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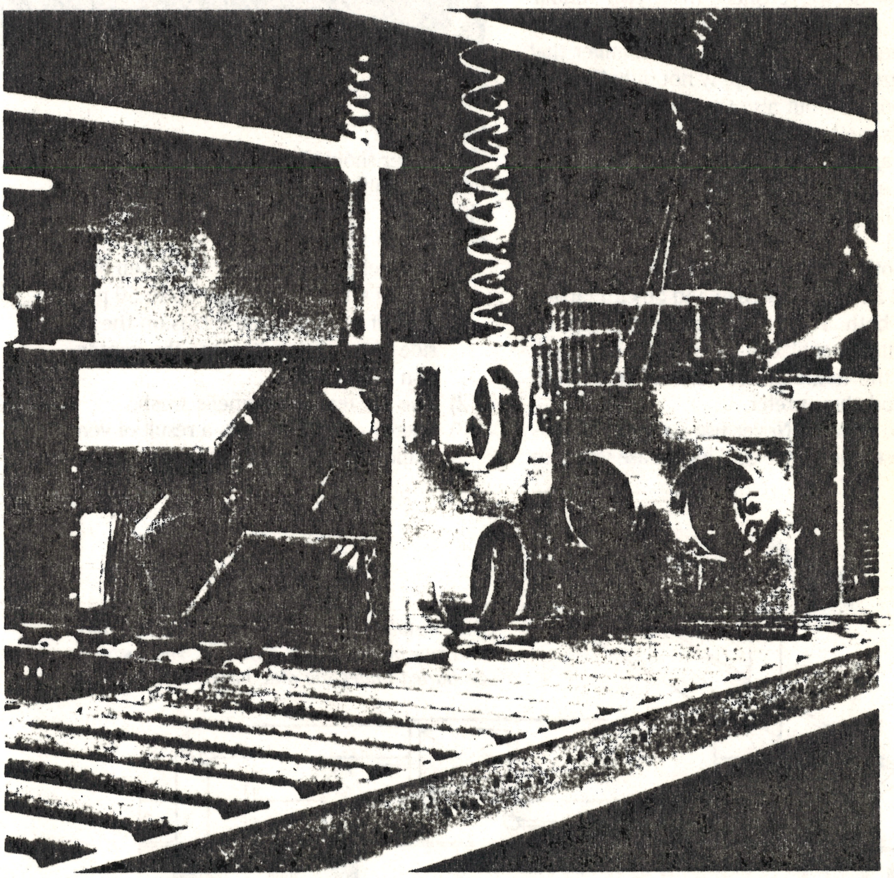
Tips & Cautions about Air Exchangers

There's more to installing ducted air-to-air heat exchangers than meets the eye. Follow these guidelines if you want reliable performance.

By Richard Karg



Heat-exchanger cores use a variety of mechanisms to transfer the heat from the exhaust to the supply air. The most common type—being assembled here—uses multiple "plates" of aluminum or plastic to increase the surface area between the two airstreams.

Many homes today are built as tightly as possible so that the occupants are living—figuratively—inside a large balloon. Without ventilation, the house can become an atmospheric dump filled with particulates, harmful gases, and excessive water vapor.

Some designers think houses should not be built so tightly and are willing to sacrifice energy efficiency. Loose houses, though, offer no way to *regulate* ventilation. At times there will be too much ventilation, at other times too little.

Ducted, whole-house air-to-air heat exchangers are one solution to this thorny problem (*Solar Age* 3/82, 9/82). These machines provide a regulated amount of fresh air, and do so while reclaiming 70 to 80 percent of the heat from the exhaust air. In many cases, they save enough energy to justify the initial investment of $1200 to $2000 for an installed system. Perhaps a greater justification for their use is one difficult to quantify, that of better health.

A heat exchanger installed incorrectly can be worse than none at all. Most failures to date can be traced to faulty installation or design rather than to bad equipment. Following are a list of tips and cautions that will help you succeed with these machines in cold-climate applications. It is important to understand that each brand is unique and that these general guidelines need to be applied accordingly.

Choosing the right size

Most manufacturers rate their machines according to *core delivery rate,* which is the amount of air in cubic feet per minute (cfm) they can supply at zero *static pressure* (with no ductwork attached). Static pressure is a measure of the resistance to airflow imposed by ductwork. The shorter the runs, the larger the ducts, and the fewer their twists and turns, the better.

