INSTALLING A Heat-Recovery Ventilator

A balanced ventilation system requires careful attention to duct sealing

by David Hansen

Poorly ventilated homes can have high levels of humidity, pollutants, and mold. Most homes depend on random cracks or exhaust-only systems for ventilation, but today's techniques for building tighter homes have made random cracks less common, and exhaust-only ventilation systems have a few disadvantages: They can contribute to backdrafting problems in combustion appliances, and they may draw their supply air from undesirable locations like basements or crawlspaces.

The best way to improve indoor air quality is to provide a balanced ventilation system that includes a heat-recovery ventilator, or HRV (see "Choosing a Whole-House Ventilation System," 9/00). Such a ventilation system will create a gentle circulation of fresh air throughout the home, will lower the levels of indoor air pollutants, and will eliminate odors and window condensation.

How They Work

An HRV exhausts stale air from a house at a calculated rate, while simultaneously bringing in the same amount of fresh makeup air. The two airstreams pass each other in the heat-exchange core, allowing much of the heat energy in the stale air to be transferred to the fresh incoming air, without any mixing of the airstreams (see Figure 1). In an air-conditioned home in a cooling climate, an HRV lowers the temperature of the incoming air by transferring some of its heat to the cooler exhaust air.

Core design. The heart of an HRV is its heat-exchanger core. Today's residential HRVs use one of three different core designs: a parallel-plate counterflow core, a parallel-plate crossflow

Figure 1. In an HRV with a parallel-plate core, like this model from Venmar, the incoming fresh air passes through every other layer of the core, which is composed of stacked air channels separated by thin plates of plastic or aluminum. The exhaust air also passes through every other layer in the core. Although there is no mixing of the airstreams, heat is transferred from one airstream to the other.

core, or a rotary wheel core (Figure 2). Parallel-plate cores, whether counterflow or crossflow, are made of aluminum, plastic, or, in the case of an energy-recovery ventilator, a moisture-permeable membrane (see "Energy-Recovery Ventilators," next page).

Some manufacturers tout the theoretical superiority of counterflow cores over crossflow cores, or aluminum components over polypropylene. In practice, however, HRV efficiency depends upon many design factors, not just core geometry or material type. The best resource for comparing HRV efficiencies is the *Product Directory* published by the Home Ventilating Institute (available online at www.hvi.org, or by calling 847/394-0150). When choosing an HRV, small differences of efficiency may be less important than the level of service provided by a local ventilation contractor.

Frost formation. When the outdoor temperature drops below about 20°F, the incoming air is so cold that frost can build up in an HRV core. All HRVs have a defrost cycle to avoid frost problems. When an outdoor temperature sensor detects cold weather, a control module activates a defrost damper, which shuts for about six minutes every half hour. When the defrost damper is shut, the stale air recirculates through the HRV, thawing the core.

Energy performance. Because an HRV recovers some of the heat from exhaust air, it uses less energy than a ventilation system without heat recovery. Nevertheless, a home with an HRV uses more energy than a home without a ventilation system.

An HRV draws between 85 and 225 watts of electrical power. Most HRVs are only about 60% to 75% efficient at recovering the heat from exhausted air, although some models can achieve efficiencies of up to 90%. HRV operating costs, including the cost of the electrical power and the cost to temper the ventilation air, range from about $160 to $200 a year, depending on climate and electricity costs.

Ducting Options

An HRV system can be ducted one of several ways, depending on the existing heating system and the customer's budget. The three most common types of systems are simplified systems, modified systems, and fully ducted systems.

In a simplified system (installed in a home with forced-air heating or air conditioning), the HRV unit pulls stale air out of the main return duct of the forced-air system and introduces the fresh air downstream a few feet, in the furnace's return plenum. A simplified system does not provide point-source control of moisture or pollutants.

