Ventilation Standards in the US

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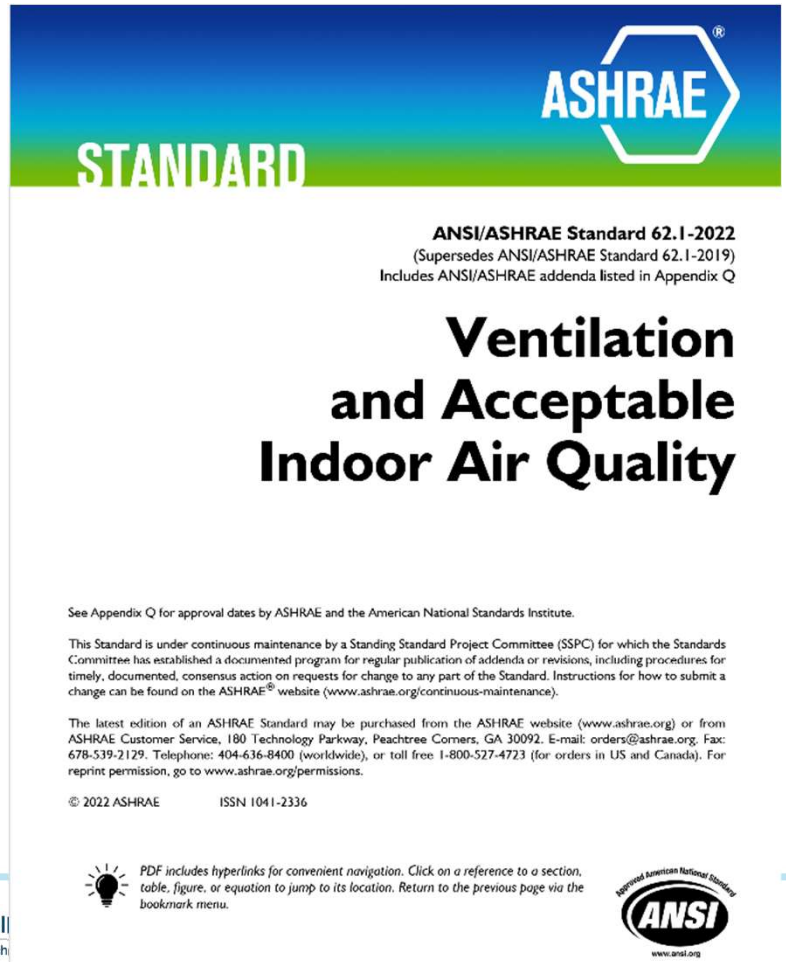
Ventilation or Airtightness Standards?

- Ventilation- Primarily used for **IAQ** reasons
  - Air flow rates
  - Filtration requirements
  - Operation: sound, controls, etc.
- Airtightness- Primarily used for **ENERGY** reasons
  - How leaky is the building envelope?
  - Determines air flows driven by wind and stack effects
  - IECC 3 ACH50 in most of country for residential
  - Area-normalized for commercial (ASHRAE 90.1 0.40 cfm/ft^2 at 75 Pa (7 m^3/h/m^2)

IECC = International Energy Conservation Code

No National building code = state-by-state adoption for regulation, often used in voluntary “above code” programs

US Ventilation Standards



STANDARD

ASHRAE

ANSI/ASHRAE Standard 62.1-2022
(Supersedes ANSI/ASHRAE Standard 62.1-2019)
Includes ANSI/ASHRAE addenda listed in Appendix Q

Ventilation and Acceptable Indoor Air Quality

See Appendix Q for approval dates by ASHRAE and the American National Standards Institute.