The actual amount of air supplied and exhausted from the house after the system is installed is the *effective delivery rate,* which can be calculated if the static pressures of the supply and exhaust ductwork are known. For most installations, the effective delivery rate is 10 to 25 percent less than the core delivery rate.

To select the right heat exchanger size, you must take into account two ventilation requirements: one for *continuous* ventilation of the entire house and one for *inter-*

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mittent use in kitchens and baths.

The first is determined by the arbitrary but so far unshaken rule of 0.5 air changes per hour (ach) for continuous ventilation. Using this rule, a 1500-square-foot house with 8-foot ceilings requires an effective delivery rate of (1500 × 8 × 0.5) / 60 = 100 cfm. The ASHRAE standard (62-1981), which recommends 10 cfm for continuous ventilation per room regardless of the room size, yields a similar rate.

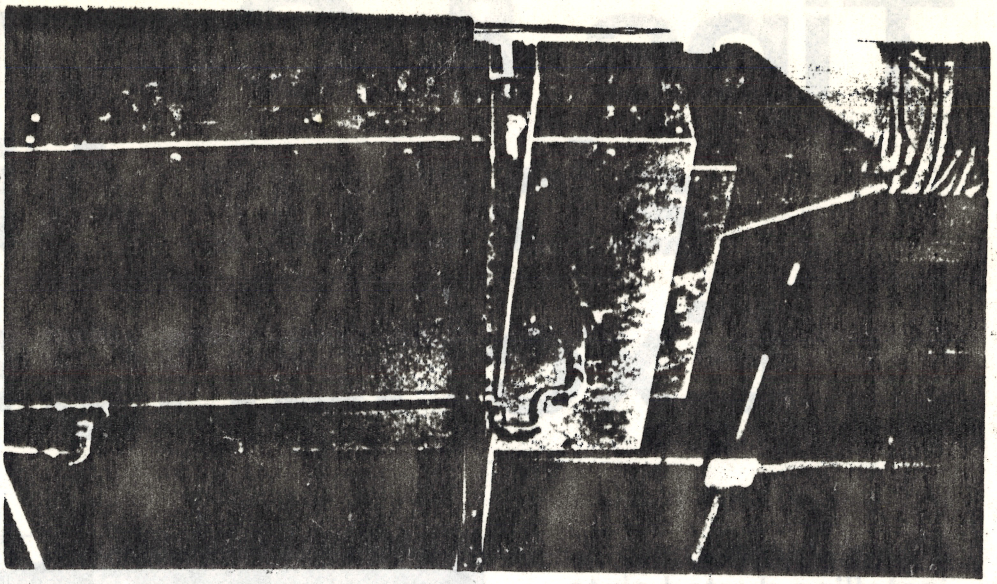
The ASHRAE standard for intermittent ventilation requires 100 cfm in kitchens and 50 cfm in each bathroom. If our example house has two bathrooms and a kitchen, the effective intermittent rate should total 50 + 50 + 100 = 200 cfm.

How do we reconcile these two ventilation rates? The best solution is to use both.

One way is to use a heat exchanger that is large enough to supply not only the continuous rate but also the intermittent rate. In this method, the ductwork is installed so that approximately 50 cfm is exhausted from each bath and 100 cfm from the kitchen when the blowers are switched to full speed.

Another option is to install a 100-cfm exhaust fan in the kitchen and 50-cfm fans in each bath. These booster fans provide intermittent ventilation when required. Check with the manufacturer to find out which method they prefer.

One caution: Never use a range hood as a booster fan, since cooking grease will gum up the heat-exchanger core.

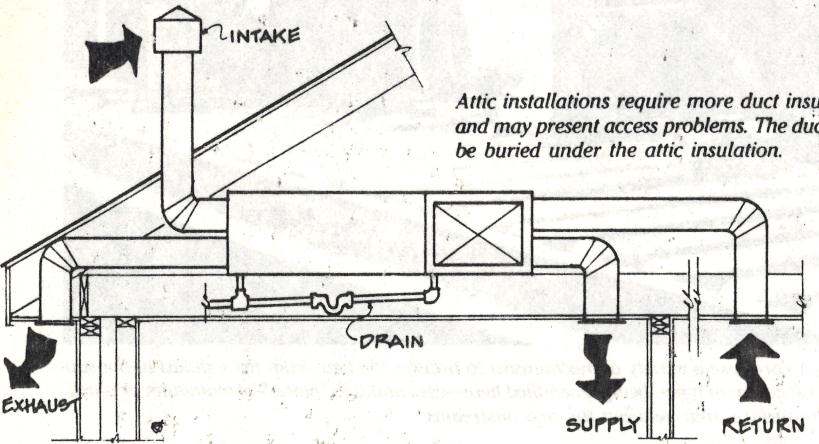


An E-Z Vent ducted air-to-air heat exchanger rests on two bars suspended from threaded steel rod. The threaded rod makes for easy leveling. A foam or fiberglass pad helps absorb vibrations.

