Testing to fugitive emissions standards: Which ones and why?

Which of the various methods and standards for low fugitive emission applications are most appropriate for a valve? Is the decision based on the type or design? Is it based on the geographic market the valves are being sold into or on the application? With ISO 15848-1, which of the various tightness, endurance and temperature classes should be applied?

By Stan Allen & Vanessa Mertes

This article provides guidelines for valve manufacturers, engineering companies and end users on which standard to apply, and when and how the different techniques of the standards should be applied. Drivers for testing, such as the environmental laws, industry standards, end user specifications and responsibility are the basis for the development of the valve test standards and impact the type and standard method that is applied.

Overview of fugitive emissions test standards

The American Petroleum Institute (API) has standards for different types of valves, such as API 624 for Rising Stem Valves and API 641 Quarter-Turn Valves. API 622 also provides test procedures and criteria for different types of packing that can be used for different applications. The International Organization for Standardization (ISO) has developed standard ISO 15848-1 for type testing, which has several different performance classes to choose from for evaluation, and ISO 15848-2 for production testing. To obtain a certificate of compliance with these standards, the valve manufacturer must complete and pass prototype testing, typically performed by an established 3rd-party testing facility. A valve manufacturer must choose from different testing procedures, acceptance criteria and test variables such as media, temperature, numbers of cycles and numbers of thermal cycles. There are several different methods for acquiring leakage rate data, such as the sniffing and bagging methods. After prototype testing has been completed, the valve manufacturer must ensure that all low emission valves can be produced consistently. The testing procedures for production and prototype valves can differ. If a valve manufacturer makes a change to the valve, there are certain situations that require new certification. Which design parameters, packing type, or application change require a retest for recertification?

Drivers for testing

The drivers for improved performance of valves to reduce emission of volatile organic compounds may be classified as follows: (1) laws, (2) industry standards, (3) end user specifications, and (4) engineering and personal responsibility.

Laws: In the United States, the Clean Air Act and subsequent amendments are federal law with the goal to improve, strengthen, and accelerate programs for the prevention and abatement of air pollution. It is administered by the U.S. Environmental Protection Agency (EPA) and is enforced by leak detection and repair (LDAR) programs and enhanced consent decrees. In Europe, the EU Air Quality Directive 2008/50/EC was a major legislation that integrated several earlier directives and created a renewed focus. In China, the 2014 Air Pollution Control Law was put in place. Other countries have legislation in place, and in the U.S., many local air quality districts have been established to implement and enforce pollution control initiatives.

Industry standards: Various industry organizations, such as American Petroleum Institute (API), International Organization for Standardization (ISO), Manufacturers Standard Society (MSS), Instrument Society of America (ISA) and others develop new standards or enhance existing standards to address industry needs.

End user specifications: Many major oil and gas companies have developed type tests, qualification requirements, general specifications and even project specifications to reduce emissions. These specifications are enforced through order contract requirements to valve suppliers and, in some cases, include 5-year warranty commitments.

Engineering responsibility: All of us in the industry, and particularly engineers, have a professional and personal responsibility to protect our environment. The quality of the environment is one of our legacies and we must do our part to improve the performance of our products and processes to maintain or improve air quality. Responsible valve manufacturers take this responsibility seriously.

Prototype qualification of valves

To meet the industry demands, valve manufacturers are required to type test their designs to standards such as API 641, ISO 15848-1, TA Luft, or ANSI/ISA S93.00.01. This involves multiple valves to be tested (usually 3rd party testing) and for various services - which all add up to a substantial investment in money, time and resources taken away from other important design initiatives. The testing is required to provide end users with valve purchase options and for the manufacturer to do business in the oil, gas and chemical markets. But the cost is real to the manufacturer and is ultimately shared with valve buyers and end users. API has led standard development efforts to comply with the US Clean Air Act using elements of EPA Method 21. These include API 622 (Type Testing of Process Valve Packing for Fugitive Emissions, Second Edition). Initially developed in 2006, it includes fixture testing for emissions with 1510 mechanical cycles and 5 thermal cycles and corrosion tests, as well as evaluation of density and other packing material composition and properties.

