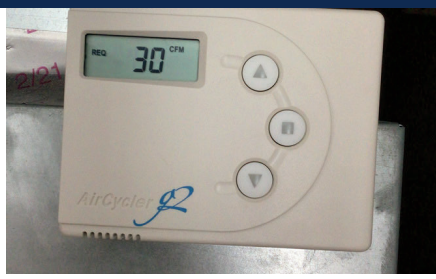
Ventilation Equipment Performance and Efficiency

2021 VRC/VECC Update Guide

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165



Required Testing of Ventilation Air Movement and Efficiency Specs for Equipment:

Summary: The Virginia Residential Code has required mechanical ventilation in new homes since the 2012 edition. Whole-house mechanical ventilation operates continuously or intermittently. Controls enable operation for not less than 25 percent (25%) of each four (4) hour segment. The intent of these systems is to provide ongoing delivery of controlled (ideally filtered) fresh air to the living space, expel stale air, dilute potential contaminants, and generally improve indoor environmental quality.

Now, the 2021 code requires that the actual airflow of that equipment be confirmed to meet the targeted amount. The energy code also stipulates energy efficiency standards for ventilation fans. These standards are more rigorous with the 2021 update.

Figure 1: Measuring exhaust fan airflow with a flow-meter box and manometer

Why: Whole-house ventilation is fundamentally concerned with the health and well-being of the occupants. Estimates show that Americans spend up to 90% of their time indoors. To maintain healthy indoor environments, homes need a controlled means of bringing in fresh air and removing stale air on a regular schedule to ensure some dilution of contaminants and dissipation of odors.[1] There are three basic strategies used to bring in whole-house ventilation: supply, exhaust, and energy recovery ventilation. Depending on the strategy and equipment utilized, fresh air systems consist of air intake (2021 VRC Section: M1602.1) and outlet vents, filters, ducts, controls, and fans (2021 VRC Section: N1103.6). The strategy and equipment should take into account exterior temperature variations, desired indoor and prevalent

Figure 2: Measuring exhaust fan airflow with a balometer

[1] https://basc.pnnl.gov/building-science-measures/dilution-whole-house-ventilation

outdoor humidity conditions, house configuration, and design objectives for the quantity and quality of air delivered.[2] The ability to test the airflow rate and the likelihood of achieving that rate should also be considered. Each system has its advantages and disadvantages, as listed in the table below.

Table 1: Pros and Cons of Various Mechanical Ventilation Systems[3]

Ventilation System Type	Advantages	Disadvantages
Exhaust	• Relatively inexpensive and simple to install • Works fine in cold climates	• Can draw pollutants into living space • Not appropriate for hot humid climates • Relies in part on random air leakage • Can increase heating and cooling costs • May require mixing of outdoor and indoor air to avoid drafts in cold weather • Can cause backdrafting in combustion appliances
Supply	• Relatively inexpensive and simple to install • Allows better control than exhaust systems • Minimizes pollutants from outside living space • Prevents backdrafting of combustion gases from fireplaces and appliances • Allows filtering of pollen and dust in outdoor air • Allows dehumidification of outdoor air • Works well in hot or mixed climates	• Can cause moisture problems in cold climates • Will not always temper or remove moisture from incoming air • Can increase heating and cooling costs • May require mixing of outdoor and indoor air to avoid drafts in cold weather • Can be difficult to achieve target ventilation rates without a supplemental supply fan
Balanced (Energy & Heat Recovery Ventilators)	• Reduces heating and cooling costs • Available as both small wall- or window-mounted models or central ventilation systems • Allows filtering of outdoor air • Cost-effective in climates with extreme winters or summers and high fuel costs	• Can cost more to install than other ventilation systems • May not be cost-effective in mild climates • May be difficult to find contractors with experience and expertise to install these systems • Require freeze and frost protection in cold climates • Require more maintenance than other ventilation systems

[2] https://basc.pnnl.gov/building-science-measures/properly-installed-whole-house-ventilation

[3] https://www.energy.gov/energysaver/weatherize/ventilation/whole-house-ventilation

Indoor air quality and ventilation needs vary greatly from home to home. Consider the following factors when choosing a specific design and equipment:

- **Occupancy:** A house or apartment with one occupant has very different ventilation needs compared to a household of five or more.
- **Occupant sensitivity:** Some people are more sensitive than others to contaminants. Pollutant levels that cause an asthma attack in one person may cause no problems for someone else.
- **Building characteristics:** The size, shape, design, and materials used in a building affect air leakage rates and pollutant sources.
- **Pollutant load:** Each house and apartment have different sources and levels of indoor pollutants.
- **Weather:** Temperature, wind, and humidity vary throughout the year in any single location and in different climate zones. Each of these weather factors affects indoor air quality.

