Fisher™ Steam Conditioning Valves Installation Guidelines

Statement of Intent

This installation guide is designed to assist you in understanding important system guideline considerations as you prepare for steam conditioning valve installation. Although the following information is considered to be correct, every installation will have unique aspects. This installation guide is intended to be for general guidance only. If you have any questions about these guidelines, contact your Emerson sales office or Local Business Partner before proceeding.

⚠ WARNING

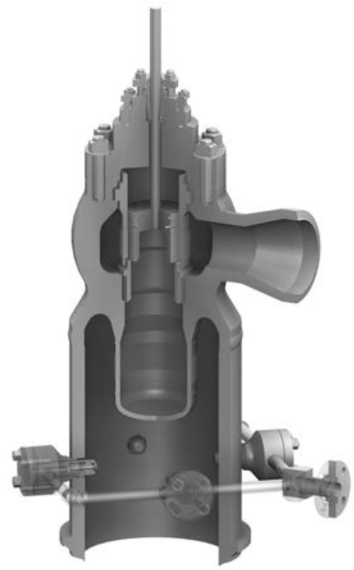
Always wear protective gloves, clothing, and eyewear when performing any installation operations to avoid personal injury.

Personal injury or equipment damage caused by sudden release of pressure may result if the steam conditioning valve is installed where service conditions could exceed the limits of the pressure class noted on the nameplate. To avoid such injury or damage, provide a relief valve for over pressure protection as required by government or accepted industry codes and good engineering practices.

Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

CAUTION

This valve is intended for a specific range of service conditions. Applying different conditions to the valve could result in parts damage, malfunction of the valve, or loss of control of the process. *Do not expose this valve to service conditions or variables other than those for which this valve is intended.* If you are not sure what these conditions are, you should contact Emerson Automation Solutions for more complete specifications. Provide the product serial number (shown on the nameplate) and all other pertinent information.



FISHER CVX STEAM CONDITIONING VALVE

X0165

FISHER TBX STEAM CONDITIONING VALVE

Overview of the Installation as a “System”

A steam conditioning valve's performance is dependent on its physical environment, the service conditions, and the desired control objectives and strategies. It is, therefore, a part of a much larger “system” in which all elements are interdependent. This installation guideline is intended to recognize these various elements and show how their parameters affect the steam conditioning valve. Following is a summary of items that are important to design considerations.

- Pipe length requirements
- Temperature and pressure sensor locations
- Control approaches
- Spraywater conditions and use of strainers
- Drain usage
- Velocity limitations
- Vibration and noise
- Valve insulation and preheating
- Valve and actuator orientation and accessibility
- Startup

Contents

Primary System Elements and Parameters

Straight Pipe Length Requirement

The proper design and layout configuration of the piping arrangement is critical for the effective operation of the steam conditioning valve. Within the initial straight pipe length (SPL) (figure 1), the important heat transfer and flow mixing functions must take place quickly and efficiently. It is expected that during this time approximately 80% of the injected spraywater will have vaporized into steam. This is a minimum requirement for preventing phase separation when the newly combined flows encounter an elbow or other flow directing piping element. If the injected water is not properly mixed and thermally transformed into the steam flow, the water could be separated out of the main flow causing poor control and possible thermal shock of the piping elements.

Determination of the exact length required from the steam conditioning valve is a complicated multiple function transient computation of independent variables, such as remaining superheat, velocity, droplet size, etc. A simplified and fairly accurate approximation of minimum length, however, can be obtained by considering the known relationship between the time for heat transfer and velocity.

