air cleaning* equipment operation
    1. In HVAC systems
    2. In room

B7. OUTDOOR AIR INCREASE VENTILATION

Increases of outdoor air ventilation shall be verified by one of the following methods:

a. An air balance report of the outdoor air
b. As measured by an outdoor air measuring station with verified calibration

B8. HEALTH CARE

B8.1 Capture Test. Capture devices placed in rooms in spaces expected to be occupied by infected people shall be verified by a capture test and compared against the design assumption of capture effectiveness to prove that air cleaner performance complies with expected performance.

B8.2 Room Pressure Test. Room pressurizations used for containment shall be verified by one of the following methods:

a. A pressure relationship test and compared to the design assumptions of pressure relationship
b. A containment test, wherein a negative-pressure single door shall achieve not less than 97% barrier effectiveness [38].

B9. COMISSIONING FUNCTIONAL PERFORMANCE TESTS (FPTs)

Test all adjustments to outdoor air control and delivery, including:

a. Ventilation alterations to DCV
b. Ventilation control if there is an increase in outdoor air
c. Ventilation control for expanded economizer mode
d. Building pressure sequences

B10. VENTILATION

B10.1 Owner Project Requirements (OPR). The OPR shall include:

a. V_{ECAi} for the HVAC systems to achieve when in *IRMM*
b. Occupancy anticipated during *IRMM*
c. Filtration MERV ratings
d. Requirements for areas designated as separation areas for infected or potentially infected occupants in *IRMM*
e. Desired *air cleaning* engineering controls for the HVAC systems and spaces

B10.2 Design Documentation. The following documentation is required to be created by the design team.

B10.2.1 The design team shall create a Basis of Design that includes

a. Analysis and identified engineering controls to achieve the target *equivalent clean airflow* for infection control (***Informative Note:*** Use the V_{ECAi} calculator described in Informative Appendix F to assist in engineering controls analysis.)
b. A complete sequence of operation and control diagrams for system operation in *IRMM*
c. A table of the normal mode and *IRMM* objectives to summarize the engineering controls applied to this facility
d. Determination of outdoor air systems compliance per applicable standard or code, as required by the local *AHJ*

B10.2.2 The commissioning provider shall review the design team calculations indicating how the systems and equipment are achieving the target *equivalent clean airflow*.

(This appendix is part of this standard. It contains requirements necessary for conformance to the standard.)

NORMATIVE APPENDIX C—IN-PLACE TEST METHOD FOR DETERMINING THE EQUIVALENT CLEAN AIRFLOW FOR INFECTION RISK MITIGATION (V_{ECAi}) OF A SINGLE OCCUPIED SPACE BY MEANS OF TRACER AEROSOL DECAY

This appendix presents an in-place method [39] of testing the *equivalent clean airflow* rate for infection risk mitigation (ECAi) for a single occupied space as induced by all physical removal mechanisms (i.e., those that remove particles from the air), including passive and mechanical ventilation, filtration, and deposition. The method does not measure contributions of pathogen inactivation techniques that do not remove particles, such as UVC. The technique is based on measurement of the decay rate of tracer particles. [40–46] ECAi metrics are calculated according to the decay rate of the tracer particles [41] during their removal from the space and compared to the target V_{ECAi} for the space. This in-place test provides a pass/fail result for the target volumetric airflow as derived from the ECAi in Table 5-1 and the occupancy category and quantity, and a value for $V_{ECAi,existing}$ for a specific space.

C1. EQUIPMENT

a. **Aerosol generator.** Device used to disperse aerosol particles into the air from a liquid solution that shall generate particles in the E_1, E_2, and E_3 size ranges as defined in ANSI/ASHRAE Standard 52.2 [5].

b. **Aerosol detector (AD).** Instrument that measures tracer aerosol concentrations. Aerosol detectors shall have demonstrated accuracy within ±10% of the reading of an ISO qualified reference aerosol detector [43]. Other aerosol detectors (e.g., instantaneous biological analyzer and collectors (IBACs), for fluorescent-tagged polystyrene beads; qPCR; and DNA sequencers, for DNA-tagged particles) shall have demonstrated accuracy, calibrated to within ±10% of a standard reference.

c. **Tracer Particles.** Particles released in the air by an aerosol generator to measure aerosol removal within an indoor environment. Qualified tracer particles include liquid aerosols, such as NaCl [39,42,44,45,46], DNA-tagged particles [41,46,48], fluorescent-tagged polystyrene latex beads [46], and smoke/other particulate-based tracers [38]. When choosing tracer particles, consideration shall be given to the toxicity or sensitizing impacts of the tracer particles used, whether the space is occupied during testing, and the response time of the detector.