Control

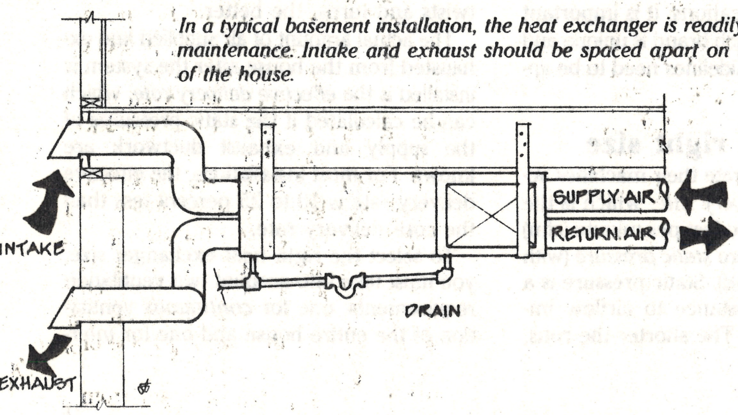
The owner should be able to adjust the continuous ventilation rate by means of a variable speed control. The speed should be adjusted so that:

1) The relative humidity level remains within a healthy range—35 to 50 percent. If condensation forms on the inside of windows, increase the ventilation rate.
2) The air feels and smells fresh.
3) Energy consumption as a result of ventilation is kept to a minimum.



Attic installations require more duct insulation and may present access problems. The ducts can be buried under the attic insulation.

In a typical basement installation, the heat exchanger is readily accessible for maintenance. Intake and exhaust should be spaced apart on the same side of the house.



The higher intermittent rate is provided by increasing the speed of the blowers or activating the booster fans. In the first type of system, wall switches in the kitchen and baths override the variable speed control, increasing the blower speed to full. In the second type, the switches activate the appropriate booster fan. Wall switches with integral pilot lights or timed switches (percent timers) can be used. Installing a three-hour timed switch in the kitchen and one-hour timed switches in the bathrooms works well.

When continuous ventilation is not needed—usually when windows are open—localized intermittent ventilation must still work. The kitchen and bath switches must be wired so they will also turn on the heat exchange blowers when the continuous ventilation is shut off.

For safety and convenience, mount a shut-off switch near the heat exchanger and protect the machine with the recommended breaker. Some manufacturers supply these and the rest of the controls as standard equipment. At the other extreme are companies that offer nothing, even as an option, and don't suggest which controls are compatible with their machines.

Location

Heat exchangers are best located within the building envelope. This minimizes the number of penetrations in the vapor barrier and the amount of insulated ductwork required. In a basement, utility room, or closet, hang the heat exchanger from ceiling joists with four threaded rods and two crosspieces of wood or angle iron. This method allows the installer to adjust the level and tilt once the installation is complete. Most brands install level.

If an attic installation is the only option, make sure you seal the vapor barrier to the ductwork at each penetration. It is usually best to place the machine on a small platform fastened to the top edges of the joists. The platform must accommodate the condensate drain. In any installation, rest the exchanger on fiberglass batts or foam to ensure that motor vibrations and noise will not transfer to the framing.

No matter where the exchanger is installed, it should be placed so that

1) The amount of ductwork is minimized.
2) The amount of insulated ductwork is minimized.
3) Condensed water can drain away easily.
4) There is easy access to the exchanger for maintenance.

Grilles and registers

Improper location of *grilles* (for exhaust air) and *registers* (for supply air) can cause drafts and improper mixing and cleansing of the indoor air. A common mistake is to position the grilles and registers like those in a heating system. While a furnace supplies air that is warmer than the room air, a heat exchanger supplies air that is cooler. Consequently, furnace registers go in the floor and heat exchanger registers go in the ceiling or high on a wall. This way, cool air enters the room above the occupied zone, "hangs" onto the ceiling, slows in velocity, and then falls slowly without causing drafts.

