Chapter 8: Ventilation

Definitions of terms used in this chapter:

ACH stands for "air changes per hour." It is a measure of the ventilation rate of a room or whole structure. If half the volume of air in a room is exchanged for fresh air in one hour, then the room is being ventilated at the rate of 0.5 ACH.

CFM (or **cfm**) stands for "cubic feet per minute" and is used to measure the volume of ventilation air required or the capacity of a fan to move air.

Fan capacity ratings are given in terms of the volume of air (in cfm) that the fan can move against a given static pressure (in inches of water gauge). For prescriptive compliance, the VIAQ Code requires that all fan capacities be rated at .25 inches of water gauge.

Fan Capacity Rating Example

Static Pressure; Inches of Water	0.0	0.1	0.125	0.250	0.375
CFM	98	94	93	84	52

Static pressure is a measure of the resistance of air movement through a duct system. Often used as a basis for the design and sizing of duct systems. The static pressure of duct system is essentially a back pressure the fan must overcome to achieve air movement through the duct.

Water gauge (or *water column*) is a scale used to show pressure differences. When you suck on a straw in a glass of water, the water rises in the straw because the pressure in the straw is reduced. The height that the water rises is a measure of the pressure difference inside and outside the straw. The height of a 1 inch diameter column of water is frequently used to describe the static pressure in a duct system. The static pressure of a residential ventilation duct system might typically be .15 inches of water.

Mechanical Ventilation Systems Required

The Washington State Ventilation and Indoor Air Quality Code (VIAQ) requires new residential structures be provided with both source-specific and whole-house ventilation systems. There are two methods for meeting this code. Section 302 provides requirements for residential ventilation systems using performance or design qualification methods. Section 302 will most likely be used by mechanical engineers on complex projects and systems designed for continuous operation. Section 303 provides prescriptive direction for spot ventilation and four prescriptive options for intermittent operation whole house ventilation systems. This guide will only cover the Section 303 prescriptive paths.

Prescriptive Paths Include:

[V303.3] • Source Specific Ventilation (all prescriptive paths)

[V303.4.1] • Whole House Ventilation Using Exhaust Fans

• Whole House Ventilation Integrated with a Forced Air Heating System

[V303.4.2] • Whole House Ventilation Using a Supply Fan

[V303.4.4] • Whole House Ventilation Using a Heat Recovery Ventilation System

Source-Specific Ventilation

[V303.3] Source-specific or spot ventilation (see Figure 8-1) is required in specific rooms of the house, including:

- Kitchens
- Bathrooms
- Water closets
- Laundry room
- Indoor swimming pools or spas
- Other rooms where excess water vapors or cooking odors are produced

VIAQ Table 3-1 lists minimum ventilation rates for source-specific fans according to their location.

VIAQ Table 3-1

Source Specific Ventilation Capacity Requirements

Mode of Operation	Bathrooms	Kitchens
Intermittently Operating	50 cfm	100 cfm
Continuous Operation	20 cfm	25 cfm

[V303.3.2] VIAQ Table 3-1 shows two exhaust rates, expressed in Cubic Feet per Minute (CFM). A lower CFM rate is required for continuously operating systems than for intermittently operated systems. Fan CFM are to be rated at 0.25 inches water gauge. This rating is included on the manufacturers fan curve. The CFM rating on the fan carton is usually the rating at the lower pressure of 0.10 and does not necessarily meet the requirements of the VIAQ.

Source Specific Fan Controls

[V303.3.3] Switches, dehumidistats, or timers that are readily accessible to the occupant are required.

