ANSI/ASHRAE Addendum *n* to
ANSI/ASHRAE Standard 62-2001

ASHRAE® STANDARD

Ventilation for Acceptable Indoor Air Quality

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ASHRAE Standard Project Committee 62.1
Cognizant TC: TC 4.3, Ventilation Requirements and Infiltration
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Foreword to Addendum 62n

This addendum revises the Ventilation Rate Procedure currently contained in Section 6.1 of ANSI/ASHRAE Standard 62-2001. This revision was developed as part of the effort to convert the entire standard to mandatory, enforceable language suitable for adoption into building codes and to reflect new technical information that has become available since the current Ventilation Rate Procedure was prepared in the mid-1980s.

The Ventilation Rate Procedure in Standard 62-2001 is essentially identical to the version in the 1989 standard and contains a number of requirements that run counter to the current objectives of minimum requirements and mandatory, enforceable language. For example, the current standard specifies outdoor air requirements in the "breathing zone," which are very difficult to actually measure and therefore to enforce. It also requires one to account for air mixing in ventilated spaces when determining outdoor air rates but provides no specific calculation approach for doing so. Standard 62 also requires the use of the so-called "multiple spaces" equation to adjust outdoor air rates for recirculating systems that serve more than one room. However, this equation is seldom used by designers (possibly due to its perceived complexity) and, as presented in the current standard, does not apply to many common system types.

The revision in this addendum addresses these issues related to the objective of code-intended language in a number of ways. It specifies the determination of design ventilation rates that can be easily measured so that compliance can be verified, both by review of the design documents and by field measurement. It does this by relating the ventilation requirements in the breathing zone to the outdoor air intake rate at the air-handling system, a quantity that is more readily measured using standard airflow measurement techniques as specified in ASHRAE Standard 111. In this revision, room mixing is addressed explicitly in the calculation of ventilation rates, with default values for the air change effectiveness provided to facilitate the application of this adjustment. In addition, multiple space calculations have been greatly simplified for the bulk of design applications, with a more detailed approach available for those who choose to use it.

Regarding the ventilation requirements themselves, most of them have been decreased relative to the 1989/2001 version of the standard. However, with the explicit requirement to account for room mixing and ventilation system efficiency, the total outdoor airflow rate at the air intake will not change much in most systems. The most significant changes in the ventilation requirements occur in densely occupied spaces, such as conference rooms and auditoria, requirements that had been strongly criticized as being much higher than needed. Furthermore, since the standard is now focused on minimum requirements, the ventilation rate requirements are based on that focus as opposed to the 1989 standard, which was not. Also, in recognition of the fact that indoor air pollutants are generated by both building occupants (and their activities) as well as by the contents of a building, the ventilation requirements include both a people component (to dilute contaminants from people and their activities) and an area component (to dilute contaminants from non-occupant-related sources that are more related to floor area than the number of people). The ventilation requirements for a particular space based on people and on floor area are then added together to determine the total ventilation requirement for a space. While acknowledging that the "additivity" approach does not apply to all aspects of indoor air quality, the committee believes that additivity is the predominant effect when considering multiple contaminant sources that impact occupant perception with respect to odor and irritation. While important questions remain regarding additivity, the majority of research data support its use in this context.

The first public review of addendum 62n occurred in 1999 and produced about 70 unique comments. Of these, about half called for increased ventilation rates, while a smaller number suggested further decreases. About 10% of the comments addressed the issue of complexity, and these were evenly split between complaints about too much complexity and requests for more detail. About one-third commented on the additive methodology for combining the ventilation requirements based on the number of people with the requirements based on floor area, but the committee retained this approach based on the principles discussed above and the ability to explicitly adjust ventilation rates based on occupant density. In response to many of the public review comments, a full second public draft was developed and issued for comment. In this draft, some of the ventilation requirements were increased (most notably in educational buildings) relative to the first public review draft. A number of changes were also made to address the concerns of complexity, including the removal of a requirement for minimum supply airflow rates and a number of changes in the language and notation.

The second public review resulted in about 80 unique comments, most of which addressed the same issues identified in the first public review. As a result, a limited number of changes were issued for a third public review, including a revised definition of "zone," simplified approaches for determining outdoor air intake rates for single-zone and 100% outdoor air systems, revision of the tables of default values of zone and system ventilation efficiencies, and a revision of the normative appendix that presents a more detailed methodology for determining system ventilation efficiencies. This more detailed methodology is an alternative that is not required for common system types.

Finally, to make application of the calculation methods easier for users of the standard, a spreadsheet called 62n-VRP.xls was developed. It is available for free download at the ASHRAE web site (currently under the SSPC62.1 directory at ftp.ashrae.org).

Addendum 62n

In Section 3, "Definitions," change the name of the term "occupied zone" and update the reference as follows:

~~occupied zone~~breathing zone: the region within an occupied space between planes 3 and 72 in. (75 and 1800 mm) above the floor and more than 2 ft (600 mm) from the walls or fixed air-conditioning equipment (see ASHRAE Standard 55-1992~~1981~~, Reference 1).

