# HOW TO REPLACE A BOILER WITHOUT LANDING IN HOT WATER

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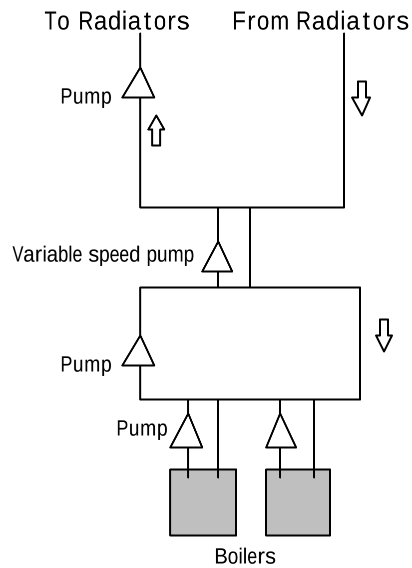
So it's finally time to replace that monster in the attic. You're in luck. There are some great boilers on the market . . . small, fuel efficient and so comely. All you need to do is make sure that new boiler is at least as big as the old one, and get your trusted wrench warrior to throw it in, right?

Hold on there! Not so fast! To begin with, the old boiler was probably grossly oversized in the first place. The guys that installed boilers in the old days used 'rules of thumb' to make sure they didn't undersize the boilers. They didn't much care if they were too big. And if the boiler has been replaced a couple of times already with a 'safety margin' added each time . . . your boiler could easily be double the capacity you need. Your building may also have been changed over the years . . . maybe you have new windows or the roof has been insulated. You don't want to make that new boiler too small, but too big can be expensive and inefficient. A detailed envelope heat loss calculation will accurately determine the right capacity for the new boiler. And if that heat loss is done on a computer program that will simulate the hour-by-hour fuel consumption throughout the year, its easy to do a cost-benefit analysis of various boiler efficiencies. Then you can pick the boiler that will save you the most money in terms of initial capital cost and fuel efficiency. With some care, you'll save enough in reduced fuel consumption to pay for the whole retrofit in 5 to 8 years.

So you know the right capacity for the new boiler. Time to call your contractor? Not yet. That new boiler probably has different characteristics than the boiler you are replacing. Does the old monster look like it came off a tramp steamer and the new boiler look like a bar fridge? You can't just replace a high mass boiler with a low mass boiler. Most 'near boiler' piping systems, even some of those still being designed by engineers, are based on fire-tube boiler systems from the 40's and 50's. Those beasts were essentially huge tubs of water. That little beauty you're about install probably holds less than the average mop bucket, and in tubes no bigger than your pinky finger! The old boiler wasn't really affected that much how much water was flowing through it . . . there was plenty of water in there. This new boiler is different. If the flow through the boiler is a just a little sluggish, you'll quickly find out why they call these things 'boilers'. The water will flash to steam in an instant or hot spots will be created that will crud up those little tubes. And it's downhill for your boiler after that. You can't assume the old pumps will maintain adequate flow through the boiler. Some old piping arrangements, and, alas, many new ones, copy old designs which actually *vary* the flow through the boilers. If your system has a motorized 3-way valve, you probably have one of these old designs. Before you go any further, make sure the flow through the boiler meets the manufacturer's recommendations under all conditions.

You're still not ready for Mr. Goodwrench. What about water temperature? Most boilers cannot tolerate return water temperatures lower than about 130°F. Any lower will cause condensation that will mix with flue gases to produce a powerful acid, which will eat your poor boiler's delicates. If you have a radiator system, the supply temperature required to return water to the boiler at 130°C will overheat your apartments in the mild weather of spring and fall. You are not scot-free with fan coils either. Higher temperatures mean higher pipe losses. Some boilers, particularly high efficiency condensing boilers and some European boilers (Viessmann and De Dietrich, for example), are designed to handle lower water temperatures, but they tend to be expensive. A cost effective alternative for larger systems is primary/secondary/tertiary pumping. This is a piping design in which the distribution system (serving the apartments) is a separate loop with its own pumps, and the boilers have their own loop with its own pump or pumps. The boiler loop can be at the temperature that the boilers like and the distribution loop can be the temperature that will keep your residents happy. When heat is needed, the right amount of hot water from the boiler loop is pumped into the distribution loop with a variable speed pump. It works great. It keeps the boilers humming and avoids overheating apartments. This system can generally save about 20% of the total heating bill.




Simplified Primary/tertiary' System

The next question is 'how many boilers'? Do you save money and put in a single boiler? Maybe there was only one boiler before. Multiple boilers are nice, because if one fails, there will still be some heat until you can get a mechanic out to fix it. But there's another good reason to have multiple boilers. Many boilers are either 'on' or 'off'. That makes it tough to maintain even temperature. It like trying to drive smoothly along the 401 by either flooring the gas pedal or taking your foot off completely. Imagine what your fuel consumption would be like! The guys that designed that old boiler didn't care because fuel was cheap in those days. Besides, the old boiler was more like driving a transport truck with a load of pig iron. Multiple boilers, or boilers with modulating burners, gives you more 'speeds' for more even heating and better fuel economy.