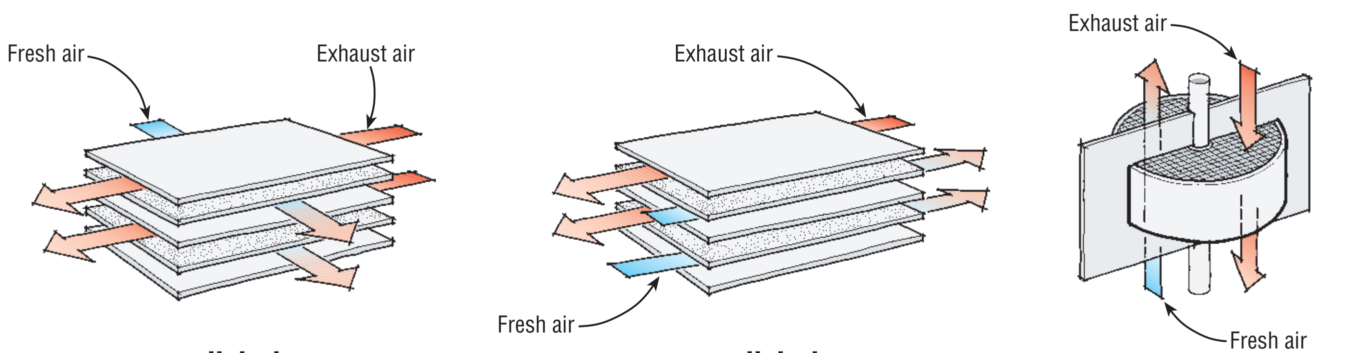
A modified system, which is an improvement over a simplified system, introduces fresh air into the forced-air duct system while exhausting stale air from the bathrooms.

A fully ducted system — the type described in this article — is typically installed in a home with hydronic heat, and requires two duct systems dedicated to ventilation: one to exhaust stale air from areas that produce most of the moisture or pollutants, and another to supply fresh air to the living spaces.

Sizing an HRV

To size an HRV unit, first check whether any local ventilation code applies. My company generally uses ASHRAE Standard 62-1989, which recommends between 0.35 and 0.5 air changes per hour. To apply this standard, we start by calculating the volume of the house, using the following formula: square feet x ceiling height x .85. (This formula reduces the house's gross volume by 15% to account for interior walls and furniture.) To find the necessary ventilation airflow, we multiply the net volume by the design

Types of HRV Cores



Parallel-Plate Crossflow Core | **Parallel-Plate Counterflow Core** | **Rotary Wheel Core**

Figure 2. All three types of HRV cores are designed to encourage some of the heat from the exhaust air to be transferred to the incoming fresh air. There are two types of parallel-plate cores: In a counterflow core (left), the airstreams cross at right angles, while in a crossflow core (center), the airstreams travel in opposite directions. Parallel-plate cores can be made from either aluminum or plastic. A rotary wheel core (right) has enough thermal mass to absorb and release heat as the wheel turns through the two separated airstreams.

air-change rate (0.5 ac/h) and divide by 60 (to convert cubic feet per minute to air changes per hour). With this information, we can select an appropriate HRV, using the airflow fan curves supplied by the manufacturer for specific HRV models. The fan curve represents the amount of air a specific fan can move, depending on the resistance of the duct system.

Residential HRV systems move relatively small volumes of air. In most homes up to about 3,500 square feet, the total design airflow will be under 200 cfm, with each bedroom receiving 25 cfm or less. For the main ducts, 6-inch round duct, which has a maximum airflow capacity of 180 cfm, is usually sufficient. When moving such low volumes of air, it's important for duct to be as short, smooth, and airtight as possible. Every extra foot of duct and every elbow or transition add resistance (or static pressure) to the airflow. If plans are available, the ducts can be laid out on paper, although their final locations are best determined on site.

Laying Out the Ductwork

Ventilation ducts can be installed once the interior walls are framed. We try to be on site during the plumbing rough-in. Sometimes locating a pipe just a few inches to one side can make enough of a difference to allow a duct to fit into a tight joist bay. In a pinch, a wall can be shimmed out to make room for ducts to get past the plumbing or a chase can be located inside a closet, but by communicating with the plumber, we usually avoid such steps.

Locating the registers. Stale air is exhausted from bathrooms, the laundry, and the kitchen. (An HRV is not intended to handle grease or smoke, so a range hood should be separately exhausted to the exterior.) Fresh air is supplied to the bedrooms, living room, and other living areas. We try to locate bedroom registers away from the bed.

When we rough-in our duct drops, we always work from the top floor down. We locate both the fresh-air and the stale-air registers high on a wall or in the ceiling. After choosing tentative locations for the registers, we follow the intended duct routes down to the basement, to be sure there are no unworkable obstacles.

In most cases, all the fresh- and stale-air registers are wall-mounted 6x10 registers, and each gets its own separate duct down to the basement. To keep airflows as high as possible, we use 6-inch duct for stale-air pickups. For fresh-air supplies into bedrooms, 4-inch ducts are usually adequate.

