Installing an Efficient Noncondensing Boiler

by Cary White

My small plumbing and heating company recently replaced a client's inefficient 25-year-old combination wood-and-oil boiler with an efficient new Buderus oil boiler. Oil was the obvious choice of fuel. The homeowners no longer wanted to deal with firewood, and natural gas isn't available in the area of Vermont where they live. And propane — though available — is ruinously expensive. But we had one important choice to make: Did it make sense to go for broke and put in an ultra-high-efficiency condensing boiler, or should we opt for a slightly less efficient noncondensing version?

Tax credits are great, but does your client really need a condensing boiler?

Condensing vs. Noncondensing Boilers

Going for maximum efficiency offered one substantial carrot: There's a 30 percent tax credit for systems with an AFUE rating of 90 percent or more. (The AFUE — or annual fuel utilization efficiency — of a given fuel-burning appliance represents the average amount of useful heat delivered relative to the amount of fuel used over the course of a heating season. A boiler with a 90 percent AFUE, for example, delivers 90 percent of the value of the fuel as heat, while venting the remaining 10 percent to the outdoors.) Although the tax credits aren't specifically reserved for condensing appliances, only condensing appliances have so far been able to meet the AFUE threshold. An average modern oil boiler, by comparison, will typically

have an AFUE of around 85 percent.

Tapping latent heat. What makes condensing appliances so efficient? Combustion gases from any source contain a certain amount of water vapor. As the gas cools, that vapor eventually condenses, changing back to liquid form. And when the vapor condenses, the gas gives off a certain amount of latent heat, which is ordinarily lost to the atmosphere.

A condensing boiler, however, is designed to make use of that latent heat by sending the flue gases through a secondary heat exchanger before they're vented to the outdoors. Here, the hot flue gases are used to preheat water returning to the boiler. As the gases give up their heat to the return water, the water vapor they contain condenses inside the heat exchanger, surrendering a substantial amount of useful additional heat .

The downside of efficiency. A complicating factor in all this is that the condensate has to be disposed of somehow, usually by routing it to an existing sewer or septic system. Ideally, this can be done with a simple gravity line, but many applications will require a condensate pump. Either way, it's important to protect the condensate line from freezing. The condensate is also fairly acidic, with a pH in the 3 to 4 range, which is roughly comparable to that of orange juice. To ensure that the condensate won't corrode metallic fittings downstream, some codes require passing it through a neutralizer containing granular calcium carbonate or a similar material to raise its pH before discharge.

Unlike a conventional boiler, a condensing boiler requires direct venting, typically through a sidewall. But we've found that direct-vented condensing boilers can have lockout issues in windy locations. Soot staining — caused by dirty fuel or lack of maintenance — can also be a problem, particularly in homes with natural wood siding, which can be very difficult to clean. Finally, flue gases produced by an oil burner contain less water vapor — and therefore less latent heat — than flue gases from a gas burner, so efficiency gains are smaller.

Making the right choice. We install and service both condensing and noncondensing versions of Buderus' new high-efficiency/low-emissions oil boiler — the condensing GB125BE and the noncondensing G125BE. The installed cost of the condensing boiler, with its 93.4 percent AFUE rating, would be about $11,300 on this job (or $9,800 after the $1,500 tax credit), compared with $9,500 for the noncondensing boiler, which has an AFUE of 89 percent. Although the difference in installed cost was fairly small, so was the 4.4 percentage-point difference between the efficiencies of the two boilers.

Given the home's existing fin tube radiators (condensing boilers work best with low-temperature heat sources, such as radiant floors) and windy location (which would have made sidewall venting problematic), we concluded that the noncondensing boiler was the way to go.

Figure 1. The Buderus G125BE noncondensing boiler can be vented either horizontally or vertically but needs a maximum 5-inch-diameter chimney liner when vented into an oversized masonry chimney flue (top left). At the top, the liner's cap is set in sealant and screwed in place with masonry screws (top right). At the base, the author packs the cavity between the new liner and old flue with mineral wool insulation and seals the opening with refractory cement (above).

Sizing and Installing the Flue Liner and Boiler

My clients' 2,100-square-foot home was typical of those built in this area in the 1980s, with 2x4 walls, clear insulated glass windows, and moderate levels of insulation in the walls and attic. In new construction, I'd normally use ACCA (Air Conditioning Contractors of America) Manual J to calculate heat loss and size the boiler. But for this home, the largest 116,000-Btu version of the G 125 BE boiler closely matched the size of the existing Tarm wood/oil boiler. Since I knew the owners might add on to the house in the future, downsizing didn't make sense.

