STANDARD

ANSI/ASHRAE Standard 62.1-2019
(Supersedes ANSI/ASHRAE Standard 62.1-2016)
Includes ANSI/ASHRAE addenda listed in Appendix O

Ventilation for Acceptable Indoor Air Quality

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

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Ventilation for Acceptable Indoor Air Quality

The ventilation outlet is usually incorporated into or mounted on the furniture. It is used in conjunction with another air distribution system that handles the area ventilation requirements and thermal loads in the space.

6.2.1.2.2.1 Personalized Air. The personalized air shall be distributed in the breathing zone and designed such that the velocity is equal to or less than 50 fpm (0.25 m/s) at the head/facial region of the occupant.

6.2.1.2.2.2 Return Air. The return air openings or pathways shall be located more than 9 ft (2.8 m) above the floor.

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

$$V_{oz} = V_{bz}/E_z \tag{6-2}$$

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

$$V_{ot} = V_{oz} \tag{6-3}$$

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

$$V_{ot} = \Sigma_{all\ zones} V_{oz} \tag{6-4}$$

6.2.4 Multiple-Zone Recirculating Systems. For ventilation systems wherein one or more air handler supplies a mixture of outdoor air and recirculated air to more than one ventilation 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 Uncorrected Outdoor Air Intake. The uncorrected outdoor air intake (V_{ou}) flow shall be determined in accordance with Equation 6-5.

$$V_{ou} = D\Sigma_{all\ zones}(R_p \times P_z) + \Sigma_{all\ zones}(R_a \times A_z) \tag{6-5}$$

6.2.4.1.1 Occupant Diversity. The occupant diversity ratio (D) shall be determined in accordance with Equation 6-6 to account for variations in population within the ventilation zones served by the system.

$$D = P_s/\Sigma_{all\ zones} P_z \tag{6-6}$$

where the system population (P_s) is the total population in the area served by the system.

Exception to 6.2.4.1.1: Alternative methods to account for occupant diversity shall be permitted, provided the resulting V_{ou} value is not less than that determined using Equation 6-5.

6.2.4.1.2 Design System Population. Design system population (P_s) shall equal the largest (peak) number of people expected to occupy all ventilation zones served by the ventilation system during use.

Informative Note: Design system population is always equal to or less than the sum of design zone population for all zones in the area served by the system because all zones may not be simultaneously occupied at design population.

6.2.4.1.3 Other Ventilation Requirements. When a zone ventilation rate is obtained from criteria other than this standard, the ventilation rate shall be converted to cfm or L/s and the value added to V_{ou} for use in system design calculations.

6.2.4.2 System Ventilation Efficiency. The system ventilation efficiency (E_v) shall be determined in accordance with Section 6.2.4.3 for the Simplified Procedure or Normative Appendix A for the Alternative Procedure.

Informative Note: These procedures also establish zone minimum primary airflow rates for VAV systems.

6.2.4.3 Simplified Procedure

6.2.4.3.1 System Ventilation Efficiency. System ventilation efficiency (E_v) shall be determined in accordance with Equation 6-7 or 6-8.

$$E_v = 0.88 \times D + 0.22 \text{ for } D < 0.60 \quad (6\text{-}7)$$

$$E_v = 0.75 \text{ for } D \geq 0.60 \quad (6\text{-}8)$$

6.2.4.3.2 Zone Minimum Primary Airflow. For each zone, the minimum primary airflow ($V_{pz\text{-}min}$) shall be determined in accordance with Equation 6-9.

$$V_{pz\text{-}min} = V_{oz} \times 1.5 \quad (6\text{-}9)$$

6.2.4.4 Outdoor Air Intake. The design outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-10.

$$V_{ot} = V_{ou}/E_v \quad (6\text{-}10)$$

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 not less than the minimum ventilation rates required in the breathing zone where the zones served by the system are occupied, including all full- and part-load conditions.

Informative Note: The minimum outdoor air intake flow may be less than the design value at part-load conditions.