Incorrect application

The Third Edition is being finalized by the API task group, which includes reduction of acceptance criteria to 100 ppmv maximum. API 624 (Type Testing of Rising Stem Valves Equipped with Graphite Packing for Fugitive Emissions, First Edition, 2014) is currently applied to "rising and rising/rotating stem" valves such as gate, globe and rising-stem ball valves. Some valve manufacturers have applied this standard to quarter-turn valves at the urging of end users and contractors, but that is an incorrect application. API 624 is in the process of being revised by the API task group. Currently, the standard requires testing to 310 mechanical cycles with 3 thermal cycles with acceptance criteria of 100 ppmv maximum with no packing adjustments. The thermal cycle is from ambient to 260°C (500°F). Leakage from body-bonnet connections are included within the scope. API 641 (Type Testing of Quarter-turn Valves for Fugitive Emissions, 1st Edition) was published in late 2016 and is applicable to ball, butterfly and plug type valves. This standard covers ASME B16.34 valves up to and including 24 NPS and Class 1500. The testing requires methane testing based on elements of EPA Method 21 and requires 610 mechanical cycles and 3 thermal cycles, with both static and dynamic leakage measurements.

"Global method"

Valve qualification groups are defined based on variables of the valve's elevated temperature, pressure at elevated temperature, and pressure at ambient temperature. Maximum test temperature is 260°C (500°F). Acceptance criteria is 100 ppmv maximum with no packing adjustments. Leakage from body-bonnet joints are included within the scope. ISO 15848-1: 2015 (Industrial valves – measurement, test and qualification procedures for fugitive emissions – Part 1: Classification system and qualification procedures for type testing of valves) includes testing procedures for evaluation of external leakage of valve stem seals and body joints of isolating valves and control valves. It requires 97% purity helium as the test media,

Typical low emissions stem packing for quarter-turn ball valve

Flow-Tek severe service ball valve

except that an alternate method is specified that permits the use of methane. Two specific methods are noted, one called the "global" method, which uses bagging and pulling a vacuum or another local leakage measurement technique (sniffing). The performance class is defined by a combination of criteria for "tightness", "endurance" and "temperature" classifications. Acceptance criteria depends on the tightness classification and the media and is different for body joints than for stem packing. When the test fluid is helium, the tightness classes are identified as Class AH, Class BH and Class CH, and when the test fluid is methane, the tightness classes are identified as Class AM, Class BM and Class CM.

Challenging to compare overall performance

A valve manufacturer may perform testing for a specific tightness class, endurance class (mechanical cycles and thermal cycles) and for a test temperature. This is a comprehensive test in which the various class designations may be chosen based on both the valve type and the intended application. The downside is that it is not truly a uniform procedure for evaluation of emission performance, which makes it challenging for end users to compare overall performance from one valve manufacturer to another valve manufacturer. Different manufacturers may decide on different performance classifications and, thus, end users must evaluate the test results for the specific need.

End users in the United States are required to provide documentation utilizing EPA Method 21 and methane as media, and so ISO 15848-1 testing is not typically accepted for consent decree documentation of valves. ISO 15848-1: 2015 has been approved by CEN as EN ISO 15848-1: 2015 with no modifications. In 2017, an amendment was made to ISO 15848-1: 2015 (called A1: 2017), which clarifies temperature classifications and qualification rules. CEN has also endorsed A1: 2017. An important aspect of the ISO 15848-1:2015 is that the method used is dependent on the tightness class. A tightness class of AH requires that a vacuum method be used, which is described in Annex A, and is considered more discriminating than a bagging method, also described in Annex A. Tightness class BH and CH permit either a vacuum method or bagging method – both of which are considered the "global method" or "total leak rate measurement method". ANSI/ISA SP93.00.01 (Standard Method for the Evaluation of External Leakage of Manual and Automated On-Off Valves) continues to be referenced and applied to valves. Additional cycle requirements may be added to this document by end users.

Application-driven

Manufacturers must decide what performance classifications of ISO 15848-1 to apply. This is not always a straightforward decision. It depends on the valve type and design features but, most importantly, the intended application of the valve. Since the

Standards Comparison

Standard	Test Fluid	Mechanical Cycles	Thermal Cycles	Acceptance Criteria	
				Stem	Body
ISO 15848-1	Helium OR Methane	CO1 = 205 (CC1 = 20,000)	2	AH = 1.78 x 10^{-7} mbar. L/s per mm stem dia.	500 PPMV
				AM = 50 PPMV	
		CO2 = 1,500 (CC2 = 60,000)	3	BH = 1.78 x 10^{-6} mbar. L/s per mm stem dia.	
				BM = 100 PPMV	
		CO3 = 2,500 (CC3 = 100,000)	4	CH = 1.78 x 10^{-4} mbar. L/s per mm stem dia.	
				CM = 500 PPMV	
ISO 15848-2	Helium	5	0	A = 50 PPMV	500 PPMV
				B = 100 PPMV	
				C = 200 PPMV	
API 624	Methane	310	3	100 PPMV	100 PPMV
API 641	Methane	610	3	100 PPMV	100 PPMV
TA Luft & VDI 2440	Helium	Unspecified	Unspecified		
			< 250°C	1 x 10^{-4} mbar. L/s per m stem dia.	same
			≥ 250°C	1 x 10^{-2} mbar. L/s per m stem dia.	same
ISA 93.00.01	Air, Nitrogen, Helium, Methane	Unspecified	≥ 1	A = 50 PPMV	A = 50 PPMV
				B = 100 PPMV	B = 100 PPMV
				C = 500 PPMV	C = 500 PPMV

