Fire Test for Soft-Seated Quarter-Turn Valves

API STANDARD 607
FOURTH EDITION, MAY 1993

STEP
Strategies for Today's Environmental Partnership

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005

Fire Test for Soft-Seated Quarter-Turn Valves

Manufacturing, Distribution and Marketing Department

API STANDARD 607
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American
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FOREWORD

This standard covers the requirements for testing and evaluating the performance of soft-seated quarter-turn valves when the valves are exposed to certain fire conditions defined in this standard. The performance requirements presented in this document establish standard limits on the acceptability of such valves. The purchaser may wish to establish more stringent requirements to meet his specific applications.

Those testing valves in accordance with this standard are encouraged to submit the data they have gathered during tests to the director of the Manufacturing, Distribution and Marketing Department.

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Suggested revisions are invited and should be submitted to the director of the Manufacturing, Distribution and Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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Fire Test for Soft-Seated Quarter-Turn Valves

SECTION 1—GENERAL

1.1 Scope

1.1.1 This standard covers the requirements for testing and evaluating the performance of straightway, soft-seated quarter-turn valves when they are exposed to certain fire conditions defined in this standard. The procedures described in this standard apply to all classes and sizes of such valves that are made of materials listed in ASME B16.34.

Note: Throughout this standard the term *class* (either capitalized or not) means pressure class as defined in ASME B16.34.

1.1.2 The performance requirements presented in this document establish standard limits of acceptability.

Note: The maximum acceptable leakage rates given in this standard are for the test temperatures and pressures specified. Leakage rates of valves in service during and after an actual fire may be substantially different.

1.2 Referenced Publications

To the extent indicated in this standard, the most recent edition or revision of the following publication forms a part of this standard.

API
- Std 609 *Lug- and Wafer-Type Butterfly Valves*

ASME[1]
- B16.34 *Valves—Flanged, Threaded, and Welding End*

ASTM[2]
- A 193 *Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service*
- A 307 *Carbon Steel Bolts and Studs, 60,000 psi Tensile*

1.3 Basic Fire-Test Conditions

Through the basic conditions in 1.3.1 through 1.3.4, the test procedure is designed to simulate circumstances that impose severe demands on a valve.

1.3.1 The test valve shall be filled with water and tested in the closed position. Since testing the valve in the closed position may create substantially higher pressures inside the valve body cavity than testing the valve in an open position, the safety provisions in 1.4.7 are mandatory.

1.3.2 The test apparatus shall be arranged or installed to provide a vapor trap that minimizes the cooling effect of the upstream liquid (see Section 2).

1.3.3 Potential piping-to-valve end-connection joint leakage (flanged, threaded, or welded) is not evaluated as part of this test and is not included in the allowable external leakage specified in 4.2. If necessary to eliminate this kind of leakage, these joints shall be modified for the test as appropriate.

1.3.4 The valve shall be tested with the manufacturer's standard manual actuating device for that valve.

1.4 Other Fire-Test Conditions

1.4.1 During the test, the test valve shall not be protected with insulating material in any way.

1.4.2 During the test, the test valve's stem and bore shall be horizontal.

1.4.3 The valve and its standard manual actuating device shall be completely enveloped in a 1400–1800°F (760–980°C) flame for 30 minutes (see 1.4.5 for the minimum calorimeter temperature).

Note: The burn duration of 30 minutes was selected because it represents the maximum time required to extinguish most refinery fires. Fires of greater duration are considered major fires, with greater consequences than those anticipated by this test.

The flame temperature shall be the average of the concurrent readings of the two required flame thermocouples with neither concurrent reading less than 1300°F (705°C). One of the two required thermocouples shall be located 1 inch (25 millimeters) beneath the valve body and the other within a 1-inch (25-millimeter) radius of the stem seal as shown in Figures 1, 2, and 3. The use of any other flame thermocouple is optional.

1.4.4 The test setup for a valve rated Class 900 or higher shall include 1½-inch (38-millimeter) cube calorimeter blocks constructed in accordance with Figure 4. Each block shall be made of carbon steel with the sensing zone of a thermocouple in its center. For a test valve NPS 6 or smaller, two blocks shall be located as shown in Figure 1. For a test valve NPS 8 or larger, three blocks shall be used as shown in Figure 2.

