Working the Bugs Out of High–Efficiency HVAC

After years of spotty performance, high-efficiency heating and cooling may have licked the reliability problem

by J.D. Ned Nisson

Gazing at the innards of the newest residential heating and cooling equipment is a little like looking under the hood of a new car. Gone are the familiar basic components of yesteryear such as distributor caps and simple air filters. In their place is a jungle of electronics and mechanical components intended to boost performance and to control polluting emissions.

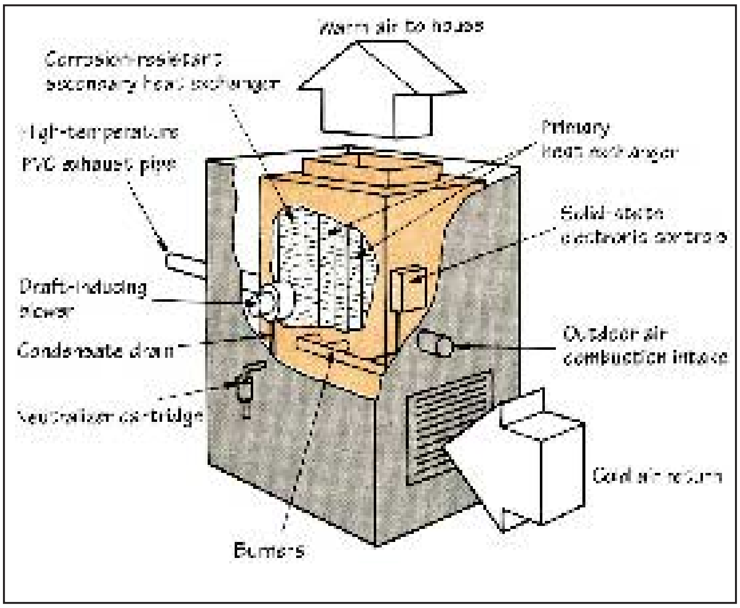


Figure 1: *Look inside a high-efficiency furnace and you'll see components not found in low- and mid-efficiency models. The draft-inducing blower plays a key role, drawing air into the combustion chamber for more efficient controlled combustion, then forcing the hot air through the primary and secondary heat exchangers for maximum heat transfer. As the combustion air passes through the secondary heat exchanger it cools to the point where moisture condenses, releasing another burst of heat.*

For cars, the technological maze under the hood has proved remarkably reliable as long as it is serviced by a well-trained mechanic. For residential hvac appliances the story is a bit more complex. Some appliances have enjoyed a relatively trouble-free evolution to higher efficiencies. Heat pumps and air conditioners, for example, were not radically modified to increase efficiency. No new major components were added and the newest units are not generally more complex or more difficult to install than older, lower-efficiency models.

Gas furnaces, on the other hand, have had a long and bumpy journey to high efficiency. Several new major components were added, including secondary heat exchangers, draft inducers, and electric ignition (see Figure 1). Some of the mechanical components in early models were poorly designed and failed regularly. A few models, such as the Amana Energy Command and Lennox Pulse used totally new technology with almost no resemblance to "conventional" furnaces.

The Amana unit, which used water and glycol heat transfer fluid, is one of only two furnaces that can heat domestic water (the other is Glowcore). However, it has run into a string of problems, including glycol leakage in early units. Last year, Amana brought out a new and less expensive condensing gas furnace using more conventional technology.

The Lennox unit pioneered "pulse combustion," and after early problems with noise, turned out to be

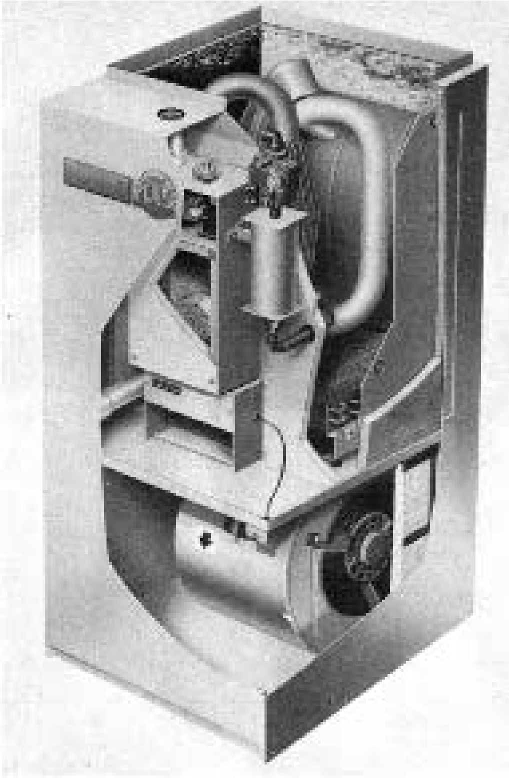


Figure 2. *After early problems with noise, the Lennox Pulse turned out to be one of the biggest success stories in high-efficiency hvac.*

