When it comes to safety and the environment, valves and appendages should not leave anything to be desired

Valve testing in practice and why

Fugitive emissions (FE) are emissions of gases or vapours from pressurised equipment due to leaks and various other unintended or irregular releases of gases, mostly from industrial activities. As well as the economic cost of lost commodities, fugitive emissions contribute to air pollution and climate change, and present a risk to employees. For example, hydrogen fluoride, which is extremely dangerous to human health even in small quantities, is widely used in the petrochemical industry.

Research has shown that leaking of faulty valves, valve parts, flanges and their appendages are responsible for the majority of fugitive emissions in (petro) chemical plants. Due to this fact it is obvious that valves need to perform to the highest standards. According to the European Sealing Association (ESA) the rate of fugitive emission in the USA has been estimated to be in excess of 300,000 tonnes per year. The rate of fugitive emissions from European refineries ranges from 600 to 10,000 tonnes of volatile organic compound (VOC) per year.

Industrial Testing and Inspection Services (ITIS) is an independent technical service company specialising in the field of NDT (Non Destructive Testing) and leak testing, especially valve testing. Most of its projects are related to the oil and gas industries.

Located in Heinkenszand, the Netherlands, the company's test facility is able to test products including valves, appendages, vessels, heat exchangers and gaskets for functionality, emission, endurance, leakage and safety. For almost all valve-related products ITIS offers solutions to all NDT and NDT-related services. The facility is a one-stop shop for testing newly manufactured products, prototypes and revised valves but on-site leak testing, project supervision and consultancy can also be provided.

In the ITIS test laboratory, hundreds of type approval and production tests are performed annually under controlled conditions for standard specifications as well as by customer-specific demands. The test conditions can vary from deep vacuum to a pressure of 1500 bar

gas with temperatures of -196°C to 800°C (and over) during high temperature tests or fire safe tests. The required operational cycles can be performed with computer-controlled actuators.

All measured data can be recorded by a log and registration system so that reporting of tests is fairly simple. It is also possible to witness valve tests 'live' via internet, including test data and video images.

Type approval

Type approval tests for valves are established to check the usefulness of valves, particularly on seat and sealing components. These tests are needed to see if a certain valve is able to withstand the required conditions. Besides the FE tests during the type approval tests and production, the measurement of fugitive emission in practice is equally important.

Most standards specify the test temperature, pressure and operational cycles. Fugitive emission type approval test standards most widely used in Europe are: TA Luft regulation in Germany, ISO 15848-1 (worldwide), and SPE 77/300 which is the current specification regarding Shell Type Acceptance Testing (TAT). A type approval test could result in a perfect fugitive emission rate but could, however, be a disaster in practice concerning seat leakage when seat testing is not part of the type approval test.

TA Luft is a test at 'practical conditions' but this is a broad concept, so the test temperature and operational cycles are not strictly prescribed. For example, a valve with a TA Luft certificate tested at ambient temperature with 10 operational cycles is only guaranteed for these conditions. These valves could then be sold with a 'guaranteed' TA Luft certificate under different conditions to those they were tested under. If built into a plant with a temperature application of -40°C and hundreds of cycles per day the consequences could be serious.

The international ISO15848-1 standard requires fugitive emission testing and operational force at specified temperature steps, the number of operational cycles is specified by the recommended endurance class.

Looking at these three type approval tests, the SPE 77/300 is the only type approval test which specifies all facets of a valve: functionality, external leakage and seat leakage at the entire specified temperature range.

Sealing materials and certification

Besides the type approval testing of valves, valve manufacturers can choose for higher reliability by only mounting sealing material in their valves which has been previously approved during testing at the entire guaranteed temperature range. An example of a type test for packings is the API 622.

Unfortunately, some valve manufacturers make their choice for sealing material for a certain valve application according to information published on a website or in a brochure without taking possible test reports into account. Sealing materials for valves include gaskets, seals or O-rings and (soft) seats. Applying these materials in their valves is actually a leap of faith and can lead to high risk.