Flue requirements. The noncondensing Buderus boiler can be vented directly to a lined masonry chimney with a correctly sized flue. But because the existing chimney flue was oversized, we installed a 5-inch-diameter stainless steel chimney liner to guarantee a good draft and avoid potential corrosion problems from any flue gases condensing inside the chimney **(see Figure 1, page 2)**. Installing the liner accounted for about $1,300 of the project's overall cost. To help ensure proper draft, the exhaust flue is fitted with a barometric damper.

Higher efficiency, lower emissions. Even though the Buderus is a new boiler in the U.S., we're comfortable recommending it because of its 10-year track record in Europe, where fuel costs are high and emissions standards are stringent. It's equipped with a low-NOx (nitrogen oxide) burner designed to operate at a lower temperature than conventional burners, and features a ceramic burner tube in the combustion chamber (**Figure 2**). As it heats up during combustion, the burner tube recirculates flue gases through the burner until the vaporized fuel is completely consumed, leading to improved fuel efficiency and a decrease in smog-producing NOx emissions.

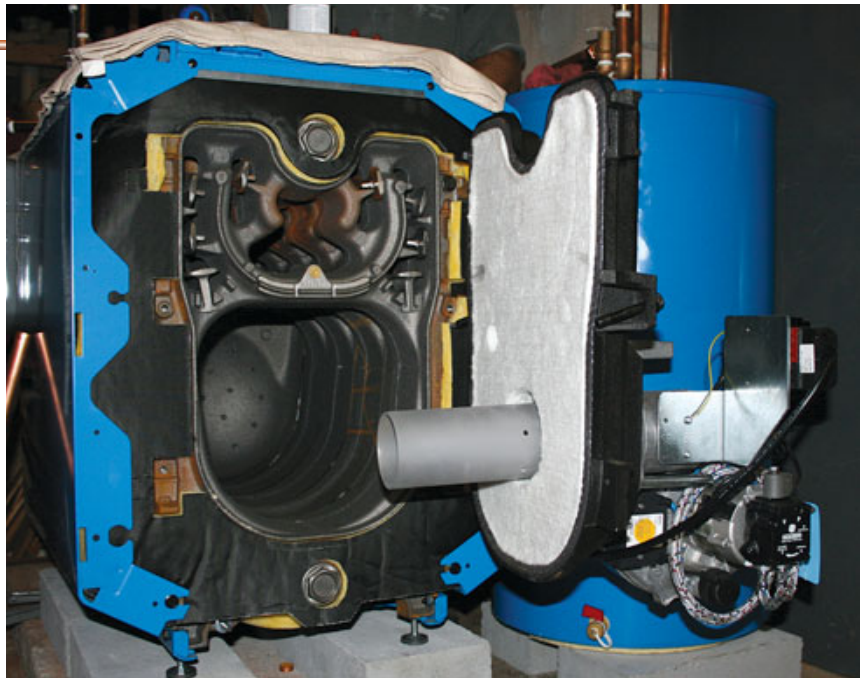

Figure 2. A perforated ceramic tube inside the cast-iron combustion chamber allows gases to recirculate past the burner before exiting the flue, resulting in more complete combustion — and bumping up the boiler's efficiency rating.

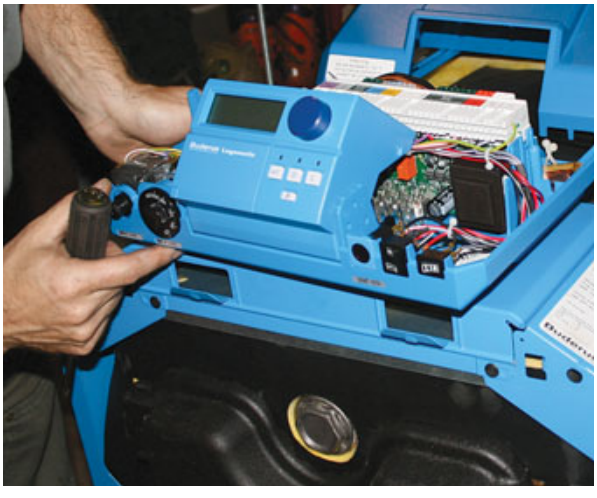

Figure 3. The boiler is controlled by a Logamatic 2107 microprocessor connected to an outdoor air temperature sensor, which modulates the boiler's firing temperature based on demand and weather conditions.

After the initial burn, the 800°F flue gases exiting the burner tube and combustion chamber make two additional passes through the center of the boiler. By the time the gases exit the rear of the boiler, baffle plates have slowed them down and cooled them to around 300°F. The smooth-wall design of the heat exchanger makes this boiler very easy to clean.

