BSR/ASHRAE Standard 153-2015R

Public Review Draft

Method of Test for Mass Flow Capacity of Four-Way Refrigerant Reversing Valves

First Public Review (January 2021)
(Complete Draft for Full Review)

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(This foreword is not part of this standard. The forward is merely informative and does not contain requirements necessary for conformance to the standard. The forward has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This standard provides a means for measuring the mass flow capacity of reversing valves used on heat pumps and other refrigerating systems. The standard was created because accurate capacity data is needed to facilitate the proper application of four-way valves in a variety of refrigerating systems that employ a variety of refrigerants.

The test method is intended to be within the capabilities of most users and producers employing conventional laboratory apparatus. This standard allows the use of a wide variety of test fluids, including the refrigerant intended for the end application.

1. PURPOSE

The purpose of this standard is to provide a test method for measuring the refrigerant vapor mass flow capacity of four-way refrigerant reversing valves. The standard aims to measure mass flow capacity with sufficient accuracy to facilitate application decisions.

2. SCOPE

This standard describes test methods, procedures, instrumentation, computations, and suggested apparatus for this test.

3. DEFINITIONS

Where the following terms occur in this standard, the definitions provided in this section apply:

capacity: the refrigerant mass flow rate through a four-way reversing valve at specific operating conditions.

four-way reversing valve: a refrigerating-system control device for changing the direction of refrigerant flow through the heat exchangers of a refrigerating system by redirecting both the high-pressure flow (discharge) from the compressor and the low-pressure flow (suction) to the compressor. Alternatively referred to as a *reversing valve*.

reversing valve: see *four-way reversing valve*.

shall and should: the word “shall” is to be understood as a requirement and the word “should” as a recommendation.

specified conditions: the conditions where the mass flow capacity of the valve is to be measured. These conditions correlate to the agreed end-use application operating conditions.

valve position: one of either of two positions of the internal parts of the reversing valve to direct refrigerant flow in a specific direction.

4. REQUIRED TEST CONDITIONS

4.1 The fluid entering both flow paths of the reversing valve shall be conditioned such that no phase change occurs in the test fluid throughout the test.

4.2 The fluid pressure, fluid temperature, and ambient air temperature surrounding the valve under test shall be stabilized during the test.

4.3 If lubricant is added to the fluid flow, the lubricant fraction flowing through the valve under test shall not be excessive. The amount must be contained in a thin coating on the internal wall of the system tubing and valve.

4.4 The fluid pressure entering the high-pressure flow path shall be higher than the pressure entering the low-pressure flow path to make certain that any pressure-sensitive seals are biased in the intended direction.

4.5 The flow rates through the reversing valve under test shall not exceed values that cause the pressure drop across the valve to exceed 10% of the absolute pressure entering the flow path to make certain that vapor flows (if vapor is used). This allows flow to be modelled as incompressible for calculations. The test system flow rates shall be adjusted as necessary to meet this requirement.

4.6 Test flow rates shall extend above and below the intended end-use flow rate for the reversing valve. Select two (2) or more test conditions using the chosen fluid (gas or liquid) that will span the desired operating range. Compute and record the flow rate and the square root of the product of fluid density and the pressure drop across each flow path for the reversing valve for each test condition $(\rho \Delta P)^{1/2}$.

5. DATA REQUIRED

The test data for each position of the valve under test shall include all of the following in Sections 5.1 and 5.2:

5.1 Test Information

a. Identification of specified conditions (end-use application operating conditions) used to establish test conditions.
b. Descriptive information concerning the valve under test, including all of the following that apply: manufacturer's name and address, model, type, serial number, size, connection type, and connection size.
c. Name the chemical formula of test fluid and identification of the source of information used to determine its thermophysical properties.
d. Ambient temperature (air temperature surrounding valve under test).
e. Orientation of the valve under test (whether high-pressure inlet connection is top, bottom, or horizontal).
f. Barometric pressure.

5.2 Test Conditions and Results (required for both flow paths in each position)

a. Valve position A or B (unless symmetrical).
b. Test fluid mass flow rate.
c. Pressure drop(s) across the flow path(s) under test.
d. Absolute pressures of the test fluid entering both flow paths of the valve under test.
e. Temperatures of the test fluid entering *and* leaving the flow paths of the valve under test.

See Informative Annex A for a sample data sheet.

6. TEST INSTRUMENTS

Instruments shall be of the types and accuracies listed in the ASHRAE standards listed in the Normative References.