Source Specific Ventilation

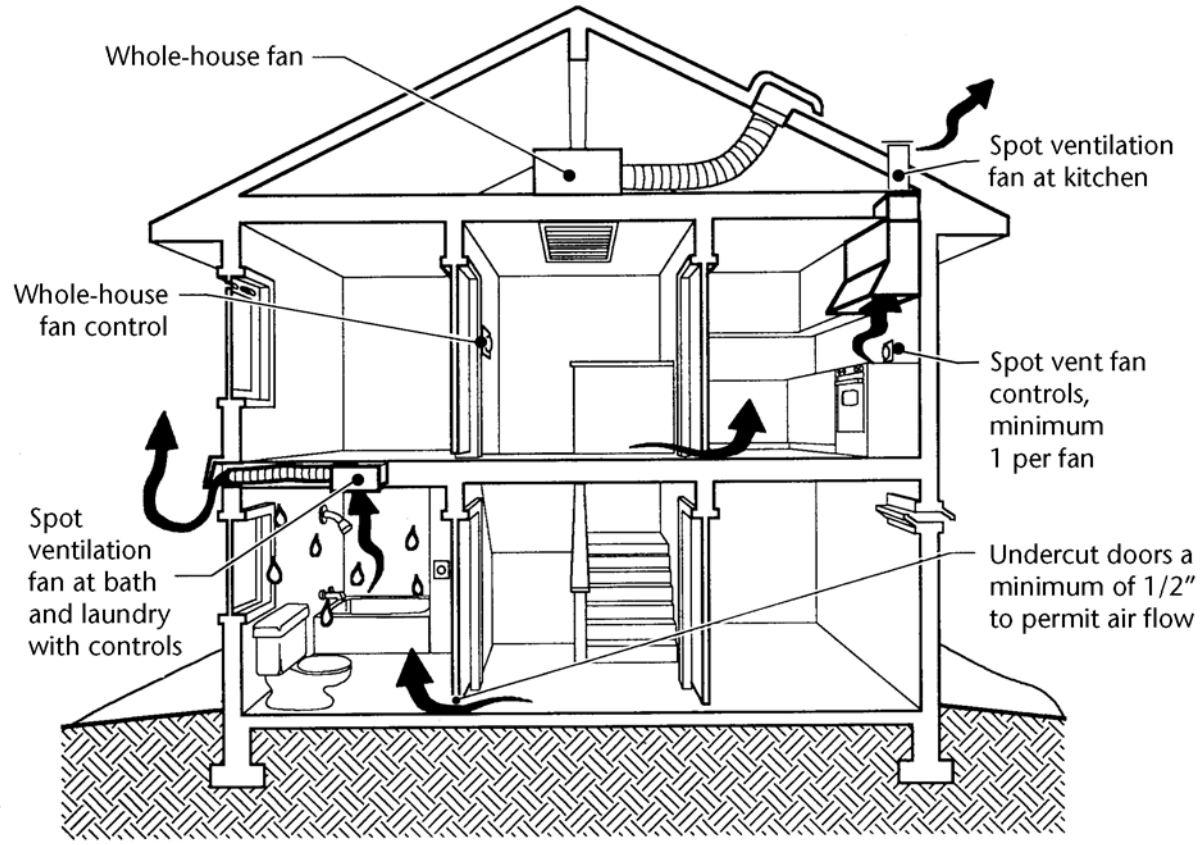


Figure 8-1

Source Specific Ventilation Ducts

[V303.3.4]

- Must be sized as per VIAQ Table 3-3.
- Must terminate outside the structure.
- Must be insulated to at least R-4 outside the heated space.
- Terminal elements must be screened and sized to be greater than or equal to the net free area of the duct.

Whole-House Ventilation Systems

[V303.4] VIAQ requires that in addition to source-specific ventilation fans, a whole-house ventilation system must be installed. Prescriptive whole-house ventilation system provides fresh air for the occupants on a timed basis. For continuously operating systems you must comply with section 302.

All Whole house ventilation systems must be capable of providing the minimum ventilation rate specified in VIAQ Table 3-2. The maximum CFM is the maximum rate allowed without a heat recovery ventilation system. Heat recovery ventilation systems do not need to comply with the maximum values.

VIAQ Table 3-2 lists prescriptive whole-house fan sizes based on conditioned floor area and number of bedrooms. The prescriptive approach requires no calculations.

VIAQ Table 3-2

Ventilation Rates (CFM) for all Group R Occupancies Four Stories

Floor Area, ft²	Bedrooms													
	2 or less		3		4		5		6		7		8*	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
<500	50	75	65	98	80	120	95	143	110	165	125	188	140	210
501-1000	55	83	70	105	85	128	100	150	115	173	130	195	145	218
1001-1500	60	90	75	113	90	135	105	158	120	180	135	203	150	225
1501-2000	65	98	80	120	95	143	110	165	125	188	140	210	155	233
2001-2500	70	105	85	128	100	150	115	173	130	195	145	218	160	240
2501-3000	75	113	90	135	105	158	120	180	135	203	150	225	165	248
3001-3500	80	120	95	143	110	165	125	188	140	210	155	233	170	255
3501-4000	85	128	100	150	115	173	130	195	145	218	160	240	175	263
4001-5000	95	143	110	165	125	188	140	210	155	233	170	255	185	278
5001-6000	105	158	120	180	135	203	150	225	165	248	180	270	195	293
6001-7000	115	173	130	195	145	218	160	240	175	263	190	285	205	308
7001-8000	125	188	140	210	155	233	170	255	185	278	200	300	215	323
8001-9000	135	203	150	225	165	248	180	270	195	293	210	315	225	338
>9000	145	218	160	240	175	263	190	285	205	308	220	330	235	353

**For residences that exceed 8 bedrooms, increase the minimum requirement listed for 8 bedrooms by an additional 15 CFM per bedroom. The maximum CFM is equal to 1.5 times the minimum.*

Fan Controls

[V302.3.2] All whole-house ventilation systems must have a control with the capability of continuous operation, manual and automatic control. Twenty-four hour timers with a manual switch are the most common control.

At the time of the final inspection, the ventilation system is required to be set for a minimum of 8 hours per day. It is recommended that the fan control setting alternate between 10 minutes on and 20 minutes off.

Fan controls must have a label that reads:

> **Whole-House Ventilation**
>
> **(See Operating instructions)**

Operating Instructions

[V101.4] Installers shall provide operating instructions. Sample operating instructions are posted at ***www.energy.wsu.edu/code/***

Whole-House Ventilation Using Exhaust Fans

[V303.4.1] In addition to the requirements listed above, whole-house ventilation using exhaust fans must comply with requirements for fan ratings, sound control, duct sizing, insulation, and outdoor air inlets (see Figure 8-2).

Fan Rating

[V303.4.1.1] VIAQ Table 3-2 shows two exhaust rates, expressed in Cubic Feet per Minute (CFM). Fan CFM must be rated at 0.25 inches water gauge. This rating is included on the manufacturers fan curve. The CFM rating on the fan carton is usually the rating at the lower pressure of 0.10 and does not meet the requirements of the VIAQ.