Each test valve rated lower than Class 900 shall be fitted with a single body thermocouple installed in the body on the top of the valve within 60 degrees of and on either side of the vertical centerline as shown in Figure 3. The use of more than one body thermocouple is optional, but if more than one is used, the temperatures of each shall be recorded. Each body

[1]American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.
[2]American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103-1187.

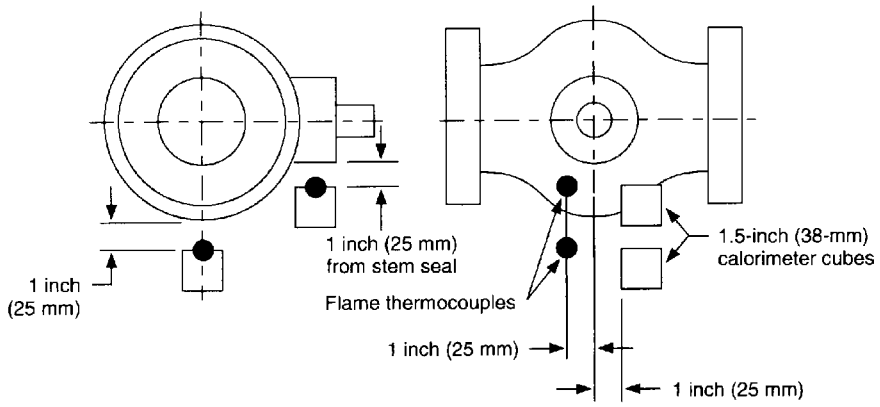


Figure 1—Installation of Temperature Measurement Sensors for Valves NPS 6 or Smaller, Rated Class 900 or Higher

thermocouple shall be installed so that its readings will not be significantly affected by the flame. Each body thermocouple either shall be installed inside the valve body or shall be recessed into the valve body a distance of ½ the thickness of the wall. If necessary to accommodate a body thermocouple's installation, materials of the same nominal chemical composition as that of the valve body may be weld deposited on the valve's surface. The test valve shall also have one thermocouple imbedded in the bonnet section as shown in Figure 3.

1.4.5 For valves rated Class 900 or higher, the temperatures of all calorimeters shall reach 1200°F (650°C) within the first 15 minutes of the 30-minute burn period. After reaching 1200°F (650°C), the temperatures of the calorimeters shall not fall below 1200°F (650°C) during the remainder of the 30-minute period.

For valves rated lower than Class 900, the temperatures of the body thermocouples shall maintain a minimum of 1100°F (593°C) for at least 5 minutes of the 30-minute burn period. The temperatures of the bonnet thermocouples shall maintain a minimum of 1200°F (650°C) for at least 15 minutes of the 30-minute burn period.

1.4.6 For upstream-sealing, dual-seated valves (such as some trunnion-mounted valves) the volume of liquid trapped in the cavity at the beginning of the test is not through-valve leakage and therefore may be deducted from the volume of liquid collected in the calibrated container during the burn period. Before the test is started, the volume of liquid trapped in the cavity when the valve is closed and in the test position shall be determined and shall be recorded and identified in the test report. Also, the report shall state that the valve is of the upstream-sealing, dual-seated type.

