STEAM VALVES FOR HEAT TRANSFER APPLICATIONS

Steam heat transfer is a primary application for Fisher steam regulators. Steam heat is transferred to a process fluid through direct injection or non-contacting devices. Examples of direct injection heat transfer equipment are deaerator tanks, humidification devices, and autoclaves. Shell and tube heat exchangers, jacketed kettles, coils, and steam tracing are examples of non-contacting devices.

There are several methods of controlling the amount of steam required to heat a fluid. The purpose of these control methods is to deliver the proper amount of heat energy to create an energy balance across a heat transfer device and to deliver the heat energy as efficiently as possible.

A heat transfer system is balanced when the process fluid's temperature is maintained under all operating conditions. If too much heat energy flows into the system, the process fluid temperature will rise above its desired temperature. When too little heat energy flows into the system, the process fluid temperature will never reach its desired temperature.

Efficiency is achieved when the lowest possible steam pressure is used to transfer steam heat energy. This energy is called latent heat and is the heat required to turn 100% steam into 100% water. Steam's latent heat increases when steam pressure is lowered. Since the energy content (Btu/lb) of the steam increases, less steam flow is required to achieve an energy balance. Lowering the steam flow reduces the demand on a boiler, which means it will burn less fuel.

There are consequences to be considered when selecting a steam delivery pressure. First, as steam pressure is lowered its temperature is reduced. Although the latent heat has increased, its energy potential or "muscle" required to deliver heat is reduced. Typically, a larger steam heat exchanger will be required to maintain the desired energy balance. Also, the warm-up time will be increased, which may have revenue impact on batch processes. Finally, the fluid mechanics of removing condensate must be considered.

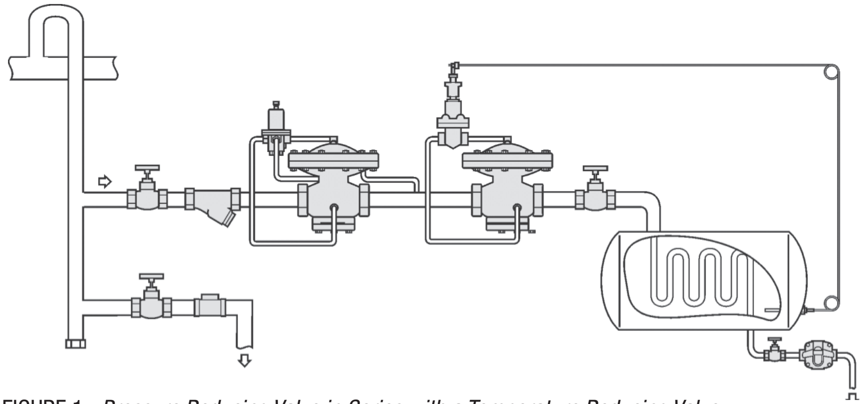

FIGURE 1 *Pressure Reducing Valve in Series with a Temperature Reducing Valve*
A pressure reducing valve installed in series with a temperature control valve is the most efficient and reliable method of controlling steam.

When steam loses all of its latent heat in a heat exchanger, the steam turns to water. This water is called condensate and must be removed from the heat exchanger and returned to the boiler. The condensate system must be designed and installed based on the pressure and flow to the heat exchanger. Using lower pressures may require alternative methods to remove and return condensate to the boiler.

HEAT TRANSFER CONTROL METHOD

In maintaining an energy balance, a process fluid's exit or outlet temperature is usually measured to adjust a valve's position or travel. Several valve configurations are used to achieve the desired result. They are described as follows:

Pressure Reducing Valves

Pressure reducing valves or PRV's are the most common method for reducing steam pressure and controlling steam flow. They are common because they are the most cost-effective valve arrangement. However, they may not be an ideal valve for process temperature control applications. PRV's only sense and position themselves based on downstream steam pressure. They respond to process temperature changes through the condensation rate in a heat exchanger. Essentially, they become open loop controllers and their accuracy is poor when a process fluid's flows and temperature rises are variable.