C2. PREPARATION

a. **Sampling**. Testing shall include at least the number of test areas determined as the larger of:

- 10% of the total occupied area in ft^3 (m^3), divided by 900 ft^3 (83.6 m^3), rounded up to the nearest whole number
- 10% of the total number of distinct occupied space counts, rounded up to the nearest whole number.

A minimum of two test areas shall be required if the occupied area is greater than 900 ft^3 (83.6 m^3). These test areas hall be randomly selected in occupancy category (as indicated in Table 5-1) that are representative of the primary use of the building.

In a mixed-use building, test areas shall be distributed proportionately across occupancy categories, such that the percentage of the test points allocated to each occupancy category is equal to the percentage that each occupancy category represents of the total number of categories. In a large open space with multiple test areas, any failures require that the entire space and its HVAC systems be evaluated.

b. All equipment shall be calibrated within one year and in accordance with manufacturer's specifications.

c. Select the test space(s). In rooms larger than 900 ft^3 (83.6 m^3), multiple test areas shall be used to cover the space.

d. Testing shall be performed under steady-state conditions for a given ventilation and filtration setup, with HVAC system and air cleaner settings held constant for the duration of the test.

e. Movement in the test area shall be restricted for the duration of the test.

f. There shall be no aerosol generating sources, whether natural or mechanical (other than those identified in Section C1.a) active in the test space(s).

g. Measure and record the volume of the space.

h. Place the aerosol generator at the center of the test area. There must be at least four aerosol detectors with at least one device placed in the center of each quadrant as per Figure C-1. (***Informative Note:*** For spaces smaller than 15 ft. × 15 ft. [4.5 m × 4.5 m], the quadrants can be smaller). The aerosol generator and aerosol detectors shall be placed at the same height within the space, 3 to 72 in. (1.2 cm to 1.8 m) above the floor.

C3. TEST EXECUTION

Particle counts shall be collected for each aerosol detector, in E_1, E_2, and E_3 size ranges for the duration of background, release, and settling periods, as represented in Figure C-2:

a. **Background period.** The period beginning five minutes prior to the aerosol generator being turned on. $PC_{Background,En}$ is defined as the average particle count in this period. If the aerosol tracer is not found in the ambient air, background levels do not need to be assessed.

b. **Release period.** The period beginning when the aerosol generator is turned on and ending when the aerosol generator is turned off. The aerosol generator shall operate until particle counts are at least three times the background particle count ($PC_{SDC} \geq 3 \times$ background) at the time the decay period begins (t_{SDC}) for all locations and for all three particle size ranges (E_1, E_2, E_3). The time at which the generator is turned off is $t = 0$ minutes. See Figure C-2.

c. **Settling period.** The six-minute period beginning when the aerosol generator is turned off.

d. **Decay period.** The period beginning when the settling period ends and ending after either $t = 60$ minutes or when 90% particle count reduction (with is 10% of [$PC_{SDC} - PC_{Background,En}$]) is reached, whichever comes first.

e. This method is valid for 0.35 to 12 air changes per hour (ach).

