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High-Efficiency Water Heaters

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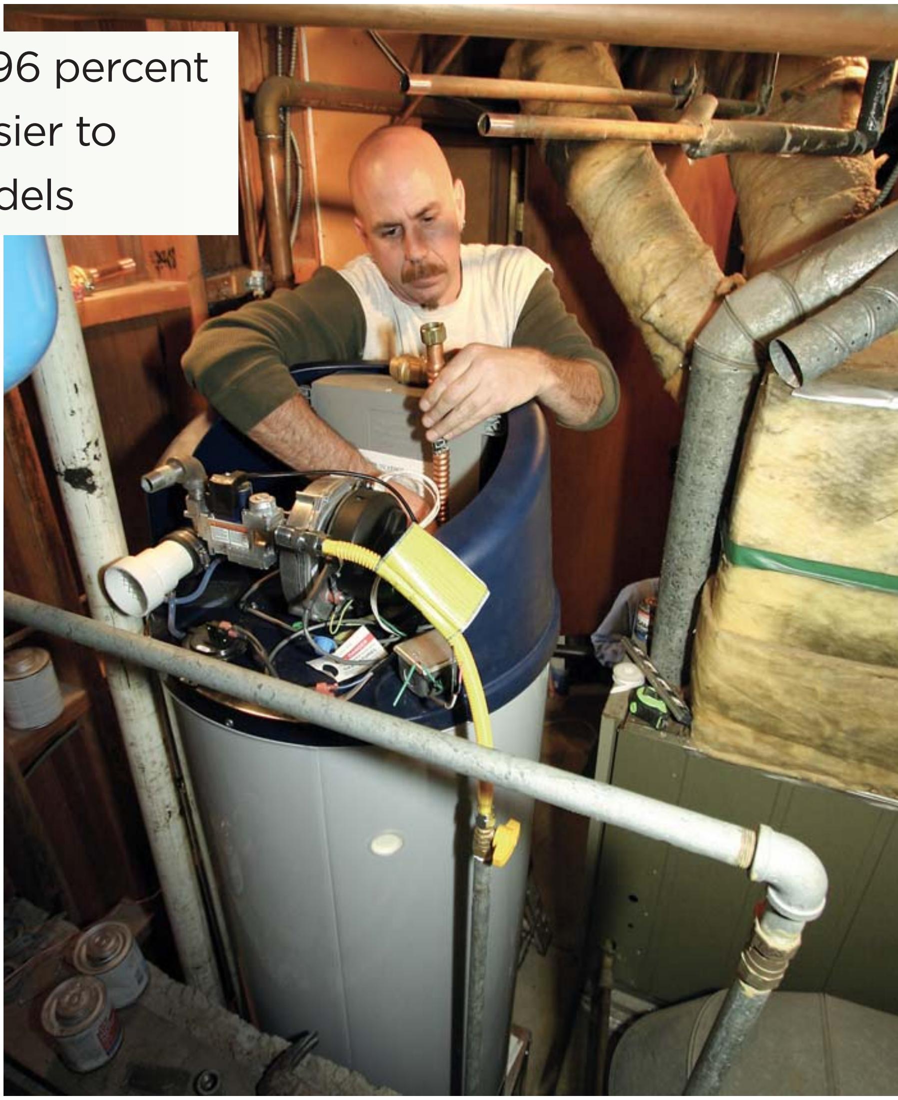
Condensing Storage Water Heaters

These heaters are up to 96 percent efficient and typically easier to retrofit than tankless models

by Jim Lunt



In my 30-plus years as a plumbing contractor, I've replaced countless water heaters. Our company, which works in the San Francisco Bay area, installs three basic kinds: conventional gas models, tankless models, and — increasingly — condensing storage heaters. Customers who want to save energy nearly always ask for a tankless water heater. That's no surprise — tankless heaters have been getting a lot of media coverage and are the only efficient heaters most people have heard of.

In most cases, however, we recommend condensing storage heaters to our replacement customers, because they are arguably more efficient than tankless models and — when used to replace an existing heater — frequently less expensive to install. For homeowners, switching from a conventional heater to a condensing model is not a big change. If they consume the same amount of hot water as before, they'll have lower gas bills and run out of hot water less often. Switching to a tankless heater, by contrast, requires some lifestyle adjustments: The homeowners will have to wait for the heater to produce hot water and they won't be able to get it at very low flow rates (see "Is a Tankless Heater Right for the Job?," next page).

