

Valve Inspection and Testing

Downstream Segment

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Notes to Purchaser

- 1) Deviations from this standard shall be specifically stated in the purchase order. This requirement includes any deviation such as those on the following list.
- 2) If no deviations are specified, then the purchase order needs only to specify testing per API 598.
- 3) If this standard is used for valves not covered by this standard, the purchaser will specify the extent to which the standard is to be applied.

Purchaser Specified Deviation List

- a) Inspections by the purchaser at the valve manufacturer's plant (see 4.1).
- b) Inspections by the purchaser outside the valve manufacturer's plant (see 4.2).
- c) Address for inspection notices (see 4.3).
- d) Any supplementary examination required (see 4.6).
- e) Type of backseat test (see 5.3.2).
- f) Low-pressure closure test (see 5.3.3, 5.3.4 and 6.4).
- g) High-pressure closure test (see 5.3.3, 5.3.4, 5.4 and 6.5).
- h) High-pressure pneumatic shell test (see 5.5).
- i) Double block and bleed high-pressure closure test (see 6.6).
- j) Test fluid (see 5.6).
- k) Use of a wetting agent in the test water (see 5.6.4).
- l) Certificate of compliance (see 7.1).

Valve Inspection and Testing

1 Scope

1.1 This standard covers inspection, examination, supplementary examinations, and pressure test requirements for resilient-seated, nonmetallic-seated (e.g. ceramic), and metal-to-metal-seated valves of the gate, globe, plug, ball, check, and butterfly types. Resilient seats are considered to be:

- a) soft seats, both solid and semi-solid grease type (e.g. lubricated plug);
- b) combination soft and metal seats;
- c) any other type valve designed to meet resilient seat leakage rates as specified in Table 6.

API 598 supplements the API standards that reference it, but it may also be applied to other types of valves by agreement between the purchaser and the valve manufacturer.

1.2 The inspection requirements pertain to examinations and testing by the valve manufacturer and any supplementary examinations that the purchaser may require at the valve manufacturer's plant. The test requirements cover both required and optional pressure tests at the valve manufacturer's plant, or at a facility mutually agreeable to both the manufacturer and purchaser.

1.3 The following tests and examinations are specified in this standard:

- a) shell test,
- b) backseat test,
- c) low-pressure closure test,
- d) high-pressure closure test,
- e) double block and bleed high-pressure closure test,
- f) visual examination of castings by the manufacturer,
- g) high-pressure pneumatic shell test.

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 594, *Check Valves: Flanged, Lug, Wafer and Butt-welding*

API Standard 599, *Metal Plug Valves—Flanged, Threaded and Welding Ends*

API Standard 600, *Steel Gate Valves—Flanged and Butt-welding Ends, Bolted Bonnets*

API Standard 602, *Steel Gate, Globe and Check Valves for Sizes DN 100 and Smaller for the Petroleum and Natural Gas Industries*

API Standard 603, *Corrosion-Resistant, Bolted Bonnet Gate Valves—Flanged and Butt-Welding Ends*

API Standard 608, *Metal Ball Valves—Flanged, Threaded and Butt-Welding Ends*

API Standard 609, *Butterfly Valves: Double-flanged, Lug- and Wafer-type*

API Recommended Practice 591, *Process Valve Qualification Procedure*

API Recommended Practice 621, *Reconditioning of Metallic Gate, Globe, and Check Valves*

ASME B16.11 ¹, *Forged Fittings, Socket-Welding and Threaded*

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

MSS SP-45 ², *Bypass and Drain Connections*

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components—Visual Method for Evaluation of Surface Irregularities*

MSS SP-91, *Guidelines for Manual Operation of Valves*

3 Terms and Definitions

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

3.1

backseat test

A pressure test used to verify leakage past the stem or shaft to bonnet seal (backseat).

3.2

class

A dimensionless number used to designate the pressure-temperature rating of a valve or piping component.

3.3

closure test

Pressure test used to confirm leakage past or through a valve's closure mechanism.

3.4

cold working pressure

CWP

Rated pressure at ambient temperature.