For general estimation purposes, the following calculation will be sufficient for most applications requiring less than 15% injected spraywater and water temperatures that are in the 100-200°F range:

$$SPL(L) = 0.1 \times VEL_{MAX}\ (L/SEC)$$

Where:

SPL(L)= Straight Pipe Length in units of length, L
VEL_{MAX}(L/SEC)= The Maximum Outlet Steam Velocity in units of length per second, L/SEC

This method of calculation is merely an approximation. When physical piping parameters make this length difficult to incorporate there are other considerations that could potentially lessen the requirement. They are:

1. **Temperature of the Spraywater--** High temperature water is much better for desuperheating than cold water. It has a lower latent heat of vaporization, as well as a reduced fluid surface tension and viscosity. Because of this, high temperature water will mix and vaporize more quickly and, therefore, require less time/distance to reach thermal equilibrium. Generally speaking, water above 93°C (200°F) will provide a vaporization benefit. It should be noted that the use of hotter water will result in greater quantities of water, but is usually insignificant in comparison to the benefits. A general rule is that the spraywater flow will increase by 1 to 1.5% for each 28°C (50°F) increase over 93°C (200°F).

2. **Remaining Superheat--** The amount of residual superheat remaining in the steam, after thermal equilibrium is reached, is an indicator of how rapidly the water will vaporize to steam. When the amount of superheat remaining in the steam exceeds 11°C (20°F), the process can be expected to be completed in a reduced length.

3. **Quantity of Water--** The amount of water required to desuperheat to desired temperature is a factor. When very large amounts of water are required, then the sheer volume can impede the vaporization. This volume of water can either be measured in terms of volumetric flow rate or in terms of the percentage of spraywater flow to steam flow. In most instances it is more meaningful to use the percentage of flow approach. When the flow of water required exceeds 15% of the steam flow, it is beginning to act as a deterrent. It increases the time for vaporization, which proportionally increases the distance requirement.

4. **Steam Pipe Size--** The size of the steam outlet pipe has a direct effect on the performance of water vaporization. Larger pipe sizes have larger flow areas thus a larger cross-sectional flow area of steam that must be exposed to the desuperheating water. The mixing of the turbulent steam with the water can be affected by the outlet pipe size because of this large diameter pipe flow. For this reason, the evaporation and mixing time will take longer for large diameter pipes.

5. **Proximity to the Pressure Reducing Valve--** If the water is injected within three pipe diameters of the PRV the turbulence coming out of the valve aids in the mixing, which can in turn reduce pipe length requirements.

Consult your Emerson sales office or Local Business Partner for the appropriate straight pipe length requirement.

