BALANCED MECHANICAL VENTILATION

A building's mechanical ventilation system is an important component of the building's air quality and durability.

The purpose of a balanced mechanical ventilation system is to, in a controlled manner, introduce and distribute fresh, filtered outdoor air throughout the home and to exhaust the stale indoor air to the exterior. A balanced mechanical ventilation systems gives you the most control on where air both enters and leaves the house.

Balanced mechanical ventilation systems are required for all residential buildings, including single family homes, twin homes, townhouses and Group R-2, R-3 and R-4 buildings three stories or less in height.

Balanced mechanical ventilation systems are also required to meet the applicable requirements of the 2015 Minnesota Mechanical Code. Pay particular attention to the following sections:

- 501.3 Exhaust discharge
- 501.4 Pressure equalization *(protection against excessive depressurization)*

RESOURCES

2015 Minnesota Residential Energy Code
2015 Minnesota Mechanical and Fuel Gas Code *(link pending ICC update)*
Green Building Advisor: Balanced Ventilation
Building Science Corp: Ventilation Guide
Building Science Corp: Balanced Ventilation Systems (HRVs and ERVs)
Lawrence Berkley National Lab: Health and Economic Impacts of Building Ventilation
Home Innovation Research Labs: Whole-House Mechanical Ventilation

DEFINITIONS

AIR CIRCULATION, FORCED. A means of providing space conditioning using movement of air through ducts or plenums by mechanical means.

AIR, COMBUSTION. The air provided to fuel-burning equipment including air for fuel combustion, draft hood dilution and ventilation of the equipment enclosure.

AIR, EXHAUST. Air discharged from any space to the outside by the residential ventilation system.

AIR, MAKEUP. Air that is provided to replace air being exhausted.

AIR, OUTDOOR. The air that is taken from the external atmosphere, and therefore not previously circulated through the HVAC system or the conditioned space.

AIR, VENTILATION. 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.

BALANCED SYSTEM. A ventilation system in which the air intake is within ten percent of the exhaust output.

CONDITIONED SPACE. An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent *conditioned space*.

CUBIC FEET PER MINUTE (CFM). The quantity of air moved in one minute. A measurement typically applied to ventilation equipment.

ENERGY RECOVERY VENTILATOR (ERV). A device or combination of devices applied to transfer energy and moisture from the exhaust air stream for use within the dwelling.

HABITABLE SPACE. A space in a building for living, sleeping, eating or cooking. Bathrooms, toilet rooms, closets, halls, storage or utility spaces and similar areas are not considered habitable spaces.

HEAT RECOVERY VENTILATOR (HRV). A device or combination of devices applied to transfer energy from the exhaust air stream for use within the dwelling.

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

RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings and multiple single family dwellings (townhouses) as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.

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

CALCULATING VENTILATION RATES

The rate of ventilation is based on the number of bedrooms and square footage of conditioned space. Conditioned space is for mechanical purposes, an area, room or space being heated or cooled by any equipment or appliance. The mechanical ventilation system design capacity must be within +/- 10% of the calculated ventilation rate.

Total Ventilation Rate is based on Table R403.5.2 or the following equation:

> ***Total ventilation rate (cfm) = (0.02 x square feet of conditioned space)+ [15 x (number of bedrooms+ 1)]***

Table R403.5.2

Conditioned space[1] (sq. ft.)	NUMBER OF BEDROOMS					
	1	2	3	4	5	6
	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous
1000-1500	60/40	75/40	90/45	105/53	120/60	135/68
1501-2000	70/40	85/43	100/50	115/58	130/65	145/73
2001-2500	80/40	95/48	110/55	125/63	140/70	155/78
2501-3000	90/45	105/53	120/60	135/68	150/75	165/83
3001-3500	100/50	115/58	130/65	145/73	160/80	175/88
3501-4000	110/55	125/63	140/70	155/78	170/85	185/93
4001-4500	120/60	135/68	150/75	165/83	180/90	195/98
4501-5000	130/65	145/73	160/80	175/88	190/95	205/103
5001-5500	140/70	155/78	170/85	185/93	200/100	215/108
5501-6000[2]	150/75	165/83	180/90	195/98	210/105	225/113

1. Conditioned space includes the basement and conditioned crawl spaces.
2. If conditioned space exceeds 6000 sq. ft. or there are more than 6 bedrooms, use Equation R403.5.2.