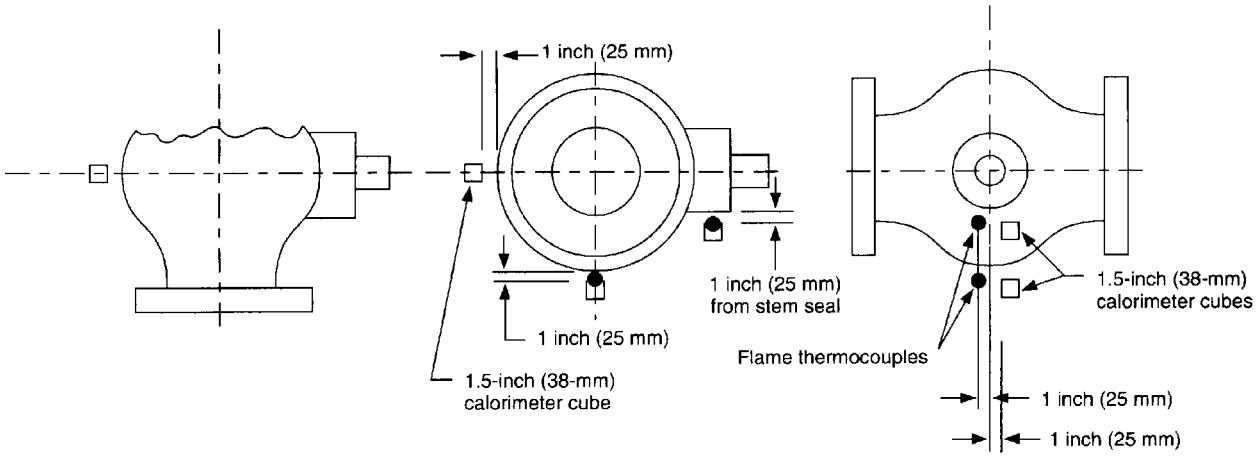
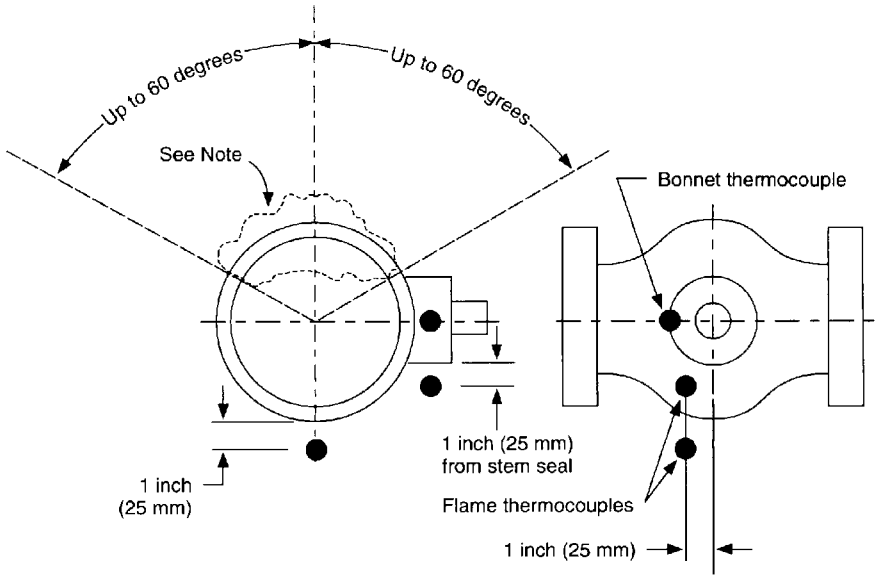
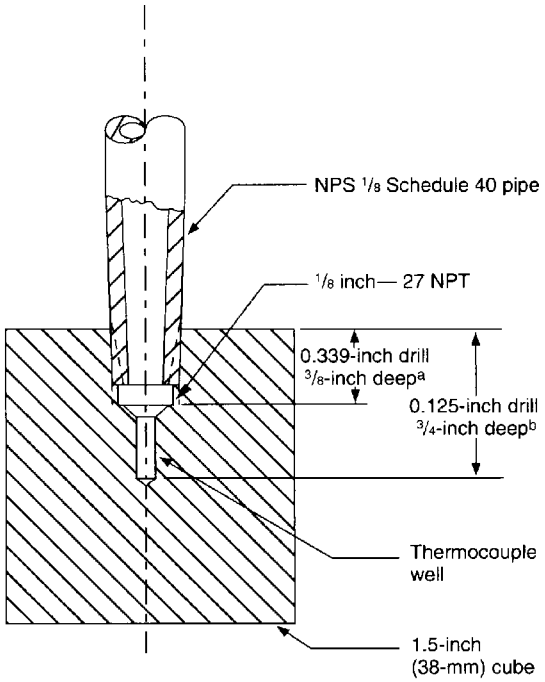


Figure 2—Installation of Temperature Measurement Sensors for Valves NPS 8 or Larger, Rated Class 900 or Higher



Note: The body thermocouple shall be installed in this area. When installed externally, the body thermocouple shall be recessed into the valve body a distance of ⅛ the thickness of the wall.