To identify products that meet the VIAQ standards, use the Home Ventilating Institute's Directory of Certified Products. The directory is certified monthly, and can be obtained from ***www.hvi.org***

Fan Noise

[V303.4.1.2] The whole-house fan must be quiet when operating. Fan noise is rated in "sones." The VIAQ allows a 1.5 sone maximum when the fan motor is installed within 4 feet of the interior pick-up grille. Remote-mounted fans (more than 4 feet from the pick-up grille) are exempt from the sound rating requirement (see Figures 8-3 and 8-4).

Whole-House Exhaust Ventilation

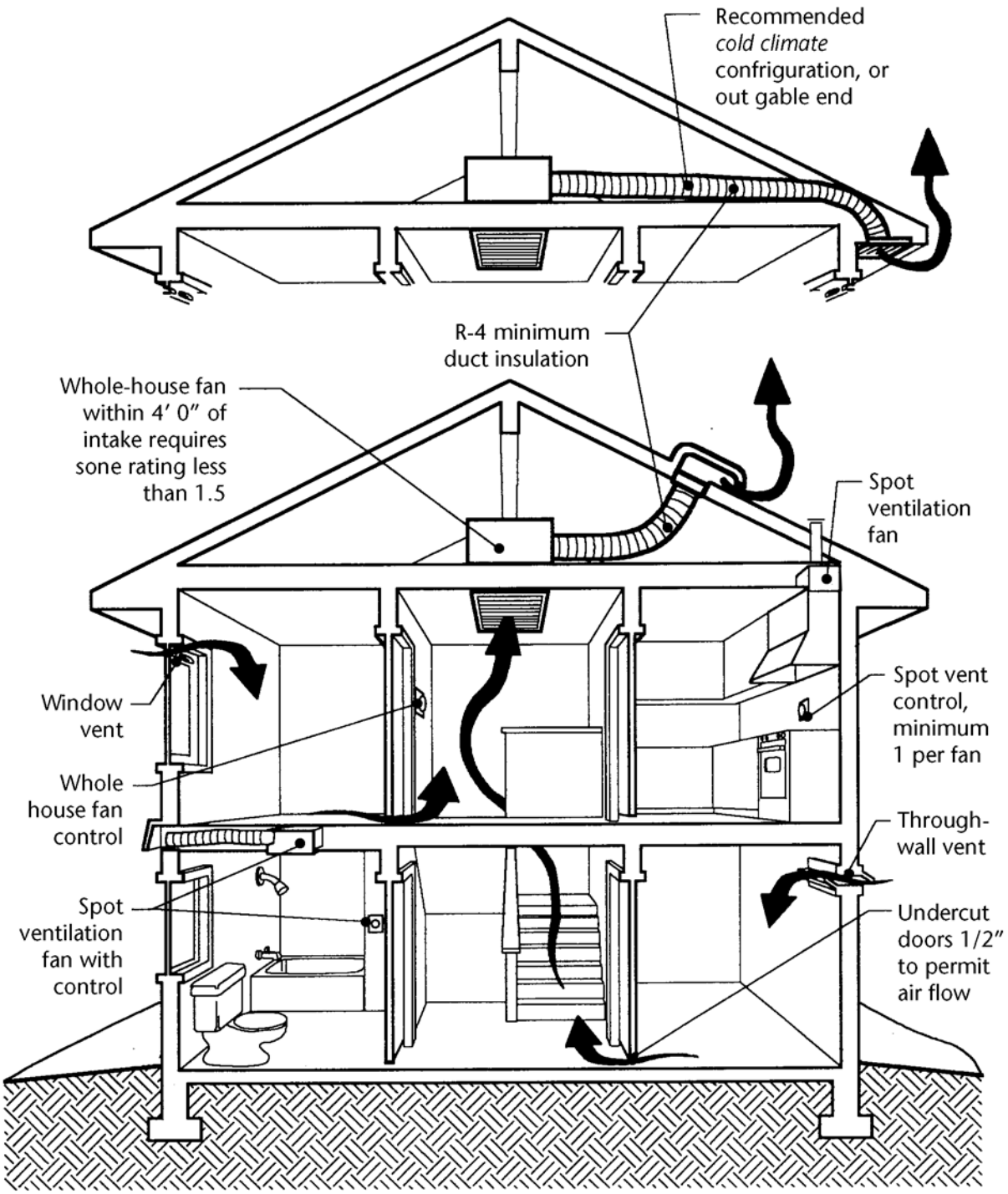
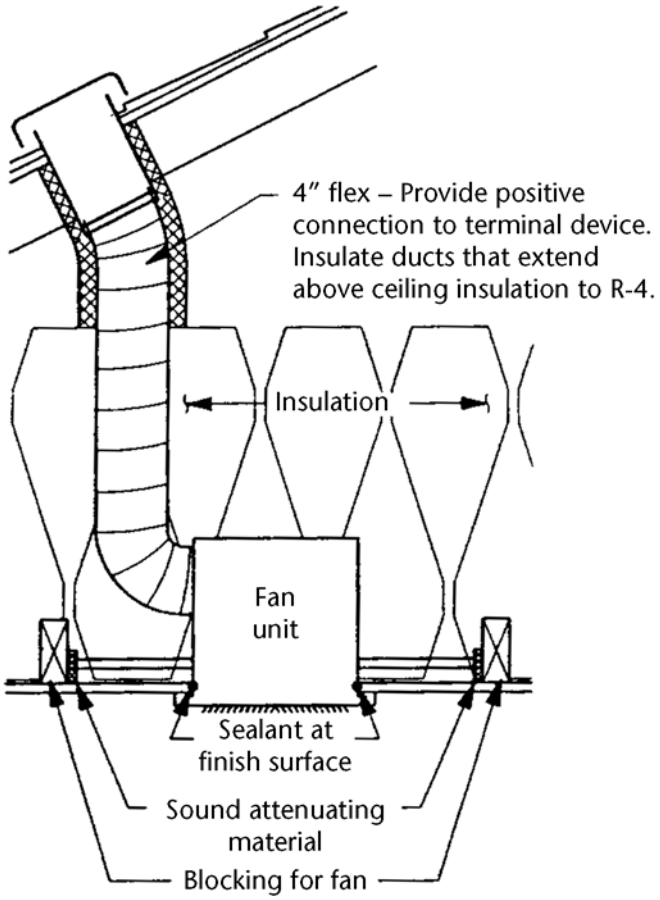


