

BEST OF THREE?



Brian Burkhart, Baker Hughes, USA, highlights three options for operators wishing to solve root cause failure modes with direct-spring pressure relief valves.

Direct-spring pressure relief valves (PRVs) are a perfect fit for many overpressure protection applications across the oil and gas, power, and chemical industries. However, when they are misapplied, direct-spring PRVs can present risky and costly consequences leading to safety hazards, frequent and costly repairs, inefficient operation, and unwanted fugitive emissions. Common failure modes include:

- Bellows failure – rapid cycling or excessive backpressure can lead to bellows failure, creating a safety concern by rendering the valve susceptible to the negative effects

of backpressure and requiring the costly replacement of the bellows.

- Seat damage – seat damage from process debris or a damaged seat is a common failure mode in PRVs. This seat damage will create an expanding leak path for process to leak during normal operation.
- Valve chatter – in applications with > 3% inlet line loss or where a valve is significantly oversized, the valve may experience a violent rapid cycling known as valve chatter. This dangerous event can damage the valve as well as the surrounding system, leading to immediate costly maintenance, repair parts, and in some cases an entire replacement valve.
- Process loss and fugitive emissions – whether it be from ruptured bellows causing backpressure to leak out of the valve bonnet, metal to metal seat damage causing seat leakage, or a violent event like valve chatter creating

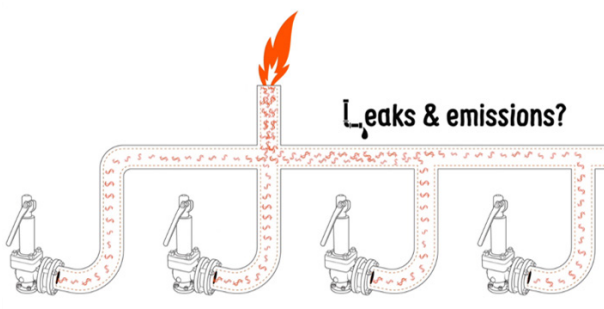


Figure 1. Direct-spring PRV leakage.



Figure 2. Damaged bellows from excessive backpressure and valve chatter.

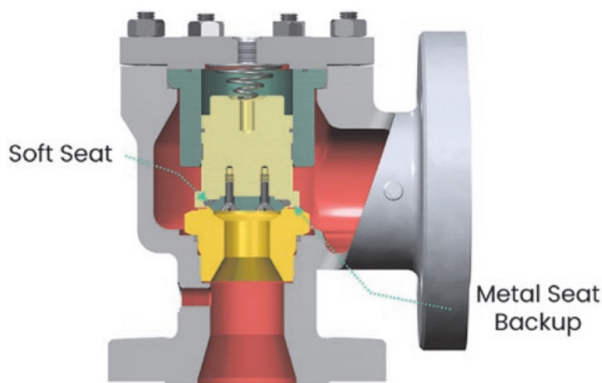


Figure 3. Pilot main valve cutaway.

major leak paths for process fluid, this unwanted leakage leads to costly loss of process and unwanted fugitive emissions into the environment (Figure 1).

Three solutions

These issues are generally not new to the overpressure protection industry. For decades, end users have been developing patches and band aids to delay or reduce their impact and, in some cases, have even become relatively efficient at doing so. But is this the best way? This article will explain two historically common responses to these issues, alongside a revolutionary, simple, and economical solution to attack and solve the root cause failure modes.

Reactive PRV maintenance

The traditional approach to managing these issues is a 'good enough' strategy through reactive PRV maintenance. While this approach may serve to stop the bleeding, it does not go so far as to attack the root cause failure modes. With reactive maintenance, most PRVs will be placed on a regular service interval ranging from 6 months to 3 years. Unfortunately, this approach has two primary drawbacks due to the unpredictable nature of PRVs and their applications:

Unplanned outages

No one can predict with certainty if or when a PRV is going to open, how long it will open, and most importantly how stable it will perform under the actual overpressure conditions it is experiencing. For this reason, unplanned outages can occur, putting operators in a major bind and causing the entire supply chain to scramble in an attempt to provide critical service, parts, and/or replacement PRVs to get the process back up and running as quickly as possible.

This is not a cheap exercise for anyone involved when considering air freight, expedite fees, overtime hours, etc. It would benefit all parties involved to re-deploy these resources into more proactive and value-add activities if a solution was available to solve the root cause failure modes.

Maintenance guesswork

PRV maintenance can be next to impossible to accurately predict. If you ask a manufacturer "How often should I service my PRV?" the answer is resoundingly the same: "It depends..." In their defence, they are not dodging the question, because it truly does depend.