Figure 3—Installation of Temperature Measurement Sensors for Valves Rated Lower Than Class 900



Note: NPT = National Pipe Taper. The cube material is carbon steel.
[a]Use a 0.339-inch bit to drill ⅜-inch deep.
[b]Use a 0.125-inch bit to drill ¾-inch deep.

Figure 4—Design of Calorimeter Cube

1.4.7 The following Caution shall be observed.

CAUTION: For the safety of the personnel conducting the test and because of environmental considerations, the following is required:

a. The test valve and all test equipment shall be clean and in good operating condition.
b. Water shall be used as the test medium.
c. Personnel shields shall be provided and used.
d. Gaseous fuel shall be used.
e. A supplemental pressure relief valve shall be used to protect the body cavity of a double-seated test valve from rupture (see 4.3). The set pressure of the pressure relief valve shall be low enough to preclude rupture of the test valve at expected test temperatures. Determination of the set pressure is the responsibility of the manufacturer of the test valve.

1.4.8 For all upstream-sealing, dual-seated valves rated lower than Class 600 and all other valves rated lower than Class 900, during the burn period and the operational test the test pressure shall be 30 pounds per square inch (2 bar). See Table 1.

For all upstream-sealing, dual-seated valves rated Class 600 or higher and all other valves rated Class 900 or higher, during the burn period and the operational test the test pressure shall be 75 percent of the allowable cold working pressure of the valve. See Table 1.

Table 1—Test Pressure During Fire Test and Operational Test

Test Valve Rating Equivalent to ASME B16.34 Standard Class	Test Pressure		
	Pounds Per Square Inch	Megapascals	Bar
Upstream-Sealing, Dual-Seated Valves			
150	30	0.2	2
300	30	0.2	2
400	30	0.2	2
600	*	*	*
900	*	*	*
1500	*	*	*
2500	*	*	*
Other Valves			
150	30	0.2	2
300	30	0.2	2
400	30	0.2	2
600	30	0.2	2
900	*	*	*
1500	*	*	*
2500	*	*	*

Note: * = 75 percent of cold working pressure. Deviations in the test pressure from the appropriate test pressure listed above [other than those during momentary pressure losses (see 3.1.4)] may be as great as ±10 percent during the fire test and the operational test.

SECTION 2—TEST APPARATUS

2.1 Arrangement of Equipment

Typical arrangements of the fire-test equipment are shown in Figures 5 and 6.

2.2 Alternative Means of Pressurization

Means other than those illustrated in Figures 5 and 6 may be used to pressurize the system, provided that the alternative source of pressure meets the other requirements of this standard and assures adequate safety.

2.3 Downstream Piping

Piping downstream of the test valve shall be at least NPS ½ or ½-inch outside diameter tubing.

SECTION 3—TEST PROCEDURE

3.1 Fire Test

To perform the fire test, follow the stepwise procedure described in 3.1.1 through 3.1.10. See Figures 5 and 6 as indicated.

