12388 88th Ave.,
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Swagelok Company – Check Valve – ISO 19880-3 Section 6 – Pressure Cycle

Prepared for: Swagelok Company
PO Reference: 4506406901

Project Number: PL-05589
Test Report Number: TR-05589-07-R0

Client: Swagelok Company
29500 Solon Road
Solon, Ohio, 44139, USA

Manufacturer: Swagelok Company
29500 Solon Road
Solon, Ohio, 44139, USA

Part Type: Check Valve

Part Numbers and Serial Numbers:

Part #	Description
SS-CVT6FK6-H2 (PLI: 3804)	3/8" CV Pressure Cycle Compound A
SS-CVT6FK6-H2 (PLI: 3805)	3/8" CV Pressure Cycle Compound B
SS-CVT9FK9-H2 (PLI: 3802)	9/16" CV Pressure Cycle Compound A
SS-CVT9FK9-H2 (PLI: 3803)	9/16" CV Pressure Cycle Compound B
SS-CVT12FK12-H2 (PLI: 3800)	3/4" CV Pressure Cycle Compound A
SS-CVT12FK12-H2 (PLI: 3801)	3/4" CV Pressure Cycle Compound B

Receipt Date: 2024-10-24

Test Dates: 2024-11-15 to 2025-02-14

Test Medium: Hydrogen gas, tap water

TEST CONDUCTED

The following test was conducted in accordance with:

- ISO 19880-3 – 2018, Gaseous hydrogen — Fuelling stations — Part 3: Valves, Clause 6
- CSA/ANSI HGV 4.4:21 Gaseous hydrogen – fuelling stations - valves

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TEST PROCEDURE

Hydrogen gas pressure cycle test (per ISO 19880-3:2018, Clause 6.2)

The samples underwent a total of 102,000 pressure cycles with hydrogen gas at a rate not less than 6 seconds per cycle as shown in Figure 1 per the following steps:

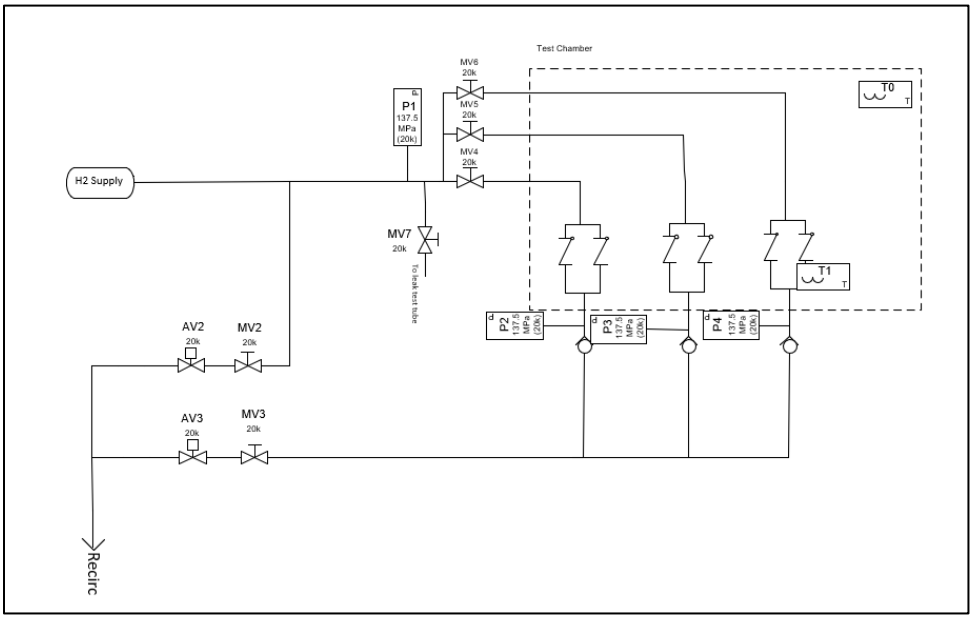

Figure 1. Pressure cycling test schematic

At ambient temperature (20±5°C) for 100,000 of the cycles as follows:

1. The samples shall be pressurized to 105+3.15/-0 MPa
2. The inlet pressure was then decreased to less than 5.25 MPa
3. The outlet pressure was then decreased to at least 5.25 MPa.

At maximum temperature (85+3/-0°C) for 1,000 cycles as follows:

1. The samples shall be pressurized to 105+3.15/-0 MPa.
2. The inlet pressure was then decreased to at least 5.25 MPa.
3. The outlet pressure was then decreased to at least 5.25 MPa.

At minimum temperature (-40+0/-3°C) for 1,000 cycles as follows:

1. The samples shall be pressurized to 105+3.15/-0 MPa.
2. The inlet pressure was then decreased to at least 5.25 MPa.
3. The outlet pressure was then decreased to at least 5.25 MPa.