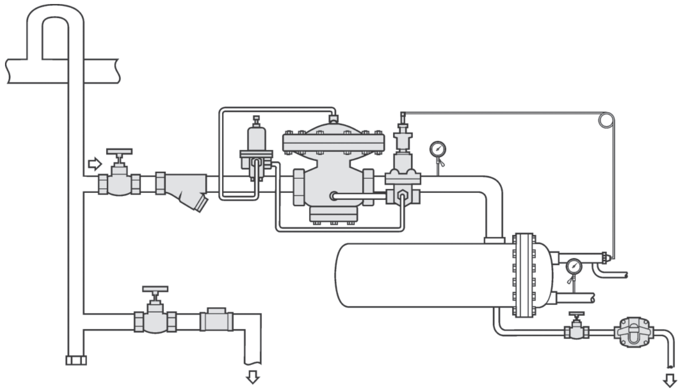

FIGURE 2 *Heat Exchanger with Temperature Control Valve*
Adding a pressure-limiting pilot will increase temperature control accuracy and steam system efficiency by ensuring the lowest possible steam pressure is used in the heat exchanger.

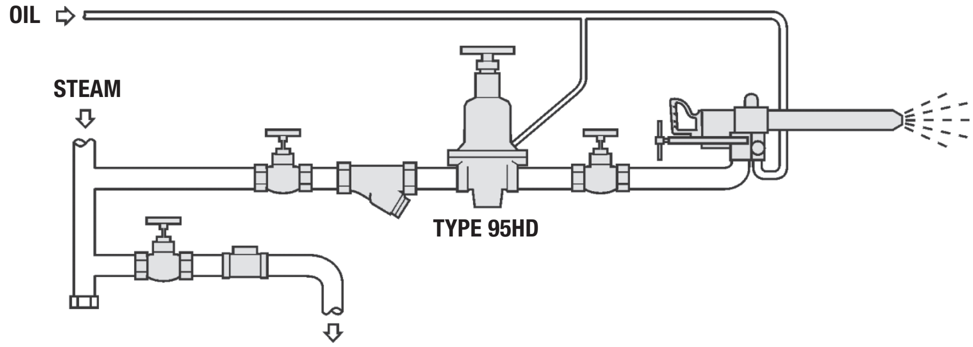

FIGURE 3 *Steam Atomizing*
Differential regulators are used to ensure steam atomizers operate correctly over varying oil flows and pressures.

Temperature Control Valves

Temperature control valves, or TCV's, measure the process fluid's temperature to control steam flow. This is accomplished through a thermostat. Pilot-operated TCV's use a liquid filled thermostat that positions a pilot valve, which opens or closes a main valve. They offer a higher degree of accuracy than a PRV; however, they do not control downstream steam pressure. Therefore, downstream equipment and piping must be rated to upstream steam pressure. In addition, since downstream pressure can rise to upstream pressure, efficiency of the system is reduced.

TEMPERATURE CONTROL VALVE WITH PRESSURE LIMITING PILOT

This type of valve offers the benefit of accuracy and efficiency. Adding a pressure pilot valve will prevent downstream pressure from rising above its setpoint. Accuracy is attained with the temperature pilot while the lowest possible steam pressure is used in the heat transfer equipment, ensuring maximum efficiency. Heat transfer equipment can be selected with a lower pressure rating, which can lower the overall installation cost.

PRESSURE REDUCING VALVE WITH TEMPERATURE CONTROL VALVE

For more critical applications, a PRV installed in series with a TCV offers efficiency, accuracy, and reliability. In applications with pressure drops greater than 10:1, valve trim erosion and noise can become a problem. Installing two valves in series helps reduce these problems. Although this is the most costly of self-powered valve installations, it is more economical when used in applications that operate 24 hours a day, year round.