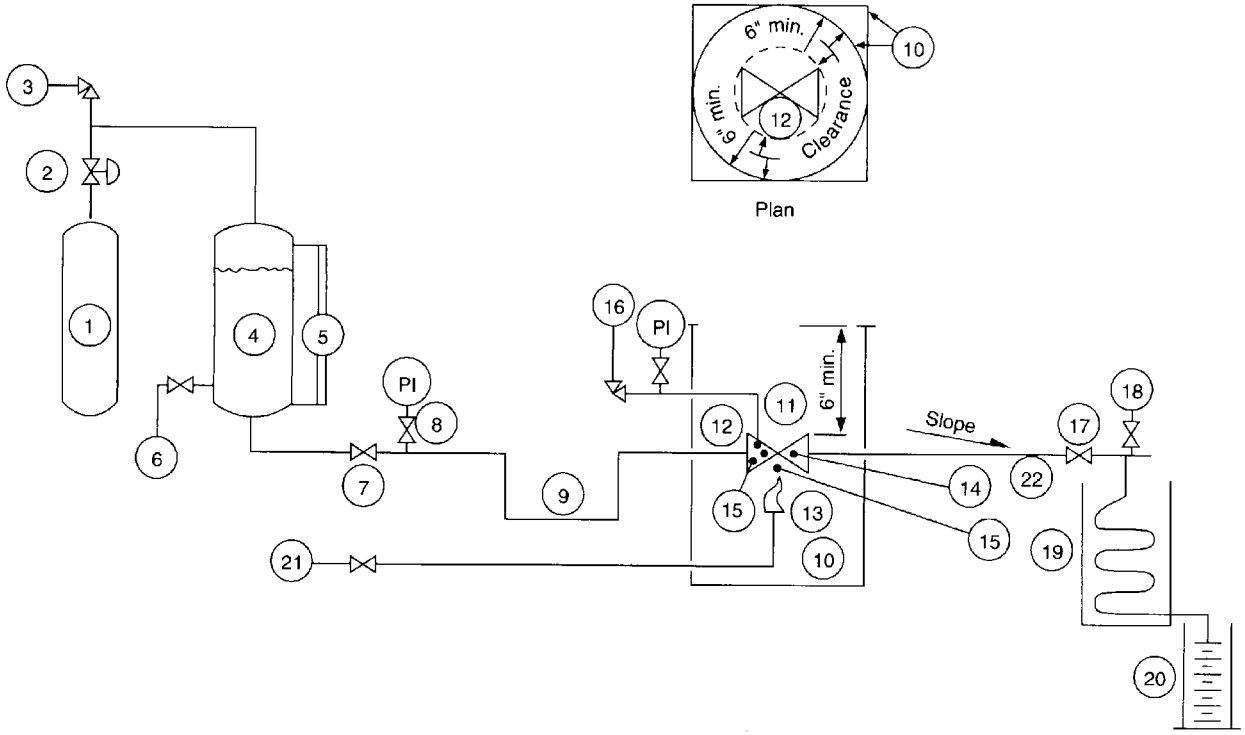
Note: No adjustment may be made to the test valve during the fire test.

3.1.1 To flood the system and purge the air, open the water supply valve and any necessary vent and drain valves. During the flood and purge operation, to ensure that the body cavity will become filled with water, turn the test valve to the half-open position.

3.1.2 First close all drain and vent valves, next close the test valve, and then close the water supply valve. At this point, the test valve and the system upstream of it shall be completely full of water. Finally, open the drain valve (Figure 5, Item 17) so that the system downstream of the test valve shall be completely empty of water.

Legend

1. Pressure source.
2. Pressure regulator.
3. Relief valve.
4. Vessel for water.
5. Calibrated sight gauge (or similar device).
6. Water supply.
7. Shutoff valve.
8. Pressure gauge.
9. Piping that is arranged to provide a vapor trap.
10. Enclosure for test [the horizontal clearance between any part of the valve and the enclosure shall be at least 6 inches (152 millimeters)].
11. Minimum height of the enclosure: 6 inches (152 millimeters) above the top of the valve.
12. Test valve and stem mounted horizontally.
13. Fuel gas burner.
14. Calorimeter cubes.
15. Flame temperature thermocouples.
16. Pressure gauge and relief valve connected to the center cavity of the valve (mandatory).
17. Drain valve.
18. Vent valve.
19. Condenser.
20. Calibrated container.
21. Fuel gas inlet.
22. Piping downstream of test valve, which shall be ½-inch outside diameter or NPS ½ tubing.



Note: PI = pressure indicator (gauge).

Figure 5—Typical Fire-Test System Using Compressed Gas as the Pressure Source

3.1.3 Pressurize the system to the appropriate test pressure indicated by 1.4.8, check the entire system carefully for leaks, and eliminate any leaks found. Note in the test report any test-valve leaks.

