Dual Certified PRVs

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outlines the latest PRV trim technology available today and how to select the most appropriate trim to cover the widest range of relief conditions that pressure relief valves could experience.

The right valve for the right application is a critical determination that must be made for pressure relief valves (PRVs), which act as the last line of defence in case of overpressurisation. However, how can the right valve be confidently specified in situations where multiple applications and cases must be covered by a single valve? For these situations, industry wide design codes and standards such as American Society of Mechanical Engineers (ASME) and American Petroleum Institute (API) dictate how pressure relief devices should be used to protect vessels or piping systems from exceeding their maximum allowable working pressure (MAWP). In pressure relief system design, the biggest challenge is often determining the worst-case flow scenario, or what is known as the controlling case of overpressurisation, especially in applications that experience multi-phase or multi-case process conditions.

This leads to confusion and risk when deciding on the proper trim design for the PRV protecting the system, because most PRV trims are engineered for optimal performance on only one media type or another, but rarely on both. This has challenged the PRV industry to a 'dual' (pun intended) to develop an innovative, single PRV solution that is flexible enough to provide reliable and efficient performance in the event of overpressurisation against the full range of these fluid media conditions. This article will not help determine that controlling overpressuriation cause, but it will help with understanding of the latest certified PRV trim technology available today, and how to select the most appropriate design to cover the widest range of relief conditions that the PRV could experience.

Cover Story

Determining the relief scenarios

Overpressure is defined as pressure increase above the set pressure of a PRV, usually expressed as a percentage of set pressure. An overpressure event within a system may result from several unique causes, or a combination of multiple causes. The pressure relief system design basis involves evaluating each cause for its consequence and probability of occurrence with other events. Common potential causes of overpressure include, but are not limited to, external fire, blocked outlets, utility failures and system thermal expansion.

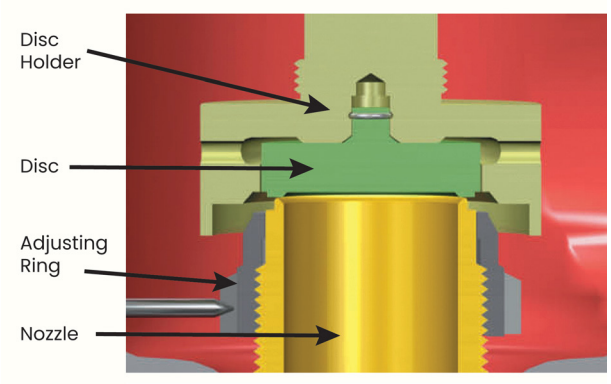

Figure 1. Gas/vapour certified trim.

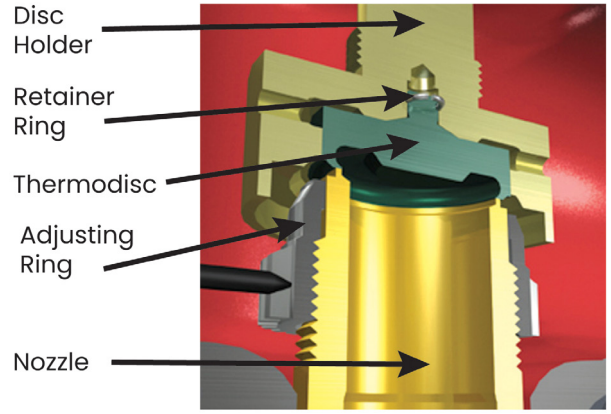

Figure 2. Steam certified trim.

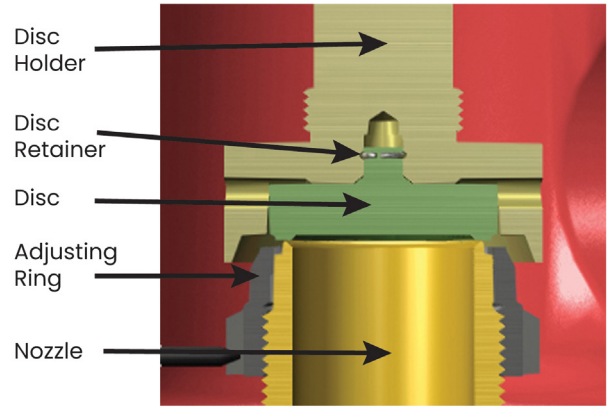

Figure 3. Liquid certified trim.

