

Fugitive emissions and control valves

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This paper describes the history of the development of the fugitive emissions requests, the standards committees and manufactures reactions to them. How do these standards differ? How do they compare?

The paper also describes the approach and issues a control valves manufacturer has to deal with to meet the various requirements on fugitive emissions. It is recognised also that control valves by their function of continuous movement have more tendency to wear out than on/off valves and are therefore more easily subject to packing leakage.

The USA introduced the Clean Air Act in 1990. The objective of this law is to reduce the emissions of various chemicals and VOC into the atmosphere. The EPA established the process to monitor, schedule and repair the leaking equipments. The frequency of the Leak Detection And Repair will depend on how many valves are leaking above the specified limit. As you know this can go from yearly to a monthly monitoring depending on the results. The approach of the problem in the USA is based on practical results measured on site and in service. In Germany the TA-Luft regulation has a different approach. The clause 3.1.8.4 in the first edition (1986), clause 5.2.6.4 in the 2000 revision, specifies the technology that should be applied to reduce the emission. Basically the requirements are that valves must be equipped with bellows seal, or equivalent sealing system.

The Clean Air act put a lot of pressure on the users to measure and report the leaks detected in the plants. The TA-Luft requirement put pressure on the manufacturers to develop designs with bellows or with packing system having equivalent sealing performances to a bellows.

The TUV initiated this equivalency testing. The argument is based on the fact that a valve having a bellows seal has also some flat gasket in its construction and these flat gaskets have a leak rate of 10⁻⁴ mbar.l/s.m. If the leak rate is not higher than this, then the design is judged equivalent to a bellows. This measurement is done in a lab using helium and a mass spectrometer. The protection of the environment is recognised in these two world areas, but they use two opposite approaches to solve the problem.

Manufacturers reaction

Following these requirements, all the valve and control valve manufacturers designed new packing arrangements. Almost at the same period the ban on asbestos was worldwide and new material for the sealing elements were introduced by the packing manufacturers (PTFE, Graphite and Aramid mainly). As the bellows seal construction is recognised to be expensive and not always practical (rotary valves or high pressure valves or long stroke valves) the valve manufacturers approached the TUV to get the equivalency to TA-Luft. We have then seen a blossom of articles and advertisements in the press, claiming compli-

ance with the CAA and/or the TA-Luft, these from valve manufacturers, packing manufacturers or service companies.

A very tight packing with high friction will deteriorate the control valve performance in the control of the process variable

Users position

Depending of their world area and their 'cultural attitude', the users had different reactions as well:

- Some may trust the supplier (valve or packing) and apply its solution
- Some require a certification of the type test
- Some require to witness a production test at the valve manufacturer's factory
- Some prepare their own testing procedure .

This variety creates confusion, does not help order handling, slows the process, so the need for clarification and standardisation is obvious.

Committee reaction

The various standardisation committees also started to react and to write drafts:

In the USA

The Fluid Control Institute (the same body that wrote the control valve seat leakage standard FCI 70-2) wrote the draft FCI 91-1. Qualification for control valves stem seal by type test. The standard is based on the US requirements and testing method: sniffing with methane expressed in ppmv. The draft was finally accepted and published in 1997. Since the first issue of the draft the situation evolved and not only 500ppmv were requested but in some States in the USA the limit was fixed at 100ppmv. Therefore the standard gets the two limits. It also has different classes for mechanical cycles, thermal cycles and allows for some classes, packing readjustment. The cycle for a control valve is defined as a full stroke from the closed position to the open position and back. The test profile in cycles, pressure and temperature is also clearly defined.

In Germany

The TUV visited many manufacturers and proceed with tests to establish an official certificate of equivalency to TA-Luft. The VDI committee also developed a draft standard based on the TUV test method and limits. The test fluid is helium, the leakage is measured with a mass spectrometer with a limit of 10-4 mbar.l/s.m for temperature at the packing box below 250°C and 10-2 mbar.l/s.m above 250°C. The leakage is a measurement of the total leak. But the definition of mechanical cycles and number is not clear. They shall be representative of the operating conditions. The VDI 2440 document in its 2000 issue specifies that the packing shall be exposed to He at least 24 hours. Today this requirement is a point of controversy.

In France

The French Valve association together

with the Cetim also developed several technical programs on packing performance and testing possibilities. It was perceived that the situation needed clarification in testing procedure and packing design. The testing method is based on mass spectrometer using helium and measuring the total leak. Many valve manufacturers (on-off and control valves) submitted some designs for testing in order to get a picture of the performance of the available designs. Further test programs were developed with packing material manufacturers in order to increase our understanding of the sealing properties and possible improvements.

A need for a global standard on fugitive emissions was clearly appearing. A work item was then proposed to the ISO TC 153 SC1 to develop a type test standard. The valves stem sealing techniques and testing are the same for on-off and control valves, therefore it was proposed to include in the same standard the control as well as the on-off valves. All specific requirements were discussed and agreed by the IEC SC 65B WG9 (the body writing the control valve standards) and at least one person was member of both working groups to ensure consistency. In parallel the French valve association and the Cetim developed a test bench to ensure that the type test according to the



Fig. 1: The CETIM (France) valves fugitive emissions test bench.

ISO 15848 procedure was realistic and achievable (see Figure 1).

Several control valves have been submitted to the procedure (sliding stem and rotary valves, with PTFE based and Graphite based packings). Some encouraging results were obtained validating the ISO testing procedure and the possibility to meet the ISO leakage class levels.

