Heating With Sealed-Combustion

With concerns about indoor air quality on the rise, heaters equipped with power vents and combustion air supplies are becoming the industry standard

by Tim Maker

The "direct exhaust system" option on this Dunkirk EV water boiler includes both a "pressure-fired" burner and a combustion air duct. Because the power burner pressurizes the vent piping, it's important to seal joints and avoid loose connections that could allow exhaust to escape into the house.

Choosing the right mechanical equipment for an airtight, energy-efficient house presents a basic problem: In a tight house, so little air leaks in from outdoors that it can be difficult for standard, chimney-vented boilers and furnaces to get enough combustion air. More important, powerful exhaust fans in the kitchen and bathroom may depressurize the house, overcoming the ability of the chimney to vent toxic combustion gases to the outdoors (see "Are Your Houses Too Tight?" 8/94). The result can be spillage of these gases back into the house, with potentially dire consequences for the occupants.

There are several solutions to the problem of depressurization in tight houses. A whole-house ventilation system, for example, supplies makeup air and keeps indoor and outdoor air pressure equal. Or, as many building codes require, a fan supplying makeup air to the furnace room can be wired to come on with the house's exhaust fans, bringing air into the house at the same rate it is flowing out.

Fortunately, there's a simpler solution — use sealed-combustion heating equipment. Codes haven't yet defined "sealed combustion" as any single feature or property of heating equipment,

Figure 1. *Like many high-efficiency condensing furnaces, Carrier's WeatherMaker uses plastic pipe both to vent through the sidewall and to bring combustion air to the burner. The acidic condensate is also carried away in plastic drain piping.*

and terminology in the hvac industry varies (see "Glossary"). For the purposes of this article, a sealed-combustion heating appliance must have one of two distinguishing characteristics (preferably both):

- It must be non-chimney-vented and resist spillage by pushing or pulling exhaust gases through a vent.
- It must duct outside air directly to the burner to feed combustion.

Furnaces and Boilers

Hundreds of furnaces and boilers meet the criteria for sealed combustion. Most of these are gas-fired furnaces, and a few are gas-fired boilers. Fewer still are oil-fired furnaces and boilers (although some companies make both gas- and oil-fired models).

All of these heating appliances are listed by the Gas Appliance Manufacturers Association (GAMA) in a book issued twice a year: *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment* ($10 per year from ETL Testing

Glossary

AFUE — Annual Fuel Utilization Efficiency, a commonly used measurement of seasonal efficiency for furnaces and boilers. Sealed-combustion units typically have an AFUE above 85%.

atmospheric furnace — A chimney-vented furnace whose combustion chamber operates at the same pressure as the ambient room air. Less efficient than a *condensing furnace* and susceptible to spillage.

CAE — Combined Annual Efficiency, a recently instituted standard for measuring the efficiency of a single appliance used for both space and water heating.

concentric vent — A double-walled vent pipe used in some sealed-combustion water heaters and space heaters. Typically, the inner pipe carries exhaust to the outdoors; the outer pipe brings fresh air to the burner. Also called a *coaxial* or *double-channel* vent.

condensing furnace — A furnace that achieves high efficiency by recovering heat from exhaust gases as they condense to liquid. Often uses stainless steel components, and provides for drainage of the acidic condensate.

depressurization — The condition of a house or part of a house when air pressure inside is less than outdoor air pressure. Commonly caused by kitchen and bathroom exhaust fans.

direct vent — Means of venting that does not rely on a chimney to produce a draft. Typically uses horizontal duct runs that directly penetrate the outside wall (duct sometimes runs vertically, using a chimney as a chase, but not for draft). Often used synonymously with sealed combustion and sidewall venting.

EF — As applied to water heaters, the Department of Energy test-certified daily efficiency (the water heater equivalent of AFUE) expressed as a decimal. Most water heater EF ratings are less than .65 (65%), but some sealed-combustion units have an EF above .70 (70%).

induced draft — see *power venting*

natural venting — Means of venting that uses natural forces, such as convection, and usually relies on a chimney to produce draft.

power burner — A gas or oil burner that creates enough positive pressure in the combustion chamber to force exhaust out through the vent. Some sidewall-vented appliances use power burners instead of power venting.

power venting — Direct venting that uses a fan to provide draft. The fan can be integral to the appliance or installed as an add-on. Also called *induced draft*.

sealed combustion — General term for combustion appliances that vent through a sidewall without a chimney, and that draw combustion air directly from outside. Sometimes denotes only the combustion-air feature.

seasonal efficiency — A measurement of average efficiency over a period of time (usually one heating season for furnaces, one day for water heaters).

sidewall venting — see *direct vent*

spillage — The leaking of exhaust gases back into the house through the vent. Spillage can occur when the area near a chimney-vented combustion appliance is depressurized.