Total ventilation rate is the required outdoor airflow rate average for each 1-hour period and can be considered to be the installed system design capacity.

Continuous ventilation rate is 1/2 of the total ventilation rate and cannot be less than 40 cfm. The Continuous ventilation rate provides a continuous average cfm flow rate for every 1-hour period or may be programmed to an intermittent schedule to satisfy the ventilation rate.

Intermittent ventilation rate is the difference between the total ventilation rate and the continuous ventilation rate.

CALCULATING VENTILATION RATES EXAMPLE 1:

3600 square feet of conditioned space
4 bedrooms
.02 x sq. ft. of conditioned space = .02 x 3600 = 72 cfm
Number of bedrooms 4 + 1 = 5
15 x 5 = 75 cfm
Total ventilation rate = 72 + 75 = 147 cfm
System design capacity (+/- 10%) = within 132.3 to 161.7 cfm
Continuous ventilation rate = 147 ÷ 2 = 73.5 cfm
Intermittent ventilation rate = 147 - 73.5 = 73.5 cfm

or per table below

Table R403.5.2

Conditioned space[1] (sq. ft.)	NUMBER OF BEDROOMS					
	1	2	3	4	5	6
	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous
1000-1500	60/40	75/40	90/45	105/53	120/60	135/68
1501-2000	70/40	85/43	100/50	115/58	130/65	145/73
2001-2500	80/40	95/48	110/55	125/63	140/70	155/78
2501-3000	90/45	105/53	120/60	135/68	150/75	165/83
3001-3500	100/50	115/58	130/65	145/73	160/80	175/88
3501-4000	110/55	125/63	140/70	155/78	170/85	185/93
4001-4500	120/60	135/68	150/75	165/83	180/90	195/98
4501-5000	130/65	145/73	160/80	175/88	190/95	205/103
5001-5500	140/70	155/78	170/85	185/93	200/100	215/108
5501-6000[2]	150/75	165/83	180/90	195/98	210/105	225/113

1. Conditioned space includes the basement and conditioned crawl spaces.
2. If conditioned space exceeds 6000 sq. ft. or there are more than 6 bedrooms, use Equation R403.5.2.

Total ventilation rate = 155 cfm
System design capacity (+/- 10%) = within 139.5 to 170.5 cfm
Continuous ventilation rate = 78 cfm
Intermittent ventilation rate = 155 - 78 = 77 cfm

CALCULATING VENTILATION RATES EXAMPLE 2:

2300 square feet of conditioned space
2 bedrooms
.02 x sq. ft. of conditioned space = .02 x 2300 = 46 cfm
Number of bedrooms 2 + 1 = 3
15 x 3 = 45 cfm
Total ventilation rate = 46 + 45 = 91 cfm
System design capacity (+/- 10%) = within 81.9 to 100.1 cfm
Continuous ventilation rate = 91÷ 2 = 45.5 cfm
Intermittent ventilation rate = 91 - 45.5 = 45.5 cfm

or per table below

Table R403.5.2

Conditioned space[1] (sq. ft.)	NUMBER OF BEDROOMS					
	1	2	3	4	5	6
	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous	Total/ Continuous
1000-1500	60/40	75/40	90/45	105/53	120/60	135/68
1501-2000	70/40	85/43	100/50	115/58	130/65	145/73
2001-2500	80/40	95/48	110/55	125/63	140/70	155/78
2501-3000	90/45	105/53	120/60	135/68	150/75	165/83
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5001-5500	140/70	155/78	170/85	185/93	200/100	215/108
5501-6000[2]	150/75	165/83	180/90	195/98	210/105	225/113

1. Conditioned space includes the basement and conditioned crawl spaces.
2. If conditioned space exceeds 6000 sq. ft. or there are more than 6 bedrooms, use Equation R403.5.2.

