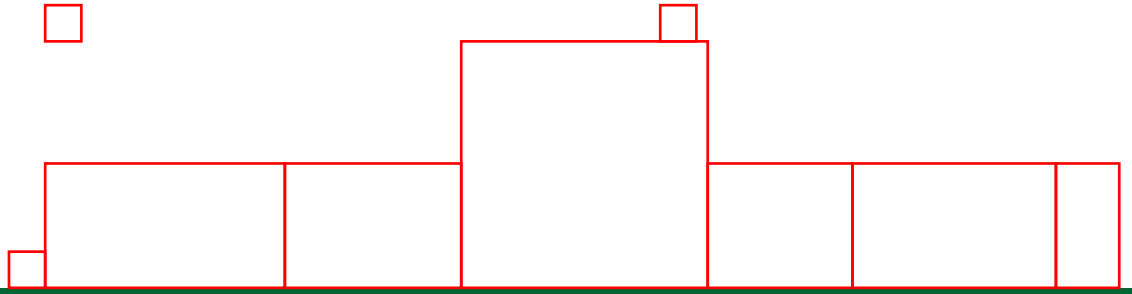




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# Home Energy Magazine Online November/December 1994

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*HEATING SYSTEMS*

# Condensing Furnaces: Lessons from a Utility

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**by Jonathan Beers**

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***If you avoid the common mistakes, condensing furnaces typically can deliver heating savings of 20%-35% assuming the old furnace was in the 60% AFUE range.***

For the last several years, about 90% of the new natural gas furnaces installed in Wisconsin have been condensing furnaces.[1] We have been arranging for installation of condensing furnaces in low-income households for several years and have learned a number of lessons. Our experience is with forced air, natural gas furnaces installed in a cold climate (7,600 heating degree-days). Bear in mind that not all of these recommendations will apply to other regions.

### Laundry and Condensing Furnaces Don't Mix

Choose a sealed-combustion furnace that uses 100% outside air for combustion. Indoor air contains traces of commonly used household products such as bleach, paint strippers, and so on. Condensing furnaces have been known to corrode rapidly if fed indoor air contaminated by these common products. Most manufacturers void warranty coverage for furnaces operated in a contaminated atmosphere. Even fabric softener and salt from water softeners have been suspected culprits. Unless the furnace is near a possible source of contaminants, such as a dry cleaning shop, outdoor combustion air is much better for the furnace. (Salt air near the ocean would probably also cause problems for condensing furnaces, but the only salt water we see in Wisconsin is when the snow melts in the road.) There is mounting evidence that even furnaces in the 80% AFUE range have problems when using contaminated air for combustion. The contaminants cause condensation and corrosion to occur more easily.

Furnace Terms

### Other Benefits of Sealed Combustion

Don't settle for optional kits that add an air intake pipe to dump air into the burner area, because they can still allow contaminated air into the furnace. Sealed combustion doesn't exhaust heated air (assuming the furnace is located indoors). Using outdoor air instead of indoor air reduces air infiltration into the home, and a sealed combustion furnace cannot become starved for make-up air and thereby backdraft the water heater, either. This does not mean that houses with sealed combustion furnaces are immune to pressure differentials caused by poorly balanced ductwork, it only means the sealed combustion system itself won't be affected by them (see "Backdrafting Causes and Cures," *HE* May/June '91, p.30).

### Follow the Installation Manual Scrupulously!

If you make it look just like the pictures in the manual, you'll probably stay out of trouble. Installers should get any available training from the manufacturer. It's better to become adept at installing one brand of furnace than to try to install several brands. Call the manufacturer for support when needed. A good distributor will be a valuable advisor, too. If the installation must deviate from the manual instructions, call the manufacturer to make sure the deviation won't void the warranty. As with any furnace, make sure the gas pressure and input are correct. On the electrical side, ground the furnace properly, and include a manual disconnect switch and fuse. Make sure the ductwork is suitable for the new furnace, and set the blower for the proper temperature rise (see "How to Avoid Potential Problems," p. 16).