How to Measure Efficiency

When it comes to combustion equipment, the terminology used to measure efficiency can be confusing. Steady-state, seasonal, AFUE, EF, heat transfer, recovery — which terms are most meaningful to builders and their clients?

For any piece of combustion equipment, whether it's a furnace, boiler, or water heater, the bottom line is the amount of energy available in the fuel that the equipment can deliver over time as heat. There are several ways to measure this, but some are more useful than others. Two of the most common gauges are *steady-state* and *seasonal efficiency*. Steady-state efficiency is a "snapshot" of a burner's efficiency while firing. But it does not account for energy lost between firing cycles, and for the effect of different types of heating loads that may occur over time.

Seasonal efficiency, on the other hand, measures average efficiency over an entire heating season, and takes into account the different operating characteristics of a heating system during peak heating months compared with fall and spring. For water heaters, however, "seasonal" efficiency applies to the *daily* cycle, since hot water demand and efficiency vary by time of day but not so much by season.

AFUE and EF. Laboratory test procedures have been established to account for the differences between how space-heating and water-heating equipment operates. The heating system standard is called the Annual Fuel Utilization Efficiency, or AFUE; for water heaters, the standard is called the Energy Factor, or EF. Actual performance of equipment in the real world will, of course, differ from efficiencies reported by lab tests, but both of these standards are generally accepted as the best means for comparing models and brands of new equipment.

Chimney-vented appliances are inherently less efficient than sealed-combustion types. Because the chimney is always drawing air — even when the burner isn't firing — it pulls heat out of the system between cycles.

Water-heating efficiency ratings are also lower than those for space-heating equipment. Most have EF ratings of less than .65 (65%), while most furnaces and boilers have an AFUE between 80% and 90% (some condensing units have an AFUE as high as 96%). The reason for this difference is that in the coldest weather, central-heating equipment fires almost constantly, operating at close to steady-state efficiency. Water heaters, by contrast, fire intermittently, and they have a large flame designed for quick temperature recovery. The infrequent firing pattern is less efficient than the longer, steadier firing cycles of space heaters.

— *T.M.*

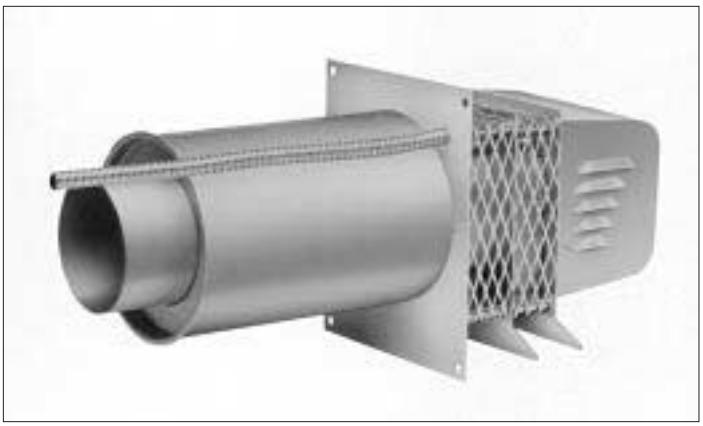


Figure 2. *The synchronized controls for this Field Controls SWG-4 power venter turn the vent fan on whenever the burner fires. Depending on the Btu output of the heating appliance, a sidewall-mounted power venter can pull exhaust to the outdoors through a long horizontal duct run.*

Figure 3. *Combustion-air kits, such as the In-Forcer by Tjernlund, usually use a 50-cfm fan to bring outside air directly to the burner. Special controls turn the air-supply fan on whenever the burner fires.*

Laboratories, 3933 U.S. Route 11, Cortland, NY 13045; 800/907-5352). The GAMA book is most useful if you need to verify efficiency ratings for a particular model. Unfortunately, it isn't very helpful if you want to browse to see what's available.

The best way to start your search for sealed-combustion gas furnaces and boilers is to talk to your local hvac supplier. Ask for product literature on high-efficiency equipment, and read it carefully. The information you want, however, may not jump out at you. Here are some features to look for. (For a list of products mentioned in this article, see "Product Information".)