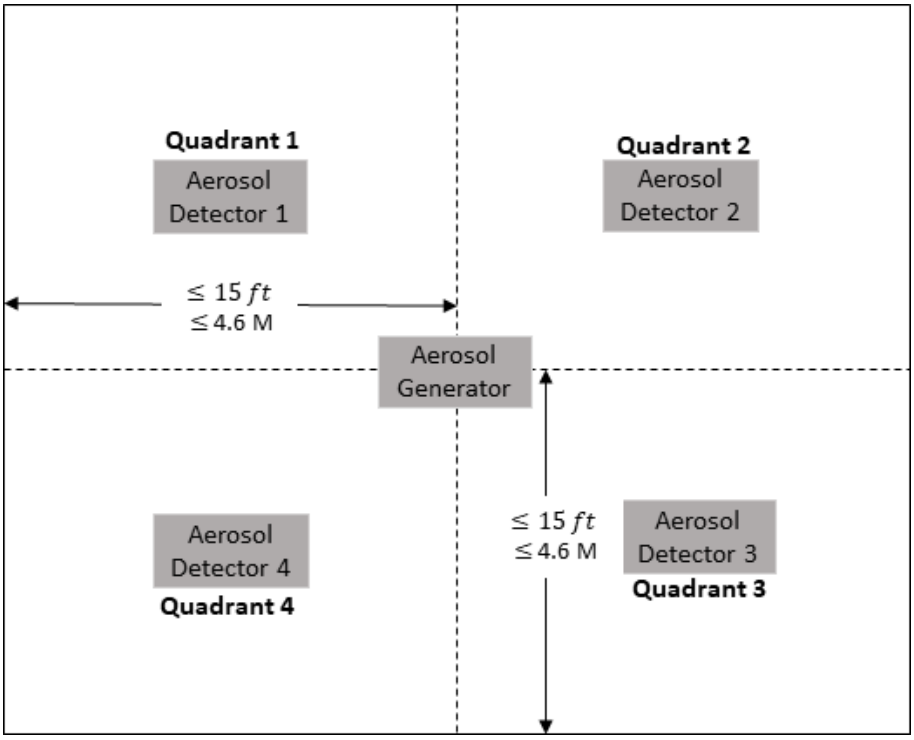

Figure C-1 Equipment configuration for determining ECAi of an occupied space.

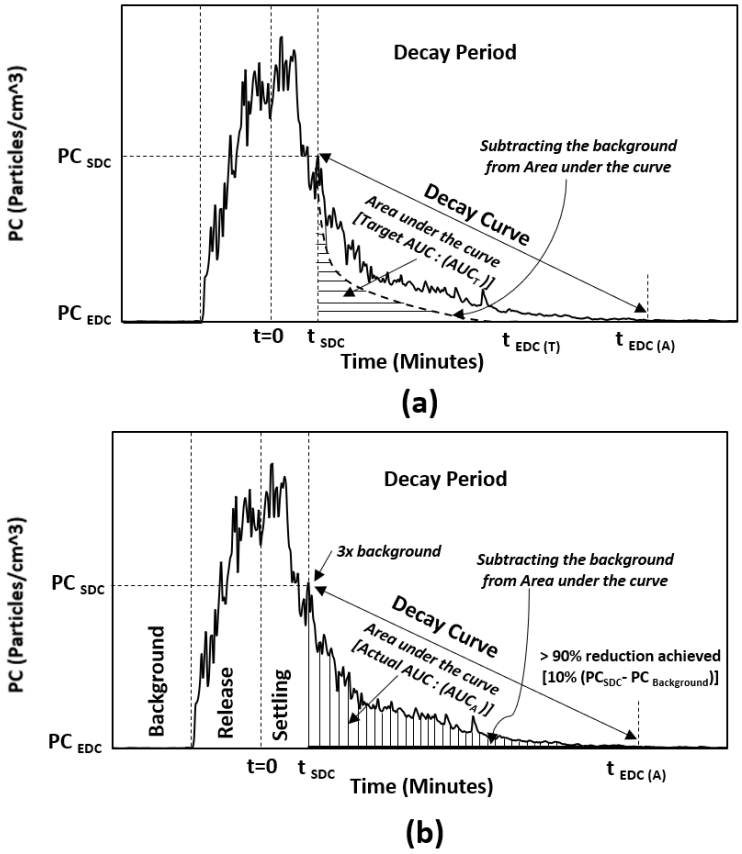

Figure C-2 Test periods for (a) target and (b) measured area under the curve.

