Reclaiming Heat From Boilers

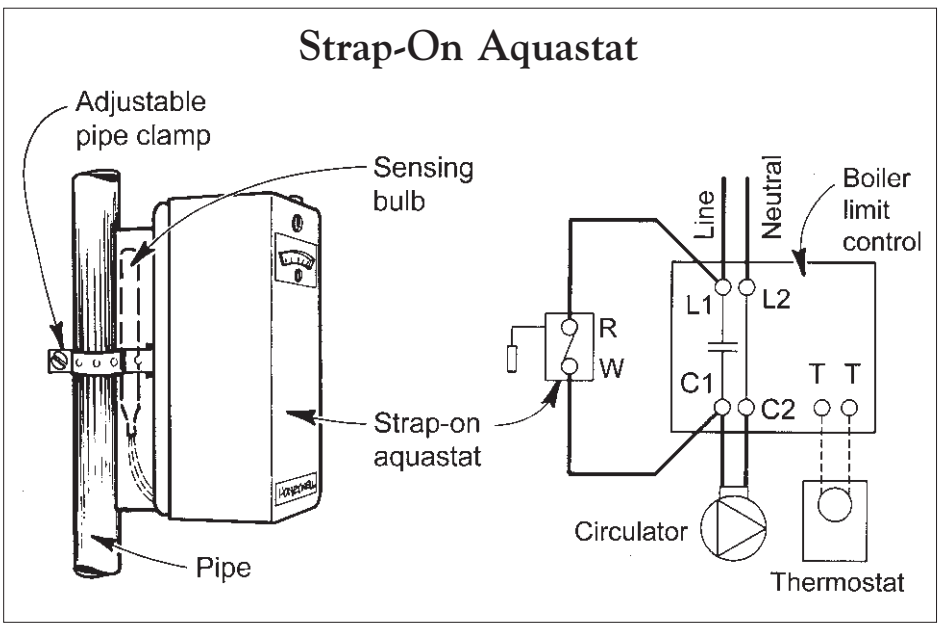
by John Siegenthaler, P.E.

The ideal hydronic boiler would continually adjust its heat output to match the heating load of the building it served so that it never produced more heat than needed. Unfortunately, residential boiler technology hasn't yet progressed this far. For the time being, boilers have only two rates of heat output: totally on or totally off.

Since boilers are often oversized for the loads they serve, once turned on, they almost always produce heat faster than the building needs it. The excess heat rapidly warms the water and metal within the boiler. In most systems, the temperature of a firing boiler will continue to climb until it reaches the temperature set on the boiler's limit control. In some systems, this can be more than 200°F. As long as the load continues to call for heat, the burner will be cycled on and off as necessary to keep the boiler water within a few degrees of this upper temperature limit.

When the heating load is finally satisfied and the thermostat shuts off the burner, a considerable amount of heat is left "stranded" in the boiler. For example, a boiler containing 400 pounds of cast iron and 10 gallons of water, when cooled from 180°F to 110°F, releases about 9,200 Btu. During the off period, air currents through the combustion passages in the boiler can carry some of this heat up the chimney. How much heat is lost depends on the age and design of the boiler, the length of the off cycle, and how well the boiler jacket is insulated. Older boilers, in general, have significantly more off-cycle heat loss than do modern units.

So-called "atmospheric" gas-fired boilers, especially older units without motorized flue dampers, are the worst offenders. Their open bottom design allows air, heated by residual boiler heat, to continue flowing upward through the boiler (and out the chimney), during the off cycle. This off-cycle loss has proven so significant that most energy codes now require that a motor-operated flue damper be used on all new installations of such boilers. Oil-fired boilers also experience some off-cycle draft heat loss,



A strap-on aquastat keeps the radiator water circulating through the heating system until it drops to a set temperature, usually around 110°F to 120°F. Typical control wiring is shown at right.

although generally not as great as atmospheric gas boilers.

Use It or Lose It

One way to capture some of the heat left in a boiler at the end of a heating cycle is to "purge" it out of the boiler before the off-cycle draft can pull it up the chimney. To do this, wire the system's circulator for continuous operation during the heating season. Continuous circulation is very common in Europe and is gaining acceptance in North America. Since the circulator keeps running after the boiler is shut off, the residual heat in the boiler is dissipated into the building through the radiators or convectors.

The only disadvantage of continuous circulation is increased electrical consumption. I've estimated that a 100-watt circulator operating continuously for 8 months of the year would use about $40 more electricity (at $.10/kWh) than if it operated only when the thermostat calls for heat.

Strap-on aquastat. For those who don't like the idea of a continuously operating circulator, a compromise measure is to mount a "strap-on" aquastat (available from Honeywell or White-Rogers) on the supply pipe to the distribution system. The aquastat's normally open contacts are wired in parallel with the boiler's high limit control (see illustration, left). Assuming the aquastat is set for 120°F with a 10°F differential, its contacts close when the supply pipe gets up to 120°F and remain closed during the on cycle. After the thermostat is satisfied, the aquastat keeps the circulator running to dissipate residual boiler heat into the building. When the supply water has cooled down to 110°F, the aquastat's contacts open and the circulator stops.

Overheating. Because the residual heat is released gradually, neither continuous circulation nor a purging aquastat will generally cause objectionable building overheating. However, there can be exceptions. Systems with greatly oversized boilers or boilers with large water or metal content (a lot of thermal mass) have the potential to create noticeable overheating. Purging into a single small zone circuit within a multi-zone system is also likely to cause some overheating.

If overheating occurs, you can set the anticipator on the thermostat for shorter cycles or lower the temperature limit on the boiler control. Make these adjustments in small increments, and observe the results for several on/off cycles before proceeding further.

How Low Can You Go?

Although it's possible to purge heat from a boiler until its water temperature drops to almost room temperature, this is not necessarily a good idea. The key is to avoid excessive condensation of exhaust gases when the boiler begins its next firing cycle. Although all demand-fired boilers are capable of starting from room temperature and can handle a small amount of condensation during such times, they don't normally undergo such cold starts on every cycle. A lower limit of 110°F for oil-fired and 120°F for gas-fired boilers is suggested. This also allows faster recovery at the start of the next heating cycle. Some boilers can handle lower temperatures, but you should verify this with the manufacturer.

Combined Heating & Domestic Hot Water Systems

Many residential hydronic systems provide both space heating and domestic hot water. Purging is a little more complicated with these systems, but can increase efficiency by shunting excess heat to the domestic hot water tank. Controls can cost from $200 to $300, but with older systems they can pay themselves back in less than two years. For a more complete description and wiring schematic, send a SASE to Boiler Purging, *JLC*, RR 2, Box 146, Richmond, VT 05477. ■

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