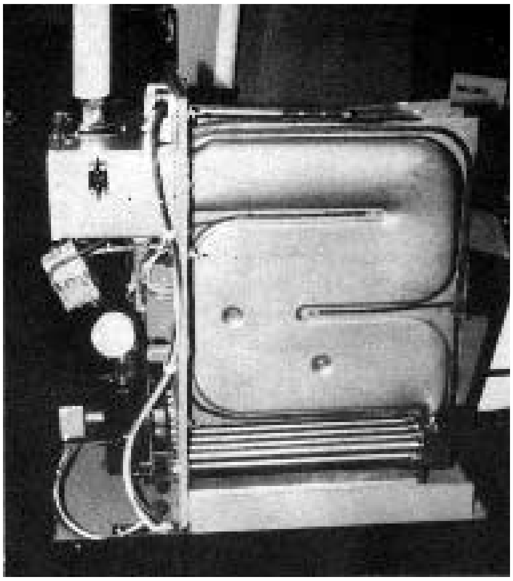


Figure 3. *The Yukon oil furnace, one of only two condensing oil furnaces on the market, uses highly resistant (and very expensive) AL29-4C stainless steel for the secondary heat exchanger and 301 stainless steel for the primary.*

one of the biggest success stories in high-efficiency hvac (see Figure 2). The first ten years of development, from 1980 to 1990, were fraught with factory recalls, contractor callbacks, and dissatisfied consumers who complained of nuisance shutdowns, noise problems, and poor comfort. Some homeowners even (unfairly) blamed their high-efficiency furnaces for moisture and indoor air quality problems.

Things got so bad that in 1985 a group of contractors at the Air Conditioning Contractors of America annual meeting offered a resolution stating that they had suffered "unacceptable loss of time, money, and reputation due to multiple failures of new high-efficiency equipment."

The good news is that after ten years of trial and error combined with applied research, most of the design problems appear to be fixed. But there is still one catch. Unlike automobiles, which are fully preassembled and ready to drive, hvac must be properly installed. High-efficiency equipment, particularly condensing furnaces and boilers, is generally less forgiving of installation error than older equipment. A few basic guidelines and specifications must be followed to ensure good performance and trouble-free, long-lasting service.

Corrosion in Condensing Gas Furnaces

The Arkla Recuperative Plus gas furnace was introduced in 1982 and recalled in 1984 after more than 2,000 reported claims of heat exchanger corrosion and carbon monoxide problems. The same furnace was also sold under different names by GE, Trane, and Snyder-General. This was the beginning of the worst problem to plague high-efficiency gas furnaces. The next five years saw recalls of Heil, Whirlpool, and Coleman condensing gas furnaces — all for heat exchanger corrosion.

The situation has been vastly improved, but not completely fixed. After extensive research at Battelle Laboratory and the American Gas Association Laboratories, manufacturers now use corrosion-resistant materials for heat exchangers and other components. Most use a special stainless steel alloy called AL29-4C for the secondary heat exchanger (see Figure 3), although some have tried different approaches with varying success. For example, Heil tried a ceramic-lined heat exchanger that had to be recalled due to scaling problems, while Carrier uses a plastic-lined heat exchanger, which seems to be working well.

Chloride a problem. Regardless of the type of heat exchanger, high-efficiency furnaces can and do still rust badly if the combustion air contains high levels of chlorides. The chloride combines with water vapor in the flue gases to form a corrosive condensate that attacks metal parts in the heat exchanger and exhaust system. Bard Manufacturing Company voids its lifetime warranty if a heat exchanger in one of its gas furnaces is corroded from "contaminated air."

Unfortunately, indoor air often contains large amounts of chloride compounds, especially in basements and near laundry rooms. It comes from chlorinated tap water, chlorine bleaches, and a host of other household products such as paint, paint stripper, and adhesives. The results of an extensive testing of 572 houses conducted by Battelle Laboratory indicated that 1 in 10 homes has indoor air chloride concentrations high enough to produce corrosive flue-gas condensate.