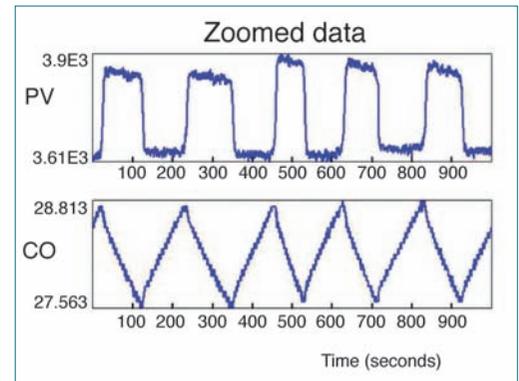


Fig. 2: Limit cycle of a process variable.

Current situation

Many developments have been made by packing manufacturers and valve manufacturers in order to improve their knowledge and the performance of the stem sealing systems. The specific requirements for control valves are: very low friction, resistance to wear, together with good sealing.

A very tight packing with high friction will deteriorate the control valve performance in the control of the process variable. This friction will create dead band in the operation of the control valve resulting in limit cycle of the process variable (see Figure 2).

A good balance between control performance (measured by the control valve dead band due to friction) and good sealing performance needs to be obtained. This development has to be made by the control valve and the packing material manufacturers working together. One knows the requirements for a good control valve and the second knows the possibilities of the packing material. This is an extensive effort in product development and the objective for both parties (valve and packing manufacturers) is to get a design that meets all requirements (CAA, TA-Luft, ISO, Customer). This will also simplify the selection of the valve packing arrangement for the customer's application, and will therefore simplify the life for the user as well.

Standards comparison

When looking at the various standards our industry should comply with, there are differences but also some areas of similitude that can be seen. Table 1 gives a comparison of the current standards. ▶

	ISO 15848	ANSI/FCI 91-1	VDI 2440
Test fluid	He or CH ₄	CH ₄ (N ₂)	He
Leakage method	global measure	Sniffing EPA 21	global measure
Rate	10-6 mg.s ⁻¹ .m ⁻¹ 10-4 mg.s ⁻¹ .m ⁻¹ 10-3 mg.s ⁻¹ .m ⁻¹	500 ppmv 100 ppmv	10 ⁻⁴ mbar.l.s ⁻¹ .m ⁻¹ (1.76 10 ⁻⁵ mg.s ⁻¹ .m ⁻¹) 10 ⁻² mbar.l.s ⁻¹ .m ⁻¹ (1.76 10 ⁻³ mg.s ⁻¹ .m ⁻¹) above 250°C
Valve type stroke	100% for on-off ±10% for control	100%	not specified
Number of cycles	20k, 60k, 100k	5k, 25k, 100k	not specified

Table 1: Comparison table of the current standards.

Test fluid

Methane and helium are the fluids to be used to do the leakage measurement. No correlation is agreed between these two mediums. Doing a continuous measurement in a laboratory environment with helium is the standard practice in Europe and will not raise safety issue. The ANSI method uses methane for the measurement at room temperature but the cycling at pressure and temperature is done with nitrogen in the valve. There are debates about the permeation of some material by helium which some consider could affect the test results. When using helium we comply with VDI and ISO.

Leakage measurement

The total leakage measurement seems to be more consistent and adapted to the helium and mass spectrometer method. Using sniffing with helium may be disturbed by the leakage itself in the laboratory air. ISO and VDI are identical on this point.

Leak rate

Using the total leakage measurement and helium the only difference between VDI and ISO is the level of acceptable leakage.

Valve stroke, number of cycles

In the case of control valves it has been agreed by the control valve committee (IEC SC 65B WG9) that a small stroke around the mid-point of the valve is more representative of a control valve operation but with a number of cycles much higher than the on-off valve types. The control valve is in a continuous movement to adjust the process variable in opposition to

the on off valve which is open or closed and not moving. Usually control valves and on-off valves are of different designs. Further analysis of packing leakage performance difference between an on off and a control valve using the same seal design may correlate these different mechanical cycling conditions. For example, what is the major factor of wear? is it the number of changes in the stem movement direction or is it the cumulative length of stroke? When the stem or shaft is closing the valves, bending, shifting, twisting can occur. What will be the effect of these on the packing sealing performance? Using the ISO standard test procedure with helium may be the common denominator for the European market. Shall every manufacturer perform also test according the FCI standard or:

- Are different designs of packing assembly required to meet the CAA and European requirements?
- Are the packing materials used to meet

CAA different from the packing material used to meet TA-Luft?

- Are the manufacturers designing packings to meet a standard or to meet the application and their regulations?

Conclusions

Any laboratory test or factory test can only classify performances of the valve packing when newly assembled. Performance on site is related to many parameters that cannot be reproduced fully in a type test. These standards can only produce a comparative ranking between the various designs. The scale may be different between FCI and ISO/VDI but I assume that the ranking will remain similar. Since the introduction of the CAA and TA-Luft many improvements have been seen in the stem sealing systems offered in the market. The standard ISO or FCI should be a tool to classify these improvements for the benefit of the users and the environment and therefore to all of us. ■

About the author



Etienne Venner works for Emerson Process Management in France.

Valve World 2004 Conference Papers

This paper was originally published and presented at the Valve World 2004 Conference, held in Maastricht, the Netherlands. For more information about this show, please see www.valve-world.net/conf2004/report.asp.

Over fifty top quality papers were presented at this show, covering topics from QA/QC systems and material selection, through to emissions control and automated valves. These papers can be accessed via the classified section of the website.

Valve World 2006 Conference Papers

More than 100 paper abstracts were recently reviewed by the Valve World 2006 Conference Steering Committee. They have selected the top 57 papers for presentation in twelve different sessions. Additional show elements will include six workshops, a masterclass and numerous networking opportunities. For more information and to register as a delegate, please visit: www.valve-world.net/expo2006/index.asp.