How much is TOO MUCH?

John Lunde, Crane ChemPharma & Energy, USA, reviews valve industry seat leak rate standards and how they relate to check valve selection and specifications.

As natural gas use continues to increase in the US and throughout the world, new markets, technologies and infrastructure have enabled companies to capitalise on the advantages delivered by this relatively clean-burning fossil fuel.

With applications throughout the natural gas value chain, from upstream supply to downstream sale, valves are a critical differentiator in protecting equipment, maximising productivity and minimising fugitive methane emissions. However, as illustrated in part by the US Environmental Protection Agency's (EPA) valve recommendations, while much is known about valve design and material selection regarding emissions control, the current standards and regulations are relevant to a variety of shut-off valves, while the implications for check valves are somewhat less clear.

Unlike on/off valves, check valves are flow sensitive and rely on the line fluid to open and close. Rather than offering emergency shut-off or complete flow control, check valves are intended only to prevent reverse flow and the resultant damage to piping systems and rotating equipment. As a consequence, seat leakage rates for check valves often differ from those imposed on other valve types, and should be evaluated within this context.

The industry has a large number of leak rate standards available (API-598, API-6D, MSS, BS6364, Shell MESC SPE 77/300, ISO 5208, ANSI, to name a few), and there is some confusion about which requirements are appropriate to impose on check valves. This article will review the valve industry seat leak rate standards, the purpose of each standard, and ultimately how they relate to check valve selection and specifications. Furthermore, it will examine the purpose and operation of check valves within LNG systems and discuss why ultra-low leak rates are generally not appropriate for check valves.

Leak rate specifications

The daily demands placed on check valves, including constant exposure to fluid mediums, make them susceptible to wear and other operational challenges such as sticking, jamming and wedging. The harsh environment inherent to LNG production can cause valves to suffer from flutter caused by turbulence and compromise reverse flow and leak protection capabilities. In cryogenic applications where temperature, pressure and environmental considerations are paramount, both manufacturers and

Table 1. Valve industry leak rates for check valves

Standard	Type	Test type	Allowable leak rate	Comments
API-598[1]	Resilient	Liquid or gas	0	
	Metal seated	Liquid	3 cm^3/min./in.	
	Metal seated	Gas	700 cm^3/min./in.	
API-6D[2]	Metal seated	Liquid	3 cm^3/min./in.	Recently updated to reflect API-598 leak rates for check valves
	Metal seated	Gas	700 cm^3/min./in.	
BS 6364[3]	Metal seated	Inert gas	300 cm^3/min./in.	Not updated since 1998. No differentiation in leak rates for check valves vs shut-off valves
	Soft seated		No visable leakage	
Shell MESC SPE 77/306[4]	Cryogenic	Helium	300 cm^3/min./in.	No differentiation in leak rates for check valves vs shut-off valves
Shell MESC SPE 77/200[5]	Cryogenic	Helium	450 cm^3/min./in.	For most check valves
Shell MESC SPE 77/300[6]	Cryogenic	Helium	1300 cm^3/min./in.	For dual plate check valves
ANSI/FCI 70-2-2006[7]	Class II	Air or water	0.5% of rated capacity	Not intended for check valves
	Class III	Air or water	0.1% of rated capacity	Not intended for check valves
	Class IV	Air or water	0.01% of rated capacity	Not intended for check valves
	Class V	Water	0.0005 ml/min./in.	Not intended for check valves
	Class VI	Air or N_2	Separate table in specification	Not intended for check valves
ISO 5208[8]	Rate A	Liquid	No visually detectable leakage	
	Rate B	Liquid	0.015 cm^3/min./in.	
	Rate C	Liquid	0.045 cm^3/min./in.	
	Rate D	Liquid	0.15 cm^3/min./in.	
	Rate E	Liquid	0.45 cm^3/min./in.	
	Rate F	Liquid	1.5 cm^3/min./in.	
	Rate G	Liquid	3 cm^3/min./in.	
	Rate A	Gas	No visually detectable leakage	
	Rate B	Gas	0.45 cm^3/min./in.	
	Rate C	Gas	4.5 cm^3/min./in.	
	Rate D	Gas	45 cm^3/min./in.	
	Rate E	Gas	450 cm^3/min./in.	
	Rate F	Gas	4500 cm^3/min./in.	
	Rate G	Gas	9000 cm^3/min./in.	

end users should regularly test check valves for pressure containment and seat leakage to ensure the valve will protect critical equipment.