performance classifications are based on shutoff, endurance and temperature, these three factors must be considered. If the primary applications include processes with lethal gases, then a tightness Class AH should be the goal. If the primary application is process isolation or infrequent operation (such as once per month), then endurance Class Co1 should be applied. But if the valve may be used in higher cycle applications, then CO2 and CO3 should be applied. If a valve is used in a lower high-temperature application, or even a temperature cyclic application (such as for isomerization processes or cryogenic loading), then a choice must be made between t-196°C, t-46°C, t-29°C, tRT, t200°C, t400°C. ISO 15848-1 also includes multiple endurance classifications for control valves, with CC1 (20,000 cycles with 2 thermal cycles), CC2 (60,000 with 3 thermal cycles) and CC3 (100,000 with 4 thermal cycles). Some valve types are used for isolation, some for control, and some for both, so deciding on a set of tests and conditions for valves used in multiple applications requires careful thought. Three obvious considerations are deciding what temperature classification is required, whether the valve and packing design can meet that classification and whether multiple classifications must be pursued. The application of the valve may result in different packing selection and design based on several factors. These include:

- Service conditions
- Application
- Mode of operation
- Frequency of operation
- Service fluid compatibility
- Lethal services
- Temperature (high temperature and cryogenic conditions)
- Fire-test requirements
- Stem position (horizontal may increase side-loading)

Production testing of valves

ISO 15848-2 (Industrial valves – Measurement, test and qualification procedures for fugitive emissions – Part 2, Production acceptance test of valves) is the most significant industry standard that addresses production testing in a valve manufacturing environment. The equipment is expensive from a valve manufacturer's standpoint because it includes helium sniffing, but the use of helium within a production environment is relatively safe. While this provides the end user with a level of confidence in stem packing and bolted joints, it does not produce specific documentation that is acceptable to auditors in the U.S. who are applying EPA Method 21 using methane gas as the test media. However, valve production data for specific valves can support type testing data. Some manufacturers have set up fugitive emissions labs dedicated to performing production testing using the helium sniffing method. This lab permits both production testing when specified by an end user, engineering company or contractor, but also serves as a validation of designs or packing changes.

Major considerations in valve selection

Valve operation types fall into two broad categories – (1) rising or rising-rotating stems, and (2) quarter-turn (part-turn) stems. Rising and rising-rotating stems are normally used in gate, globe, and rising stem ball valves. These designs are considered the most susceptible to stem leakage, since the stem is exposed to the service fluid and then drawn through the packing during the valve operation. These valve designs are the most prevalently used in refineries. Quarter-turn valves, which include most ball valves, offset butterfly valves and plug valves are often considered significantly less susceptible to stem leakage due to the short quarter-turn rotation and the service fluid not being drawn through the packing during the valve operation. However, if not properly designed, manufactured or maintained, quarter-turn designs are still possibilities for release of emissions. Particularly for ISO 15848-1 requirements, end users and engineering companies should compare the tightness, endurance and temperature classifications that a manufacturer has applied for testing. Compare with the application requirements and compare with each other, making sure that the needs of the application are met.

Variables that require retesting

Variables that may require a retest or requalification are:

- Body/bonnet or other pressure containing bolted joint changes
- Packing chamber design changes
- Packing manufacturer and type changes
- Changes by the packing manufacturers in their product
- Changes to required tightness, endurance or temperature rating and application of the valve
- Changes in standards, using A1:2017 of ISO 15848-1 as an example

Summary

There is more to performing a fugitive emissions test of a valve and calling the work complete. Deciding which type of test (or tests) is required is the first choice, and that is based on the design, features and valve application. Following the initial type test, production testing to validate designs and manufacturing processes are critical to assuring that there are no surprises once the valves are installed. If design changes are made or packing manufacturers change, requalification may be required. Testing and standard compliance is a continuous process for leading valve manufacturers who provide low emissions valves.

About the authors

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Both Mertes and Allen will present this topic during a workshop at the Fugitive Emissions Summit Americas which will take place June 26-27 in Houston, Texas.