Type Testing of Quarter-turn Valves for Fugitive Emissions

API STANDARD 641
FIRST EDITION, OCTOBER 2016

AMERICAN PETROLEUM INSTITUTE

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

Introduction

The purpose of this standard is to establish a uniform procedure for the evaluation of emission performance of process valves. The testing program will provide a basis for the comparison of the emissions and performance of process valves.

Use of this standard assumes the execution of its provisions is entrusted to appropriately qualified and experienced personnel because it calls for procedures that can be injurious to health if adequate precautions are not taken. This standard refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage of the procedure.

Type Testing of Quarter-turn Valves for Fugitive Emissions

1 Scope

This standard specifies the requirements and acceptance criteria for fugitive emission type testing of quarter-turn valves. The type testing requirements contained herein are based on elements of EPA Method 21.

Valves larger than NPS 24 and valves greater than ASME B16.34 class 1500 are outside the scope of this standard. Valves with a pressure rating at ambient temperature less than 6.89 barg (100 psig) are outside the scope of this standard. Repacking or resealing of valves is outside the scope of this standard.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Standard 622, *Type Testing of Process Valve Packing for Fugitive Emissions*

EPA Method 21 [1], *Determination of Volatile Organic Compound Leaks*

ASME B16.34 [2], *Valves—Flanged, Threaded, and Welding End*

3 Terms and Definitions

For the purposes of this standard, the following definitions apply.

3.1
ambient temperature
Temperature that is between 15 °C to 40 °C (59 °F to 104 °F).

3.2
auxiliary connection(s)
Drain(s), vent(s), thermal relief(s), or injection port(s).

3.3
closing torque
The amount of torque required to achieve valve closure and seat leakage tightness meeting manufacturer's published acceptance criteria at maximum pressure differential.

3.4
dynamic leak measurement
Measurement of leakage taken at the valve stem while the stem is travelling through an opening and/or closing cycle per elements of EPA Method 21.

3.5
EPA Method 21
A leak check method established by the United States Environmental Protection Agency (EPA) for performing emission measurements on equipment such as valves, pumps, and flanges.

3.6
emissions
Gaseous leak given off by a piece of equipment used in reference to volatile organic compounds and expressed in parts per million volumetric (ppmv or ppm) for methane.

[1] United States Environmental Protection Agency, 1200 Pennsylvania Avenue, NW, Washington, DC 20460, www.epa.gov.
[2] ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

3.7
leakage
Measurable amount of test medium escaping from the valve.

3.8
manufacturing facility
Location of final assembly, inspection, and testing of the valve selected for evaluation.

3.9
mechanical cycle
A motion of the stem that moves a valve from the fully closed (or opened) position to the fully open (or closed) position, and returning to the fully closed (or opened) position.

3.10
obturator
Part of a valve, such as a ball, disc, or plug, that is positioned in the flow stream to permit or prevent flow.

3.11
packing torque
The amount of torque on the gland bolts that transfers a compressive force to the packing.

3.12
qualification facility
A testing entity capable of type testing quarter-turn valves for fugitive emissions in accordance with this standard.

3.13
quarter-turn valve
A rotary valve that will fully open or close with approximately 90° rotation of the obturator with a nonrising stem.

3.14
running torque
The amount of torque required to continue stem rotation between full open and closed positions.

3.15
static leak measurement
Measurement of leakage taken with valve in the partially open position when the stem is not turning, per elements of EPA Method 21.

3.16
stem
Metal rod that connects the obturator of a valve to a handwheel, handle, or actuator.

3.17
thermal cycle
A change in temperature from ambient temperature, to elevated and/or lower temperature(s), and back to ambient temperature.

3.18
third party
A person, group, company, agency, corporation, or designated representative independent from the manufacturer responsible for valve certification.

3.19
type testing
A test, or series of tests, conducted to determine if a valve design is capable of complying with a prescribed set of acceptance criteria.

4 Symbols

For the purposes of this standard, the following symbols are used.

P_a valve pressure at ambient temperature

P_e valve pressure at elevated temperature

T_e valve elevated temperature

T_a ambient temperature

5 Packing Testing

The manufacturer shall define the valve service temperature range for its sealing material. Packing sets used as the stem seal for purposes of controlling fugitive emissions within the scope of API Standard 622 shall be qualified for the fugitive emissions (either the rising or rotating stem test), corrosion, and materials tests required by API Standard 622. Packing outside the scope of API Standard 622 and other materials used as the stem seal do not require pretesting.