*Venting*

Condensing furnaces exhaust the combustion products to the outdoors through plastic pipes. In new construction, these exhaust (and intake) pipes sometimes extend up through the roof. For replacement furnaces, it's more typical to vent through the sidewall. Common venting mistakes include:

- Sloping the exhaust pipe down toward the outdoors rather than back towards the furnace. The exhaust piping must be pitched at least 1/4-inch per foot so condensate can drain freely back through the furnace.
- Inadequate support of the exhaust piping. If sags develop in the exhaust piping, condensate can pool in the low spots, blocking the vent enough to trigger a furnace shut-down.
- Sizing the exhaust pipe incorrectly. Manufacturers specify the maximum length and number of elbows a given pipe diameter can handle.
- Attempting to run the exhaust and intake pipes out different sides of the house. The pipes must be next to each other so that wind pressures are the same on both of them.

Tips on Venting

*Chimney Liners*

As the new furnace no longer uses the chimney for venting, chimney damage may ensue if the water heater is left venting into the original chimney all by itself, at least in a cold climate, (see "Furnace Retrofits Solve One Problem, Cause Another," *HE*

Sept/Oct '89, p.6). The chimney was sized to have a furnace venting into it, and water heater exhaust gases usually don't contain enough heat to rise all the way up and out of a chimney without condensing. The corrosive condensate eats away at the chimney gradually. The usual solution is to snake a flexible aluminum liner down the chimney, downsizing the chimney to match the water heater. The installed cost of a 4-inch diameter flexible aluminum chimney liner in Madison, Wisconsin, is typically $175-$300.

The chimneys most likely to have condensation problems are those that are the coldest and most massive. Masonry chimneys exposed to outdoor temperatures, such as those built into an exterior wall, are particularly susceptible. For very cold chimneys, the chimney liner may need insulation surrounding it to prevent condensation within the liner. Special insulating sleeves can be purchased along with the liner. It's worth noting that chimney liners (or other means of re-sizing the chimney) are often required by code when new non-condensing (78%-82% AFUE) furnaces are installed. The cost of the liner is often higher for a furnace than for a water heater because a larger diameter liner is usually required. When comparing the cost of condensing versus non-condensing new furnaces, don't forget the costs of chimney re-lining and other venting modifications.

Even the lowest efficiency gas-fired furnaces and water heaters allowed by law[2] are prone to condensation problems in the venting system in a cold climate. To meet the federal minimum efficiencies, furnaces and water heaters must send less heat up the chimney. In a cold climate, the choice is often: "Do I want a 90% efficient furnace that's designed to deal with condensate, or an 80% efficient furnace that will require protecting the venting system against condensate?"

Replacing a water heater with a power-vented model and capping off the chimney is an alternative to chimney lining. (Power-venting kits can also be added to an existing water heater.) Lining the chimney, however, is preferable to capping it off for three reasons:

- A chimney-vented water heater doesn't require electricity to operate.
- When the time comes to replace the water heater, chimney-vented models are cheaper to replace and are generally more efficient than side-vented ones.
- Power-vented water heaters are more complex and have had some problems with nuisance shutdowns when their pressure safety switches have mistaken windy conditions for blocked vents.

However, sometimes there are good reasons to abandon the chimney. Among these are persistent backdrafting of the

water heater, the desire to remove the chimney as part of remodeling or re-roofing, and avoiding the cost of needed chimney repairs. In new construction, avoiding the cost of building a chimney can make power-venting very attractive.

*Condensate Drainage*

The furnace must be level or pitched slightly towards the drain so condensate can drain out. The tubing that carries the condensate to a drain can't be pinched or otherwise obstructed. (If flexible condensate tubing is used, avoid kinking by installing a rigid elbow or tee where the tubing joins the furnace.) Also, stuffing the tubing down into a basement drain can pinch it. The condensate is about as acidic as beer or orange juice, and hasn't caused any disposal problems that we are aware of, even with septic systems. Don't bother with a neutralizer cartridge unless it's a code requirement in your area.

If the condensate can't be drained by gravity, install a condensate pump to pump it to an acceptable drain. (Don't use a sump.)

