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Fugitive emissions testing: Its origins, current realities and the future

Ladish Valves, partnering with TEADIT and its ®2236 low emission packing product, successfully completed API 624 fugitive emissions testing on its gate and globe valve product line in early October at United Valve, an industrial valve modification, repair and testing company, headquartered in Houston, TX. Given the heightened awareness of fugitive emissions both at the end user and valve manufacturer level, this article serves to offer up key findings of the testing process, highlight the realities of API 624 testing and provide proposals for future revisions of fugitive emissions standards.

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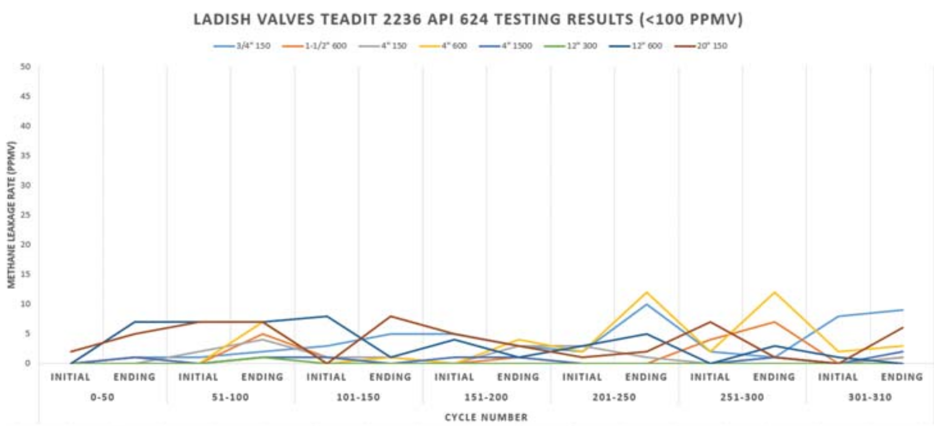
As background, the U.S. Environmental Protection Agency (EPA) implemented consent decree requirements on refinery and chemical processing end users to use low emission technology within their valves and sealing systems. The American Petroleum Institute (API) Sub Committee on Piping and Valves standards group had already published API 622 "Type Testing of Process Valve Packing for Fugitive Emissions." However, the publishing of API 622 2nd edition in 2011 removed the option of testing a production valve leaving only testing of the packing in a fixture. The packing systems used in API 622 testing are of a more dense and robust design which requires higher bolting tensile strength to achieve the necessary seal. Thus, the testing for the packing is performed in a test fixture with A193 B7 studs. The test requires the packing to go through 1510 mechanical cycles comprised of five 150 cycle ambient, five 150 cycle thermal segments and finishing with a 10 cycle ambient segment. Emissions are not to exceed 500 ppmv methane leak rate throughout the testing. In addition to the fugitive emissions test, a corrosion and material composition test is required on the packing product.

With the elimination of the option of testing the packing in a process valve, the subcommittee began developing a test standard that would qualify process valves as low emission technology products to meet the tougher EPA requirements. Upon meeting for well over two years, the subcommittee released API 624 1st edition, "Type Testing of Rising Stem Valves Equipped with Graphite Packing for Low Emissions" in February 2014. The intent was to provide a uniform procedure to evaluate the emission performance of process valves and a testing format that allows for comparing the emissions and performance of process valves. As a prerequisite, API 624 requires that the packing used in the test has passed API 622 2nd edition.

Implications of API 624

With the release of the API 624 specification, the response from the valve and end user communities has been swift. Valve manufacturers desire to insure that their product line meets the strict requirements of the standard. End users desire to meet EPA fugitive emission standards and enhance existing leak detection and repair programs.

Ladish Valves, a manufacturer of stainless steel and high nickel alloy corrosion resistant valves headquartered in Houston, TX, began pursuit of API 624 certification on its product line in early August 2014 becoming one of the first manufacturers to perform the full battery of tests at United Valve. As prescribed by API 624, each valve design underwent 310 mechanical cycles with six alternating ambient / thermal 50 cycle segments and a final 10 cycle ambient segment. Emissions are not to exceed 100 ppmv methane leak rate throughout the testing. As seen in the graph below,



the combination of TEADIT ®2236 low emission packing and Ladish Valves product line achieved impressive results in respect to emissions leakage rates. Further to the emissions performance, the mechanical integrity of the Ladish Valves

product line endured the demanding nature of the testing. As seen in the picture above, minimal to no wear was observed on the stem thread or its corresponding bushing.

API 624 key success factors

Critical to successful testing is a solid understanding between packing manufacturer and valve manufacturer. Ladish chose to partner with TEADIT and its ®2236 valve packing product for its technical excellence and long history of exemplary performance in the field. The TEADIT ®2236 valve packing is self-lubricating, non-hardening, dimensionally stable and resistant to gases and fluids as well as heat, pressure and chemicals. Its high temperature flexible graphite and Inconel® filament jacket affords mechanical stability while the advanced construction provides leakage control and high integrity in steam service. It meets the U.S. EPA low emissions technology requirements having successfully passed the API 622 2nd Edition with a maximum static leak rate of 22 ppmv and an average of 2 ppmv. It was the packing used for an ISO 15848-1 globe valve test that achieved a bellows seal class rating at 750 deg. F and 100,000 mechanical cycles.

Another critical success factor is a proficient third-party that has experience in testing industrial valves. Ladish Valves and TEADIT chose United Valve due to its extensive valve testing experience and sterling reputation among the end user

community. As one of the first facilities to perform API 624 testing, United identified several key considerations when conducting the test:

- Safe, secure testing apparatus.
- Valve size, pressure class, and material of construction.
- Stem construction – rising vs. non-rising design.
- Valve operation – gear or hand-wheel operator.
- Valve and stem lubricant.
- Accurate gland eyebolt torque data.