OTHER IMPORTANT APPLICATIONS

Differential Regulators

These regulators are used for fuel oil atomizing. As the cost of natural gas and oil fluctuate, many boilers have dual fire capability. They can switch fuels when required to insure the lowest cost fuel is burned. Most fuel oils require preheating and atomizing to insure complete and clean combustion. Oil is typically preheated to 120° to 140°F (49° to 60°C) and then atomized with steam or air.

Preheating makes the oil easier to pump and atomize, while atomizing increases the surface area of the oil that is available for combustion.

Atomizing steam is fed into the atomizer at a higher pressure than the oil. Oil pressure may fluctuate due to pumping and combustion conditions so the steam pressure must follow proportionally. In order to do this, oil is tubed to the spring case of the valve to bias the spring setting of the valve. This ensures that proper differential pressure between the steam and the oil occurs before entering the atomizer.

Relief Valves

Fisher steam relief valves are not ASME certified. They are used in applications where non-coded devices are acceptable.

Flash Tanks

Flash tanks help improve steam system efficiency. They receive high pressure condensate. Condensate is then exposed to a low pressure steam source. When this occurs a certain percentage of condensate will vaporize or "flash" to steam at the lower pressure. This steam can be used on other low pressure steam heat transfer devices.

A relief valve is used to vent steam when flash steam exceeds the demand of the low pressure system. It is normally set at a lower pressure than the safety relief valve to prevent nuisance pops of the safety valve and build-up of pressure in the low pressure steam header.

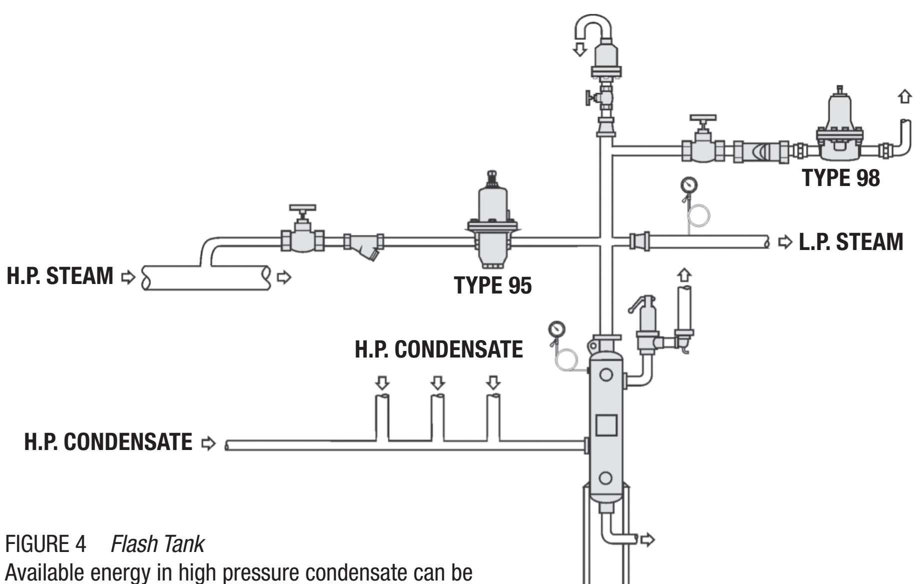

FIGURE 4 *Flash Tank*
Available energy in high pressure condensate can be recovered by using flash tanks. The steam from the flash tank can supplement low pressure steam heating needs.

Accumulators

Accumulators are one of the most overlooked devices in today's steam industry. Essentially, they are large high pressure flash tanks that protect boilers from operating under capacity. Most boilers are rated for maximum demand; however, they can not respond to instantaneous demands that often occur in the process industries. When the steam demand is instantaneous, cooler feedwater is pumped into the boiler and must be heated to boiling temperature. Since this process takes time, the boiler will temporarily operate under capacity. Problems associated with under capacity operation are carry over of wet steam, dissolved solids, and water slugs that occur with the shrink and swell of the water level in the boiler. A worst case scenario occurs when the boiler's water level shrinks below the tube level, exposing tubes to combustion gases.