6.2.5.2 Short-Term Conditions. Where it is known that peak occupancy will be of short duration, ventilation will be varied or interrupted for a short period of time, or both, the design shall be permitted to be based on the average conditions over a time period (T) determined by Equation 6-11a (I-P) or 6-11b (SI).

$$T = 3v/V_{bz} \quad (6\text{-}11a)$$

$$T = 50v/V_{bz} \quad (6\text{-}11b)$$

where

T = averaging time period, min

v = the volume of the ventilation zone where 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:

a. Zones with fluctuating occupancy: The zone population (P_z) shall be permitted to be averaged over time (T).
b. Zones with intermittent interruption of supply air: The average outdoor airflow supplied to the breathing zone over time (T) shall be not less than the breathing zone outdoor airflow (V_{bz}) calculated using Equation 6-1.
c. Systems with intermittent closure of the outdoor air intake: The average outdoor air intake over time (T) shall be not less than the minimum outdoor air intake (V_{ot}) calculated using Equation 6-3, 6-4, or 6-5 as appropriate.

6.2.6 Dynamic Reset. The system shall be permitted to be designed to reset the outdoor air intake flow (V_{ot}), the space or ventilation zone airflow (V_{oz}) as operating conditions change, or both.

6.2.6.1 Demand Control Ventilation (DCV). DCV shall be permitted as an optional means of dynamic reset.

Exception to 6.2.6.1: CO_2-based DCV shall not be applied in zones with indoor sources of CO_2 other than occupants, or with CO_2 removal mechanisms, such as gaseous air cleaners.

6.2.6.1.1 For DCV zones in the occupied mode, breathing zone outdoor airflow (V_{bz}) shall be reset in response to current population. Current population estimates used in DCV control calculations shall not result in ventilation rates that are less than those required by the actual population during any one-hour time period.

6.2.6.1.2 For DCV zones in the occupied mode, breathing zone outdoor airflow (V_{bz}) shall be not less than the building component ($R_a \times A_z$) for the zone.

6.2.6.1.3 Where CO_2 sensors are used for DCV, the CO_2 sensors shall be certified by the manufacturer to be accurate within ±75 ppm at concentrations of both 600 and 1000 ppm when

measured at sea level at 77°F (25°C). Sensors shall be factory calibrated and certified by the manufacturer to require calibration not more frequently than once every five years. Upon detection of sensor failure, the system shall provide a signal that resets the ventilation system to supply the required minimum quantity of outdoor air (V_{bz}) to the breathing zone for the design zone population (P_z).

6.2.6.1.4 For DCV zones in the occupied standby mode, breathing zone outdoor airflow shall be permitted to be reduced to zero for the occupancy categories indicated "OS" in Table 6-1, provided that airflow is restored to V_{bz} whenever occupancy is detected.

6.2.6.1.5 Documentation. A written description of the equipment, methods, control sequences, set points, and the intended operational functions shall be provided. A table shall be provided that shows the minimum and maximum outdoor intake airflow for each system.

6.2.6.2 Ventilation Efficiency. Variations in the efficiency with which outdoor air is distributed to the occupants under different ventilation system airflows and temperatures shall be permitted as an optional basis of dynamic reset.

6.2.6.3 Outdoor Air Fraction. A higher fraction of outdoor air in the air supply due to intake of additional outdoor air for free cooling or exhaust air makeup shall be permitted as an optional basis of dynamic reset.

6.3 Indoor Air Quality (IAQ) Procedure. Breathing zone outdoor airflow (V_{bz}) shall be determined in accordance with Sections 6.3.1 through 6.3.5.

6.3.1 Contaminant Sources. Each contaminant of concern, for purposes of the design, shall be identified. For each contaminant of concern, indoor sources and outdoor sources shall be identified, and the emission rate for each contaminant of concern from each source shall be determined. Where two or more contaminants of concern target the same organ system, these contaminants shall be considered to be a contaminant mixture.

6.3.2 Contaminant Concentration. For each contaminant of concern, a concentration limit and its corresponding exposure period and an appropriate reference to a cognizant authority shall be specified. For each contaminant mixture of concern, the ratio of the concentration of each contaminant to its concentration limit shall be determined, and the sum of these ratios shall be not greater than one.

Exception to 6.3.2: Consideration of odors in determining concentration limits shall not be required.

Informative Note: Odors are addressed in Section 6.3.4.2.

6.3.3 Perceived Indoor Air Quality. The design level of indoor air acceptability shall be specified in terms of the percentage of building occupants, visitors, or both expressing satisfaction with perceived IAQ.

6.3.4 Design Approach. Zone and system outdoor airflow rates shall be the larger of those determined in accordance with Section 6.3.4.1 and either Section 6.3.4.2 or 6.3.4.3, based on emission rates, concentration limits, and other relevant design parameters.

6.3.4.1 Mass Balance Analysis. Using a steady-state or dynamic mass-balance analysis, the minimum outdoor airflow rates required to achieve the concentration limits specified in Section 6.3.2 shall be determined for each contaminant or contaminant mixture of concern within each zone served by the system.