Applicable relief scenarios should be evaluated based on the flowrates and pressures generated in the system. The effects of these scenarios will then translate into requirements for the PRV sizing and selection, including required relieving capacity, fluid properties to be relieved, fluid state (i.e. gas, liquid, two-phase gas and liquid, flashing), operating and set pressure, back pressures and temperatures. The scenario that requires the largest PRV orifice area would be the controlling case.

There are often other scenarios that are not considered as the controlling, or worst-case, in terms of required relieving capacity, but perhaps have a higher probability of occurring. There are many scenarios where the controlling case can be a gas, but a common secondary case is a different fluid phase such as a liquid, or vice versa. At other times, the fluid will be two-phase gas and liquid during relief. For these scenarios, what options are available to select the best PRV trim with the widest range of performance to protect the system for not only the controlling case, but also for that second or third scenario that will cause an overpressure event?

The three common PRV trim types

Most PRV manufacturers have specific spring-loaded PRV trim designed to handle three different types of fluid media. PRV trim typically consists of the nozzle, disc, disc holder and adjusting (blowdown) ring. These trims are specifically designed, and capacity certified, to relieve on single phase of flow media, such as steam, gases/vapours or liquids. Capacity certification requirements are given in ASME Boiler and Pressure Vessel Code Section VIII, and these devices are certified through The National Board of Boiler and Pressure Vessel Inspectors. The database of the PRVs authorised by the National Board with approval to apply the 'NB' symbol can be found on its website.[1]

PRV manufacturers typically have valve designs certified to meet the performance criteria of each unique fluid media type, resulting in three common types of certified trim: gas/vapour trim, steam trim or liquid trim. Performance criteria includes seat tightness, opening or set pressure, stability in opening and closing cycles, full lift and flow capacity within a required overpressure (typically 10% above the PRV set pressure), and the point at which the valves close, also referred to as the blowdown range. Examples of each are shown in Figures 1 – 3.

Gas/vapour certified trim

This has a specifically designed nozzle, disc, disc holder and adjusting ring. The position of the adjusting ring is usually different to the liquid adjusting ring setting.

Steam certified trim

Typically has the same trim components as the gas/vapour trim except for a specialised disc for seat tightness performance on steam service. The position of the blowdown ring is usually different to the liquid setting.

Liquid certified trim

This will usually be the same nozzle and disc as the gas trim with a specifically designed disc holder and adjusting ring.

These components are designed to trap the liquid and generate enough momentum and reactive forces to cause the valve to go into full lift within 10% overpressure. The position of the adjusting ring is usually different to the gas or steam adjusting ring settings.

For decades, end users, EPCs and PRV manufacturers have specified these trim types for controlling case PRV selection without giving consideration to the other relief case scenarios and how the selected PRV would perform in those cases. Over the last decade, end users, EPCs and codes/standards committees have put more emphasis on PRV trim selection and the effect on performance in liquid, gas, two-phase or multi-relief cases.

Evolution of industry codes and standards

Industry codes and standards, such as ASME B&PVC Section VIII and API 520 Sizing, Selection, and Installation of Pressure-relieving Devices, have evolved over the last 30 years with respect to guidance for PRV selection and capacity certifications.

ASME B&PVC Section VIII approved Code Case 2787 in November 2013, allowing multiple marking of certified capacities on a PRV nameplate. The requirements of this Code Case are listed below:

1. The PRV has been capacity certified by the manufacturer per the requirements of ASME B&PVC Section VIII UG-131 for each media with the following additional requirements:
   - During the certification of capacity testing required per UG-131, the PRV shall be tested first on one of the certified media (steam, air, gas or water) and then tested on all other media requested by the manufacturer.
   - There shall be no adjustments to any of the PRVs after completion of the testing on the first media.
   - The measured set pressure for the valve tested on the additional medias shall meet the tolerance requirements of UG-134(d)(1), based on the pressure at which the valve was set to operate in (1)(a), or market set pressure for sample production valves.
2. The PRV shall meet all the requirements of UG-136 for all certified capacities stamped on the valve or nameplate except as follows:
   - For sample production PRVs selected for capacity certification or re-certification per UG-136(c)(3)(a) the same requirements per (1) shall apply.
   - Production testing per UG-136(d)(4) shall be performed using any one of the certified medias to be marked on the valve except steam shall be used when one of the certified media is steam.
   - This case number shall be on a plate permanently attached to the PRV.

Prior to the publication of Code Case 2787, PRVs could only have one certified capacity stamped. This Code Case remains the only method recognised by ASME and The National Board of Boiler and Pressure Vessel Inspectors to 'dual certify' a PRV.