An accumulator can cushion the instantaneous demand spike by flashing high pressure steam into the main steam header while the boiler catches up to the demand. A pilot operated back pressure relief valve is installed in the steam header to maintain header pressure, which keeps the boiler operating at a constant pressure and stabilizing water level in the boiler. Adverse effects of under capacity operation are avoided as long as there is an appropriate amount of water available for flashing during the demand spike.

When replacing an older boiler, it may be a good idea to save the shell if space permits. It can be filled with feedwater and used as an accumulator.

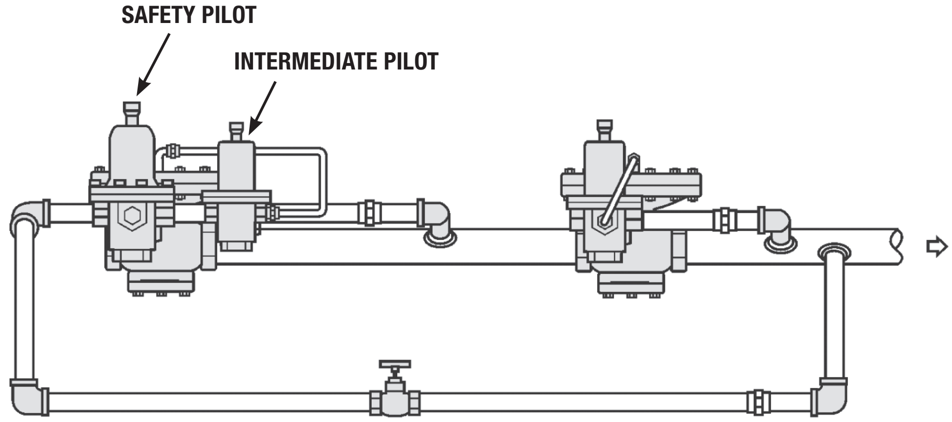

FIGURE 5 *Series Pressure Reducing Station with Safety Override*
This installation is approved under ASME B31.1, section 122.14.2 and can replace an ASME relief valve when upstream steam pressure does not exceed 400 psig (27,6 bar).

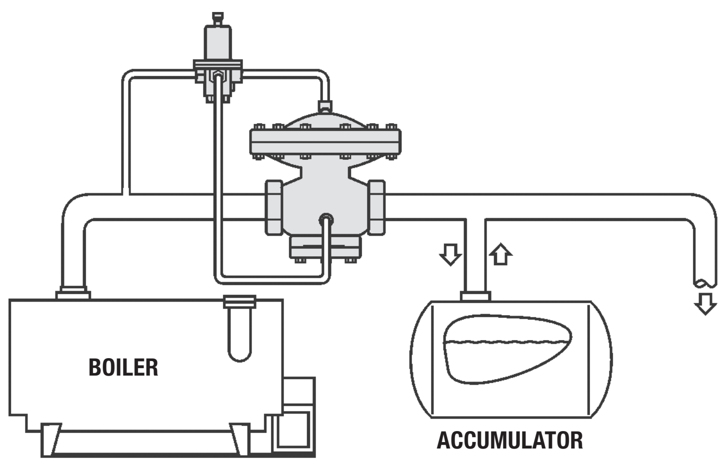

FIGURE 6 *Accumulators*
Accumulators cushion instantaneous steam demand spikes to boilers by flashing steam into the boiler header as header pressure begins to drop. A backpressure regulator valve maintains boiler pressure preventing carry-over.