Following the 102,000 cycles, the samples were subjected to an external and internal leakage test per 5.4.2 and 6.4, and a proof pressure and hydrostatic test per 5.6 and 5.7.

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External and Internal Leakage (per ISO 19880-3:2018, Clause 5.4.2 and 6.4)

The samples were subjected to an external and internal leakage test using hydrogen gas. Samples were conditioned at 31.5 MPa and the test temperature for 1 hour before testing.

The test temperatures and pressure conditions for the external leakage test were as follows:

1. 85°C (+3/-0°C) @ 105 MPa
2. -40°C (+0/-3°C) @ 105 MPa

The test temperatures and pressure conditions for the internal leakage test were as follows:

1. 85°C (+3/-0°C) @ 105 MPa
2. 85°C (+3/-0°C) @ 10.5 MPa
3. -40°C (+0/-3°C) @ 105 MPa
4. -40°C (+0/-3°C) @ 10.5 MPa

External leakage tests were performed using SNOOP® leak detection agent and a handheld detector, whereas internal leakage tests were performed via the bubble leak test method. The leak rate shall not exceed 10 Ncm^3/h.

Worst case fault pressure cycle test (per ISO 19880-3:2018, Clause 5.5)

The samples underwent a total of 10 pressure cycles with hydrogen gas at a rate of not less than 6 seconds per cycle. The samples shall be conditioned at 20±5°C for at least an hour prior to testing.

Once cycle shall consist of pressurizing the samples to 115.5+3.15/-0 MPa, and then decreasing the pressure to 5.7 MPa. After a hold period, the outlet shall then also be depressurized to 5.7 MPa (<5% of the component pressure rating).

Following the 10 cycles, the samples were subjected to the external and internal leakage tests per 5.4.2 and 6.4.

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Proof pressure test / Hydrostatic strength test (per ISO 19880-3:2018, Clause 5.6 / 5.7, CSA/ANSI HGV 4.4:21 Clause 5.7)

In accordance with client specifications, the samples were subjected to a proof pressure and hydrostatic strength test to the following standards: ISO 19880-3:2018 clause 5.6 & 5.7, and CSA/ANSI HGV 4.4:21 clause 5.7. The test setup is shown in Figure 2.

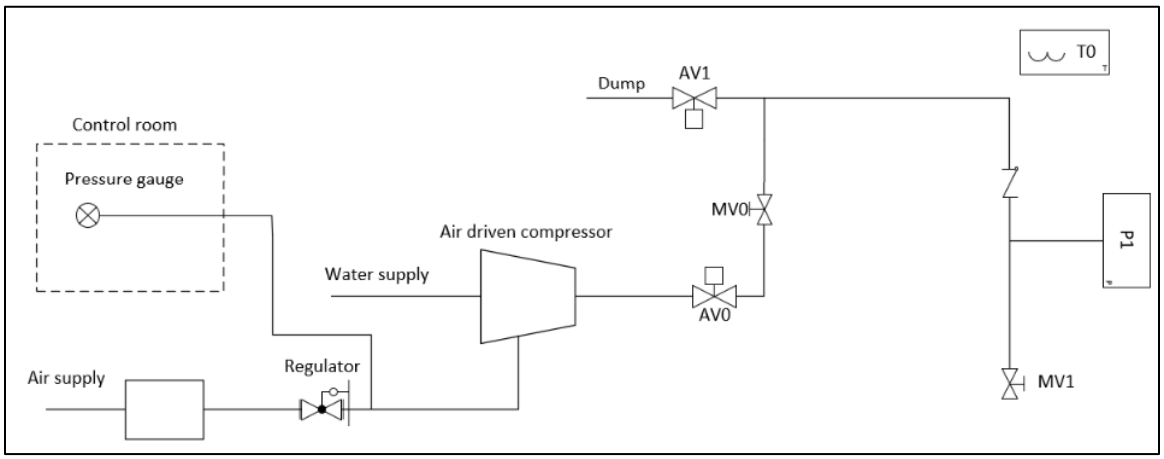

Figure 2. Proof pressure and hydrostatic strength test schematic

With the outlet plugged, the inlet was pressurized to 157.5 MPa (150% of the component pressure rating) and held for 10 minutes. No leakage shall be found. Then the sample was pressurized until the sample burst. According to ISO 19880-3:2018, the samples must withstand without rupture a test pressure of 2.4 times the component pressure rating, while for CSA/ANSI HGV 4.4:21, the samples must withstand without rupture a test pressure of 2.5 times the component pressure rating. The stricter of the two requirements was therefore observed, and thus no rupture shall occur before 262.5 MPa (250% of the component pressure rating). Both standards allow for leakage if it has occurred above 150% of the component pressure rating.

