Steam Systems & Zone Valves

Be very cautious...

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I received a call from a local oil company this past summer about a problem steam system. They had me come out to look at the job this past fall because it had given them a headache all winter long. His customer had purchased a two-family house the previous summer, so last winter was the first heating season with this property. Because the boiler was new, the owners were surprised to learn that the heating system was giving them such problems. The previous owner had it installed just before the house was sold.

The house was heated with a one-pipe system. The former owner had lived in one of the apartments and the other unit was occupied by a family member. The thermostat was located in the owner's unit, so he controlled the heat to both units. This had never presented a problem before, but now that he was selling the house he wanted to "modernize" the heating system. He called in a local plumber who quoted him a price to install two boilers (one for each unit), but the price was too steep. The plumber then came up with the idea of installing one brand new boiler and two motorized zone valves. The plumber explained to him how each unit could operate independent of each other. By installing a thermostat in each unit and wiring it to its respective zone valve, the units had individual control of their own heat. The owner liked the idea so he had the plumber do the job. Now he could sell the building.

The new property owners rented both units just prior to the winter and everything seemed fine. Once the thermostats started calling for heat, however, problems appeared. The water hammer was incredible; the boiler flooded repeatedly and both tenants were very dissatisfied and threatened to hold back their rent. The new owner was also very upset. He called the service manager of the oil company to get a technician to come by the building. When the technician arrived, the boiler was over-filled with make-up water. The feeder was replaced, with the reasoning being that maybe it was "bad," but when the boiler continued to flood, they just disconnected it from the system. This stopped the boiler from flooding, but the other problems did not go away. The system still had massive water hammer and the burner short cycled on the low water cut-off control. This caused unbalanced heating in the apartments and consumed a lot of fuel. The oil company was under pressure to fix the problem before the next heating season or they were going to lose this account.

To understand what was causing all the problems, we first talked about how a one-pipe gravity return system works. There is a supply main connected to the near boiler piping that delivers steam out to the radiation. When this steam enters the radiation, it condenses back to water, giving off its heat, and drains back to the boiler where it repeats the entire cycle. Consider this, though: if the boiler is under pressure, how does the water get back in? The condensate drains to the end of the main and falls into the vertical portion of the wet return. There is also leftover steam sitting on top of this condensate. As the steam travels through the piping, it rubs against the inside walls. This frictional resistance causes the

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steam to lose some of its pressure. This means there isn't as much pressure at the end of the main as there is in the boiler. The only way the condensate can get back into the boiler is to stack up in the vertical column, and, together with the leftover steam pressure, develop enough pressure to overcome the boiler's pressure. The next question is: how high does it stack in the vertical pipe?

The amount of "stacking" the condensate requires is determined by the pipe size and the load the piping has to carry. We usually don't have to worry about this because we are not installing new systems, but the original contractors had to take it into consideration. They knew exactly how high the condensate had to collect to overcome the boiler pressure. In one-pipe residential steam systems, the maximum is 28" of vertical stacking between the boiler water line and the lowest steam-carrying pipe. By combining this 1psig column of water with the leftover steam pressure, there was enough pressure to overcome the pressure in the boiler. The contractors knew that, based on the pipe they selected from the pipe sizing charts, the steam would take no more than 1/2 psig pressure drop from the boiler to the furthest radiator.

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This is how one-pipe, gravity return systems operate—that is, until the new boiler and zone valves were installed and upset the balance. As long as the valves are wide open, everything works fine, but what happens when one of the zones closes because the thermostat is satisfied? Suddenly, the condensate in the return piping of the "off-zone" doesn't see any leftover steam pressure. The only pressure it sees is the backpressure from the boiler. This forces the water to back out of the boiler and up into the returns. As this occurs, the low-water cutoff either shuts off the burner or tells the automatic feeder to bring water into the boiler. If there is only a low-water cutoff, the burner will short cycle because the water that backed up into the returns will eventually drain back to the boiler. If there is a water-feeder, it will raise the water line too close to the exit holes at the top of the boiler. On the next call for heat, water will leave the boiler with the steam causing water hammer in the mains. Other problems can occur when zone valves are applied on gravity return systems (systems with no condensate or boiler-feed pumps). This particular system, for example, was experiencing severe water hammer that would last 20–60 seconds and then quiet down. During that time, though, it felt like the building was shaking! When both valves were open, responding to their respective thermostats, everything was fine. When one of the zone valves closed, the water in that return would start backing up into the supply main. If the zone valve reopened while the boiler was still making steam, the fresh supply of steam would go flying down the main. The noise was incredible.

When you use motorized zone valves on steam systems, the best way to avoid these problems is to use a condensate/boiler feed pump and receiver. Now, instead of relying on water columns and leftover steam pressure to return the condensate, you can use the pump's pressure to overcome the pressure in the boiler. The pump also isolates the returning condensate from this shifting back and forth of pressure changes as the valves open and close. When you install a boiler feed pump, the system changes from a closed gravity return, to an open pumped return. This means you will need to add an F&T (float and thermostatic) trap at the end of each main. The traps will stop the steam from entering the return piping and allow it to eventually blow out the receiver's vent pipe. So if you plan on "modernizing" a system by adding motorized zone valves, make sure you include a boiler feed pump and some F&T traps in your quote.

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