6 Valve Selection and Test Preparation

6.1 The test valve shall be fully assembled, tested to applicable industry standards, and ready for fugitive emission testing. The test valve shall be randomly selected from manufacturer or distributor stock, where such stock is available. For valves not in stock, the manufacturer shall certify that the test valve was not modified in any way to meet type test requirements and is a typical representation of the manufacturer's stock product. The method of valve selection shall be documented on the Fugitive Emissions Test Report in Annex A.

6.2 Leakage from body joints and auxiliary connections can affect leak measurement readings and shall be corrected prior to testing. Torque values for these connections shall be in accordance with manufacturer's published values prior to starting the test.

6.3 Packing gland torque shall be verified and, if necessary, adjusted to be in accordance with manufacturer's published installation specifications.

6.4 No other modifications to the valve beyond those mentioned in 6.1 through 6.3 are permitted. All pretest activities performed on the valve shall be documented on the Fugitive Emissions Test Report in Annex A.

7 Safety Considerations for Type Testing

7.1 The test medium used shall be methane 97 % minimum purity.

Caution: Methane used during testing is a pressurized flammable gas that requires that appropriate safety measures be taken.

7.2 Testing of valves is potentially hazardous, and it is essential that the safety of personnel be given prime consideration. Given the nature of this test, hazardous release of pressurized gas could occur. Adequate shields or barriers in the area of the test enclosure and other appropriate means for the protection of personnel shall be provided.

7.3 The valve may be depressured between thermal cycles.

7.4 The qualification facility shall be designed to ensure that all the test operations are conducted in a safe and protected environment appropriate for the test conditions. It is the responsibility of the qualification facility to analyze the hazards resulting from the pressure and temperatures and take proper safety precautions. All applicable safety regulations shall be complied with.

7.5 All equipment shall have appropriate certification that verifies its suitability to withstand the minimum and maximum pressures and temperatures in the testing environment.

7.6 Hoses or pipes used for inlet and outlet supply of methane shall be suitable for maximum pressures and temperatures. Where hoses are used, appropriately designed restraints shall be used to prevent hose detachment from the test rig in the event that a blowout occurs.

7.7 All testing shall be in accordance with local and national codes and regulations.

7.8 Purge the partially open valve with methane gas to eliminate air in the valve cavity prior to starting the testing.

8 Type Testing

8.1 Testing shall adhere to the requirements below. The testing profile can be found in Annex B.

8.2 The manufacturer shall either engage an independent qualification facility to perform the tests or a third party to witness and certify tests done in their own facility.

8.3 The stem orientation for a test valve shall be vertical.

8.4 Valves shall be subjected to a total of 610 mechanical cycles and 3 thermal cycles per Figure 1. Mechanical and thermal cycling shall begin with the valve at ambient temperature.