Even outdoor air sometimes contains high chloride levels, particularly near swimming pools, hot tubs, and clothes dryer exhausts. One horror story is told by David Hahn, a training specialist at Wisconsin Natural Gas who has inspected hundreds of failed systems.

Hahn was called in to inspect a Lennox Pulse furnace with corrosion problems. The house was located near a road-salt storage depot and the road was usually covered with spilled salt. The chloride concentration in the outdoor air was so high that the furnace rusted out completely in only eight months! The solution, according to Hahn, was to install a new furnace with the combustion air intake at the back side of the house, away from the road.

Venting Problems

Venting high-efficiency condensing furnaces (those in the 83% to 97% AFUE, or *annual fuel utilization efficiency*, range) is actually easier and less problematic than venting mid-efficiency furnaces (78% to 83% AFUE). But despite their apparent simplicity, these vent systems have had problems.

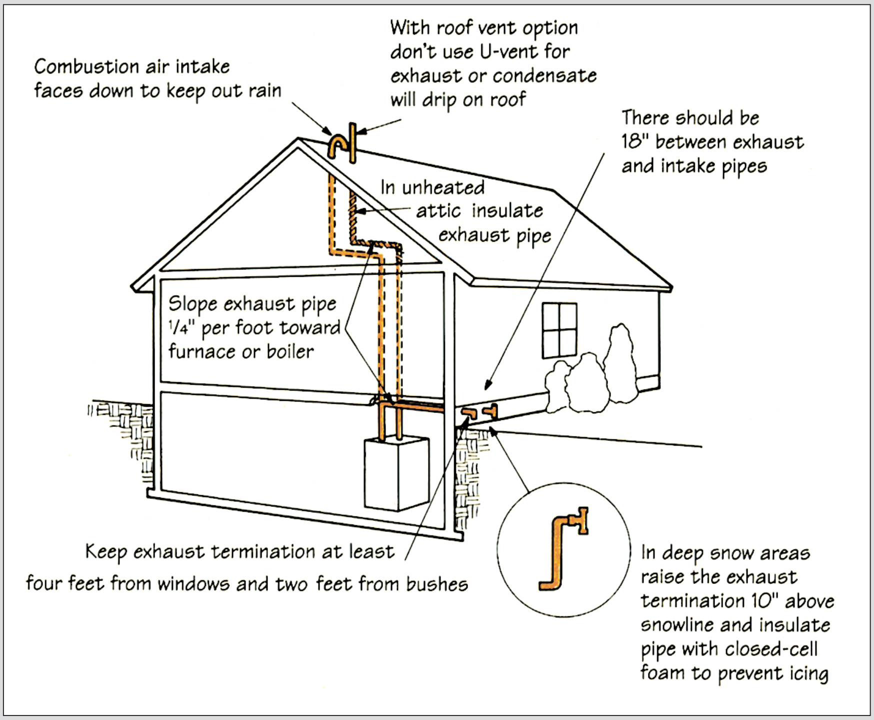
Nuisance shutdowns. A 600-house Canadian study of high-efficiency gas furnaces found that 16% of the installations suffered frequent shutdown due to improper vent installation. These "nuisance shutdowns" are most likely to occur if the vent system is too long or improperly sloped. Some building codes prohibit venting a furnace in the direction of neighboring houses. To comply with this restriction, contractors sometimes install long horizontal runs to reach the back or front of the house. The long pipe creates high static pressure. A wind against the termination may then be all that is needed to raise the back pressure above

Avoiding Corrosion Problems.

To minimize corrosion problems with high-efficiency furnaces and boilers, follow these recommendations:

- Use only outdoor air for combustion.
- Locate air intake away from potential outdoor chloride sources such as swimming pools and dryer exhaust vents. If necessary, run the air intake through the roof rather than a sidewall.
- Make sure the furnace is installed level. If not, condensate may collect in the heat exchanger, increasing the potential for corrosion.
- Never use an installed high efficiency furnace as a construction heater. Not only is this likely to contaminate the furnace and duct system with construction dust (true for any type of furnace), but sealers and adhesives can quickly damage the heat exchanger surfaces.

Venting Guidelines



By following a few basic guidelines, most of the annoying problems associated with venting high-efficiency furnaces and boilers can be eliminated.