Add the following definition to Section 3:

zone: One occupied space or several occupied spaces with similar occupancy category (see Table 6.1), *occupant density*, *zone air distribution effectiveness* (see Section 6.2.1.2), and *zone primary airflow* (see Section 6.2.4.1) per unit area. **Note**: A ventilation zone is not necessarily an independent thermal control zone; however, spaces that can be combined for load calculations can often be combined into a single zone for ventilation calculations.

Delete the current Section 6.1, Ventilation Rate Procedure (currently numbered as Section 6.2 in accordance with addendum 62i, approved in 2002) and replace it with the following:

6.2 Ventilation Rate Procedure

The design *outdoor air intake flow* (V_{ot}) for a ventilation system shall be determined in accordance with Sections 6.2.1 through 6.2.5.

Note: Additional explanation of terms used below is contained in Appendix G, along with a ventilation system schematic (Figure G-1).

6.2.1 Zone Calculations. *Zone* parameters shall be determined in accordance with Sections 6.2.1.1 through 6.2.1.3.

Note: In some cases it is acceptable to determine these parameters for only selected *zones* as outlined in Appendix G.

6.2.1.1 Breathing Zone Outdoor Airflow. The design outdoor airflow required in the *breathing zone* of the occupiable space or spaces in a *zone*, *i.e., the breathing zone outdoor airflow* (V_{bz}), shall be determined in accordance with Equation 6-1.

$$V_{bz} = R_p P_z + R_a A_z \quad (6\text{-}1)$$

where*:*

A_z = *zone floor area*: the net occupiable floor area of the *zone* m^2, (ft^2).

P_z = *zone population*: the largest number of people expected to occupy the zone during typical usage. If the number of people expected to occupy the zone fluctuates, P_z may be estimated based on averaging approaches described in Section 6.2.5.2. **Note**: If P_z cannot be accurately predicted during design, it may be an estimated value based on the zone floor area and the default occupant density listed in Table 6.1.

R_p = outdoor airflow rate required per person as determined from Table 6.1. **Note**: These values are based on adapted occupants.

R_a = outdoor airflow rate required per unit area as determined from Table 6.1.

Note: Equation 6.1 is the means of accounting for people-related sources and area-related sources for determining the outdoor air required at the *breathing zone*. The use of Equation 6-1 in the context of this standard does not necessarily imply that simple addition of sources can be applied to any other aspect of indoor air quality.

6.2.1.2 Zone Air Distribution Effectiveness. The *zone air distribution effectiveness* (E_z) shall be determined using Table 6.2.

6.2.1.3 Zone Outdoor Airflow. The design *zone outdoor airflow* (V_{oz}), i.e., the outdoor airflow that must be provided to the zone by the supply air distribution system, shall be determined in accordance with Equation 6-2.

$$V_{oz} = V_{bz}/E_z \quad (6\text{-}2)$$

6.2.2 Single-Zone Systems. When one air handler supplies a mixture of outdoor air and recirculated air to only one zone, the *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Equation 6-3.

$$V_{ot} = V_{oz} \quad (6\text{-}3)$$

6.2.3 100% Outdoor Air Systems. When one air handler supplies only outdoor air to one or more zones, the *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Equation 6-4.

$$V_{ot} = \Sigma V_{oz} \quad (6\text{-}4)$$

6.2.4 Multiple-Zone Recirculating Systems. When one air handler supplies a mixture of outdoor air and recirculated return air to more than one zone, the *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Sections 6.2.4.1 through 6.2.4.4.

6.2.4.1 Primary Outdoor Air Fraction. When Table 6.3 is used to determine system ventilation efficiency, the *zone primary outdoor air fraction* (Z_p) shall be determined in accordance with Equation 6-5.

$$Z_p = V_{oz}/V_{pz} \quad (6\text{-}5)$$

where V_{pz} is the zone primary airflow, i.e., the primary airflow to the zone from the air handler including outdoor air and recirculated return air. **Note**: For VAV systems, V_{pz} is the minimum expected primary airflow.

6.2.4.2 System Ventilation Efficiency. The *system ventilation efficiency* (E_v) shall be determined using Table 6.3 or Appendix G.

6.2.4.3 Uncorrected Outdoor Air Intake. The design *uncorrected outdoor air intake* (V_{ou}) shall be determined in accordance with Equation 6-6.

$$V_{ou} = D\,\Sigma_{all\ zones}\, R_p P_z + \Sigma_{all\ zones}\, R_a A_z \quad (6\text{-}6)$$

The *occupant diversity*, *D*, may be used to account for variations in occupancy within the zones served by the system. The *occupancy diversity* is defined as

$$D = P_s/\Sigma_{all\ zones}\, P_z \quad (6\text{-}7)$$

where the *system population* (P_s) is the total population in the area served by the system. Alternative methods may be used to account for population diversity when calculating V_{ou}, provided the resulting value is no less than that determined by Equation 6-6.

Note: The *uncorrected outdoor air intake* (V_{ou}) is adjusted for diversity but uncorrected for ventilation efficiency.