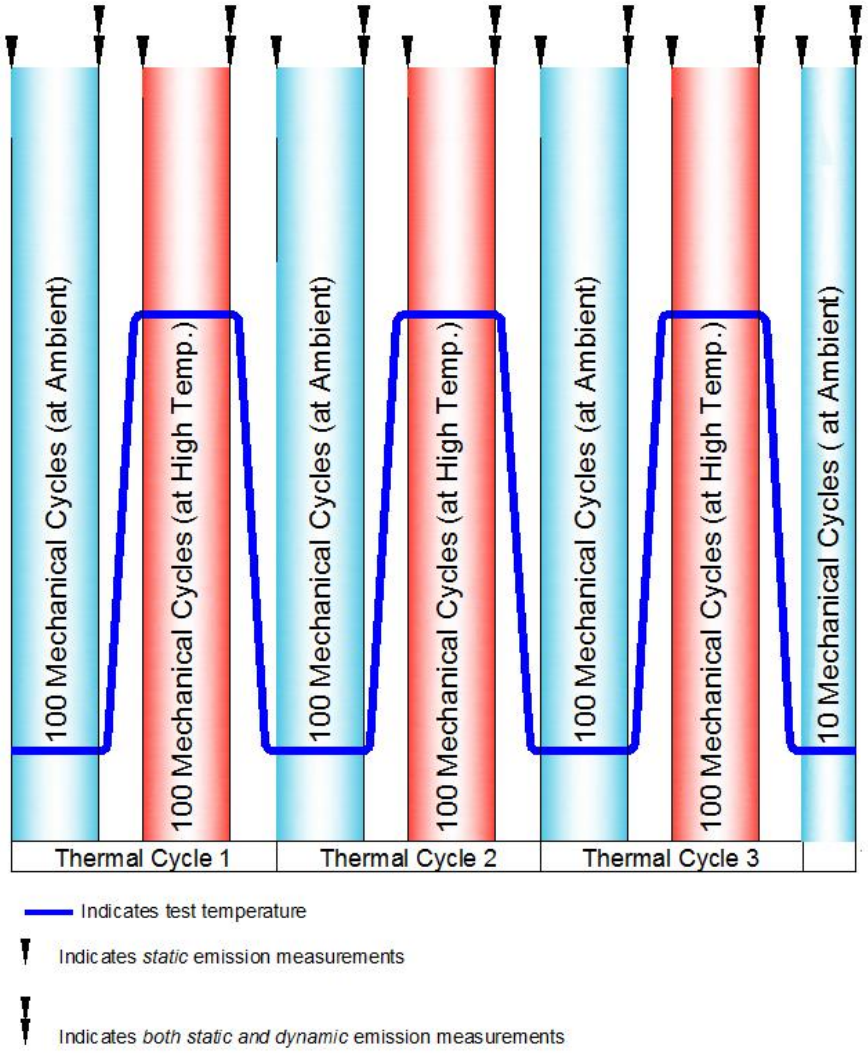

Figure 1—Valve Cycling

8.5 The valve shall be heated using an internal or external heat source such as electric heating blanket, coils, or other suitable equipment.

8.6 A valve group and values for the variables T_e, P_e, and P_a shall be determined for each valve, per 8.7 or 8.8, in order for the valve to be qualified or tested per this standard. All test pressures and temperatures shall be within ±5 % of the values shown.

8.7 All valve designs with a maximum temperature rating greater than or equal to 260 °C (500 °F) shall be classified per the valve groups in Table 1. Annex C may be used to assist with determining the appropriate valve group and values for T_e, P_e, and P_a.

Table 1—Valve Groups: Valve Temperature Rating ≥ 260 °C (500 °F)

Valve pressure rating at 260 °C (500 °F) is ≥ 41.1 barg (600 psig)	Valve pressure rating at 260 °C (500 °F) is < 41.1 barg (600 psig) and ≥ 6.89 barg (100 psig)	Valve with a temperature rating ≥ 260 °C (500 °F) and does not comply with the requirements of Group A or Group B
Group A (see 8.7.1)	Group B (see 8.7.2)	Group C (see 8.7.3)
NOTE Valves with a pressure rating less than 6.89 barg (100 psig) at ambient temperature are outside the scope of this standard.		

8.7.1 For Group A valves:

T_e = 260 °C (500 °F);
P_e = 41.4 barg (600 psig);
P_a = 41.4 barg (600 psig).

8.7.2 For Group B valves:

T_e = 260 °C (500 °F);
P_e = valve pressure rating at 260 °C (500 °F);
P_a = valve pressure rating at ambient temperature or 41.4 barg (600 psig), whichever is less.

8.7.3 For Group C valves:

T_e = maximum temperature rating of the valve at 6.89 barg (100 psig) or 500 °F, whichever is lower;
P_e = 6.89 barg (100 psig);
P_a = valve pressure rating at ambient temperature or 41.4 barg (600 psig), whichever is less.

8.8 All quarter-turn valve designs with a maximum temperature rating less than 260 °C (500 °F) shall be classified per the valve groups in Table 2. Annex C may be used to assist with determining the appropriate valve group and values for T_e, P_e, and P_a.

Table 2—Valve Groups: Valve Temperature Rating < 260 °C (500 °F)

Valve pressure rating at its maximum-rated temperature is ≥ 41.1 barg (600 psig)	Valve pressure rating at its maximum-rated temperature is < 41.1 barg (600 psig) and ≥ 6.89 barg (100 psig)	Valve with a temperature rating < 260 °C (500 °F) and does not comply with the requirements of Group D or Group E
Group D (see 8.8.1)	Group E (see 8.8.2)	Group F (see 8.8.3)
NOTE Valves with a pressure rating less than 6.89 barg (100 psig) at ambient temperature are outside the scope of this standard.		

8.8.1 For Group D valves:

T_e = maximum temperature rating of valve;
P_e = 41.4 barg (600 psig);
P_a = 41.4 barg (600 psig).