In this article, I'll discuss condensing storage heaters and how they're installed. Since natural gas is the primary fuel in our region, I'll be describing gas-fired models, many of which can be field-converted for propane.

How They Work

In several respects, a condensing storage heater is like a conventional model. Both burn gas, have exhaust flues, and store hot water in an insulated tank. But a condensing heater is much more efficient because of how heat is transferred to the water.

In a conventional heater, the fuel is burned in an open chamber, and hot combustion gas rises through a flue in the center

Is a Tankless Heater Right for the Job?

When a customer asks us to replace a conventional water heater with an on-demand — or tankless — model, we often have to explain why a tankless unit may not be the right choice. In many cases we'll steer the homeowner toward a condensing storage heater instead.

Prominent among the selling points of tankless heaters are that they're more efficient than conventional storage models and, within limits, able to produce an endless stream of hot water. However, the same can be said of condensing storage heaters. The unique advantage of tankless heaters is that they're small enough to fit where storage models will not (see "Installing On-Demand Water Heaters," 2/06).

Efficiency Claims

Much of a tankless heater's efficiency stems from the fact that it has no standby losses — no gas-consuming pilot light and no stored water losing heat through the walls of the tank. But its actual thermal efficiency (TE) is not all that high — typically around 82 percent. A number of companies have introduced condensing tankless heaters with TE ratings of up to 98 percent, but I won't recommend these to clients until they've been around for a while and have proven to be reliable.

The endless stream. The output of a tankless heater is rated in gallons per minute (gpm) of water at an assumed temperature rise

of 77°F. However, advertised flow rates are frequently based on a 45°F temperature rise and may not be achievable — something we point out to customers.

Installation Details

Although tankless units may cost less than condensing storage heaters, installation costs can be a lot higher. This is particularly true in replacement jobs.

Gas line. Tankless heaters have very large burners, so existing 1/2-inch gas lines will have to be replaced with 3/4- or 1-inch line. This could entail the last few feet of line or everything all the way back to the meter.

Flues. Most tankless heaters require expensive Type III stainless steel vent pipe, which means existing flues cannot be reused in replacement jobs. In areas where the temperature doesn't drop below freezing, it's sometimes possible to eliminate the cost of the flue by installing the heater outside.

Operation

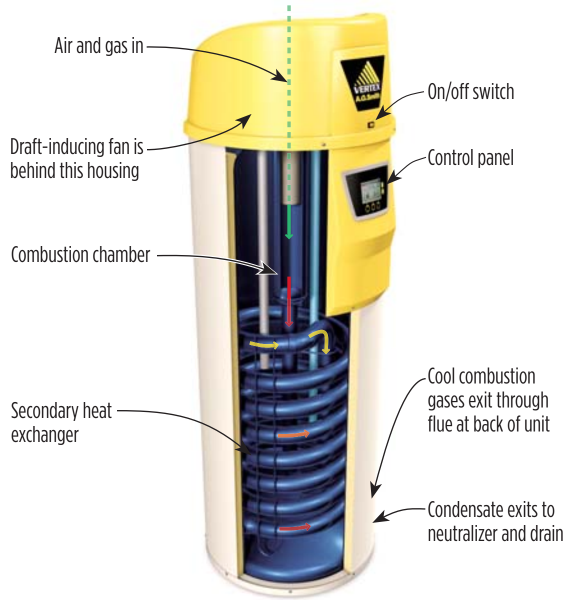
When a tankless heater's flow sensor detects a demand for hot water, it activates a vent fan and a burner that heats water as it passes through a heat exchanger. The burner will not be activated at flows less than about 0.5 gpm, and once activated, it takes 5 to 10 seconds for the flow to go from cold to hot. If the drain is open, that several seconds of flow results in wasted water. A recirculation pump can reduce the amount of waste, but most recirculation systems are not directly compatible with tankless heaters.

