by Tom Morgan

HEATING SYSTEM RETROFITS

Few heating systems last forever. They may be replaced due to damage, or because newer models offer greater energy efficiency. But often parts of the original system—piping, radiators, ducts, or flues—are worth salvaging. When tying the new system into existing components, it's critical that the new equipment be well matched to the old. If not, the updated system will not live up to its potential. In my work as a commercial and residential home inspector, I see three main types of systems: steam, hydronic, and warm air.

Steam

Steam systems can be finicky and their heating output difficult to fine-tune. But they are common in older New England homes and may be worth upgrading with a new boiler. Although it may be tempting to switch to hot water, this is not a good idea. The steel piping and radiators will be full of slag (from corrosion), which will interfere with the water distribution. Also, much of the basement piping would need to be replaced with smaller diameter tubing.

The first step in retrofitting a steam heating system is to determine the size and heat output of existing radiators. While in new construction one calculates the heating load as a function of window area, insulation levels, and so on, in retrofitting, the best guide usually is to match the existing amount of radiation. An exception to this would be a house where new radiation is being added for an addition or new finished area.

When installing a new steam boiler, make sure the steam-discharge pipe from the top of the boiler matches the one being removed. This pipe (usually 2 to 3 inches inside diameter) goes into a header of the same diameter. If the new boiler does not have the same header size as the one removed, the steam system will lack adequate pressure to conduct heat to the radiation.

In the typical early steam plants in this area, the piping was steel with threaded fittings assembled on site. Newer methods use copper tubing with copper fittings soldered together. Make sure any piping that is replaced matches the diameter of the original.

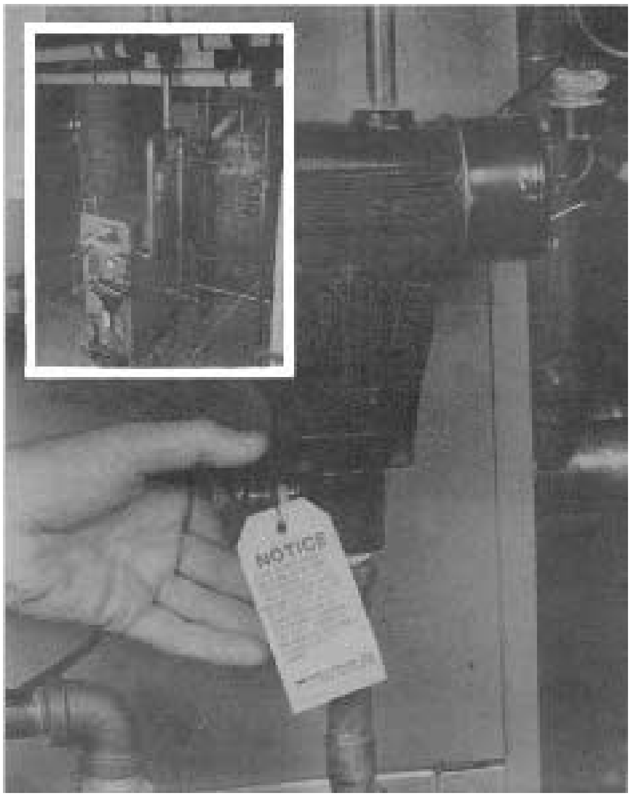

***Figure 1.** On a retrofitted steam system, instruct the homeowner to flush the blow-down regularly during the heating season. Otherwise, the low-water cut-off safety control can malfunction.*

Pipe insulation is also important. Most steam systems were installed with asbestos insulation on the piping between the boiler and radiators. If this was removed and not replaced with new fiberglass pipe insulation, the uninsulated piping will over-heat the basement area and not deliver heat to the living space.

Also critical is the piping design. A steam system has a piping configuration called a "Hartford Loop," which allows the condensate to return to the boiler. When installing the new boiler, it is imperative that the vertical distance between the loop and the water level in the boiler remain the same. Otherwise the water in the sight glass will read incorrectly and the system will malfunction.

The new boiler should have a large, easy-to-read glass so the homeowner can see the water level, which tells you whether the steam is "wet" or "dry":

- *Wet Steam:* Steam that has some entrained water and is heavier per cubic foot than dry steam, and cause a "hammering" noise.
- *Dry steam:* Steam with less water. It moves faster through the piping system and has a higher heat potential.

Wet steam is caused by too high a water level in the boiler vessel, which will be visible in the sight glass. We typically recommend that the water be kept at about the three-fourths level. The water level must be maintained manually by the homeowner.

Many homeowners assume that the manual feeders now installed (typically the McDonnell & Miller #101A, Electric Water Feeder) does the job for them, but this is really just a safety device to maintain a minimal water level of one inch in the sight glass. This low level might not produce enough steam to heat the building efficiently.

All systems have a second safety control called a low-water cut-off, which shuts down the burner if the boiler runs dry. To keep this device working, however, someone needs to regularly flush and maintain the adjacent blow-down valve (see Figure 1). Otherwise sludge and residue develop and block the float that operates this safety device.