8.8.2 For Group E valves:

T_e = maximum temperature rating of valve;
P_e = valve pressure rating at maximum temperature rating of valve;
P_a = valve pressure rating at ambient temperature or 41.4 barg (600 psig), whichever is less.

8.8.3 For Group F valves:

T_e = maximum temperature rating of the valve at 6.89 barg (100 psig);
P_e = 6.89 barg (100 psig);
P_a = valve pressure rating at ambient temperature or 41.4 barg (600 psig), whichever is less.

8.9 The elevated test temperature, test pressure while at the elevated test temperature, and test pressure while at ambient temperature shall be as follows for any valve tested per this standard.

8.9.1 The elevated test temperature shall be equal to the value established for variable T_e per 8.7 or 8.8.

8.9.2 The test pressure while at the elevated test temperature shall be the value established for variable P_e per 8.7 or 8.8.

8.9.3 The test pressure while at ambient temperature shall be the value established for variable P_a per 8.7 or 8.8.

8.10 The test valve may be equipped with a method of actuation capable of mechanically cycling the valve. The method of actuation shall not impose additional side loads on the stem or stem seal. Depending on the method of actuation, torque values may be determined by direct measurement at the valve stem or by indirect measurement of actuator input torque, force, or pressure and derived through calculation.

8.11 For torque-seated valves with offset stems, the closing torque shall be set to the manufacturer's published torque used for seat closure at the corresponding maximum test pressure. The setting shall be documented on the Fugitive Emissions Test Report in Annex A.

8.12 Running torque values shall be recorded at approximately mid-stroke on the first and last mechanical cycle of testing.

8.13 The leak measurement instrument shall be adjusted to compensate for the background methane level.

8.14 Leak measurements of the valve pressure-boundary connections shall be sniffed at the beginning and end of the test. The detector probe speed shall be approximately 25 mm (1 in.) per second. Any leak measurement that exceeds the allowable per Section 9 during the test constitutes failure of the valve. Leakage from end connections or test apparatus does not constitute valve failure but shall be corrected prior to continuing the test.

8.15 Static and dynamic stem leakage measurements shall be taken (see Figure 1).

8.15.1 To ensure leak measurements are conducted in still air, potential leak paths shall be shielded from environmental impacts with a foil (or similar) enclosure. The enclosure shall include the stem outside diameter and stem seal outside diameter.

8.15.2 Stem seal leakage measurements shall be taken within the enclosure and the maximum reading shall be recorded.

8.15.3 The static/dynamic leakage shall be recorded after a time delay of twice the response time of the instrument.

8.16 The valve shall be equipped with thermocouples for monitoring the temperature during testing. The temperature shall be monitored and recorded at two locations. Both TC-1 and TC-2 shall be controlled to within ±5 % of test temperature.

8.16.1 TC-1—adjacent to the stem seal (within ½" of the stem seal).

8.16.2 TC-2—at the external body adjacent to the flow path.

8.17 Stem seal adjustment is not allowed during valve testing.

8.18 Leak measurements shall be recorded at established intervals as detailed in 8.14, and the parameters listed in Annex A shall be reported.

8.19 Leakage rate units of measurement for methane shall be [ppmv].

8.20 The independent qualification facility or manufacturer shall issue a certificate stating that the valve successfully passed testing in accordance with API Standard 641 if the valve meets the acceptance criteria as per Section 9. When the manufacturer is the issuer of the certificate, it shall be certified by a third party inspector. The certificate shall include reference to the API Standard 641 Fugitive Emissions Test Report number recorded on the Annex A form. For graphitic packing, the API Standard 622 certificate (where applicable per Section 5) shall be provided and attached to the API Standard 641 report.

8.21 Packing gland torque values are to be recorded prior to disassembly. Valve shall be disassembled and components including stem, stem seal, gland follower, and stem seal chamber shall be inspected and the condition documented. The results of the inspection shall be provided as an attachment to the Fugitive Emissions Test Report.

As a minimum, test results shall be provided as defined by the Fugitive Emissions Test Report provided in Annex A. In addition, photographic evidence shall be documented as follows:

8.21.1 Valve marking and tagging.

8.21.2 Stem sealing area.

8.21.3 Stem bushing.

8.21.4 Stem seal gland follower.

8.21.5 Stem seal chamber interior.

8.21.6 Stem seals and spacers

8.21.7 Body seals

9 Acceptance Criteria

The Fugitive Emissions Test Report in Annex A shall indicate “pass” when the measured leakage does not exceed 100 ppmv.

