

Choosing a Domestic Hot-Water System

Indirect water heaters vs. direct-fired tank heaters

By HENRY GIFFORD
Gifford Fuel Saving Inc.
New York, N.Y.

An indirect water heater is a tank of water that is heated by the same boiler that heats the building. Usually, the tank is heated by pumping hot boiler water through a coil in the tank. A similar arrangement in which tank water is pumped through a coil in the boiler also can be considered an indirect water heater.

WHAT'S THE BEST WAY TO MAKE HOT WATER?

Most homes in North America used to make hot water with a coil in a boiler, but the water came out of the coil too hot to send to the faucets, and there was no accurate way to mix the water down to a reasonable temperature. The increasing popularity of furnaces also increased the need for making hot water separately from the boiler.

So, separate, direct-fired water heaters became the preferred way of making hot water in gas- and oil-heated buildings, and tanks heated by electric resistance heaters became standard in electrically heated buildings. So for many years a "separate" 40-gal. gas-fired water heater with an input of 40,000 Btuh and warranted for five years was standard for sin-

gle family houses. Similar heaters with larger tanks and larger heat inputs were used in large houses and multifamily houses.

PROBLEMS WITH SEPARATE WATER HEATERS

A typical water heater is a glass-lined steel tank with a gas fire underneath, a single flue pipe up the middle of the tank, and an exhaust flue out the top.

Unfortunately, a direct-fired gas water heater has some disadvantages. Most geographic areas have lime in the water (dissolved salts of magnesium or calcium), which accumulates on the inside of the tank at the bottom because heating the water brings the lime out of solution. This occurs because magnesium and calcium have a lower solubility in hot water than in cool water. The lime on the bottom of the tank acts as insulation between the tank shell and the water in the

tank. This leads to terribly uneven heating of the steel at the bottom of the tank, which stresses the steel unevenly, and can eventually cause the tank to leak. There is no practical way to fix a leaking water heater, so

a leak means replacing the water heater.

Direct-fired water heaters fail with alarming regularity even in areas with almost no lime in the water, such as New York City, where the municipal water supply comes from rain-fed lakes. The tanks simply rust out, despite the glass lining applied by manufacturers to the inside (waterside) of the tank.

If a typical five-year warranted heater lasts significantly longer than five years, it

usually means not much hot water is being used in the structure. Heaters do not last as long in buildings with higher hot-water consumption. Multifamily buildings are the worst. If a heater lasts three or four years, the owner is lucky (the typical warranty for those installations is much less than five years).

In theory, water heaters can be made to last much longer by periodically changing the sacrificial anodes. Sacrificial anodes are pieces of magnesium or aluminum screwed into the tank that corrode instead of the tank corroding, but replacing them once they dissolve is rarely done. Different types of anodes work better with different water, which makes protection with them harder to achieve. Heaters with longer warranties are available, the main difference being larger or more numerous anodes, but most people resist paying the slightly higher purchase cost for what looks like exactly the same unit.

Direct-fired water heaters used to be available with copper tanks, which lasted halfway between now and infinity, but they have not been available for many years. Plastic tanks are reportedly available now, as well.

Energy efficiency is another problem with a typical direct-fired water heater. A standard water heater is rated at about 84-percent steady state efficiency. That means that while the fire is on, 84 percent of the heat from the fire enters the tank, while 16 percent of the heat goes up the chimney. That sounds pretty good, but a water heater is not a steady state device: the fire turns on and off. While the heater is off heat is still going up the chimney.

The annual fuel utilization efficiency (AFUE) rating of a typical water heater is much lower, in the range of 70 percent for a 40-gal. heater and dropping to 51 percent for a 75-gal. heater. An AFUE of 51 percent means that 51 percent of the heat in the fuel leaves the heater by going



Indirect water heater shown connected to sealed combustion boiler.

Henry Gifford is president of Gifford Fuel Saving Inc. and is the author of numerous articles on boiler system optimization. He can be reached by fax at 212-316-9377

out the hot water pipe. Except for a little heat lost through the jacket of the heater, the rest goes up the chimney. So while about 16 percent of the heat goes up the chimney while the fire is burning, about another 15 to 35 percent, called "standby loss" goes out the chimney while the fire is not burning.

