# Qualifying quarter-turn valves for low emissions

Currently, two test procedures are available to qualify a quarter-turn valve design for fugitive emissions service. This article compares ISO 15848-1 and API 641.

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The two test procedures in question are: International Standards Organization (ISO) 15848-1 (2nd Edition, 2015) *Industrial valves -- Measurement, test and qualification procedures for fugitive emissions -- Part 1: Classification system and qualification procedures for type testing of valves* and American Petroleum Institute (API) 641 (1st edition, 2016) *Type Testing of Quarter-turn Valves for Fugitive Emissions*. Both standards are technically sound options that can be used for valve qualification and both are considered good engineering practice which clearly define conditions and procedures that help ensure the test is repeatable, and represents realistic operating conditions for the valve in service. Either protocol can qualify valves for higher temperature service where graphitic seals are typically used and for lower temperature service where PTFE-based seals are more usually selected.

Both standards follow the same general process. The valves are set up with blank flanges on both ends; fittings are installed on the blanks to allow the valve to be internally pressurized with test media. The static joints on the valve bonnet and flanges are tested for leaks before testing commences. The valve is pressurized with the test gas, and the valve stem is then actuated a specific number of open and close cycles at ambient temperature. Leakage measurements are taken at prescribed intervals using a calibrated leak detection unit that meets specific requirements defined in the standard (e.g. sensitivity, response time, etc.). Then, the valve is heated to a predetermined temperature based on valve design and materials used and the stem cycling and measurement process is repeated. This cycle of ambient and elevated temperature operation is repeated a number of times. The number of thermal cycles depends on the standard used.

## Differences between ISO 15848-1 & API 641

There are a number of major differences between ISO 15848-1 and API 641 that may influence the valve manufacturer or end user to select one test method over the other. The most significant differences are; test conditions, number of stem and thermal cycles, valves qualified under the standard, related valve design standards that may specify one or other of the above referenced test methods and the end user's specification.

The ISO procedure permits the use of two different test media, helium and methane, each with different leakage measurement methods. When helium is used

*Both standards specify 'sniffing' to monitor leakage when testing with methane*

leakage is measured by bagging the test valve and measuring the mass rate of helium leaking through the packing set. If methane is used, leakage from the packing set is measured as a concentration (in parts per million by volume [ppmv]) using a vapour analyser and 'sniffing' around the packing set. It is

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not possible to convert results from one gas to the other, the ISO standard specifically states "*… there is no correlation intended between measurements of total leak rate … and local sniffed concentration."*

API 641 tests with methane only, and since helium is generally not accepted as a suitable test medium by enforcement agencies in the U.S., and current field monitoring techniques are done using 'sniffing' and not 'bagging,' only the methane portion of ISO 15848-1 would generally be considered acceptable for leakage measurement for valves destined for the markets where API valves are used or specified.

## Temperature

Both standards are written to accommodate qualification of valves using seals intended for high temperature service as well as for other valve designs and materials intended for lower temperature services that may be sealed with non-graphitic seals (e.g. PTFE packing or v-rings).

API 641 has two temperature groups: valves intended for services above and below 500°F (260°C). For the high temperature group, the maximum test temperature and pressure is 500°F (260°C) and 600 psig (41.4 bar). Valves for lower pressures are tested at their allowable rating and at the 500°F test temperature. The lower temperature valves are tested at their maximum temperature rating using the corresponding pressure rating at that temperature. The maximum test pressure is 41.4 bar. These maximum temperature and pressure ratings in API 641 correspond to the values used in API 622 and 624 testing and these limits are set to ensure safety in the laboratory using methane at high temperatures.

ISO 15848-1 follows a similar methodology using two defined temperature limits—400°C for high temperature valves typically sealed with graphitic seals and 200°C for the lower temperature valve applications. The test pressure is based on the maximum rated pressure of the valve at the chosen test temperature.

As noted earlier, the ISO test can be done with either methane or helium. However, most test facilities will only carry out the 400°C testing using helium gas because of the safety concerns with methane. The ISO standard also defines cryogenic temperatures for testing, -46°C and -196°C, whereas there are no cryogenic parameters defined in API 641.

