xylem
Let's Solve Water

SteamTeam®

Bell & Gossett®
McDonnell & Miller™

VOLUME 3 / ISSUE 1/ MARCH 2016

Jarek Berezowski
Hoffman Specialty, Product Specialist

Two Pressure-Reducing Valves (PRVs) in Series (Two-Step Pressure Reduction)

Application

Reduce a steady or varying high inlet pressure to a constant adjustable low delivery pressure.

General

Two pressure-reducing valves in series are generally used when the total reduction in pressure is greater than that attainable with one valve. Here's the rule of thumb:

- Use a two-step reduction whenever the supply pressure and desired downstream pressure differ by more than a factor of 10, or
- When the total pressure drop is more than 100 psig.

This arrangement may also be used in some cases where more accuracy is desired.

System Operation

- As in a single-stage reduction, the main valves are operated and controlled by incoming pressure acting through the spring pilots.
- As delivery pressure nears the spring settings of the pilots, the pilots modulate the main valves to maintain the set pressures.

Hoffman Series 2000 Main Valve

Hoffman SPS Spring Pilot

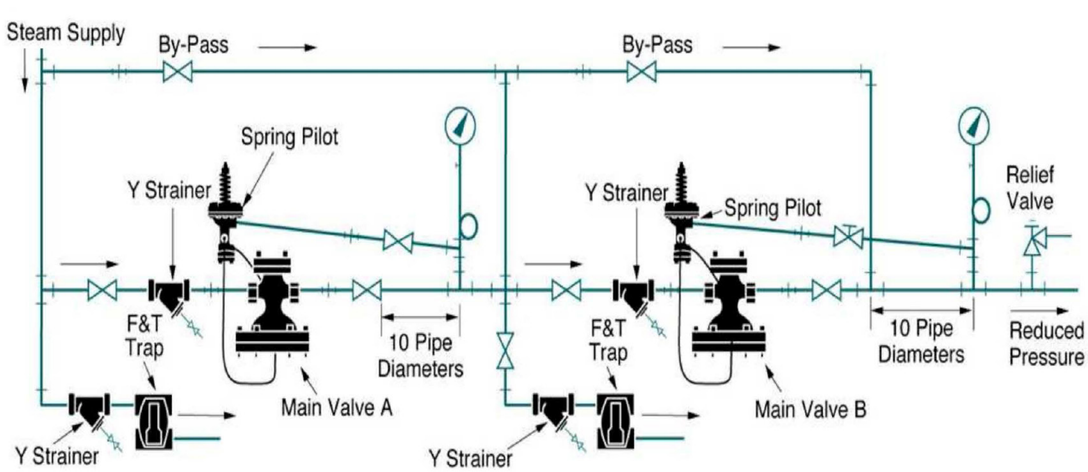
Equipment Required

2 Main Valves
2 Spring Pilots
2 Hardware Kits for spring pressure pilots

For product selection of the Main Valve and Spring Pilot, use Series 2000 Selector on the Hoffman Specialty website: https://rcwapp.xyleminc.com/esponline/hoffman/SteamMain.asp

or see Hoffman Specialty Catalog HS-900F.

Remember that the desired pressure drop will be made in two steps. (See System Pressure Drop.)



Two-Step Pressure Reduction Station

Capacity

Use HS-900 for capacity at a given Δ P. The application capacity should be between 50 percent and 100 percent of the selected valves' capacity in HS-900. The capacity of the system will equal the lower of the two valves' capacities, if they differ.

Do not oversize the valves. Oversized valves will "hunt" and also wear prematurely. Resist the temptation to size the valve to the surrounding pipe size. The correct valve will normally be smaller.

System Pressure Drop

This application is made up of two complete PRV stations piped in series. The total pressure drop is divided between the two main valves.