Like registers, return grilles should be placed in or near the ceiling. This is because many indoor contaminants, including water vapor, are lighter than air and should be drawn out of the house where they are most concentrated.

In which rooms should you place the grilles and registers?

In general, grilles go where contaminants are created and registers go where the occupants spend the most time. The following guidelines are suggested:

1) Install both grilles and registers in or within a foot of the ceiling.
2) Install exhaust grilles in kitchen, bath, and laundry areas.
3) Do not connect a range hood directly to the heat exchanger. Use a recirculating hood and locate the grille 8 to 12 feet away from the range.
4) Install supply registers in bedroom, living room, and family room areas. Use wall registers or ceiling diffusers that direct the air just below and parallel to the ceiling. Choose registers with adjustable directional vanes.
5) Doors should be undercut about an inch in rooms with registers or grilles.
6) All grilles and registers should have dampers either integral or in the branch duct.
7) Registers should be long and thin. Select sizes that satisfy a 1-to-1 ratio between the cfm at the register and its free area. This yields an air speed of about 150 feet per minute (fpm).
8) Select grille sizes that satisfy a 3-to-1 ratio between the cfm at the grille and the free area of the grille. This yields an air speed of about 450 fpm.

The two outside air hoods should vent downward like dryer vent hoods but need to be larger. The hood sold by Jenn Air for their cooktops works well. It is plastic and fits a 6-inch round duct, but needs an insect screen added. Also, the damper must be removed for the supply air hood.

Install the two hoods on the same side of the house to minimize pressure differences caused by winds. Keep them at least 8 feet apart so stale exhaust air does not contaminate incoming fresh air. Keep the inlet clear of dryer vents, garages, parking areas, chimney gases, kennels, and other sources of odors or noxious fumes. If possible keep the supply hood upwind of the exhaust hood. If it is placed on the south side, the supply air will be solar preheated.

Never vent air into or draw air out of the attic. In attic installations, you can install vent hoods in the gable ends or vent through (not into) the soffits.

Ductwork

Whole-house heat exchangers require two distinct duct systems, one for the stale exhaust air and one for the fresh supply air. Different types of ductwork may be used with heat exchangers. These include, in order of increasing cost: interior wall cavities, round rigid plastic (PVC or ABS), round flexible plastic, round sheet metal, and rectangular sheet metal.

Plastic ductwork, both rigid and flexible, is the favorite of most installers because of its low cost and easy installation. But some building codes do not allow it. Wall cavities can serve, in some instances, as inexpensive ducts. It is best to line the back of the affected drywall with poly, stretched taut so it does not "flap in the breeze."

Heat exchangers have *cold-side* ductwork between the heat exchanger and outside and *warm-side* ductwork between the heat exchanger and the grilles and registers. Also, ductwork systems have *trunks* and *branches*, analogous to a tree. The trunks are connected directly to the heat exchanger. On the cold side, the trunks should lead directly to the outside with no reductions in size. On the warm side, smaller branches are attached to the trunks and wander through the walls, floors, and attic.

The size of the trunk duct is determined by the collars on the machine. Branch ducts, if not specified by the manufacturer, should be 4 to 6 inches in diameter (or the rectangular equivalent) for machines rated from 150 to 350 cfm. Be aware that the smaller the duct, the greater the airflow velocity, and the greater the resistance to airflow due to friction. Also, too great an air velocity on the warm side can create unpleasant drafts.

When installing ductwork:

1) Keep supply and exhaust duct systems as short as possible.
2) Minimize joints, elbows, and bends.
3) Make elbows and bends as gradual as possible.
4) Seal all joints.
5) Use ductwork with a smooth interior surface. The smoother the surface, the lower the losses due to friction.
6) Do not install ductwork in outside walls.
7) Install a damper at each grille and register so airflow can be regulated. Or install a damper at each branch duct.

Insulation

The heat exchanger and ductwork are insulated for two reasons: to cut heat losses to the outdoors and to reduce condensation on the outer surfaces of ducts and exchanger. Some exchangers come factory-insulated, some partially insulated, and some not at all. If the exchanger is installed within the heated envelope of the house, insulation is primarily installed to prevent condensation. Follow these rules:

1) Insulate all cold-side ductwork with 1½ inches of fiberglass, or equivalent, and cover with an unbroken vapor barrier. Insulated flexible ductwork is widely available and works well.
2) Insulate the heat exchanger, if not factory-insulated, to R-5. Rigid insulation works well. Carefully cut, fit, and install it, and then tape the seams. Remember to cut a separate piece for each access door in the exchanger casing. In some locations fire codes require that rigid insulation be covered.
3) The warm-side ductwork need not be insulated except for any sections that run through uninsulated space.

