

Leak testing of Valves

Standards for acceptable Rates of Valve Leakage

American Petroleum Institute (API)

The API standard 598: Valve Inspection and Testing, covers the testing and inspection requirements for gate, globe, check, ball, plug & butterfly valves. It has acceptable leakage rates for liquid as well as gas testing. All valves built to the various API standards are required to meet API-598 leakage criteria prior to shipment from the manufacturer or supplier.

API 598 states for shell and backseat tests, no visible leakage is permitted. If the fluid is a liquid, there shall be no visible evidence of drops or wetting of the external surfaces (no visible leakage through the body, body liner, if any, and body-to-bonnet joint and no structural damage).

If the test fluid is air or gas, no leakage shall be revealed by the established detection method. 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 (Plastic deformation of resilient seats and seals is not considered structural damage). The allowable rate for leakage of test fluid past the seats, for the duration of the tests, is listed in the following table:

Valve Size NPS	All Resilient Seated Valves	All Metal-Seated Valves (except Check Valves)		Metal-Seated Check Valves	
		Liquid Test (drops/min.)	Gas Test (bubbles/min.)	Liquid Test (drops/min.)	Gas Test (bubbles/min.)
< 2	0	0 (1)	0 (1)	(2)	(3)
2 - 6	0	12	24	(2)	(3)
8 - 12	0	20	40	(2)	(3)
> 12	0	28	56	(2)	(3)

General Notes:

- 1 milliliter is considered equivalent to 16 drops.
- For check valves larger than NPS 24, the allowable leakage rate shall be per agreement between purchaser and manufacturer.

Notes:

1. There shall be no leakage for the minimum specified test duration. For liquid test, 0 drop means no visible leakage per minimum specified test duration. For gas test, 0 bubble means less than 1 bubble per minimum specified test duration.
2. The maximum permissible leakage rate shall be 0.18 cubic inch (3 cubic centimeters) per minute per inch of nominal pipe size.
3. The maximum permissible leakage rates shall be 1.5 standard cubic feet (0.042 cubic meter) of gas per hour per inch of nominal pipe size.

Manufacturer's Standardisation Society (MSS)

VB VALVES & AUTOMATION

The MSS standard MSS-SP-61: Pressure Testing of Valves was originally adopted in 1961. It was developed for the purpose of providing a uniform means of testing valves commonly used in the "full open" and "full closed" type of service. It is not intended for use with control valves. Refer to standard ANSI/FCI 70-2 for Control Valves.

Section 5 of their Pressure Testing of Steel Valves, relates to seat closure tests, and defines the following leakage rates:

- Gate, Globe, Ball valves
10 cc/hr per inch of nominal pipe diameter (Example: A 6" globe valve is allowed to leak 60 cc/hr in a test)
- Check valves
40 cc/hr per inch of nominal pipe diameter

All shutoff or isolation valves specified to MSS-SP-61 must pass the above standards. The seat closure test must be performed at a fluid (liquid or gas) pressure no less than 1.1 times the 1000°F (380°C) rating rounded to the next 5 psi (0.5 bar).

American National Standards Institute (ANSI)

The ANSI standard FCI 70-2: Control Valve Seat Leakage, establishes a series of six seat leakage classes for control valves and defines the test procedures.

Class I. Is also know as dust tight and can refer to metal or resilient seated valves.

Class II. This class establishes the maximum permissible leakage generally associated with commercial double-seat control valves or balanced single-seat control valves with a piston ring seal and metal-to-metal seats.

Class III. This class establishes the maximum permissible leakage generally associated with Class II (4.2.2), but with a higher degree of seat and seal tightness.

Class IV. This class establishes the maximum permissible leakage generally associated with commercial unbalanced single-seat control valves and balanced single-seat control valves with extra tight piston rings or other sealing means and metal-to-metal seats.

Class V. This class is usually specified for critical applications where the control valve may be required to be closed, without a blocking valve, for long periods of time with high differential pressure across the seating surfaces. It requires special manufacturing, assembly and testing techniques. This class is generally associated with metal seat, unbalanced single-seat control valves or balanced single-seat designs with exceptional seat and seal tightness.