Informative Notes:

1. Informative Appendix E includes steady-state mass-balance equations that describe the impact of air cleaning on outdoor air and recirculation rates for ventilation systems serving a single zone.
2. In the completed building, measurement of the concentration of contaminants or contaminant mixtures of concern may be useful as a means of checking the accuracy of the design mass-balance analysis, but such measurement is not required for compliance.

6.3.4.2 Subjective Evaluation. Using a subjective occupant evaluation conducted in the completed building, the minimum outdoor airflow rates required to achieve the level of acceptability specified in Section 6.3.3 shall be determined within each zone served by the system.

Informative Note: Level of acceptability often increases in response to increased outdoor airflow rates, increased level of indoor or outdoor air cleaning, or decreased indoor or outdoor contaminant emission rate.

6.3.4.3 Similar Zone. The minimum outdoor airflow rates shall be not less than those found in accordance with Section 6.3.4.2 for a substantially similar zone.

6.3.5 Combined IAQ Procedure and Ventilation Rate Procedure. The IAQ Procedure in conjunction with the Ventilation Rate Procedure shall be permitted to be applied to a zone or system. In this case, the Ventilation Rate Procedure shall be used to determine the required zone minimum outdoor airflow, and the IAQ Procedure shall be used to determine the additional outdoor air or air cleaning necessary to achieve the concentration limits of the contaminants and contaminant mixtures of concern.

Informative Note: The improvement of IAQ through the use of air cleaning or provision of additional outdoor air in conjunction with minimum ventilation rates may be quantified using the IAQ Procedure.

6.3.6 Documentation. Where the IAQ Procedure is used, the following information shall be included in the design documentation: the contaminants and contaminant mixtures of concern considered in the design process, the sources and emission rates of the contaminants of concern, the concentration limits and exposure periods and the references for these limits, and the analytical approach used to determine ventilation rates and air-cleaning requirements. The contaminant monitoring and occupant or visitor evaluation plans shall also be included in the documentation.

6.4 Natural Ventilation Procedure. Natural ventilation systems shall comply with the requirements of either Section 6.4.1 or 6.4.2. Designers shall provide interior air barriers, insulation, or other means that separate naturally ventilated spaces from mechanically cooled spaces to prevent high-dew-point outdoor air from coming into contact with mechanically cooled surfaces.

6.4.1 Prescriptive Compliance Path. Any zone designed for natural ventilation shall include a mechanical ventilation system designed in accordance with Section 6.2, Section 6.3, or both.

Exceptions to 6.4.1:

1. Zones in buildings that have all of the following:
   a. Natural ventilation openings that comply with the requirements of Section 6.4.1.
   b. Controls that prevent the natural ventilation openings from being closed during periods of expected occupancy, or natural ventilation openings that are permanently open.
2. Zones that are not served by heating or cooling equipment.

6.4.1.1 Ceiling Height. For ceilings that are parallel to the floor, the ceiling height (*H*) to be used in Sections 6.4.1.3 through 6.4.1.5 shall be the minimum ceiling height in the zone.

For zones wherein ceiling height increases as distance from the ventilation increases, the ceiling height shall be the average height of the ceiling determined over a distance not greater than 6 m (20 ft) from the openings.

6.4.1.2 Floor Area to be Ventilated. The naturally ventilated area in zones or portions of zones shall extend from the openings to a distance determined by Sections 6.4.1.3, 6.4.1.4, or 6.4.1.5. Openings shall meet the requirements of Section 6.4.1.6. For zones where ceilings are not parallel to the floor, the ceiling height shall be determined in accordance with Section 6.4.1.1.

6.4.1.3 Single Side Opening. For zones with openings on only one side of the zone, the naturally ventilated area shall extend to a distance not greater that two times the height of the ceiling from the openings.

6.4.1.4 Double Side Opening. For zones with openings on two opposite sides of the zone, the naturally ventilated area shall extend between the openings separated by a distance not greater than five times the height of the ceiling.

6.4.1.5 Corner Openings. For zones with openings on two adjacent sides of a zone, the naturally ventilated area shall extend to a distance not greater than five times the height of the ceiling along a line drawn between the outside edges of the two openings that are the farthest

apart. Floor area outside that line shall comply with Section 6.4.1.3 as a zone having openings on only one side of the zone.