API 520 Part 1 – Sizing and Selection contains guidance related to vapour certified PRVs relieving liquids and liquid certified PRVs relieving vapour, which has improved with each new edition published.

In the latest API 520 Part 1, 10th Edition, published October 2020, there is now detailed guidance added relating to spring-loaded PRV performance as a function of PRV trim. There is also an introduction to a new type of PRV with the defined term 'dual certified'. This brings to the industry a fourth type of PRV trim, one that is dual certified for multiple fluid media.

API 520 Part 1 – Sizing and Selection Guidance, Previous Editions

API 520 Part 1, 7th Edition, published in January 2000, included guidance to the extent that PRVs designed for liquid service may also be designed to operate on gas but may have different operational characteristics, depending on whether the flow stream is a gas or a mixture of gas and liquid. The main operational characteristics highlighted were:

- Set pressure: there could be some variation in set pressure when a valve is set on liquid and required to operate on gas or vice versa.
- Blowdown: PRVs designed for liquid service will have a much longer blowdown (typically 20% or higher) on gas than on liquid.

Regarding PRV trim selection, the guidance stated that PRV manufacturers recommend that a valve designed for liquid or liquid-and-gas service be used for two-phase applications where the fluid may be liquid, gas or a multi-phase mixture, and if the mass percentage of the two-phase mixture at the valve inlet is 50% vapour or less. In addition, if the application required the PRV to relieve a liquid or a gas depending on the condition causing the overpressure (multiple relief cases), then a valve designed for liquid or liquid-and-gas is recommended. Lastly, it also provided guidance that some pilot-operated PRVs operational characteristics are unaffected by the state of fluid (liquid and gas) and that these types are also recommended for two-phase flow applications.

API 520 Part 1, 9th Edition, published in July 2014, expanded upon the guidance of the 7th and 8th Editions by cautioning users that vapour certified relief valves relieving liquid are prone to chatter, a rapid opening and closing of the valve, at higher overpressures. Vapour certified valves relieving liquid may exhibit stable flow at overpressures of 20% or higher or where the valve lift is mechanically limited.

API 520 Part 1 – Sizing and Selection Guidance, 10th Edition

The latest API 520 Part 1, 10th Edition, published in October 2020, includes very specific and detailed guidance related to spring-loaded PRV performance characteristics as a function of trim selection. The key highlights from this new edition are as follows:

'Dual certified' is defined – "PRVs that are both vapour/gas flow certified, and liquid flow certified where dual certification is achieved without making any modifications or adjustments to the relief device when switching fluids during the flow testing." This definition also meets the requirements of ASME B&PVC Code Case 2787 discussed earlier.

Table 1. API 520 Part 1 – Table 1 – spring-loaded PRV performance characteristics as a function of valve trim

Characteristic	Vapour certified PRV	Liquid certified PRV	Dual certified PRV
Liquid relief	Capacity is not certified but can be estimated using guidance in 5.9 (may need up to 25% overpressure to achieve full lift)	Capacity is certified	Capacity is certified
Vapour relief	Capacity is certified	Capacity is not certified and is not addressed herein. See manufacturer for estimated capacity	Capacity is certified
Range of blowdown available (see manufacturer for PRV blowdown values, see Note 1)	Up to 10% for vapour, and up to 10% for liquid	Up to 25% for vapour. Typically, up to 12% for liquids. Some manufacturers may have higher blowdowns	Up to 25% for vapour. Typically, up to 12% for liquids. Some manufacturers may have higher blowdowns
Tendency to chatter in liquid service	Increased	Neutral	Neutral
Effect of medium on the opening characteristic	PRV set on gas but relieving liquid may open 3% to 5% higher	PRV set on liquid but relieving vapour may open 3% to 5% lower	Within ASME tolerances
Effect of required valve overpressure vs set medium	Any shift up or down in the opening point may result in a similar shift in the point at which full lift is achieved		

Note 1: these are typical values obtained from the valve manufacturers. User is cautioned to fully understand the impact on operations when blowdown exceeds the operating margin

A dual certified trim is a hybrid design of a gas trim and a liquid trim. The trim components are specifically designed to have optimum performance on both gas and liquid and to meet all the requirements of ASME CC 2787, which is not an easy thing to accomplish. This trim is designed to ensure, for both gas and/or liquid, that the opening pressure is within ASME tolerances; that the PRV has a stable, chatter free opening and closing cycle; that the PRV achieves full lift within 10% overpressure; and that the blowdown range is as short as possible (particularly on gas/vapour relief).

