North America seat leakage guide

Leakage testing of metal seated valves can be a subject of much confusion and conflicting expectations. This booklet presents summaries of three common leakage testing standards as well as comparisons between them and actual product examples.

Important notes

- The information in this booklet is not intended as a replacement for the official leakage standards referenced on these pages.
- Examples are for demonstration purposes only. All leakage rates are not available for all valves. Please consult with the factory to determine the available leakage rates for a specific valve model.
- Leakage rates are measured for new valves on the bench after assembly. The standards referenced in this booklet do not set any requirements for leakage performance for valves once in service. Long term leakage rate performance is dependent on the valve and application and cannot be guaranteed.

Guide to ANSI/FCI 70-2-2013

Class I

- Modified class II, III or IV valves. No test required by agreement between user and supplier

Classes II, III and IV

- Media – Clean air or water
- Temperature – 50 °F to 125 °F
- Pressure – 45 to 60 psig or within +/- 5% of max operating dP, whichever is less
- Acceptable leakage for Class II – 0.5% of rated valve capacity (12,100 ml/min for a 2" RE)
- Acceptable leakage for Class III – 0.1% of rated valve capacity (2,420 ml/min for a 2" RE)
- Acceptable leakage for Class IV – 0.01% of rated valve capacity (242 ml/min for a 2" RE)

Class V

- Media – Clean water
- Temperature – 50 °F to 125 °F
- Pressure – Within +/- 5% of max operating dP, not to exceed max pressure rating of valve body at ambient temperature per ASME B16.34 and B16.5
- Acceptable leakage – 0.0005 ml/min of water per inch of seat diameter per psi dP

-or-

- Media – Air or nitrogen gas
- Temperature – 50 °F to 125 °F
- Pressure – 50 psig
- Acceptable leakage – 4.7 standard ml/min of air per inch of seat diameter

Class VI

- Media – Air or nitrogen gas
- Temperature – 50 °F to 125 °F
- Pressure – Maximum rated valve dP or 50 psig, whichever is less

Notes for all leakage classes:

- 1) Leakage rates shall be measured once flow is stabilized
- 2) Seat diameter is measured at the point of seating contact to the nearest 1/16 inch (2 mm).
- 3) bubble is approx. equivalent to 0.15 ml as long as a 0.25 inch (6 mm) O.D. x 0.032 inch (1 mm) wall tube is submerged in water to a depth from 0.125 to 0.25 inches (3 to 6 mm).

Acceptable leakage per ANSI Class VI

Seat diameter (inches)	Leakage (ml/min)	Leakage (bubbles / min)*
≤1	0.15	1
1.5	0.30	2
2	0.45	3
2.5	0.60	4
3	0.90	6
4	1.70	11
6	4.00	27
8	6.8	45
10	11.5	
12	16.4	
14	20.4	
16	27.0	

* 1 bubble is approx. equivalent to 0.15 ml

Guide to ISO 5208 4th edition

Required closure tests

Closure test	Sizes	ASME Class	Seat supported ball valve	Trunnion mounted ball valve	Butterfly valve
Low pressure gas	≤ 4"	≤ 1500	Required	Required	Required
		> 1500	Required	Optional	Optional
	≤ 4"	≤ 600	Required	Required	Required
		> 600	Required	Optional	Optional
High pressure liquid	≤ 4"	≤ 1500	Optional	Optional	Optional
		> 1500	Optional	Required	Required
	≤ 4"	≤ 600	Optional	Optional	Optional
		> 600	Optional	Required	Required

Low pressure gas test

Media	Air or other suitable gas
Temperature	5 °C to 40 °C (41 °F to 104 °F)
Pressure	6 bar +/- 1 bar (87 psi +/- 14.5 psi)

High pressure liquid test

Media	Water with optional corrosion inhibitor, kerosene or other appropriate liquid having a viscosity not greater than that of water. If the valve shell is an austenitic stainless steel, water chloride content is not to exceed 100ppm.
Temperature	5 °C to 40 °C (41 °F to 104 °F)
Pressure	1.1 x CWP of full rated valves or 1.1 x rated differential pressure of reduced rated valves.

