Consolidated
a Baker Hughes business

White Paper

2900/3900 BT Design - Backpressure Enhancement

In the pressure relief valve (PRV) industry, few valve types can resolve the wide range of complex applications like a pilot-operated pressure relief valve (POPRV). One of the most common situations where a POPRV is preferred over a direct spring-loaded PRV is on systems with high back pressure. Due to the way that a POPRV is designed and operated, they are capable of withstanding much higher levels of back pressure than traditional direct spring-loaded PRVs.

Back pressure has a direct relationship with de-rating the standard capacity and can affect performance as it creates resistance to flow within the PRV body. For reference, API 520 Part I Section 5.3.3.2.1 recognizes that "high backpressure will tend to produce a closing force on the unbalanced portion of the disc" in a direct spring-loaded PRV, resulting in a "reduction in lift and an associated reduction in flow capacity." To account for this undesirable effect, API 520 recommends incorporating a back pressure correction factor (K_b) in capacity equations for direct spring-loaded PRVs to ensure that the safety of the overpressure protection application is not compromised.

With the POPRV design, it is generally accepted among PRV manufacturers and end-users that they are inherently balanced against the effects of back pressure. API 520 Part I Section 5.3.3.3 supports this acceptance by stating that "for pilot-operated PRVs, the valve lift is not affected by back pressure" and that "a backpressure correction factor of 1.0 should be used" for "compressible fluids at critical flow conditions." The POPRV's piston/disc holder design and basic understanding of fluid dynamics would appear to support this claim, giving POPRVs a significant capacity advantage over direct spring-loaded PRVs in high back pressure applications. Yet, most of the predominant POPRV manufacturers publish K_b curves, contradicting API guidance. Advanced back pressure testing methods and Computational Fluid Dynamics (CFD) analysis conducted by Consolidated engineers have shown that high back pressure levels do affect a POPRV's capacity at a certain point suggesting that past assumptions should be checked and verified.

Backpressure Defined - Types and Sources

Back pressure is static pressure that exists downstream of a PRV's discharge area when the outlet flange is connected to a discharge piping system, usually venting either to the atmosphere or flare header. Not all PRV applications are the same and as such back pressure can vary depending on the piping design and other sources of pressure present in a shared header system. There are two common types of back pressures related to most pressurized systems:

Built-up back pressure is pressure that develops at the PRV outlet during a relief event from flow through the valve into a discharge piping system. The cause of built-up back pressure is from long piping runs or bends that create resistance to flow. Most PRV installations will incur this type of back pressure because PRVs are rarely vented directly to the atmosphere without discharge piping.

Superimposed back pressure is pressure that is present downstream of the PRV's discharge area when closed. The source of this type of back pressure comes directly from the connected closed discharge system. In most of these applications, built-up back pressure and superimposed back pressure can exist when the valve is relieving. When sizing for this condition, there are two types of superimposed back pressure that end-users must account for.

- **Constant** superimposed back pressure: outlet pressure that is constant at any given time when the PRV is in the closed position. This type of back pressure is typically from a flare header system equipped with an inert gas purge or a flare recovery system. Both system designs will create constant positive pressure in a closed header system.
- **Variable** superimposed back pressure: outlet pressure that will vary over time when the PRV is in the closed position. Sources of variable backpressure are normally from other devices, such as PRVs, that vent to a common header system for the safe disposal of fluid waste. At any given time, the pressure can change depending on which device or combination of devices are venting.

To better understand the effects of back pressure on PRV performance and capacity, all three types must be considered. The amount of total back pressure (built-up + constant + variable) will be a factor in PRV capacity calculations as it is used to determine the K_b value. Total back pressure when the PRV is open and flowing has an indirect relationship with its K_b value; high back pressure equals a lower K_b value resulting in a reduction in capacity.

Consolidated's Patent Pending BT Design

Consolidated engineering has developed a patent pending trim design to minimize the impact of back pressure on a valve's capacity, resulting in more efficient flow when compared to similar valves on the market today. This new trim is now standard for the 2900 and 3900 series valves where the impact of back pressure would have de-rated the K_b below the established API and ISO curves. With these design updates, Consolidated is able to increase the allowable total back pressure for the 2900 and 3900 (including Full Bore) Series POSRV with a backflow preventer (BFP) or pilot exhaust to the main valve outlet from 65% to 80% of set pressure with total backpressures as high as 97% under certain conditions.

The 2900 and 3900 standard bore valve lines will utilize the standard API 520 K_b curve. The 2900, 3900 standard and full bore valve lines the K_b curve are shown in Figure 1.