Within the industry, a vast range of parameters define acceptable seat leakage rates, as evidenced in Table 1, which illustrates common standards and the permissible seat leakage rates for each. The variance is considerable. API-598 and ISO 5208 Rate A, for example, dictate that resilient-seated valves must operate with 'no visable leakage,' while the Shell MESC SPE 77/300 – 2010 specification allows 1300 cm^3/min./in. (helium) and ISO 5208 Rate G (gas) establishes the limit at 9000 cm^3/min./in.

Why is there such a wide range of allowable leakage rates in the industry? The answer harkens to the purpose and usage of different valve types. For low-end shut-off or control valves that operate in non-hazardous, low pressure water, air or steam service, higher leakage rates may be acceptable when compared to the increased valve cost required to further reduce leak rates. For shut-off and control valves that are running in more severe services, or that contain media that is either expensive or dangerous, more stringent leakage rate requirements and the resultant increase in equipment costs are appropriate to ensure the safety of workers, the community and the environment. Therefore, determining the most applicable standard for a particular application relies on an assessment of multiple factors, including the operating environment and the value of the equipment being protected.

Leak rates for check valves

While the leakage rates described in Table 1 are often appropriate for shut-off and control valves in instances where the purpose of the valve is to stop flow completely, some do not apply to check valves. Intended primarily to protect pumps, compressors and piping systems from dangerous system deceleration and water hammer, check valves are not generally intended to serve as shut-off valves. With the exception of specific stop-check valves or actuated check valves, whose purpose is to check backflow in addition to shutting it off completely, the requirements for seat leakage in check valves should be set to limit the pressure wave and backflow that can damage the operational components they are designed to protect.

Limiting backflow: how much is too much?

As already discussed, the requirements for seat leakage in check valves should be set to limit the pressure wave and reverse velocity that can damage the pumps, compressors and piping systems they are designed to protect. Therefore, in assessing seat leakage for check valves, the primary assessment becomes the degree of backflow that can be accommodated without risking damage.

In 2008, Robert Talbot, Field Engineer at Sulzer Pumps, released a presentation entitled 'Hazards of Reverse Pump Rotation'. Talbot estimates that 40% of a pump's flow capacity is required to turn the pump backward (i.e. 390 gal./min. of the 975 gal./min. pump capacity in the example used).[9] Thus, this metric should be considered in evaluating ideal check valve performance.

Another perspective is to consider the allowable leakage in reference to day-to-day operations. With the API-598 specification, a 6 in. valve is allowed 18 cm^3/min. of leakage. This equates to 3.65 teaspoons of liquid per min. or approximately 18 g/min. of liquid. It is important to consider this metric in regard to check valves when evaluating the varying industry standards and determining which applies most appropriately to check valve selection and leakage performance in a particular application.

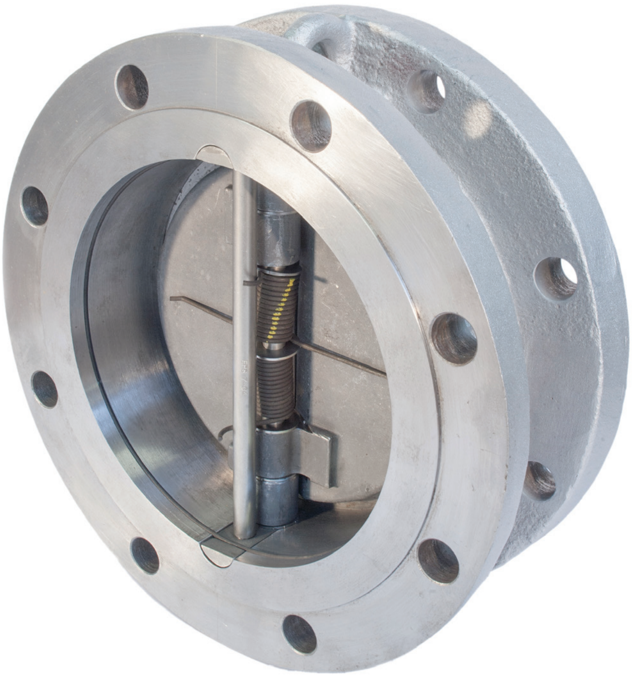

Figure 1. Highly-engineered Duo-Chek® valve.