We use mainly 30-gauge galvanized ductwork. In 2x4 partitions, we use 6-inch oval duct, which measures $3^1/_2$ x $7^1/_2$ inches and comes in 5-foot lengths. Oval duct has a smaller airflow capacity than round but is perfectly adequate for the individual wall stacks. Each register mounts in a 6x10-inch stackhead, a duct fitting that makes the transition from a rectangular register to oval duct.

Installing the Ducts

Stackheads are installed $^1/_2$ inch proud of the studs, like electrical boxes (Figure 3). On most jobs, the top of the

Figure 3. Each wall-mounted fresh-air and stale-air register requires a rectangular duct fitting called a stackhead. Stackheads are installed $^1/_2$ inch proud of the joists, like electrical boxes.

Energy-Recovery Ventilators

An energy-recovery ventilator, or ERV, is a special type of HRV that tempers the extremes of humidity in the incoming fresh air. Like an HRV, an ERV transfers heat between the two streams of air passing through the ERV core. But an ERV also transfers some of the moisture from the more humid stream of air to the drier stream of air.

In winter, when outdoor air is usually dry, an ERV increases the humidity of the incoming air, while in summer, when outdoor air is usually more humid, an ERV can lower the humidity of the incoming air, as long as the house is air conditioned. (In a house without air conditioning, the humidity levels of the indoor and outdoor air are essentially the same, so an ERV can't help lower humidity.)

ERVs are recommended for air-conditioned homes in hot, humid climates. In cold climates, where winter indoor air can be humid enough to cause window condensation, one of the main goals of a ventilation system is to lower indoor humidity levels. For that purpose, an HRV makes more sense than an ERV. For the same reason, ERVs are not recommended for pool or spa rooms, where HRVs are more appropriate.

An ERV core, sometimes called an enthalpic core, can be either a fixed core or a rotary-wheel core, and is usually made of treated paper or polyester fiber. Rotary ERV cores are often impregnated with a desiccant to improve moisture transfer.

Figure 4. Because this is a fresh-air duct, the crimped end of the duct points toward the stackhead. The photo shows two styles of 90-degree ells that can be used to make the transition from oval duct to round: the ell at the top of the photo is a longways ell, while the ell at the bottom is a shortways ell.

Figure 5. Ventilation systems remove relatively small volumes of air, so ducts should be as airtight as possible. All galvanized duct connections should be secured with sheet-metal screws and aluminum tape.

stackhead is installed about 4$^1/_2$ inches down from the top of the wall. If the room will receive crown molding, we install the stackhead lower.

The crimped end of a stale-air duct always points toward the HRV unit, while the crimped end of a fresh-air duct points the opposite way, toward the stackhead (Figure 4). By consistently following this system, we can distinguish between stale-air and fresh-air ducts in the basement just by looking at which direction the crimped end is pointing.

We secure every galvanized duct connection with two or three $^1/_2$-inch sheet-metal screws and aluminum duct tape (Figure 5). We've had good success with foil hvac tape (#1520 CW) from Venture Tape Co. (800/343-1076; www.venturetape.com), which is easy to apply, because it has a paper release backing.

We extend all the stacks, both fresh and stale, down from the stackheads into the basement. Wherever an oval duct passes through the top plate of a wall, we use a piece of plumber's strapping to secure the duct to the plate. Because sweep ells for oval pipe take up too much room, we transition from oval to round duct as soon as possible, using straight transition fittings or transition elbows. Once the stacks are installed, we use aerosol foam to seal the gaps between the ducts and the bottom plates. This helps stop air leakage between floors and secures the stack to the framing (Figure 6).

PVC ducts. In houses where the installation of wall-mounted registers is difficult, we often install round ceiling-mounted diffusers, working from the attic. Since attic ducts, being cool in winter, are prone to condensation, we use 4- or 6-inch thin-wall PVC (sewer and drain pipe, type ASTM D 2729) for all attic ducts. (Because PVC is available in 10-foot lengths, it's also useful wherever a long section of straight duct is needed.) If condensation occurs, the glued joints of the PVC will prevent leaks. We always insulate any ducts that run through unheated space.

We like to use PVC pipe made by Flying W (800/327-4735; www.flyingw-plastics.com), because it is thinner than some other brands, making it easier to slide 6-inch galvanized duct into the pipe. To ease the transition, we chamfer the inside edge of the PVC pipe with a utility knife. The connection is then secured with screws and sealed with aluminum tape.