10 Leak Test Equipment and Calibration

10.1 Monitoring equipment shall be certified as intrinsically safe for use with the test medium.

10.2 The equipment shall meet the following performance requirements in the flame ionization mode:

10.2.1 Maximum variation: ± 1.0 ppmv at 0 to 100 ppmv.

10.2.2 Maximum variation at leakages from 100 to 500 ppmv: ±2.5 ppmv.

10.2.3 Minimum detectable level: $\leq$ 1.0 ppmv.

10.2.4 Maximum response time to reach final value (from 0 to 100 ppmv): 10 seconds.

10.2.5 Maximum recovery time to return to 10 % of initial value (from 100 ppmv to 0): 10 seconds.

10.2.6 Sample flow rate at probe inlet: 0.5 to 1.5 L/min (0.13 to 0.40 gal/min).

10.3 The test equipment shall be inspected prior to each use to ensure against fouling of the detector probe. This shall be done per EPA Method 21 using an external calibration gas with a known methane concentration.

To increase accuracy of readings between different measuring instruments and testers, the leakage measuring device shall be calibrated to known leak rate standards daily prior to testing. A record of test equipment calibration shall be maintained by the test facility.

A porous or sintered metal/ceramic leak standard or similar device shall be used per the following procedure (see Figure 2).

10.3.1 Verify the sampling flow rate of the leakage monitoring device to be in the range of 0.5 to 1.5 L/min (0.13 to 0.40 gal/min) with a calibrated flow meter.

10.3.2 Verify the flow rate of the calibrated standard leak at a regulated differential pressure using 97 % minimum purity test gas. The calibrated standard leak shall be in the range of 0.025 to 0.075 mL/min (6.6×10^{-6} to 1.98×10^{-5} gal/min) of methane. The inverted beaker technique may be used with a sufficient amount of time to collect a measurable amount of sample. The test time shall be sufficient to fill the tubing and fittings used in the calibration setup. Regardless of the method used, calibration shall be in accordance with a formalized calibration procedure.

10.3.3 After the flow rate is verified and it is ensured that the test gas has completely saturated the calibrated leak standard, the leakage monitor probe shall be attached to the tee fitting connected to the standard.

10.3.4 Using a nominal flow rate of 1.00 L/min (0.26 gal/min), a 0.05 mL/min (1.32×10^{-5} gal/min) leak standard shall produce by definition a 0.05 / (1.00 L x 1000 mL/liter) = 0.005 % [1.32×10^{-5} / 0.26 = 0.005 %] concentration of test gas by volume or 50.0 ppmv concentration. Therefore, the reading of the leakage monitor shall be tuned to be the verified flow rate of the leak standard in mL/min times 1000 in ppmv.

10.3.5 Steps 10.3.1 through 10.3.4 shall be repeated with a methane flow rate of 0.050 mL/min to produce 50.0 ppmv ±1.0 ppmv.

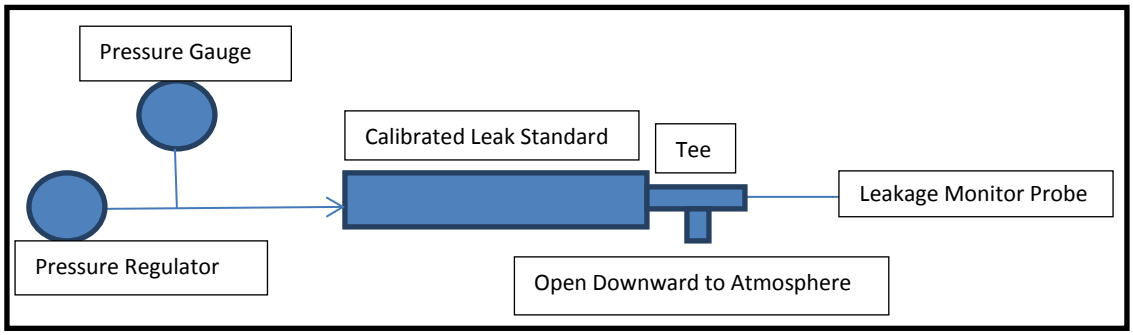

Figure 2—Calibration Setup

10.4 The emissions leak test system shall conform to all local and governmental safety standards and shall be equipped with pressure relief valve(s), rupture disc(s), and/or vents as required.