- The first PRV will reduce the high-pressure steam to an intermediate pressure.
- The second PRV will reduce the intermediate pressure to the final desired pressure.
- Select PRV station as follows:
  - Pressure drop (Δ P) no greater than 150 psig.
  - A maximum Δ P of 100 psig per valve is recommended, as higher pressure drops shorten plug and seat life.

Leakage

Dead-end flow applications must allow for leakage of 0.01% of the rated capacity of the second PRV, downstream of the PRV station. Applications with more leakage may experience relief valve popping. Be particularly careful of this when the valve station connects to the load through a single soft-seated valve with tight shutoff. Solutions may include adding a length of pipe or removing a section of insulation so condensation can occur.

Relief Valve Size

Size the relief valve for the steam capacity of the **full port (FP)** valve, regardless of the application's port size. This is required by ASME code, in case the seat is replaced in the field with one of a different size. Use the maximum steam capacity at the selected Δ P.

Relief Valve Set Point

Select the relief valve opening set point pressure based on the downstream pressure from the regulator, which is controlled by the spring pressure pilot setting. The actual relief valve set point pressure depends on the relationship of the flow (load) to the main valve rated capacity.

Determine the relief valve set point pressure as follows:

Downstream system pressure (DSP)	Flow (load) condition	Relief valve opening set point pressure
< 35 psig	< 50% of capacity	DSP + 5 psig
< 35 psig	≥ 51% of capacity	(1.1 x DSP) + 5 psig
≥36 psig	< 50% of capacity	DSP + 10 psig
≥36 psig	≥ 51% of capacity	(1.1 x DSP) + 10 psig

Accuracy of Regulation

The Series 2000 valve's accuracy in regulating and holding pressures is not absolute. It depends on:

- accurate sizing of the main valve
- up and downstream pipe sizes
- speed of system requirement changes
- several other factors

According to ASME and FCI standards, an individual valve capacity is based on 10 percent accuracy of regulation with the set point at minimum controllable flow, usually 2 percent of maximum flow.

Assuming correct selection and installation, a Series 2000 can be expected to meet the following for accuracy of regulation at flow rates between 2 percent and 10 percent of catalog rated capacity.

Range of controlled pressure, psig	Expected maximum deviation, percent of scale
2 - 20	10 or 2 psi minimum
21 - 250	10

Product Installation

- Refer to "Planning the Installation," page 7, and "Installation Detail," page 8, for general installation information.
- Install PRV station as recommended in HS-601 for a spring and solenoid pilot.

Piping Considerations

Feedback line to the pilot should be pitched away from the spring pilot (1/4" per foot) to avoid water pockets. Installation of a 1/4" strainer in the feedback line helps reduce dirt contamination in the spring pilot.

Bleed Orifice

The 1/16-inch bleed orifice is standard, and normally should be used on all pressure reduction applications. If a particular application is experiencing repeated opening of the relief valves, do the following: increase the regulator's closing speed by replacing the standard 1/16-inch bleed orifice with the 3/32-inch orifice. This **MAY** resolve the problem **provided the application falls within the following guidelines**:

- Relief valve is opening due to a fast-acting device downstream (pneumatic control valve or solenoid valve), and
- Desired pressure drop (Δ P) across the Series 2000 valve is 50 psig or more.
- **Caution!** Installation of the 3/32-inch orifice will reduce the sensitivity, capacity and accuracy of control of the Series 2000 valve. This will also increase the lockup pressure and may adversely affect the relief valve.
- Changing orifice orifice size also requires readjustment of pilot settings.

On two-stage reducing stations, it may be necessary to install the 3/32-inch orifice on the upstream valve if pressure surges occur at the intermediate pressure.

Start-Up and Calibration

Complete start-up procedure and pilot adjustment as stated in HS-601 and HS-621 for spring pilots for each valve, as follows:

- Adjust the low pressure PRV for a small amount of flow, about 2 percent of the valve's capacity.
- Adjust the high pressure PRV while the low pressure PRV is allowing a small capacity of steam through it.
- Adjust the high pressure PRV to the intermediate pressure.
- Adjust the low pressure PRV to reduce the intermediate pressure to the final desired pressure.