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

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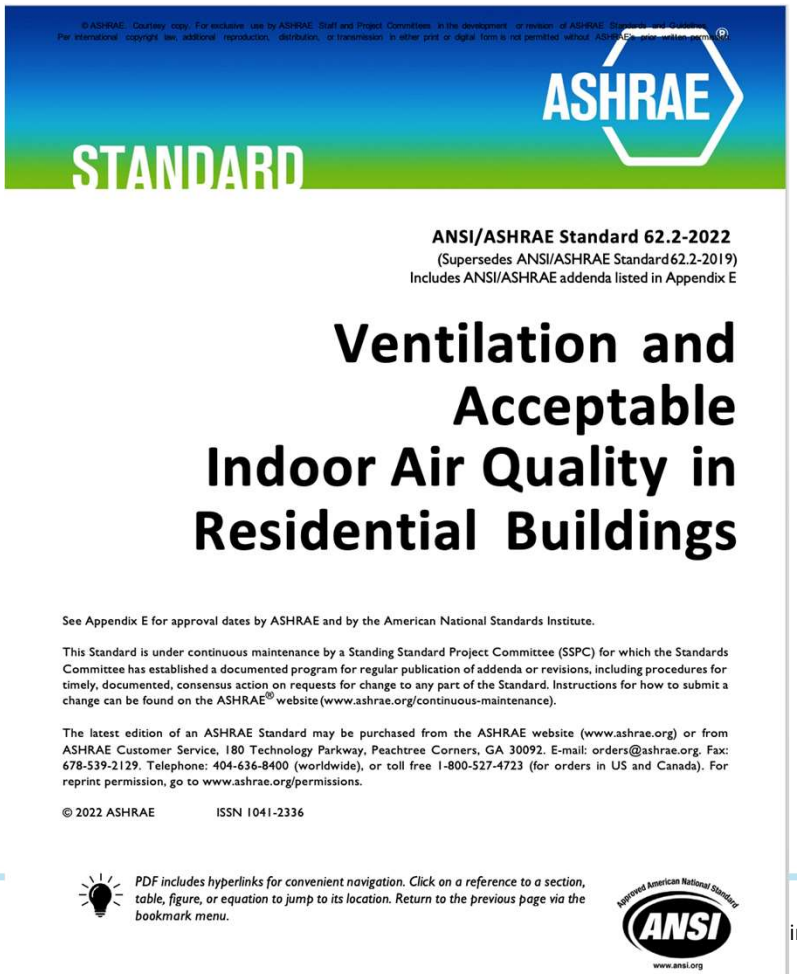

STANDARD

ASHRAE

ANSI/ASHRAE Standard 62.2-2022
(Supersedes ANSI/ASHRAE Standard62.2-2019)
Includes ANSI/ASHRAE addenda listed in Appendix E

Ventilation and Acceptable Indoor Air Quality in Residential Buildings

See Appendix E for approval dates by ASHRAE and by the American National Standards Institute.

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ASHRAE 62.2 – 2022 Dwelling Ventilation Rate

- Specifies dwelling ventilation rate based on floor area and number of occupants

$$Qtot\ (L/s) = 0.15 \times Afloor + 3.5 \times (Nbr + 1)$$

- Installed fan size can be reduced by taking credit for infiltration if envelope leakage is measured

$$Qfan\ (L/s) = Qtot - \Phi \times (Qinf \times Aext)$$

- Qinf = infiltration rate calculated using predefined weather and building geometry factors
- Φ = 1 for balanced ventilation, Qinf/Qtot for unbalanced ventilation
- Aext = 1 for detached dwelling units; otherwise, for horizontally attached dwelling units, the ratio of dwelling-unit boundary area that is not attached to garages or other dwelling units to total dwelling-unit boundary area

ASHRAE 62.2 – 2022 Weather Factors for Natural Infiltration

(This is a normative appendix and is part of the standard.)