TABLE 6.1
Minimum Ventilation Rates In Breathing Zone

(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_P		Area Outdoor Air Rate R_A		Notes	Default Values		
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)	
	cfm/person	L/s•person	cfm/ft^2	L/s•m^2		#/1000 ft^2 (#/100 m^2)	cfm/person	L/s•person
Correctional Facilities								
Cell	5	2.5	0.12	0.6		25	10	4.9
Day room	5	2.5	0.06	0.3		30	7	3.5
Guard stations	5	2.5	0.06	0.3		15	9	4.5
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4
Educational Facilities								
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6
Classrooms (ages 5-8)	10	5	0.12	0.6		25	15	7.4
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0
Art classroom	10	5.0	0.18	0.9		20	19	9.5
Science laboratories	10	5.0	0.18	0.9		25	17	8.6
Wood/metal shop	10	5	0.18	0.9		20	19	9.5
Computer lab	10	5	0.12	0.6		25	15	7.4
Media center	10	5	0.12	0.6	A	25	15	7.4
Music/theater/dance	10	5.0	0.06	0.3		35	12	5.9
Multi-use assembly	7.5	3.8	0.06	0.3		100	8	4.1
Food and Beverage Service								
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1
Cafeteria/fast food dining	7.5	3.8	0.18	0.9		100	9	4.7
Bars, cocktail lounges	7.5	3.8	0.18	0.9		100	9	4.7
General								
Conference/meeting	5	2.5	0.06	0.3		50	6	3.1
Corridors	-	-	0.06	0.3		-		
Storage rooms	-	-	0.12	0.6	B	-		
Hotels, Motels, Resorts, Dormitories								
Bedroom/living room	5	2.5	0.06	0.3		10	11	5.5
Barracks sleeping areas	5	2.5	0.06	0.3		20	8	4.0
Lobbies/prefunction	7.5	3.8	0.06	0.3		30	10	4.8
Multi-purpose assembly	5	2.5	0.06	0.3		120	6	2.8
Office Buildings								
Office space	5	2.5	0.06	0.3		5	17	8.5
Reception areas	5	2.5	0.06	0.3		30	7	3.5
Telephone/data entry	5	2.5	0.06	0.3		60	6	3.0
Main entry lobbies	5	2.5	0.06	0.3		10	11	5.5
Miscellaneous spaces								
Bank vaults/safe deposit	5	2.5	0.06	0.3		5	17	8.5
Computer (not printing)	5	2.5	0.06	0.3		4	20	10.0
Pharmacy (prep. area)	5	2.5	0.18	0.9		10	23	11.5
Photo studios	5	2.5	0.12	0.6		10	17	8.5

TABLE 6.1 *(Continued)*
Minimum Ventilation Rates In Breathing Zone
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_P		Area Outdoor Air Rate R_A		Notes	Default Values		
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)	
	cfm/person	L/s•person	cfm/ft^2	L/s•m^2		#/1000 ft^2 (#/100 m^2)	cfm/person	L/s•person
Shipping/receiving	-	-	0.12	0.6	B	-		
Transportation waiting	7.5	3.8	0.06	0.3		100	8	4.1
Warehouses	-	-	0.06	0.3	B	-		
Public Assembly Spaces								
Auditorium seating area	5.0	2.5	0.06	0.3		150	5	2.7
Places of religious worship	5.0	2.5	0.06	0.3		120	6	2.8
Courtrooms	5.0	2.5	0.06	0.3		70	6	2.9
Legislative chambers	5.0	2.5	0.06	0.3		50	6	3.1
Libraries	5.0	2.5	0.12	0.6		10	17	8.5
Lobbies	5.0	2.5	0.06	0.3		150	5	2.7
Museums (children's)	7.5	3.8	0.12	0.6		40	11	5.3
Museums/galleries	7.5	3.8	0.06	0.3		40	9	4.6
Retail								
Sales (except as below)	7.5	3.8	0.12	0.6		15	16	7.8
Mall common areas	7.5	3.8	0.06	0.3		40	9	4.6
Barber shop	7.5	3.8	0.06	0.3		25	10	5.0
Beauty and nail salons	20	10	0.12	0.6		25	25	12.4
Pet shops (animal areas)	7.5	3.8	0.18	0.9		10	26	12.8
Supermarket	7.5	3.8	0.06	0.3		8	15	7.6
Coin-operated laundries	7.5	3.8	0.06	0.3		20	11	5.3
Sports and Entertainment								
Sports arena (play area)	-	-	0.30	1.5		-		
Gym, stadium (play area)	-	-	0.30	1.5		30		
Spectator areas	7.5	3.8	0.06	0.3		150	8	4.0
Swimming (pool and deck)	-	-	0.48	2.4	C	-		
Disco/dance floors	20	10	0.06	0.3		100	21	10.3
Health club/aerobics room	20	10	0.06	0.3		40	22	10.8
Health club/weight rooms	20	10	0.06	0.3		10	26	13.0
Bowling alley (seating)	10	5.0	0.12	0.6		40	13	6.5
Gambling casinos	7.5	3.8	0.18	0.9		120	9	4.6
Game arcades	7.5	3.8	0.18	0.9		20	17	8.3
Stages, studios	10	5.0	0.06	0.3	D	70	11	5.4

GENERAL NOTES FOR TABLE 6.1

1 Related Requirements: The rates in this table are based on all other applicable requirements of this standard being met.