Larger size direct-fired water heaters are manufactured with motorized flue dampers that close after the fire shuts off. Flue dampers reduce standby losses, but at the expense of higher purchase cost, lower reliability, and increased heater height, which is critical in many installations.

New legislation in the U.S. has increased the minimum allowable steady state efficiency of direct-fired water heaters. Increasing steady state efficiency is easy: Decrease the size of the fire, or increase the capacity of the heat-absorbing surfaces. The immediate result is a measurable decrease in the temperature of the flue gases.

However, reducing the amount of heat a water heater sends up the chimney has an unintended consequence: a cooler chimney. That's the idea, but it can cause other problems. If a chimney cools off enough it can stop drawing. When the heater turns on again, it hopefully can still exhaust into the cold chimney, but it might not. This can cause carbon monoxide to enter the building, which is extremely dangerous.

There is another problem with cold chimneys: condensation. When a chimney is not hot enough, the moisture in the exhaust condenses into liquid water which is acidic because of other chemicals in the exhaust. Essentially, "acid rain" happens inside chimney, which can destroy it. The exact exhaust temperature at which this starts to be a problem depends on many factors, including the diameter and height of the chimney, the exhaust-gas velocity, the location of the chimney (inside or outside the building), and the insulating value of the chimney, if any. The problem is worse if the chimney is oversized for the water heater because it is large enough to accommodate both the water heater and a separate heating boiler.

ADVANTAGES OF INDIRECT WATER HEATERS

An indirect-fired water heater can reduce or eliminate most or all of these problems. They are available in stainless steel with a 15-year guarantee. The lime problem is greatly reduced because the lime collects on the outside of the coil instead of inside the tank. When the lime coating on the coil gets thick enough, it cracks and falls harmlessly to the bottom of the tank. This is triggered by the sudden expansion of the coil when the pump turns on and starts pumping hot boiler water

through the coil. Aside from taking up space, these lime deposits at the bottom of the tank cannot damage the tank. Periodic draining of the tank can supposedly remove the lime, as with a direct-fired water heater, but most people won't bother. Lime accumulation will not destroy an indirect water heater because there is no fire under the metal at the bottom of the tank.

Indirect-fired water heaters take heat from the boiler they are connected to, so they do not need their own chimney. No chimney means no standby losses from the tank except minor jacket losses, which don't count in the winter. There is no problem with two combustion appliances sharing one chimney.

But what about standby losses from the boiler that heats the indirect water heater? In the winter, the boiler is presumably already hot most or all the time, so standby loss from the boiler probably does not increase, while standby loss from the water heater is eliminated. Therefore, an indirect

water heater can be expected to sharply reduce standby losses in the winter.

Presumably the heating boiler would not be warm in the summer if the indirect water heater was not connected to it, so it is fair to attribute all the boiler's summertime standby losses to the indirect water heater. This leads to the question of which would be higher: the summertime standby losses from a boiler heating an indirect water heater, or the annual losses from a direct-fired water heater? The answer: it depends.

If the boiler is a sealed combustion, direct-vent boiler, the standby losses are very small. If the boiler is chimney vented, the losses are higher. If the unit is an atmospheric-gas boiler, there is little internal resistance to the flow of air, so the standby losses will be very high. If the boiler has a motor-driven fan for combustion air, such as an oil-fired boiler or a boiler equipped with a motorized gas burner, the smaller flue passages reduce the off-cycle flow of air through the heat exchanger. Therefore,

standby losses will be smaller than with an atmospheric gas boiler. The standby loss question is further complicated by the very important but frequently ignored chimney question: Is the chimney brick or metal, single-wall or insulated, internal or external, and how tall is it? Available research sheds little light on the subject of differences in standby losses as related to different types of boilers, different types and heights of chimneys, and different boiler-standby temperatures.

CONCLUSION

Part 2 of this series will review fuel-use profiles of indirect water heaters vs. tank heaters as well as review installation consideration for indirect water heaters.

For previous Equipment Notebook articles, visit www.hpac.com.