Figure 1. Straight Pipe Length Requirement

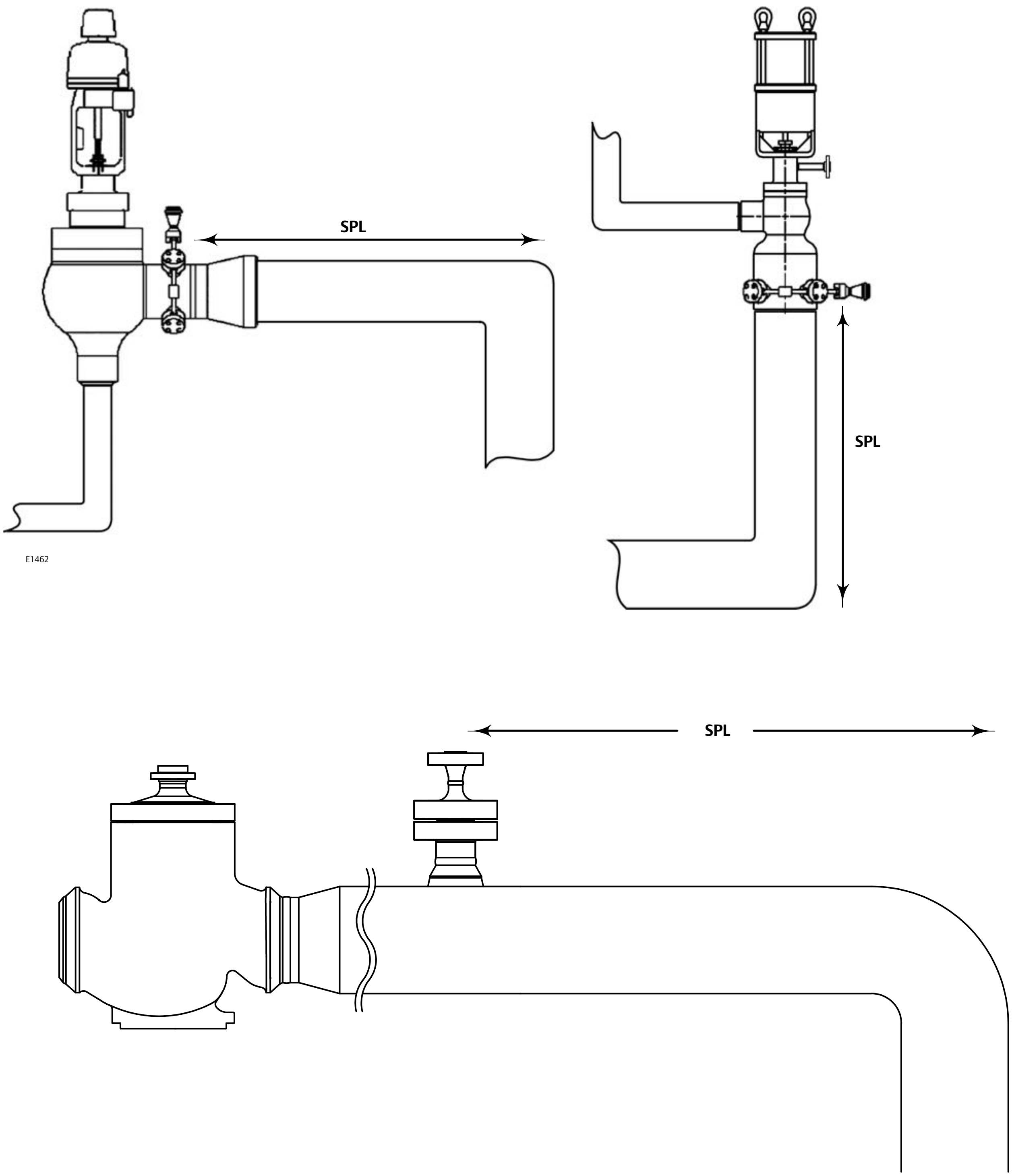
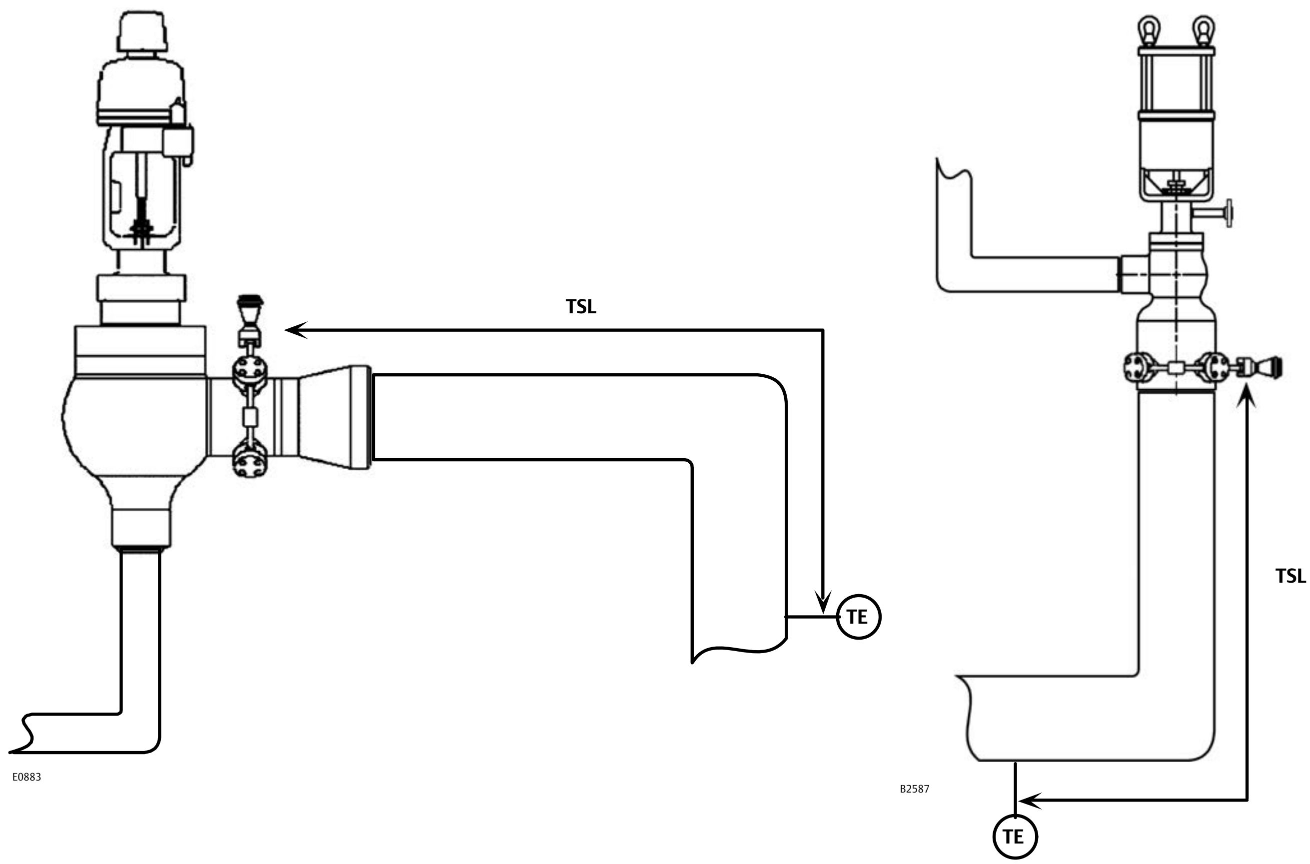


