Boiler Facts

Pumping Away… What does it really mean?

by George Carey

I was walking a tradeshow with a couple heating contractor friends of mine when we encountered this exchange between a heating contractor and one of the exhibitors. The exhibitor had a boiler in his booth that was piped with an air separator and expansion tank on the supply coming out of the boiler…just like you should. After this, he had a supply manifold with three zone circulators and three flo control valves located on the supply, "pumping away". When the "heating contractor" walked into the booth, he complained to the exhibitor/salesman saying "you can't pipe a boiler like this…it will never work!"

For the next 10-15 minutes, I listened as the exhibitor tried his best to convince the contractor that in fact, not only *could* they go there…they would work so much better on the supply than the return.

Well, the heating contractor would hear none of it! The exhibitor even mentioned that Dan Holohan published a book about this very subject—"Pumping Away"—that has become a best seller in the hydronics industry! The contractor's response… "Well, he's also wrong!"

I love it; you just can't make it up. Truth is better than fiction. After this all took place, I couldn't stop thinking about an article I came across 15+ years ago from a man named Ed Tidds. He worked for Bell & Gossett back in the '50s & '60s. He used to publish a collection of hydronic stories back then that he called "Tidd-Bits". One of them was titled "All the Dirt Goes Ahead of the Broom." In this article, he attempted to explain through the use of an old country expression, that "if we pump out of the boiler, the pump force 'pushes' the air bubbles ahead of the flow, and this continuing 'push' eventually forces them back to the boiler or the separating chamber. Now, we are pushing the dirt ahead of the broom." He was around B&G at the same time as the famous Gil Carlson. I think Ed Tidd was trying to say what Carlson explained so simply…

But first, who was Gil Carlson? He was a mechanical engineer who worked at Bell & Gossett who became known as the "Father of Modern Hydronics". He invented products and developed various theories and applications that today we consider standard procedures. One of his most popular and probably most important discoveries was the "Point of No Pressure Change." This subject deals with the importance of proper pump location in a closed hydronic system.

What is meant by the proper location of a circulator in a closed system? The circulators in the system should be located so they are "pumping away" from the expansion tank. Installed in this manner, when the circulator turns on, the pressure differential it develops will be added to the system's static pressure. The static pressure is the pressure that exists throughout the system when the circulator is off. It is simply the weight of water. If you were to place a gauge at the bottom of a column of water 28" high, the gauge would register 1 psi. That is one pound of pressure *per square inch*.

When centrifugal pumps are used in closed, pressurized hydronic systems, they are referred to as circulators. The reason is the circulator is not pushing or pulling the water around the system, but rather it is *circulating* the water through the system. This might sound like just a play on words but there is a big difference. You see, the circulator does not create pressure, only pressure differential. In addition, the pressure on the discharge side of the circulator has to be higher than the pressure found on its inlet side.

Remember the old saying, "high pressure goes to low pressure"? In a hydronic system, think of it this way: the system is a closed, pressurized wheel. When the circulator is off, the water does not circulate through the wheel. However, when the circulator turns on, it upsets the balance that existed. The direction the water flows is determined by the higher pressure found on the discharge side of the circulator. The key difference between pressure and pressure differential is when the circulator turns on, it does not care if its discharge pressure increases or if its suction pressure drops, so long as the pressure on the discharge side of the circulator is higher than the pressure on its suction side. And because there *is* a difference in pressure across the circulator, the water in the system circulates! In fact, all the water in the piping circuit moves instantly. That is because water is not compressible, so when the circulator comes on and upsets the balance that existed in the circuit, all the water circulates.

So if the water in this closed hydronic system is going to circulate, regardless of whether the circulator is on the supply or return, why all the fuss about its location? The answer has to do with how the circulator can change the system's static pressure. If the circulator is located on the supply, pumping away from the expansion tank, the system's pressure will be increased. If the circulator is located on the return, pumping towards the expansion tank, the pressure in the system will be decreased. And this drop in pressure can cause all sorts of problems. Air that is entrained in water, when exposed to a lower pressure will come out of solution in the form of bubbles. This can cause gurgling noises, a reduction in heat transfer efficiency and quite possibly air-binding of radiation, requiring a service call to purge the air.

If the circulator's pressure differential is high, it can drop the system's pressure on the top floor into a vacuum. Of course, any float vents exposed to vacuum will draw air *into* the system. This is definitely not a good thing! How big does that circulator need to be to cause this situation? It depends on each individual job, but typically, the type of circulators found in most commercial jobs, such as apartment buildings, office buildings and churches are of that size. Any of your commercial accounts could have one of these circulators.

Point of NO Pressure Change

Why can't the circulator change the system's pressure at the point where the expansion tank connects to the system? This is a question asked often, both in the field and at our hydronic seminars. The answer is based on Boyle's Law of Perfect Gases, which the science community has referenced for hundreds of years. Boyle's Law says that if you have a gas (air) trapped in a tank (expansion tank), its volume will shrink if you add pressure to it. Likewise, its volume will expand if the pressure is lowered. In other words, if you squeeze a gas, its pressure will rise and conversely, let the gas expand and its pressure will drop. How does all of this relate to hydronic systems?

To change the pressure in the expansion tank (diaphragm or steel), you have to squeeze the air that is in there. When the boiler heats the water in the system, the water expands, compressing the air in the expansion tank. This causes an increase in the system's pressure, which you can see on the gauge of the boiler. When you open the fill valve to add more water to the system, because the piping is already filled with water, the additional water enters into the expansion tank, compressing the air, causing a rise in system pressure which is indicated on the boiler's gauge.

When a circulator turns on, does it heat the water? Does it add more water to the system? Or does it just circulate the water? Can you see the difference? If there is no change in volume or temperature of the water, there can't be a change in its pressure.

If the circulator is pumping away from the expansion tank, can it take water out of the tank? If you think yes, where would you put it? The piping is already filled and you can't compress water. If the circulator is pumping towards the expansion tank, can it put water into the tank? Air *is* compressible, so water can enter the tank.

But where would the water come from? If you think it can come from the piping circuit, that means there would be a void in the piping circuit. And Mother Nature hates a vacuum (void)! No, when a circulator comes on, it can neither add nor remove water from the expansion tank. And if it can't change the volume of the water in the tank, it can't change the volume of the air (gas) in the tank. This means it can't change the pressure in the tank or the piping connecting the tank to the system.

Every time a circulator turns on, it "looks" for this point. Depending upon whether it's pumping away or towards the expansion tank, it either increases its discharge pressure or drops its suction pressure. And this is why since the 1960's, when *Gil Carlson* wrote his famous paper on the "Point of No Pressure Change", circulators should be located on the supply "pumping away" from the expansion tank.

If you have any questions please call me at 1-800-423-7187 or email me at gcarey@fiainc.com