C4. ANALYSIS OF DATA

C4.1 Calculate the target volumetric airflow $V_{ECAi,ADn,T}$ for all aerosol detectors ADn (n = 1 – 4+) using Equation C-1 and calculate the target air changes per hour (ACHT) using Equation C-2.

$$V_{ECAi,ADn,T} = [(\text{ECAi} \times P_{Z,IRRM})] \quad \text{(C-1)}$$

$$\text{ACH}_{ADn,T} = \left(\frac{60 \times V_{ECAi,ADn,T}}{V}\right) \quad \text{(C-2)}$$

where

$V_{ECAi,ADn,T}$ = target volumetric airflow per aerosol detector, cfm (L/s)

ECAi = *equivalent clean airflow* rate required per person in *IRMM* from Table 5-1, cfm per person (L/s/person)

$P_{Z,IRMM}$ = number of people in the space in *IRMM* as defined in Section 5.1

V = volume of the chamber, ft^3 (m^3)

ACH$_{ADn,T}$ = target air changes per hour per aerosol detector, h^{-1}

C4.2 Calculate the global areas under the curve for target (AUC$_T$) and actual (AUC$_A$) as follows:

a. Background actual (calculated as the area under the curve using the average background value extrapolated over the decay period ([t_{SDC} to $t_{EDC(A)}$])

b. Background target (calculated as the area under the curve using the average background value extrapolated over the decay period ([t_{SDC} to $t_{EDC(T)}$])

c. The decay period

1. AUC$_T$ shall be calculated as the area under the exponential decay curve defined by ACH$_T$ from Equation C-2 from t_{SDC} to $t_{EDC(T)}$, minus background target.
2. Calculate equation constant a using Equation C-3.

$$a = \frac{\mathrm{PC}_{SDC}}{e^{-ACH_T \times t}} \quad \text{(C-3)}$$

3. Calculate particle concentration (PC) associated with each time step using Equation C-4. The last time step is when either the calculated PC is reduced by 90% of the starting value minus the background [10% of (PC$_{SDC}$ – PC$_{Background}$] or t = 60 minutes.

$$\mathrm{PC} = ae^{-ACH_T \times t} \quad \text{(C-4)}$$

4. Calculate the area under the curve (Global AUC$_T$) using Equation C-5, or by integration between (t_{SDC}, PC$_{SDC}$) and ($t_{EDC(T)}$, PC$_{EDC}$).

$$\text{Global AUC}_T = \sum_{n=0}^{n=t_{EDC(T)}} \frac{(t_{n+1}-t_n)(\mathrm{PC}_{n+1}+\mathrm{PC}_n)}{2} - \mathrm{AUC}_{B(T)} \quad \text{(C-5)}$$

where

t_{SDC} = time at the start of the decay curve, min

PC$_{SDC}$ = particle concentration at the start of the decay curve

$t_{EDC(T)}$ = time at the end of the decay curve for the target decay curve, min

PC$_{EDC}$ = particle concentration at the end of the decay curve

n = time steps from 0 to $t_{EDC(T)}$, min

$AUC_{B(T)}$ = target air changes per hour per aerosol detector, h^{-1}

5. The actual AUC$_A$ (decay period AUC minus background actual):

i. Calculate the area under the curve (AUC$_{A,ADn,En}$) for all aerosol detector for each size range using Equation C-6 between (t_{SDC}, PC$_{SDC}$) and ($t_{EDC(A)}$, PC$_{EDC}$).

$$\mathrm{AUC}_{A,ADn,En} = \sum_{n=0}^{n=t_{EDC(A)}} \frac{(t_{n+1}-t_n)(\mathrm{PC}_{n+1}+\mathrm{PC}_n)}{2} - \mathrm{AUC}_{B(A)} \quad \text{(C-6)}$$

ii. Calculate the weighted average area under the curve using weights W_{E1}, W_{E2}, and W_{E3} from Section 7.4.1 for all aerosol detectors *and* (n = 1 – 4+) using Equation C-7.