Condensing furnaces have water in them, and will be damaged if they freeze. If a house will be unheated during the winter, check the furnace instruction manual for shutdown and drainage procedures.

*Sizing*

Oversizing a condensing furnace doesn't increase energy costs the way oversizing a conventional furnace used to. However, it's still important to size a condensing furnace correctly for three reasons:

- **Oversizing leads to short firing cycles**. This can cause what's known as "condensate dwell" or excessive "wet-time." The furnace seldom gets a chance to get hot enough to dry out, and condensate forms in areas not designed to handle it. The condensate gets increasingly acidic, and corrosion sets in. This is analogous to driving a car only on very short trips, so the exhaust system stays wet and rusts out prematurely.

- **Oversizing leads to uncomfortable temperature swings** in the living area.

- **Oversized furnaces usually have bigger blowers**. This aggravates one of the common complaints about modern furnaces: excessive air flow out of the registers. These last two problems with oversizing apply to all new furnaces.

*Electrical Consumption*

Most new furnaces are likely to use more electricity than the furnaces they replace, because of bigger blowers and induced

draft fans. Looking at actual consumption records, the average customer in Madison uses about 400-500 kWh more per heating season after a new furnace is installed. Go ahead and weigh the increased electrical consumption against the gas savings, if keeping the old furnace is an alternative. But if you're going to replace the furnace anyway, it's a moot point.

To compare the electrical consumption of different furnaces, check out the *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment* (known as the "GAMA Book," because it is sponsored by the Gas Appliance Manufacturers Association).[3] In general, new furnaces of the same size have similar electrical consumption whether they are condensing or non-condensing. Variable-speed furnaces with DC current blowers are the exception. When operating on low fan speed and low fire, they use less electricity. Variable-speed furnaces save fewer than 500 kWh per heating season under normal cycling operation. But, if the blower is used for continuous air circulation, the electricity savings can be much higher. (Some people operate the blower continuously to make more use of a furnace-mounted air cleaner, or to mix the air in order to de-stratify it, or to circulate fresh air if the blower is part of a balanced whole-house ventilation system.)

How to Avoid Potential Problems

**A Few Final Pointers**

Three final recommendations apply to any furnace:

Bricks, or a concrete pad placed under the furnace prevent water damage. If the basement gets wet, having the furnace raised up a few inches can keep it out of the water.

Get an external filter rack (slot) so that the access panel doesn't have to be removed to change the filter. At a minimum, use pleated filters for better dust removal. For even better filtration, use deep pleated media filters. The locally made Space-Gard dominates the Madison market. Replacement costs for Space-Gard media filters run about $25 per year. Electronic air cleaners are very good, and eliminate buying replacement filters, but the equipment costs more to buy. Some homeowners neglect to maintain their electronic air cleaners to the point that the air cleaner fails. Electronic air cleaners may also produce low levels of ozone, which can be a lung irritant.

Seal the ductwork, especially the filter slot and where the supply plenum meets the furnace. Permanently close any grille in the return duct near the furnace.[4] n

**References**

1. Jeff Schlegel and Ralph Prahl, "Market Transformation: Getting More Conservation and Energy Efficiency for Less Money" *Selected Readings, Affordable Comfort '94*, Philadelphia, PA, March 1994.

2. "Energy Conservation Standards for Consumer Products" from the Electric Power Research Institute, Inc. (EPRI) 1992, is a concise guide to Federal energy efficiency standards. Call (510)934-4212 to order a copy.

3. *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment*, The Gas Appliance Manufacturer's Association (GAMA) provides a copy of this directory to all public libraries. To order a copy, call ETL Testing Laboratories, Inc. at (607)753-6711.

4. Ted Haskell and David Brook, "Duct Sealing and Insulating" from Oregon State University Extension Service, 1530 S.W. Taylor Street, Portland, Oregon, 97205. Tel: (503)737-3004; Fax:(503)731-4570.

5. Madison Gas and Electric Co. has a furnace brochure written for consumers called *Furnaces*, and an electronic version is available. Contact: Jonathan Beers, MG&E, P.O. Box 1231, Madison, WI 53701-1231.