Figure 2. Temperature Sensor Pipe Length Requirement



Temperature Sensor Pipe Length Requirements

The temperature sensor length (TSL) (figure 2), after the steam conditioning valve, is needed for the water to complete its vaporization into steam and become evenly distributed across the pipe area before interfacing with the temperature sensor in a feedback control system. If the water has not completely vaporized, the resulting input control data will be inaccurate due to moisture contacting the sensing temperature element. The exact length required after the valve is a function of several of the factors already described in the straight pipe length section. The primary considerations are the amount of water being added and the steam velocity within the pipeline during maximum flow conditions. For general estimation purposes, use the following simplified calculation.

Applications with less than 15% spray water

TSL(L) = 0.2 x VEL_{MAX} (L/SEC)

Applications with greater than 15% spray water

TSL(L) = 0.3 x VEL_{MAX} (L/SEC)

Where:

TSL(L)= Temperature Sensor Length in units of length, L
VEL_{MAX}(L/SEC)= The Maximum Outlet Steam Velocity in units of length per second, L/SEC

This method of calculation is merely an approximation. When piping requirements make this formula's result difficult to obtain, other considerations could potentially reduce the requirement. These other factors are:

- Temperature of the spraywater
- Amount of remaining superheat
- Exact quantity of water required
- Piping geometry

For further explanation of these factors, refer to Straight Pipe Length Requirement. Consult your Emerson sales office or Local Business Partner for the appropriate temperature sensor length (TSL) requirement.

Steam Conditioning Valve Control Approaches

The reasons for combining the pressure and temperature reduction in steam conditioning valves are numerous, but the strategy for accurate temperature control is the key function in the control strategy.

Pressure control design is standard, seldom encounters any problems, and is always a closed loop feedback system. The process variable can be either the upstream or downstream pressure, depending on the application.

The temperature control strategy can be either feedforward or feedback depending on external factors and application requirements.

