

Experiences performing API standard 622

Type testing of process valve packing for fugitive emissions

The publication of the API 622 specification has marked a departure from the common method of evaluating packing performance as a part of valve qualification tests. Instead, API 622 evaluates packing performance in a standardized fixture, outside the influence of a particular valve's design. This article will outline the use of API 622 in tests performed by Yarmouth Research and Technology. The general experiences performing API 622 emissions tests were positive ones. This paper describes the test procedures, our results in performing the tests on a braided flexible graphite packing, and the lessons that were learned.

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Description of Test Procedures

Several important distinctions set API 622 apart from other packing performance tests. The scope of the specification highlights several of these unique points:

- API-622: specifies requirements for comparative testing of block valve stem packing for process applications where fugitive emissions are a consideration
- API-622: is not simply a performance test, but rather a range of tests that evaluate many factors that are determined to affect fugitive emissions performance. These include: temperature, pressure, thermal cycling,

mechanical cycling, corrosion, and material makeup

- API-622: does not provide acceptance criteria for valve packing, nor is it intended to replace proof testing of valve assemblies or valve production testing

The specification consists of three parts: fugitive emissions testing, corrosion testing, and materials testing. API-622 provides very detailed specifications, descriptions, and guidelines for both the test fixtures and procedures. The following is a very brief summary of these tests.

1. Fugitive emissions testing

The fugitive emissions portion of the test is performed on a test fixture that simulates valve packing gland conditions. The fixture uses 97 % pure, dry methane as the detectable, pressurizing fluid. Over the course of the three day test, the packing gland is subjected to three thermal cycles from ambient to 500 deg F, three pressure cycles from 0 psig to 600 psig, and 1500 actuation cycles. Each day, 250 actuation cycles are performed at ambient temperature and 250 cycles are performed at 500 deg F. Methane leakage is monitored by a flame ionization vapor analyzer. Leakage is collected from around the stem/packing interface by way of a specially designed gland follower to which the detector is connected. It should be noted that none of the leakage from the packing OD is collected.

2. Corrosion testing

The corrosion testing portion of the specification involves two different tests. One test is performed at ambient temperature, and the other at 300 deg F.

- *Ambient temperature corrosion testing*
In the ambient test, a packing sample is soaked in demineralized water and then inserted into a small fixture that compresses the packing sample around a

metal specimen. These fixtures are stored in an enclosure that is equipped with a shelf, suspending the fixtures over a water bath, and ensuring a moist environment for the 28 day duration of the test. Following the 28 day exposure period the metal samples are photographed. After they undergo an x-ray corrosion analysis, the amount and severity of corrosion is quantified in terms of percentage of surface corroded, and mean and maximum pitting depth.

- *High temperature corrosion testing*

The high temperature corrosion test uses a fixture similar to the ambient corrosion test, except that the packing and metal samples are subjected to demineralized water at a temperature of 300 deg F and 650 psig for 35 days. The same post-exposure analysis and measurements are performed.

3. Packing Materials Testing

- *Weight Loss at Elevated temperature*
Packing samples are subjected to progressively elevated temperatures (in air) at 300, 500, 600, 700, 800, 900, and 1000 deg F for one hour. After each exposure, the sample is removed from the oven and any resulting loss of mass is measured.

- *Density*

Simple density measurements are performed on a packing sample by dividing the mass of the sample by its volume.

- *Lubricant content*

Two tests are performed to determine lubricant content. First, the PTFE content in the packing is determined by performing a total Fluorine content measurement per ASTM D129 and D1179. The PTFE content can be derived from the total Fluorine content. The second test is a solvent extraction

test used to measure wet lubricant content in the sample. The procedure is outlined in the specification.

• *Leachables*

Two ASTM standards are referenced in API-622 to be used in measuring leachable Chloride and Fluoride content; ASTM D512 and ASTM D1179, respectively.

Lessons Learned

What was difficult?

For the emissions portion of the specification the primary difficulty is the daily duration of the test. With a cycling rate of 1 cycle per 60 seconds and a 2 hour heat-up time, an average test day is about 12 hours. If another more massive test rig were to be created, the heat up time would be even greater.