Figure 8-2

Sound Attenuation for Surface Mounted Fans



Note: Remember, the noise rating applies to whole-house ventilation fans, not source-specific fans.

Figure 8-3

Exhaust Fans

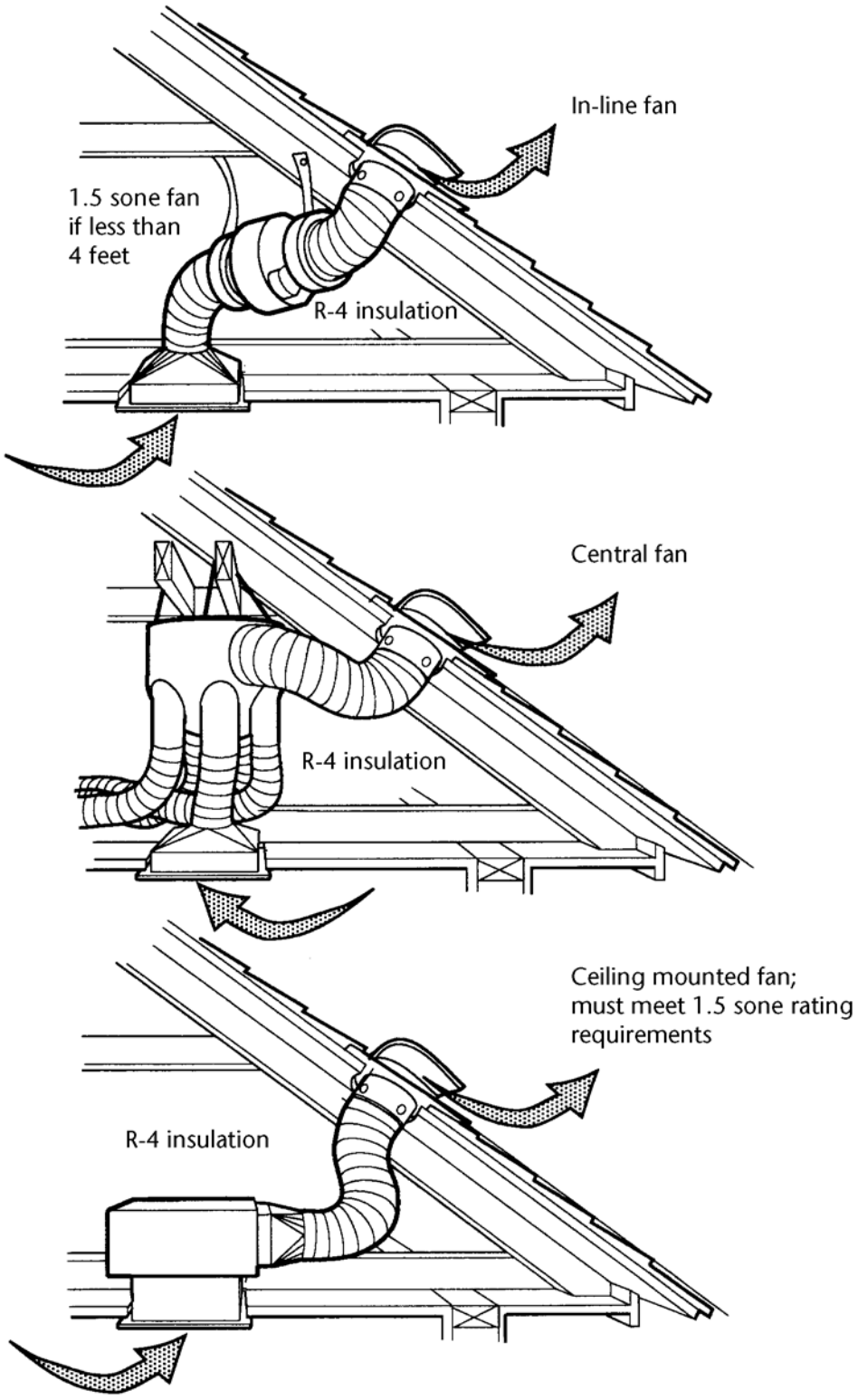


Figure 8-4

Exhaust Ducts

[V303.4.1.4] Prescriptively installed ventilation systems have specific ductwork requirements to ensure adequate air flow, minimize condensation, and exhaust moisture and pollutants to the outside. Exhaust ducts must:

- Be sized and installed according to VIAQ Table 3-3.
- Have a backdraft damper.
- Be insulated to R-4, if run in an unheated space.
- Terminate outside the building.