Informative Note: *Floor area outside that line* refers to the remaining area of the zone that is not bounded by the walls that have the openings and the line drawn between the openings.

6.4.1.6 Location and Size of Openings. Zones or portions of zones to be naturally ventilated shall have a permanently open airflow path to openings directly connected to the outdoors. The minimum flow rate to the zone shall be determined in accordance with Section 6.2.1.1. This flow rate shall be used to determine the required openable area of openings, accounting only for buoyancy-driven flow. Wind-driven flow shall be used only where it can be demonstrated that the minimum flow rate is provided during all occupied hours. Openings shall be sized in accordance with Section 6.4.1.6.1 (Path A) or Section 6.4.1.6.2 (Path B).

Informative Note: *Permanently open airflow path* refers to pathways that would allow airflow unimpeded by partitions, walls, furnishings, etc.

6.4.1.6.1 Sizing Openings—Path A. Where the zone is ventilated using a single opening or multiple single openings located at the same elevation, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6-5. Where the zone is ventilated using two openings located at different elevations or multiple pairs of such openings, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6-6.

Where openings are obstructed by louvers or screens, the openable area shall be based on the net free area of the opening. Where interior zones, or portions of zones, without direct openings to the outdoors are ventilated through adjoining zones, the opening between zones shall be permanently unobstructed and have a free area of not less than twice the percent of occupiable floor area used to determine the opening size of adjacent exterior zones, or 25 ft^2 (2.3 m^2), whichever is greater.

Informative Note: Tables 6-5 and 6-6 are based solely on buoyancy-driven flow and have not been created to address thermal comfort.

6.4.1.6.2 Sizing Openings—Path B. The required openable area for a single zone shall be calculated using CIBSE AM10, Section 4.3.

6.4.2 Engineered System Compliance Path. For an engineered natural ventilation system, the designer shall

a. determine hourly environmental conditions, including outdoor air dry-bulb temperature; dew-point temperature; outdoor concentration of contaminants, including PM2.5, PM10, and ozone where data are available; wind speed and direction; and internal heat gains during expected hours of natural ventilation operation.
b. determine the effect of pressure losses along natural ventilation airflow paths on the resulting flow rates, including inlet openings, air transfer grills, ventilation stacks, and outlet openings during representative conditions of expected natural ventilation system use.
c. quantify natural ventilation airflow rates of identified airflow paths accounting for wind induced and thermally induced driving pressures during representative conditions of expected natural ventilation system use.
d. design to provide outdoor air in quantities sufficient to result in acceptable IAQ as established under Section 6.2.1.1 or 6.3 during representative conditions of expected natural ventilation system use.

6.4.3 Control and Accessibility. The means to open required openings shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to coordinate operation of the natural and mechanical ventilation systems.

6.4.4 Documentation. Where the Natural Ventilation Procedure is used, the designer shall document the values and calculations that demonstrate conformance with the compliance path and the controls systems and sequences required for operation of the natural ventilation system, including coordination with mechanical ventilation systems. Where the Prescriptive Compliance Path is used for buildings located in an area where the national standard for one or more contaminants is exceeded, any design assumptions and calculations related to the impact on IAQ shall be included in the design documents.

Table 6-5 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
V_{bz} = breathing zone outdoor airflow, per Table 6-1.
A_z = zone floor area, the net occupiable floor area of the ventilation zone.
W_S = aggregated width of all single outdoor openings located at the same elevation.
H_S = vertical dimension of the single opening or the least vertical dimension of the openings where there are multiple openings.

a. Volumetric airflow rates used to estimate required openable area are based on the following:
- Dry-air density of 0.075 lbda/ft^3 (1.2 kgda/m^3) at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C)
- Temperature difference between indoors and outdoors of 1.8°F (1°C)
- Gravity constant of 32.2 ft/s^2 (9.81 m/s^2)
- Window discharge coefficient of 0.6

Table 6-6 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

where
V_{bz} = breathing zone outdoor airflow, per Table 6-1.
A_z = zone floor area, the net occupiable floor area of the ventilation zone.
H_{vs} = vertical separation between the center of the top and bottom openings' free operable area; in case of multiple horizontally spaced pairs of openings, use shortest distance encountered.
A_s = openable area of smallest opening (top or bottom); in case of multiple horizontally spaced pairs of top-and-bottom openings, use aggregated areas.
A_l = openable area of largest opening (top or bottom); in case of multiple horizontally spaced pairs of top-and-bottom openings, use aggregated areas.

a. Volumetric airflow rates used to estimate required operable area are based on the following:
- Dry-air density of 0.075 lbda/ft^3 (1.2 kgda/m^3) at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C)
- Temperature difference between indoors and outdoors of 1.8°F (1°C)
- Gravity constant of 32.2 ft/s^2 (9.81 m/s^2)
- Window discharge coefficient of 0.6

6.5 Exhaust Ventilation. The Prescriptive Compliance Path or the Performance Compliance Path shall be used to meet the requirements of this section. Exhaust makeup air shall be permitted to be any combination of outdoor air, recirculated air, or transfer air.

