TechTalk

Would a certified fugitive emission valve truly meet the Low E needs with existing technology limitations?

Demand for Valves with Low E

With increasing regulations to reduce fugitive emission (FE) from industrial facilities, performance of valve designs with low emissions (Low E) has become a hot topic in the past few years. Therefore, end users are adding pressure on valve manufacturers to comply with current fugitive emission testing standards to guarantee low emission in their valves and refineries. However, it is important to understand the testing standards' limitations before applying them to your specific application.

Temperature Limitations in FE Standards

There are several standards that influence the design and performance of certified fugitive emission valves, such as API 641 *Type testing of Quarter-turn valves for Fugitive Emissions* and ISO 15848-1 and -2 *Measurement, test and qualification procedures for fugitive emissions*, *Part 1: Classification systems and qualification procedures for type testing of valves* and *Part 2: Production acceptance test of valves*. However, none of these standards addresses high temperature applications above 752° F (400° C), such as delayed coker, fluid catalytic cracking, hydrotreating and hydrocracking applications.

API 641 was designed to address approximately 80% of the refining and petrochemical applications. Although the latest edition of API 608 (January 2020) requires all metal ball valves to be FE qualified to API 641, this standard was never intended to address all applications, and certainly not high temperature applications.

Quarter-turn valves such as ball valves and butterfly valves qualified to API 641 are required to use API 622, *Valve Packing for Fugitive Emissions* qualified packing. API 622 indicates that the packing maximum testing temperature is 500° F (260° C), but their qualification goes up to twice the testing temperature or 1,000° F (538° C). Similar to API 622, API 641 tests the valves to a maximum temperature of 500° F (260° C) and does not extend a `qualification temperature´, just lists the test temperature.

ISO 15848-1 is another common standard that is more applicable for high temperature severe service valves, as it offers several classes of temperature qualification and includes testing for higher temperatures up to 752° F (400° C) and does not extend the qualification above the test temperature. It is worth mentioning that ISO measures the test temperature at the center of mass for the valve body but records the temperature in the area around the packing box for information.

Table 1 shows the comparison between ISO 15848-1 and -2 and API 622 and 641 standards. In terms of testing, ISO 15848-1 is more stringent than API 622 and 641 since the maximum testing temperature is 752° F (400° C), compared to 500° F (260° C) for the API standards. Currently, testing temperatures above 752° F (400° C) are not considered in any fugitive emission standard.

Table 1 – Brief comparison of Fugitive Emissions standards ISO and API

	ISO 15848-1	ISO 15848-2	API 622	API 641
Qualifies	Valve types	Production valves where fugitive emission standards are specified	Packing suitable from -20° F to 1000° F (-29 to 538° C)	Valve design up to NPS 24 and 1500 Class
Pre-Requisite	None	ISO 15848-1 qualified valve design	None	API 622 qualified packing
Test Medium	Helium or methane	Helium	Methane	Methane
Packing Tested In	Valve	Valve	Fixture	Valve
Test Pressure	Rated valve pressure at test temperature per ASME B16.34	87 psi (6 bar)	0–600 psi (0–41.4 bar)	The lower of 600 psi (41.4 bar) or maximum allowable pressure at temperature per ASME B16.34
Test Temperature	Variable up to 752° F (400° C) [1]	Ambient	Ambient and 500° F (260° C) [2]	Ambient and 500° F (260° C) [2]
Mechanical Cycles	Variable [1]	5	1510	610
Thermal Cycles	Variable [1]	0	5	3
Allowable Packing Adjustments	1	0	0	0
Measured Units	mg/sec-m	ppm	ppm	ppm
Acceptance Criteria	Variable [1]	Variable [3]	500 ppm	100 ppm
Qualification Coverage	Same basic design. Stem diameters: 50% lower and 200% higher. Pressure class: same class and lower [5]	N/A	Packing Only	Variable [4, 5]

[1] ISO 15848-1 has several different classification criteria for classes for the allowable leakage rates, number of mechanical test cycles and test temperatures.
[2] There is a proposal for higher temperature testing.
[3] Acceptance criteria is based on the tightness class the design was tested to per ISO 15848-1.
[4] Valve must be the same basic stem and packing design.
[5] The scope of the standard is 150 to 1500 Class and valves NPS 24 and smaller.

End users are starting to realize this inconsistency. Also standards committees are having discussions to add an optional test to the API standard with a high temperature test for valve and packing, as well as changes to the scope of the API 622 test standard to limit the qualification range up to 800° F (427° C) to align more closely with the ISO standard qualification.