- Keep vent runs as short as possible. Never exceed manufacturers' guidelines (typically 30 to 40 feet with two elbows).
- On horizontal runs, the vent pipe must slope toward the furnace, allowing condensate to drain back into the furnace.
- Keep the exhaust termination 10 inches from the wall to reduce icing on the wall and to prevent paint damage. If the vent faces prevailing winds, install a protective plate around the termination to protect the wall.
- Maintain about a 2-foot clearance from shrubbery.
- Never use a "U" termination on a roof vent. Dripping condensate can damage roofing and gutters. The roof vent should be a straight vertical pipe. Rain will not be a problem since it will drain through the condensate drain.
- Insulate any section of vent pipe that passes through unheated spaces or extends more than 3 feet outdoors. The vent pipe should also be insulated if an exterior masonry chimney is used as a chase.
- Do not install exhaust vents over anything that cannot tolerate dripping condensate. This includes walkways, windows, air conditioners, gas meters, etc.
- Do not install the exhaust vent near any air intakes or under windows. Aside from the obvious hazard of drawing exhaust gases into the house, rising water vapor will be visible through windows and can even condense moisture on the glass surface.
- Locate the vent terminal so that the noise will be directed toward open space or through the roof rather than toward a neighboring house which could echo the sound (and annoy the neighbor).

the setpoint of the safety pressure switch, which then shuts down the system. (This typically occurs around midnight on Christmas eve.)

Annoying fumes. Flue gases from condensing furnaces are not terribly toxic, but they do contain slightly acidic vapors, considerable moisture, and trace amounts of pollutants. They are also accompanied by noise. Improperly positioned exhaust vents can kill bushes, steam up windows, and annoy neighbors. In one installation in Madison, Wis., a contractor put the exhaust vent directly over the outdoor air conditioner unit. Dripping condensate corroded the air conditioner casing and eventually penetrated into the outdoor coil, causing the air conditioner to fail.

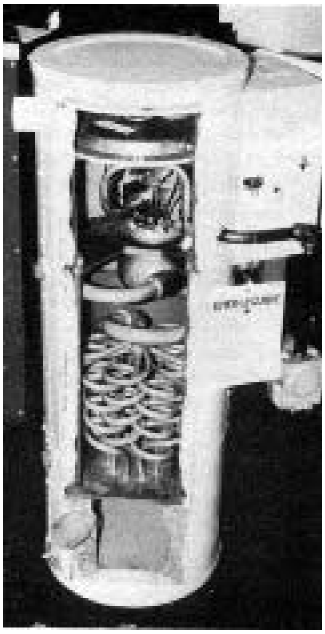


Figure 4. *The Hydropulse is the first and only residential pulse boiler. Like its furnace cousin, the Lennox Pulse, it has enjoyed a relatively trouble-free history.*

In another installation, a dripping roof vent termination rusted out the metal rain gutters. And one disgruntled homeowner in Arlington, Mass., had her contractor move the vent termination for her Glowcore furnace because of the unsightly "steam" visible through the living room picture window.

Noise. High-efficiency gas furnaces are generally noisier than low efficiency units because the main blowers are bigger and because they have an additional draft-inducing blower that is not used in low-efficiency furnaces. The original Lennox Pulse furnace was terribly noisy, especially when not installed properly. (Lots of jokes were made about small outboard motors in the basement.)

The best news regarding noise is the development of variable-speed furnaces by Carrier and Trane, both of which are so quiet that it is hard to tell they are operating when standing 2 feet away. And Lennox has significantly reduced sound levels from the Pulse furnace and has announced an even quieter variable-speed Pulse, which is due out this winter.

Boilers

Despite some radical departures from conventional design, high-efficiency boilers have been relatively trouble free (see Figure 4). One nagging problem that plagued the first high-efficiency systems was condensate formation in the heat exchangers and flue pipes.

To protect the heat exchangers, all high-efficiency boilers now have thermostatic bypass valves which shunt supply water back to the heat exchanger to prevent flue gas condensation. Unfortunately, nothing is foolproof. In one case, a contractor in Springfield, Mass., neglected to install the bypass valve on a Heatmaker boiler. With no temperature control, the boiler ran too cool, resulting in serious condensate damage to the heat exchanger.