6.5.1 Prescriptive Compliance Path. The design exhaust airflow shall be determined in accordance with the requirements in Tables 6-2 and 6-3.

Exception to 6.5.1: Laboratory spaces that comply with all requirements of ANSI/AIHA Z9.5.

6.5.1.1 Laboratory Hoods. Exhaust from laboratory hoods shall be Air Class 4 unless determined otherwise by the Environmental Health and Safety professional responsible to the owner or to the owner's designee.

6.5.1.2 Pressure Requirements. While the required exhaust systems are operating, the exhaust airflow of zones listed in Table 6-2 shall be larger than their respective supply airflow.

If zones listed in Table 6-2 are adjacent, the difference between the exhaust and the supply airflow shall be larger for the zone with the higher number class of air.

Exception to 6.5.1.2: Where airflow offset requirements are established by the Environmental Health and Safety professional responsible to the owner or owner's designee.

Informative Notes:

1. Exhaust systems are required for any occupancy category listed in Table 6-2.
2. Where intermittent operation is allowed in Table 6-2, exhaust equipment is intended to be operated when the space is in use.

6.5.2 Performance Compliance Path. The exhaust airflow shall be determined in accordance with the following subsections.

6.5.2.1 Contaminant Sources. Contaminants or mixtures of concern for purposes of the design shall be identified. For each contaminant or mixture of concern, indoor sources (occupants, materials, activities, and processes) and outdoor sources shall be identified, and the emission rate for each contaminant of concern from each source shall be determined.

6.5.2.2 Contaminant Concentration. For each contaminant of concern, a concentration limit and its corresponding exposure period and an appropriate reference to a cognizant authority shall be specified.

6.5.2.3 Monitoring and control systems shall be provided to automatically detect contaminant levels of concern and modulate exhaust airflow such that contaminant levels are maintained at not greater than the specified contaminant concentration limits.

6.6 Design Documentation Procedures. Design criteria and assumptions shall be documented and made available for operation of the system after installation. See Sections 4.3, 5.1.3, 5.18.4, 6.2.6.1.5, 6.3.6, and 6.4.4 regarding assumptions to be detailed in the documentation.

7. CONSTRUCTION AND SYSTEM START-UP

7.1 Construction Phase

7.1.1 Application. The requirements of this section apply to ventilation systems and the spaces they serve in new buildings and additions to or alterations in existing buildings.

7.1.2 Filters. Systems designed with particle filters shall not be operated without filters in place.

7.1.3 Protection of Materials. When recommended by the manufacturer, building materials shall be protected from rain and other sources of moisture by appropriate in-transit and on-site procedures. Porous materials with visible microbial growth shall not be installed. Nonporous materials with visible microbial growth shall be decontaminated.

7.1.4 Protection of Occupied Areas

7.1.4.1 Application. The requirements of Section 7.1.4 apply when construction requires a building permit and entails sanding, cutting, grinding, or other activities that generate significant amounts of airborne particles or procedures that generate significant amounts of gaseous contaminants.

7.1.4.2 Protective Measures. Measures shall be employed to reduce the migration of construction-generated contaminants to occupied areas.

Informative Note: Examples of acceptable measures include, but are not limited to, sealing the construction area using temporary walls or plastic sheathing, exhausting the construction area, or pressurizing contiguous occupied areas.

7.1.5 Air Duct System Construction. Air duct systems shall be constructed in accordance with the following standards, as applicable:

a. The following sections of ANSI/SMACNA 006, *HVAC Duct Construction Standards—Metal and Flexible*:

- Section S1.9 of Section 1.3.1, "Duct Construction and Installation Standards"
- Section 7.4, "Installation Standards for Rectangular Ducts Using Flexible Liner"
- Section 3.5, "Duct Installation Standards"
- Section 3.6, "Specification for Joining and Attaching Flexible Duct"
- Section 3.7, "Specification for Supporting Flexible Duct"