For the Weight Loss portion of the materials testing, it is important to insure that the oven being used to heat the samples will provide an accurate and even temperature distribution throughout. Testing of several samples is recommended in order to insure that hot or cold spots in the oven do not affect the test results.

What went well?

The emissions test fixture is well designed with the leak probe at a fixed location. This provides repeatable results. Actuating the stem by means of a hydraulic cylinder provides fairly smooth motion. The flow rate of hydraulic fluid needs to be controlled so that actuation speed is kept within the required limits.

The emissions test produced results that are consistent in magnitude and in pattern with other emissions test procedures performed on the same materials. In many emissions test procedures, using a wide variety of materials, it is common to see a leakage rate increase following the first thermal cycle. The same behavior was noted in this procedure. Following a single, allowable packing adjustment, leakage control was sustained at very low levels for the remainder of the test. This same behavior has been noted in other emissions test procedures with this material.

The tests for Density, Lubricant Content, and Leachables are very straightforward

Results

Emissions test results

Test Parameter	Results of test 1	Results of test 2
Average Test Pressure	602 psi (41.5 bar)	600 psi (41.4 bar)
Number of Actuation Cycles Completed	1500	1500
Number of Thermal Cycles	3	3
Number of Packing Adjustments Required Cycle at which adjustment occurred	1 adjustment at cycle 600 at ambient temperature	1 adjustment at cycle 650 at ambient temperature
Average Leakage Throughout Test	58 ppmv	41 ppmv
Maximum Leakage Throughout	877 ppmv	598 ppmv

Results observed were consistent for the two tests run, indicating repeatability of the method.

tests with well defined procedures.

Recommendations


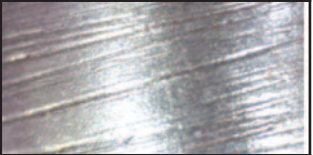






Based on the experience with the specification there are several changes to the test standard that we would like to submit for consideration.

- The addition of a final leak

measurement point at 1500 cycles after cooling to ambient temperature is recommend. This will complete readings for the 3rd thermal cycle.

- Further it is recommended that the primary and secondary thermocouple positions be reversed. There are well defined requirements for the

Corrosion test results

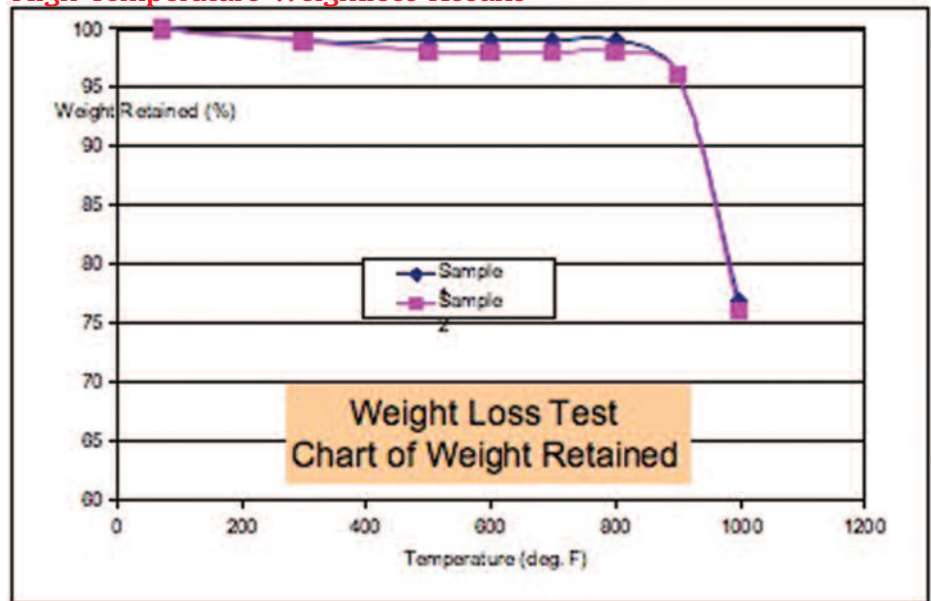
Temperature Condition and Magnification	Metal not in contact with packing	Metal in contact with packing
Ambient 100X magnification		
Ambient 200X magnification		
300°F (149°C) 100X magnification		
300°F (149°C) 200X magnification		