3.5

diameter nominal

DN

An alpha numeric designation of size that is common for components used in a piping system, used for reference purposes, comprising the letters DN followed by a dimensionless number indirectly related to the physical size of the bore or outside diameter of the end connection as appropriate. The dimensionless number following DN does not represent a measurable value and is not used for calculation purposes except where specified in ASME B16.34. DN usage is applicable to steel valves bearing PN designations.

¹ ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.

² Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, www.mss-hq.com.

3.6**double block and bleed valve**

Valve with two seating surfaces that when in the closed position, blocks flow from both valve ends when the cavity between the seating surfaces is vented through a bleed connection provided in the body cavity.

3.7**nominal pipe size****NPS**

An alpha numeric designation of size that is common for components used in a piping system, used for reference purposes, comprising the letters NPS followed by a dimensionless number indirectly related to the physical size of the bore or outside diameter of the end connection as appropriate. The dimensionless size identification number following NPS does not represent a measurable value and is not used for calculation purposes except where specified in ASME B16.34. Prefix NPS usage is applicable to steel valves bearing class designations.

3.8**shell test**

A pressure test in excess of the cold-working-pressure, CWP, rating of the valve for the purpose of validating the soundness and strength of the valve pressure containing structures.

3.9**visually detectable leakage**

Leakage during a valve pressure test, either through or past a pressure boundary or closure member that is validated by normal vision.

4 Inspection, Examination, and Supplementary Examination**4.1 Inspection at the Valve Manufacturer's Plant**

The purchaser shall specify in the purchase order his intention to inspect valves and witness tests and examinations at the valve manufacturer's plant. The purchaser's inspector shall have free access to any part of the plant concerned with manufacture of the valves whenever work on the order is under way.

4.2 Inspection Outside the Valve Manufacturer's Plant

When the valve purchaser specifies that the inspection will include shell components manufactured at locations other than the valve manufacturer's plant, these components shall be subject to the valve purchaser's inspection at the location where they are manufactured.

4.3 Inspection Notice

When inspection by the purchaser is specified, the valve manufacturer shall notify the purchaser five working days prior to the required valve testing and any specified supplementary inspections or examinations, addressing the notice as stated in the purchase order. The valve manufacturer shall also give the purchaser five working days' notice of where and when shell components manufactured outside the valve manufacturer's plant may be inspected, if such inspection is required.

4.4 Extent of Inspection

The extent of inspection may be specified in the purchase order and, unless otherwise indicated, will be limited to the following.

- a) Inspection of the valve during assembly to ensure compliance with the specifications of the purchase order. Inspection may include the use of specified nondestructive methods.
- b) Witnessing of the required and specified optional pressure tests and examinations.

- c) Witnessing of any supplementary examinations (see 4.6).
- d) Review of mill records and nondestructive examination records (including specified radiographs).

4.5 Examination

4.5.1 A visual examination shall be performed by the valve manufacturer on all castings of bodies, bonnets, covers, and closure elements to assure conformance with MSS SP-55.

4.5.2 Each valve shall be examined to assure compliance with this standard and the referenced purchase specification (e.g. API 599).

4.5.3 All examinations shall be performed in accordance with written procedures that comply with the applicable standards.

4.6 Supplementary Examination

Supplementary types of examination are required only if specified in the purchase order and only to the extent specified. Magnetic particle, radiographic, liquid penetrant, and ultrasonic examination of steel castings or forgings shall be in accordance with Part 8 of ASME B16.34 or with the purchaser's own procedures and acceptance criteria, if so specified. These examinations shall be made by the valve manufacturer subject to witnessing by the purchaser's inspector.

5 Pressure Tests

5.1 Test Location

Pressure tests shall be performed by the valve manufacturer at the valve manufacturer's plant or at a facility mutually agreeable to both the manufacturer and purchaser.

5.2 Test Equipment

The equipment used by the valve manufacturer to perform the required pressure tests shall not apply external forces that affect seat leakage. If an end-clamping fixture is used, the valve manufacturer shall be able to demonstrate that the test fixture does not affect the seat sealing capability of the valve being tested. End clamping is allowed for valves designed to function between mating flanges, such as wafer check and wafer butterfly valves.