Total ventilation rate = 95 cfm
System design capacity (+/- 10%) = within 85.5 to 104.5 cfm
Continuous ventilation rate = 48 cfm
Intermittent ventilation rate = 95 - 48 = 47 cfm

BALANCED VENTILATION CRITERIA

Balanced ventilation systems can be configured in different ways, however, all systems must meet, at least, the following criteria: *(Kitchen and bath fans that are not included as part of the mechanical ventilation system are exempt from these requirements.)*

- ☐ Ventilation system is within +/- 10% of the system's design capacity
- ☐ Meet the calculated continuous and total mechanical ventilation rates
- ☐ Provide a minimum of 1 supply duct and 1 return duct to all conditioned levels
  - ☐ Unfinished basement supply and return ducts must be separated by 1/2 the diagonal dimension of the basement
- ☐ Surface mounted exhaust fans used to meet the intermittent ventilation rate are required to have a maximum 1.0 sone per HVI Standard 915
- ☐ Fans are required to meet the efficiency requirements of Table R403.5.1 *(see table below)*
- ☐ Fans are to be capable of delivering the designed air flow at the point of air discharge or intake according to HVI Standard 916
- ☐ Fans are designed and certified by the equipment manufacturer to be capable of continuous operation at the maximum fan-rated cfm
- ☐ System is installed to minimize noise and vibration per manufacturer's instructions. If there are no instructions, rubber grommets and flexible straps are required when connecting fans and HRV/ERV to the building structure
- ☐ Isolation duct connectors are required to mitigate noise transmission
- ☐ System controls are readily accessible and labeled to indicate the control's function
- ☐ Outdoor air is delivered to each habitable space
- ☐ Outdoor air intakes and exhausts have automatic or gravity dampers that close when the ventilation system is not operating
- ☐ Outdoor air intake is verified to be within +/- 10% of the exhaust output
- ☐ Outdoor air is filtered at a minimum of MERV 4
- ☐ Outdoor air intake is to be located:
  - ☐ 12 inches above grade level
  - ☐ 10 feet from contaminant sources
  - ☐ 3 feet below contaminant sources, that are within 10 feet

  (Combination air intake and exhaust hoods may be approved by the building official)
- ☐ Outdoor air intake openings are protected with corrosion-resistant screen between 1/4 - 1/2 inch mesh
- ☐ Outdoor air intake and exhaust outlets are labeled on the buildings exterior
- ☐ All mechanical ventilation system airflows greater than 30 cfm need to be tested and verified
- ☐ Operation and maintenance instructions are provided and accessible

Table R403.5.1

Fan Location	Air Flow Rate Minimum (CFM)	Minimum Efficacy (CFM/Watt)	Air Flow Rate Maximum (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

The ventilation strategy you choose will impact the additional criteria you will need to include in addition to the above.

BALANCED VENTILATION STRATEGIES

Balanced ventilation strategies include: HRV/ERV or site-built solutions with multiple fans. The outdoor air can be distributed and circulated by the forced air circulation system or by independent ducts.

FORCED AIR CIRCULATION SYSTEMS

Many ventilation system designs distribute the outdoor air to the habitable spaces with the forced air system. When outdoor air is connected to a forced air circulation system, the system will also need to meet the following criteria:

- ☐ Controls will allow the forced air system to provide an average circulation flow rate each hour of not less than 0.075 cfm per square foot of conditioned floor area.
- ☐ The mixed air temperature cannot be less than the heating equipment manufacturer's installation instructions.
- ☐ The outdoor air can be supplied directly to the forced air circulation system, or the exhaust air can be drawn directly from the forced air circulation system, but not both. The air duct will be installed according to the manufacturer's installation instructions.
  - ☐ Both outdoor air and exhaust air may be connected to the forced air circulation system only if controls are installed to operate the forced air circulation system when the mechanical ventilation system is operating or other means are provided to prevent short circuiting of ventilation air in accordance with the manufacturer's recommendations.