Wiring

Once we've roughed-in the stacks to the basement, we install the low-voltage control wiring, following the manufacturer's instructions. Usually, we run 4-conductor wire from the location of the HRV unit to each bathroom and laundry for an override timer, which permits the exhaust ventilation fan to be controlled from the bathroom. These override timers are located next to the room's light switch. We install a separate run of wire for the main control, which is usually located near the central thermostat on the first floor, about 5 feet from the floor.

Most residential HRV units come with a cord and a plug, so we coordinate with the electrician for the installation of a standard duplex receptacle near the HRV unit. When the stacks are installed and the wiring is complete, the first stage of our work is finished. We usually return later to complete the basement ducts and install the HRV unit.

Basement Ducts

In the basement, the various stale-air wall stacks are connected to a main round duct running to the HRV. A second main duct connects all of the fresh-air supply stacks. For most residential jobs, all basement ducts, galvanized or PVC, are 6-inch round ducts.

We determine the main duct run locations and then position a wye along this line with the leg of the wye pointing up into the joist bay of the stale-air stack nearest the unit. For galvanized ducts, we use #160 wyes, which come with three uncrimped ends, and crimp the ends as required. Because galvanized wyes aren't airtight, we seal all joints in a wye with silicone caulk, duct mastic, or aluminum tape before installation (Figure 7).

We then fasten the wye to a length of duct and use perforated nylon strapping to hang the duct from the floor joist. By adding adjustable elbows as necessary, we aim the branch of the wye toward the oval stack boot. The main duct runs should end near, but a little short of, the HRV unit. Once the ducts have been installed, we seal all connections not secured by aluminum tape, including the joints in adjustable elbows, with duct sealant or silicone caulk.

Installing the HRV Unit

The HRV unit is generally located inside the tempered space of the building, usually in the basement mechanical space close to the outside ports. Other possible locations include a closet, laundry room, workshop, top-floor kneewall area, or even a garage. We usually hang it from the ceiling joists.

We avoid the use of flex duct as much as possible, because its interior corrugations impede airflow. However, because insulated flex duct prevents problems with condensation drips, we use it to connect the HRV unit to the outside vent hoods. The flex duct needs to be sealed to both the HRV unit and the house vapor retarder. We also use short lengths of noninsulated vinyl flex duct to connect the HRV unit to the house ducts.

We keep our flex duct runs as short as possible, and we always seal any rips or tears in the outside cover of the flex duct. (If moist interior air comes in contact with the cold fresh air in the intake duct, condensation will saturate the duct insulation.) Where flex duct connects with the HRV unit, we seal the connection with silicone caulk and screw the duct to the collar on the HRV.

Outside vent hoods. Exterior vent hoods protect the intake and exhaust ports from weather and animals (Figure 8). A 6-inch exhaust duct needs a 6-inch or equivalent exterior hood, not a 4-inch dryer vent. The vent hood should include a cleanable rodent screen made from $^1/_4$-inch hardware cloth. We usually install Jenn-Air wall caps (Maytag part #A406; 800/688-1100; www.jennair.com).

The two outside vents are typically installed through the basement rim joist, level with one another. They should be located at least 6 feet apart to minimize the chance of the fresh-air intake pulling back any stale air. Sometimes a corner of the building can be used to better separate the fresh intake from the exhaust port. The fresh-air port should be as far as possible from any combustion flues, dryer exhaust vents, and places where cars may idle. An exhaust vent can be located under a deck or porch, but we avoid pulling fresh air from an enclosed space.

Since we usually install the vent hoods on trim blocks, we prefer to schedule this part of the work before the siding is on. We use a short (about 6- to 12-inch) section of 6-inch PVC pipe (including a bell end) to connect the insulated flex duct to the vent hood. We cut a series of 1-inch slots, about $1^1/_2$ inches apart, in the male end of the pipe section, and then slip the flex duct over the PVC. The connection is sealed with aluminum tape and screws. We insert the bell end of the PVC through the hole in the building, flush with the outside face of the trim block. The Jenn-Air hood is then inserted into the PVC. We always seal the gap where the PVC duct penetrates the building with aerosol foam.

Figure 6. Where an oval duct penetrates a floor, aerosol foam helps secure the stack to the framing.

Figure 7. Galvanized #160 wyes come with three uncrimped ends and are crimped as required on site. As purchased (left), the wyes are not airtight, so the seams of each should be sealed with caulk before installation (right).

Figure 8. An HRV system requires two exterior ports, an intake port and an exhaust port. These identical 6-inch ports are protected by vent hoods and are usually located at the rim joist.