VIAQ Table 3-3 gives minimum duct sizes, length of run, and number of elbows (90° bends) based on the size of the fan. The table applies to smooth wall and flexible ducts.

VIAQ Table 3-3

Prescriptive Exhaust Duct Sizing

Fan Tested CFM @ 0.25" W.G.	Minimum Flex Diameter	Maximum Length Feet	Minimum Smooth Diameter	Maximum Length Feet	Maximum Elbows[1]
50	4 inch	25	4 inch	70	3
50	5 inch	90	5 inch	100	3
50	6 inch	No Limit	6 inch	No Limit	3
80	4 inch[2]	NA	4 inch	20	3
80	5 inch	15	5 inch	100	3
80	6 inch	90	6 inch	No Limit	3
100	5 inch[2]	NA	5 inch	50	3

1. For each additional elbow subtract 10 feet from length.
2. Flex ducts of this diameter are not permitted with fans of this size.

Outdoor Air Inlets

[V303.4.1.5] Each habitable space of the building must be provided with outdoor air. Outdoor air distribution is accomplished through the use of outdoor air inlets (see Figure 8-5). These openings must:

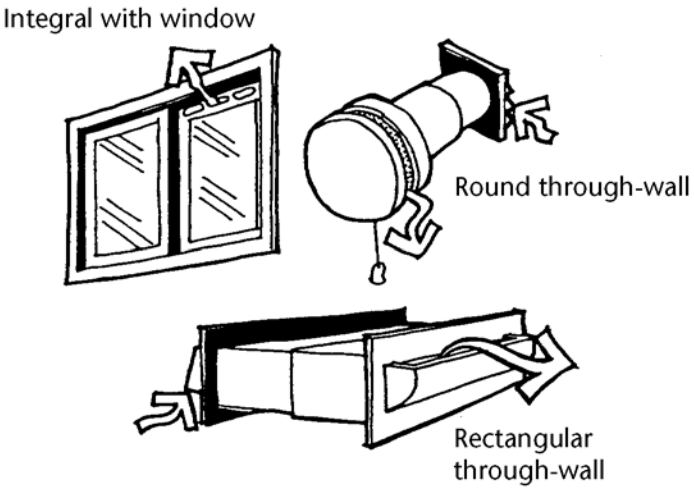
- Have controllable and secure openings.
- Be sleeved when installed through a wall or window frame.
- Have a minimum of 4 square inches of net free area or provide a minimum of 10 CFM @ 10 pascals tested by HVI.

If a door separates a fresh air inlet from an exhaust point, airflow can be ensured by either:

- Undercutting doors a minimum of 1/2-inch above the finish floor material.
- Or installing distribution ducts, grilles, or transoms.

Exception: Exhaust only ventilation systems do not require outdoor air inlets if the home has a ducted forced air heating system that communicates with all habitable rooms and the interior doors are undercut to a minimum of $^1/_2$ inch above the surface of the finish floor covering.

Outdoor Air Inlets



(See Figure 3-15 for installation detail.)
Double duty spot/whole-house ventilation system.

Figure 8-5

Types of Whole-House Ventilation Using Exhaust Fans

Double-Duty Spot/Whole-House: A common whole-house ventilation strategy is to combine a source-specific and whole-house ventilation fan. If possible, choose a bathroom or laundry room with a centrally located spot fan for the double-duty system. To prescriptively size the fan, use VIAQ Table 3-2. Don't add both spot CFM rates and whole-house rates together to determine the fan size. Use the larger of the two rates (see Figure 8-2 for a typical spot/whole-house system set-up).

This type of ventilation system includes:

- A 1.5 sone (or less) rated fan.
- Automatic and manual controls.

- Undercut doors (or other means) for air distribution.
- Proper duct sizing, length, and insulation (when outside the conditioned space).
- Fresh air supplied to habitable spaces.

Separate Spot/Whole-House: Another ventilation strategy is installing a dedicated whole-house fan in addition to the spot ventilation fans. An advantage to this system is the ability to centrally locate the whole-house fan and have it operate independently of the spot ventilators. This system may be a good choice in large houses where there are no centrally located spot fans. CFM rates, controls, air distribution, and duct requirements for the double-duty system also apply to this system.

Central Ducted Whole-House: A central ducted system is typically installed in the attic and ducted to individual areas of the house, bathrooms, kitchen, laundry room, or any room where ventilation is required or desired. Advantages to this system include: replacement of individual spot ventilation fans, quiet operation, and better overall ventilation of the structure. This system can also be operated continuously, which eliminates the need for controls.

[V303.4.2] **Integrated Ventilation System:** If a forced air heating system is installed, fresh air may be ducted into the system to meet ventilation requirements (see Figure 8-6). An integrated system consists of:

- A fresh air duct, connected to the furnace return plenum, sized per VIAQ Table 3-5.
- A damper allowing the proper amount of outside air to the system.
- A clock timer set to appropriate ventilation periods.