HRV/ERV SYSTEMS

The Heat Recovery (HRV) and Energy Recovery (ERV) systems transfer heat from exhaust air expelled from the house to the fresh air entering the house, without mixing the stale air and the fresh air.

HRV/ERV systems can be independently ducted or ducted to the forced air circulation system.

HRV/ERV systems will also need to meet these additional criteria:

- ☐ Meet either the requirements of HVI Standard 920, 72 hours minus 13°F cold weather test; or certified by a registered professional engineer and installed per manufacturer's installation instructions.
- ☐ Meet the rated design capacity of the continuous ventilation rate under low capacity and the total ventilation rate under high capacity.
  - ☐ HRV/ERV systems may include separate exhaust fans to meet the intermittent ventilation rate.

SEPARATE SUPPLY AND EXHAUST FANS

These systems depend greatly on the quality of the design, installation, control interface and testing to assure proper operation and resident comfort. These systems are also typically ducted to the forced-air circulation system.

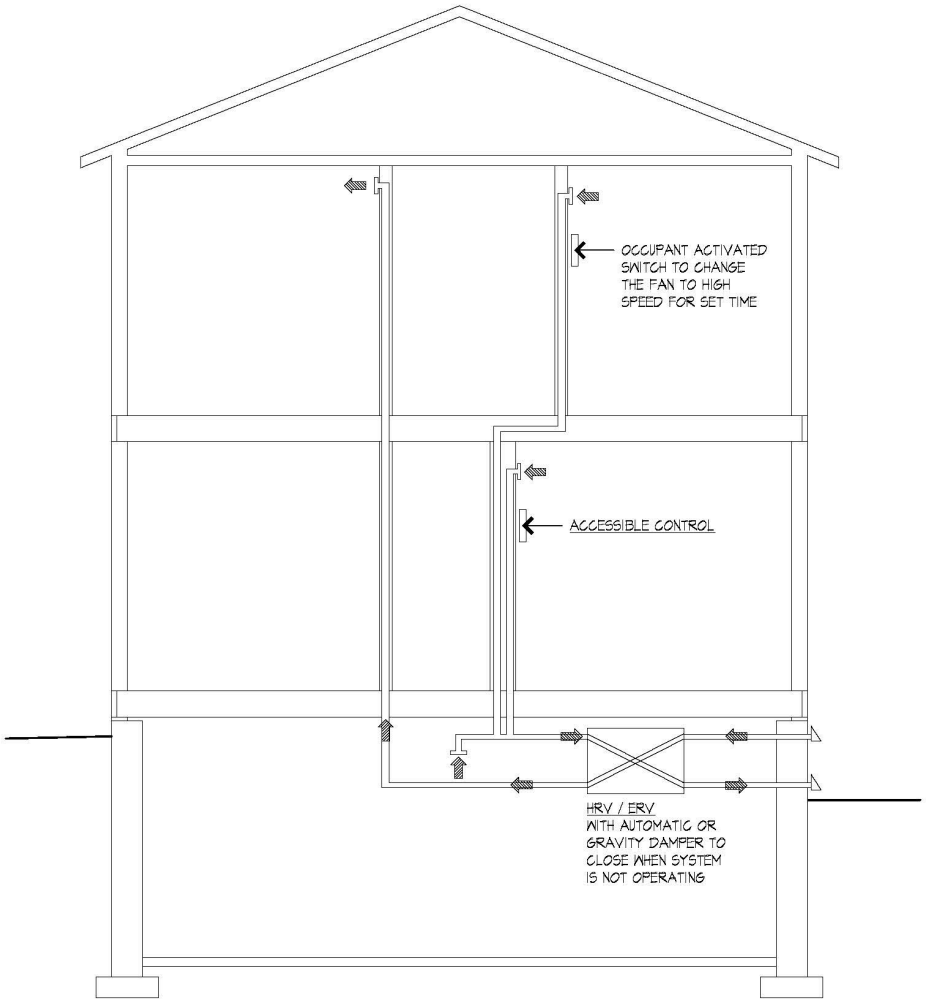
The system design should be reviewed with the local Building Official to determine if it meets the requirements of the code for a balanced ventilation system.