Registers. Once the drywall has been painted, we install the various controls and registers. The controls are installed according to the manufacturer's instructions.

Both stale-air and fresh-air registers require a damper to allow airflow balancing. For wall-mounted registers, we use either a Lima 12V register (888/861-6452; www.milcorlp.com) or a Hart & Cooley 661 (616/392-7855; www.hartandcooley.com). We check the registers with a level before fastening them with screws through the ears of the stackhead. To provide better air distribution and hide the inside of the stackhead, we always adjust the register dampers to direct the airflow up toward the ceiling.

For round ceiling registers, we use molded plastic Scandinavian-style diffusers. These are secured to the inside of the round PVC duct with sheet-metal screws. Then we spin in the trim ring, making a friction fit, and adjust the damper rings to about three-fourths of the full opening size.

Balancing. Once the installation is complete, the system must be tested for airflow balance. Small airflows are hard to test, but most manufacturers provide a recommended balancing procedure, generally requiring the use of an airflow measuring station or unit-mounted pressure taps and a calibrated magnehelic gauge.

The final step of any job is an important one: homeowner instruction. We provide the homeowner with the operation manual and an on-site orientation, explaining:

- control operation (most HRVs can be set for intermittent operation, low-speed continuous operation, or high-speed continuous operation);
- humidistat function (most HRVs include a humidistat that automatically operates the fan at high speed when the indoor humidity rises above a user-adjustable level);
- the filter cleaning schedule (every three months, HRV filters should be vacuumed, washed, or replaced); and
- the importance of keeping the outside intake and exhaust ports free of leaves and mulch.

***David Hansen** is the owner of Memphremagog Heat Exchangers, a ventilation contractor in Newport, Vt.*

Sources

HRV Manufacturers

American Aldes Ventilation Corp.
Sarasota, Fla.
800/255-7749
www.americanaldes.com

Broan-Nutone
Hartford, Wisc.
800/558-1711
www.broan.com

Bryant Heating & Cooling Systems
Indianapolis, Ind.
800/428-4326
www.bryant.com

Carrier Corp.
Syracuse, N.Y.
800/227-7437
www.carrier.com

Des Champs Laboratories Inc.
Natural Bridge Station, Va.
800/265-6921
www.deschamps.com

Honeywell Inc.
Morristown, N.J.
800/328-5111
www.honeywell.com

Kanalflakt Inc.
Bouctouche, New Brunswick
800/565-3548
www.kanalflakt.com

Lennox International Inc.
Richardson, Texas
972/497-5000
www.lennoxinternational.com

New Age Ventilation
Sackville, Nova Scotia
902/865-2284

Nu-Air Ventilation Systems
Newport, Nova Scotia
902/757-1910
www.nu-airventilation.com

Nutech Energy Systems Inc.
London, Ontario
519/457-1904
www.lifebreath.com

Raydot Inc.
Cokato, Minn.
800/328-3813
www.raydot.com

RenewAire
Madison, Wisc.
800/627-4499
www.renewaire.com

Research Products Corp.
Madison, Wisc.
800/334-6011
www.aprilaire.com

Rheem Air Conditioning Division
Fort Smith, Ark.
501/646-4311
www.rheemac.com/residential/erv_hrv/

Ruud
Fort Smith, Ark.
800/848-7883
www.ruudac.com

Stirling Technology Inc.
Athens, Ohio
800/535-3448
www.lychonia.com

Trent Metals Limited Summeraire Division
Peterborough, Ontario
705/745-4736
www.summeraire.com

United Air Specialists, Inc.
Cincinnati, Ohio
800/551-5401
www.uasinc.com

Venmar Ventilation Inc.
Drummondville, Quebec
800/567-3855
www.venmar-ventilation.com

HRV Distributors

Brock Inc.
St-Laurent, Quebec
888/344-1323
www.brock-inc.ca

Energy Federation Inc.
Westborough, Mass.
800/876-0660
www.efi.org

Memphremagog Heat Exchangers
Newport, Vt.
800/660-5412
www.mhevt.com

Positive Energy Conservation Products
Boulder, Colo.
800/488-4340
www.positive-energy.com

Powrmatic of Canada
Finksburg, Md.
800/966-9100
www.powrmatic.com

Snappy Air Distribution Products
Detroit Lakes, Minn.
218/847-9258

Therma-Stor Products
Madison, Wisc.
800/533-7533
www.thermastor.com