5.3 Tests Required

5.3.1 The pressure tests listed in Table 1 or Table 2 shall be performed on each valve in accordance with written procedures that comply with this standard.

5.3.2 At the manufacturer's option, the backseat test for valves that have the backseat feature may be either a high-pressure or a low-pressure test unless stated otherwise in the purchase order.

5.3.3 Valves DN 100 (NPS 4) and smaller, having pressure ratings up to and including ASME Class 1500, and valves larger than DN 100 (NPS 4), having pressure ratings up to and including ASME Class 600, shall be tested in accordance with Table 1. The purchaser may elect to require an "optional" pressure test in Table 1.

5.3.4 Valves DN 100 (NPS 4) and smaller, having pressure ratings greater than ASME Class 1500, and valves larger than DN 100 (NPS 4), having pressure ratings greater than ASME Class 600, shall be tested in accordance with Table 2. The purchaser may elect to require an "optional" pressure test in Table 2.

5.3.5 Leakage rates for reduced port valves shall be based upon the DN (NPS) of the valve.

Valves: DN (NPS) $\leq$ DN 100 (NPS 4) and ASME Class $\leq$ 1500
 DN (NPS) $>$ DN 100 (NPS 4) and ASME Class $\leq$ 600

Valves: DN (NPS) $\leq$ DN 100 (NPS 4) and ASME Class > 1500
 DN (NPS) $>$ DN 100 (NPS 4) and ASME Class > 600

5.4 High-pressure Closure Test

The high-pressure closure test is required for several valve types, as shown in Table 1 and Table 2. For the valve types for which, according to Table 1 and Table 2, the high-pressure closure test is optional, the valves are still required to be able to pass the test (as a test of the design of the valve closure structure). Results of tests confirming the capacity of the valve design to pass the high-pressure closure test shall be supplied when requested in the inquiry purchase requisition, or by the purchaser. See Table 4, Footnotes b and c for calculation of test pressure.

5.5 High-pressure Pneumatic Shell Test

When specified by the purchase order, a high-pressure pneumatic shell test shall be performed. This test shall be performed after the shell test, using appropriate safety precautions. The pneumatic shell test pressure shall be 110 % of the maximum allowable pressure at 38 °C (100 °F) or as specified in the purchase order. Visible leakage is not allowed.

5.6 Test Fluid

5.6.1 For shell, high-pressure backseat, and high-pressure closure tests, the test fluid shall be air, inert gas, kerosene, water, or a noncorrosive liquid with a viscosity not higher than that of water. Unless otherwise specified in the purchase requisition, the test fluid temperature shall be within the range 5 °C (41 °F) to 50 °C (122 °F).

5.6.2 For the low-pressure closure and low-pressure backseat tests, the test fluid shall be air or inert gas.

5.6.3 When air or gas is used for closure, shell, or backseat tests, the valve manufacturer shall be capable of demonstrating the adequacy of the method of leakage detection.

5.6.4 Water used for any test may contain water-soluble oil or rust inhibitor. When specified by the purchaser, a wetting agent shall be included in the water. For testing of austenitic stainless steel valves, water with chloride content not exceeding 100 ppm shall be used. The valve manufacturer shall be able to document the chloride content.

5.7 Test Pressures

5.7.1 The shell test pressure shall be as listed in Table 3.

5.7.2 Other test pressures shall be as listed in Table 4.

5.8 Test Duration

For each type of test, the required test pressure shall be maintained for at least the minimum time specified in Table 5.

5.9 Test Leakage

5.9.1 Shell, Stem Seals, and Backseat

5.9.1.1 For shell tests, visually detectable leakage through the pressure boundary walls and any fixed body joint is not permitted.

5.9.1.2 For backseat tests, visually detectable leakage is not permitted.

5.9.1.3 For valves with adjustable stem seals, leakage through the stem seals during the shell test shall not be cause for rejection. However, the manufacturer shall demonstrate that the stem seals are capable of retaining pressure at least equal to the 38 °C (100 °F) valve rating without visible leakage.

