A Steam System with a problem?

Think about the refrigeration cycle...

By George Carey
gcarey@fainc.com

George R. Carey Jr. is Vice President at Fluid Industrial Associates (FIA), a manufacturer's representative of steam and hydronic productssold through Wholesale Distribution for all of New England. George is in charge of all of the Training and Education for FIA has taught steam and hydronic courses for Northeastern University's Continuing Education program.

Recently, steam systems with problems—for whatever reason—have been coming at me fast and furious. I have been receiving phone calls, emails and called to jobsites with steam systems that are experiencing all kinds of problems. I have noticed though, with all of the jobs, there is one constant—the guy or guys solving (or creating) the problem really didn't understand the nuances that a steam system brings to the table. I'm talking about such things as the fact that:

- ☑ A steam system is filled with air any time the system is off and if you want heat, you have to get rid of all the air before the steam can get in and heat the radiation.
- ☑ A steam system operates NOTHING like a water system…the steam, when manufactured in the boiler, desperately wants to turn back into water and it will do so whenever it touches something cooler than itself. If you don't make enough, it will NEVER reach the furthest radiators.
- ☑ Steam boilers today really aren't capable of producing dry steam internally, which is why manufacturers insist that you pipe the boiler according to their installation manuals.
- ☑ Steam boilers today are VERY different from the old boilers we are replacing. Some of those differences are good; unfortunately there are several that can be very bad and make someone want to quit their job if those differences aren't taken into account!

In addition to looking at these problem steam jobs, I have also been writing stories about and designing hydronic systems that use *Air to Water Heat Pumps*.

Many in the industry view these machines as "State of the Art" technology. Their compressors incorporate invertor technology which, in the "compressor world" is state of the art. The invertor basically allows the compressor to operate like a variable speed pump, and the expansion valve can operate over a wide range of loads, allowing the heat pump to extract heat from lower outdoor air temperatures than was previously possible. But at the end of the day, for any of these air conditioners and heat pumps to work at all, it all comes down to the vapor compression refrigeration cycle.

What does this have to do with an article about steam systems with problems? If you understand the vapor compression cycle—and IF you understand what a steam system is trying to accomplish—both systems have similar attributes.

Here is what I mean…

To make steam, the boiler HAS to heat the water in the boiler up to the water's boiling point. What is the boiling point? It depends on what pressure the system is operating under. When a steam system operates under higher pressure, the water's boiling point is higher. Also the temperature of the steam is hotter.

Two types of heat

Now, when I say the boiler has to heat the water, there two types of heat needed to make steam. *Sensible Heat* is the type of heat that a thermometer can sense. For example, when the boiler is operating at 2 psig, the boiler has to provide enough sensible BTUs to heat the water to 219°F.

The other type of heat is known as *Latent Heat*. This is the amount of energy (BTUs) that is required to change the water's state from liquid to vapor. Why? Remember, we are dealing with a steam system. For it to work, you HAVE to change the water into vapor. So in our example, the boiler would have to add an additional 966 BTUs of latent heat per pound of steam. That is five times greater than the amount of sensible BTUs that was needed to bring the water to a boil under 2 psig. Now when this 219°F steam travels out into the system and fills a radiator, it condenses back to water. And the temperature of the water can be 219°F, but the radiator has received 966 BTUs that it uses to warm the room.

When any medium goes through a phase change, it will either be absorbing or releasing a *tremendous* amount of energy. And that is how I was drawing a parallel between the vapor compression cycle and steam systems. In the compression cycle, instead of water, refrigerant is used which has many favorable characteristics for the refrigeration process. It can operate under extreme temperature conditions (extreme relative to what we consider normal); it can also change state and go from a liquid refrigerant to a vapor and then condense back to liquid, all the while absorbing and releasing energy (heat) to where it's needed (as a heating application) or from where it is not wanted (as in an air conditioning application).

Of course there is no boiler in the refrigeration cycle.

Instead, an evaporator is used to help change the refrigerant's phase and the compressor is used to increase the pressure on the vapor, resulting in a high temperature gas.

Before the vapor enters the compressor, it first flows across the evaporator as a cold liquid refrigerant. The volume and temperature of the cold liquid is controlled by an expansion valve. Outdoor air, or some other substance (such as geothermal) is flowing across the other side of the evaporator. The cold liquid absorbs the heat from the outdoor air (or geothermal field) and changes its state into a low temperature vapor.

To prevent damage to the compressor, it is critical that only vapor and NO liquid enter the compressor. The low temperature vapor gets "compressed" into a high temperature gas that now flows across a heat exchanger. The cooler medium (return air from the ductwork or water from a hydronic system) flows across the other side of the exchanger. This cooler substance (air or water) absorbs the energy from the vapor, causing it to condense back to its liquid form. In the condensing process, a tremendous amount of energy is transferred.

When we take it back to our steam heating systems, the boiler is our evaporator—and to some extent—our compressor. Its job is to add enough sensible AND latent BTUs so that the water is changed into steam (vapor). When the steam enters the radiator, its surface and surrounding air temperature is cooler than the vapor (steam) causing it to condense back to water (liquid). In doing so, it gives off a tremendous amount of energy (BTUs) to the space.

So how does analogy help solve or prevent steam system problems? Make sure the boiler is making good, DRY steam. When it makes wet steam, the water in its liquid state "robs" the vapor of its latent BTUs. When this happens, the steam is condensing in the piping network and NOT where it's needed…in the radiators!

How do we make good DRY steam? Make sure the new boiler is piped according to the manufacturer's installation instructions. Do what they say!

A bouncing water line in the boiler can also make wet steam. If the water is moving in the gauge glass, it's an indicator that the water in the boiler is dirty. It needs to be skimmed to rid the boiler of any oils and debris that cause surface tension on the water, prohibiting the steam bubbles from making their way through the surface and out to the system.

·When a boiler is undersized or underfired, it can't produce enough steam to fill all of the radiators. The condensor side of the system (the radiators) is bigger than the evaporator side (the boiler). It is imperative that when you replace a steam boiler, go upstairs and measure the amount of radiation in the house (apartment, school, church, etc…). Then size the replacement boiler to the connected load.

Whenever you are dealing with a steam system, it is vital that the boiler is making DRY steam. If it isn't, don't waste your time chasing other symptoms or complaints…ALWAYS start with DRY steam.

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