NORMATIVE APPENDIX B
INFILTRATION EFFECTIVENESS WEATHER AND SHIELDING FACTORS

Table B-1 U.S. Climates

TMY3	wsf	Weather Station	Latitude	Longitude	State
722230	0.42	Mobile Regional AP	30.68	–88.25	Alabama
722235	0.42	Mobile Downtown AP	30.63	–88.07	Alabama
722260	0.39	Montgomery Dannelly Field	32.30	–86.40	Alabama
722265	0.40	Maxwell AFB	32.38	–86.35	Alabama
722267	0.34	Troy Af	31.87	–86.02	Alabama
722268	0.41	Dothan Municipal AP	31.23	–85.43	Alabama
722269	0.36	Cairns Field Fort Rucker	31.27	–85.72	Alabama
722280	0.41	Birmingham Municipal AP	33.57	–86.75	Alabama
722284	0.35	Auburn–Opelika Apt	32.62	–85.43	Alabama

ASHRAE 62.2 – 2022 Local Exhaust from Kitchens and Bathrooms

Table 5-1 Demand Controlled Local Exhaust Airflow Rates

Application	Airflow
Enclosed kitchen	• Vented range hood (including appliance-range hood combinations): 100 cfm (50 L/s) • Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s) or a capacity of 5 ach
Nonenclosed kitchen	• Vented range hood (including appliance-range hood combinations): 100 cfm (50 L/s) • Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s)
Bathroom	50 cfm (25 L/s)

Table 5-2 Continuous Local Exhaust Airflow Rates

Application	Airflow
Enclosed kitchen	5 ach, based on kitchen volume
Bathroom	20 cfm (10 L/s)

ASHRAE 62.2 – 2022 Filtration Credit

- Filtration Credit – reduces total air flow requirements, Qtot if filtered air supplied at the following rate:

$$Q_{filtered\ air} = F \times Q_{tot}$$

- Where F is a factor depending on the filter used

Table 4-4 Filtration Factor for Filters with a PM2.5 Efficiency Designation

PM2.5 Efficiency	f_{fx}
35%	4.3
50%	3.0
70%	2.1
85%	1.8
90%	1.7
95%	1.6

ASHRAE 62.2 – 2022 Variable Ventilation

- Short term Averaging – over 3 hours or less, average ventilation is greater than or equal to constant rate
- Scheduling, real-time control and equivalent ventilation

C3.1 Nonzero Ventilation. The relative exposure for a given time step shall be calculated from the relative exposure from the prior step and the current ventilation using the following equation, unless the real-time or scheduled ventilation is zero:

$$R_i = \frac{Q_{tot}}{Q_i} + \left(R_{i-1} - \frac{Q_{tot}}{Q_i}\right) e^{-Q_i \Delta t / V_{space}} \quad \text{(C-9)}$$

where *Ri* is the relative exposure for time step *i*.

C3.2 Zero Ventilation. If the real-time or scheduled ventilation at a given time step is zero then the following equation shall be used:

$$R_i = R_{i-1} + \frac{Q_{tot} \Delta t}{V_{space}} \quad \text{(C-10)}$$

ASHRAE 62.2 – 2022 Variable Ventilation

- Can use Annual average infiltration or calculated using weather data and “enhanced” infiltration model from ASHRAE Handbook Of Fundamentals.
- Calculations must show:
  1. Annual average exposure less than or equal to that from a continuously operating system.
  2. Peak exposure < 5.

ASHRAE 62.2 – 2022 Existing Homes

- Local exhaust not required to meet minimum air flows – but additional dwelling air flow needed to compensate
- Does not have to meet sound ratings
- Does not have to meet compartmentalization requirements for multifamily
  - Uses “prescriptive” alternative

A5.1 The spaces around accessible penetrations through the dwelling-unit boundary, including but not limited to the following, shall be sealed:

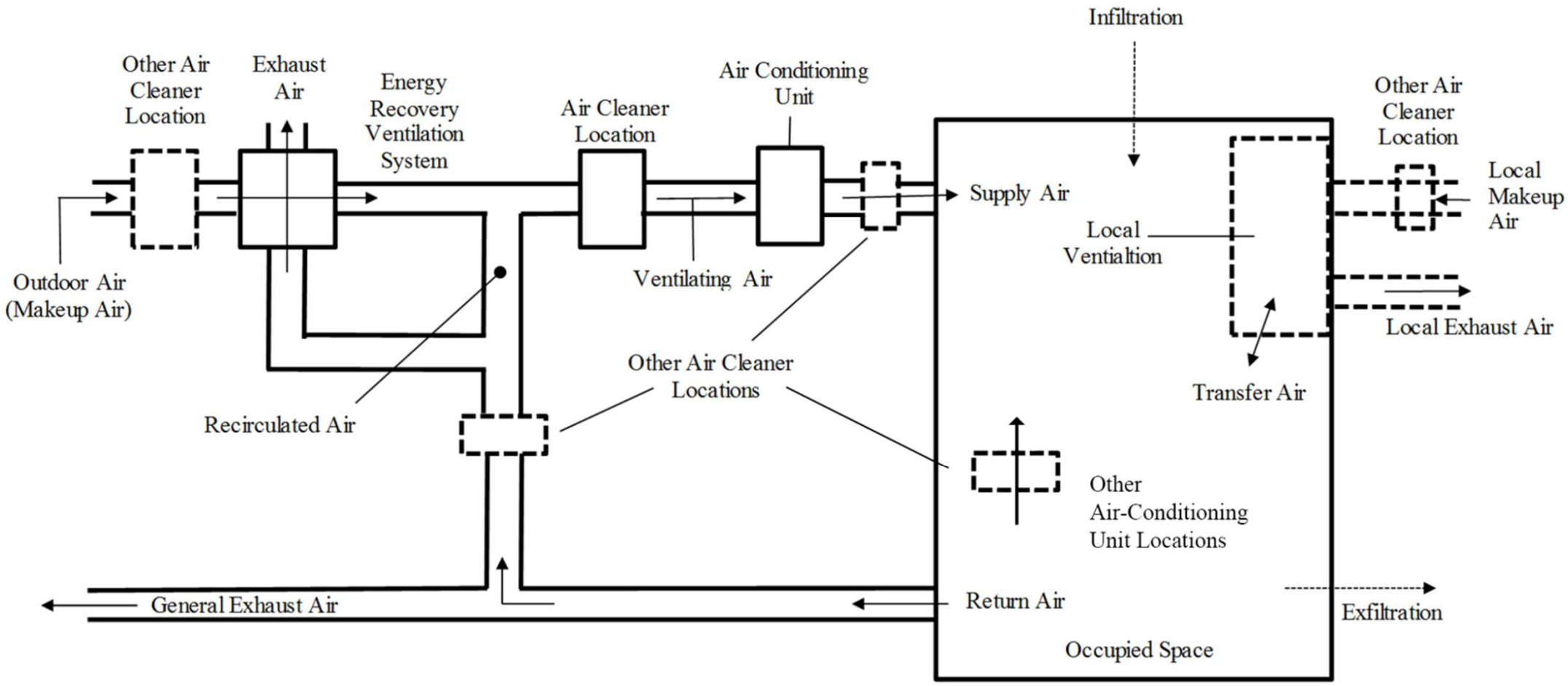
a. Vent and pipe penetrations, including those from water piping, drain waste and vent piping, HVAC piping, and sprinkler heads
b. Electrical penetrations, including those for receptacles, lighting, communications wiring, and smoke alarms
c. HVAC penetrations, including those for ventilation systems

A5.2 Accessible leaks and gaps in the dwelling-unit boundary shall be sealed, including but not limited to the intersections of baseboard trim and floor, the intersections of walls and ceilings, around window trim and dwelling-unit doors, and the termination points of internal chases in attics and crawlspaces.