2 Smoking: This table applies to no-smoking areas. Rates for smoking-permitted spaces must be determined using other methods.

3 Air Density: Volumetric airflow rates are based on an air density of 1.2 kg_{da}/m^3 (0.075 lb_{da}/ft^3), which corresponds to dry air at a barometric pressure of 101.3 kPa (1 atm) and an air temperature of 21 °C (70 °F). Rates may be adjusted for actual density, but such adjustment is not required for compliance with this standard.

4 Default Occupant Density: The default occupant density shall be used when actual occupant density is not known.

5 Default Combined Outdoor Air Rate (per person): This rate is based on the default occupant density.

6 Unlisted Occupancies: If 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, activities, and building construction shall be used.

7 Residential facilities, Health care facilities, and Vehicles: Rates shall be determined in accordance with Appendix E.

ITEM-SPECIFIC NOTES FOR TABLE 6.1

A For high school and college libraries, use values shown for *Public Spaces – Libraries*.

B Rate may not be sufficient when stored materials include those having potentially harmful emissions.

C Rate does not allow for humidity control. Additional ventilation or dehumidification may be required to remove moisture.

D Rate does not include special exhaust for stage effects, e.g., dry ice vapors, smoke.

TABLE 6.2
Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air at least 8°C (15°F) above space temperature and ceiling return.	0.8
Ceiling supply of warm air less than 8°C (15°F) above space temperature and ceiling return provided that the 0.8 m/s (150 fpm) supply air jet reaches to within 1.4 m (4.5 ft) of floor level. **Note**: For lower velocity supply air, E_z = 0.8.	1.0
Floor supply of cool air and ceiling return provided that the 0.8 m/s (150 fpm) supply jet reaches at least 1.4 m (4.5 ft) above the floor. **Note**: Most underfloor air distribution systems comply with this proviso.	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust and/or return	0.8
Makeup supply drawn in near to the exhaust and/or return location	0.5

Notes for Table 6.2
1. "Cool air" is air cooler than space temperature.
2. "Warm air" is air warmer than space temperature.
3. "Ceiling" includes any point above the *breathing zone.*
4. "Floor" includes any point below the *breathing zone.*
5. As an alternative to using the above values, E_z may be regarded as equal to air change effectiveness determined in accordance with ASHRAE Standard 129 for all air distribution configurations except unidirectional flow.

6.2.4.4 Outdoor Air Intake. The design *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Equation 6-8.

$$V_{ot} = V_{ou}/E_v \qquad (6\text{-}8)$$

6.2.5 Design for Varying Operating Conditions.

6.2.5.1 Variable Load Conditions. Ventilation systems shall be designed to be capable of providing the required ventilation rates in the breathing zone whenever the zones served by the system are occupied, including all full- and part-load conditions.

6.2.5.2 Short-Term Conditions. If it is known that peak occupancy will be of short duration and/or ventilation will be varied or interrupted for a short period of time, the design may be based on the average conditions over a time period *T* determined by Equation 6-9:

$$T = 3\ v\ /\ V_{bz} \qquad (6\text{-}9a)\ \text{IP}$$

$$T = 50\ v\ /\ V_{bz} \qquad (6\text{-}9b)\ \text{SI}$$

TABLE 6.3
System Ventilation Efficiency

Max (Z_P)	E_V
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
> 0.55	Use Appendix G

Notes for Table 6.3
1. "Max Z_p" refers to the largest value of Z_p, calculated using Equation 6-5, among all the zones served by the system.
2. For values of Z_p between 0.15 and 0.55, one may determine the corresponding value of E_v by interpolating the values in the table.
3. The values of E_v in this table are based on a 0.15 average outdoor air fraction for the system (i.e., the ratio of the *uncorrected outdoor air intake* V_{ou} to the total *zone primary airflow* for all the zones served by the air handler). For systems with higher values of the average outdoor air fraction, this table may result in unrealistically low values of E_v and the use of Appendix G may yield more practical results.

where:

T = averaging time period, (min)

v = the volume of the zone for which averaging is being applied, ft^3 (m^3).

V_{bz} = the *breathing zone outdoor airflow* calculated using Equation 6-1 and the design value of the zone population P_z, cfm (L/s).

Acceptable design adjustments based on this optional provision include the following:

1. Zones with fluctuating occupancy: The *zone population* (P_z) may be averaged over time *T.*
2. Zones with intermittent interruption of supply air: The average outdoor airflow supplied to the *breathing zone* over time *T* shall be no less than the *breathing zone outdoor airflow* (V_{bz}) calculated using Equation 6-1.
3. Systems with intermittent closure of the outdoor air intake: The average outdoor air intake over time *T* shall be no less than the *minimum outdoor air intake* (V_{ot}) calculated using Equation 6-2, 6-3, or 6-4 as appropriate.

6.2.6 Dynamic Reset. The system may be designed to reset the design *outdoor air intake flow* (V_{ot}) and/or space or zone airflow as operating conditions change. These conditions include but are not limited to:

1. Variations in occupancy or ventilation airflow in one or more individual zones for which ventilation airflow requirements will be reset. **Note**: Examples of measures for estimating such variations include: occupancy scheduled by time-of-day, a direct count of occupants, or an estimate of occupancy or ventilation rate per person using occupancy sensors such as those based on indoor CO_2 concentrations.
2. Variations in the efficiency with which outdoor air is distributed to the occupants under different ventilation system airflows and temperatures.
3. A higher fraction of outdoor air in the air supply due to intake of additional outdoor air for free cooling or exhaust air makeup.