Factors to consider when developing a PRV service interval plan include criticality of the service, how often the PRV is expected to cycle, the amount of debris and particulate in the line, the stability of the PRV during the overpressure event, and countless other variables. As a result, end users tend to err on the side of caution and service their PRVs more often than required, throwing away precious money to service PRVs that in some cases did not require service at that time. Although it is better to be safe than sorry, there is a better way.

Pilot-operated PRV replacement

Pilot-operated PRV technology offers many solutions to some of the most challenging applications in overpressure protection.

Here are just a few ways that upgrading to pilot-operated PRV technology can counter the challenges that arise from a misapplied direct-spring PRV:

Failure mode: bellows failure

Countermeasure: balanced without a bellows

'Bellows are the most fragile component in a spring-operated SRV and also the most expensive to replace.'¹

Pilot valves are balanced against backpressure without needing a bellows and are not susceptible to backpressure

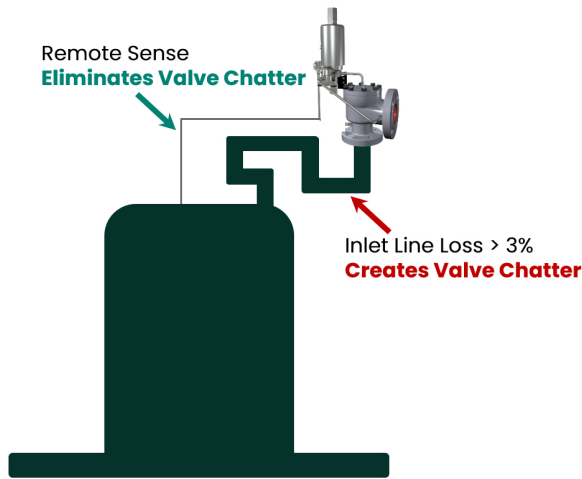
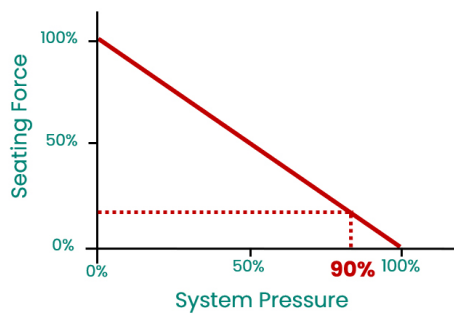


Figure 4. Pilot valve remote sense option.

Direct-Spring



Pilot-Operated

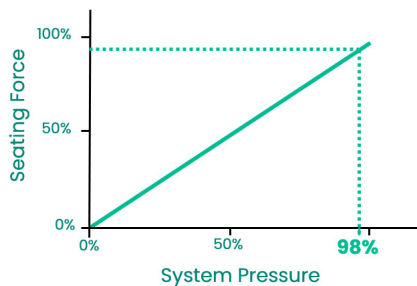


Figure 5. Seating force vs system pressure charts.

due to bellows failure. There is no need to constantly replace expensive bellows (Figure 2).

Failure mode: metal seat damage

Countermeasure: soft seat with metal seat back-up

When a metal seat becomes damaged, even slightly, the PRV will begin to leak even under normal operating conditions. Pilot valves come with a soft seat and metal seat backup, which is more forgiving than traditional direct-spring metal seats due to their elasticity. They are also far cheaper to replace than metal components such as nozzles and discs and do not require labour intensive lapping (Figure 3).

Failure mode: valve chatter

Countermeasure: remote sense and modulation

Pilot valves are able to overcome the failure mode of valve chatter due to high inlet line loss or oversized valves with the options of remote pressure sense and modulating action (Figure 4).

Remote sensing pilots allow the pilot to sense the pressure directly from the source, eliminating valve chatter caused by inlet line loss. Modulating action ensures the main valve opens proportional to the overpressure, thus only relieving the required capacity and mitigating valve chatter.

Failure mode: process loss and fugitive emissions

Countermeasure: enhanced seat tightness

Direct-spring PRVs have a decreasing seating force as system pressure increases. When system pressure reaches 90% of set pressure, the valve is allowed to leak up to 100 bubbles/min. according to API 527, and often at a much higher rate in real operating conditions.

By contrast, pilot-operated PRVs have an increasing seating force as system pressure increases. This advanced design allows most pilot valves' main valve seats to remain leak tight up to 98% of set pressure (Figure 5).

Clearly, pilot-operated PRV technology can solve many of the root cause failure modes in misapplied direct-spring PRV applications, but is this the best possible solution? Unfortunately, there are many hidden costs when it comes to upgrading an existing direct-spring PRV to a traditional pilot-operated PRV, and most traditional pilot-operated PRVs see main valve leakage starting as early as 95% of set pressure, thus negating some of the main valve seat tightness advantages. Hidden costs primarily stem from inlet/outlet piping modifications due to centre-to-face (CTF) dimensional differences and associated management of change (MOC) activities.