If additional radiation is needed for a steam system, you will need to add cast-iron baseboards, rather than the hot-water fin-tube radiation used for hydronic systems. Any added radiation will need to be on the same zone since steam systems are not practical to zone.

Hot-Water Systems

Hydronic systems have the advantage of easy zoning and easy homeowner maintenance. Unlike a steam system, the homeowner does not have to add water to the system. In upgrading a hot-water system, you must choose between a wet-base and dry-base boiler, and between cast-iron and steel.

As the name implies, a wet-base boiler permits the returning boiler water to pass at the very bottom or base of the boiler and circulate around three sides of the combustion chamber. This creates greater water exposure and more efficient heat transfer. In a dry-base boiler, the returning boiler water enters at the top of the combustion chamber and does not have as much exposure to the combustion chamber. Of course, other factors affect energy efficiency as well. In general, look for a product with a high AFUE rating.

Many of the old components can be salvaged, but tying in the new takes special know-how

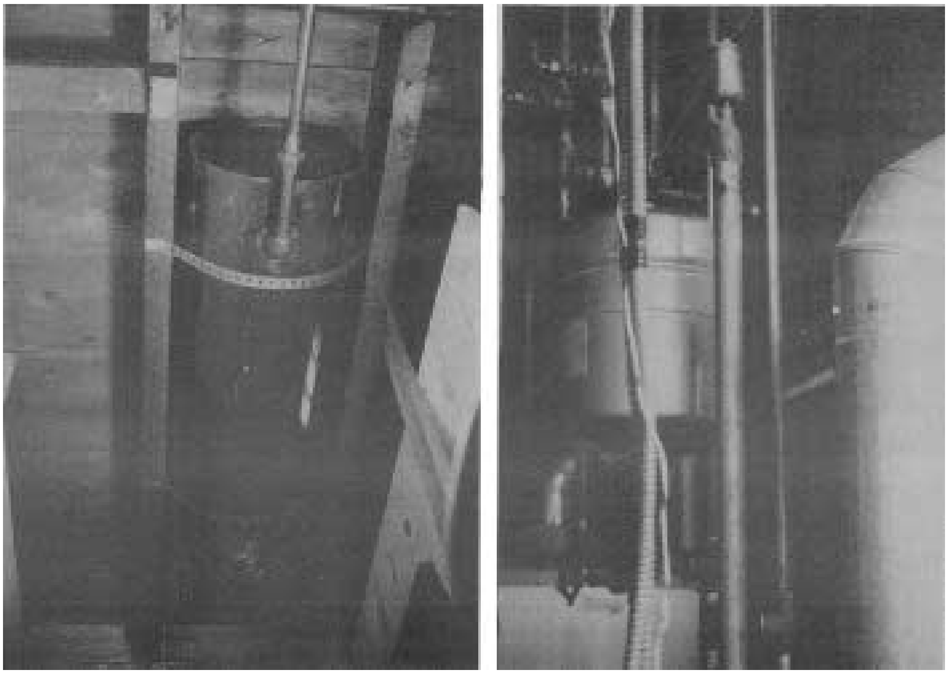

Figure 2. When replacing an old boiler, replace the old expansion tank (left) with a pre-pressurized Extrol tank (right). This will help prevent "hammering" noises and air blocks in the system.

The choice of boiler materials is also important. Cast-iron is more expensive than steel, but will last a lot longer. I've seen steel boilers rust out in as little as ten years.

The other major choice is whether to zone the system. The zones or loops are controlled either by a circulating pump with multiple zone valves, or by multiple pumps controlled by zone thermostats.

The advantage of multiple circulating pumps over zone valves are: (1) the thermostat sends a message directly to the particular pump which provides a faster response; and (2) fewer mechanical moving parts. With a separate pump for each zone, a home will stay warm even if one pump fails.

As a home inspector, I've seen numerous faulty upper units or "heads" of zone valves discarded on the floor near the boiler. Recently, however, the hydronic industry has introduced more effective and more reliable zone valves to the market.

When installing a new hydronic system, it's important that you install a new pre-pressurized expansion tank (commonly known as an "Extrol" tank), and remove the old expansion tank traditionally placed in the basement ceiling between the joists (see Figure 2). The old tanks are typically "waterlogged," meaning that most of the air in the tank has been lost by being dissolved into the circulating water. The new tanks have the air in a bladder to avoid this problem. (The air is pressurized at 12 psi to match the pressure of the incoming water supplied to the automatic feed valve.) The new tank, air scoop, and automatic air eliminator vent will work together to eliminate noise and "air blocks" within the system.

Warm-Air Systems

New warm-air furnaces may use oil, gas, electricity, or heat pumps to provide heat to the airstream. Some systems use more than one fuel source. Some even use hot water in a fin-coil to heat the air in the furnace. A key advantage of air systems is their ability to provide air conditioning. A disadvantage is that they are not practical to zone in residential applications, although motorized zoning dampers are available.

