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Tech Sheet #CVR 411

Understanding Entrained Moisture in Steam: Impact on Control Valves and Regulators

Steam, a cornerstone of industrial processes, is generally thought of as a pure gas. Steam carries within it, liquid water that is entrained as water droplets, making any steam system a bi-phase (wet steam) system. These water droplets can significantly influence the performance and longevity of control valves and regulators. As essential components in steam system, these devices face unique challenges when exposed to varying levels of moisture. Exploring the effects of this moisture is crucial for maintaining efficiency, reliability, and safety in industrial operations.

There are many examples of products in steam systems that are designed to operate with bi-phase flow. Distribution piping generally will always have a small amount of condensate to be drained to drip traps. Heat exchangers and steam traps often have a mix of condensate and steam within them. Control valves and regulators are not designed in the same way. Control valves and regulators are intended to operate with only clean, dry steam. Both liquid water and water entrained in steam can have an adverse effect on valves. This can range from causing poor valve sealing to leaving the valve completely inoperable.

Effect on Flow Through the Plug and Seat

The primary concern of moisture flowing through the main valve and seat of a control valve or regulator is the effects of flash steam. It is important to know that not all the water droplets will flash. When moisture flashes into steam it undergoes a rapid expansion. With this expansion comes an associated increase in velocity. This increase in velocity, partnered with the fact that not all the moisture will flash, means that there is liquid water flowing rapidly over the trim surface. This can cause erosion on the valve plug.

Control Valve Plug

Control Valve Plug with Flashing Damage

Image provided courtesy of Emerson Electric Co.

This Tech Sheet was developed by the members of the Fluid Controls Institute (FCI) Control Valve/Regulator/Solenoid Valve Section. FCI is a trade association comprising of the leading manufacturers of fluid control and conditioning equipment. FCI Tech Sheets are information tools and should not be used as substitutes for instruction from individual manufacturers. Always consult with individual manufacturers for specific instructions regarding their equipment.

This will cause control valves to lose the ability to control desired conditions, and regulators will lose the ability to regulate downstream pressure. It will also cause the valve to leak when the valve needs to shut off completely.

Liquid water can also have mineral buildup. When this liquid water flashes, solids can build up on the valve sealing surface. Over time, this build up can affect the ability of the valve to shut off. If there is sufficient buildup to stop the valve from sealing, steam can still flow past the valve. This can cause unwanted downstream effects as well as steam cutting on the valve and seat.

Flowing Through Pilot Valves

The mechanism through which pilot valves are affected by flashing water is similar to main plugs and seats with one exception; the velocity through pilot valves is typically quite low. This means that steam cutting will typically not occur. Solids can still be deposited on the sealing surface due to the flashing of the liquid water across the pilot valve. This prohibits the pilot valve from closing entirely and leaks steam to the diaphragm case and downstream. Pilot valves have a very low C_v, so a small amount of leakage can cause a large change in downstream conditions. This will often cause downstream pressure to "creep" above the setpoint or allow flow through the valve when the adjusting bolt is completely backed out. Refer to #CVR 404, Simple Reference Guide: Differences Between Direct and Pilot-Operated Regulating Valves.

Managing moisture within steam systems is paramount for ensuring optimal performance and longevity of control valves and regulators. For critical applications, a moisture separator can be used to extract entrained and liquid water from the piping upstream from a valve. These devices are often designed with baffles or cyclonic elements in combination with velocity increase to separate as much water from steam as possible while maintaining a low pressure drop. These devices can vastly extend the lifespan of a valve. By understanding the impact of moisture on these critical components, industries can implement effective maintenance practices, appropriate material selections, and advanced technologies to mitigate risks and enhance operational efficiency. Addressing these challenges proactively not only improves reliability but also contributes to safer and more sustainable industrial processes in the long run.