For Two-Step Steam Pressure Reducing Valve Selection, see the Steam – 2000 Pressure and Temperature Regulator Selection Tool at http://bellgossett.com/selection-sizing-cad-tools/ or contact your local Bell & Gossett/Hoffman Specialty Representative.

Steve Almgreen
Assistant Product Line Manager –
Steam Products

Sizing boiler feed units vs. condensate return units

We've previously discussed how to size condensate return units. Sizing a boiler feed unit requires similar information but is affected by differences in design and operation.

Condensate return units are generally smaller, fitting their function of collecting steam condensate and pumping it back into the system before too much energy (heat) is lost. Returning condensate can fill the smaller tank quickly, triggering a pumping cycle. Note that the control to start/stop the pumping cycle is on the condensate return unit.

Boiler feed units are larger, with greater condensate reserves. This fits their function of maintaining the boiler's water line so steaming can occur even when condensate is not returning. The control that starts and stops the pump is on the boiler.

Understanding the cycle

Just imagine the cycle if you had to rely on the condensate return unit to feed your boiler. The boiler starts, raising condensate temperature to 212 degrees at sea level. Steam generation begins and the water expands, minutely increasing the volume in the boiler. Suddenly the volume expands about 160 times as steam moves from the boiler into the header and system piping. The water level drops as more and more water becomes steam.

We all know that if the water level drops too low and the boiler keeps running, you run out of water—and the low-water cutoff control will engage safely shutting down the burner. But if you have a condensate return unit, and it has not yet collected any condensate, it won't pump to return water to the boiler. Your choices are to add water directly to the boiler—or to shut off the heat, wait for the condensate to come back, and re-start the boiler. Shutting off the boiler and waiting is uncomfortable when the temperature in the house/apartment/factory is 55 degrees. At a midwinter ten below zero, it's downright nasty. So you add water to the boiler, make more steam, and eventually everything comes back.

Managing water

About that coming back…What happens when the boiler has made all that steam, put heat in the building and shut down until it's needed again? The condensate return unit doesn't care. As soon as its tank fills, the unit triggers the pump to

Hoffman Specialty Horizontal Boiler Feed Series 50 Duplex

empty the tank—even if the boiler's not running. All that water you added gets pumped back to the boiler, which promptly floods. A bigger condensate unit tank might take longer to fill, but the pump will still start whenever the tank is full. Enlarging the return unit also means condensate sits there longer, getting cooler and causing the unit to consume more energy. Plus, a bigger unit probably costs more.

Somehow you need to provide water when the boiler needs it, not just when the tank is full, and even when condensate hasn't completed the cycle of becoming steam, providing heat and turning back into condensate. In other words, you need a boiler feed unit.

You can maintain the water level at the boiler's optimum water line with a dedicated PUMP control on the boiler. The boiler can then turn the pump on and off based on when the boiler needs water, not just when the collection tank is full.

On to the calculations

Let's start with the load. Boilers are rated to show how much steam they can put out, expressed as boiler horsepower, pounds per hour of steam, BTUs, etc. It makes sense to convert system numbers to a common denominator. Almost every manufacturer of steam condensate handling equipment uses one of these frameworks for sizing.

When everything is said and done, what comes back from the boiler as condensate is .000496 gpm per 1 sq ft EDR. Rounding off, you can say the boiler puts out one half gallon per minute of water in the form of steam per 1000 sq ft. EDR. When the steam cools and turns back to water, that's the condensate that can be returned to the boiler feed unit. Here are some of the more common conversion factors:

Multiply	BY	to get
Boiler Horsepower (BHP)	34.5	Lb. of Steam (Water per hour (lb/hr)
Boiler Horsepower (BHP)	0.069	Gallons of Water per Minute (GPM)
Boiler Horsepower (BHP)	33,479	B.T.U.
Boiler Horsepower (BHP)	139	Square feet of Equivalent Direct Radiation (Sq. Ft. EDR)