Notes:

- *Providing fresh air by mechanical means uses energy – to operate fans and to heat/cool the incoming air. Optimize systems to avoid increasing relative humidity within the living space. Design for efficient operation and commission the fresh air system to ensure operation as designed.*
- *Best Practice: Select positive pressure or balanced ventilation systems in Virginia's mixed-humid climate. Avoid negative pressure/exhaust-only systems). See* ***www.buildingscience.com/documents/insights/bsi069-unintended-consequences-suck***

How: Fan airflow is measured using calibrated equipment such as a bolometer or a flow meter box with a manometer. Typically, measurements can be obtained by fitting these devices over the intake or exhaust point. With the fan turned on, they quickly report the CFMs moving through the system. Typically, the most challenging aspect is creating a good seal around the intake/exhaust point in order to isolate the airflow through the measuring device.

When intake/exhaust points are inaccessible or cannot be adequately sealed, it also is possible to measure airflow using a probe inserted into a duct through which only ventilation air travels. To get an accurate reading, this should be a straight section of smooth duct. Finally, some heat or energy recovery ventilators are outfitted in the factory with probe points where a technician can obtain actual airflow measurements.

Plan Review Focus: Per section N1101.5 (R103.2), whole-home mechanical ventilation equipment details should be noted on plans.

Figure 3: Image: Measuring whole-home ventilation air flow via probes in the energy recovery ventilator.

Whole-house Ventilation Equipment Examples:

Figure 4: Exhaust Ventilation Strategy – requires controls to ensure run times are met.

Figure 5: Common Supply Ventilation Systems – duct run from exterior to return plenum, automated damper, and controls

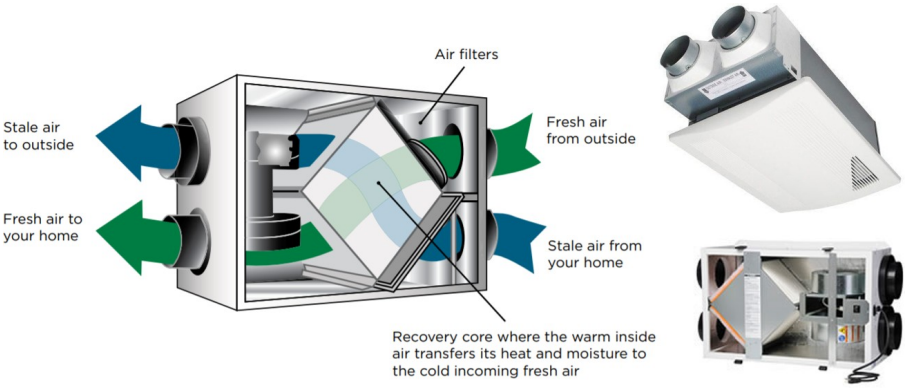


Figure 6: Balanced Ventilation Strategy utilizing heat or enthalpy recovery

Additional Resources:

- https://basc.pnnl.gov/resource-guides/testing-mechanical-ventilation-systems
- https://sws.nrel.gov/spec/6 Detailed installation guidelines

2021 VRC/VECC Code References:

M1505.4 Whole-house mechanical ventilation system. Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1505.4.1 through M1505.4.4.
M1505.4.1 System Design. The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.
M1505.4.2 System Controls. The whole-house mechanical system shall be provided with controls that enable manual override. Controls shall include text or a symbol indicating their function.

M1505.4.3 Mechanical ventilation rate. The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate not less than that determined in accordance with Table M1505.4.3(1) or not less than that determined by Equation 15-1.