TABLE 6.4
Minimum Exhaust Rates

Occupancy Category	Exhaust Rate cfm/unit	Exhaust Rate cfm/ft^2	Notes	Exhaust Rate L/s-unit	Exhaust Rate L/s-m^2
Art classrooms	-	0.70		-	3.5
Auto repair rooms	-	1.50	A	-	7.5
Barber shop	-	0.50		-	2.5
Beauty and nail salons	-	0.60		-	3.0
Cell with toilet	-	1.00		-	5.0
Darkrooms	-	1.00		-	5.0
Arena	-	0.50	B	-	2.5
Kitchen - commercial	-	0.70		--	3.5
Kitchenettes	-	0.30		--	1.5
Locker rooms	-	0.50		-	2.5
Locker/dressing rooms	-	0.25		-	1.25
Parking garages	-	0.75	C	--	3.7
Janitor, trash, recycle	-	1.00		-	5.0
Pet shops (animal areas)	-	0.90		-	4.5
Copy, printing rooms	-	0.50		-	2.5
Science lab classrooms	-	1.00		-	5.0
Toilets - public	50/70	-	D	25/35	-
Toilet - private	25/50	-	E	12.5/25	-
Woodwork shop/classroom	-	0.50		-	2.5

Notes For Table 6.4

A—Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.

B—When combustion equipment is intended to be used on the playing surface, additional dilution ventilation and/or source control shall be provided.

C—Exhaust not required if two or more sides comprise walls that are at least 50% open to the outside.

D—Rate is per water closet and/or urinal. Provide the higher rate where periods of heavy use are expected to occur, e.g., toilets in theaters, schools, and sports facilities. The lower rate may be used where use is intermittent.

E—Rate is for a toilet room intended to be occupied by one person at a time. For continuous system operation during normal hours of use, the lower rate may be used. Otherwise use the higher rate.

6.2.7 Exhaust Ventilation. Exhaust airflow shall be provided in accordance with the requirements in Table 6.4. Exhaust makeup air may be any combination of outdoor air, recirculated air, and transfer air.

Delete the following references from Section 9. [Text containing these references has been deleted from the standard.]

~~[7] ACGIH. 1986. *Industrial Ventilation--A Manual of Recommended Practice. 1986 ed.* American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, P.O. Box 16153, Lansing, MI 48901.~~

~~[20] *NIOSH Manual of Analytical Methods*, 2d Ed., April 1977. Pub. No. 77-157, 4 vols. Cincinnati: National Institute for Occupational Safety and Health.~~

~~[21] *NIOSH Manual Sampling Data Sheets* with Suppl., Pubs. Nos. 77-159 and 78-189, March, 1977 and August, 1978. Note: The Clearinghouse for Occupational Safety and Health of NIOSH, 4676 Columbia Parkway, Cincinnati, OH 45226, is willing to fill occasional requests for separate sheets of the information on individual air contaminants from these publications on request. National Institute for Occupational Safety and Health, Cincinnati.~~

~~[22] *ACGIH Threshold Limit Values and Biological Exposure Indices for 1986-87.* American Conference of Governmental Industrial Hygienists, 6500 Glenway, Bldg. D-7, Cincinnati, OH 45211-4438, 1987.~~

~~[23] Standards Association of Australia. 1980. *Australian Standard AS1668 Part 2, 1980 - Ventilation Requirements*, Clause 3.5.2, Appendix A&B. Standards Association of Australia, Standards House, 80 Arthur St., North Sydney, NSW, 2060. 1980.~~

~~[24] Kowalczewski, J.J. 1973. "Quality of air in air conditioning." *AIRAH*, Feb. Australian Institute of Refrigeration, Air Conditioning and Heating.~~

~~[25] Janssen, J.E., T. Hill, J.E. Woods, and E.A.B. Maldonado. 1982. "Ventilation for control of indoor air quality: A case study." *Environment International*, EI 8-487-496.~~

Delete the current Appendix E and replace it with the following:

[Note: The current Appendix E uses a definition of ventilation effectiveness that is not consistent with that used in this addendum. Because the definition is now included in the body of the standard and in ANSI/ASHRAE Standard 129, which is referenced, this appendix is no longer required. This new Appendix E contains ventilation requirements for occupancies that are not covered in Table 6.1 but that are currently covered in ANSI/ASHRAE Standard 62-2001. These occupancies are expected to be covered by other ASHRAE standards and, once those standards are approved, will be removed from the scope of this standard. At that time, this appendix will be deleted. Since this appendix is simply a relocation of ventilation rates from the normative body of Standard 62-2001 to a normative appendix, it is not a substantive change. The values and wording of this appendix were therefore not open to comment during the public review process.]