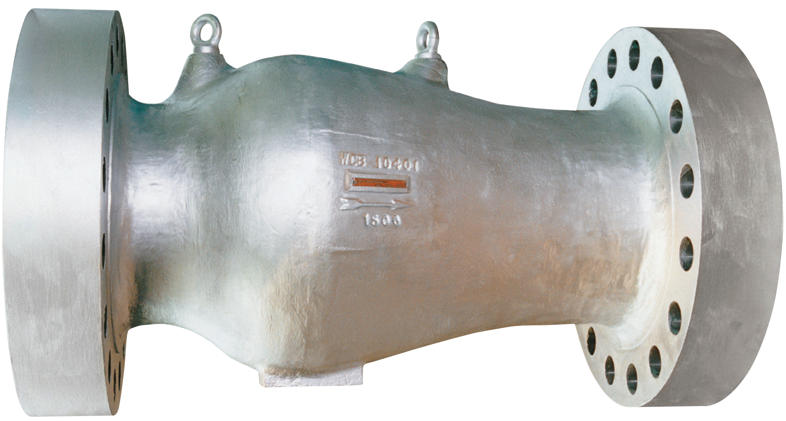

Figure 2. Nozzle-style Noz-Chek® valve.

Check valve selection considerations

In addition to, and regardless of, leak prevention abilities, check valves are crucial components in the LNG value chain. They offer a solution to the destructive effects of flow reversal and provide essential protection to plant infrastructure, pipelines and turbomachinery.

Critical applications such as LNG liquefaction and regasification are challenged by extreme temperatures and require equipment that delivers the fastest dynamic performance and lowest pressure drop while still protecting against reverse flow. For these reasons, check valve selection is very important in LNG applications where the upfront investment and maintenance costs are high.

To avoid the challenges often present with basic swing check and tilting disc valves, highly-engineered solutions such as dual-plate and nozzle-check valves can offer a more reliable solution to the challenges of severe service.

Dual-plate, wafer design check valves are generally stronger, lighter, smaller and more efficient than conventional swing check valves. To best protect the costly elements of liquefaction and regasification terminals and deliver the lowest total cost of ownership, dual-plate designs use springs to decrease valve reaction and response time. This design feature accelerates dynamic response and reduces water hammer and slam.

Nozzle-style valves are also highly effective in protecting the equipment throughout the natural gas and LNG value chain. Nozzle-style check valves likewise minimise the damaging effects of reverse flow and slam in fluid systems, eliminate the chatter associated with conventional valves, protect rotating equipment from damage due to flow reversal, minimise pressure loss in piping systems and provide quick dynamic response to reduce reverse velocity.

Conclusion

As long as the global marketplace seeks cleaner, more cost-effective methods of energy production, LNG utilisation will continue to expand within the US and across the globe. With this growth will come increasingly stringent regulations and innovative valve solutions to address them.

However, it is essential that valve users and manufacturers ensure that equipment not only adheres to the standards implemented by regulators, but that it delivers cost-effective performance in both severe and non-severe service applications. For this reason, users must evaluate how to achieve the delicate balance between product performance requirements and cost restraints.

This article reviewed valve industry seat leak rate standards and how they relate to check valve selection and specifications, ultimately illustrating why ultra-low seat leak rates may not always be appropriate for check valves. The author does not intend to suggest that industry specifications should be updated to allow 40% of flow capacity as backflow leakage for check valves. However, engineers should consider the system requirements as well as the cost-benefit analysis before specifying ultra-low leak rates for check valves. It is important to work directly with a proven manufacturer to ensure that valve equipment is equipped to address the needs of next-generation LNG plants and the global energy market. **LNG**

References

1. American Petroleum Institute, (2009), Standard 598, Valve Inspection and Testing, 9th Edition.
2. American Petroleum Institute, (2015), Standard 6D, Specification for Pipeline Valves, 24th Edition.
3. British Standards Institute, (1984), Standard 6364, Specification for Valves for Cryogenic Service.
4. Shell MESC SPE 77/306, (2005), Production Testing of Valves in Low Temperature Services.
5. Shell MESC SPE 77/200, (2008), Valves in Low Temperature and Cryogenic Services.
6. Shell MESC SPE 77/300, (2010), Procedure and Technical Specification for Type Acceptance Testing (TAT) of Industrial Valves.
7. Fluid Control Institute, (2006), American National Standard – Control Valve Seat Leakage.
8. International Organization for Standardization, (2008), Industrial Valves – Pressure Testing of Metallic Valves.
9. TALBOT, R., 'Hazards of Reverse Pump Rotation', (2008), http://turbolab.tamu.edu/proc/pumpproc/P27/Hazards%20of%20Reverse%20Pump%20Rotation.pdf