Limitations of FE Packing

Typically, the packing used for API 622 qualifications contains some volume of lubricant agent such as polytetrafluoroethylene (PTFE), which has a low coefficient of friction. Although API 622 refers to PTFE as a lubricant agent, in reality it serves a dual purpose as lubricant and blocking agent because it significantly increases the sealing performance of the packing. Moreover, it is proven that packings without PTFE content are highly unlikely to successfully pass FE qualification testing. This is especially evident when testing with helium (smaller molecule size than methane) or at high pressures and temperatures since there is a direct correlation between the sealing performance and the PTFE content of the packing. The earliest version of the API 622 standard limited the PTFE content to a maximum of about 15% by volume. However, there is no PTFE content limit in the latest edition of this standard, which now requires only that it be reported.

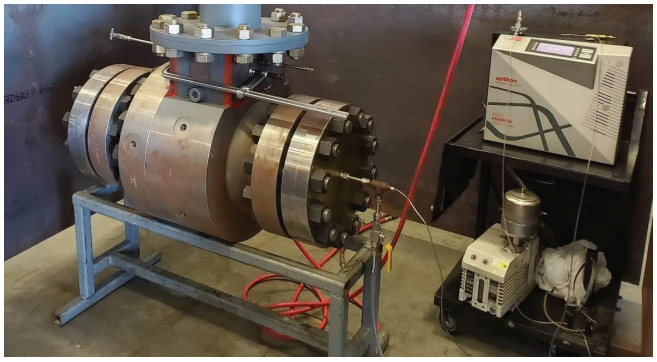

Figure 1 – FE test setup example for MOGAS valve before insulation

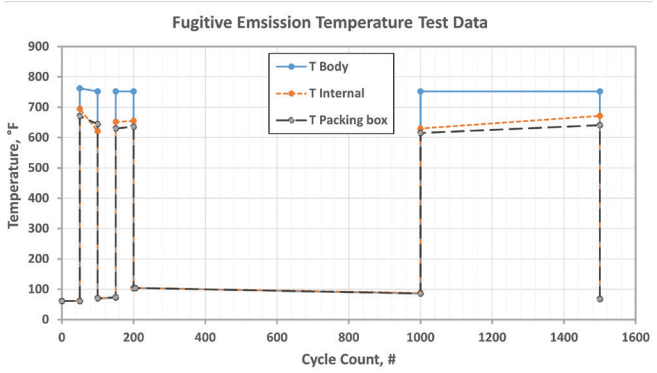

Figure 2: Fugitive emission temperature test data for MOGAS valve

Even though the PTFE is widely used as a lubricant and blocking agent in packings for FE purposes, PTFE melting temperature is 599–642° F (315-339° C) and it is proven that at 750° F (400° C) the PTFE gases off (sublimes), leaving no residue. Studies show that for temperatures above 750° F (400° C), packings with PTFE content will lose between 2 and 17% in volume due to PTFE sublimation, and this weight loss in the packings creates a leak path and potentially increases emission to the environment.

As a result, the qualification to FE standards does not guarantee low-emission in performance valves at temperatures over 752° F (400° C). This is because of the temperature limitations of both API and ISO standards and due to the sublimation of PTFE present in FE packings at elevated temperatures.

One common question end users ask is, “What is the temperature difference between the media and the packing?” They have observed in FE testing as shown in **Figure 1**, that the packing box temperature typically lags the body by a differential of approximately 100° F (56° C) as shown in **Figure 2**. However, in steady state conditions, the packing on some insulated heavy oils and delayed coking valves will operate at a much similar temperature than the media, which is considerably higher than the testing standards, in the range of 850° F (454° C) and or above.

Valve Designs Consideration for FE Service

Complying with API 641 and ISO 15848-1 standards additionally impacts valve design and performance. FE qualified valves will not be standard valves, as additional changes are required:

- Higher packing compression is needed at assembly as recommended by FE packing manufacturers. This increases operating torque and potentially increases actuator size on smaller valves.
- To adequately compress the packing, more or larger gland fasteners, or higher strength bolts may be required, as well as heavy gland flanges to accommodate the increased loads. These could change the design of the top works, resulting in a larger valve body to accommodate larger fasteners.
- Generally, fugitive emission packing requires approximately twice the gland load to compress the packing to the level necessary to achieve low emissions performance. To achieve this load, a higher-than-normal gland stud torque is required.

Recommended Solution for Low Emissions Valves in High Temperature Applications

Considering the testing temperature limitations of API 622, API 641 and ISO 15848-1 FE standards and the sublimation of PTFE commonly present in FE packing, they recognize the need to develop technologies for high temperature applications that will help end users to lower the emissions at industrial sites.

At MOGAS, their commitment is to supply severe service valves that comply with industry standards, and even offer valves qualified to API 641 and ISO 15848-1. To achieve low emissions in high temperature applications, they recommend a packing with no PTFE content.