Integrated Ventilation

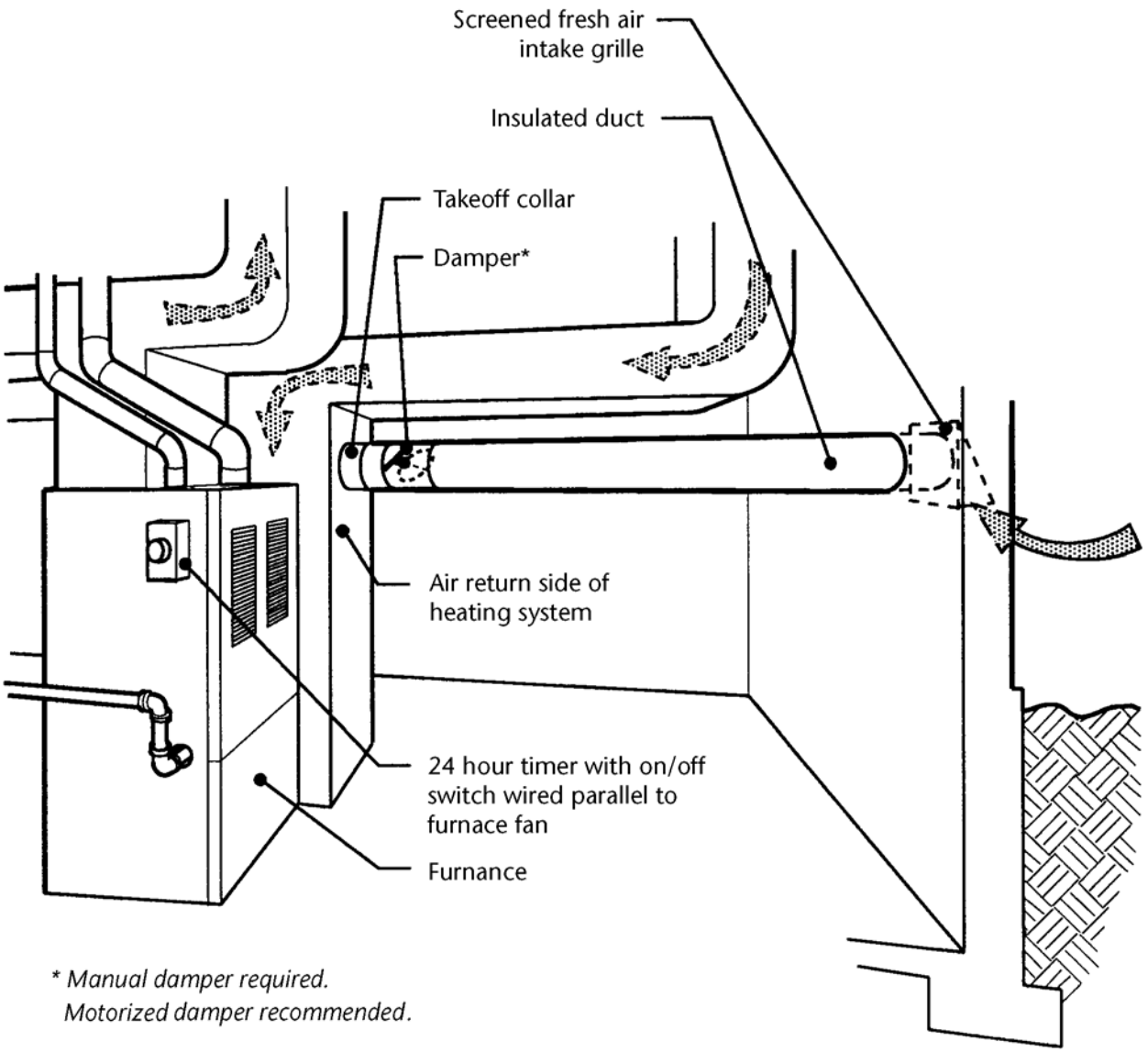


Figure 8-6

VIAQ Table 3-5

Prescriptive Integrated Forced Air Supply Duct Sizing

Required Flow (CFM) Per Table 3-2	Minimum Smooth Duct Diameter	Minimum Flexible Duct Diameter	Maximum Lenght [1]	Maximum Number of Elbows [2]
50-80	6 inches	7 inches	20 feet	3
80-125	7 inches	8 inches	20 feet	3
115-175	8 inches	10 inches	20 feet	3
170-240	9 inches	11 inches	20 feet	3

1. For lenghts over 20 feet, increase duct diameter 1 inch.
2. For elbows numbering more than 3, increase duct diameter 1 inch.

[V303.4.2.1] The Code requires that the fresh air duct be connected to a terminal element outside the building and run to the return plenum within 4 feet of the air handler (see Figure 8-7). Terminal elements must be screened and sized to be greater or equal to the net free area of the duct.