Full-nozzle pilot valve upgrade with bolt-on modulation technology

There is a new solution that delivers the full benefits of a pilot-operated PRV, adds the benefit of the 'true zero leakage' modulating pilot with bolt-on modulation technology (more on that in a moment), and completely

API 526 Direct-Spring PRV



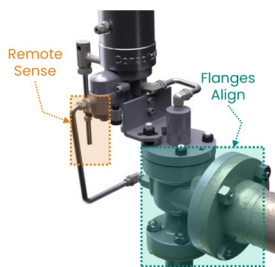
Typical Pilot-Operated PRV



Full-Nozzle Integral Sense



Full Nozzle POSRV Remote Sense



Full-Nozzle POSRV Sensing Ring

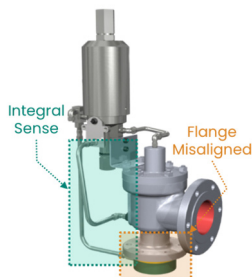


Figure 6. PRV centre-to-face dimensional comparison.

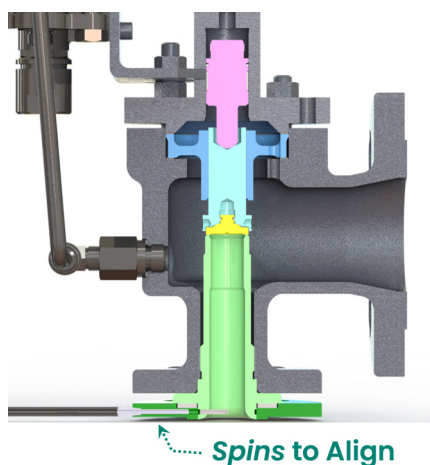


Figure 7. Generation II 2900 Series pilot-operated PRV.

eliminates hidden costs associated with piping modifications due to CTF dimensional differences. But first, a bit of background.

As depicted in Figure 6, when replacing an API 526 direct-spring PRV with a typical pilot-operated PRV, the CTF dimensions of the inlet and outlet flanges will not align to the existing piping. This creates high levels of MOC activities and costly piping modifications that can range from US\$5000 – US\$15 000 per installation. This additional cost and complexity diminishes the benefits that a typical pilot valve provides. With a full-nozzle integrally sensed pilot valve, the CTF dimensions match exactly to the API 526 direct-spring PRV without the need for any costly piping modifications. However, there is historically one catch with these designs.

In legacy designs for full-nozzle pilot designs, the end user had to choose between two options, each with potential pros and cons:

■ If the end user prefers to hold the CTF dimensions the same as their existing API 526 direct-spring PRV, they must select the remote sense option. This requires them to run the pressure sensing tube to an alternate location and tap into the vessel in order to sense the pressure, requiring additional installation cost and MOC activities.

■ If the end user prefers the integral sense option to avoid the complexity and cost of remote sense, the CTF dimension of the outlet flange is altered due to the addition of an inlet sensing ring which is added under the full-nozzle, thus diminishing part of the operational cost savings that the pilot-operated PRV provides.


Figure 7 shows an example of how Baker Hughes has faced these challenges by designing an integrally sensed full-nozzle pilot while managing to maintain CTF dimensions with its Generation II 2900 Series pilot-operated PRV.

Whether the application calls for remote sense due to inlet line loss, or integral sense is required to avoid additional installation costs and MOC activities, this design ensures a match to existing API 526 direct-spring PRV CTF dimensions and therefore will never require piping modifications.

The challenge with a full-nozzle design is that it is threaded into the body and can potentially become misaligned to the sensing tube after service. A spinning sensing ring eliminates maintenance headaches by ensuring alignment between the sensing tube and the sensing ring after service and assembly.

This design is also available with the Consolidated™ ‘true zero leakage’ modulating pilot, which features advanced bolt-on modulation technology to keep the main valve and the pilot valve leak tight all the way up to set pressure, keeping processes efficient, and dramatically reducing unwanted fugitive emissions.

Conclusion

Whether the goal is to reduce carbon footprint, eliminate valve chatter, improve operating efficiency, or reduce maintenance costs, consider upgrading or replacing existing misapplied API 526 direct-spring PRVs with a full-nozzle integrally sensed pilot-operated PRV. By modernising overpressure protection solutions with the latest pilot valve technology, operations can be positioned for a safer, cleaner, and more profitable future. 

Reference

1. HELLEMANS, M., ‘The Safety Relief Valve Handbook’, (2010).