Venting. First, look to see what the literature has to say about venting. Instead of a natural-draft chimney, sealed-combustion units use a vent pipe to exhaust combustion gases. The literature may use several different terms to indicate this, including "sidewall venting," "power venting," and "direct venting." Some units may show a plastic vent pipe running vertically

inside a chimney, but the chimney is used only as a chase and does not supply the draft.

The type of material used for the vent pipe is another clue. Sealed-combustion appliances usually use small-diameter plastic vent pipe instead of large-diameter metal vent pipe (Figure 1), although some models still use stainless steel. Always check the specs to see how far from the sidewall the unit can be placed. Models with built-in power venting can typically be installed with much longer vent runs than those without.

Air supply. As is the case with venting, there is also no single term used by the industry to denote direct supply of outside combustion air. The terms "sealed combustion" or "outside air" often signal that the air supply is decoupled from indoor air, but these terms are not used consistently by all manufacturers.

Not all direct-vent heating appliances use outside air for combustion. Condensing gas furnaces and boilers, for example, are high-efficiency, direct-vent appliances, but they do not always draw combustion air from outside. If you're not sure after reading the product literature, question your supplier or consult the GAMA book to verify this feature.

Efficiency. Also look for efficiencies above 85% AFUE (condensing units will be in the range of 90% to 96%). Sealed-combustion gas furnaces and boilers may also have features associated with high-efficiency equipment, such as electronic ignition or hot-surface ignition.

Sealed-Combustion Retrofits

So far, we've looked at how to identify furnaces and boilers that incorporate sealed-combustion features into their design. But it's also possible to convert conventional appliances to sealed combustion with retrofit equipment that ducts outside air directly to the burner, switches the appliance from chimney-venting to sidewall venting, or both. Install only those venting options recommended by the manufacturer and certified for safe operation by a test lab such as ETL.

Power burner. You can convert an oil boiler to sealed combustion, for example, by installing an optional power burner and an outside air duct with an air inlet hood attached to the burner (photo). The power burner creates enough positive pressure in the combustion chamber to force exhaust out through the vent. It's imperative that the vent pipe is installed according to the manufacturer's instructions, because any leaks or loose connections in the vent will allow combustion products to escape into the house.

Figure 4. *Some gas water heaters, such as this State model 850 (left), use a concentric pipe (also called "coaxial" or "double channel" pipe) for both venting and combustion air. Since this type of unit relies on natural venting to move exhaust out of the house, it must be installed close to the outside wall. Water heaters with integral power venters, such as the A.O. Smith Sealed-Shot (right), may be installed as far as 40 feet from an outside wall.*

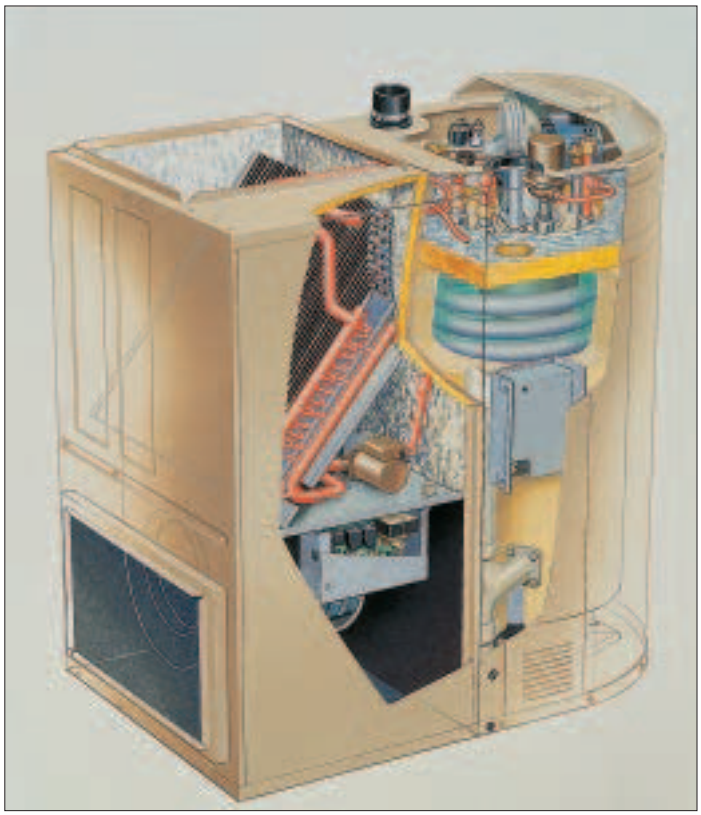
Power venting. A power burner can only be used when the furnace or boiler is installed close to the outside wall. For longer duct runs, you need power venting — an induced-draft fan that mounts on a horizontal vent run as close as possible to the sidewall where the vent penetrates to the outside (Figure 2). Unlike a power burner, a power venter located at the wall penetration will keep the vent under negative pressure for its entire length. This reduces the chances of spillage when the power venter is in use.