Terminal Element

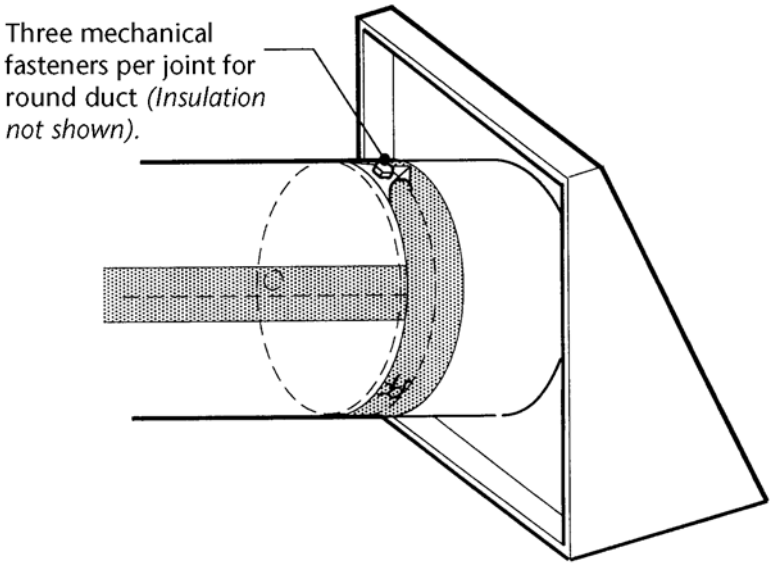


Figure 8-7

[V303.4.2.1] The duct must also be equipped with a damper and three choices are given:

- A motorized damper connected to the automatic ventilation control (see Figure 8-8).
- A manual damper installed and set to meet measured flow rates in VIAQ Table 3-2.
- Or an automatic or flow-regulated device.

Motorized Damper. When this damper is used, no testing of ventilation flow rates is required, as long as the prescriptive duct sizing VIAQ Table 3-5 requirements are met. Operation should be described in the required instruction manual.

Damper Meeting VIAQ Table 3-2 Flow Rates. This is a manual or volume type damper set to a certain CFM at the site. This system must either be tested or installed according to manufacturer's installation instructions based on site conditions. Operation should be described in the required instruction manual.

Automatic or Flow-Regulated Device. This type of damper refers to a constant airflow regulator, which limits airflow to a specified CFM. This device may be used when it is demonstrated, by field testing or calculation, that there is at least .07" water gauge negative pressure at the connection of the outside air duct and the return air plenum must be the same size as the connecting duct work or 8 inches in diameter, whichever is larger (see Figure 8-8).

Types of Dampers

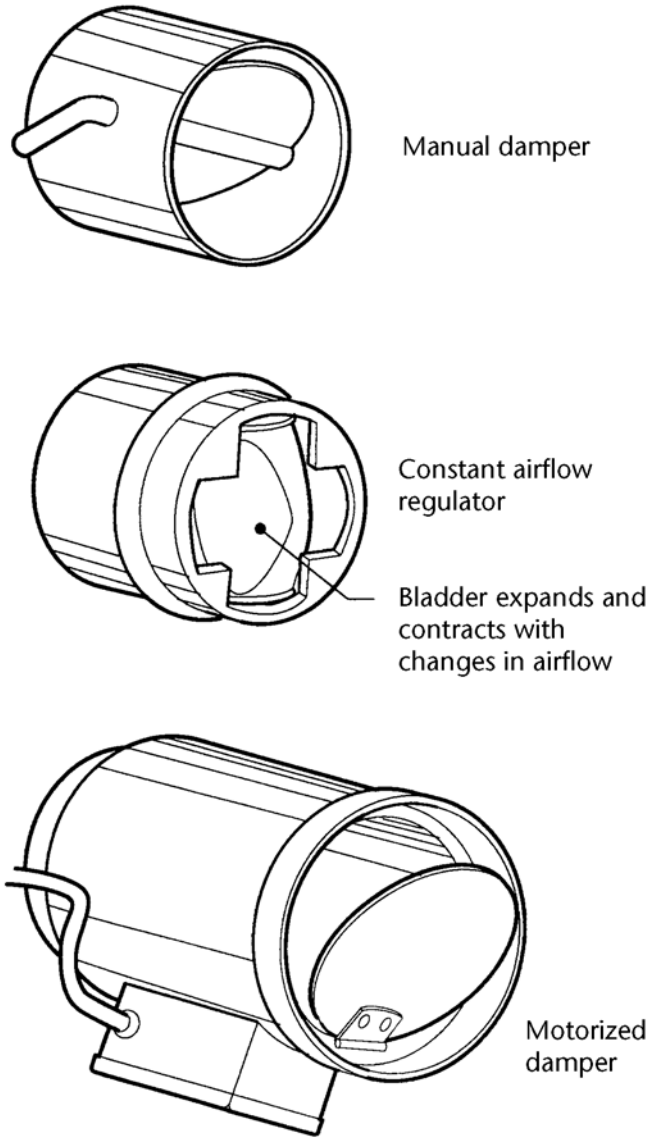


Figure 8-8

[V303.4.3]

Prescriptive Requirements for Ventilation Using a Supply Fan

[V303.4.3.1] This option provides fresh air to all habitable spaces through the use of a dedicated supply fan. This system can be installed in conjunction with a forced air heating system, or as a stand alone supply air system. In both cases, duct runs are required to each habitable room.

This system provides fresh air with a smaller and quieter fan than systems integrated with forced air heating/cooling fan. This reduces ventilation energy cost.