$$\mathrm{AUC}_{A,ADn,avg} = \mathrm{AUC}_{A,ADn,E1} \times W_{E1} + \mathrm{AUC}_{A,ADn,E2} \times W_{E2} + \mathrm{AUC}_{A,ADn,E3} \times W_{E3} \quad \text{(C-7)}$$

where

AUC$_{A,ADn,avg}$ = area under the curve for the actual decay, aerosol detector n, averaged over all particle bins ($E1$, $E2$, $E3$)

AUC$_{A,ADn,E1}$ = area under the curve for the actual decay, aerosol detector n, $E1$

W_{E1} = particle size distribution weighting in the 0.3 to 1.0 micron range, %, from Section 7.4.1

AUC$_{A,ADn,E2}$ = area under the curve for the actual decay, aerosol detector n, $E2$

W_{E2} = particle size distribution weighting in the 1.0 to 3.0 micron range, %, from Section 7.4.1

AUC$_{A,ADn,E3}$ = area under the curve for the actual decay, aerosol detector n, $E3$

W_{E3} = particle size distribution weighting in the 3.0 to 10.0 micron range, %, from Section 7.4.1

iii. Calculate the global average (Global AUC$_A$) using Equation C-8:

$$\text{Global AUC}_A = \frac{\text{AUC}_{A,AD1,avg} + \text{AUC}_{A,AD2,avg} + \text{AUC}_{A,AD3,avg}}{n} \quad \text{(C-8)}$$

where

Global AUC$_A$ = global average of the area under the curve for all aerosol detectors and size ranges $E1$, $E2$, and $E3$

n = number of aerosol detectors in a test

C4.3 Calculate the actual volumetric airflow $V_{ECAi,ADn,En}$ for each aerosol detector and each $E1$, $E2$, and $E3$ particle size range, using Equation C-9 [40].

$$V_{ECAi,ADn,En} = \frac{V_{ECAi,target} \times \text{Global AUC}_T}{\text{AUC}_{A,ADn,En}} \quad \text{(C-9)}$$

where

$V_{ECAi,ADn,En}$ = volumetric airflow per aerosol detector, actual

$V_{ECAi,target}$ = volumetric airflow, target from Equation C-1

Global AUC$_T$ = area under the curve, target from Equation C-5

AUC$_{A,ADn,En}$ = area under the curve, actual from Equation C-6

C4.4 Calculate the actual weighted average, $V_{ECAi,ADn,avg,A}$ for each particle size range, $E1$, $E2$, and $E3$, and each aerosol detector using the weights W_{E1}, W_{E2}, and W_{E3} from Section 7.4.1 using Equation C-10.

Actual Weighted Average

$$V_{ECAi,ADn,avg,A} = V_{ECAi,ADn,E1,A} \times W_{E1} + V_{ECAi,ADn,E2,A} \times W_{E2} + V_{ECAi,ADn,E3,A} \times W_{E3} \quad \text{(C-10)}$$

where

$V_{ECAi,ADn,avg,A}$ = actual volumetric airflow, aerosol detector n, averaged over all particle bins ($E1$, $E2$, $E3$)

$V_{ECAi,ADn,E1,A}$ = actual volumetric airflow, aerosol detector n, $E1$

W_{E1} = particle size distribution weighting in the 0.3 to 1.0 micron range, %, from Section 7.4.1

$V_{ECAi,ADn,E2,A}$ = actual volumetric airflow, aerosol detector n, $E2$

W_{E2} = particle size distribution weighting in the 1.0 to 3.0 micron range, %, from Section 7.4.1

$V_{ECAi,ADn,E3,A}$ = actual volumetric airflow, aerosol detector n, $E3$

W_{E3} = particle size distribution weighting in the 3.0 to 10.0 micron range, %, from Section 7.4.1

C4.5 Calculate the target and actual global averages, $V_{ECAi,avg,T}$ and $V_{ECAi,avg,A}$, using the average of all the respective values of $V_{ECAi,ADn,T}$ and $V_{ECAi,ADn,avg,A}$ calculated for the space in Section C4.1 and Section C4.4 using Equation C-11 and Equation C-12.