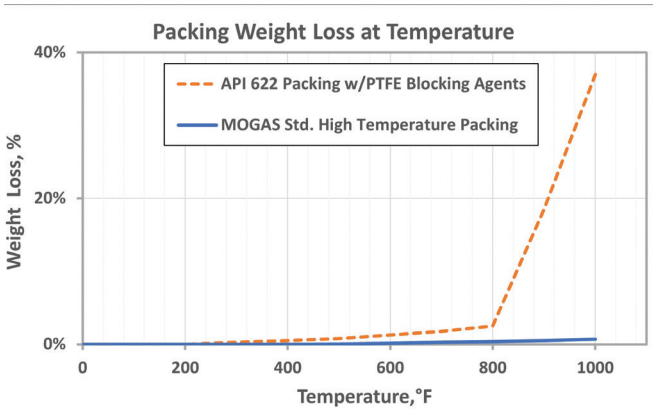

Figure 3: Comparison of packing weight loss curve

Figure 3 illustrates the degradation of API 622 fugitive emission packing at various temperatures as compared to MOGAS' standard high temperature packing with no PTFE content.

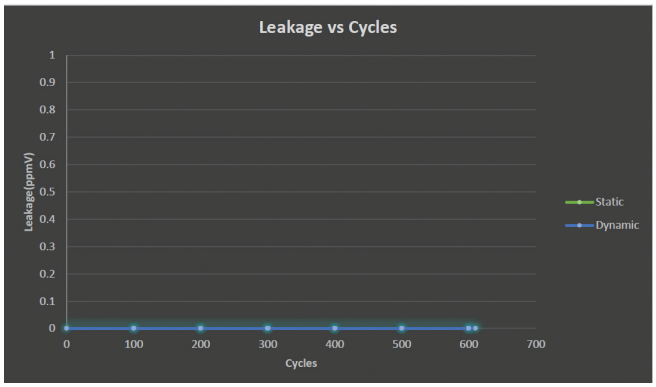

Figure 4: API 641 stem seal leak results showing zero PPM for MOGAS 3-in ASME 1500 Class valves

As clearly shown in Figure 4, the weight loss of the API 622 packing increases exponentially over 800° F (427° C), while MOGAS' standard high temperature packing weight loss remains linear and is much lower at the actual operating temperatures of heavy oils applications since it does not contain any PTFE blocking agents. What the graph cannot illustrate is the effect of the initial packing box pressure (internal packing stress), which is required to be typically twice as high for the API 622 packing.

MOGAS can provide valves qualified to API 641 and ISO 15848-1, when required, per limited scope mentioned above. However, qualification to these standards does not guarantee low emission performance at temperatures over 752° F (400° C) because of the limitations of both API 641 and ISO 15848 standards. Due to the sublimation of PTFE (present in FE packings) at elevated temperatures, API 622 packings are more likely than MOGAS' standard packing to lose volume and impact the performance of the packing in higher temperature services.

They understand the need for low emissions valves installed in high temperature applications. That's why MOGAS offers a packing solution for high temperature applications that guarantees the packing sealing capabilities even at temperatures above 752° F (400° C).

Reiterating, qualification to these standards does not guarantee emission performance for valves exposed to temperatures higher than the test temperatures:

- API 641; 500° F (260° C)
- ISO 15848-1; 752° F (400° C)

In addition, ASME 2500 Class valves cannot be certified to API 641, as they are outside the scope of that standard.

Even though MOGAS has achieved the highest API and ISO fugitive emission standards requirements (**Figure 4**), as a severe service manufacturer they strongly advise their customers only to use FE packing with PTFE at or below temperatures specified in the test standards.

Conclusion and Recommendations

It is important for the end users to understand their needs for low emission and recognize the limitations of existing technology. As a leading manufacturer in the severe service technology market, MOGAS will continue to educate their customers on existing FE packing limitations. The topic of FE compliance is a complicated one and it is a topic that some manufacturers are counting on the customer not fully understanding within the complete application's ramifications.

It is critical to understand the difference between FE test qualifications and low emissions. The FE test qualifications are pressure and temperature limited, and it is well proven that the existing packing will degrade significantly at temperatures higher than 500° F (260° C) causing even higher emission. In such instance, the requirements of FE represent a case where meeting the specification will likely result in excessive emissions from the valves that fail to meet performance expectations.

Packing manufacturers are aware of this limitation and working on the next generation fugitive emission packings not containing any PTFE, but until then it is critical to understand the limitation of existing technology.

References

1 *API STD 641 – Type Testing of Quarter-turn Valves for Fugitive Emissions. 1st Edition*, (October 2016)
2 *ISO 15848-1 – Industrial valves – Measurement, Test and Qualification Procedures for Fugitive Emissions (Part 1: Classification system and qualification procedures for type testing of valves). 2nd Edition* (June 2015)
3 *ISO 15848-2 – Industrial valves – Measurement, Test and Qualification Procedures for Fugitive Emissions (Part 2: Production acceptance test of valves) 2nd Edition* (June 2015)
4 *API STD 622 – Type Testing of Process Valve Packing for Fugitive Emission. 3rd Edition* (October 2018)