Ventilating Your Home

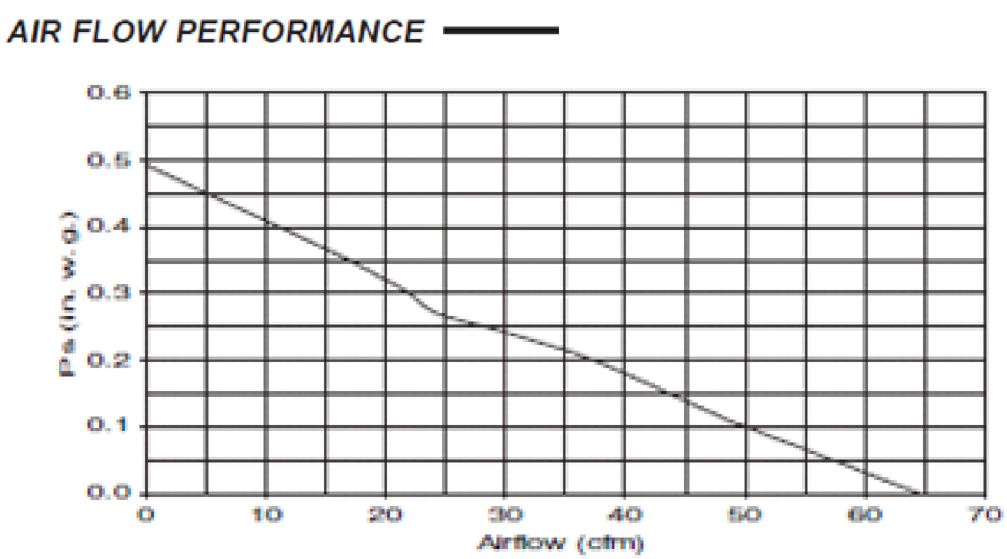
With the push to build tighter homes, HVAC designers need to be cognizant of indoor air quality and providing mechanical ventilation to dilute indoor contaminants. In older (commonly leakier) homes, this dilution occurs from natural infiltration and exfiltration. As air bypasses are eliminated in newer homes, a controlled source of ventilation is necessary.

A proper ventilation system should be able to perform a combination of processes that result in the exchange of indoor air with ambient air. The ventilation processes comprises of:

- Bringing in outdoor air to dilute indoor contaminants
- Mixing and distributing this mixed air throughout the living space
- Exhausting a portion of the indoor air to the outdoors

Local / Point-Source Exhaust Ventilation

Many builders do not properly address indoor point source moisture control. Common practice is to put a 50 cfm rated exhaust fan in most bathrooms and an 80 cfm fan in the master bath. Most bath fans deliver their rated flow at pressure drops of 0.1 inches of water gauge (wg). As a reference, this is roughly the pressure drop created by 50 CFM of flow through a grille, 5 ft of 3-inch flex duct, and a wall cap for the fan...that's it. It's best to use the rated flow at 0.25" wg. to meet the recommended or required flow rate, since this is more likely to be the typical static pressure when fans are installed. A typical fan rated at 50 cfm @ 0.1" static pressure will operate closer to 23-31 cfm at 0.25" static pressure. An 80 cfm fan at 0.1" will operate at roughly 48-57 cfm at 0.25" static pressure.



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The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) *Standard 62.2-2007, Ventilation and Acceptable Indoor Air Quality in Low-rise Residential Buildings* recommends a minimum local exhaust of:

	Intermittent Exhaust	Continuous Exhaust
Application	**airflow**	**[cfm]**
Kitchen	100 cfm	5 ACH*
Bathroom	50 cfm	20 cfm

* Air changes per hour (ACH) based on kitchen volume

The Home Ventilating Institute (HVI), a nonprofit association of the manufacturers of residential ventilating products, recommends 8 air changes per hour (ACH) for intermittent spot ventilation in bathrooms. This typically works out to be comparable to *ASHRAE Standard 62.2* for most bathrooms, except larger master bathrooms. CARB recommends following HVI's guidelines for master bathrooms, as we are seeing master bathroom volumes and the sources of indoor moisture within these spaces increasing. A reasonable limit to the master bedroom exhaust fan size is 150 cfm. As a simple example, a bathroom that is 8 ft x 12ft x 8 ft (768 cubic feet) would need a fan that can provide 102 cfm to achieve the HVI recommendation. Proper sizing of exhaust fans and the use of delay-off switches (at least 10 minutes) will allow proper control of indoor moisture issues.

$$fan\ \ flowrate\ [cfm] = \frac{8\ \ ACH \times room\ \ volume\ [cubic\ \ ft]}{60\ [\min/hr]}$$

All exhaust fans need to be vented directly to the outside (including kitchen exhaust).