3.1.4 During the test, maintain the specified test pressure. Momentary pressure losses of 50 percent of the test pressure are permissible during the test provided that their cumulative duration is less than 2 minutes. These pressure losses and their times of occurance shall be noted in the test report.

3.1.5 Record the amount of water in the vessel (Figures 5 and 6, Item 4). Empty the calibrated container (Figure 5, Item 20).

3.1.6 Open the fuel supply valve and establish the fire. Not more than 2 minutes after ignition, the flame temperature shall reach 1400°F (760°C). Once the temperature reaches 1400°F (760°C), the 30-minute burn period shall begin. Maintain the test conditions as indicated in 1.4.3 through 1.4.5.

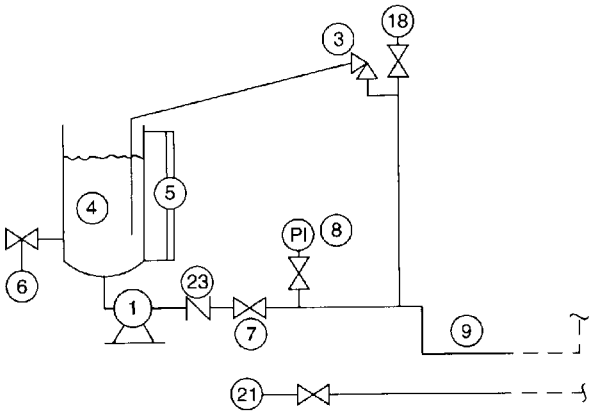
3.1.7 At least as often as every 30 seconds for the duration of the 30-minute burn period, record instrument readings (Figures 5 and 6, Item 8, and Figure 5, Items 14, 15, and 16).

3.1.8 At the end of the 30-minute burn period, close the fuel supply valve.

3.1.9 Immediately record the amount of water collected in the calibrated container (Figure 5, Item 20), to establish total through-valve leakage.

Legend

1. Pressure source.
3. Relief valve.
4. Vessel for water.
5. Calibrated sight gauge (or similar device).
6. Water supply.
7. Shutoff valve.
8. Pressure gauge.
9. Piping that is arranged to provide a vapor trap.
18. Vent valve.
21. Fuel gas inlet.
23. Check valve.



Note: PI = pressure indicator (gauge). A pump with appropriate control devices may be used as a pressure source provided that the system delivers a reasonably nonpulsating pressure.

Figure 6—Typical Fire-Test System Using a Pump as the Pressure Source

3.1.10 Spray the test valve with water so that it rapidly cools to below 212°F (100°C) within 10 minutes.

CAUTION: For safety, no personnel should approach the valve until it has cooled to 212°F (100°C) or less.

Record the amount of water in the vessel (Figures 5 and 6, Item 4). To enable the calculation of external valve leakage, record the amount of water collected in the calibrated container (Figure 5, Item 20).

3.2 Operational Test

After completing the static leakage tests (3.1.9 and 3.1.10), close the drain valve (Figure 5, Item 17), operate the test valve against the test pressure to the fully open position and then to the fully closed position. Open the drain valve (Figure 5, Item 17). Allow the system to stabilize for 5 minutes. Once the 5-minute stabilization period has been completed, record in the test report the through-valve leakage and the external leakage separately at the end of the next 5-minute period.

Note: No adjustment may be made to the test valve during the operational test.

Note: The operational test is completely separate from the fire-exposure tests, in which data is recorded during the burning and cooldown periods.

SECTION 4—PERFORMANCE REQUIREMENTS

4.1 Through-Valve Seat Leakage

4.1.1 In the burn period of the test, the maximum allowable through-valve seat leakage (not including leakage at the bonnet joint, the stem, or the body joint) shall be 100 milliliters per minute per NPS valve size for all NPS 10 or smaller upstream-sealing, dual-seated valves (such as some trunnion-mounted ball valves) rated lower than Class 600 and for valves of other types rated lower than Class 900. For valves larger than NPS 10, the maximum allowable seat leakage shall be 1000 milliliters per minute (regardless of valve size). See Table 2.

