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Temperature Change and Dry Pipe Systems

Fluctuations Can Cause Problems

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Temperature fluctuations can wreak havoc on certain types of systems in certain configurations. The most susceptible type of system to temperature fluctuations are dry-type systems, specifically dry-type systems which utilize a direct differential style dry valve. By direct differential style dry valves, it is understood to mean valves that do not have a side chamber, which utilize the water pressure and a mechanism to gain mechanical advantage. Because the rise in pressure would also increase the force acting on the latching mechanism, these types of valve are not as susceptible to pressure fluctuations. The direct differential style dry valve utilizes the mechanical advantage of the difference in area of the air in contact with the clapper and the area of the water in contact with the clapper. Basically, most valves that do not have a side chamber or latching mechanism are a type of direct differential dry valve. Although the excuse, "the valve tripped on its own" is used frequently, dry valves rarely trip on their own. Typically, the culprit is a field condition which is difficult to recreate and observe, which can cause a perfectly good valve to trip. Two scenarios where direct differential style dry valves tend to trip under mysterious circumstances, which have been seen with regularity, have to do with thermal expansion.

The first configuration which has been known to cause issues is an auxiliary dry system off of a wet system. No matter how the system is filled, there are always pockets of air trapped in certain sections of the system piping. All of the air is never evacuated from the system (even with the newly required air vent on all systems). Generally, a little air is not a bad thing (with no regard to corrosion and MIC) for pressure fluctuations. It acts as a spring or cushion for water hammer and absorbs some of the thermal expansion from the water as steel and water expand at different rates. What can cause issues with the auxiliary dry system is when there is too much air in a system, which is subject to large temperature changes. One typical example of this would be a large warehouse with a loading dock. A small auxiliary system may be utilized to protect the loading dock area. During the period of time where the days are very warm and the nights are cool, that system is susceptible to pressure increases.

During a cold night, the system contracts due to change in temperature. Any loss in pressure is made up by the system supply. The alarm valve or check valve may "burp" and allow more water into the system. Once the sun starts shining on the roof of the storage building, the temperature starts to increase up at the ceiling level, near the sprinkler piping. At the expected temperatures and pressures of a sprinkler system, air acts as an ideal gas. As the temperature increases, the pressure increases directly proportional to the ratio of the higher temperature to the lower temperature ($P_2=P_1(^{T_2}/_{T_1})$). This is true because the piping network creates a constant volume not allowing the air to increase in volume and the water incompressible. This creates what is called an isochoric or constant volume process. The air will try to expand and cause the system pressure to increase. This increased pressure is checked by the wet system valve. The increase in air pocket pressure in the wet system will pressurize the wet system up to the bottom side of the dry valve. The air can potentially increase the system pressure to a point where the dry system air pressure can no longer keep the dry valve closed, and the valve will trip. Another time of year when this phenomenon has been seen is when the heating systems in large warehouses are turned on for the first time in the fall.

The second and more common scenario which can be the culprit for the mystery valve trip, is when a valve trips the night after an inspection. This is especially true if the system riser is in a small riser room, inclusive of the backflow preventer or fire pump arrangement including a check valve. The riser room is required to be maintained at a temperature over 40°F but during summer months it can get much warmer. The water in the underground supply piping is generally kept cool by the ground.

When an inspector does their main drain test on the system, the inspector introduces cold water from the supply piping, closes the main drain valve, finishes their inspection and leaves. As the cold water introduced to the piping located in the warm riser room starts to increase in temperature, the water starts to expand. In this scenario typically there is very little to no air trapped in the piping to act as a cushion. Because water is incompressible, as the water expands it has nowhere to expand to and can create large pressure spikes. This issue is more common when the volume of piping from the check valve at the discharge of the system pump or backflow preventer to the water side of the dry valve is relatively small. If the pressure spike is large enough, it can overcome the dry system air pressure holding the dry valve closed and cause an unexpected trip of the valve.

As fire protection designers and engineers, we tend to think of sprinkler systems as very static systems. Hydrant flow tests are run and sprinkler designers design the system around the expected pressures. In actuality, sprinkler systems tend to be expanding and contracting, pressurizing and depressurizing, heating and cooling, in cyclical periods. Most of the time the pressure increases are not significant enough to cause problems but occasionally the perfect storm arises and several installed conditions and atmospheric conditions come together and can cause "the valve to trip on its own." Both of the aforementioned conditions can be combated by the introduction of a relief valve. It is now required on all wet systems to include a relief valve, but I would recommend a relief valve on the water side of any direct differential style valves. The fairly inexpensive valve has the potential to prevent some false activations, which can save trips to a site and the headaches associated with false activations. ■

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