Observations from the Field

Homeowner – "We have recently been noticing evidence of molding around the bathroom window, resulting from very high humidity level throughout the house (but especially the master bath). This is really a big concern to us because we have been living in the house for just under 2 months, and to have evidence of molding and mustiness reappear is a big issue to us."

Here is a perfect example why performance testing is essential to quality control/assurance. Three of the bath fans were restricted in one fashion or another causing blow back into the conditioned space. It is common to see the exhaust fan backdraft damper screwed shut at the connection of the fan housing to the ductwork. Though the exhaust fans were operating, they were not extracting the excess moisture.

Builder – "the homeowner is observing excessive steam not being removed from the master bath after showers. He claims that the floor remains wet indefinitely and that towels do not dry unless a dehumidifier is introduced into the space. It would seem that 80 CFM should be sufficient to empty the master bath space in two hours or less, but I have no way to verify the CFM discharge of the main fan."

This bath fan was rated for 80 cfm at 0.1 in. w.c., but was not installed to the manufacturer's requirements. This situation was compounded by the non-use of the HVAC system since outdoor temps had been moderate. It is common to see pressure losses as high as 0.4 in. w.c. in exhaust fan ductwork. It wa recommended that the airflow rating at a pressure of 0.25 in. w.c. (62.5 Pa) be used and that the duct sizing meets the manufacturers' design criteria.

Whole-House Ventilation

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) *Standard 62.2-2007, Ventilation and Acceptable Indoor Air Quality in Low-rise Residential Buildings* recommends a minimum continuous ventilation equal to:

$$Q_{fan} = 0.01A_{floor} + 7.5(N_{br} + 1)$$

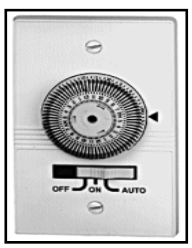
where,

Q_{fan} = continuous fan flow rate (cfm)
A_{floor} = floor area (ft^2)
N_{br} = number of bedrooms

Whole-house ventilation – "exhaust-only"

An "exhaust-only" ventilation strategy is the most affordable solution for climate zones without significant moisture concerns. SWA does not necessarily recommend exhaust-only ventilation systems in hot-humid climates, as this will depressurize the house and force make up air to be drawn through the building envelope (infiltration). Under extreme conditions, moisture in this air may condense as it moves through the wall an hits cooler surfaces (like drywall adjacent to the air conditioned home). Exhaust-only ventilation strategy is also not appropriate in a home with any atmospheric combustion appliances (including natural draft fireplaces).

A good exhaust-only system requires at least one bath fan in the home be upgraded to a model that has been rated for energy-efficiency, continuous use, and quiet operation (low-sone). These three features are fundamental to the success of this strategy. An efficient fan will not cost the homeowner a lot to operate. A fan rated for longer run times will not fail after a few months of operation. And lastly, the homeowner is less likely to disable the fan if it runs quietly.



All three of these criteria can typically be achieved by installing one ENERGY STAR® bath fan. The fan can operate continuously or in conjunction with a timer control (such as the Grasslin pin-timer shown to the left). If on a timer, the fans should be also wired to allow occupants to turn the fan "On" from a manual switch within the bathroom. The timer then should be set-up to comply with the guidelines set forth by the ASHRAE *Standard 62.2-2007, Ventilation and Acceptable Indoor Air Quality in Low-rise Residential Buildings*. Tamarack Technologies manufactures the AireTrak 62.2 fan controller for new or existing bath fans. This add-on device allows operation of some efficient exhaust fans continuously at low speeds; when the bathroom fan switch is turned on, the fan runs at full speed to exhaust moisture.