CLASS VI. This class establishes the maximum permissible seat leakage generally associated with resilient seating control valves either unbalanced or balanced single-seat with "O" rings or similar gapless seals.

Leakage Class	Maximum Leakage Allowable	Test Medium	Test Pressure	Test Procedure

VB VALVES & AUTOMATION

I	No test required, as long as purchaser and vendor both agree.
II	0.5% of rated capacity	Air or water at 50-125°F (10-52°)	45-60 psig or max. operating differential whichever is lower	Pressure applied to valve inlet with outlet open to atmosphere or connected to a low head loss measuring device full normal closing thrust provided by actuator.
III	0.1% of rated capacity	As above	As above	As above
IV	0.01% of rated capacity	As above	As above	As above
V	0.0005 ml per minute of water per inch of port diameter per psi differential	Water at 50 to 125°F (10 to 52°C)	Max service pressure drop across valve plug, not to exceed ANSI body rating.	Pressure applied to valve inlet after filling entire body cavity and connected piping with water and stroking valve plug closed. Use net specified max actuator thrust, but no more, even if available during test. Allow time for leakage flow to stabilize.
VI	Not to exceed amounts shown in following table based on port diameter.	Air or nitrogen at 50 to 125 F (10to52C)	50 psig or max rated differential pressure across valve plug whichever is lower.	Actuator should be adjusted to operating conditions specified with full normal closing thrust applied to valve plug seat. Allow time for leakage flow to stabilize and use suitable measuring device.

CONTROL VALVE SEAT LEAKAGE CLASSIFICATIONS

Nominal Port Diameter Inches	Nominal Port Diameter mm	Leak Rate ml/min	Leak Rate bubbles/min
3	76	0.9	6
4	102	1.7	11
6	152	4	27
8	203	6.75	45

VB VALVES & AUTOMATION

10	250	11.1	...
12	300	16	...
14	350	21.6	...
16	400	28.4	...

Note:

Bubbles per minute as tabulated are a suggested alternative based on a suitable calibrated measuring device, in this case a 0.25-inch OD X 0.032-inch wall tube submerged in water to a depth of from 1/8 to 1/4 inch.

The tube end shall be cut square and smooth with no chamfers or burrs. The tube axis shall be perpendicular to the surface of the water. Other measuring devices may be constructed and the number of bubbles per minute may differ from those shown as long as they correctly indicate the flow in milliliters per minute.

International organization for standardization (ISO)

The purpose of ISO standard 5208: Industrial valves - Pressure testing of metallic valves, is the establishment of basic requirements and practices for pressure testing valves of various configurations that are used in general purpose, power generation, petroleum, and petrochemical or allied industry applications. The intent is to provide a consistent set of procedural requirements and acceptance criteria that can be considered in conjunction with valve specific standards appropriate for specific applications. Account has been taken of the valve testing requirement needs of EN 12266 and API 598 with requirements referenced for PN designated valves for the former and Class designated valves for the latter.

Prescribed pressure tests								
TEST	DN	PN OR CLASS	GATE VALVE	GLOBE VALVE	PLUG VALVE (A)	CHECK VALVE	FLOATING BALL OR DIAPHRAGM VALVE	BUTTERFLY OR TRUNNION MOUNTED BALL VALVE
SHELL TEST LIQUID	ALL	ALL	REQUIRED	REQUIRED	REQUIRED	REQUIRED	REQUIRED	REQUIRED
SHELL TEST GAS	ALL	ALL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL
BACKSEAT TEST (B, C) LIQUID	ALL	ALL	OPTIONAL	OPTIONAL	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED

VB VALVES & AUTOMATION

CLOSURE TEST GAS LOW-PRESSURE	DN ≤ 100	CLASS ≤ 1500 AND PN ≤ 250	REQUIRED	OPTIONAL	REQUIRED	OPTIONAL	REQUIRED	REQUIRED
		CLASS >1500 AND PN >250	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	REQUIRED	OPTIONAL
	DN >100	CLASS ≤ 600 AND PN ≤ 100	REQUIRED	OPTIONAL	OPTIONAL	OPTIONAL	REQUIRED	REQUIRED
		CLASS >600 AND PN >100	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	REQUIRED	OPTIONAL
CLOSURE TEST LIQUID HIGH-PRESSURE	DN ≤ 100	CLASS ≤ 1500 AND PN ≤ 250	OPTIONAL	REQUIRED	OPTIONAL	REQUIRED	OPTIONAL	OPTIONAL
		CLASS >1500 AND PN >250	REQUIRED	REQUIRED	REQUIRED	REQUIRED	OPTIONAL	REQUIRED
	DN >100	CLASS ≤ 600 AND PN ≤ 100	OPTIONAL	REQUIRED	OPTIONAL	REQUIRED	OPTIONAL	OPTIONAL
		CLASS >600 AND PN >100	REQUIRED	REQUIRED	REQUIRED	REQUIRED	OPTIONAL	REQUIRED

Notes:

1. Successful completion of an optional test does not relieve the manufacturer from also successfully completing the required test.
2. In the case of resilient seated valves, a high-pressure closure test may degrade subsequent closure sealing performance in low-pressure applications.
 - (A) Plug valves that rely on a sealing compound to effect a closure seal may be closure tested with the compound installed.

VB VALVES & AUTOMATION

- (B) Successful completion of a backseat test should not be interpreted as a recommendation by the valve manufacturer that, while an installed valve is pressurized, the stem seal may be altered, repaired or replaced when backseated.
- (C) In the case of bellows stem sealed valves, a backseat test is not required.

Maximum allowable closure test leakage rate											
TEST FLUID	UNIT LEAKAGE RATES	RATE A	RATE AA	RATE B	RATE C	RATE CC	RATE D	RATE E	RATE EE	RATE F	RATE G
LIQUID	MM3/S	(1)	0.006 X DN	0.01 X DN	0.03 X DN	0.08 X DN	0.1 X DN	0.3 X DN	0.39 X DN	1 X DN	2 X DN
	DROPS/S		0.0001 X DN	0.00016 X DN	0.0005 X DN	0.0013 X DN	0.0016 X DN	0.0048 X DN	0.0062 X DN	0.016 X DN	0.032 X DN
GAS	MM3/S	(1)	0.18 X DN	0.3 X DN	3 X DN	22.3 X DN	30 X DN	300 X DN	470 X DN	3000 X DN	6000 X DN
	BUBBLES/S		0.003 X DN	0.0046 X DN	0.0458 X DN	0.3407 X DN	0.4584 X DN	4.5837 X DN	7.1293 X DN	45.837 X DN	91.673 X DN

Notes:

- (1) No visually detectable leakage for the duration of the test
1. The leakage rates only apply when discharging test fluid to the atmosphere.
 2. The closure leakage rate that applies is either that identified in a valve product standard or a leakage rate identified in a purchaser's valve procurement purchase order that is more stringent than that specified in the product standard.
 3. The meaning of "No visually detectable leakage" is that there is no visible weeping or leakage in the form of drops or bubbles.
 4. There is a loosely defined correspondence between the leakage rate acceptance values of API 598 and the leakage values Rate A as applied to DN ≤50, Rate AA-Gas and Rate CC-Liquid for other than metal seated check valves and for check valves Rate EE-Gas and Rate G-Liquid. Rates A, B, C, D E, F and G correspond to values in EN 12266-1.

Types of Leakage

There are two types of leakage from a valve, namely; fugitive emissions from the valve to atmosphere, and leakage through the valve but contained within the piping system. Fugitive emissions can both be detrimental to the environment and a potential safety hazard. Valves are considered to be the major contributors to fugitive emission losses. Leakage through the valve can also be a safety hazard, and can be detrimental to the process.

Reasons that Valves leak

Common causes of leakage through the valve include:

- Valve is not fully closed. This can be due to various reasons, including;
- Valve seat is prevented from closing fully due to dirt, rust, or line debris
- Insufficient actuator travel
- The seat is damaged, e.g. scored
- The seal is damaged

Common causes of leakage to atmosphere:

- Gasket between valve-body and valve-bonnet is damaged
- Stem Packing is worn, loose or damaged

Both of them can have several causes