Minimum test duration

Valve size	Time (sec)
≤ 2"	15
2.5" to 6"	60
≥ 8"	120

Maximum acceptable leakage tates (mm^3/second x DN number) *

Test Media	Rate A	Rate B	Rate C	Rate D
Liquid	0	0.01	0.03	0.1
Gas	0	0.3	3.0	30.0

* 1000 mm^3 = 60 ml/min

DN numbers

Valve size	1/2"	3/4"	1"	1.5"	2"	2.5"	3"	4"	6"	8"	10"	12"	14"	16"
DN	15	20	25	40	50	65	80	100	150	200	250	300	350	400

Guide to API 598 10th edition

	≤ 4" and > 1500 > 4" and > 600		≤ 4" and ≤ 1500 > 4" and ≤ 600	
Closure test	Seat supported ball valve	Trunnion ball valve & BFV	Seat supported ball valve	Trunnion ball valve & BFV
Low pressure	Required	Optional	Required	Required
High pressure	Optional	Required	Optional	Optional

Low pressure test

Media	Air or inert gas
Temperature	41 °F to 122 °F (5 °C to 50 °C)
Pressure	60 to 100 psig (4 to 7 barg)

High pressure test

Media	Air, inert gas, kerosene, water
Temperature	41 °F to 122 °F (5 °C to 50 °C)
Pressure	110% of maximum rated pressure at 100 °F for ball valves, and 110% of for butterfly valves

Minimum test duration

Valve size	Time (sec)
≤ 2"	15
2.5" to 6"	60
≥ 8"	120

Maximum acceptable leakage rates

Valve size	Liquid test (drops/min)*	Gas test (bubbles/min)**
≤ 2"	0	1
2.5"	5	10
3	6	12
4	8	16
5	10	20
6	12	24
8	16	32
10	20	40
12	24	48
14	28	56
16	32	64
18	36	72
20	40	80
24	48	96
26	52	104
28	56	112
30	60	120
32	64	128
36	72	144
40	80	160
42	54	168
48	96	192

* Liquid test: 1 mL is considered equivalent to 16 drops
** Gas test: 1 mL is considered equivalent to 100 bubbles

Leakage rates comparison charts

Comparison of leakage rates using air / nitrogen

	Maximum acceptable leakage (ml/min)						Drops / min
	ANSI / FCI 70-2 2013		ISO 5208				API-598
Test pressure (psig) ->	50		73 to 102				60 to 100
Valve size (in)*	Class V	Class VI	Rate A	Rate B	Rate C	Rate D	Low pressure test
1	4.7	0.15	0	0.45	4.5	45	0
1.5	7.05	0.30	0	0.72	7.2	72	0
2	9.4	0.45	0	0.9	9	90	0
2.5	11.75	0.60	0	11.7	11.7	117	10
3	14.1	0.90	0	1.44	14.4	144	12
4	18.8	1.70	0	1.8	18	180	16
6	28.2	4.00	0	2.7	27	270	24
8	37.6	6.75	0	3.6	36	360	32
10	47	11.1	0	4.5	45	450	40
12	56.4	16.0	0	5.4	54	540	48
14	65.8	21.6	0	6.3	63	630	56
16	75.2	28.4	0	7.2	72	720	64

* Assumed full size seat diameter for ANSI / FCI 70-2-2013

Comparison of leakage rates using water

Pressures based on ASME class 300 carbon steel body rating 740psig per ASME B16.34

	Maximum acceptable leakage (ml/min)					Bubbles / Min
	ANSI / FCI 70-2 2013	ISO 5208				API-598[1]
Test pressure (psig) ->	740	814				814
Valve size (in)*	Class V	Rate A	Rate B	Rate C	Rate D	High pressure test
1	0.37	0	0.015	0.045	0.15	0
1.5	0.56	0	0.024	0.072	0.24	0
2	0.74	0	0.03	0.09	0.3	0
2.5	0.93	0	0.039	0.117	0.39	5
3	1.11	0	0.048	0.144	0.48	6
4	1.48	0	0.06	0.18	0.6	8
6	2.22	0	0.09	0.27	0.9	12
8	2.96	0	0.12	0.36	1.2	16
10	3.70	0	0.15	0.45	1.5	20
12	4.44	0	0.18	0.54	1.8	24
14	5.18	0	0.21	0.63	2.1	28
16	5.92	0	0.24	0.72	2.4	32

* Assumed full size seat diameter for ANSI / FCI 70-2-2013
1) API-598 leakage rate is in drops / minute. 16 drops / minute equals 1 ml/min

Valve test example – XT04CWTAS6SJHADD

ANSI/FCI 70-2-2013

Class V water test

- Test pressure = 275 psig based on CF8M body rating from ASME B16.34 class 150
- Seat diameter = 4”
- Acceptable leakage = 0.0005 ml/min x 4” x 275 psi = 0.55 ml/min

Class V air test

- Test pressure = 50 psig
- Seat diameter = 4”
- Acceptable leakage = 4.7 ml/min x 4” = 18.8 ml/min