ASHRAE 62.2 – 2022 Other Requirements

- Air flows must be measure/verified
- Sound: < 1 sone for dwelling unit fans, < 3 sone for local exhaust
- MERV 11 minimum filtration (about 35% of PM2.5)
- Compartmentalization test for Multifamily: < 100 L/s/100m^2
- Duct leakage <6% of fan flow at 25 Pa
- Intakes > 3m from known sources of contamination such as a stack, vent, exhaust hood, or vehicle exhaust
- Exhaust limit for homes with atmospherically vented combustion devices (furnaces, water heaters, boilers, fireplaces) of 75 L/s/100m^2
- No unvented combustion (NEW!)
- CO alarms required

ASHRAE 62.1 – Fully Designed Systems



ASHRAE 62.1 – A lot more design information

- Air balancing
- Air intake separation
- Plenum systems
- Regional Air Quality
- Maintaining pressure control in d
- Erosion and mold growth on surfaces
- Louver design (rain entrainment,
- Classifying air for recirculation
- Defines “ventilation zones”

Table 5-1 Air Intake Minimum Separation Distance

Object	Minimum Distance, ft (m)
Class 2 air exhaust/relief outlet	10 (3)
Class 3 air exhaust/relief outlet	15 (5)
Class 4 air exhaust/relief outlet	30 (10)
Evaporative heat-rejection equipment exhaust	25 (7.5)
Evaporative heat-rejection equipment intake or basin	15 (5)
Driveway, street, or parking place	5 (1.5)
Garage entry, automobile loading area, or drive-in queue	15 (5)
Garbage storage/pick-up area, dumpsters	15 (5)
Plumbing vents terminating at least 3 ft (1 m) above the level of the outdoor air intake	3 (1)
Plumbing vents terminating less than 3 ft (1 m) above the level of the outdoor air intake	10 (3)
Roof, landscaped grade, or other surface directly below intake	1 (0.30)
Thoroughfare with high traffic volume	25 (7.5)
Truck loading area or dock, bus parking/idling area	25 (7.5)
Vents, chimneys, and flues from combustion appliances and equipment	15 (5)

Table 6-3 Airstreams or Sources

Description	Air Class
Kitchen grease hoods	4
Kitchen hoods other than grease hoods	3
Diazo printing equipment discharge	4
Hydraulic elevator machine room	2
Laboratory hoods	4
Paint spray booths	4
Refrigerating machinery rooms	3

ASHRAE 62.1 – Air flows by Space Type

- ***Breathing Zone*** air flow rates for different applications

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density	Air Class	OS (6.2.6.1.4)
	cfm/ person	L/s· person	cfm/ft^2	L/s·m^2	#/1000 ft^2 or #/100 m^2		
Animal Facilities							
Animal exam room (veterinary office)	10	5	0.12	0.6	20	2	
Animal imaging (MRI/CT/PET)	10	5	0.18	0.9	20	3	
Animal operating rooms	10	5	0.18	0.9	20	3	
Animal postoperative recovery room	10	5	0.18	0.9	20	3	
Animal preparation rooms	10	5	0.18	0.9	20	3	
Animal procedure room	10	5	0.18	0.9	20	3	
Animal surgery scrub	10	5	0.18	0.9	20	3	
Large-animal holding room	10	5	0.18	0.9	20	3	
Necropsy	10	5	0.18	0.9	20	3	
Small-animal-cage room (static cages)	10	5	0.18	0.9	20	3	
Small-animal-cage room (ventilated cages)	10	5	0.18	0.9	20	3	
Correctional Facilities							
Booking/waiting	7.5	3.8	0.06	0.3	50	2	
Cell	5	2.5	0.12	0.6	25	2	
Dayroom	5	2.5	0.06	0.3	30	1	
Guard stations	5	2.5	0.06	0.3	15	1	
Educational Facilities							
Art classroom	10	5	0.18	0.9	20	2	
Classrooms (ages 5 to 8)	10	5	0.12	0.6	25	1	
Classrooms (age 9 plus)	10	5	0.12	0.6	35	1	
Computer lab	10	5	0.12	0.6	25	1	
Daycare sickroom	10	5	0.18	0.9	25	3	
Daycare (through age 4)	10	5	0.18	0.9	25	2	
Lecture classroom	7.5	3.8	0.06	0.3	65	1	✓
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	150	1	✓
Libraries	5	2.5	0.12	0.6	10		
Media center	10	5	0.12	0.6	25	1	
Multiuse assembly	7.5	3.8	0.06	0.3	100	1	✓