Cold-water sandwich. Cold water is introduced into the line every time the burner turns off — the so-called "cold-water sandwich." To eliminate this slug of cold water, some plumbers may install a tempering tank — a small electric storage heater — downstream from the tankless unit. In my opinion, this is a poor solution because it wastes energy and adds to the cost of the system.

Maintenance

There is a filter screen on the supply side that prevents rust and sediment from clogging the passages in the heat exchanger. The screen should be cleaned and the heat exchanger flushed and delimed annually.

Inside a Condensing Water Heater



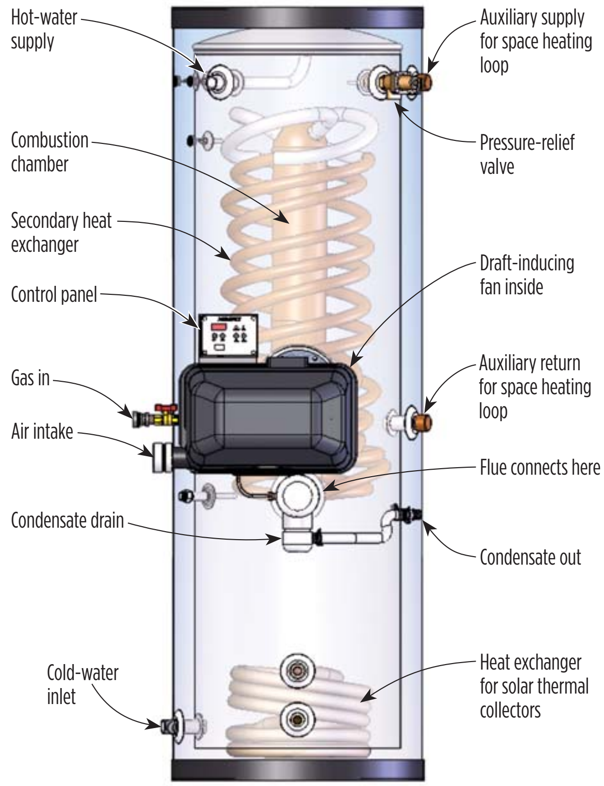


Figure 1. A cutaway drawing of a Vertex heater (above) shows the combustion chamber and secondary heat exchanger coil inside the tank. In the Phoenix model at right, the combustion chamber and secondary heat exchanger are located in the upper part of the tank, with a second heat exchanger for a solar thermal collector below.

of the tank. A lot of this heat is transferred to the water in the storage tank, but a good portion exits through the vent pipe and is wasted.

In a condensing heater, a draft-inducing fan pushes air and fuel into a sealed combustion chamber inside the tank (**see Figure 1**). As the fuel burns, combustion gas is exhausted through a secondary heat exchanger — a coiled steel tube submerged inside the tank. The combustion chamber and heat exchanger have large surface areas to maximize heat transfer to the water. So much heat is transferred that the combustion gases cool to the point where the water vapor in the exhaust stream condenses, releasing its latent heat, which is also transferred to the stored water. By the time the exhaust gas leaves the heater, it's cool enough to be safely vented through inexpensive plastic plumbing pipe. (Each manufacturer accepts different kinds of pipe; options include specified types of PVC, CPVC and ABS. All are far less expensive than stainless steel.)

The thermal efficiency (TE) of a condensing storage heater is quite high, typically between 90 and 96 percent. (For an explanation of thermal efficiency standards, see "Making Sense of Gas Water-Heater Ratings," page 7.) Standby losses are low because the storage tanks are covered with thick foam insulation — plus these units all have electronic ignition, so there is no standing pilot.

Heating Capacity

Most people think of storage heaters in terms of tank and burner size — as in a 40-gallon 40,000-Btu heater (see chart, next page). The Btu rating is a measure of fuel input to the burner; output is measured in gallons of water heated per hour to a particular temperature rise. The condensing heaters we install have an input range from 76,000 Btu all the way to 199,000 Btu. (By comparison, the typical tankless model we install is rated at 199,000 Btu.)

Recovery. The recovery rate tells how fast the heater can replenish hot water as it is drawn from the tank. Recovery is measured in gallons per hour at a 90°F temperature rise; it's a function of the burner size (Btu input) and heat-transfer efficiency.