Each of these considerations affects the safety, set-up and operation of the valve during testing. It goes without saying that the most important consideration is a safe, secure testing apparatus, especially when using a flammable gas such as methane (as API 624 requires).

Prior to setting up the valve, specialized equipment commensurate with the size and class of valve is required. The set-up needs to be able to accommodate both hand-wheel operated and gear operated valves as required. To test efficiently, the testing apparatus needs to be highly adaptable to accommodate a variety of valve sizes and pressure classes.

There are still many details that have to be addressed based upon each specific valve tested. The first consideration is deciding the best method to actuate the valve. Once that is accomplished, fixtures must be adjusted and attached to the valve to create a steady foundation during the test. Any instability can introduce outside stresses not associated with a normal mechanical cycle. End flanges or seals along with the requisite test fluid tubing and fittings must be double-checked to prevent the possibility of erroneous methane leakage.

Since API 624 requires the stem to be in the vertical position, the possibility of yoke bushing grease becoming less viscous and dripping down the stem to the packing area is a real issue. Therefore, one of the first steps is to check the bushing and stem and evaluate the lubricant. The best solution to prevent this contamination is to replace low-temperature grease with a high-temperature lubricant that will not drip at high test temperatures.

While the set-up for the testing is an important step in testing the packing system of the valve, the process really starts with the valve and packing manufacturer. Both the valve and the packing manufacturer have distinct responsibilities in order to create an effective low emissions valve that will pass the test and later function effectively while in service.

From the valve manufacturer's side critical mechanical and design elements that can affect the low emissions sealing capability include: eyebolt type selection, gland follower design, bushing and stem material compatibility, and out-of-tolerance parts (i.e., stems, glands and stuffing boxes). All of these potential abnormalities can create leak paths and ultimate failure of the test.

Similarly, the information provided by the packing manufacturer prior to testing is critical. If for instance, the packing manufacturer provides a torque value that is high, the gland or bolts could yield causing unequal compression in the packing which would likely allow leakage. If however the torque is low, the packing would not properly compress and seal. So to complete API 624 successfully, both valve and packing manufacturer must provide a quality product and agreed upon accurate load data.

Realities of API 624 testing

Once the test has begun there are still some key procedural points to consider. Namely testing time and revolution speed. Testing time is most altered by revolution speed, revolutions to open, and valve size and class. The size and class and their related differences in body mass most affect the time to heat or cool the valve. The number of revolutions affect the cycle time. Whereas API 622 defined cycling and stroke rates, API 624 leaves that determination up to the testing facility. Take for instance a ¾" Class 150 gate valve which would easily be able to stroke 50 times, then heat and stroke 50 times again in a single day. Now, compare that to testing a 12" Class 600 manual gear-equipped gate valve. With 40 times the number of revolutions at the same speed as the previous valve it could take days to finish one thermal cycle, and with 50 times the mass, heating is an over-night endeavor. A valve like this being run at the same speed as the ¾" valve would take a month to finish which is one reason revolution speed is so important.

On the other hand, while increasing revolution speed decreases the testing time to a manageable time frame, the more the revolution speed is increased the risk is potentially raised for thermal expansion or increased load, causing either binding or severe wear on the threads of the bushing or stem. For this reason, a balance in speed must be found for each valve based on its size, class, and gear, if any.

While the test is being conducted it is always important to remember safety. Methane gas is highly flammable, open flames and sparks must be avoided within the testing area. Due to increasing pressure caused by heating, the internal valve pressure should be carefully monitored as well.

It is also important to remember that hot methane gas is contained in the test valve and any releases into the testing atmosphere, besides causing interference with leakage readings, creates a serious safety hazard. For this reason a bleed line leading from the valve exit to a safe release point should be included in the test piping system. Handling this line after releasing pressure should only be done with proper insulated hand protection. Aside from dealing with hot gas and high pressures it is always necessary to wear proper eye protection and to use caution when dealing with heavy equipment and heavy valves.

The future of API 624

As with any API standard, it is an iterative process to arrive at a standard that meets the original intent and is agreeable to both end user and manufacturers. As testing progressed, there were questions for consideration that jumped out:

- Is the intent of API 624 to test the mechanical integrity of the valve or to test emissions levels of a packing within a valve design? For example, does a test valve that meets all fugitive emission requirements but the bushing has to be replaced multiple times equate to a test valve that meets all fugitive emission requirements and has no mechanical failures?
- Should API 622 and API 624 requirements be made more alike? Cycle speeds are included in API 622, but not referenced in API 624. API 622 does not require dynamic readings while API 624 does. Perhaps most important from a safety perspective, API 622 allows the system to be pressured down at the end of each day while API 624 does not.
- Completing the testing takes significant time and resources. In many cases, the stuffing box design remains the same over size ranges and pressure classes. Does defining the test around stuffing box sizes make more sense than using an array of valve sizes that may have the same stuffing box designs?
- The language pertaining to requirements for valve size is unclear. For example, within the specification it states that all gate valve sizes below 4" are qualified but Table B.4 recommends testing a 3/4" and 1-1/2" gate valve. These additional valves require more time and resources. Is testing these valves necessary?
- The typical stem design for gate and globe valves utilize a non-rotating and rotating stem, respectively. Driven, in part, by the emphasis on low fugitive emissions, many valve manufacturers are moving to a non-rotating stem design for their globe valves. Would a test on a gate valve of the same sealing system design as a globe valve certify both products?

In conclusion, the API 624 specification has ushered in a new era of compliance that valve manufacturers, packing manufacturers and end users will need to adhere to. This adherence will involve significant planning and resources for all parties. However, this process should bolster leak detection and repair programs and achieve significant reduction in plant emissions.

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