Combustion air. Converting to a direct supply of outside air is less critical than venting changes, because high-efficiency combustion appliances use relatively little combustion air.

Figure 5. *The Myson DV325 direct-vent tankless hot water heater uses a concentric pipe to both vent exhaust and draw combustion air.*

Factory-approved kits that supply outside air are available, however. These are usually hard-ducted all the way to the burner, although in some cases the duct is not actually sealed at the burner connection.

You can also use a supply-air fan kit, such as the In-Forcer by Tjernlund, to bring outside air to the burner (Figure 3). These kits usually include a plastic outside-air inlet duct,



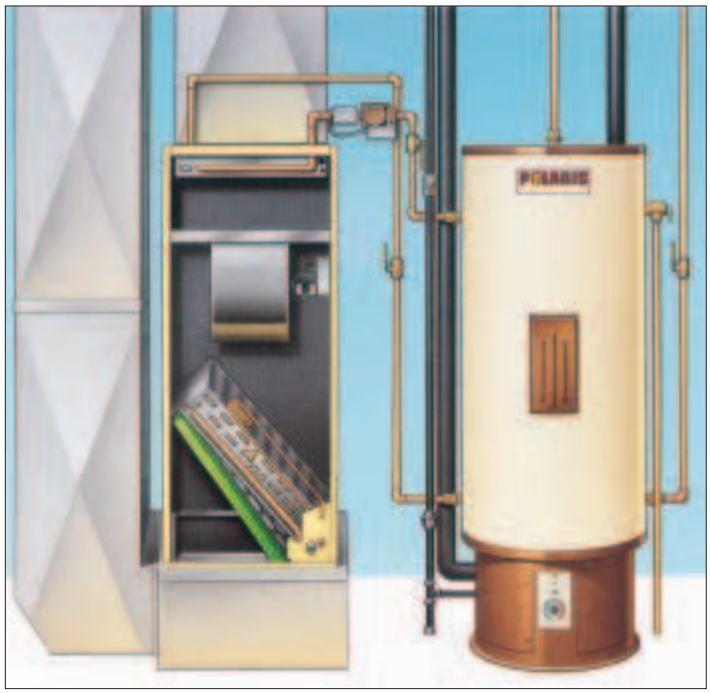


Figure 6. *Combined systems, such as the Polaris Comfort System (above) and Lennox's new CompleteHeat system (left), use a water heater to provide both domestic hot water and space heating. These systems are very efficient, with an EF of about .86.*

a fan (about 50 cfm), and controls. The controls interlock with the burner so that the fan comes on whenever the burner fires. The air inlet can usually be connected to the burner using flexible duct.

Water Heaters

Vented water heaters use even less combustion air than high-efficiency furnaces and boilers. This means that direct-vent options are more important than providing combustion air to the burner, even in tight houses. GAMA lists 12 manufacturers with "direct vent" water heaters. In most cases, this means the appliances vent through the sidewall and get their combustion air from the room in which they are located. Some units, however, also supply outside air directly to the burner.

The allowable length of duct runs is an important consideration. Water heaters with integral power venters may be approved for installation as far as 40 feet from an outside wall (Figure 4). Other units, however, use a concentric pipe (also called "coaxial" or "double channel" pipe) that serves for both venting and combustion air. Since they rely on natural venting to move exhaust out of the house, water heaters with concentric venting must be installed close to the outside wall.

Efficiency. In terms of fuel cost, water-heating efficiency is often more important than heating-system efficiency, especially in tight houses. Unfortunately, you cannot assume (as you can with central-heating appliances) that sealed-combustion water heaters will automatically operate at high efficiency (see "How to Measure Efficiency"). Don't be fooled by product literature filled with terms like "energy efficient," "deluxe high efficiency," "high recovery efficiency," and "energy saver." As good as these descriptions may sound, the bottom line on efficiency is the *energy factor* (EF) — the water heater equivalent of AFUE — as reported by GAMA and in some (but not all) product literature. The EF combines measurements of both "steady state" and "heat transfer" efficiency over many cycles, and is expressed as a decimal fraction (an EF of .65, for example, translates to 65% efficiency). Almost all water heater EF ratings are in the range of .55 to .65. Only two water heater product lines have an EF above .70: the Polaris from American Water Heater Group, with an EF of .86, and the new HM30 from Lennox, with an EF of .86.