(This is a normative appendix and is part of this standard)

APPENDIX E

Ventilation Rates for Health Care Facilities, Residential Buildings, and Vehicles

TABLE E-1*
Outdoor Air Requirements for Ventilation of Health Care Facilities (Hospitals, Nursing and Convalescent Homes)

Application	Estimated Maximum** Occupancy P/1000 ft^2 or 100 m^2	Outdoor Air Requirements cfm/ person	L/s · person	cfm/ft^2	L/s · m^2	Comments
Patient rooms	10	25	13			Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency. Procedures generating contaminants may require higher rates.
Medical procedure	20	15	8			
Operating rooms	20	30	15			
Recovery and ICU	20	15	8			
Autopsy rooms	20			0.50	2.50	Air shall not be recirculated into other spaces.
Physical therapy	20	15	8			

* Table E-1 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to dilute human bioeffluents and other contaminants with an adequate margin of safety and to account for health variations among people and varied activity levels.

** Net occupiable space.

TABLE E-2 [a]
Outdoor Air Requirements for Ventilation of Residential Facilities (Private Dwellings, Single, Multiple)

Applications	Outdoor Requirements	Comments
Living areas	0.35 air changes per hour but not less than 15 cfm (7.5 L/s) per person	For calculating the air changes per hour, the volume of the living spaces shall include all areas within the conditioned space. The ventilation is normally satisfied by infiltration and natural ventilation. Dwellings with tight enclosures may require supplemental ventilation supply for fuel-burning appliances, including fireplaces and mechanically exhausted appliances. Occupant loading shall be based on the number of bedrooms as follows: first bedroom, two persons; each additional bedroom, one person. Where higher occupant loadings are known, they shall be used.
Kitchens [b]	100 cfm (50 L/s) intermittent or 25 cfm (12 L/s) continuous or openable windows	Installed mechanical exhaust capacity.[c] Climatic conditions may affect choice of the ventilation system.
Baths, Toilets [b]	50 cfm (25 L/s) intermittent or 20 cfm (10 L/s) continuous or openable windows	Installed mechanical exhaust capacity[c]
Garages: Separate for each dwelling unit	100 cfm (50 L/s) per car	Normally satisfied by infiltration or natural ventilation
Common for several units	1.5 cfm/ft^2 (7.5 L/s m^2)	See “Parking garages” in Table 6.4.

[a] In using this table, the outdoor air is assumed to be acceptable.

[b] Climatic conditions may affect choice of ventilation option chosen.

[c] The air exhausted from kitchens, bath, and toilet rooms may utilize air supplied through adjacent living areas to compensate for the air exhausted. The air supplied shall meet the requirements of exhaust systems as described in Section 5.8 and be of sufficient quantities to meet the requirements of this table.

TABLE E-3*
Outdoor Air Requirements for Ventilation of Vehicles

Application	Estimated Maximum** Occupancy P/1000 ft^2 or 100 m^2	Outdoor Air Requirements cfm/ person	L/s · person	cfm/ft^2	L/s · m^2	Comments
Vehicles	150	15	8			Ventilation within vehicles may require special considerations.

* Table E-3 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to dilute human bioeffluents and other contaminants with an adequate margin of safety and to account for health variations among people and varied activity levels.

** Net occupiable space

Delete Appendix G Rationale for Reducing Outdoor Air When Loads on a Multi-Zone System are Unequal. [This entirely informative appendix is no longer referenced in the standard.]

Add the following new Appendix G, which is normative.

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

APPENDIX G

Multiple-Zone Systems

This appendix presents an alternative procedure for calculating the *system ventilation efficiency* (E_v) that must be used when Table 6.3 values are not used. In this alternative procedure, E_v is equal to the lowest calculated value of the *zone ventilation efficiency* E_{vz} (see Equation G-3 below). Figure G-1 contains a ventilation system schematic depicting most of the quantities used in this appendix.

The *zone ventilation efficiency* E_{vz}, i.e., the efficiency with which a system distributes outdoor air from the intake to an individual *breathing zone*, shall be calculated using Equation G-1 or G-2.

Single Supply Systems $E_{vz} = 1 + X_s - Z_d$ (G-1)

Equation G-1 (or G-2) shall be used for "single supply" systems, where all the ventilation air is a mixture of outdoor air and recirculated air from a single location, e.g., Reheat, Single-Duct VAV, Single-Fan Dual-Duct, and Multizone.

General Case $E_{vz} = (F_a + X_s * F_b - Z_d * F_c)/F_a$ (G-2)

Equation G-2 shall be used for systems that provide all or part of their ventilation by recirculating air from other zones without directly mixing it with outdoor air, e.g., dual-fan dual-duct, fan-powered mixing box, and transfer fans for conference rooms.

The system ventilation efficiency shall be calculated using Equation G-3.

$$E_v = \text{minimum } (E_{vz}) \quad \text{(G-3)}$$

Alternative Calculations

The above equations may be rearranged to calculate other design parameters of interest based on known parameters. This includes, but is not limited to, calculating *minimum zone discharge* (supply) *airflow* (V_{dzm}) when the *outdoor air intake flow* V_{ot} is known.

Other mass or flow balance equations for multiple zone systems may also be used provided that they result in *outdoor air intake airflow* (V_{ot}) that is within 5% of the airflow value obtained using the *system ventilation efficiency* calculated using Equation G-3 or they more accurately represent a particular system configuration.