Modulating control. In most conventional boilers, a simple aquastat turns on the boiler when there's a call for heat or hot water. That causes the burner to fire until the boiler's internal temperature reaches 180°F, regardless of the season or weather. But the Buderus boiler has a remote sensor integrated with an electronic controller, which takes outdoor temperatures into account when regulating the temperature of the boiler water (**Figure 3**).

In moderate conditions, when the boiler doesn't need to heat 6 or 7 gallons of

Figure 4. To provide warm, clean fuel for the burner, the boiler is equipped with a fuel line preheater and a 10-micron filter and deaerator, which removes air and gas bubbles in the fuel oil that can interfere with combustion.

Figure 5. Outside combustion air flows through flexible metal duct (top) and 4-inch-diameter rigid duct to the rear of the boiler (left). The screened air-inlet fitting on the outside wall is protected by a metal cap (inset).

water all the way up to 180°F to maintain the house at a comfortable temperature, the boiler may stop firing at only 130°F or 140°F. The Logamatic controller, as Buderus calls it, also manages the system's new indirect domestic hot-water tank. If my clients ever decide to upgrade, the controller can integrate solar panels or radiant heating into the system, too.

Fuel and Combustion Air

Buderus has incorporated some features that also help address the declining fuel-oil quality issues we've been noticing over the past year or so. In particular, refineries seem to be leaving more impurities in #2 heating oil, which can lead to clogged nozzles and filters and lower efficiency. I've heard that some of this has to do with the growth of a variety of bacteria that can live in fuel tanks. Whether that's true or not I can't say — I'm an hvac guy, not a microbiologist — but it makes sense, because I've noticed that fuel problems seem to be most common in systems with outdoor storage tanks warmed by the sun.

Bubbles and heavies. In addition to the standard tank prefilter, which catches most of the heavy particles in the fuel, the boiler comes equipped with a Tigerloop deaerator (800/442-1630, Westwoodproducts.com). The deaerator has a secondary 10-micron filter that removes tiny air and gas bubbles that can interfere with combustion (**Figure 4**). There's also a fuel-line preheater, basically a low-wattage resistance element that briefly turns on when there's an initial call for heat, warming oil in the nozzle line. The burner operates more efficiently because it's using warm, clean oil instead of cold or dirty oil.

Bringing in outside air. Although Buderus recommends an outside air source for the G 125 BE, it's not strictly required. Given the age and construction of the home we were working in, it would not have been unreasonable to draw combustion air

Figure 6. As part of the system upgrade, the author installed new circulator pumps and expansion tanks (left) and an indirect-fired domestic hot-water storage tank (above).

from inside the living space and count on air leaks in the building envelope to provide makeup air. But doing so would have been short-sighted: If the homeowner (or a future owner) were to significantly tighten things up at a later date, the boiler could find itself starved for air.

With that scenario in mind, we installed a combustion air system using a screened intake air hood from Field Controls (252/522-3031, fieldcontrols.com) and 4-inch-diameter 30-gauge galvanized steel pipe. The pipe connects to a termination collar on the back of the boiler (**Figure 5, page 4**). Buderus has specific clearance guidelines for the wall termination, but the basic rule of thumb is not to place it facing the prevailing wind (though with vertical rather than sidewall venting, this isn't as critical).

Cold air can cause some burners to operate at less than maximum efficiency, so many boilers require tempered combustion air. But because of the design of the low-NOx burner, this makeup air system doesn't require the vacuum relief valve we usually install to provide it. Valves are typically located as close to the wall termination as possible but inside the conditioned space, and they open partway in very cold conditions, allowing warm inside air to mix with cold outside air. If the wall termination gets blocked for any reason, the valve allows the boiler to draw combustion air completely from inside the basement. Since this system doesn't have that valve, we made it a point to remind the homeowner to keep the intake air hood clear of drifting snow.

Evaluating Performance

Because the Buderus boiler hasn't been in operation for a complete heating season yet, it's hard to predict how my clients' energy bills will compare with the ones they had under their old system. The old boiler had a tankless coil for domestic hot water — which is an energy hog during the warm months — so we replaced it with a new indirect-fired DHW tank (**Figure 6**). While we were at it, we also replaced the circulator pump, zone valves, and expansion tanks.

Based just on the difference in AFUE ratings, fuel consumption should be about 15 percent less annually — but AFUE ratings don't reflect energy savings achieved by the Logamatic control and outdoor reset. We'll have to wait a few years and gather a little data to find out for sure, but I'd be surprised if annual fuel savings turn out to be much less than 30 percent.

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