API 641 calls for three full thermal cycles; during each cycle, the valve stem is actuated 100 stem cycles at ambient temperature and 100 stem cycles at elevated temperature. The valve is allowed to cool overnight and the process is repeated until completion, with a final 10-stem cycles at ambient temperature conducted before the final emissions reading.

To pass the test there must be no emissions readings above 100 ppmv throughout the test and no stem adjustments to the packing gland are allowed. Also it should be noted that the API standard does not specify the type of service for which the valve is intended, i.e. control valve service or on/off (isolating) service.

The ISO has a similar process of ambient and elevated temperature cycling, but it details two specific endurance classes, each with three stages. For valves intended for on/off service, the class 'CO' is used. CO1 is two full thermal cycles, each with 50 stem cycles (fully open to fully closed) at ambient and 50 at elevated temperature; 10 ambient cycles are done at the end of the two full thermal cycles/stages. CO2 is a continuation of CO1 with 790 stem cycles at ambient and 500 stem cycles at elevated temperature (for a total of 1,500 stem cycles). CO3 extends from CO2 with 500 stem strokes at ambient and then 500 at elevated temperature for a total of 2,500 cycles.

For control valves, the three levels are CC1, CC2 and CC3. CC1 is 10,000 cycles at ambient followed by an equal amount at elevated temperature, CC2 continues with 20,000 more cycles at ambient and 20,000 at elevated temperature and CC3 repeats CC2 once more. In CC testing, all stem cycles are plus-10 percent of their stroke or angle from the midpoint of the valve stroke or angle. Speed of the stem movement is also dictated to be 1 to 5 degrees per second. One packing gland adjustment

> *API 641 calls for three full thermal cycles*

is allowed in each endurance class level (i.e. one in CO or CC1, an additional adjustment in CO2 or CC2, etc.). The ISO standard contains multiple leakage classes as well. If we consider only methane for the purposes of comparison to API 641, ISO specifies leakage classes- AM (≤50ppm), BM (≤100ppm) and CM (≤500ppm).

## Measurement point

While on the subject of thermal cycles, another key consideration between the two standards is the position on the valve at which the temperature for the test is monitored.

API 641 specifies the temperature is measured in two places: within ½ inch (12.7 mm) of the stem seal and externally on the valve body adjacent to the flow path. The test temperature must be controlled within +/-5% at both points.

ISO specifies three measurement points: the flow path inside the test valve, an external point adjacent to the flow path and an external point adjacent to the stem/shaft seal. The flow path temperature defines the test temperature and is controlled within +/-5% of the target temperature, the other two locations are taken for informational purposes only.

This is a significant point as valve testing has shown that the fluid process temperature can be significantly higher than the temperature at the stuffing box where the seal is located. This, of course, will vary depending on the valve design. Where API 641 specifies that the stuffing box temperature defines the test, the actual temperature of the fluid (i.e. test gas) can be significantly higher than the test temperature. Conversely, with ISO using the test fluid as the controlling factor, the stuffing box temperature can be much lower than the test temperature.

To be able to practically compare ISO 15848-1 and API 641 test data, you would have to compare the API 641 test temperature with T3 temperature measurement in the ISO test.

So, looking closely at the two standards, there are significant differences. Number of temperature and stem cycles differs, one allows adjustments and one does not, and it is difficult to compare data given that the test temperature is defined differently in each standard. Both procedures, however, are considered examples of good engineering practice.

## Which standard should I use?

The answer will depend on the valve design standard that end-users are requesting. API 641 first edition was released in October 2016, whereas ISO 15848-1 is in its second edition, released in 2015. Either could be deemed acceptable assuming methane is used as the test gas. However, one has to consider what valve standards currently call out for required type tests, as well as what will be added to valve standards in the future. API has done this for gate valves for instance by adding a requirement to various standards such as API 600, 602, etc. specifying that the valves shall be API 624 compliant (which requires API 622 compliant packing) in order to be tagged as API 600 or API 602 valves.

The current editions of API quarter turn valve standards (API 608, API 609) do not have API 641 certification as a requirement. However, in the next edition of API 608 this requirement will be added and API 609 and API 599 are expected to require API 641 testing as well. ISO is not referenced in any of the API standards, nor is there any expectation that it will be in the future. However, given the global environmental concerns, there is a good chance that ISO 15848-1 could be added as a requirement to international valve standards as they are re-published.

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