Design Process

The *system ventilation efficiency* and therefore the outdoor air intake for the system (V_{ot}) are determined as part of the design process based on the design and minimum supply flows to individual zones as well as the outdoor air requirements to the zones. In this process, the designer shall assume that the critical zone is at its minimum supply or discharge airflow in VAV systems. **Note**: The designer may increase the zone supply flows during the design process, particularly to the critical zones requiring the highest fraction of outdoor air, and thereby reduce the system outdoor air intake requirement determined in the calculation, sometimes dramatically.

Selecting Zones for Calculation

Since *system ventilation efficiency* E_{vs} is determined by the minimum value of the *zone ventilation efficiency* ($E_{vz,}$) in accordance with Equation G-3, calculation of E_{vz} is required only for the *zone* with the minimum value of E_{vz} at ventilation design conditions. It is not required for any zone that clearly has an E_{vz} that is equal to or larger than that of the zone for which a calculation has been done. E_{vz} for a zone will have a larger (or equal) value if all of the following are true relative to the zone with minimum E_{vz}:

1. Floor area per occupant (A_z/P_z) is no lower
2. Minimum discharge airflow rate per unit area (V_{dzm}/A_z) is no lower
3. Primary air fraction E_p is no lower
4. *Zone air distribution effectiveness* E_z is no lower
5. Area outdoor air rate R_a is no higher
6. People outdoor air rate R_p is no higher

If all of the above six parameters are the same for different spaces or areas, then those spaces or areas may be treated as a single zone for calculation of E_{vz}.

Example: In office buildings it is generally necessary to calculate E_{vz} for one typical interior zone. If overhead supply air is used to heat the perimeter, it is also necessary to calculate for the perimeter zone with the lowest supply airflow rate per unit area. No other calculations for E_{vz} are typically necessary, even if the building has 1,000 zones, provided the ventilation for any conference rooms is separately calculated.

Definitions

A_z **Zone Floor Area:** the net occupiable floor area of the *zone* m^2, (ft^2).

D **Occupant Diversity:** the ratio of the *system population* to the sum of the *zone populations*: $D = P_s/\Sigma P_z$.

F_a Fraction of supply air to the *zone* from sources outside the *zone*: $F_a = E_p + (1 - E_p) * E_r$.

F_b Fraction of supply air to the *zone* from fully mixed primary air: $F_b = E_p$.

F_c Fraction of outdoor air to the *zone* from sources outside the *zone*: $F_c = 1 - (1 - E_z) * (1 - E_r) * (1 - E_p)$.

E_p Primary air fraction to the *zone*: $E_p = V_{pz}/V_{dz}$ ($E_p = 1.0$ for single-duct and single-*zone* systems.)

E_r In systems with secondary recirculation of return air, fraction of secondary recirculated air to the zone that is representative of average system return air rather than air directly recirculated from the zone. **Note**: For plenum return systems with local secondary recirculation (e.g.,

fan-powered VAV with plenum return), E_r <= 1.0. For ducted return systems with local secondary recirculation (e.g., fan-powered VAV with ducted return), typically E_r = 0.0.

E_z **Zone Air Distribution Effectiveness (E_z):** a measure of how effectively the zone air distribution uses its supply air to maintain acceptable air quality in the *breathing zone*. E_z is determined from Table 6.2.

E_{vz} **Zone Ventilation Efficiency:** the efficiency with which the system distributes air from the outdoor air intake to the breathing zone in a particular zone. E_{vz} is determined from Equations G-1 or G-2.

E_v **System Ventilation Efficiency:** the efficiency with which the system distributes air from the outdoor air intake to the breathing zone in the ventilation-critical zone, which requires the largest fraction of outdoor air in the primary air stream. E_v is determined from Table 6-3 or Equation G-3.

P_s **System Population**: the maximum simultaneous number of occupants in the area served by the system. Where population fluctuates, it may be averaged as described in Section 6.2.5.2. **Note**: Occupant load for egress often determines system population.

P_z **Zone Population:** the largest number of people expected to occupy the zone during typical usage. If P_z is not known, it is determined from the default occupant densities listed in Table 6-1. Where population fluctuates, it may be averaged as described in Section 6.2.5.2.

R_a **Area Outdoor Air Rate**: the outdoor airflow rate per unit area to be provided in the breathing zone to dilute contaminants that are emitted at a rate that is related more to floor area than to population. The value of R_a for a zone is determined from Table 6.1.

R_p **People Outdoor Air Rate**: the outdoor airflow rate per person to be provided in the breathing zone to dilute contaminants that are emitted at a rate that is related more to population than to floor area. The value of R_p for a zone is determined from Table 6.1.

V_{bz} **Breathing Zone Outdoor Airflow:** the outdoor airflow required in the breathing zone of an occupiable space, $V_{bz} = R_pP_z + R_aA_z$.

V_{oz} **Zone Outdoor Airflow:** the design outdoor airflow required in the zone, i.e., $V_{oz} = V_{bz}/E_z$.

V_{ot} **Outdoor Air Intake Flow**: the design outdoor airflow required at the ventilation system outdoor air intake.

