Wet returns and zone valves... not good!

By George R. Carey

A local oil company recently called and asked for some help regarding a new customer they recently "landed". The customer was an Old Catholic elementary school which naturally had an old steam system. That, in and of itself, isn't necessarily bad, but unfortunately that wasn't the case for the oil dealer. We met one morning at the school to check out what they had "inherited".

The steam system originally was a two-pipe air vent system (See figure 1). Each radiator had both a supply pipe that delivered steam to the radiator through a supply valve and a separate return pipe with its own radiator valve (on the return) which returned the condensate to the main return line.

Each radiator also had its own steam vent to release the air, allowing steam to enter, but there were no steam traps because, at the time the system was installed, they hadn't been invented yet! The way this system worked was each return line from the radiators dropped down individually to the main return line. This return line ran along the basement hallway about knee high and then all the way back to the boiler room. The water line of the original steam boiler established the water line across the entire system.

Because the return line from each radiator connected to the main return line below the boiler's water line, the water seal acted like a trap, preventing the steam from entering places it didn't belong. Over the years, the original boiler failed and had been replaced. At some point, someone realized that the replacement boiler needed a boiler feed tank because its water content was inadequate to support the needs of this system.

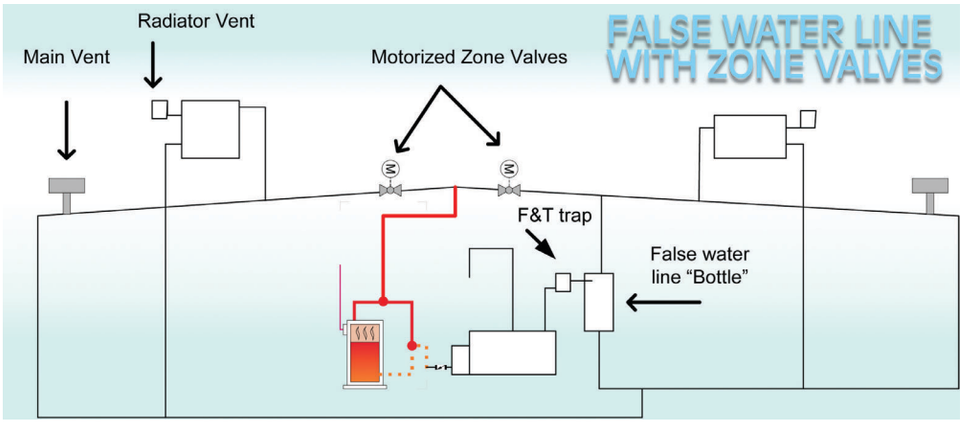
A feed tank acts like a reservoir for a new boiler that doesn't contain nearly as much water as its older companion. The feed tank has a pump attached to it, which turns on and off in response to a pump controller located on the new boiler.

As the boiler makes steam, its corresponding water level drops. The pump controller senses this drop, closes a switch and turns the feed pump on. The pump "shoves" water from the feed tank into the boiler, replacing the water that left the boiler as steam. As the water line in the boiler returns to its normal level, the pump controller turns the feed pump off. As the steam condenses out in the system, the condensate (water) gravity drains back into the feed tank.

The size of the tank is critical and is based upon boiler capacity, system conditions and sometimes a bit of luck. One important note is that these receivers are non-pressurized vessels. This means they all have a vent line which is opened to the atmosphere. This vent line can also double as a vent to release air from the steam system.

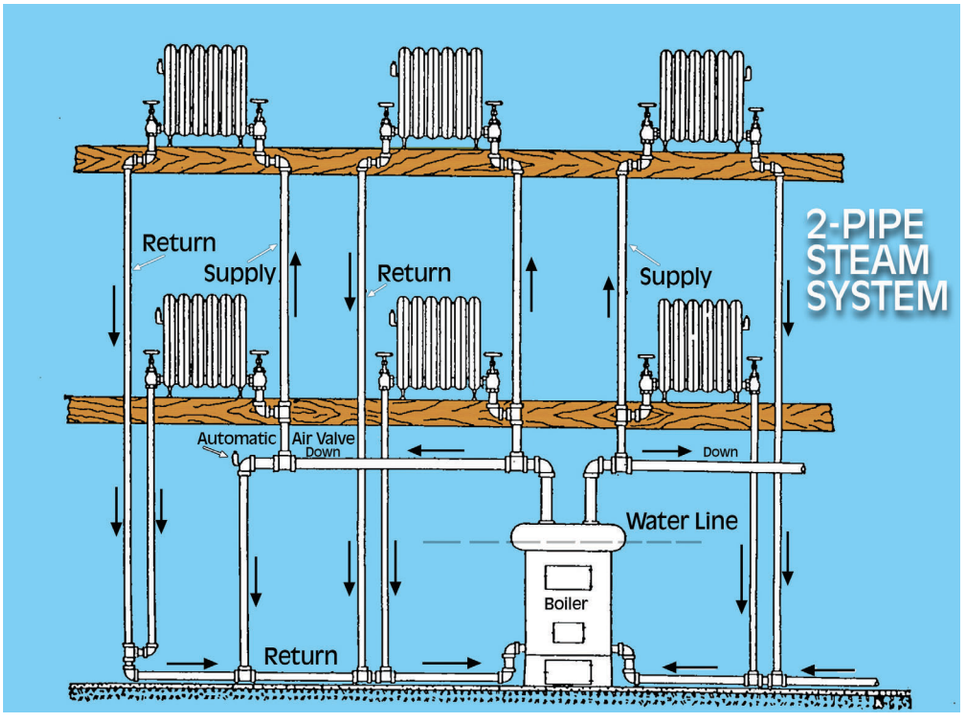
Once this vented receiver was installed into this particular system, it drastically changed the operating characteristics. With all of the returns draining into the vented receiver, there was no back pressure to equalize the pressure coming from the steam on the supply side. Therefore the steam was able to push down on the wet returns, shove all the water back into the receiver, flooding it and causing incredible water hammer in the process.