In the burn period of the test, for NPS 5 or smaller upstream-sealing, dual-seated valves (such as some trunnion-mounted ball valves) rated Class 600 or higher and for valves of other types rated Class 900 or higher, the maximum allowable seat leakage shall be 200 milliliters per minute per NPS valve size. For valves larger than NPS 5, the maximum allowable seat leakage shall be 1000 milliliters per minute (regardless of valve size). See Table 2.

4.1.2 During the operational test described in 3.2, the maximum allowable through-valve seat leakage for valves NPS 10 or smaller shall be 20 milliliters per minute per NPS valve size for all upstream-sealing, dual-seated valves (such as some trunnion-mounted ball valves) rated lower than Class 600 and for valves of other types rated lower than Class 900. For valves larger than NPS 10, the maximum allowable seat leakage during the operational test shall be 200 milliliters per minute (regardless of valve size). See Table 2.

During the operational test, for NPS 10 or smaller upstream-sealing, dual-seated valves (such as some trunnion-mounted ball valves) rated Class 600 or higher and for valves of other types rated Class 900 or higher, the maximum allowable seat leakage shall be 100 milliliters per minute per NPS valve size. For valves larger than NPS 10, the maximum allowable seat leakage during the operational test shall be 1000 milliliters per minute (regardless of valve size). See Table 2.

4.2 External Leakage

4.2.1 External leakage includes leakage at the stem, the bonnet joint, and the body joint, but does not include leakage at the piping-to-valve end connections.

4.2.2 External leakage for valves NPS 10 or smaller for the total fire-test period, including cooldown, shall not ex-

Table 2—Maximum Allowable Leakage Rates

Valve Size	Maximum Leakage Rate
For Through-Valve Seat Leakage	
During the Burn Period	
For Upstream-Sealing, Dual-Seated Valves < Class 600 and For Other Valves < Class 900	
≤ NPS 10	100 milliliters/minute/NPS
> NPS 10	1000 milliliters/minute
For Upstream-Sealing, Dual-Seated Valves ≥ Class 600 and For Other Valves ≥ Class 900	
≤ NPS 5	200 milliliters/minute/NPS
> NPS 5	1000 milliliters/minute
During the Operational Test	
For Upstream-Sealing, Dual-Seated Valves < Class 600 and For Other Valves < Class 900	
≤ NPS 10	20 milliliters/minute/NPS
> NPS 10	200 milliliters/minute
For Upstream-Sealing, Dual-Seated Valves ≥ Class 600 and For Other Valves ≥ Class 900	
≤ NPS 10	100 milliliters/minute/NPS
> NPS 10	1000 milliliters/minute
For External Leakage	
≤ NPS 10	25 milliliters/minute/NPS
> NPS 10	250 milliliters/minute

ceed 25 milliliters per minute per NPS valve size. For valves larger than NPS 10, the maximum allowable external leakage shall be 250 milliliters per minute (regardless of valve size). See Table 2.

4.2.3 After operating the test valve in the operational test as described in 3.2, the maximum allowable external leakage shall be as specified in 4.2.2.

4.3 Pressure Relief Provisions

The test is void if the supplemental pressure relief valve described in 1.4.7 is activated. If the design of the test valve includes an externally discharging relief device that relieves during the test, the test is not void. However, all discharge through the device shall be considered external leakage.

Note: Qualification based on the use of an external relief device must be noted in the final test report.

4.4 Valve Qualification

As an alternative to testing each size and class of a given valve design, similar valves of the same basic design (including calculation method) and construction as the test valve and of the same nonmetallic materials as the test valve in the seat-to-closure member seal, seat-to-body seal, stem seal, and body joint and seal may be qualified subject to the limitations in 4.4.1 through 4.4.9.

4.4.1 One test valve may be used to qualify valves of sizes other than that of the test valve in accordance with Table 3. A successful test of a valve NPS 8 or larger also qualifies valves of the next smaller size and those of all larger sizes. The nominal size of a valve is determined by the size of the end connections.