Feedback Temperature Control

A closed loop feedback temperature control system is used when there is an accurate and consistent method for temperature measurement. By definition, the system is dependent on detecting a deviation in setpoint and feeding this information back to the control system to initiate final control element adjustment. The primary factor that can adversely influence the accuracy of this type of system in steam conditioning is the presence of water in the steam. In many instances, especially in heat transfer applications, there is a need for controlling the steam temperature as close to saturation as possible. The inherent problem with this is that the closer the temperature gets to saturation the more likely the steam flow will have residual water droplets. This is due to the fact that the temperature profile of a steam flow is uneven, often with cooler temperatures in the center and progressively hotter temperatures moving outwards. It is, therefore, important to not control too close to the point of saturation. It is recommended that the setpoint should not be less than 6°C (10°F) above the steam saturation point. See figure 3.

Feedforward Temperature Control

A feedforward control system is one that responds to input variables, other than that which it is responsible to control, and makes pre-empted or anticipated adjustments to the final control element so as to keep the desired setpoint constant.

An external feedforward control strategy is used when it is not possible to get accurate temperature measurement using normal feedback control techniques, when control performance requires more responsiveness, or when the control variables are changing in a disproportionate manner. Such control is available via the use of an external logic controlling device, e.g. PLC or DCS, and incorporating a control algorithm to determine the appropriate system response to achieve the desired outlet temperature. In order to calculate the quantity of spraywater required, via a heat balance, the enthalpy of the inlet and outlet steam and spraywater must be known. The enthalpies can be calculated by measuring the inlet/outlet steam pressure and temperature and spraywater temperature. Additionally, steam flow can be determined by a flow meter or by calculation from measured process variables. The algorithm controlling for outlet temperature, or more accurately outlet enthalpy, can vary in complexity depending on how the steam generating plant operates. In general, the measured spraywater flow is used as a feedback signal in the feedforward outlet steam temperature control loop. See figure 4.

Figure 3. Feedback Temperature Control

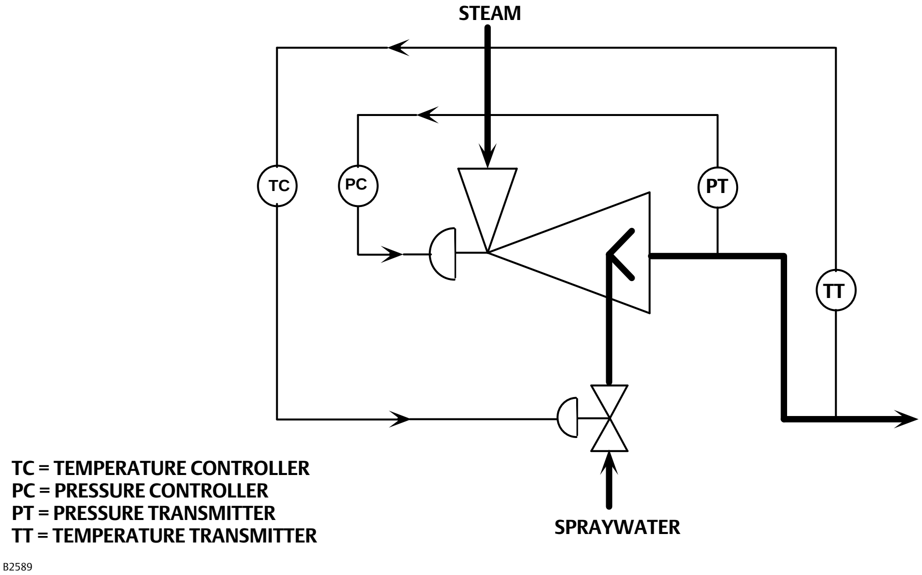
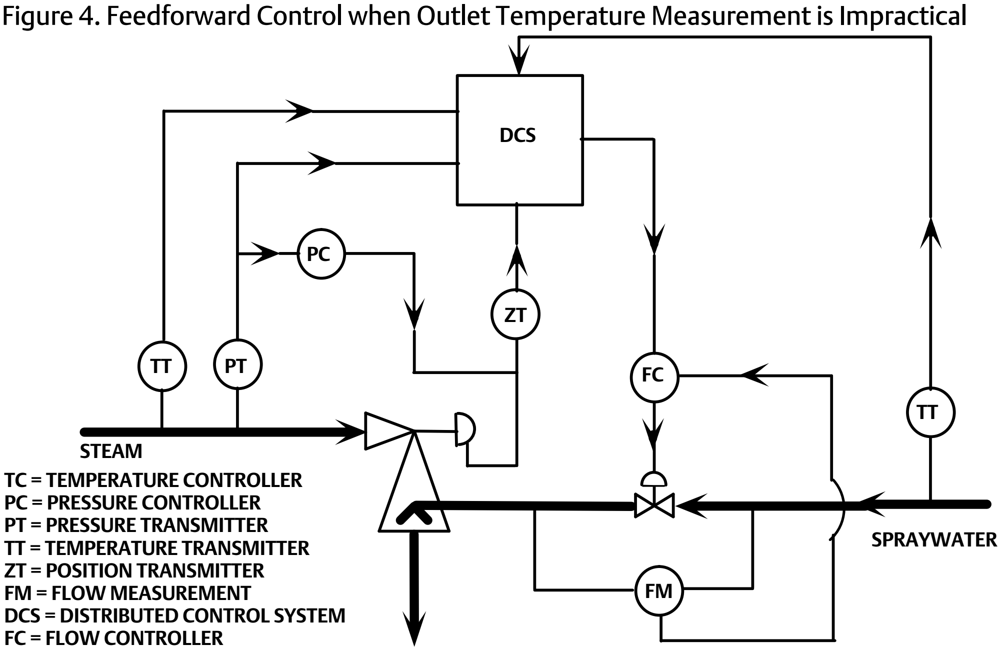