The discharge pressure required from the feed pump includes the static head lift, plus the friction loss in the piping (including pipe, fittings and valves). Manufacturers and ASHRAE typically recommend that for requirements up to 50 psi, you take the total of these values and add 5 psi. If the total required is more than 50 psi, add 10 psi. This can be a daunting calculation for a condensate return system; you have to determine how much pipe there is, the pipe size, and the number of elbows, unions, etc. Boiler feed systems tend to be simpler, since the unit is generally located near the boiler. But remember that we said with condensate return systems you typically pump to the boiler feed unit which is vented to atmosphere. Discharge pressure required also includes any pressure in the vessel that you're pumping into. If you're pumping into the boiler, you have to add the maximum boiler pressure. For example, if the boiler is operating at 5 psi, factor that in—or you end up deadheading the pump against the pressure in the boiler until the boiler pressure falls and the pump can overcome it.

More considerations

All the other things we covered for condensate return units apply here as well.

NPSHA vs. NPSHR. In most systems that have both condensate return and boiler feed units, NPSH is less of a factor for the boiler feed unit, because the feed unit occurs later in the system. Sufficient sub-cooling has occurred, and the NPSHA (available) is sufficient to avoid pump cavitation. However, never presume. Check temperatures / NPSHA to avoid problems later.

Unit sizing. As mentioned earlier, feed units tend to be larger to ensure sufficient reserves for pumping to the boiler as needed, even if steam in the system is not yet re-condensing and returning. Condensate return units are typically sized for one minute net storage. Boiler feed units are generally sized for 5 minutes of net storage. You can feed your boiler for 5 to 10 minutes, depending on the load, to keep it steaming while waiting for condensate to come back. In smaller systems, up to 150,000 sq ft EDR, 5-minute pumping capacity is a good rule of thumb. For systems larger than 150,000 sq ft EDR, 10-minute net storage is better, because steam takes longer to travel through the entire system and return as condensate. Recall that 1 minute net storage is 1 minute based on pumping capacity, which is really twice the steaming rate of the boiler. So in a 15,000 sq ft EDR system, where your pump is sized for 1 gpm per thousand square foot EDR, or 15 gpm, the boiler feed unit tank storage should be 15gpm times 5 minutes, or about 75 gallons of storage.

A word about make-ups

The components of condensate return and boiler feed units are pretty much the same, with one noticeable difference. Almost every boiler feed unit has some sort of make-up. It may be a simple manual fill valve or float-operated mechanical fill valve. Other models use solenoid valves controlled by float switches, admitting water when the feed unit pumps to a predetermined point of insufficient reserves. Some suppliers furnish their boilers with combination low-water cutoff / feed devices that can add make-up water to a boiler, although all you need to protect the boiler is a lowwater cutoff.

You can actually make a case against adding make-up directly to the boiler. Untreated "city" water can cause scaling and other problems in the boiler and the rest of the system. What's more, injecting cold make-up water into the boiler generally stops the steaming process. On the other hand, adding make-up water to the feed unit tank lets you add a bit of cold water to a larger volume of hot system condensate. This creates condensate in the feed unit with a higher blended temperature and requires smaller amounts of water treatment, as the addition mixes with already-treated condensate.

A couple final points about sizing boiler feed units: The pumps are sized the same as for condensate return units, one gpm per thousand sq ft EDR. The tanks (receivers) are sized for 5- to 10-minute net storage (depending on the size of the system).

For assistance sizing Boiler Feed Units, please contact your local Bell & Gossett/Domestic Pump Representative.

xylem
Let's Solve Water

Xylem Inc.
8200 N. Austin Avenue
Morton Grove, Illinois 60053
Phone: (847) 966-3700
Fax: (847) 965-8379
www.bellgossett.com