Table 3—Shell Test Pressures

Valve Type	Class	Shell Test Pressure (Minimum)	
		Bar Gauge	Pounds per Square Inch Gauge (psig)
ductile iron	150	26	400
	300	66	975
cast iron	125		
DN 50 to 300 (NPS 2 to 12)		25	350
DN 350 to 1200 (NPS 14 to 48)		19	265
cast iron	250		
DN 50 to 300 (NPS 2 to 12)		61	875
DN 350 to 600 (NPS 14 to 24)		37	525
steel			
flanged	150 to 2500	b	b
butt weld	150 to 4500	b	b
threaded ^a and socket weld	800	c	c
	150 to 4500	b	b
^a ASME B16.34 limits threaded-end valves to Class 2500 and lower. ^b Per ASME B16.34. ^c For Class 800 valves, the shell test pressure shall be 1 1/2 times the pressure rating at 38 °C (100 °F), rounded off to the next higher bar (25 psig), (see Table 2 of API 602).			

5.9.1.4 For valves with nonadjustable stem seals (O-rings, fixed single rings, and the like), visually detectable leakage during the shell test is not permitted.

5.9.1.5 Where no visual detectable leakage is permitted, the following definitions apply:

- a) if the test fluid is a liquid, there shall be no visible evidence of drops or wetting of the external surfaces of the test valve;
- b) if the test fluid is air or inert gas, no leakage will be revealed by the established detection method.

5.9.2 Closure

5.9.2.1 For both the low-pressure closure test and the high-pressure closure test, visual evidence of leakage through the disk, behind the seat rings, or past the shaft seals (of valves that have this feature) is not permitted and structural damage is not permitted. [Plastic (permanent) deformation of resilient seats and seals is not considered structural damage.] The allowable rate for leakage of test fluid at the seat-sealing surface interface, for the duration of the tests, is listed in Table 6.

5.9.2.2 The allowable leakage rate for closure tests of valves with nonmetallic (e.g. ceramic) seat materials shall be equal to that specified in Table 6 for a metal-seated valve of equivalent size and type.

Table 4—Other Test Pressures

Test	Test Pressure ^d	
	Bar Gauge	Pounds per Square Inch Gauge (psig)
Valves Except Butterfly and Check		
high-pressure closure and backseat ^a	b	b
low-pressure closure and backseat ^a	4 to 7	60 to 100
Butterfly Valve		
high-pressure closure	c	c
low-pressure closure	4 to 7	60 to 100
Check Valve		
high-pressure closure		
Class 125 (cast iron)		
DN 50 to 300 (NPS 2 to 12)	14	200
DN 350 to 1200 (NPS 14 to 48)	11	150
Class 250 (cast iron)		
DN 50 to 300 (NPS 2 to 12)	35	500
DN 350 to 600 (NPS 14 to 24)	21	300
Class 150 (ductile iron)	17	250
Class 300 (ductile iron)	44	640
carbon, alloy, stainless steel, and special alloys	b	b
low-pressure closure (see Table 1 and Table 2)	4 to 7	60 to 100
^a The backseat test is required for all valves that have this feature. ^b 110 % of maximum allowable pressure at 38 °C (100 °F) in accordance with the applicable purchase specification. ^c 110 % of design differential pressure at 38 °C (100 °F) in accordance with the applicable purchase specification. ^d Single values shown are minimum test pressures. A range of values indicates both minimum and maximum test pressures.		

6 Pressure Test Procedures

6.1 General

6.1.1 Valves designed to permit emergency or supplemental introduction of an injectable sealant to the seat area shall be tested with the injection system empty and not in use, except for lubricated plug valves.

6.1.2 When a liquid is used as the test fluid, the valve shall be essentially free from trapped air during the test.

6.1.3 Required protective coatings, such as paint, which may mask surface defects, shall not be applied to any surface before inspection or pressure testing. (Phosphatizing and similar chemical conversion processes used to protect valve surfaces are acceptable even if applied before the tests, provided that they will not seal off porosity.)