Figure 4. Feedforward Control when Outlet Temperature Measurement is Impractical



Spraywater Pressure and Temperature Requirements

Spraywater pressure and temperature factors affect desuperheating performance of a steam conditioning valve. The important considerations are:

1. **Spraywater Pressure--** The spraywater pressure entering the spraywater control valve should exceed the outlet steam pressure by at least 150 psid. Differences less than this amount can affect the rangeability of the steam conditioning valve and could contribute to the incomplete atomization of the water droplets. If the available differential is between 500-1000 psid, the performance of the system will be enhanced, but some limitations may apply to the type of spraywater control valve employed. This is especially important when water temperature is very high. At higher pressure differentials, cavitation potential increases, therefore the factory should be consulted before any control elements are selected.

2. **Spraywater Temperature--** Spraywater temperature will directly affect the quantity of water required, the distances required for straight pipe, and the distance for the temperature sensor location. Colder water requires reduced quantities. This is important if there is a shortage of available water supply, however, hotter water is best for desuperheating performance. This is due to the fact that hot water requires less heat to vaporize, has reduced surface tension, and lower viscosity; all important factors in speeding up the vaporization process. At water conditions approaching vaporization, care should be taken to prevent flashing across the spraywater control valve.

Spraywater Strainer Considerations

Many steam conditioning valve applications require nozzles/orifices with small diameter openings. The supply of some industrial water, additionally, can be filled with considerable particulate material. It is best therefore, to include a strainer immediately before the spraywater control valve. The strainer needs to be sized based on the smallest opening which is usually located in the spray nozzle/drilled orifice inside the steam conditioning valve. When selecting a strainer, consideration must be given to the pressure drop created by the strainer. Consult your Emerson sales office or Local Business Partner when ordering a steam conditioning valve for the size of strainer required (generally in the 40-100 mesh range).