First-hour-rating. The number that we look at when sizing a storage heater is the first-hour-rating (FHR) — the amount of water it can provide in one hour at a

Figure 2. This 50-gallon condensing water heater will be installed in the space (right) previously occupied by a 40-gallon conventional storage model.

90°F temperature rise. FHR is a function of the size of the heater's tank and the recovery rate. The tank factors in because it's a reservoir of heated water, most of which is considered to be available for immediate use. The FHR is equal to the recovery rate plus 70 percent of the tank size.

Installation

Condensing heaters have the same footprint as conventional water heaters, so they work well for replacement jobs (**Figure 2**). The units cost more than tankless models, but because they're easier to install in existing construction, the higher equipment cost is often offset by lower labor figures. A typical tankless heater wholesales for about $950, and a 90-percent-efficient condensing storage model for about $1,700.

Many models can be connected to an existing 1/2-inch

Condensing Storage-Heater Specifications

Brand	Model No.	Tank Size (gallons)	Maximum Input (Btu)	First-Hour Rating (gallons)	Recovery (gallons per hour at 90° rise)	Thermal Efficiency	Standby Loss (in Btu per hour)	Tank	Gas Supply
Phoenix Heat Transfer Products 800/323-9651 htproducts.com	PH100-55	55	100,000	169	128	95%	392	stainless-steel	3/4-inch
	PH130-55	55	130,000	205	164	94%	389	stainless-steel	3/4-inch
	PH199-55	55	199,000	295	254	95%	409	stainless-steel	3/4-inch
	PH100-80	80	100,000	189	129	96%	445	stainless-steel	3/4-inch
	PH130-80	80	130,000	227	167	95%	498	stainless-steel	3/4-inch
	PH199-80	80	199,000	314	255	95%	495	stainless-steel	3/4-inch
	PH100-119	119	100,000	214	130	96%	528	stainless-steel	3/4-inch
	PH130-119	119	130,000	257	168	96%	526	stainless-steel	3/4-inch
	PH199-119	119	199,000	335	256	96%	507	stainless-steel	3/4-inch
Polaris American Water Heaters 800/937-1037 americanwaterheater.com	PG10 34-100-2NV	34	100,000	153	129	96%	286	stainless-steel	1/2-inch
	PG10 34-130-2NV	34	130,000	192	168	96%	245	stainless-steel	1/2-inch
	PG10 34-150-2NV	34	150,000	216	192	95%	239	stainless-steel	1/2-inch
	PG10 50-130-2NV	50	130,000	201	166	95%	225	stainless-steel	1/2-inch
	PG10 50-150-2NV	50	150,000	227	192	95%	250	stainless-steel	1/2-inch
	PG10 50-175 3NV	50	175,000	261	226	96%	294	stainless-steel	3/4-inch
	PG10 50-199-3NV	50	199,000	292	257	96%	244	stainless-steel	3/4-inch
Premier Power-Vent State Water Heaters 800/365-0024 statewaterheaters.com	GP6 50 YTVIT	50	76,000	127	92	90%	364	glass-lined	1/2-inch
	GP6 50 YTPDT	50	100,000	164	129	96%	548	glass-lined	1/2-inch
Vertex A.O. Smith 800/527-1953 hotwater.com	GPHE-50	50	76,000	127	92	90%	364	glass-lined	1/2-inch
	GDHE-50	50	100,000	164	129	96%	548	glass-lined	1/2-inch

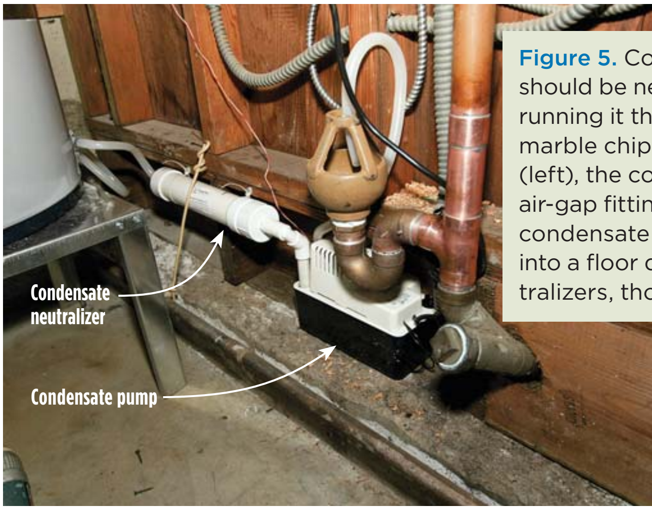
Figure 3. Condensing heaters can often connect to an existing 1/2-inch gas line. The plumber extends the line (far left) to reach the inlet at the top of the heater. The air intake (above left) — the PVC fitting with the screen inside — is connected to a draft-inducing fan. Combustion gas and condensate exit through a fitting near the bottom of the tank (below left). The elbow connects to the flue and the condensate hose runs to a drain.