Class VI air test

- Test pressure = 50 psig
- Seat diameter = 4”
- Acceptable leakage = 1.70 ml/min

ISO 5208

Low pressure air test

- Test pressure = 87 psig
- DN number = 100 for a 4” valve
- Rate A = 0 ml/min
- Rate B = 0.3 mm^3/sec x 100 x 1 ml/1000 mm^3 x 60 sec/min = 1.8 ml/min
- Rate C = 3.0 mm^3/sec x 100 x 1 ml/1000 mm^3 x 60 sec/min = 18 ml/min
- Rate D = 30.0 mm^3/sec x 100 x 1 ml/1000 mm^3 x 60 sec/min = 180 ml/min

High pressure water test

- Test pressure = 302 psig based on 1.1 x CF8M body rating from ASME B16.34 class 150
- DN number = 100 for a 4” valve
- Rate A = 0 ml/min
- Rate B = 0.01 mm^3/sec x 100 x 1 ml/1000 mm^3 x 60 sec/min = 0.06 ml/min
- Rate C = 0.03 mm^3/sec x 100 x 1 ml/1000 mm^3 x 60 sec/min = 0.18 ml/min
- Rate D = 0.1 mm^3/sec x 100 x 1 ml/1000 mm^3 x 60 sec/min = 0.6 ml/min

API 598

Low pressure air test

- Low pressure air test
- Test pressure = 60 to 100 psig
- Acceptable leakage = 16 bubbles / minute

High pressure water test

- Test pressure = 302 psig based on 1.1 x CF8M body rating from ASME B16.34 class 150
- Acceptable leakage (water test) = 8 drops /min

Valve test example – RECA04CJJST

ANSI/FCI 70-2-2013

Class IV water test

- Test pressure = 3.5 barg (50 psig)
- Capacity = 620
- FL = 0.53
- Capacity coefficient = "0.1 × " "C" _"V" " × 0.865 ×" "1000" /"60" "× " "F" _"L"
- Capacity coefficient = 0.1 x 620 x 0.865 x 16.667 x 0.53 = 473.73
- Class IV leakage = "1 × capacity coefficient × " √("dP+1")
- Class IV leakage = 1 × 473.73 ×" " √(3.5+1) = 1005 ml/min

Class IV air test

- Test pressure = 3.5 barg (50 psig)
- Capacity = 620
- XT = 0.25
- Capacity coefficient = "100 × " "C" _"V" " × 0.667 ×" √("X" _"T" /"8497") "× 37.5"
- Capacity coefficient = 100 x 620 x 0.667 x √(0.25/"8497") x 37.5 = 8,408.45
- Class IV leakage = "1 × capacity coefficient × (dP +1")
- Class IV leakage = 1 × 8,408.35 ×" (3.5+1)" = 37,838 ml/min
- Class V water test
- Test pressure = 275 psig based on CG8M body rating from ASME B16.34 class 150
- Seat diameter = 3.346”
- Acceptable leakage = 0.0005 ml/min x 3.346” x 275 psi = 0.46 ml/min

ISO 5208

Low pressure air test

- Test pressure = 87 psig
- DN number = 400 for a 16” valve
- Rate B = 0.3 mm^3/sec x 400 x 1 ml/1000 mm^3 x 60 sec/min = 7.2 ml/min
- Rate C = 3.0 mm^3/sec x 400 x 1 ml/1000 mm^3 x 60 sec/min = 72 ml/min
- Rate D = 30.0 mm^3/sec x 400 x 1 ml/1000 mm^3 x 60 sec/min = 720 ml/min

High pressure water test

- Test pressure = 1628 psig based on 1.1 x WCB body rating from ASME B16.34 class 600
- DN number = 400 for a 16” valve
- Rate B = 0.01 mm^3/sec x 400 x 1 ml/1000 mm^3 x 60 sec/min = 0.24 ml/min
- Rate C = 0.03 mm^3/sec x 400 x 1 ml/1000 mm^3 x 60 sec/min = 0.72 ml/min
- Rate D = 0.1 mm^3/sec x 400 x 1 ml/1000 mm^3 x 60 sec/min = 2.4 ml/min

Leakage rates in context – Metal seated ball valve gas test

It is often easier to understand the comparisons between different leakage rates if they are put in the context of everyday values.

Here are some real-world examples to illustrate the leakage rates for a 4" valve tested with air.