Warm-air heat was introduced into the marketplace prior to hydronic, and it was much less expensive. The most basic system used one large through-the-floor grate over the furnace that functioned as both supply (in the center) and return (around the perimeter). The next generation of warm-air heat had holes cut in the floor with floor registers and one large return. These early systems had no fan-forced returns, relying strictly upon gravity and convection.

There are problems in retrofitting a newer forced warm-air system to an old warm-air gravity system. First, the old ducted warm-air systems were referred to as "octopus" systems because they had large 8- to 12-inch circular heating ducts (tentacles) branching from the furnace assembly. These often led to centrally located registers. The newer systems are much smaller, work best with smaller ducts, and need the supply registers located on outside walls, so they can't generally make use of the existing large ductwork.

The humidifiers often installed in new systems clog up soon after installation and cease working, producing complaints of dryness. Another criticism of modem air systems is that they are dusty—in part because homeowners do not change the filters. (Extra dusting by the homeowner would also help.) Comfort, also, can be a problem since the new systems are either "on," with a blast of hot air, or "off." The older gravity systems tended to run more continuously.

Finally, the noise from the blower and belts on the return side can be a problem. Systems can be particularly noisy if they use a single large return duct, which can act as an "echo chamber." To reduce noise levels, you should connect the return ductwork to the furnace with a flexible connector.

In changing from a gravity system to a fan-forced one, you cannot just tie into existing ducts in "handyman" style and expect to get the desired airflow. The new duct runs must be sized and designed according to good heating practices. To fine-tune systems, I use a velocity meter to determine the output of registers, then make the necessary volume damper adjustments. Of course, adjustments are only possible if the installer has put volume dampers in each branch duct—an inexpensive step I strongly recommend.

Add a New Burner

In some applications, you can leave the original heating plant in place and simply update the burner to something more energy efficient. In fact, many of the oil-fired boilers in the Northeast at one time burned coal (see Figure 3). Similarly, you can replace a conventional burner in an oil-fired boiler with a new flame-retention-head model, which is much more efficient. Some of the old, heavy cast-iron boilers were built to outlast you or me.

In a furnace, however, if the warm-air plenum has malfunctioned or deteriorated, which you can evaluate with a combustible gas detector, then you have no choice but to replace the entire unit.

In summary, retrofitting for steam, hydronic, or warm air, has many considerations other than selecting the right Btu output. Whichever route you go, don't skimp on the initial design work, or on using the correct piping, ductwork, or controls. ■

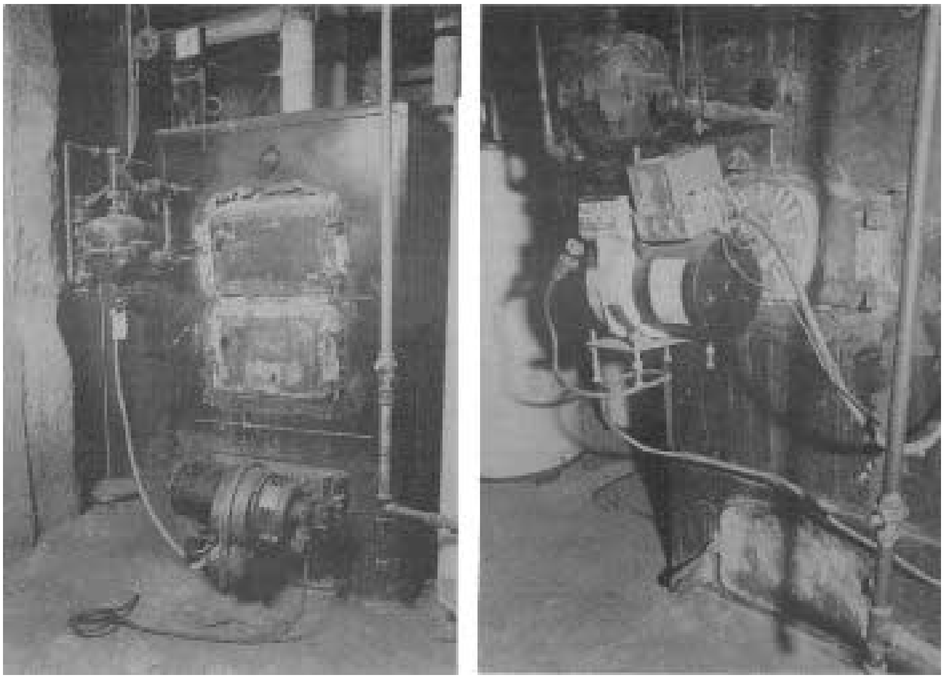

Figure 3. Many coal-fired central heating systems have been converted from coal to oil or gas. Typically, the burner is retrofitted to the lower ash door (left), but this wastes energy due to the 18-inch gap left between the fire and heat exchanger. A better approach is to use the upper loading door (right) for the burner.

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