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**Furnace Terms**

**AFUE** - Annual Fuel Utilization Efficiency. Similar to mileage ratings for cars. The higher the AFUE for a furnace, the more efficient the furnace. All furnace models are tested using U.S. Department of Energy procedures to assign their AFUE rating. The lowest allowable AFUE (as of 1992) is 78%.

**Chimney Liner** - A protective metal tube inserted into a chimney. It prevents damage and sizes the chimney to match the equipment vented into it. For natural gas appliances, flexible aluminum chimney liners are usually the best value. Be sure to get a liner that has building code approval and is specifically manufactured for use as a chimney liner.

**Condensate** - The mixture of water and combustion by-products formed by a condensing furnace when heat is reclaimed from exhaust gases.

**Condensing Furnace** - This is a furnace with an AFUE of 89% or higher. Efficiency is achieved by extracting heat from the exhaust gases to the point where water is condensed out of the gases. This condensed water is typically disposed of in a

floor drain.

**Heat Exchanger** - The part of the furnace that transfers heat from the burners to the house air circulating though the furnace, while acting as a barrier between the house air and combustion gases. If cracks or holes develop in the heat exchanger, combustion gases can mix with the house air. If this happens, the furnace needs to be replaced.

**Heat Loss** - The rate at which heat is lost from the home. Contractors should calculate the heat loss for the coldest weather expected when sizing a furnace for a home.

**Humidifier** - For adding moisture to the house air, and used only during the heating season, furnace-mounted humidifiers are an optional add-on.

**Power Venting** - To blow combustion products outdoors using a small fan. Typically the vent pipes energy from the side of the house at least 11/2 feet above the ground. Also called induced draft or fan-assisted draft. Most new furnaces are power vented and the exhaust blower is part of the furnace.

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**Tips on Venting**

Most condensing furnaces are vented using the same types of PVC plastic pipes commonly used for plumbing.

Most manufacturers sell vent termination kits that hold the plastic pipes in the correct configuration. The installer has the sometimes tricky task of finding an acceptable location for the plastic pipes to exit the building. Required clearances for vent terminations vary. Most manufacturers prefer venting their furnaces vertically through the roof. This is better for the equipment and avoids the hassle of finding an appropriate sidewall vent termination. Nevertheless, almost all replacement furnaces vent out of the wall because it's easier than running plastic pipe up through the living area and out the roof.

*Some common restrictions on sidewall venting:*

The exhaust and intake pipes must be above the highest anticipated snow level. (Don't forget drifting snow.) Exhaust pipes can't be near windows or fresh air intakes that might draw exhaust gases into the house. Don't put an exhaust vent above a walkway: ice condensation on the pavement below the vent could freeze and cause a fall. Air intake pipes on sealed combustion furnaces can't be close to vents for dryers or power-vented water heaters, or they'll draw in contaminated

air. Similarly, don't point the vent the direction of a strong prevailing wind. Combustion products can blow back into the air intake and feed contaminated air to the furnace. More rarely, a safety switch may sense the wind as a blocked vent and shut the furnace down. Or, the moist exhaust air can blow back and ice up the wall, causing problems with the siding.

Some homeowners are concerned that kids will dump balls or gravel down the vent pipes, or that birds will get into them. Some contractors have responded by screening the exhaust vent with wide mesh. While this may be good for the homeowner's peace of mind, it is prohibited by some manufacturers. During very cold and windy weather the screening collects ice, blocking the vent and causing a furnace shutdown. And even if screening is installed, it will corrode into rust flakes within a year or two. A more likely problem is killing a treasured plant with exhaust gases.

*Other common venting questions:*

**Why can't a condensing furnace just vent into a chimney?**

The exhaust gases from a condensing furnace are cooler and therefore aren't buoyant enough to create a draft in a chimney. As a result, they would condense inside the chimney and corrode conventional chimney materials.

**Can the plastic exhaust pipes run up through the chimney, using it as a raceway?**

Only if there is no water heater or other appliance still venting into the chimney. Check the manufacturer's requirements carefully. The vent pipe must be protected from freezing when run through an unheated space such as a chimney.