At ITIS, test operators have seen plenty of sealing materials which should perform

perfectly according to the brochure of the sealing manufacturer concerning pressure and temperatures. Too often these materials are sold for a pressure temperature (PT) range without ever being tested at these conditions. In some cases these materials are not sufficient for applications other than low pressure and ambient temperature. Valves to be type approval tested with these sealing materials should, in theory, be able to pass a test easily. However, it is not unknown for a valve to fail on the first helium pre-test.

Stem leakage due to leaking bellow during valve pre-testing

In the past the company has tested valves for a project that were equipped with a special 'low temperature' O-ring as stem sealing. Unfortunately, the valves were tested at ambient temperature only. All valves passed the ambient tests perfectly. Once built into the plant and exposed to the practical conditions of -40°C, all valves failed.

Leakage of an O-ring at low temperatures

Hold duration

When conducting tests, ITIS is not only focused on fugitive emissions from seals or gaskets but the entire valve body. Sometimes it can happen that the leakage is via thread or bolting and not through a gasket. It is even a possibility that a valve is leaking through the body.

Leakage of body gasket via bolting

Crack in valve body casting

During random retests by ITIS, some valves have arrived at the company's test facility with a test report showing that they have been tested with a certain leak rate 'A'. However, a retest has resulted in a leakage rate 'C', or worse. Sometimes even a new stem seal replacement by a different type or brand seal has been required to meet the maximum allowable leak rate required by the end-user.

One reason for the different test results might indicate that, during previous tests, the hold duration is not respected. A general observation of many international standards teaches us that the defined hold time for general testing and fugitive emission testing is often too short. Most leakages will appear after a hold duration of minutes instead of seconds.

Often a hydrostatic body test of 15 seconds is too short for most valves (for a 2" valve the hydrostatic test duration is 15 seconds, according to API 598 or ISO 5208). The hold duration should be minutes rather than seconds, especially for higher ratings ≥class 600. The performance of valves in practice should be guaranteed longer than a service of 30 seconds.

Leaking valve during hydrostatic and FE testing

Certificate and test report

A certificate of a type approval test says something about the performance of the valve at certain test conditions. However, it is arguable that the associated test report is actually more important when it comes to the performance and operation of the valve in practice.

In the test report you can find all necessary information, such as test temperatures, the necessary torque for the gland bolts bush needed to meet the minimum requirements to start the test, including some possible adjustments of the gland bush bolts during the test. This information is essential to guarantee a proper valve operation in practice and the valve performance in relation to fugitive emission.

On site fugitive emission testing

ITIS is often asked to test complete industrial installations for leakages after overhaul or during shut down. Usually all components of the installation will be independently tested for possible leaks.

Any potential leaks, such as valve stem seals, flanges, gaskets, fittings, etc., will be taped to create accumulation chambers (hood method), as tracer gas – usually helium or hydrogen – will be used.

After pressurising the system with a tracer gas (mixture) and respecting a certain hold duration, all chambers of the parts to be tested will be checked for an increase of tracer gas concentration by a mass spectrometer.

The hold duration depends on the tracer gas concentration, volume of the accumulation chambers and maximum allowable leak rate.

The cause of leaks can be attributed to any number of things; wrong gasket, gasket installed incorrectly, loose bolts/nuts, or absence of a gasket or bolts.

Most of the time only the parts which have been disassembled and reinstalled during the overhaul or shut down have to be tested for leaks. However, during some tests it is necessary to measure a high tracer gas background in the plant, for example with 'high leaker' stem seals of valves, where leak rates of more than 10cm^3/second per stem seal are no exception.

Routine inspections of process equipment with gas detectors can be used to identify leaks and estimate the leak rate in order to decide on appropriate corrective action. Proper routine maintenance of equipment reduces the likelihood of leaks.

For more information:
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