Project and Validation of Industrial Valves for Low Fugitive Emissions

Abstract

It is remarkable how the world is concerned over the control of fugitive emission rates on equipment installed in the oil and gas industry. Losses arising from the fuel in production and from the environmental impact make the companies in the field seek projects which are more efficient, particularly with respect to industrial valves, which is a piece of equipment used to manage fluids in equipment with the purpose of blocking, guiding or controlling the flow of a certain flowing product in an industrial plant.

Fugitive emissions are leaks of chemicals, which come into contact with the atmosphere in an unexpected or undesired way in equipment. This study aims at developing and validating the project of an industrial ball valve type for applications requiring low fugitive emissions. We initially identified and assessed the requirements stated in standard ISO 15848-1, as to the tests that should be performed on an isolating valve prototype for project qualification. The sealing systems were sized for a ball valve prototype, Top Entry, Trunnion, gauge NPS 4", CL600 pressure class, using, as construction patterns, standards API 6D, ASME B16.34 and ABNT NBR 15827. A prototype of this equipment was manufactured and used to perform project qualification tests. Opening and closing cycles of the valve plug were carried out using the maximum working pressure according to the construction standards and helium gas was used as the test fluid. The tests were performed in a valve cycling chamber fitted with a helium mass spectrometer, where it was possible to monitor and record test data such as: leaks, number of cycles, test pressure, temperature and torque during the valve actuation.

The results obtained with respect to the requirements in standard ISO 15848-1 were as follows: number of cycles 2500, complying with rating CO3, Class B leak class, qualification temperature from -29°C to 200°C. Fire Test qualification according to standard ISO 10497 was also held as a complement. In conclusion, this paper achieved its preset goals concerning the approval of the prototype and contributed to the preservation of the environment, because the design of efficient projects, which minimize atmosphere pollution rates, contribute to the preservation of ecosystems. (Teles, 2015).

Materials and Method

Data of the prototype chosen for this paper: Trunnion ball valve type, NPS 4", Top Entry mount, CL600 pressure class, a project developed at Micromazza Company. Qualification tests performed according to standard ISO 15848-1:2006, using the Vacuum-type leak measurement methods for the stem local and the Sniffing-type for the seals of the body and using helium gas as the test fluid.

The selected test temperatures are: -29°C and 200°C, which ranges from -29°C to 150°C. A complementary Fire Test was performed according to standard ISO 10497:2010 in the prototype.

Sizing of seals used in the prototype are divided into two parts: sizing of the stem seals and sizing of the valve body seals.

Sizing of Stem Seals

The prototype stem has three types of sealing: one with a graphite base called gasket, another one with an elastomer material commercially known as O-ring and a gasket made of a polymeric material called poly-tetra-fluoro-ethylene (PTFE) reinforced with carbon. This combination of sealing systems with several different materials allows compliance with several qualifications required for the positioning of the product in the oil and gas market. In addition to the low fugitive emission according to ISO 15848, the product must also undergo a Fire Test, according to standard ISO 10497:2010. The details of this system are shown in Figure 5, Table 2.

Sizing of the Body Seals

The body seals the general purpose valve must be provided with a primary resilient sealing, for example O-ring, having the corresponding construction standards and must additionally be provided with a complementary sealing in a graphite to prevent leakage by the body if there is failure of resilient rings. For the Fire Test according to ISO 10497: 2010 may be used a gasket of the spiral type made of austenitic stainless steel with graphite filler. This is a recommendation made by the ABNT NBR 19827: 2007. The 2014 revision of this standard does not have the mandatory use of spiral gaskets, but due to the excellent results of this type of sealing in high temperature testing, this gasket was maintained in Micromazza projects. The details of this system are shown in Figure 6 and Table 3.

Results and Discussions

Initially, a Sniffing test was performed to verify the concentration of helium gas in the atmosphere. The maximum amount found was 11 ppmv. At this stage, the valve body seals and the test system were tested. The temperature employed was around 21°C with maximum working pressure of 102 bar according to ASME B16.34/2013.
After compliance with the criteria of the Sniffing method, the stem sealing tests were started using the vacuum method. This method was first measured on the valve with a semi-open ball and a static stem. At this stage, the smallest leak rate was found. The mass flow rate in this period was no more than 2.1E-06 atm·cm³/s. After this stage, the cycling of 125 cycles of movements of a quarter turn was started to open and close the valve. The leak rate was monitored throughout the cycling, which took place at 21°C room temperature. After this initial cycling phase, the leak rate was measured again in the static mode without moving the ball at room temperature, and soon after, the system was heated to 200°C. After the static test, a high temperature cycling was started, and more than 125 cycles were performed.