BALANCED VENTILATION STRATEGIES

Balanced ventilation systems can be configured in a variety of ways to meet the Minnesota code requirements, the following illustrations and descriptions provide details on some of the most common balanced ventilation strategies used by contractors in Minnesota, but certainly not the only ones.

HRV/ERV - INDEPENDENTLY DUCTED

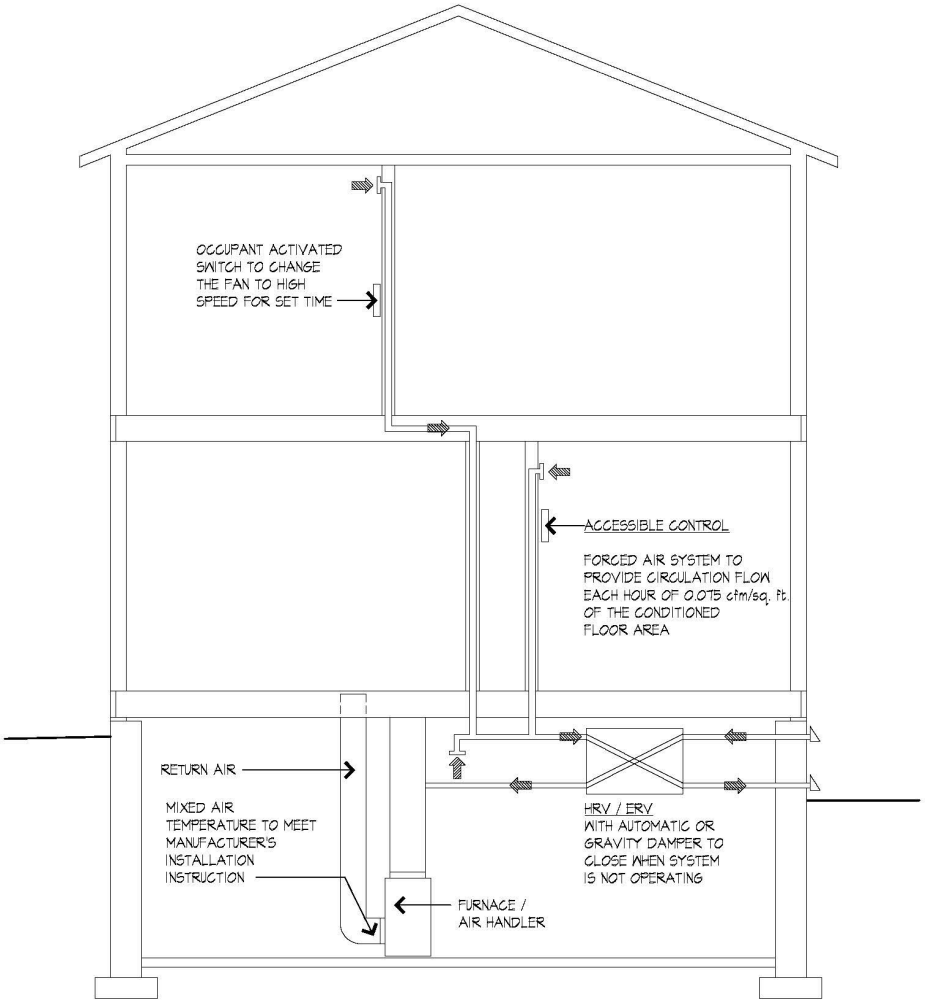
- Typically installed in homes without forced air systems (i.e. hydronic heating)
- Air is typically exhausted from basement, common rooms, bathrooms, kitchen, etc.
- Tempered fresh air is supplied to bedrooms and living areas
- Dampers close the openings to outside when the ventilation fan is off
- Control for automatic cycling operation if not designed to operate continuously