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TEST EQUIPMENT AND INSTRUMENTATION

Details of the instrumentation used for the pressure cycling and leakage tests are outlined below in Table 1.

Table 1. Pressure cycling and leakage tests instrumentation summary

Parameter	PLI Asset No.	Instrument Type	Make and Model	Range
P1	PLI2075	Pressure Transducer	Stellar Technology, GT3200-20000G-118	0 to 137.9 MPa
P2	01554	Pressure Transducer	Stellar Technology, GT1800-20000G-317	0 to 137.9 MPa
P3	01556	Pressure Transducer	Stellar Technology, GT1800-20000G-317	0 to 137.9 MPa
P4	35733	Pressure Transmitter	Canada Sensors Technology, Process 2	0 to 137.9 MPa
T0	33309	Thermocouple	Omega, TMQSS-125U-6	-200°C to 200°C

Details of the instrumentation used for the proof pressure and hydrostatic strength test are outlined below in Table 2.

Table 2. Hydrostatic strength test instrumentation summary

Parameter	PLI Asset No.	Instrument Type	Make and Model	Range
P1	01114	Pressure Transducer	Stellar Technology, GT1800-100000G-318	0 to 689 MPa
T0	35183	Thermocouple	Conax Technologies, T-316SS12-U-MPJ-6	-200°C to 200°C

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TEST RESULTS

Hydrogen gas pressure cycle test (per ISO 19880-3:2018, Clause 6.2)
Test Date: 2024-11-15 to 2025-01-09
Test Location: Powertech Labs, Surrey, BC
Serial Number: 3800 to 3805

The samples completed 100,000 pressure cycles at 20±5°C, 1,000 cycles at -40+0/-3°C and 1,000 cycles at 85+3/-0°C. The samples functioned properly and did not have any issues during the test cycles.

External and Internal Leakage (per ISO 19880-3:2018, Clause 5.4.2 and 6.4)
Test Date: 2025-01-13 to 2025-01-14
Test Location: Powertech Labs, Surrey, BC
Serial Number: 3800 to 3805

The samples were subjected to an external and internal leakage test at -40°C and 85°C. The samples showed no signs of leakage using SNOOP® leak detection agent, a handheld detector, and the bubble leak test method. The results can be seen in Table 3.

Table 3. Leakage test results for sample # 3800 to 3805

Sample #	Previous test	External Leakage		Internal Leakage			
		85°C	-40°C	85°C		-40°C	
		105 MPa	105 MPa	10.5 MPa	105 MPa	10.5 MPa	105 MPa
3800 & 3801	Pressure cycle	No leak	No leak	No leak	No leak	No leak	No leak
3802 & 3803	Pressure cycle	No leak	No leak	No leak	No leak	No leak	No leak
3804 & 3805	Pressure cycle	No leak	No leak	No leak	No leak	No leak	No leak

Worst case fault pressure cycle test (per ISO 19880-3:2018, Clause 5.5)
Test Date: 2025-01-20
Test Location: Powertech Labs, Surrey, BC
Serial Number: 3800 to 3805

The samples completed 10 worst case fault pressure cycles. The samples functioned properly and did not have any issues during the test cycles.

The samples were then subjected to an external and internal leakage test. The samples showed no signs of leakage using SNOOP® leak detection agent, a handheld detector, and the bubble leak test method, and thus are considered to have passed the test.

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Proof pressure test / Hydrostatic strength test (per ISO 19880-3:2018, Clause 5.6 and 5.7, per CSA/ANSI HGV 4.4:21 Clause 5.7)

Temperature: 20±5°C
Test Date: 2025-02-13 to 2025-02-14
Test Location: Powertech Labs, Surrey, BC
Serial Number: 3800 to 3805

The samples were pressurized to 150% of component pressure rating and held for 10 minutes. No leakage was observed for any of the samples. The samples did not show any signs of rupture or fracture during pressurization to and at 250% of component pressure rating. Pressurization continued past the requirement until the samples burst.

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SUMMARY

All tested samples met the criteria of ISO 19880-3:2018, section 6.2 Hydrogen gas pressure cycle test, section 6.5 Worst case fault pressure cycle test, 6.6 Proof pressure test, 6.7 Hydrostatic strength test, and CSA/ANSI HGV 4.4:21 section 5.7 Hydrostatic strength test, and thus are considered to have passed the tests.

Tested By:	Approved By:
Alan Yen, EIT Project Engineer Hydrogen Industry Technology & Testing	Marcus Treacy, P.Eng Senior Engineer Hydrogen Industry Technology & Testing EGBC Permit to Practice: 1002531
Date signed: 2025-05-16	Date signed: 2025-05-16

Revision	Description of changes	Date
0	Initial issue	2025-05-16

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Andre Fregeau

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Date: 2025.05.16 15:49:35 -08'00'