PRV trim selection

An entirely new section was also added specific to PRV trim selection. It defines the common types of PRV trim: ASME vapour certified, ASME liquid certified and ASME Dual Certified. It uses prescriptive language that indicates it is up to the user to select the appropriate valve trim with guidance from the PRV manufacturer. It emphasises that the user understands how different trims perform within the range of relief conditions that the PRVs could experience with attention to vapour certified valves that have applicable liquid relief scenarios.

It also includes a new Table for spring-loaded PRV performance characteristics as a function of valve trim (Table 1).

Five main take-aways from Table 1

1. Vapour certified trim

Vapour certified PRVs are not capacity certified for liquid and are not recommended for use on liquid relief due to an increase in opening pressure and the high probability of chatter.

2. 'Double' certified trim

Some PRV manufacturers have liquid certified valves that are also certified for use in gas applications. Table 1 does not address this type of certified trim. These are not dual certified PRVs as adjustments/modifications are required between use in liquid and gas service, such as set pressure, spring changes, adjusting ring settings, etc. These valves do not meet Code Case 2787, and it must be clearly understood that they cannot be claimed as dual certified by code. If the PRV has not been certified to Code Case 2787, then it is not dual certified per the definition in API 520 Part 1, 10th Edition. These PRVs may be referred to as 'double' certified and will only have one certified capacity stamped on the PRV nameplate. The performance characteristics of the liquid certified trim would apply for these 'double' certified PRVs, as they are simply the manufacturers' liquid certified PRV design with adjustments/modifications and then tested/certified on gas/vapour. This term is becoming more widely used in the industry to distinguish a lower technology valve from a proper dual certified PRV.

3. Blowdown

The range of blowdown are typical values as indicated in note 1 in Table 1. Depending on the manufacturer and the PRV trim type, the blowdown range will vary. For example, for dual certified PRVs, which have a hybrid of a vapour certified and liquid certified trim, the blowdown range for vapour/gas relief could be much less than 25% (as noted in Table 1) and can range from 5 to 15%. It is important to consult the PRV manufacturer to obtain the actual values for their dual certified trim, as this performance characteristic is very important when it comes to operating pressure, system efficiency, loss of valuable media, and fugitive emissions.

4. Opening pressure

There is indeed an effect on the PRV opening point between the certified trim types. Vapour certified valves are factory set on air or nitrogen and liquid certified valves are factory set on water. Vapour certified valves could open up to 5% higher than set pressure when opening on liquid, and liquid certified valves could open as much as 5% lower than set pressure when opening on vapour, both outside the ASME Section VIII set pressure tolerance. There are many liquid certified, or 'double' certified PRVs installed that have gas relief scenarios and are likely leaking and/or opening low when the operating pressures are approaching 90% of set pressure or higher and a gas relief scenario is occurring. The solution to this is a dual certified trim, which is certified to open on gas or liquid within ASME Section VIII tolerances.

5. Overpressure

For vapour certified and liquid/double certified trims, any shift up or down in the opening point may result in a similar shift in the point at which full lift is achieved. This is particularly important if the opening point is 5% high. In this case, the required overpressure for the PRV to reach full lift could be 5% higher than the overpressure that was used in the valve sizing/selection and the design conditions used for the system. Again, the solution to this is a dual certified trim, which is certified to open on gas or liquid within ASME Section VIII tolerances and will, therefore, achieve full certified lift within the PRVs' certified overpressure.

Conclusion

A dual certified PRV will ensure system protection with a valve that opens within ASME B&PVC Section VIII code tolerances, is stable in the opening and closing cycle, has both gas and liquid capacities stamped on the PRV nameplate and has greatly improved blowdown performance, particularly when relieving gas/vapour.

End users and EPCs should become familiar with the available trim solutions offered by the PRV manufacturers. It is important to understand the details of the various PRV trims and how they are capacity certified (single media, 'double' media or dual media). Operations can be optimised by knowing the performance characteristics (opening pressure, stability, capability of full lift within 10% overpressure, blowdown range) of the PRV trim for the media(s) to be relieved, when the PRV is being selected for both the controlling and a non-controlling overpressurisation cause.

The technological step change of a dual certified PRV offers a win/win scenario for the overpressure protection industry, enabling risk mitigation in multi-case/phase applications with a single economical valve. Now that the guesswork of specifying a gas or liquid trim valve has been eliminated with a dual certified PRV trim, end users and EPCs should initiate plans to upgrade their PRV specifications and/or their existing single trim PRV fleet to the latest dual certified PRV technology.

Reference

1. https://buscenter.nationalboard.org/TestLab/nb-18