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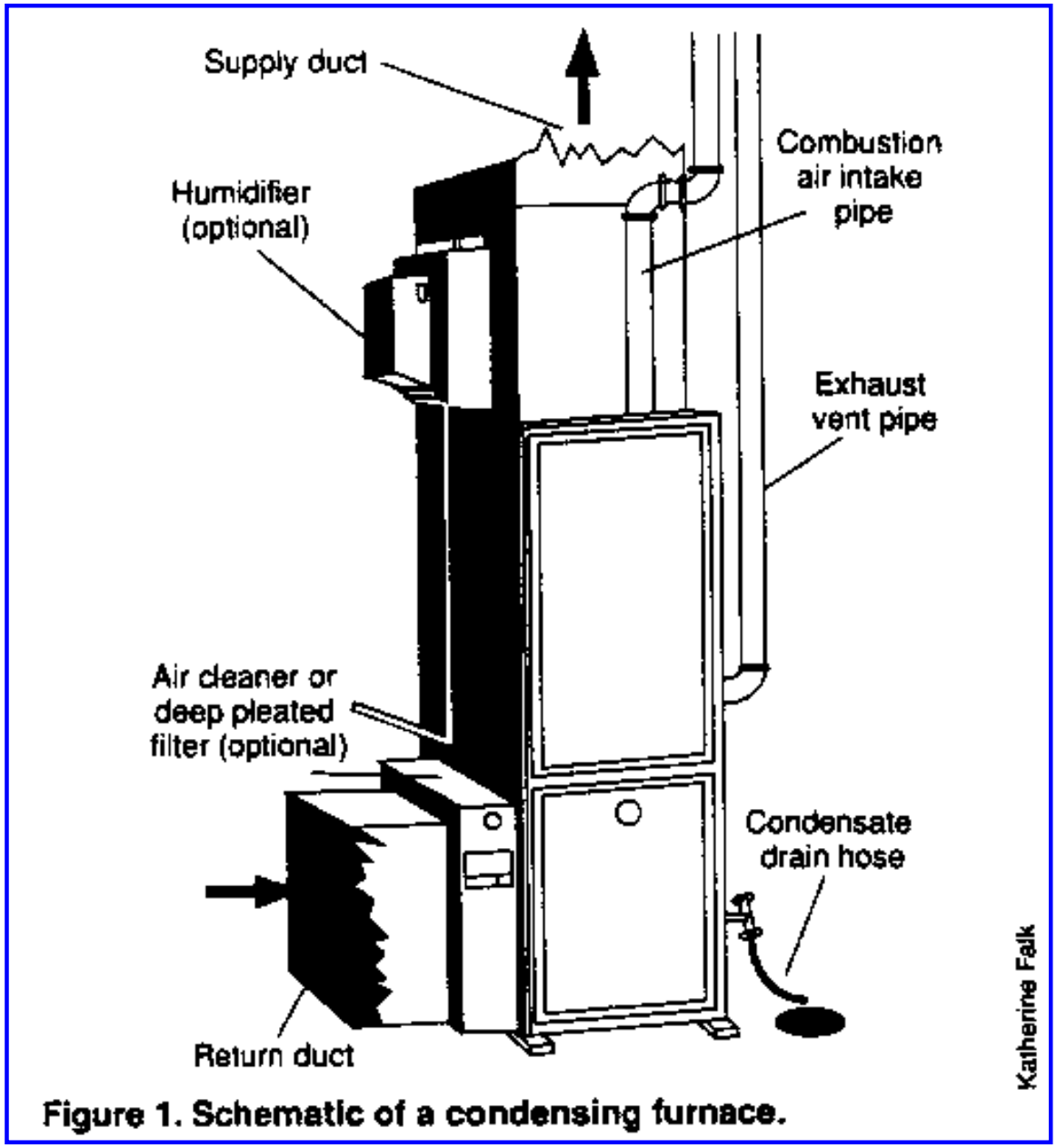


**Figure 1. Schematic of a condensing furnace.**

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### How to Avoid Potential Problems