Figure 4. A plumber installs a section of flue pipe (above left), taking care to slope it so that condensate drains back to the heater. With the particular heater shown here, the flue can be ABS or PVC; in this case, it's a combination of the two (above) because the plumbers ran out of ABS. The flue passes out through the wall and terminates at a screened fitting (left).

gas line (**Figure 3**), though some of the larger units require a 3/4-inch line. All condensing heaters require a 120-volt electrical circuit to run the fan and electronics.

Flue. The existing flue can't be reused, but a new plastic flue is inexpensive and easy to install. The draft is fan-induced, so flue runs can be long — up to 128 equivalent feet, depending on the heater and whether the vent is 2-, 3-, or 4-inch-diameter pipe. Makeup air can be drawn from the room or piped directly to the heater from the exterior. We try to terminate the flue at an inconspicuous location on the outside, because it may emit a visible plume of vapor and the fan may be audible there (**Figure 4**).

Condensate. The water that condenses in the heat exchanger and flue drains to a condensate trap and is fed through a plastic hose to the nearest plumbing drain. The condensate is acidic enough to erode concrete and metal, so it has to be neutralized before discharge; this is done by running it through a cartridge filled with



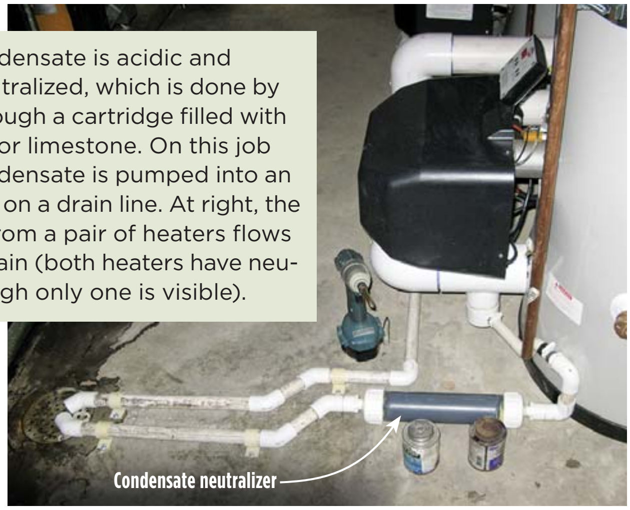


Figure 5. Condensate is acidic and should be neutralized, which is done by running it through a cartridge filled with marble chips or limestone. On this job (left), the condensate is pumped into an air-gap fitting on a drain line. At right, the condensate from a pair of heaters flows into a floor drain (both heaters have neutralizers, though only one is visible).

Figure 6. In this installation, the heater and condensate pump are plugged into a nearby electrical outlet (left). A digital readout (above) allows the homeowner to adjust the water temperature and the plumber to diagnose problems.

Figure 7. The Vertex (A.O. Smith) and Premier Power-Vent (State Water Heaters) heaters are the same units sold under different labels. Shown here is a 96-percent-efficient Vertex and a 90-percent-efficient Premier Power-Vent model.

crushed limestone or marble (**Figure 5**). The cartridge needs to be checked yearly and the stones topped off or replaced if they've dissolved.

Base Models

Condensing heaters have been used commercially for about 15 years; they're a proven technology. Because of the size of their burners, the heaters from the four manufacturers targeting the residential market are technically commercial units. Most of them have electronic controls and diagnostic sensors that can be accessed by a digital screen (**Figure 6**).

