Diaphragm Tanks & Pressure Reducing Valves

and how they work hand-in-hand

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I received a call from a service technician the other day inquiring about some information on hydronic systems. In particular, he was asking about diaphragm expansion tanks and pressure reducing valves (PRVs) and how they interact with each other. He was interested in finding out what the proper settings were and, more importantly, why.

Before you can start answering those questions, it is important to really understand what the functions of these hydronic heating system components are. Pressure reducing valves are pretty much as their name implies: they take the incoming street pressure and reduce it down to what's needed inside the particular building in which it has been installed. You see, a hot water heating system has to have the system filled with water. And how do we do that? By filling the boiler and all of the piping and radiation with water that comes from the city water main.

The question comes up often: how do we know how much water is needed to fill the system? By using the pressure gauge on the boiler, we can determine when the system is completely filled with water. Water has weight and as you stack more water on top of itself, it weighs more. By using the pressure gauge on the boiler, we can determine how high up into the system the water has gone.

The pressure gauge reads in *pounds per square inch* (psi), and we know that a column of water that is 2.31' tall or 28" weighs 1 psi at the bottom of that column. The key to using a pressure gauge in determining the height of a column of water is the expression pounds "per square inch." Whether the piping system you are looking at has ¾" copper pipes or 4" steel pipes, the measurement on the pressure gauge is the same; a column of water 2.31' tall weighs 1 psi.

So, to properly fill a hydronic system, you would measure from the boiler pressure gauge/PRV location up to the highest piece of piping or radiation (whichever is higher) in the building. You would then take that number and divide by 2.31' to convert to pressure in psi. But you don't stop there; the pressure reading would ensure that the water is all the way to the top of the system.

What would the pressure be in the system at the highest point? It would be zero pounds per square inch. If you had any high vents located at the top, how effective would they be? With zero lbs. of pressure inside the system and zero lbs. of pressure (atmosphere) on the outside of the system, there is no motive force for any air bubbles to vent out of the system. To ensure that high vents will be able to do their job, the industry has standardized the adding of an additional 4 psi to the number required to get water up to the highest point. So, to establish the proper PRV setting for each application, measure in feet the distance between the boiler pressure gauge/PRV location to the highest pipe/radiation in the building, divide by 2.31', and to that number add 4psi. The result will be the proper cold water fill pressure for that system. The key is to fill the system when it's cold so that you will have an accurate reading from the pressure gauge.

Expansion tanks play a very important role in the proper operation of a hot water heating system. That function is very different from the pressure reducing valve's job, but for both to be effective they must work hand in hand. To appreciate this relationship, you want to have a good understanding of what the expansion tank's role is and how it does what it does.

When a system is completely filled with water and then heated to the operating control's high limit, there is anywhere from 3.5–5% more water in the system. This is because it expands when heated. Here's the problem: water is not compressible, so when this increase occurs—if there is no place to put this extra water—the relief valve on the boiler will open up and dump system water onto the floor. This is where those diaphragm tanks come into play. Air is a gas which *is* compressible, and so the expansion tank becomes the place where the

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expanded water goes while keeping the pressure in the system below the relief valve's setting. The air in the diaphragm tank acts like a spring, allowing the system water to push against it as it is heated and expands. The air in the tank is separated from the system water by using butyl rubber that is flexible.

These tanks are different from the older style steel compression tanks. In those tanks, the system water and air cushion came into direct contact with each other. Because of that, the tanks were larger than the diaphragm tanks. With a diaphragm tank, the air side is fully expanded, pushing the rubber diaphragm all the way against the other side of the tank. When connected to the system, the air side pressure is now seeing the system's fill pressure. Remember: when cold, there should be *no* system water in the tank. For that to occur, the diaphragm tank's air charge pressure must match the system's fill pressure.

Diaphragm tanks are sized to accept the volume of expanding water in the system while keeping the pressure in the system below the relief valve's setting. Normally, PRVs and diaphragm expansion tanks come pre-set at 12 psi. The reason is that most of the applications are for two-story buildings. If you have a system in a building that requires a higher pressure setting, the expansion tank must be pre-charged to the higher fill pressure setting. If you did not match the air charge to the fill pressure, then once the tank was attached to the system, a certain amount of cold system water would enter the tank. Remember: there should be *no* water in the expansion tank when the system is cold. The net result is the expansion tank acts like it is too small, causing the relief valve to open and discharging the excess pressure. The only proper way to check the tank's pre-charge setting is while it is disconnected from the system. If you were to check the pressure while the tank is attached to the system, it would be a faulty reading because the water pressure from the system is "squeezing" against the diaphragm. The gauge would just be reading the system pressure.

As you can see, each of these components has their own job to do, but to do them properly, they have to work hand in hand.

If you have any questions or comments, e-mail me at gcarey@fiainc.com, call me at 1-800-423-7187 or follow me on Twitter at @Ask_Gcarey. ICM