If the exchanger is installed outside the building envelope, insulation is used primarily to cut heat losses. In this case, follow these rules:

1) Insulate the warm-side ductwork to the point where it enters the building. The R-value should roughly equal $(\frac{DD}{1000})^2/4$. Install a vapor barrier facing out.
2) In attic installations, some prefer to bury the warm-side ductwork under the attic insulation. In this case the ductwork should still be insulated (with 1½ inches of fiberglass) and wrapped with a vapor barrier before it is buried.
3) Insulate the exchanger to the same level as the warm-side ductwork.
4) The cold-side supply duct need not be insulated and shouldn't be buried in the attic insulation.
5) The cold-side exhaust duct should be insulated with about 1½ inches of fiberglass to prevent condensation and freezing inside the duct. Make sure the joints in this section are well sealed and that it slopes so that any condensate will drain either to the outside or back to the exchanger.
6) Protect the condensate drain from freezing.

Condensate drainage

Most heat exchangers require a method of draining away condensed water vapor. The amount of condensate depends on how cold it is outside and how humid inside. As much as a gallon of water per day can be collected in the northern United States. Rotary-wheel heat exchangers are less likely to condense water than other types, but condensation may still be an issue in severe climates.

The condensate drain pipe may drain into the house sewer system, the foundation drain, or a bucket. The first option is preferred. Make sure a trap is installed to keep sewer gases from venting into the house. (By the way, fill the trap with water immediately after installation.)

Manufacturers usually recommend that the pipe slope ¼ inch per foot away from the exchanger. Also, if the machine is in an unheated space, insulate the drain.

Freeze protection

When the air temperature outside falls below 20°F, ice can form in the heat exchanger core. This can block airflow and, in severe cases, damage the core and the exhaust blower. Rotary-wheel heat exchangers are not as likely to freeze up as counter-flow or cross-flow parallel plate types.

Some heat exchanger manufacturers provide *freeze protection* as an option. If the heat exchanger is to be installed where the temperature is often below 20°F (above 4000 degree-days, typically), freeze protection should be provided. Ask the manufacturer whether your exchanger requires freeze protection for your climate.

For freeze protection, the machines use a defrost cycle, during which only the exhaust fan runs, melting any ice. The cycle is activated either by a remote bulb thermostat that senses when the cold-side duct is below 35°F or an airflow sensor that reacts to reduced airflow caused by ice formation.

Balancing the system

After the heat exchanger system is installed, the airflow at each grille and register needs to be regulated and the total supply and exhaust balanced.

Regulating the airflows is easy if you have the right equipment. Without it, however, you can still do an adequate job. Run the blowers at full speed and adjust each damper to the desired airflow. Then do the same for the grilles. If you don't own a manometer, a thread, cigarette, or a piece of plastic kitchen wrap draped over the bottom of a coat hanger will do. Grilles close to the exchanger may need to be closed down to get air to the more remote grilles and registers.

Balancing the aggregate supply and exhaust airflows is more difficult and more important. Both positive and negative pressures induce infiltration. In the extreme, positive pressures can force moisture into the walls, causing condensation, or can cause icing up of door locks. High negative pressures can draw radon from the soil or cause flue gases to backdraft. Ideally, the exhaust air should be a little stronger than the supply air, creating slight negative pressure.

The airflows are balanced either by adjusting main dampers in the main trunks or by varying the blower speeds (possible on some models). One person adjusts the dampers or speed controls while another gauges the airflow in and out of a slightly cracked window.

While balancing the system open all interior doors and shut tight all exterior doors and windows and vents. Shut off appliances that might affect airflows. This method works best when there is no wind and indoor and outdoor temperatures are similar. The person at the window should have a thread, cigarette, or smoke pencil. Adjust the system till no air movement is detected. Allow plenty of time for the effects of adjustments to appear. (If a slightly cracked window does not work, cut a board to fit in the window opening, drill a ½-inch hole in it and use that.) Finally, set the system slightly in favor of drawing air in, slightly depressurizing the house. ✽