Drain Considerations

Drains are important in any steam conditioning system. They assist in the protection of the system piping by collecting and eliminating free water that has accumulated over time or in operation. This water may be the result of condensation during system inactivity or by incomplete water evaporation. The presence of water in the steam line upstream of the steam conditioning valve can be very damaging to the internals of the valve. Unvaporized water after the steam conditioning valve can cause damage to piping and other instrumentation, and create inaccurate temperature measurements. It is, therefore, highly recommended to have drains upstream and downstream of the steam conditioning valve if there is any chance of condensation or incomplete water evaporation. Due to the special nature of steam conditioning equipment, consideration must be made in trap sizing. For steam conditioning applications that require quick opening, upstream drains must be sized to take into account the potential for rapid condensate formation.

Downstream drains should be located at the lowest point after the valve and a dripleg should connect the pipe to the drain. The dripleg should typically be located before the temperature sensor. Drain connections on steam conditioning valves are available upon request.

Steam Pipe Liner

Liners are sometimes used to protect the steam pipes against water impingement and thermal shock where spraywater is injected. If spraywater comes in contact with liners, the potential for serious damage exists. Careful consideration of installation factors can replace the need for such a device. However, when no alternative is available and the potential for spraywater fallout is great, a liner can protect against cracking of the main pressure retaining pipe.

Steam Piping Velocity Considerations

An important consideration in designing a steam conditioning system is the issue of the velocity of steam at the point of water injection, and downstream piping. Minimum steam velocities should be adequate to keep the water in suspension until it can evaporate and ensure proper mixing. Maximum steam velocities should be limited to prevent pipeline vibration and avoid excessive distances before evaporation. These velocity limitations vary by installation geometry and desuperheater model. Contact your Emerson sales office or Local Business Partner for these limitations.

Piping Vibration and Noise Considerations

For Fisher products, the IEC (International Electrotechnical Commission) method for noise considerations is used in order to determine the potential noise that will be generated by the operation of a steam conditioning valve. This method attempts to take into consideration all the various elements of noise generation from the pressure reduction. In order to minimize noise generation, numerous piping design aspects should be considered. They are as follows:

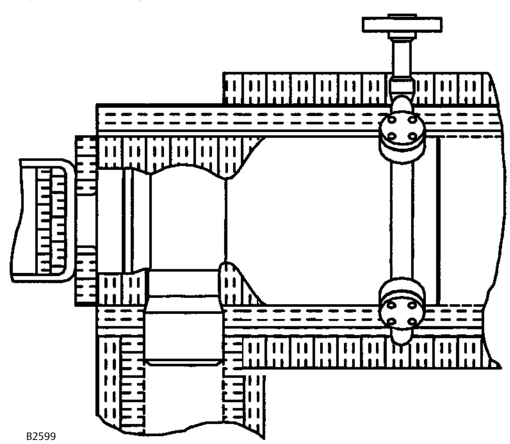
- Avoid multiple bends/ elbows immediately before and after the valve.
- Noise levels that exceed 110 dba, as predicted with standard weight pipe with no insulation, may cause structural fatigue leading to associated failures. Noise abatement trims, insulation, and downstream silencers can be used to reduce transmitted noise.
- Avoid deadlegging tees directly upstream or downstream of the valve.
- When piping several valves on branches from a common header, locate them at different distances from the header to avoid pressure oscillations caused by resonance phenomena.
- Piping layout should avoid projections, branches, T-connections, manifolds, or short radius elbows prior to previously discussed recommended straight pipe requirement.
- Use of T-connection instead of long radius elbow for the first directional change is not recommended due to the potential for increasing equipment vibration levels.

Valve Insulation Requirements

The steam conditioning valve and its associated spraywater control valve should be insulated with appropriate materials that will address both noise and thermal reduction requirements. The entire valve should be insulated, including the valve's bonnet surface that faces the actuator (see figure 5). This insulation should be designed with easily removable covers over the area of the bonnet and, on applicable models, over each externally mounted spraywater nozzle fixture. Be certain not to create thermal and noise bridges to uninsulated taps, anchors, or other external attachments. Typical insulation used on steam conditioning valves is as follows:

- Insulation thickness and density should be based on the thermal/noise requirement.
- The insulation should be clad with aluminum or steel lagging.