Valve test example - XT04CWTAS6SJHADD

Gas test	Leakage rate (ml/min)	Time to fill the volume of a basketball
ISO 5208 Rate A	0	
API 598	0.16	30 days, 19 hours
ANSI/FCI 70-2-2013 class VI	1.7	2 days, 22 hours
ISO 5208 Rate B	1.8	2 days, 18 hours
ISO 5208 Rate C 18.0		6.6 hours
ANSI/FCI 70-2-2013 class V	18.8	6.3 hours
ISO 5208 Rate D	180	40 minutes
ANSI/FCI 70-2-2013 class IV[1]	103883	About 4 seconds

1) Class IV is regarded as a control valve leakage rate. This is as an example only as a metal seated ball valve would not typically be used in control service

Leakage rates in context – Metal seated ball valve liquid test

Here are some real-world examples to illustrate the leakage rates for a 4" valve tested with water.

Valve test example - XT04CWTAS6SJHADD

Liquid test	Leakage rate (ml/min)	Time to fill a medium cup of coffee (14oz)
ISO 5208 Rate A	0	
ISO 5208 Rate B	0.06	4 days, 19 hours
ISO 5208 Rate C	0.18	1 day, 14 hours
ANSI/FCI 70-2-2013 class V	0.55	12.5 hours
ISO 5208 Rate D	0.60	11.5 hours
ANSI/FCI 70-2-2013 class IV[1]	3431	7 seconds

1) Class IV is regarded as a control valve leakage rate. This is as an example only as a metal seated ball valve would not typically be used in control service

Leakage rates available for standard ball valves

		ANSI / FCI 70-2-2013				ISO 5208				API 598	
						Air test		Water test			
Valve series	Seat style	Class IV (water)	Class V (water)	Class V (air)	Class VI (air)	Rate C	Rate D	Rate C	Rate D	Air test	Water test
X-MBV seat supported	H		optional	optional	optional	CF	optional	standard	optional	optional	optional
	S[1]		optional	optional	optional	CF	optional	standard	optional	optional	optional
	K[1]		optional	optional	optional	CF	optional	standard	optional	optional	optional
	G		optional	optional	optional	CF	optional	standard	optional	optional	optional
	J[2]		CF	optional	CF	CF		CF	CF	CF	CF
M2 seat supported	S[1]		optional	optional	optional	optional		optional	standard	optional	optional
	P[1]		optional	optional	optional	optional		optional	standard	optional	optional
	E		optional	optional	optional	optional		optional	standard	optional	optional
S6	H, X, K[6]		optional	optional	optional	optional		optional		optional	optional
	J[2]			optional			standard				
X-MBV trunnion	H		optional	optional		optional		standard			
	S		optional	optional	optional	optional		standard		optional	optional
	B		optional	optional	optional	optional		standard		optional	optional
M2 trunnion	L		optional	optional	optional	optional		standard		optional	optional
	S		optional	optional	optional	optional		optional		optional	optional
D	H		standard	optional		optional		optional			
	S		standard	optional	optional	optional		optional		optional	optional
	E		standard	optional	optional	optional		optional		optional	optional
	C		standard	optional		optional		optional			
	K		standard	optional	optional	optional		optional		optional	optional

View all notes on next page

Leakage rates available for standard butterfly & control valves

		ANSI / FCI 70-2-2013				ISO 5208				API 598	
						Air test		Water test			
Valve series	Seat Style	Class IV (water)	Class V (water)	Class V (air)	Class VI (air)	Rate C	Rate D	Rate C	Rate D	Air test	Water test
LG/LW	All		optional	optional	optional[3]	optional	standard	optional	optional	optional	optional
L1/L2	All		optional	optional	optional[3]	optional	standard	optional	optional	optional	optional
L6	All		optional	optional	optional[3]	optional	standard	optional	optional	optional	optional
R-series	S	standard[4]							optional[5]		
	T				standard						
Finetrol	S, R	standard[7]									
	T				standard						
ZX	All	standard									

Notes:
1) Seat supported ball valves with locked seat designs require a minimum dP of 30psi to meet required leakage rates
2) J-seated valves with UOP construction "UU" are tested with helium per customer specification UOP-671
3) Optional Class VI leakage rate is bidirectional.
4) Optional test to 1/10 class IV (air) (+T10 Word Modifier)
5) Optional metal seated RE leakage is 10x ISO 5208 Rate D
6) Tested to MSS-SP-61 as standard
7) Finetrol valves tested with FCI 70-2 Class IV air
n/a = Not applicable
use std = Standard leakage test exceeds leakage requirements
CF = Consult factory

Valmet Flow Control Oy
Vanha Porvoontie 229, 01380 Vantaa, Finland.
Tel. +358 10 417 5000.
www.valmet.com/flowcontrol