Determining Steam Flow

A common formula for determining steam flow for heat transfer applications is the LMTD or Log Mean Temperature Difference method:

Lbs/hr of steam = U x A x LMTD/h_{fg}

Where:

U = universal heat transfer coefficient (Btu/hr/sq. ft, °F)

A = area (sq. ft)

h_{fs} = latent heat (BTU/lb)

LMTD = Log Mean Temperature Difference (°F)

Where:

LMTD =

$$\ln\left[\frac{(T_s - T_{in}) - (T_s - T_{out})}{\dfrac{(T_s - T_{in})}{(T_s - T_{out})}}\right]$$

T_s = steam temperature (°F)

T_{in} = inlet temperature (°F)

T_{out} = outlet temperature (°F)

This expression is used to find steam flow as the variables in the formula are readily found. It is the most important step in designing a steam heat transfer system as it ensures proper sizing of the equipment in the system.

Steam Applications

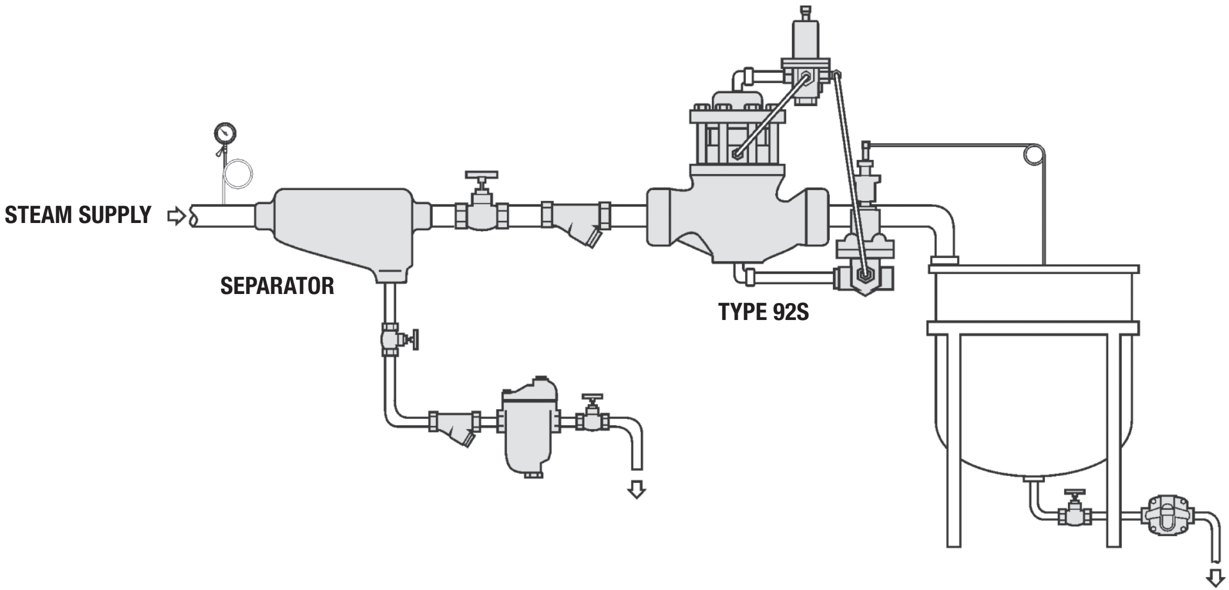

FIGURE 7 *Process Kettle Application*
Batch applications like kettles require piston actuated valves. Piston actuated valves require clean and dry steam to prevent scale from building up on the piston wall. A steam separator installed upstream of the valve will help valve performance.

TIPS

- **When heating liquids, use an approach temperature around 30° to 50°F (17° to 37°C).**
- **Install heat transfer compound in all thermowells.**
- **To reduce noise and erosion, limit pressure drops across the valve to 10:1.**
- **Use the lowest possible steam pressure to increase efficiency.**
- **Steam valves should be lapped annually to improve shut-off**
- **If scale and rust are found in regulator valves, inspect the boiler and review boiler operation because most noncondensibles originate from the boiler.**