Therefore, compliance with the CO1 rating included 500 cycles divided into four cycling stages, two at room temperature and two at the maximum extreme temperature at 200°C. There was full compliance with Class B in the CO1 step with slight increases in leak rate reaching 6.5E-05 atm·cm³/s in the 500 cycles during the final measurement of CO1.

Then, step CO2 was started, with cycling at room temperature, and soon after, another cycling at 200°C. Halfway through the thermocycling step, the leak rate was found to have reached values exceeding those from the intended Class B, and rising at the cycling’s end to a rate of 2.3E-04 atm·cm³/s. In this step, after the valve returns to room temperature, there occurred the first re-tightening of the packing gland fasteners, with an 80 Nm controlled torque according to an internal procedure at Micromazza.

After adjusting the overlap, measurement was started with the static stem and the leak rate was reduced to 3.9E-05 atm·cm³/s, returning to compliance with Class B. Then, cycling was performed in step CO3, which was also completed with compliance with Class B without the need to re-tighten the packing gland.

At the end of the tests, the prototype valve and the devices used for the vacuum chamber assembly were disassembled. A visual examination was conducted in the components of the body sealing and of the valve stem. No significant damage was found in the body and in the stem seals. Therefore, the whole qualification process of valve Top Entry, NPS 4” CL600 for low fugitive emissions was performed according to standard ISO 15848:2006. The name of the qualification is as follows: ISO FE BH – CO3 - SSA 1 - t (-29°C, 200°C) – CL600 – ISO 15848-1. The qualification test chart is shown in Figure 8.

For the prototype valve qualified in this paper, the project was designed to meet both qualifications: Fire Test and Low Fugitive Emissions. This was possible because the design includes a system of Belleville spring which operates to keep the pressure constant in the gaskets and was designed to compensate for the space left in the packing system when the ring at the base of PTFE is sublimated in the burning process.

Compliance to the Fire Test qualification according to standard ISO 10497 became possible due to the way the project was designed. During burning, the components called seats and sealing rings at the base of PTFE, located in the packing system, start to sublimate due to high temperature. At this time, the space of the gaskets is compensated by the Belleville spring. As to the ball local, sealing occurs through contact with the metal seal designed in the valve component itself, called a seat holder ring. This area has a radius with the same size of the ball with a refined finish so that a seal called “Metal x Metal” may occur. Figure 9 shows pictures of the test and Figure 10 shows a prototype behavior sketch during the Fire Test qualification.

In the final stages of preparation for this paper, the 2015 revision of standard ISO 15848-1:2015 was released. There were few changes in this version.
A relevant change was the number of cycles for CO1, which went from 500 to 205, however, the number of cycles for CO2 increased, going from 1000 to 1295, and CO3 remained with 1000 cycles, totaling the same 2500 cycles of the 2006 version. The leak rates remained the same. It is believed that this revision was conducted with the aim of making the qualification process more agile for customers requiring only the CO1 classification, because it reduces the number of cycles for CO2, going from 1000 to 205, however, the number of cycles for CO1, which went from 500 to 205, and CO3 remained the same 1000 cycles. It is believed that customers already install approved valves in their applications, improving the quality of operations.

It was possible to perform, as a complement to Low Fugitive Emission, the Fire Test qualification according to standard ISO 10497:2010, where the valve burning process was performed, simulating an environment of fire at an industrial site. The prototype valve showed an operating ensured in this extreme type of application, especially regarding the ability of performing sealing before and after the cycling of the valve during the test. In conclusion, this paper achieved its preset goals concerning the approval of the prototype and contributed to the preservation of the environment, because the design of efficient projects, which minimize atmosphere pollution rates, helps in preserving the ecosystems and unites the development of technologies applied to equipment in the oil and gas sector with emphasis on environmental preservation.

REFERENCES


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