SOURCE POINT VENTILATION
WITH FULLY DUCTED FRESH AIR

HRV/ERV - FORCED AIR CIRCULATION SYSTEM WITH SOURCE POINT VENTILATION DUCT DESIGN

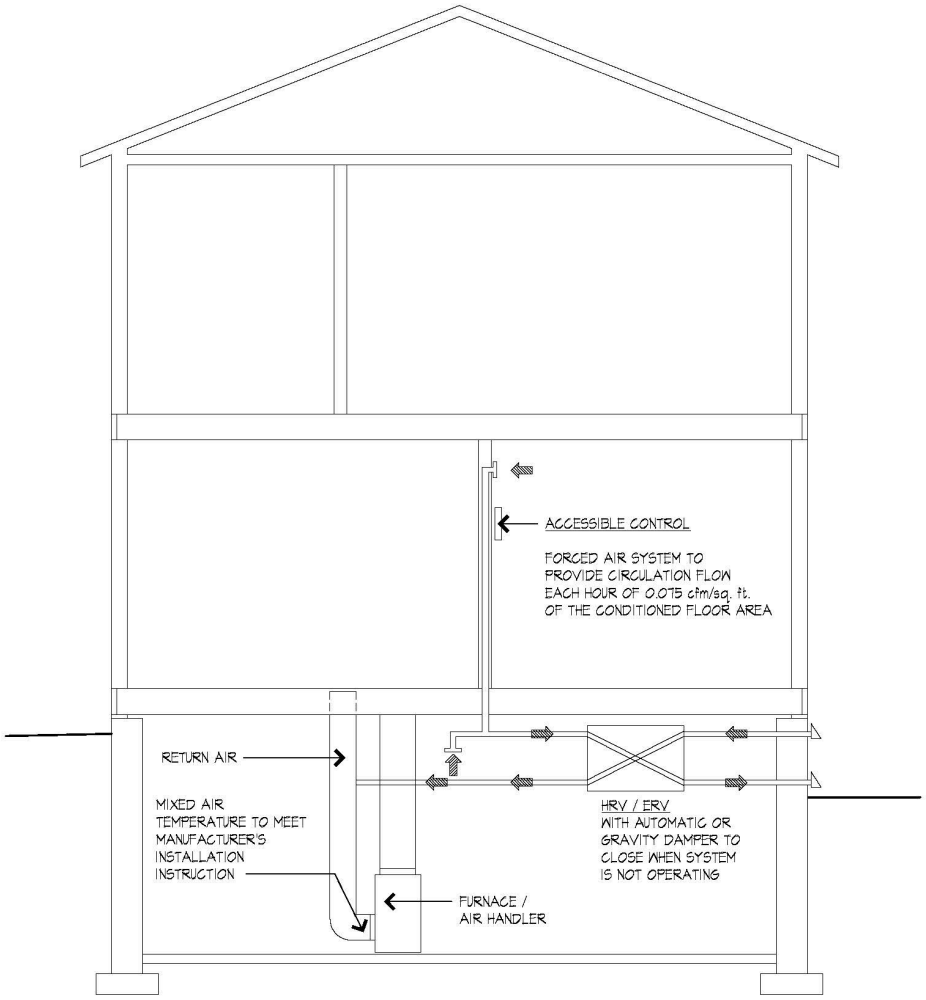
- Air is typically exhausted from the basement, bathrooms, kitchen and laundry room
- Tempered fresh air is supplied to the cold air return or the supply duct of the furnace
- Dampers close the openings to outside when the ventilation fan is off
- Control for automatic cycling operation if not designed to operate continuously