Tankless hot water. "Tankless" or "instantaneous" gas water heaters are also available as sealed-combustion units. The Myson Tankless product line of conventional water heaters, for example, also includes a "direct vent" model (Figure 5). The direct vent mounts on an outside wall and uses a concentric horizontal pipe to penetrate to the outside.

Combination units. There are also a variety of sealed-combustion appliances that provide both space heat and domestic hot water. One design uses a boiler to supply hydronic space heat, with one zone dedicated to domestic hot water. The hot water is heated using either an external heat exchanger and storage tank, or an "indirect water heater" consisting of a heat-exchange coil submersed in a storage tank. The combination of equipment is considered a sealed-combustion unit if the boiler is equipped for sealed combustion.

Another approach is to use a water heater to generate both domestic hot water and space heating, as do both the Polaris Comfort System and the Lennox CompleteHeat (Figure 6). Part of the water heater output is run through an air handler connected to a ducted warm air distribution system to provide space heat. Again, the combined unit meets sealed-combustion criteria if the water heater uses sealed-combustion equipment. One

advantage to combined units is improved water-heater efficiency because the burner will run longer with less cycling.

Space Heaters

Vented space heaters are located in the space that they heat, and do not have any ducts to distribute heat to other parts of the house. (Many space heaters do, however, have internal circulating fans that force more heat into the room, provide more even heat, and sometimes move heat to adjacent rooms.) Space heater types include wall-mounted gas and kerosene heaters, wood stoves and fireplaces, and gas-burning wood stove look-alikes.

Gas wall-mounts. About half of the gas space heaters or "wall furnaces" sold are the direct-vent type. In this case, "direct vent" means that the heater is sidewall-vented and also gets its combustion air directly from the outside.

Wall-mounted units vent to the outside through a short concentric pipe. Currently, Rinnai is one of only a few manufacturers that uses electronic ignition and power venting in its units. Consequently, Rinnai has the highest efficiency on the market, with models at 80.4% and 81.1% AFUE (Figure 7). Empire plans to have a similar product line out next year. Most other gas space heaters have AFUEs in the range of 60% to 70%.

Figure 7. *The Rinnai wall-mounted gas space heater vents to the outside through a short concentric pipe. The inner pipe carries exhaust, while the outer pipe brings fresh air to the burner. With electronic ignition and power venting, these heaters have AFUEs of more than 80%.*

Kerosene heaters. Wall-mounted kerosene space heaters are very similar to gas wall-mounts. They attach to an exterior wall and use a concentric vent to duct both exhaust and outside combustion air. Because they use liquid fuel, however, they do not allow as much flexibility as gas appliances in locating the fuel supply in relation to the heater. Kerosene heaters usually require an outside oil tank located slightly higher than the heater to avoid having to pump the fuel.

Stoves and fireplaces. There are no sealed-combustion wood-burning stoves or fireplaces. Since all of these units are chimney vented, codes consider them to be susceptible to spillage. Even the tightest door system will spill to some extent when the room is depressurized.

There are, however, gas-burning stoves and fireplaces available that look almost identical to wood-burning stoves and fireplaces. Often called "direct vent" appliances, these units vent through the sidewall and bring outside combustion air to the firebox. Check product literature carefully, however, to differentiate between direct-vent and chimney-vent models. ■

Tim Maker owns Energy Associates, a consulting company in Calais, Vt.

Product Information

American Water Heater Group
2134 French Settlement Rd.
Dallas, TX 75212
800/288-1899
Polaris Comfort System

Carrier Corp.
318 First St.
Liverpool, NY 13088
800/227-7437
WeatherMaker

Dunkirk
85 Middle Rd.
Dunkirk, NY 14048
716/366-5500
EV direct-exhaust system

The Field Controls Co.
2308 Airport Rd.
Kinston, NC 28501
919/522-3031
SWG-4 power venter

Lennox Industries
P.O. Box 799900
Dallas, TX 75379
800/453-6669
CompleteHeat

McNeely-Yuill Corp.
9911 Horn Rd., Suite 100A
Sacramento, CA 95827
800/456-3761
Myson DV325

Rinnai America Corp.
1662 Lukken Industrial Dr. West
La Grange, GA 30240
800/621-9419
Wall-mounted space heaters

State Industries
500 By Pass Rd.
Ashland City, TN 37015
615/792-4371
State 850

Tjernlund Products
1601 Ninth St.
White Bear Lake, MN 55110
800/255-4208
In-Forcer