Designer's Guide

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Thermal Expansion in Hot Water Systems

Thermal expansion in domestic water heaters is what happens when water in the water heater is heated up and expands. This phenomenon is often neglected because most people do not know it is happening. Thermal expansion is often diagnosed by a wet spot on the floor under the relief valve discharge pipe on the water heater. In the last couple of decades recent code requirements for backflow preventers on water services have created closed systems in domestic water systems. Many people are not aware of the new code requirements and some seem to think there is not a problem.

Let's take a look at what happens with expansion in water heaters. In the past a water service would come into a building and there would be a shut-off valve and sometimes a water meter with no check valve or pressure-reducing valve. After the water service entrance the water line would branch off serving the water heater and the cold water main. Often there would be an isolation valve and union at the water heater for maintenance and no check valve. If the water heater burner came on and there was no flow the water would simply heat up, expand back into the cold water supply line and there would be no significant pressure buildup.

In recent years concerns about a cross-connection from a residence or building backing up into the public water supply and contaminating the public water main have led to water utility and code requirements for backflow prevention devices being placed on water services to every building. In areas where the pressure exceeds 80 psi there are code requirements for pressure reducing valves. When the water heater burner comes on with a backflow preventer or pressure reducing valve on the water service, the water is heated and because water is not compressible there is no place for the water to expand, if there is no flow in the system. The result is a rapid buildup of pressure and usually the relief valve will discharge.

A video tape made by a manufacturer's representative of a 250-gallon water heater in an industrial facility documents the effect of thermal expansion. The usage after a break depleted the water heater of hot water. When the shift change was over, the water heater burner came on and started to heat the water. There was a check valve in the supply line to the heater in addition to a reduced pressure backflow preventer on the water supply main. The pressure gauge on the cold water pipe read 55 psi and began rising to 150 psi in a matter of minutes. The relief valve discharged into the floor drain and the pressure dropped back to about 65 psi. The cycle repeated itself a couple of more times until the water heater burner went off. I could see the energy that was building up and being released through the pressure relief valve.

The code requires a maximum of 80 psi in the domestic water system.

Pressure increases resulting from thermal expansion, occurring frequently and repeatedly on a daily basis, produce stress and strain on the hot water piping and components. Continuous stress and strain can cause harm to the piping system and can rupture the pipe and fittings that have been weakened by stress and corrosion. The excess pressures can also cause water heater tanks to flex, cracking the glass linings and collapsing the flues of gas-fired water heaters. A collapsed flue can cause a dangerous backup of carbon monoxide gas in the building and is a deadly situation. If the right conditions are present, corrosion, stress cracks and collapsed flues can lead to rupture or an explosion of the water heater. Continuous pressure increases from thermal expansion can also cause problems with pump seals, o-rings, valve packings and solenoid valves. Some water heater manufacturers have realized this problem in closed piping systems and have started placing warnings in their literature to provide a means of relieving thermal expansion.

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How do we control thermal expansion and keep pressures within safe limits? Ideally we would accommodate the expansion of water in a closed system the same way we do in other closed systems, like "chilled water" and "heating water systems," with an

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expansion tank. An expansion tank uses a compressible air cushion that will compress as an increased volume of water enters the tank. The difference between a chilled water expansion tank and a domestic water expansion tank is that the expansion tank for domestic water systems has to be approved for use in domestic water systems. This means that the tank is lined and has either a diaphragm or an expandable bladder to prevent the loss of air through absorption of the water. Most manufacturers have expansion tanks that are approved for domestic water use by NSF International.

All manufacturers have sizing charts that help you select the proper expansion tank size based on some of the following factors:

1. Water heater volume.
2. Hot water piping circuit volume (if recirculated).
3. Cold water supply temperature.
4. Thermostat setting of water heater.
5. Static (non-flow) supply pressure, in psig.
6. Pressurized diaphragm expansion tank pre-charge pressure, in psig.
7. Pressure setting of pressure reducing valve, in psig (if used).
8. Maximum allowable working pressure in psig (relief valve pressure minus 10% of setting).

Designers should consult the manufacturers literature for sizing charts using "Boyle's Law" for calculating the expansion of heated water and the acceptance factor for expansion tanks.

One important item of note is the placement of the expansion tank in the system. The expansion tank should be located between the backflow preventer or pressure reducing valve and the water heater in the cold water line. Locating the expansion tank on the cold water side of the heater does not expose the diaphragm in the tank to the hot water and will increase the life of the expansion tank. □

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