Target Global Average

$$V_{ECAi,avg,T} = \frac{(V_{ECAi,AD1,T} + V_{ECAi,AD2,T} + V_{ECAi,AD3,T} + \dots)}{n} \quad \text{(C-11)}$$

Actual Global Average

$$V_{ECAi,avg,A} = \frac{(V_{ECAi,AD1,avg,A} + V_{ECAi,AD2,avg,A} + V_{ECAi,AD3,avg,A} + \dots)}{n} \quad \text{(C-11)}$$

where

$V_{ECAi,avg,T}$ = target global average volumetric airflow

n = total number of aerosol detectors

$V_{ECAi,avg,A}$ = actual global average volumetric airflow

C4.6 To determine the test outcome:

a. Pass: The actual global average $V_{ECAi,avg,A}$ shall be greater than or equal to the target global average $V_{ECAi,avg,T}$. If Normative Appendix C is used as an alternative method per Section 8.2.4.3, $V_{ECAi,existing} = V_{ECAi,avg,A}$, which shall be used to show compliance with Equation 6-1.

b. Fail: The actual global average $V_{ECAi,avg,A}$ is less than the target global average $V_{ECAi,avg,T}$

C5. REPORTING

The test report shall include the following:

a. Test pass/fail outcome

b. The target and actual global averages ($V_{ECAi,avg,T}$, $V_{ECAi,avg,A}$)

c. The actual weighted average ($V_{ECAi,ADn,avg,A}$) for each aerosol detector, highlighting the minimum

d. The aerosol detector make, model, serial number, and date of last calibration

e. Environmental conditions in the test area, including HVAC settings, air cleaners, position and status of all-natural ventilation system (doors, windows, and other openings), temperature, humidity, supply and return vents. Interfering factors such as placement of the aerosol generator and detectors relative to neighboring vents shall be noted.

f. Test area location and equipment placement

g. Identification and status of operational devices:

1. All electrically powered devices that may contribute to particle decay during the test, including but not limited to fans, deodorizers, or other devices that emit additive or active substances into the air, whether operating in the room or air delivery system, shall be identified and their status clarified as either “contributing to decay” or “not”.
2. Devices identified as “contributing to decay” shall meet the safety requirements outlined in Normative Appendix A. This includes devices that may serve other functions but could impact air quality measurements.
3. Any additional devices not identified as *air cleaning* devices shall also be noted in the report and certified as inactive or not contributing to decay to air quality during testing. A reference manual provided by the manufacturer explaining the function of the device shall be available upon request.
4. A statement from the testing company verifying that no other unreported devices that may impact particle decay were operational during the test period shall be provided.

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INFORMATIVE APPENDIX D—RISK ASSESSMENT MODEL FOR DETERMINATION OF MINIMUM EQUIVALENT CLEAN AIRFLOW RATES

Minimum *equivalent clean airflow* rates per person (ECAi) in Table 5-1 are intended to provide equivalent personal risk per hour so that all occupants of a space have the same infection risk over a given period regardless of space type. To do this we employ the widely-used model of infection risk originally proposed by Wells and Riley. The Wells-Riley model relates the probability of infection to the dose of infectious agent received using a Poisson distribution. To make a reasonable estimate with this model requires an understanding of the concentration of infectious pathogens an individual is exposed to as well as the infectious dose. A distribution of pathogen emission rate is calculated as a function of the number of infected people present, the viral load of their respiratory aerosols, their respiratory activity, and the probability that a single viable virion initiates an infection. The model accounts for the changes in viral load over time and differences in emission rate between people using laboratory-acquired quanta emission rates. A distribution (not a single value) is assumed for each model input. These distributions are sampled to create and simulate thousands of scenarios that are extreme, but still likely, using a statistical framework. The model output is a distribution of the ECAi that is necessary to keep the probability of infection low in each scenario for a high percentage of the time.

