Current standards for fire testing of flange gaskets & stem packing

Fluid handling systems used in process industries, such as the petrochemical industry, are under a potential fire hazard. This is why they must be specially designed to keep a certain sealing and operating performance under high-temperature fire. Fire testing should ensure these performances.

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Fire tests determine the resistance of a piece of equipment to fire under controlled conditions. There are various parameters that are relevant. First, the burn period. This represents an estimate of the time required for the extinction of the fire. Second, the testing conditions (pressure, temperature and timing regardless of equipment size or pressure rating), and third, the acceptance requirements. The acceptance of the test results is related to the internal and external leakage level of the equipment during the burn and cooldown periods.
Fire test standards for valves date back to the 1960s, although specific tests for stem packing and gaskets did not appear until the 1990s. In the early 1990s, Exxon‹Mobil› was an industry leader in developing and requiring fire testing, possibly because of increased concern after a large fire in 1994. Driven by safety and insurance requirements, fire-tested valve designs became mandatory.

Stem packing

The first standard written specifically to test valve stem packing was American Petroleum Institute (API) 598, released in January 1993. The test was revised to the 2nd Edition in 1998, and then cancelled several years ago (though it is still available for sale on the API website). The 589-standard was written with clear parameters, but the API Committee on Refinery Equipment (CRE) felt it unnecessary to maintain the standard due to the prominence of the valve test standard API 607. This standard has been adapted for use for many products outside of its scope due to necessity. Gasket tests will be reviewed later in this article. The interesting point about using API 607 as a packing test standard is that the valve typically used for the test is a metal-seated gate valve, which is outside the scope of API 607 (Fire test for quarter-turn valves and valves equipped with nonmetallic seats. This way ball valves, butterfly valves and plug valves are included).
Using an API 600 gate valve, provides standardized dimensions for a 5-ring packing chamber. A quarter-turn product would not do so since the packing chamber is not defined in the applicable design standard.
While a 6-inch valve was typical for the API 589 test, since it is not defined, a 4-inch Class 300 gate valve is often used for an API 607 test. This makes the packing size the same as that used for the fugitive emission test of API 622.

Similar test parameters

In general, the test parameters of time and temperature are similar between all API fire test standards. For the API 589 test, the temperature of the bonnet must reach 650 °C within 15 minutes from the start of the test. Since temperature thermocouples are inserted directly into the valve bonnet, the packing chamber temperature for an API 589 test may reach 40 to 90 °C above 650 °C. For the API 607 test, a calorimeter cube placed below the packing chamber must also reach 650 °C within 15 minutes from the start of the test, but since the calorimeter cubes are only 1 1/2-inch cubes of steel, they can get hotter quicker than the bonnet of a large gate valve.

Fig. 1: API 589 fire test.

Four common standards

Today, four common fire test standards for valves are published by API:

1. API 607, 7th Ed. Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats
2. API 6FA, 3rd Ed. Specification for Fire Test for Valves
3. API 6FB, 3rd Ed. API Specification for Fire Test for End Connections
4. API 6FD, 1st Ed. Specification for Fire Test for Check Valves

API 607 and 6FA are different standards. API 607 has special provisions for soft-seated quarter-turn valves and that API 607 and 6FA are for different categories of valves and controlled by two different wings in API (while the API 607 standard is written by the refinery wing, API 6FA is under the jurisdiction of the API Subcommittee on Valves and Wellhead Equipment, API Subcommittee 6).
The fifth edition of API 607 was released in 2004, already after the alignment of API, International Organization for Standardization (ISO) and American National Standards Institute. The ISO equivalent was ISO 10497.

Table 1: Comparison of API 607 and 589 (Images courtesy of Yarmouth Research and Technology)		
API 607 vs 589		
	API 589 – 2nd Edition	API 607 – 7th Edition *
Valve / Fixture Type	6, 8, 10 or 12 inch Class 300 API 600 gate valve	Quarter-turn valves and other valves with non-metallic seats
Fire Test Duration	30 minutes	30 minutes
Test Pressure	540 psig/3.72 MPa	75% of CWP (540 psig/3.72 MPa for Class 300 CS)
Cool-Down Time	10 minutes	10 minutes
Post-Burn Low Pressure Test	50 psig/0.34 MPa	30 psig/0.21 MPa – through leakage only
Post-Burn Operational Test Pressure	540 psig/3.72 MPa	75% of CWP (540 psig/3.72 MPa for Class 300 CS)
Allowable Leakage During Burn/Cool-Down	10 ml/min per NPS	100 ml/min per NPS
Allowable Leakage for Low Pressure Test – Post Cool-Down	0.5 ml/min per NPS	Through leakage only
Allowable Leakage for High Pressure Test – Post Operation	10 ml/min per NPS	25 ml/min per NPS