Equation 15-1: Ventilation rate in cubic feet per minute = (0.01 x total square foot area of house) + [7.5 x (number of bedrooms + 1)]

Exceptions:

1. Ventilation rate credit. The minimum mechanical ventilation rate determined in accordance with Table M1505.4.3(1) or Equation 15-1 shall be reduced by 30 percent, provided that both of the following conditions apply:
   - 1.1. A ducted system supplies ventilation air directly to each bedroom and to one or more of the following rooms:
     - 1.1.1. Living room.
     - 1.1.2. Dining room.
     - 1.1.3. Kitchen.
   - 1.2. The whole-house ventilation system is a balanced ventilation system.
2. Programmed intermittent operation. The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25 percent of each 4-hour segment and the ventilation rate prescribed in Table M1505.4.3(1), by Equation 15-1 or by Exception 1 is multiplied by the factor determined in accordance with Table M1505.4.3(2).

N1103.6 (R403.6) Mechanical ventilation. The buildings complying with Section N1102.4.1 shall be provided with ventilation that complies with the requirements of Section M1505 or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

N1103.6.1 (R403.6.1) Heat or energy recovery ventilation. Dwelling units shall be provided with a heat recovery or energy recovery ventilation system in Climate Zones 7 and 8. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

N1103.6.2 (R403.6.2) Whole-dwelling mechanical ventilation system fan efficacy. Fans used to provide whole-dwelling mechanical ventilation shall meet the efficacy requirements of Table N1103.6.2 at one or more rating points. Fans shall be tested in accordance with HVI 916 and listed. The airflow shall be reported in the product listing or on the label. Fan efficacy shall be reported in the product listing or shall be derived from the input power and airflow values reported in the product listing or on the label. Fan efficacy for fully ducted HRV, ERC, balanced and in-line fans shall be determined at a static pressure of not less than 0.2 inch water column (49.82 Pa). Fan efficacy for ducted range hoods, bathroom, and utility room fans shall be determined at a static pressure of not less than 0.1 inch water column (24.91 Pa).

TABLE N1103.6.2 (R403.6.2) WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM FAN EFFICACYa

SYSTEM TYPE	AIRFLOW RATE (CFM)	MINIMUM EFFICACY (CFM/WATT)
HRV, ERV; or balanced	Any	1.2 cfm/watt
Range hood	Any	2.8 cfm/watt
In-line supply or exhaust fan	Any	3.8 cfm/watt
Other exhaust fan	< 90	2.8 cfm/watt
	≥ 90	3.5 cfm/watt
Air-handler that is integrated to tested and *listed* HVAC equipment	Any	1.2 cfm/watt

For SI: 1 cubic foot per minute = 28.3 L/min.

a. Design outdoor airflow rate/watts of fan used.

N1103.6.3 (R403.6.3) Testing. Mechanical ventilation systems shall be tested and verified to provide the minimum ventilation flow rates required by Section N1103.6. Testing shall be performed according to the ventilation equipment manufacturer's instructions, or by using a flow hood or box, flow grid, or other airflow measuring device at the mechanical ventilation fan's inlet terminals or grilles, outlet terminals or grilles, or in the connected ventilation ducts. Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Exception: Kitchen range hoods that are ducted to the outside with 6-inch (152 mm) or larger duct and not more than one 90-degree (1.57 rad) elbow or equivalent in the duct run.

Definitions:

AUTOMATIC. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature or mechanical configuration (see "Manual").

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the conditioned space.

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and that is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

DWELLING UNIT ENCLOSURE AREA. The sum of the area of ceiling, floors, and walls separating a dwelling unit's conditioned space from the exterior or from adjacent conditioned or unconditioned spaces. Wall height shall be measured from the finished floor of the dwelling unit to the underside of the floor above.

INFILTRATION. The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, approved agency or other organization concerned with product evaluation that maintains periodic inspection of the production of such labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

MANUAL. Capable of being operated by personal intervention (see "Automatic").

OCCUPANT SENSOR CONTROL. An automatic control device that detects the presence or absence of people within an area and causes lighting, equipment or appliances to be regulated accordingly.

VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

VENTILATION AIR. That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

VISIBLE TRANSMITTANCE (VT). The ratio of visible light entering the space through the fenestration product assembly to the incident visible light. Visible Transmittance includes the effects of glazing material and frame and is expressed as a number between 0 and 1.

WHOLE HOUSE MECHANICAL VENTILATION SYSTEM. An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air with outdoor air when operating continuously or through a programmed intermittent schedule to satisfy the whole house ventilation rates.

ZONE. A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.