Someone had recognized this issue and they addressed it by creating a false water line in the boiler room. A false water line is an old-timer's trick whereby you create a pressurized wet return to keep the steam pressure from the supply mains in check while allowing the new vented receiver to work seamlessly with the new lower water content boiler.



The false water line provides the necessary pressure on the wet return mains that originally was provided by the old steam boiler. This back pressure keeps the steam from pushing down on the end of main piping and all of the riser drips and reaching into the horizontal

portion of the wet returns, which would create incredible banging and clanging noises. The key to a successful false water line installation is to mount the bottle or large Float & Thermostatic trap (F&T) at the water line height of the original boiler. That way, you are assured that all of the original piping that was wet remains wet and everything above the old boiler's water line stays dry. (See Figure 2)



The school's principal and some of the teachers were complaining to the service technicians that the system was creating some very loud banging noises. Upon further questioning, the service techs found out that the banging didn't occur all the time and, in fact, it was very inconsistent. But when it did bang, it felt like the whole building was shaking. It turns out that the previous oil company couldn't solve the banging problem, which is what caused them to lose the account. We spent some time poking around, checking out the distribution piping, the radiation in the classrooms and finally we made our way into the boiler room. And that's where we saw the source of the water hammer!

To "modernize" the system, someone had convinced the school to add motorized zone valves and thermostats to provide better control. Unfortunately these valves completely changed how the system operates. Look at figure 2 again-see how the "bottle" pressurizes the wet returns? The false water line is the piping trick that keeps the system operating just like it was on day one. Condensate returns back to the boiler room with the help of two forces…one being the leftover steam pressure. Remember there are no steam traps in this system. So once the steam reaches the radiation, there is nothing to stop it from reaching down into the pressurized wet returns. Of course the amount of pressure the steam has at the end of the main is going to be less than the pressure in the boiler because as it moves through the piping, it "rubs" along the pipe wall, losing energy. But the "dead men" knew about this and sized the piping appropriately.

The other force that helps put the condensate back is gravity. This gravity, combined with the remaining steam pressure, develops more force than what is in the boiler (or the false water line bottle that my friend was dealing with). This force is developed by allowing the returning condensate to "stack" in the vertical return pipes. The required height of stacking was calculated by the original installers back in the day. So, as long as you honor the system's original water lines, everything will work as it should with your new boiler.

Unfortunately these new motorized zone valves mess up this balance of power every time one of them closes. You see, when they are open, everything works fine because it's as if they aren't there. The steam is allowed to help the returning condensate get back into the bottle. But when the thermostat says it's had enough, it tells the zone valve to close and there is no longer any leftover steam pressure to help the returning condensate. Without the pressure, the returning condensate is forced to back up the return piping and enters the steam main, trying to develop enough pressure (through stacking).

Of course, if and when the zone valve re-opens, a fresh supply of hot steam goes flying down the main and meets the condensate. And that's when the school feels like its being knocked off its foundation. Which is also why the school was describing the banging as inconsistent. It was related to the closing and re-opening of the zone valves. The other part of the equation that was exacerbating the problem was the pressuretrol setting. The school's janitor was concerned with being able to get the steam all the way out to the ends of the building, so he had the pressure set as high as 4-5 psig. And at that pressure setting, condensate could stack up as high as 9-10 feet!

To eliminate the banging problem in this school, the oil dealer decided to replace the pressuretrol with a vapor-stat. The vapor-stat had a maximum setting of 1 psi which provided more than enough pressure to allow the steam to travel throughout the entire system (Despite protests from the school janitor!). It also was low enough so that when the zone valve closed and the returning condensate started backing up, it only backed up about 28-30", which was well below any of the steam carrying pipes.

The oil dealer also decided to add some additional high-capacity main vents to make sure the lower pressure setting didn't cause the boiler to short cycle. The principal called the oil dealer a few days after they made the changes to comment that the school was heating better than ever and it hadn't made those loud banging noises yet!

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