Figure 5. Typical Valve Insulation



Preheating Recommendation

Preheating is recommended when the steam conditioning valve is normally closed (e.g. startup, turbine bypass, etc.) and the difference in temperature between the inlet live steam and the valve body is in excess of 100°C (212°F). When the live steam line is passing at a point within four to five feet from the actual location of the valve, the goal is to preheat the valve adequately with the minimum of piping/valving cost and least energy consumption. Quite often the most effective method is determined by the existing or planned piping layout. Typically a preheating arrangement requires an isolation valve and varies upon application. The ideal preheating temperature is within 200°F of the steam operating temperature. Preheating valve connections are available upon request.

Orientation and Accessibility Requirements

Orientation/Support

Due to the size of many modern steam conditioning valves, Emerson Automation Solutions recommends the piping system be designed for vertical orientation of the valve actuator. Vertical actuator orientation allows for easier disassembly and reassembly during required maintenance operations and reduced wear of internal components.

At no time should the valve body or the actuator be used as a fixed anchor point in the design of the pipe hanger and support system. From the valve manufacturer's standpoint, a piping system is properly designed if the valve body can accept and transmit forces and torques without exceeding allowable stress levels, thus permitting operation without impairing the functionality of the valve trim.

If the use of a pipe support is required, a constant load spring hanger is recommended to minimize the possibility of overloading the actuator or valve during movement from the hot to cold piping condition.

Accessibility

Due to the size and weight of many actuators, bonnets, and trim, adequate adjacent space should be allowed for installation and maintenance functions, including crane or chain lift access. Factory drawings address this requirement and should be followed. When the valve is in an elevated position, a platform should be located at the valve that is large enough to accommodate a minimum of two people, their tools and temporary space for the valve parts.

Startup Considerations

Each steam conditioning valve is intended for a specific range of pressures, pressure drops, temperatures, process fluids, and possibly other specifications. Do not expose the product to service conditions or variables other than those for which the product was intended. If you are not sure what these conditions are, contact your Emerson sales office or Local Business Partner for complete specifications. Provide the product project number and all other pertinent information.

If hoisting the equipment, use a nylon sling to protect the surfaces. Carefully position the sling to prevent damage to the actuator tubing and any accessories. Take care to prevent people from being injured in case the hoist or rigging slips. Be sure to use adequately sized hoists and chains or slings to handle the valve.

Before a new installation is placed in operation, all dirt, scale, and debris within the newly constructed piping must be removed. This normally is achieved by acid-cleaning, flushing, or steam blowdown of the system. Without appropriate precautions or protection, the valve trim could be irreparably damaged before it is ever put into service. To prevent this from happening, it is strongly recommended that all valve trim be removed from the valve body and that an appropriate blowdown device be inserted in its place. For assistance in this matter consult your Emerson sales office or Local Business Partner.

There are a number of other considerations when preparing to install a steam conditioning valve. Several of these are:

- Post Weld Heat Treatment-- This is normally dictated by the applicable pressure vessel code in the state/country of installation. It is highly recommended that the valve trim be removed before any such treatment is performed.

- Blowout/Blowdown Trim-- These fixtures clean the piping upstream of the steam conditioning valve while taking care not to damage internal valve parts. The blowout fixture replaces the valve cage, plug, and bonnet allowing steam flow from the inlet or outlet to be directed through the valve, out the blowout fixture, and through temporary piping. The blowdown fixture replaces the valve plug and cage allowing steam flow from the upstream piping to be directed through the valve body and out the valve outlet and downstream piping.

- Hydrostatic Test Trim-- This fixture is needed in order to properly hydro-test the upstream piping system, including the newly installed steam conditioning valve, before startup.

- Startup Spares-- A complete set of consumable spares is recommended for startup and should include as a minimum replacement gaskets and packing to be used on site when reassembling valve after testing.

- Standard Spares-- Major components such as plug/stem assemblies and cages often have lengthy leadtimes. It is recommended that a standard set of spares be stocked to minimized downtime in the event of an unexpected part replacement.

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