11 Valves Qualified

11.1 Valves of the same quarter-turn design as the test valve may be deemed to be qualified, subject to the following additional limitations:

11.1.1 The value for T_e, as determined by 8.7 or 8.8, is not greater than the value for T_e of the test valve.

11.1.2 The value for P_e, as determined by 8.7 or 8.8, is not greater than the value for P_e of the test valve.

11.1.3 The value for P_a, as determined by 8.7 or 8.8, is not greater than the value for P_a of the test valve.

11.1.4 Stem diameter is between one-half to two times the test valve.

11.1.5 The stem seal is of the same material, design, sealing stress, shape, and construction, independent of the seal size.

11.1.6 The dimension of the overall seal set height is between 75 % and 125 % of the test valve.

11.1.7 The type of motion, the type of obturator, the type of obturator support, the type of offset, and the type of stem support are identical.

11.1.8 Tolerance classes (grades) and surface finish specifications of all valve components that affect sealing performance are identical.

11.2 Any change in valve sealing system design including, but not limited to, stem seal material, stem seal manufacturer, or stem seal model requires a requalification.

12 Valve Marking

Valves qualified by this standard shall be clearly and permanently marked as “API 641” on the nameplate or attached to the valve as a separate metal tag.

Annex A
(normative)

Fugitive Emissions Test Report

All units of measure shall be specified

API Std. 641 Fugitive Emissions Testing Report Number:_____

Valve Type (check one):	Valve Information:
( ) Butterfly	Manufacturer:
( ) Ball	Manufacturing Facility (Location):
( ) Plug	Valve Size and Class:
( ) Other: _____	Valve Model # (S/N):
Style: _____	API/ASME Design Standard(s):
	Valve Group:

Valve Stem Seal Information:

Number of Rings:	Stem Seal Description:
O.D.:	Manufacturer:
I.D.:	Model/Type:
Stack Height:	Other Stem Seal Materials:
Stem Seal Chamber Depth:	Minimum Sealing Stress:

Valve Materials:	Valve Selection (check one):
Body:	( ) Manufacturer ( ) Purchaser
Stem:	( ) Distributor ( ) Other:_____
Body Seal:	Date Selected:_____

Personnel:	Manufacturer Published Torque Values:
Qualification Facility:	Running Torque:
Test Technician:	Closing Torque:
Third Party (if applicable):	Packing Torque:
Start Date:_____ End Date:_____	

Pretest Preparations and Adjustments (see Section 6):

Fugitive Emissions Test Report (Continued)

API 641 - TESTING DATA						
Test Segment	**Cycle Count**	**Temperature @ TC-1**	**Temperature @ TC-2**	**Static Leak Measurement**	**Dynamic Leak Measurement**	**Pressure Boundary Leak Measurement (Specify Location)**
P_a = _____	0				**N/A**	
T_a = _____	100					**N/A**
P_e = _____	101				**N/A**	**N/A**
T_e = _____	200					**N/A**
P_a = _____	201				**N/A**	**N/A**
T_a = _____	300					**N/A**
P_e = _____	301				**N/A**	**N/A**
T_e = _____	400					**N/A**
P_a = _____	401				**N/A**	**N/A**
T_a = _____	500					**N/A**
P_e = _____	501				**N/A**	**N/A**
T_e = _____	600					**N/A**
P_a = _____	601				**N/A**	**N/A**
T_a = _____	610					

Torque Measurements:

Running Torque (During First Mechanical Cycle):

Running Torque (During Last Mechanical Cycle):

Additional Data:

Avg. Cycle Time:

Final Test Results:

( ) **PASS** ( ) **FAIL**

Qualification Facility Representative:

Company: _____

Signature: _____

Date: _____

Notes:

Third-party Witness (if applicable):

Company: _____

Signature: _____

Date: _____

Annex B
(normative)

Testing Profile

The testing profile is as follows:

1. Ensure safety considerations per Section 7 are being followed.

2. Stabilize internal valve pressure to test pressure with the valve partially open.

3. Zero the calibrated leakage device to < 1 ppmv.

4. At the start (0 cycles), perform leakage tests on all static external leak paths (bonnet gasket, body gaskets, fittings, etc.), as described in 8.14.