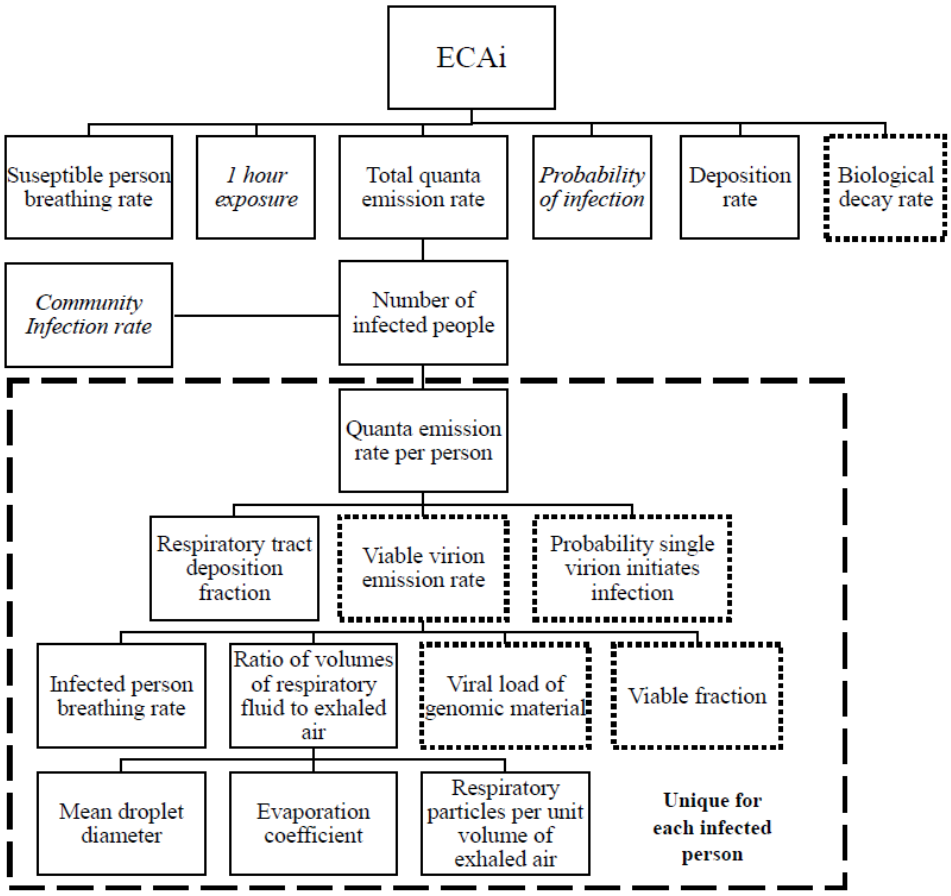

Figure D-1 Probabilistic model of infection ECAi. Variables may vary as a function of metabolic and respiratory activity. Dashed box shows variables unique for each infected person. Dotted boxes show biological terms specific to SARS-CoV-2. Italic text shows deterministic inputs. All other boxes are probabilistic.

Figure D-1 shows the inputs and assumptions of the probabilistic model used to determine ECAi following Jones et al. [12] and Iddon et al [13]. The quanta emission rate is unique for each infected person because of variation in key model inputs. These include breathing rate, viral shedding rate, mean respiratory droplet diameter, and aerosols per unit volume of exhaled air, for which values are sampled from distributions based on published data. When multiple infectors are present in a space, the total infectious quanta produced is the sum of their individual values. The number of infected people is generated according to a binomial distribution using the number of occupants and the community infection rate. This approach assumes one hour duration of exposure and accounts for deposition and biological decay.

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INFORMATIVE APPENDIX E—BUILDING READINESS PLAN TEMPLATE

E1. BUILDING READINESS PLAN AND ASSESSMENT WORKSHEETS

This standard requires the development of a *building readiness plan* (*BRP*) to document the sequences of operations, specifically the added engineering controls to the HVAC&R system to operate in *infection risk mitigation mode* (*IRMM*) in lieu of normal mode. This also indicates the evaluation of the engineering controls and the items chosen to achieve the *equivalent clean airflow* for infection control required.

Figure E-1 shows a sample table of contents for a *BRP*. Figure E-2 shows a sample building readiness assessment worksheet that can be used instead of a report. The worksheet can be downloaded from **www.ashrae.org/241-2023**.