** Parameters for metal-seated valves*

Besides the lower temperature, what would otherwise make a packing supplier prefer API 607 test? Table 1 shows that the allowable leakage of API 607 is greater, as much as 10 times greater, during the burn and cool-down period. Keep in mind that the API 607 test is a valve test standard, so the external allowable leakage is not only for the stem packing but also for the bonnet gasket and any other body gaskets. So, for a stem packing only test, this can be quite an advantage.

Flange gasket tests

There are two standards used for fire testing gaskets in the United States: API 607 and API 6FB. The latter is the dominant test standard for testing flange gaskets used in upstream, midstream and downstream oil and gas applications.
Prior to this, the Exxon-modified API 607 4th edition test was the leading standard for testing flange gaskets. What started as an internal test for Exxon in 1995 to evaluate supplier's gaskets, turned into an industry standard that is still used in some cases. That standard used a pair of gaskets separated by a spool piece with thermocouples inserted into the flange material and required 650 °C temperatures to be reached within 15 minutes of the start of the burn. The test setup required millions of British thermal units (BTUs)/hour to achieve those temperatures.

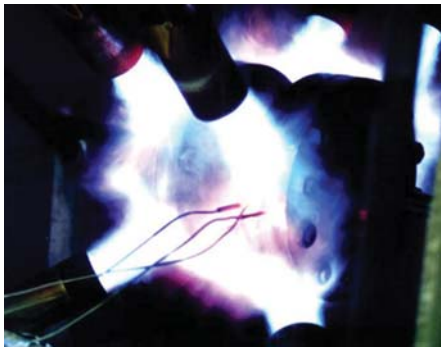

Fig 2: Exxon-modified API 607 gasket fire test.

Recent update

API 6FB title: "Standard for Fire Test for End Connectors", states that it is the test standard for end connections, so a variety of products can be tested to this standard. The standard has the option for onshore and offshore tests both with a bending moment applied or not. The bending moment option is not a common request. The temperature differences of each option are shown in Table 2. API 6FB was updated recently to the 4th edition in May 2019. While changes were made to address other components that use this standard, some details specific to gasket testing were not addressed.

Fig. 3: On-Shore.

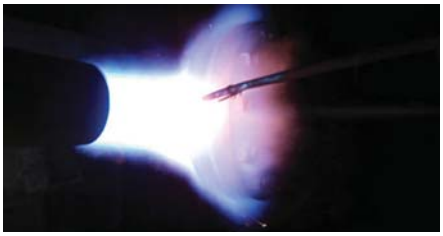

Fig. 4: Off-Shore.

Part of the reason behind the inaction is that the Upstream API committee is responsible for API 6FB, whilst the flange gaskets are mostly considered a downstream product. One of the biggest changes needed is to determine how qualifications are extended to non-tested gaskets (i.e., scaling).

Size range

As shown in parts 5.3 and 5.4 of the API 6FB: "Allowances of Scaling by Size" and "Allowances of Scaling by Pressure Rating", if two sizes are tested, then all sizes between them are qualified and all pressure ratings lower than the tested one's rating, are qualified. That may be fine for some components but does not hold true for all the gaskets that could have a size range from a 1/2 inch to 60 inches or more and Class 150 to 4,500. Ninety-five percent of the tests that are performed are done with 6-inch ANSI Class 300 gaskets and that is all. There are only one or two manufacturers that have tested larger and smaller gaskets to try to fulfill the requirement of API 6FB. In those cases, 2-inch and 24-inch gaskets were tested.

The future

While testing can currently be performed for both packing and gaskets using the available standards and modifications to them, there is a need to make changes to the existing ones or create something new.
Currently, API 607 is under review. The committee will address making addendums for packing and/or gasket tests as part of 607. If not, API 589 may be reactivated.

Table 2: Temperature differences		
	On-Shore	Off-Shore
Number of Burners	Multiple or widespread	1
Flame Temperature (°F / °C)	1400 / 760 - 1800 / 980	2000 / 1090 - 2500 / 1370
Calorimeter Block Temperature (°F / °C)	1200 / 650	1800 / 980