5. Insert leakage probe into stem enclosure area, as described in 8.15.

6. After leakage reading has stabilized, record the static leakage reading. For each measurement, a minimum of ten (10) readings shall be taken over a 1-minute duration. The maximum reading shall be recorded. If the maximum reading is more than fifty percent (50 %) greater than the average of the ten, except for when the average leakage rates are less than 10 ppmv, the readings shall be repeated.

7. After the static leakage reading is achieved, cycle the valve 100 times. Leakage probe may be removed from enclosure. During the first mechanical cycle, record the running torque.

8. Repeat Steps 1, 2, 3, 5, and 6.

9. Perform one mechanical cycle. During the mechanical cycle, record maximum dynamic leakage. If a full cycle is not achievable during the 1-minute duration, the leakage recording time shall be adjusted so that the maximum reading throughout the entire cycle is recorded.

10. Heat the valve to the elevated test temperature. After temperature is reached, adjust pressure to test pressure and allow the temperature and pressure to stabilize.

11. Repeat Steps 1, 2, 3, 5, and 6.

12. After the static leakage reading is achieved, cycle the valve 99 times. Leakage probe may be removed from enclosure.

13. Repeat Steps 1, 2, 3, 5, 6, and 9.

14. Shut off heaters and allow valve to cool. Insulation removal and/or fan cooling may be done at the discretion of the laboratory considering the mass of the valve.

15. Repeat Steps 1–3 and 5–14 an additional two times. (NOTE Subsequent Step 7 mechanical cycles shall be 99 to keep cycle counts as notes in Annex A as noted.)

16. After the static leakage reading at ambient temperature and 601 mechanical cycles have been completed, cycle the valve 9 more times and repeat Steps 1, 2, 3, 5, 6, and 9.

17. Record the valve running torque during the last mechanical cycle.

18. Release pressure.

19. Disassemble valve for inspection.

Annex C
(informative)