ASHRAE 62.1 – Zone Distribution Effectiveness

Zone Air Flow:

Divide ***Breathing Zone*** air flow rates by ***Effectiveness***

Complex calculation procedures for ventilation zones within the building

Table 6-4 Zone Air Distribution Effectiveness (E_z)

Air Distribution Configuration	E_z
Well-Mixed-Air Distribution Systems	
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above average space temperature where the supply air-jet velocity is less than 150 fpm (0.8 m/s) within 4.5 ft (1.4 m) of the floor and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above average space temperature where the supply air-jet velocity is equal to or greater than 150 fpm (0.8 m/s) within 4.5 ft (1.4 m) of the floor and ceiling return	1.0
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply outlet located more than half the length of the space from the exhaust, return, or both	0.8
Makeup supply outlet located less than half the length of the space from the exhaust, return, or both	0.5
Stratified-Air Distribution Systems (Section 6.2.1.2.1)	
Floor supply of cool air where the vertical throw is greater than or equal to 60 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor and ceiling return at a height less than or equal to 18 ft (5.5 m) above the floor	1.05
Floor supply of cool air where the vertical throw is less than 60 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor and ceiling return at a height less than or equal to 18 ft (5.5 m) above the floor	1.2
Floor supply of cool air where the vertical throw is less than 60 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor and ceiling return at a height greater than 18 ft (5.5 m) above the floor	1.5
Personalized Ventilation Systems (Section 6.2.1.2.2)	
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with ceiling supply of cool air and ceiling return	1.40
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with ceiling supply of warm air and ceiling return	1.40
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with a stratified air distribution system with nonaspirating floor supply devices and ceiling return	1.20
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with a stratified air distribution system with aspirating floor supply devices and ceiling return	1.50

ASHRAE 62.1 – IAQ Procedure

- Alternative to fixed air flow table
- Determine emission rates for sources
- Determine air flow rates to nc exceed given concentration limits using a mass balance analysis

Table 6-5 Design Compounds, PM2.5, and Their Design Limits

Compound or PM2.5	Cognizant Authority	Design Limit
Acetaldehyde	Cal EPA CREL (June 2016)	140 µg/m^3
Acetone	AgBB LCI	1,200 µg/m^3
Benzene	Cal EPA CREL (June 2016)	3 µg/m^3
Dichloromethane	Cal EPA CREL (June 2016)	400 µg/m^3
Formaldehyde	Cal EPA 8-hour CREL (2004)	33 µg/m^3
Naphthalene	Cal EPA CREL (June 2016)	9 µg/m^3
Phenol	AgBB LCI	10 µg/m^3
Tetrachloroethylene	Cal EPA CREL (June 2016)	35 µg/m^3
Toluene	Cal EPA CREL (June 2016)	300 µg/m^3
1,1,1-trichloroethane	Cal EPA CREL (June 2016)	1000 µg/m^3
Xylene, total	AgBB LCI	500 µg/m^3
Carbon monoxide	U.S. EPA NAAQS	9 ppm
PM2.5	U.S. EPA NAAQS (annual mean)	12 µg/m^3
Ozone	U.S. EPA NAAQS	70 ppb
Ammonia	Cal EPA CREL (June 2016)	200 µg/m^3

ASHRAE 62.1 – IAQ Procedure

- Includes “perceived” IAQ based on % of occupants satisfied with IAQ
- Examples of emission rates, concentration limits and mass balance calculations given in appendices.
- Verification by measurement