V_{ou} **Uncorrected Outdoor Air Intake**: The outdoor air intake flow required if the system ventilation efficiency E_v were 1.0. $V_{ou} = D^*\Sigma R_p{}^*P_z + \Sigma R_a{}^*A_z$.

V_{ps} **System Primary Airflow:** The total primary airflow supplied to all *zones* served by the system from the air-handling unit at which the outdoor air intake is located, $V_{ps} = \Sigma V_{pz}$, in L/s (cfm).

V_{pz} **Zone Primary Airflow:** The primary airflow supplied to the *zone* from the air-handling unit at which the outdoor air intake is located, L/s (cfm). It includes outdoor intake air and recirculated air from that air-handling unit but does not include air transferred or air recirculated to the zone by other means.

V_{dzm} **Minimum Zone Discharge Airflow:** The minimum expected discharge (supply) airflow to the zone that includes primary airflow and locally recirculated airflow, L/s (cfm).

X_s **Average Outdoor Air Fraction**: At the primary air handler, the fraction of outdoor air intake flow in the system primary airflow, $X_s = V_{ou}/V_{ps}$.

Z_d The outdoor air fraction required in air discharged to the zone based on the minimum discharge airflow, $Z_d = V_{oz}/V_{dzm}$.

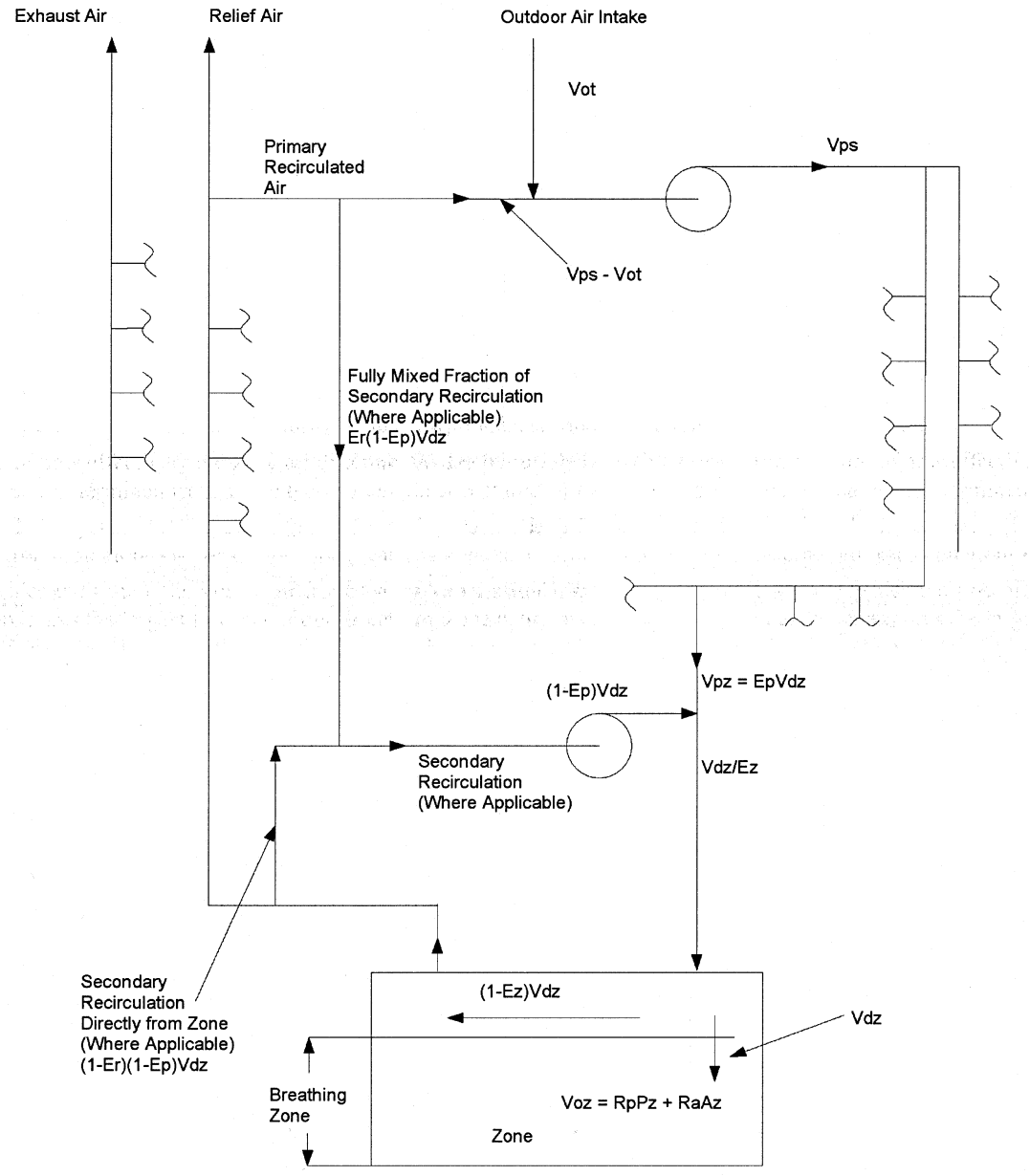

Figure G-1 Ventilation System Schematic

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.