People who change from a conventional to a condensing furnace often notice differences. The most common of these is cooler air coming from the registers. ("How can it heat my house if it blows cold air?") One way of making a furnace more efficient is to blow more air across the heat exchanger and deliver that warm air at a lower temperature. But, even 100deg.F air feels cool if it's blowing across your skin. Combine that higher flow of cooler air out of the registers with the extended running time for the blower (to wring more heat from the heat exchanger), and you are likely to have a recipe for a dissatisfied customer. Smaller homes with shorter duct runs are especially prone to this problem, and the noise from too much air pushing through inadequate ducts can magnify the annoyance. When the time comes for a new heating system, small houses or houses with low heating costs may be better served by a non-condensing furnace (or an integrated "combo heater," see "Once Heated, Twice Used," *HE* July/Aug '92, p.14).

There are at least four ways to minimize these problems:

- Choose a furnace with the smallest blower possible. Some manufacturers offer a choice of two blower sizes for a furnace with the same gas input. (For example, the Carrier/BDP line of condensing furnaces has a 40,000 Btu/hour input model that comes with a choice of blowers sized for 2 tons or 3 tons of air-conditioning.) Unless the larger blower size is needed to overcome the restriction of a big air conditioner coil or unusual ductwork, the smaller blower will throw less air out of the registers, and the air will be warmer. The smaller blower will use less electricity, too.

- Set the blower to the lowest speed that will keep the temperature rise across the heat exchanger within the upper half of the range specified by the manufacturer.

- Add more supply (and/or return) registers. This may not change the air-delivery temperature, but it can slow down the air velocity and lessen noise. It's a good sign if an installer recommends more ducts, as it shows some thought went into matching the blower to the ductwork. The supply and return ductwork should be balanced so they have roughly the same capacity in cubic feet per minute (CFM).

- Buy a variable-speed furnace with a direct current (DC) blower. These top-of-the line furnaces operate at low blower speed and low fire (low heating capacity) most of the heating season. The result is quieter operation, slower air delivery at a higher temperature, and more even temperature control. Be sure to buy from a contractor with experience installing and servicing these more complex furnaces. *Note that the more-restrictive filters will also reduce air flow, and that all of these methods (except adding registers) will save blower energy.*

**Noise** complaints can also originate from the induced draft fan (exhaust blower), pulse combustion (the Lennox Pulse

furnace requires mufflers and vibration isolation), and even the clicking of spark ignition. Induced draft fans and spark ignition are found on many new non-condensing furnaces, as well.

**Higher Humidity**: Unlike conventional 60% efficient AFUE furnaces, new furnaces don't continuously exhaust air up the chimney because of the stack effect. Getting rid of an old furnace located indoors can have the same effect as removing a continuously running exhaust fan. An existing moisture problem may get worse. On the other hand, a too-dry house may no longer need a humidifier.

**Equipment Failures**: The most common equipment failures have been associated with induced draft fans and intermittent ignition devices (IIDs). Manufacturers have been fairly responsive in addressing and dealing with these problems. If you want to avoid buying a condensing furnace with an induced draft fan, the Lennox Pulse condensing furnace is the only choice on the market. The Lennox Pulse does have a fan that purges the system before the furnace ignites, but this fan turns off after ignition. There seems to be an industry trend away from spark ignition and toward ceramic glow-bar-type IIDs. The glow bars (similar to those used in gas clothes dryers) appear to be more reliable, but are more fragile during shipment.

Heat exchanger corrosion was a problem with some earlier generations of condensing furnaces, but we haven't seen this problem on fully sealed combustion furnaces. Warranties on heat exchangers are typically at least 20 years.

## Related Articles

"The Best Boiler and Water Heating Retrofits" (Lobenstein and Hewett)
"Combustion Safety Checks: How Not to Kill Your Clients" (deKieffer)
"Don't Force Air, Go with the Flow" (Springer)
"Downsizing Steam Systems" (Gifford)
"Fireplaces: Studies in Contrasts" (Hayden)
"Integrated Heating and Ventilation: Double Duty for Ducts" (Jackson)
"The Key to Persistence" (Nolden)
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