Table 7-1 Allowed Laboratory Test Methods

Compound	Allowed Test Methods
VOCs except formaldehyde, acetaldehyde and acetone	ISO 16000-6; EPA IP-1, EPA TO-17; ISO 16017-1; ISO 16017-2; ASTM D6345-10
Formaldehyde, acetaldehyde and acetone	ISO 16000-3; EPA TO-11; EPA IP-6; ASTM D5197
Carbon monoxide	ISO 4224; EPA IP-3

Table 7-2 Direct Reading Instruments Minimum Specifications

	Ozone	PM2.5	Carbon Monoxide
Accuracy (±)	5 ppb	Greater of 5 µg /m^3 or 20% of reading	Greater of 3 ppm or 20% of reading
Resolution (±)	1 ppb	5 µg/m^3	1 ppm

Table 7-3 Number of Measurements Points

Total Occupied Floor Area, ft^2 (m^2)	Number of Measurements
≤25,000 (2500)	1
>25,000 (2500) and ≤50,000 (5000)	2
>50,000 (5000) and ≤100,000 (10,000)	4
>100,000 (10,000)	6

ASHRAE 62.1 – Natural Ventilation

- Calculation procedure with many requirements
- Based on minimum opening areas

Table 6-7 Minimum Openable Areas: Single Openings [a]

$V_{bz}/A_z \leq$, (L/s)/m^2	$V_{bz}/A_z \leq$, cfm/ft^2	Total Openable Areas in Zone as a Percentage of A_z		
		$H_S/W_S \leq 0.1$	$0.1 < H_S/W_S \leq 1$	$H_S/W_S > 1$
1.0	0.2	4.0	2.9	2.5
2.0	0.4	6.9	5.0	4.4
3.0	0.6	9.5	6.9	6.0
4.0	0.8	12.0	8.7	7.6
5.5	1.1	15.5	11.2	9.8

where

Table 6-8 Minimum Openable Areas: Two Vertically Spaced Openings [a]

$V_{bz}/A_z \leq$, (L/s)/m^2	$V_{bz}/A_z \leq$, cfm/ft^2	Total Openable Areas in Zone as a Percentage of A_z					
		$H_{vs} \leq 8.2$ ft (2.5 m)		8.2 ft (2.5m) $< H_{vs} \leq 16.4$ ft (5 m)		16.4 ft (5 m) $< H_{vs}$	
		$A_s/A_l \leq 0.5$	$A_s/A_l > 0.5$	$A_s/A_l \leq 0.5$	$A_s/A_l > 0.5$	$A_s/A_l \leq 0.5$	$A_s/A_l > 0.5$
1.0	0.2	2.0	1.3	1.3	0.8	0.9	0.6
2.0	0.4	4.0	2.6	2.5	1.6	1.8	1.2
3.0	0.6	6.0	3.9	3.8	2.5	2.7	1.7
4.0	0.8	8.0	5.2	5.0	3.3	3.6	2.3
5.5	1.1	11.0	7.1	6.9	4.5	4.9	3.2

ASHRAE 62.1 – Other Requirements

- Time averaging allowed for variable occupancy and/or air flow rate
  - Limited to a time period based on space volume and air flow rates
- Demand control air flow reset permitted based on CO_2
- MERV 8 filters required to protect equipment
- MERV 11 filters on air inlets if in a location where National Guideline for outdoor PM2.5 is exceeded
- Requirements for parking garages – pressure control
- Requirements for smoking – pressure control and transfer air controls and signage
- Requirements for ozone generating devices
- Requires and Operation and Maintenance manual and compliance with O&M requirements

Use in regulation

- ASHRAE 62.1
  - In most jurisdictions using “model energy codes” – i.e., almost universal
- ASHRAE 62.2
  - A few states require it in new construction
  - EPA Energy Star homes
  - DOE Weatherization
  - By default in home energy ratings that are now used in regulations in many states
  - Overall – much less universal than 62.1

Questions/comments

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