Vertex and Premier. The least expensive condensing heater is A.O. Smith's Vertex. It's sold in two versions, both with 50-gallon tanks: a 76,000-Btu 90-percent-TE unit and a 100,000-Btu 96-percent-TE unit. Both have glass-lined tanks and taps that allow them to be used for combination space-heating and water-heating applications. The same heaters are also sold by State Water Heaters under the Premier brand (**Figure 7**).

We like these heaters for retrofits because they're easy to install. They can often use existing gas lines, so field-supplied materials are limited to piping and fittings near the heater, the neutralizer cartridge, and flue pipe. The heater itself is prewired; all we have to do is plug it into an adjacent outlet. As a replacement unit, the installed cost of one of these heaters is frequently less than the installed cost of a comparable tankless model.

Making Sense of Gas Water-Heater Ratings

In a perfect world, water heaters would be 100 percent efficient: Every Btu they consumed would be turned into hot water that was available for use. Of course, this never happens. Instead, heat is lost up the flue, and storage models contend with standby losses — which refers to the gas consumed by a pilot light (if there is one) and the heat lost through the jacket of the tank.

Apples and oranges. Under federal law, different efficiency standards apply to different kinds of heaters. Storage heaters with inputs at or under 75,000 Btu and tankless models at or under 199,000 Btu are considered to be residential models and fall within the scope of the National Appliance Energy Conservation Act (NAECA), which requires heaters to be rated on the basis of energy factor (EF). Units with inputs greater than these are considered to be commercial units and fall under the Energy Policy Act (EPACT), which requires heaters to be rated on the basis of thermal efficiency (TE). It's illegal for manufacturers to put TE ratings on a residential models or EF ratings on commercial ones. This presents a problem: EF and TE are so different that there is no way to use them to make an apples-to-apples comparison between residential and commercial models.

Energy factor. The EF test is intended to rate the efficiency of the heater over the course of a typical day. The test assumes that the homeowner uses 64.3 gallons of hot water at a temperature rise of 77°F and that the water is consumed in six equal draws. The EF is derived by calculating the amount of thermal energy added to the water and dividing it by the energy used to heat it. Also, if a fuel-burning water heater uses electricity (to power a controller or fan), the electrical consumption is measured, converted to a Btu equivalent, and added to the input amount. The test is performed over a 24-hour period, so standby loss is automatically accounted for. EF is used to compute the projected annual operating cost listed on the yellow Energy Guide label found on new residential water heaters. A typical conventional storage heater has an EF of about .59. For a typical noncondensing tankless model the EF would be around .82.

Thermal efficiency. TE refers to the ratio between the energy contained in delivered water and the energy consumed to heat it. It's derived by measuring the flow of water the heater can heat to a 70°F temperature rise with the burner at full fire, calculating the amount of energy that was added to the water, and dividing it by the energy used to heat it. The result is expressed as a percentage and does not account for standby loss. Condensing storage models are between 90 and 96 percent thermally efficient.

Standby loss. One of the descriptors for a commercial storage heater is standby loss, which for a gas model is expressed as the number of Btu lost per hour when the burner is not firing. Rarely listed on spec sheets, this number can be found in the Air-Conditioning, Heating, and Refrigeration Institute's Directory of Certified Product Performance (ahridirectory.org). When comparing two heaters with the same TE, the one with the lower standby loss will be more "efficient" overall. *— David Frane*

Premium Units

The next step up is to a Polaris, made by American Water Heaters, an A.O. Smith company, or a Phoenix, manufactured by Heat Transfer Products (**Figure 8**). These heaters have long-lasting stainless steel tanks and come in a variety of tank and burner sizes, with inputs up to 199,000 Btu. Both brands include taps that allow them to be used for combined space and water heating. Several of the Phoenix models also contain heat exchangers that can be connected to solar collectors for heating or preheating the water. Although we have installed both brands, we have more experience with the Phoenix because it's readily available and better supported in our area.

__Jim Lunt__ co-owns The Lunt Marymor Co. in Emeryville, Calif., with Leigh Marymor.

Figure 8. The Polaris (far left) has a stainless steel tank and a simple interface — indicator lights and a dial for setting temperature. This Phoenix heater (left) provides hot-water storage and boiler backup for a solar thermal space-heating (radiant) and domestic hot-water system.