Table 5—Duration of Required Test Pressure

Valve Size		Minimum Test Duration (Seconds) ^a			
DN	NPS	Shell	Backseat (for Valves with Backseat Feature)	Closure Check Valves (API 594)	Closure Other Valves
≤ 50	≤ (2)	15	15	60	15
65 to 150	(2 1/2 to 6)	60	60	60	60
200 to 300	(8 to 12)	120	60	120	120
≥ 350	≥ (14)	300	60	120	120

^a The test duration is the period of inspection after the valve is fully prepared and is under full pressure.

6.1.4 When closure testing valves, the valve manufacturer's test procedure shall ensure that excessive force is not used to close the valve. The applied force may be determined from the appropriate figures in MSS SP-91, but in any case shall not exceed the values published by the valve manufacturer.

6.1.5 The valve shall be visually examined for leakage after it has been fully prepared and is under full test pressure.

6.2 Backseat Test

6.2.1 The backseat test is required for all valves, except for bellows seal valves, that have the backseat feature and shall be performed by applying pressure inside the assembled valve with the valve ends closed, the valve fully open, and the packing gland loose or packing not installed. If the backseat test is performed after the shell test, the packing shall be installed and/or packing glands retightened after the backseat test.

6.2.2 For valves DN 100 (4 in. NPS) and smaller, the backseat test may be combined with the shell test when volumetric devices are used to monitor leakage from the shell and backseat. When tested by this method, the packing shall be loose. The manufacturer shall be responsible for demonstrating that the packing will not leak at the valve's rated pressure at 38 °C (100 °F).

6.2.3 The successful completion of the backseat test shall not be construed as recommendation by the valve manufacturer that, while the valve is pressurized, the valve may be repacked or packing may be replaced.

6.3 Shell Test

Except as provided in 6.2.2, the shell test shall be made by applying the pressure inside the assembled valve with the valve ends closed, the valve partially open, and any packing gland tight enough to maintain the test pressure, thereby, except for bellows seal valves, testing the stuffing box.

6.4 Low-pressure Closure Test

6.4.1 The low-pressure closure test shall be performed with the seat sealing surface interface clean and free from oil, grease, and sealant. If necessary to prevent galling, the sealing surfaces may be coated with a film of oil that is not heavier than kerosene. This requirement does not apply to a valve that uses a lubricant as its primary seal (e.g. lubricated plug valves).

6.4.2 Any leakage at the seat sealing surface interface, behind the seat ring, or through the disk on the open side of the valve shall be detected when bubbles are observed coming from the closure (disk, seat, and seat ring), covered with water.

Table 6—Maximum Allowable Leakage Rates for Closure Tests

Valve Size		All Resilient Seated Valves	Metal Seated Valves Except Check		Metal Seated Check Valves		
DN (mm)	NPS (in.)		Liquid Test ^a (drops/minute)	Gas Test (bubbles/minute)	Liquid Test (cc/min)	Gas Test (m ³ /h)	Gas Test (ft ³ /h)
≤ 50	≤ 2	0	0 ^b	0 ^b	6	0.08	3
65	2 1/2	0	5	10	7.5	0.11	3.75
80	3	0	6	12	9	0.13	4.5
100	4	0	8	16	12	0.17	6
125	5	0	10	20	15	0.21	7.5
150	6	0	12	24	18	0.25	9
200	8	0	16	32	24	0.34	12
250	10	0	20	40	30	0.42	15
300	12	0	24	48	36	0.50	18
350	14	0	28	56	42	0.59	21
400	16	0	32	64	48	0.67	24
450	18	0	36	72	54	0.76	27
500	20	0	40	80	60	0.84	30
600	24	0	48	96	72	1.01	36
650	26	0	52	104	78	1.09	39
700	28	0	56	112	84	1.18	42
750	30	0	60	120	90	1.26	45
800	32	0	64	128	96	1.34	48
900	36	0	72	144	108	1.51	54
1000	40	0	80	160	120	1.68	60
1050	42	0	84	168	126	1.76	63
1200	48	0	96	192	144	2.02	72

^a For the liquid test, 1 mL is considered equivalent to 16 drops.