SOURCE POINT VENTILATION

HRV/ERV - FORCED AIR CIRCULATION SYSTEM WITH GENERAL VENTILATION DUCT DESIGN

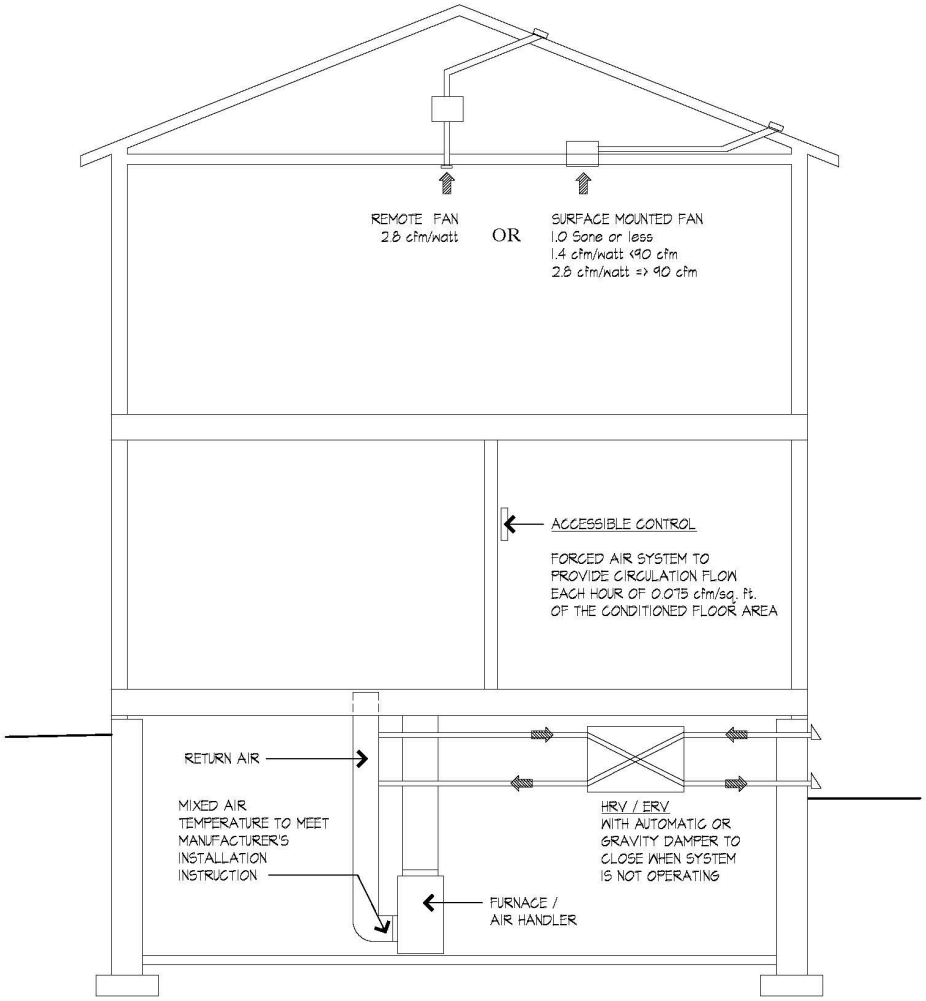
- Air is typically exhausted from the basement and a common area in the home.
- Tempered fresh air is supplied to the cold air return or the supply duct of the furnace
- Dampers close the openings to outside when the ventilation fan is off
- Control for automatic cycling operation if not designed to operate continuously



GENERAL VENTILATION
(One exhaust per level)