A Ventilation System Using a Supply Fan includes:

- A Dedicated Supply Fan.
- A fresh air duct, connected to the furnace supply plenum or a dedicated whole house ventilation duct. The duct shall be sized according to VIAQ Table 3-6.
- A clock timer set to operate only the dedicated supply fan for appropriate ventilation periods.
- A filter located in fresh air supply duct, fan housing or in the case of connection to the return duct, in the furnace.

VIAQ Table 3-6

Prescriptive Supply Fan Duct Sizing

Supply Fan Tested CFM at 0.40" WG		
Specified Volume from Table 3-2	**Minimum Smooth Duct Diameter**	**Minimum Flexible Duct Diameter**
50 – 90 CFM	4 inch	5 inch
90 - 150 CFM	5 inch	6 inch
150 - 250 CFM	6 inch	7 inch
250 - 400 CFM	7 inch	8 inch

The supply duct must also be equipped with a damper and three choices are given:

- A motorized damper connected to the automatic ventilation control (see Figure 8-8).
- A manual damper installed and set to meet measured flow rates in VIAQ Table 3-2. (see Figure 8-8).
- An automatic or flow-regulated device. (see Figure 8-8).

Motorized Damper. When this damper is used, no testing of ventilation flow rates is required, as long as the prescriptive duct sizing VIAQ Table 3-5 requirements are met. Operation should be described in the required instruction manual.

Damper Meeting VIAQ Table 3-2 Flow Rates. This is a manual or volume type damper set to a certain CFM at the site. This system must either be tested or installed according to manufacturer's installation instructions based on site conditions. Operation of this system is required as described in the instruction manual.

Automatic or Flow-Regulated Device. This type of damper refers to a constant airflow regulator, which limits airflow to a specified CFM. This device may be used when it is demonstrated, by field testing or calculation, that there is at least .07" water gauge negative pressure at the connection of the outside air duct and the return air plenum must be sized using VIAQ Table 3-6. Manufacturer's instructions should be part of the required instruction manual.

Example of Ventilation Using a Supply Fan

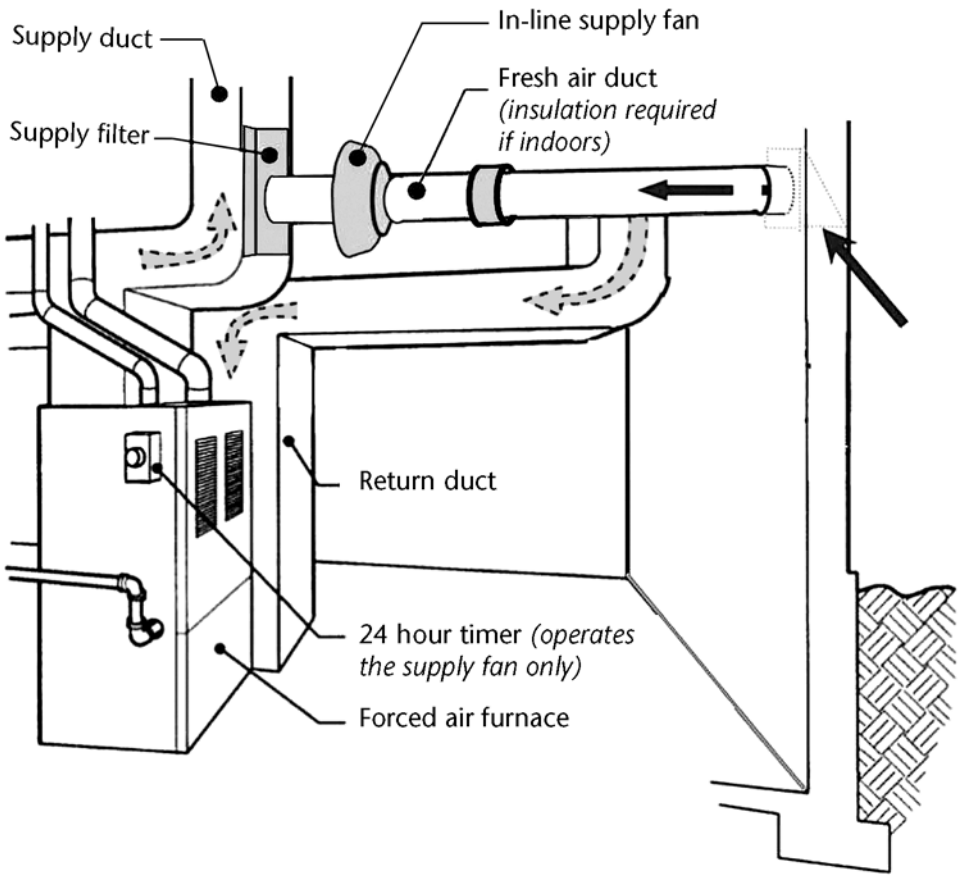


Figure 8-9

Heat Recovery Ventilation

[V303.4.4] Heat recovery systems are exempt from maximum flow rates and sound rating requirements. Either air-to-air heat exchangers or exhaust air heat pumps may be used.

Air-to-air heat exchangers must meet the following requirements:

- Minimum 6 inch ducts.
- Balancing dampers on the inlet and exhaust ducts.
- Flow grids installed on both supply and return ducts (for balancing).