^b There shall be no leakage for the minimum specified test duration (see Table 5). For liquid test, 0 drops means no visible leakage per minimum specified test duration. For gas test, 0 bubbles means less than 1 bubble per minimum specified test duration.

As an alternative, displacement measuring devices may be used, provided that the detectable leakage rate is equivalent to that given in Table 6, the valve manufacturer can demonstrate and validate that the procedure yields results equivalent to the requirements of this standard, and the device has been accepted by agreement between the purchaser and the manufacturer. Bubbler testing, when used for valves larger than DN 50 (NPS 2), shall only be acceptable when agreed to by the purchaser.

When volumetric devices (bubblers) are used to measure leakage, the test duration shall not begin until flow through the test tubing is established and stabilized. The device shall be calibrated to yield results equivalent to the units per minute listed in Table 6. Volumetric devices shall be calibrated with the same test fluid and at the same temperature as used for the production tests.

6.4.3 When closure testing gate, plug, and ball valves, a method of testing seat leakage shall be used that fills and fully pressurizes the body cavity to the test pressure between the seats and the bonnet area, as applicable, with the test fluid. This will ensure that no seat leakage can escape detection because of gradual filling of these volumes during the test period.

For a valve (other than a double block and bleed valve or globe valve) designed to close against pressure from either direction, the pressure shall be applied successively to each side of the closed valve with the other side open to the atmosphere to check for leakage at the atmospheric side of the closure. For a globe valve, pressure shall be applied in one direction with the pressure applied under the disk.

For a valve designed to close against pressure from one direction only and so marked, the pressure shall be applied on the pressure side of the valve only. For a check valve, the pressure shall be applied on the downstream side.

A closure test is required only in one direction for butterfly valves furnished with encapsulation or resilient internal liners and designed for use with Class 125 or Class 150 flanges (API 609, Category A valves). For other resilient-seated butterfly valves (API 609, Category B valves), the closure test is required in both directions. For butterfly valves with a preferred flow direction, the closure test in the nonpreferred direction shall be based on the reduced differential pressure rating in that direction.

6.4.4 Trapping test air or gas in the body cavity between the seats of a one-piece (solid or flexible) wedge gate valve and subsequently covering the seats with water or coating them with soap or a similar solution does not constitute an acceptable low-pressure closure test.

6.4.5 If a tapped connection in the body cavity is made to permit testing procedures described under double block and bleed valve in 6.6.1, the connection shall be in accordance with MSS SP-45 and shall be fitted before shipment with a solid pipe plug (in accordance with ASME B16.11) whose material composition is equivalent to that of the valve shell.

6.5 High-pressure Closure Test

The procedure for the high-pressure closure test shall be the same as the procedure for the low-pressure closure test except that, in the case of a liquid test, leakage shall be detected when drops, not bubbles as described in 6.4 are observed.

6.6 Double Block and Bleed High-pressure Closure Test

For a double block and bleed valve, the pressure shall be applied successively to each side of the closure through the valve port. Leakage into the body cavity shall be checked through an opening in the bottom of the valve (Position "G" per ASME B16.34). Where operational considerations do not allow for an opening in the bottom of the valve, an alternative opening location may be specified by the purchaser, and the valve shall be double block and bleed tested in a position that results in the alternative opening location being at the bottom of the valve during test. Testing in all positions and specifically in alternative positions will require procedures that meet the requirement of 6.1.2. Test duration shall be no less than twice (2×) the values provided in Table 5.

7 Valve Certification and Retesting

7.1 Certificate of Compliance

When specified by the purchaser, the valve manufacturer shall submit to the purchaser a certificate of compliance as required in the purchase order.

7.2 Retesting

A completed valve does not require retesting unless inspection by the purchaser is specified in the purchase order. This retesting may be waived by the purchaser's inspector upon written certification by the manufacturer that the valve has been inspected, tested, and examined for conformance with the requirements of this standard. Painted valves need not have paint removed for retesting. Stored valves shall be commercially cleaned before retesting and before shipment.