4.4.2 One test valve may be used to qualify valves of higher pressure ratings that are not greater than twice the pressure rating of the test valve (see Table 4).

4.4.3 Providing that all other qualifications criteria have been met, valves with ends different from those of the test valve will also qualify provided that their mass is not less than 90 percent of that of the test valve.

Note: Although the type of the valve's body ends is not otherwise considered by this standard, the mass of the valve is determined in part by the body-end type.

4.4.4 Asymmetric-seated valves shall be tested by carrying out the test procedure twice, once in each direction.

Note: An asymmetric-seated valve is a valve with a single seat offset from a plane that is perpendicular to the pipe axis and that passes through the shaft centerline, such as a Category B butterfly valve conforming to API Standard 609. Valves with asymmetric body-joint seals are not considered asymmetric-seated valves if they do not have asymmetric seating.

4.4.5 Valves intended for single-direction installation shall be marked accordingly and shall be tested in the direction of marking.

4.4.6 Qualification of a full-port valve also qualifies a reduced-port valve of the same size provided that both are of the same construction. Qualification of a reduced-port valve also qualifies a full-port valve of the same size provided that both are of the same construction.

4.4.7 Qualification of a valve with a carbon steel body also qualifies valves of any materials listed in Table 1 of ASME B16.34. Qualification of a stainless steel valve also

Table 3—Qualification of Other Valve Sizes

Size of Test Valve (NPS)	Valve Sizes Qualified (NPS)
½	¼, ⅜, ½, ¾
1	¼, 1, 1¼, 1½
2	1½, 2, 2½, 3
4	3, 4, 5, 6
8	6 and larger

Note: See 4.4.1. Testing of valves larger than NPS 8 is not required because they would not reach the specified test temperature in the duration of the test. An actual fire of a duration greater than that of the test would cause substantial damage to adjacent pipe and equipment before it would cause valve failure.

Table 4—Qualification of Other Valve Pressure Ratings

Pressure Rating of Test Valve (Class)	Valve Pressure Ratings Qualified (Class)
150	150, 300
300	300, 400, 600
400	400, 600, 800
600	600, 800, 900
800	800, 900, 1500
900	900, 1500
1500	1500, 2500
2500	2500

Note: See 4.4.2.

qualifies valves of any Group 2 and 3 materials listed in Table 1 of ASME B16.34.

4.4.8 Qualification of a valve with ASTM A 193, Grade B7, fasteners also qualifies valves with fasteners conforming to other ASTM specifications listed in Table 1 of ASME B16.34, except ASTM A 307, Grade B. Qualification of a valve with listed fasteners other than Grade B7 fasteners only qualifies valves with the tested fasteners. Valves with pressure-retaining fasteners conforming to ASTM A 307, Grade B, shall not be tested.

4.4.9 Qualification of a valve with filled PTFE components also qualifies valves with virgin PTFE components. Qualification of a valve with virgin PTFE components also qualifies valves with filled PTFE components.

Double-seated valves with components of polymers other than PTFE must be individually qualified in accordance with this standard.

Qualification of a single-seated valve with virgin PTFE or filled PTFE components may be extended to single-seated valves with components of another polymer by a successful qualification test of an NPS 4 valve that has the same basic design (same construction) as the test valve and that has components of the other polymer.

Valves with ceramic or graphitic components require a complete range of tests in accordance with this standard.

Once a valve has been tested and qualified, any subsequent change in material of seals affecting external leakage requires full requalification of the valve.

4.5 Certification and Witnessing of Tests

4.5.1 Requirements for certification and witnessing of tests shall be by agreement between the manufacturer and the purchaser.

4.5.2 When a purchase order stipulates fire-tested valves, valves qualified by fire testing as specified in the third or fourth edition of this standard (API Standard 607) may be supplied for a period of 3 years after the date of this standard. After that 3-year period, all certified valves must meet all the requirements of the fourth edition of this standard.

API STD*607 93 ■ 0732290 0509026 T95 ■

Order No. 822-60700

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