There are a few more things to consider. The rads in your building were designed for a specific 'delta T' (that's just a fancy term for the difference between the supply water temperature and return water temperature). Old cast iron rads and newer radiant panels could be designed for a 'delta T' of 30 or 40°F. Newer baseboard convectors may be designed for 20°F or less. The boiler plant has to be designed to accommodate that delta 'T'. If your boiler plant raises the water by 30°F and the distribution system sucks only 15°F out, then there is a mismatch and a problem. The boilers will cycle and you will get slugs of water through the system that are either too hot or too cold. There goes fuel efficiency, if not comfort. This is not a problem with a primary/tertiary system, however.

Ready to call the mechanical contractor now? Not quite yet. How are you going to control your new boilers? Your old boiler probably had a simple indoor/outdoor control. This control senses the outdoor temperature and varies the supply temperature to compensate for the heat loss of the building. For example, when it's 10°F outside, the control might fire the boiler when the supply temperature drops to 140°F, fire until it reaches 160°F and turn it off until it drops down to 140°F again. This is still a big temperature swing. More modern controls contain computer logic to *anticipate* the needs of the system and fire the boilers to minimize these big temperature swings for better fuel economy. They also have logic to prevent rapid cycling of the boilers. This is when they fire and then shut off every few minutes. Rapid cycling is a leading killer of boilers.

Don't forget instrumentation. When it comes time to troubleshoot your heating plant, if you have no instrumentation, you have no information to go on. Thermometers on the supply and return lines of the distribution system and on the supply and return lines to each boiler should be an absolute minimum. Do yourself a favour and get good quality instruments. They're worse than no good if they are not accurate.

Consider also the poor, overlooked expansion tank. It allows water in the heating system to expand and contract without breaking anything, as it heats up and cools down. You probably don't absolutely need to change it, but you might want to. Older expansion tanks work by trapping air in the top half of the tank. As water heats and expands, it compresses the air caught in the tank. The trouble with these tanks is that they expose the heating water to oxygen. Oxygen causes corrosion in pipes and equipment. Modern bladder tanks have a rubber membrane between the air and the water. They are maintenance free and do not allow the water to become oxygenated.

The chimney should also be checked. While the boilers are being replaced is a good time to see if that chimney is properly sized, lined and not obstructed. We have come across a few buildings where the chimney is so high, and creates such a strong draft, it was sucking the flame right out of the combustion chamber. If the draft is too high, special provisions have to be made. While you are at it, make sure that the ventilation and the combustion air ductwork in the boiler room is up to code. The details are in the Gas Code.

Don't forget to have a detailed boiler room layout done. Otherwise the system tends to get piped together in a sort of 'stream of consciousness' that may make some equipment hard to maintain later. The saving grace is that plumbers tend to start with the boilers, otherwise there would be more boilers hung from the ceiling sideways. What we often see is valves that can't be turned, motors that can't be oiled and strainers that can't be cleaned. And for some reason, motorized valves always seem get squeezed up against the ceiling! They almost seem ashamed to be in the boiler room! They always remind me of my first dance, huddling red-faced in a corner. I bet they're wishing they could go hang out in the valve washroom and have a smoke with the flush valves.

Finally, you might consider using the heating boilers to heat your domestic hot water (DHW). You'll need some additional pumps and controls. And a double wall heat exchanger, because you don't want to be drinking boiler water. If your domestic water heating boilers are in poor condition, it's worth considering. Domestic water boilers are usually 'direct fired'. That means the potable water from the City is heated directly in a boiler. 'Indirect fired" means that the potable water is heated in a water-to-water heat exchanger. When heated directly in a boiler, fresh water readily gives up its minerals, which ends up lining those delicate boiler tubes. Besides becoming increasingly inefficient as scale builds up, the scale causes hot spots that shorten boiler life. There is also the question of low temperature water entering the boiler and the corrosion it causes. That's why the lifespan of direct-fired DHW boilers is so much shorter than those for space heating.

Now you can call your contractor. Or maybe you should call an engineer who specializes in heating and cooling systems, because I've just scratched the surface. No matter who you hire, ask them how they will address the above issues and make sure you are satisfied with the answers. One final word about engineers. Sometimes you hire an engineer for an expert opinion. *This is not one of those times*. You need actual engineering. The end result should look like your kid's math homework for the year. Besides the heat loss calculations, there are flows, delta T's, and system volumes to be calculated, pumps to be selected based on flow and head, pipes to sized, etc. When this is all done, the engineer should provide you with a schematic drawing, a boiler room layout, and a specification. Strangely, some firms have a 'standard' specification, which seems to be a contradiction. The 'spec' should list the equipment to be used and how it is to be installed for your particular job. Ask for copies of all the calculations, too. When it comes time to troubleshoot or upgrade the heating system, these will save a lot of time and money.

*Before you replace your boiler, make sure that the following basic steps are followed:*

1. Determine the capacity of the new boiler plant by having a heat loss calculation done.
2. Decide how many boilers you need.
3. Determine how the new system will avoid low return water temperatures that will damage the boilers.
4. Design the new heating plant to control supply temperature to prevent overheating in mild weather of spring and fall.
5. Ensure the boiler output is matched with the distribution system requirements.
6. Get good controls with a well thought out control logic.
7. Detail the instrumentation required to troubleshoot the system.
8. Determine if the expansion tank is to be changed.
9. Ensure the ventilation & combustion air ducting is suitable for the new boilers.
10. Confirm the chimney is suitable for the new boilers.
11. Have a detailed boiler room layout made.
12. Consider using the system to heat domestic hot water.

***Weinstein Taylor and Associates are consulting mechanical and electrical engineers who specialize in the design, troubleshooting and upgrading of heating and air conditioning systems.***