SWA has found Panasonic's WhisperGreen line of exhaust fans to be an excellent solution for "exhaust-only" ventilation systems as it has a very low power consumption. Maybe more important is the WhisperGreen's ability to maintain a constant airflow over a wide range of pressure drops – providing a great deal of forgiveness for elbows, long duct runs, and other installation issues. Also, Panasonic's CustomVent™ Variable Speed Control is a nice feature that allows the fan to run constantly a low speed (30-70 cfm), but will boost to high-speed (80 cfm) when the bathroom is in use. This eliminates the need for a separate timer control to be utilized for the whole-house ventilation system.

Whole-house ventilation – "supply-only"

A "supply-only" ventilation strategy is commonly recommended for hot, humid climates. The simplest version of this is a 4"-6" duct running from outdoors to the return plenum of the central air handler. Suction from the air handler provides a supply of fresh air when the air handler is operating. An "Air Cycler" or similar control needs to be used to provide additional ventilation when the air handler is not running for space conditioning. A mechanical run-time switch (such as Honeywell's Y8150A Fresh Air Ventilation System, Aprilaire's Model 8126 Ventilation Control System, or the AirCycler FR-V) needs to be installed to ensure that the *ASHRAE 62.2* requirement is met. SWA highly recommends that anyone using this ventilation strategy utilizes an air handler unit with an ECM motor. Inefficient fan motors can lead to extremely high electrical usage when the air handler is operating.

In efficient homes in humid climates, a ventilating dehumidifier may be a good option. These units can introduce a controlled amount of outdoor and can dehumidify indoor air (when no cooling is needed but indoor humidity is still high). A few specific options are Ultra-Aire's XT150H Whole House Ventilating Dehumidifier, AprilAire's 1750/1770 series with optional ventilation damper, and Honeywell's whole-house dehumidifier with H8908C Dehumidistat and W8150 ventilation controller.

Fan integrated (and other) supply-only ventilation systems are generally not recommended by CARB in cold climates. Pressurizing building interiors may force air through wall assemblies, potentially leading to moisture condensation and related problems.

Whole-house ventilation – "balanced"

The third option is a "balanced" ventilation system in which equivalent amounts of air are introduced from outside and exhausted to outdoors. This is typically accomplished through the use of heat recovery ventilators (HRVs) or energy recovery ventilators (ERVs). An HRV uses the exhaust air to partially condition (pre-cool or pre-heat) the incoming fresh air. Efficiency of these units is described in terms of Sensible Recovery Effectiveness (SRE). An ERV allows for the additional transfer of moisture (as well as sensible heat) across the heat exchange media. Efficiency of these units is commonly described in terms of a Total Recovery Effectiveness (TRE).

Even though many HRV and ERV manufacturers recommend connecting ventilation ducts to central heating and cooling ducts (certainly the least costly approach), SWA generally recommends against this. When ventilation is completely connected to the central distribution system, the primary air-handler unit needs to run whenever the ventilation unit is running to properly distribute air throughout the home. As ventilation systems often run continuously, this can use a tremendous amount of electricity. If this method is employed, an efficient air handler motor (ECM) is strongly recommended.

CARB recommends that, at a minimum, either the supply or exhaust portion (or both) of the ventilation duct system should be isolated from the central heating and cooling duct system. As a best practice, SWA recommends supplying to bedrooms and main living spaces and exhausting from one or two central locations.

SWA does not generally recommend using an ERV or HRV to exhaust from bathrooms. While this is a common practice and recommended by many equipment manufacturers, CARB suggests that bathrooms should have independent exhaust fans so that excess moisture can be removed directly from the home.

SWA recommends an ERV such as the Stirling Ultimate Air RecoupAerator or Fantech's SE series because of their low power consumption. The RecoupAerator is an interesting product as it has a programmable, variable-speed, brushless DC motors; 83% SRE and ~50% TRE; optional CO_2 override control sensor (carbon dioxide acts as a surrogate for indoor pollutants); and adjustable air flow.

There is not widespread agreement on when to use an ERV and when to use an HRV. In hot humid climates, an ERV is recommended to reduce the humidity in outdoor air brought into the home. In cold climates, some designers chose ERVs to maintain indoor humidity in the winter; other designers choose HRVs to deliberately keep indoor humidity lower. In cold climates, keep in mind that condensate and freezing can be an issue. Some ventilators have defrost kits or controls; others are simply not recommended for use in very cold climates.

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