Contents

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

Building Readiness Worksheet	**Address**
Date	City, State

This worksheet will help HVAC professionals to assess the ability of existing systems, particularly multiple-zone recirculating systems, to deliver the necessary *equivalent clean airflow for infection control* according to ASHRAE Standard 241-2023. It can also be used to document the Building Readiness Plan for a particular space or system.

For more information on ASHRAE Standard 241, visit ashrae.org/241-2023

Assessment Process Tasks	**Referenced Section in 241-2023**
Step 1 - Gather Data	Section 8.2.3.1 and 8.2.3.2
Obtain the following relevant documents (if available): record or as-built MEP drawings, Cx documents, BAS documentation, TAB reports	
Site observations must be performed, but can be done after Step 7 if there's sufficient documentation	
Step 2 - Inventory Occupied Spaces	Section 8.2.3.3 and Appendix B.1
Determine space categorization related to Table 5-1 and ASHRAE 62.1 Table 6-1 and relevant occupancy details	
Step 3 - Inventory Equipment	Section 8.2.3.4
Note the type and size of equipment serving each zone (e.g. VAV box or fan coil unit). Note the min and max airflow rates from the TAB report.	
Note the type and size of the central HVAC equipment serving the building (e.g. rooftop unit or AHU). Note the filter type that is installed, and outdoor airflow setpoints	

AHU Data		
AHU Designation	AHU-X	<--From drawings, BAS, or facility managers
AHU-X maximum supply airflow		<--This can come from TAB reports, design data, or BAS
AHU-X minimum supply airflow		<--This can come from TAB reports, design data, or BAS
AHU-X expected supply airflow		<--This airflow rate will be used to evaluate if additional Vecai is needed. The higher the airflow rate towards the maximum setpoint, the more conservative the results.
AHU-X filter MERV rating		<--This can be found from submittals, site observations, or design docs
AHU-X filter effectiveness		<--Table 7-1
AHU-X minimum OA airflow		<--This can come from TAB reports, design data, or BAS
AHU-X maximum OA airflow		<--This can come from TAB reports, design data, or BAS
AHU-X expected OA airflow		<--This airflow rate will be used to evaluate if additional Vecai is needed. <--The higher the airflow rate towards the minimum setpoint, the more conservative the results.

Zone Level Data									
Drawing Takeoffs or TAB Data								**Veca**	
Zone Designation	**Occupancy Category (Table 5-1)**	**SF**	**People**	**SA CFM MAX**	**SA CFM MIN**	**Vacs**	**Vnv**	**ECAi per person**	**Vecai,target**

Figure E-2 Sample building readiness assessment worksheet.

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INFORMATIVE APPENDIX F—EQUIVALENT CLEAN AIRFLOW CALCULATOR

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

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 from **www.ashrae.org/241-2023**.

(This appendix 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 ANSI 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 or ANSI.)

INFORMATIVE APPENDIX G—PRACTICAL GUIDANCE FOR EPIDEMIC OPERATION OF ENERGY RECOVERY VENTILATION SYSTEMS

ASHRAE Technical Committee (TC) 5.5, Air-to-Air Energy Recovery, along with ASHRAE's Epidemic Task Force (ETF) Building Readiness Team, created *Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems* to evaluate energy recovery ventilators to determine if they should operate during the *IRMM* or what needs to be corrected to have them operate in *IRMM*. The guidance document can be downloaded from **www.ashrae.org/241-2023**.

(This appendix 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 ANSI 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 or ANSI.)

INFORMATIVE APPENDIX H—EXHAUST RE-ENTRAINMENT GUIDE

ASHRAE's Epidemic Task Force (ETF) Building Readiness Team created the *Exhaust Re-entrainment Guide* to evaluate potential for exhaust air re-entrainment into a facility's outdoor air. The guide can be downloaded from **www.ashrae.org/241-2023**.

(This appendix 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 ANSI 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 or ANSI.)

INFORMATIVE APPENDIX I—INFORMATIVE REFERENCES AND BIBLIOGRAPHY

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