Valve Groups Flowchart

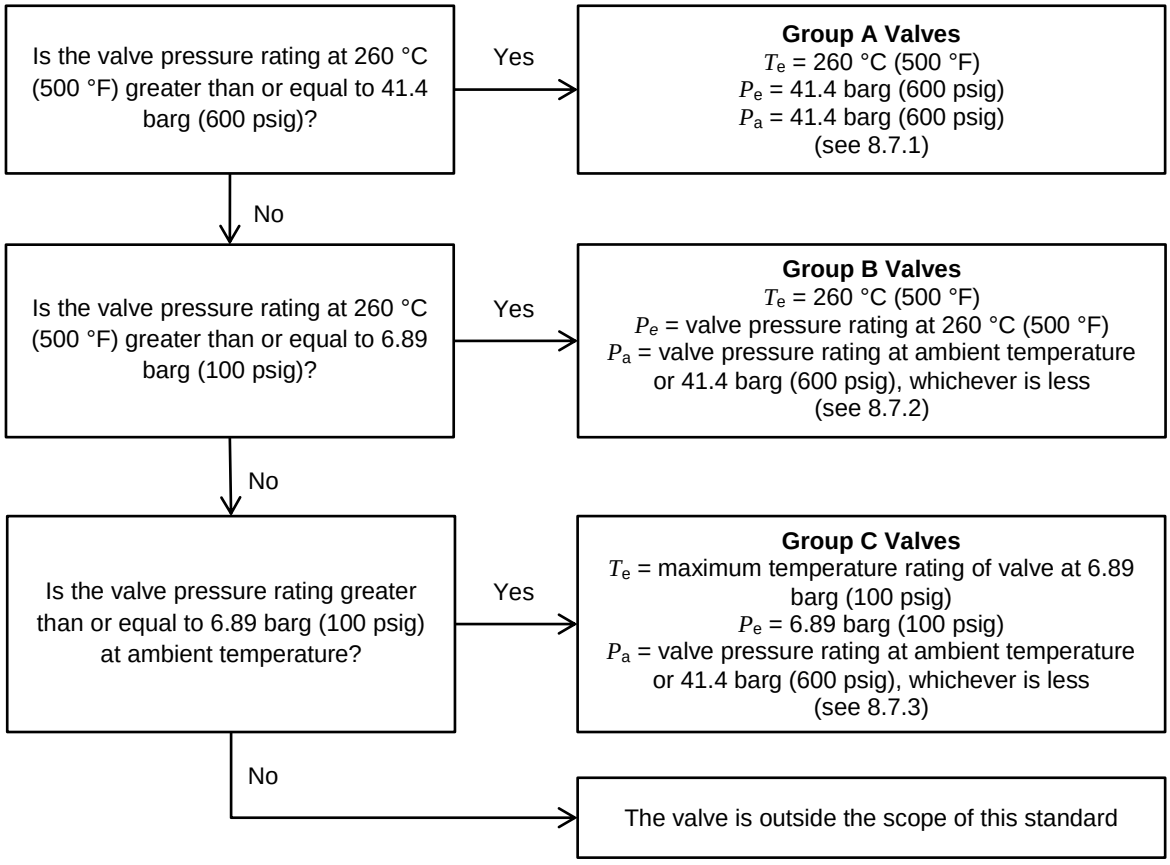

Figure C.1—Test Temperature and Pressure: Valve Temperature Rating ≥ 260 °C (500 °F)

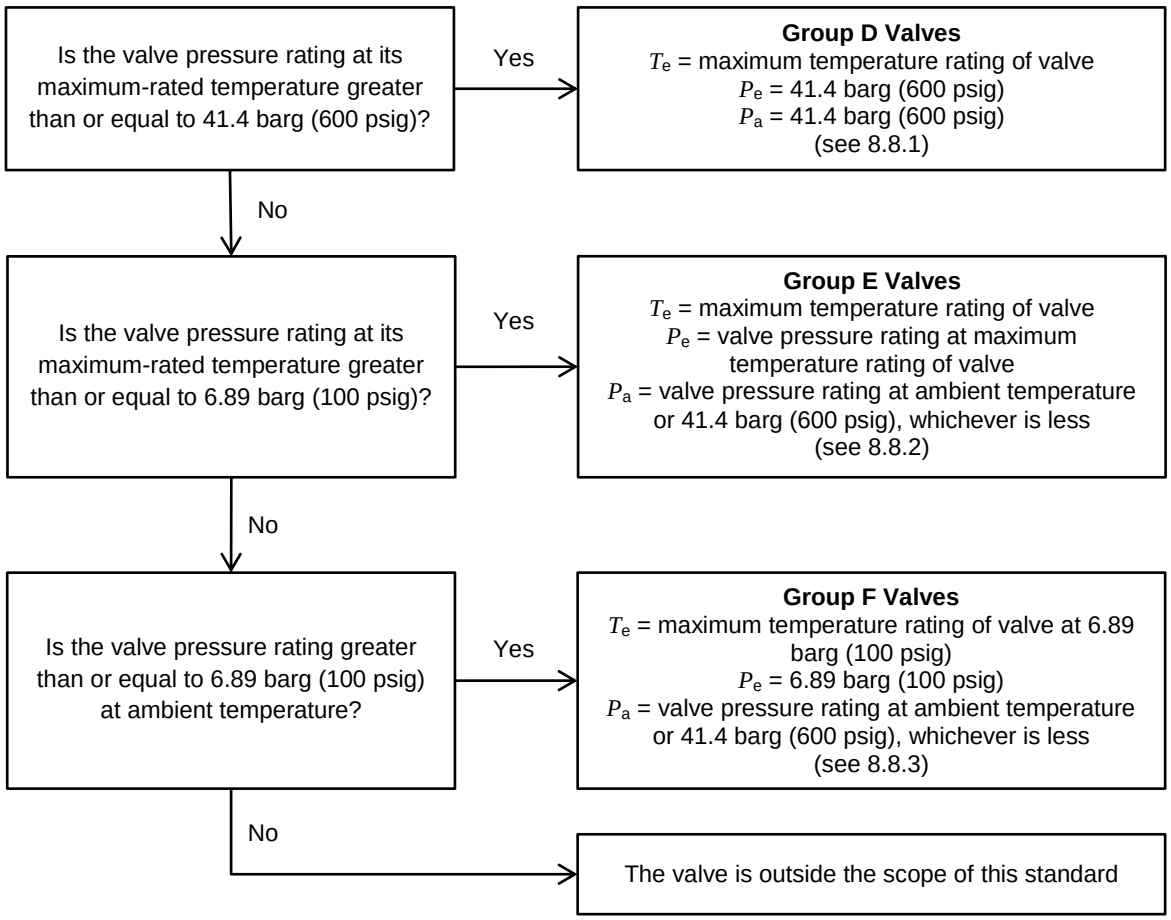

Figure C.2—Test Temperature and Pressure: Valve Temperature Rating < 260 °C (500 °F)

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