2900, 3900 Standard Bore & 3900 FB Backpressure Correction (K_b) Curves

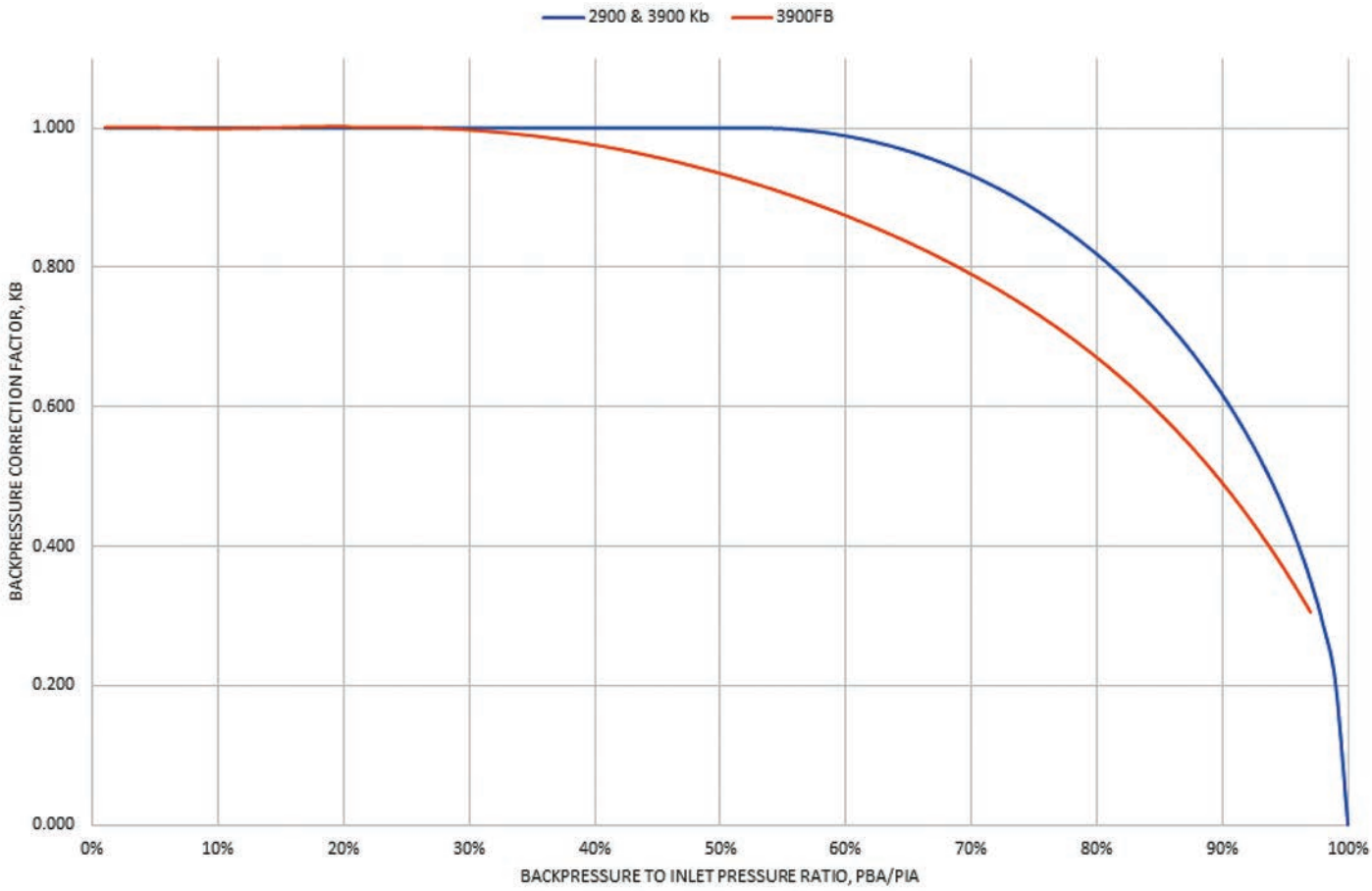

Figure 1 - Backpressure Correction (KB) Curves

The BT design offers customers with a solution to address their complex application needs. With the expanded pressure ranges and improved K_b curves provided by this enhancement, a drop-in solution is now available for challenging back pressure applications. Higher capacities gained by the BT design helps reduce the overall valve size required, providing customers with an optimized valve with a lower cost of ownership over the valve's full lifecycle. Combine the 2900's ability to directly replace API 526 direct spring-loaded valves without any piping changes and the 3900's compliance with API 526 pilot dimensional requirements, Consolidated has the most comprehensive pilot valve offering in the marketplace.

Frequently Asked Questions

1	Question	What are the impacts on valve coding when sizing a replacement valve for an existing 2900 or 3900 series valve?
	Answer	If the back pressure is within the scope of the BT design, the model coding will be updated to include a -BT which reflects the updated trim set.
2	Question	How should replacement situations be handled where the latest sizing results in a smaller orifice valve?
	Answer	For replacement situations, it is acceptable to proceed with the same size valve as originally supplied. It would be recommended to utilize a modulating pilot in these situations.
3	Question	Does this design update impact my currently installed valve's compliance with API?
	Answer	No. All existing valves would still be compliant with the guidance from API 520.
4	Question	How should situations where increased capacity results in 1 orifice size smaller valve than what is requested be handled?
	Answer	This more economical offering should be presented and ultimately the user must make the decision to accept. Should the larger orifice be required it is recommended that a modulating pilot be utilized.
5	Question	Are retrofit kits available for existing 2900 and 3900 series valves?
	Answer	Yes.
6	Question	Does this change have any effect on ASME B&PVC certifications?
	Answer	No. The 2900 and 3900 POSRV are fully ASME certified and will be provided with a code stamp.
7	Question	Does the BT design allow for better performance in situations where inlet losses exceed 3%?
	Answer	In situations where the expanded capacity of the BT design allows for a smaller orifice size valve to be used, improved performance such as reduced chatter would be expected.
8	Question	Can I retrofit my existing 2900 and 3900 valves in the field with the BT trim?
	Answer	Yes. A new nameplate may have to be provided in compliance with the ASME VR or similar program
9	Question	If the backpressure conditions of an existing valve installation changes, how can the Consolidated BT design help?
	Answer	• If the backpressure increases to potentially obsolete existing API spring loaded valves (Consolidated or other manufacturers), the 2900 Gen II POPRV with BT trim can be a drop in replacement with no piping modifications and more efficient flow. • If the backpressure increases, say from critical flow to sub-critical flow regime, the BT trim can provide the most efficient flow for the valve size. If the backpressure increase results in a larger valve size requirement based on the sizing of other PRV manufacturers, Consolidated can determine if the BT trim can provide a better, more efficient solution.

Baker Hughes

BHCN-2900/3900BTI-WP-34637A-1222 12/2022