No corrosion effects were noted on the metal samples in either the ambient or the high temperature corrosion tests. There were no notable visual differences between the surfaces in contact or not in contact with the packing. Because of this fact, quantification of corrosion products utilizing X-Ray diffraction was not performed.

temperature and tolerance for the primary thermocouple, where the reference thermocouple has no such requirements. The current version of the standard has the primary thermocouple position about 12 inches away from the packing location, whereas the reference probe is about 1 inch from the bottom of the packing. With the current configuration, the temperature in the packing area can vary by 20 deg C or more depending upon heater and insulation position and amount. This change would result in better control of the temperature to which the packing is exposed. (See Figure bottom right)

- Although there is not a clear recommendation, the current version requires a long test day for laboratory personnel, with a typical test running about 12-14 hours. Readings are required about every hour. Possible methods for reducing the daily duration of the test would include increasing the speed of actuation or allowing actuations to continue during the temperature increase from ambient to 500 deg F
- The current standard does not measure actuation force. While the test fixture can handle high loads, excessive packing friction can cause operating problems in valves. Opening and closing forces can be easily calculated from the actuator pressure
- If the test standard is to be performed on various sized fixtures, the standard should note that variations in the temperature rise rates are allowed. Also, larger fixtures might require 2 days for each thermal cycle
- The metal test specimens that are used in the corrosion tests do not have a well defined material specification. API-622 simply states: "sample steel rings shall be machined from metal rods having the same properties as the finished valve stem". While this does allow the user to tailor the test to their own requirements, it does not ensure that results from various tests will be directly comparable. In our test, 410 Stainless Steel was chosen for the metal samples
- The corrosion test specification calls for photos to be taken at both 100X and 200 X magnifications. It is recommended that a reduction in the magnification

High Temperature Weightloss Results



level to 50X will help to provide images that will show the overall area more clearly, while still being able to differentiate corroded areas. It is felt that the 600X magnification is much too high

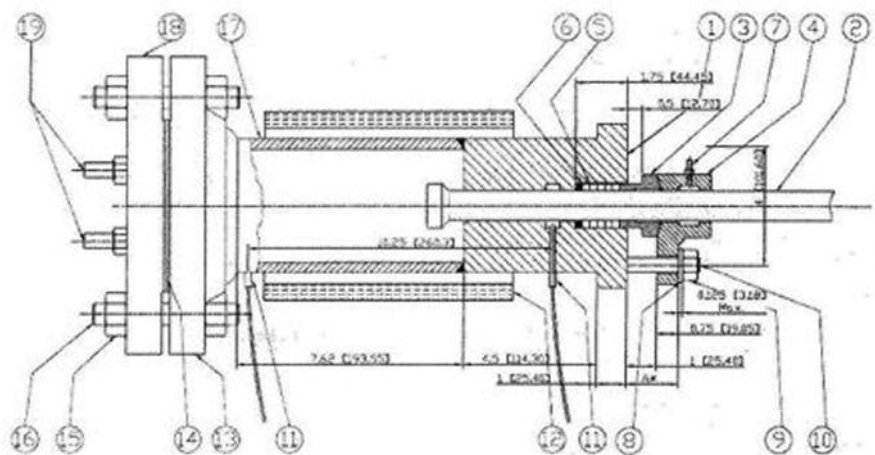
- It is recommended that photos of the corrosion test metal specimens be taken both before and after the test and that the after photos should include areas of the metal specimen that were both in contact with the packing and not in contact with the packing

Conclusions

The tests prescribed by API-622 provide methods for the end user to evaluate valve stem packing in three key areas; emissions performance, corrosion behavior, and general physical and

chemical attributes. When combined with fire safe test specification such as API-589, a very thorough assessment of packing materials can be achieved.

The results can be used to effectively compare the relative performance of packing materials and configurations as well as assess their strengths and weaknesses in the areas of chemical purity and physical properties. While the specification itself does not impose any pass/fail criteria, it does provide a consistent means of quantitative measurement. The user is free to determine what measured variables hold the most significance for their application and whether they will set their own minimum requirements.



Cross sectional view of the API 622 Emissions test fixture. Thermocouple locations are noted as part 11 (by permission of The American Petroleum Institute)