HRV/ERV - FORCED AIR CIRCULATION SYSTEM WITH VOLUME VENTILATION (RETURN/RETURN) DUCT DESIGN

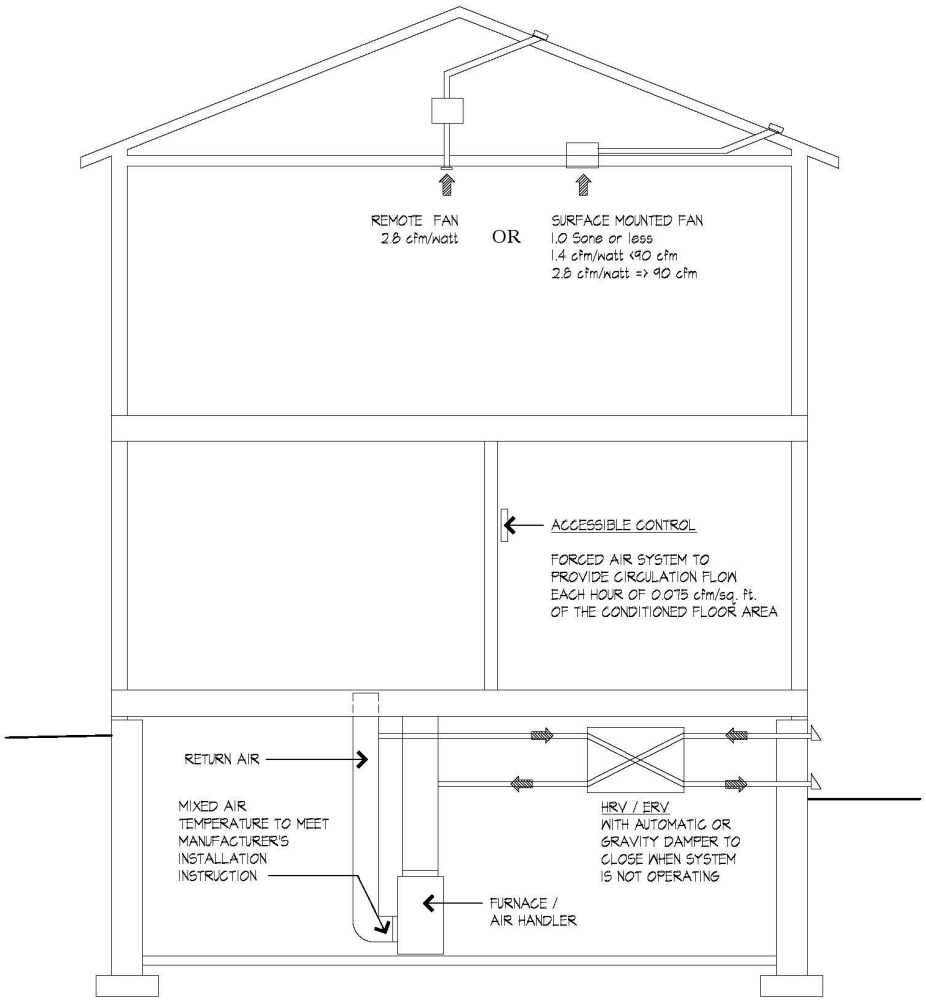
- The forced air system ductwork is used to exhaust and supply fresh air to the building
- Tempered fresh air is supplied to the cold air return duct of the furnace
- Dampers close the openings to outside when the ventilation fan is off
- Control to operate the forced air circulation system when the mechanical ventilation system is operating
- Control for automatic cycling operation if not designed to operate continuously



RETURN - RETURN VENTILATION

HRV/ERV - FORCED AIR CIRCULATION SYSTEM WITH VOLUME VENTILATION DUCT DESIGN (RETURN/SUPPY)

- The forced air system ductwork is used to exhaust and supply fresh air to the building
- Tempered fresh air is supplied to the cold air return or the supply duct of the furnace
- Dampers close the openings to outside when the ventilation fan is off
- Control to operate the forced air circulation system when the mechanical ventilation system is operating
- Control for automatic cycling operation if not designed to operate continuously



SUPPLY - RETURN VENTILATION

SEPARATE SUPPLY AND EXHAUST FANS - FORCED AIR CIRCULATION SYSTEM INTEGRATED WITH EXHAUST FAN(S)

- The forced air system ductwork is used to supply fresh air to the building
- Untempered fresh air is supplied to the cold air return or the supply duct of the furnace
- Dampers close the openings to outside when the ventilation fans are off
- Control for automatic cycling operation of the forced air system and separate exhaust fan if not designed to operate continuously