To eliminate flue corrosion, literally every manufacturer now recommends high-temperature plastic flue pipe made of GE "Ultem" resin (see Figure 5, next page). Some manufacturers also allow Type 301 stainless steel, which is almost as resistant to corrosion, but much more difficult to work with.

One problem with mid-efficiency (83% to 88% AFUE) boilers has to do with condensation in masonry chimneys, particularly with chimneys located on outside walls. The corrosive condensate can attack mortar joints in unlined chimneys and can even cause damage in chimneys with clay liners. If possible, mid-efficiency boilers should be side-vented using stainless-steel or high-temperature plastic vent pipe.

Air Conditioners and Heat Pumps

High-efficiency air conditioners and heat pumps have not suffered any notable problems other than those normally associated with compressor technology. If anything, the new high-efficiency air conditioners and heat pumps are more reliable than older equipment.

The most noteworthy development was the scroll compressor (see Figure 6, next page), which was first introduced by Lennox in 1987 in its HP-20 heat pump. Most of the other major equipment manufacturers quickly followed. Using far fewer parts than conventional piston-type compressors, scroll

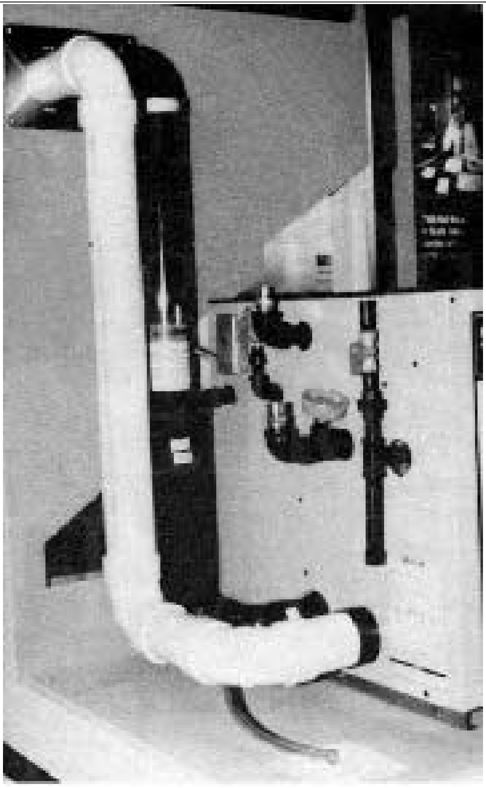


Figure 5. *Corrosion-free venting.* *To prevent corrosion in a high-efficiency boiler, such as the Weil McLain GV model shown here, the venting system must be Ultravent or Plexvent high-temperature plastic vent pipe (the black pipe in the photo). Made of GE Ultem plastic, these vent systems can withstand temperatures up to 480°F. The white pipe is the fresh air intake, which is made of ordinary Schedule 40 PVC.*

Figure 6. *The new Copeland Compliant Scroll compressor is more efficient and reliable than conventional piston compressors. Most major heat pump manufacturers now sell models equipped with scroll compressors.*

compressors are not only more efficient, they also are quieter and more durable.

One problem with high-efficiency cooling equipment is its generally lower dehumidification capacity. During very humid weather, these units sometimes reduce indoor temperature without removing sufficient humidity — the so-called "cool but clammy" effect.

Manufacturers have effectively addressed this problem with variable-speed (Carrier and Trane) and two-speed (Lennox) equipment that has variable dehumidification capacity. Contractors can also help the problem by not installing oversized equipment, which naturally tends to cycle more frequently. Since dehumidification is lowest during startup, frequent cycling causes poor dehumidification.

New Federal Regs

High-efficiency heating and cooling equipment has captured only a small share of the residential market so far. The situation will most likely change, however, when the new federal minimum efficiency standards take effect on January 1, 1992.

The federal regulations will completely eliminate low-efficiency furnaces, boilers, and air conditioners from the marketplace. Given the relatively small price differential between the remaining mid- and high-efficiency models, the buying public may tend to skip to top-of-the line models. So it makes sense to familiarize yourself with the new technology.

Training available. When Weil McLain introduced its new GV series boiler, it also produced an excellent training video and workbook that explains exactly how and why the system works and then shows detailed step-by-step installation procedures. Carrier, Trane, and Lennox all produce comprehensive training materials and seminars. In addition, the installation manuals that accompany all appliances usually (but unfortunately not always) include most of the recommendations and guidelines given in this article, along with all the necessary details for proper installation and startup. ■

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