7. TEST APPARATUS

7.1 The four-way valve under test shall be installed in a test apparatus as shown in Figures 1, 2, 3, and 4. The reversing valve shall be mounted in the manufacturer's recommended orientation. An example of a complete test system is shown in Figure C-1 in Informative Annex C.

7.2 The test apparatus shall be composed of the following essential elements:

a. A supply of single-phase fluid to the high-pressure flow path of the valve under test.
b. A supply of single-phase fluid to the low-pressure flow path of the valve under test.
c. A flow-measuring instrument located such that the mass flow rate through both the high- and the low-pressure flow paths is measured.

7.3 Installation of test instrumentation shall conform to the following requirements:

a. The temperature measuring instruments shall be immersed in the fluid stream and located such that there will not be an impact on the pressure values measured. Refer to Figures 1, 2, 3, and 4 for locations.
b. The pressure-tap distance to the nearest upstream flow interruption (for example, connecting tube, temperature measurement device, or elbow) is defined in Figures 1, 2, 3, and 4. No flow interruptions shall be located between the pressure tap and the valve under test.
c. Pressure-tap holes shall be located at appropriate points on the circumference of the tube with respect to the adjacent surroundings. Pressure-tap holes shall not be positioned on the bottom of the tube to prevent blockage of the hole by foreign matter. The inner rim of the hole shall be flush with the inner surface of the tube and be free of burrs, extreme chamfers, or jagged edges.
d. Pressure-tap hole diameters shall not exceed 10% of flow passage diameter.

8. TEST PROCEDURE

8.1 Install the valve to be tested in the test apparatus (see Figures 1, 2, 3, and 4) and check the installation for external leakage, employing appropriate purging or evacuation procedures and ensuring that the system has adequate working fluid charge to satisfy the preselected test conditions.

8.2 Start the system and bring it to preselected operating conditions.

8.3 Valve Position A. Test the valve in both position A and B unless the valve is symmetrical.

8.3.1 Take two (2) or more data points for each flow path in valve position A (see Section 4.6).

For each data point, maintain steady-state operating conditions surrounding the valve under test. For the purposes of this standard, steady-state operating conditions exist when the mass flow rate, the temperatures, and the absolute and differential pressures remain within 2% of the reported value before taking the data point.

8.3.2 Record all data required by Section 5 (see Informative Annex A for a sample data sheet).

8.4 Valve Position B (optional if valve is symmetrical)

8.4.1 Shift valve to position B.

8.4.2 Repeat the instructions in Sections 8.3.1 and 8.3.2 with the valve under test in position B.

9. MASS FLOW-RATE CALCULATION

9.1 Compute the value of $(\rho_T \Delta P_T)^{1/2}$ corresponding to each of the measured mass flow rates, where ρ_T is the density of test fluid entering the flow path under test, and ΔP_T is the measured pressure drop across the flow path under test.

9.2 Plot each of the data points on four (4) separate linear graphs—one (1) graph each for the high-pressure flow path and the low-pressure flow path for both valve position A and valve position B. Plot $(\rho_T \Delta P_T)^{1/2}$ on the abscissa versus the corresponding measured mass flow rate on the ordinate.

9.3 Fit the best straight line to each set of data using the least- squares method and including the origin (0, 0) as a data point in each data set.

Informative Note: The line is not forced through the origin but (0,0) is included as a data point in the least-squares computation.

9.4 Capacity of either flow path at its specified condition shall be found graphically by entering the graph for the flow path of interest on the abscissa at the specified value of $(\rho \Delta P)^{1/2}$, projecting vertically to the point of intersection with the plotted straight line and then projecting horizontally to read the predicted mass flow rate.

Informative Note: The equation of the plotted line may be used to predict flow rates with other fluids at other conditions as long as the calculated flow rates are not extrapolated beyond the range of fluid density and pressure drop of the original test measurements.

10. NORMATIVE REFERENCES

1. ASHRAE. 2020. ANSI/ASHRAE Standard 41.1, *Standard Method for Temperature Measurement*. Atlanta: ASHRAE.

2. ASHRAE. 2014. ANSI/ASHRAE 41.3, *Standard Method for Pressure Measurement*. Atlanta: ASHRAE.

3. ASHRAE. 2015. ANSI/ASHRAE 41.7 *Standard Methods for Gas Flow Measurement.* Atlanta: ASHRAE *for Gas flow measurement.* Atlanta: ASHRAE.

4. ASHRAE. 2020. ANSI/ASHRAE 41.10 *Standard Methods for Refrigerant Mass Flow Measurement Using Flowmeters.* Atlanta: ASHRAE.

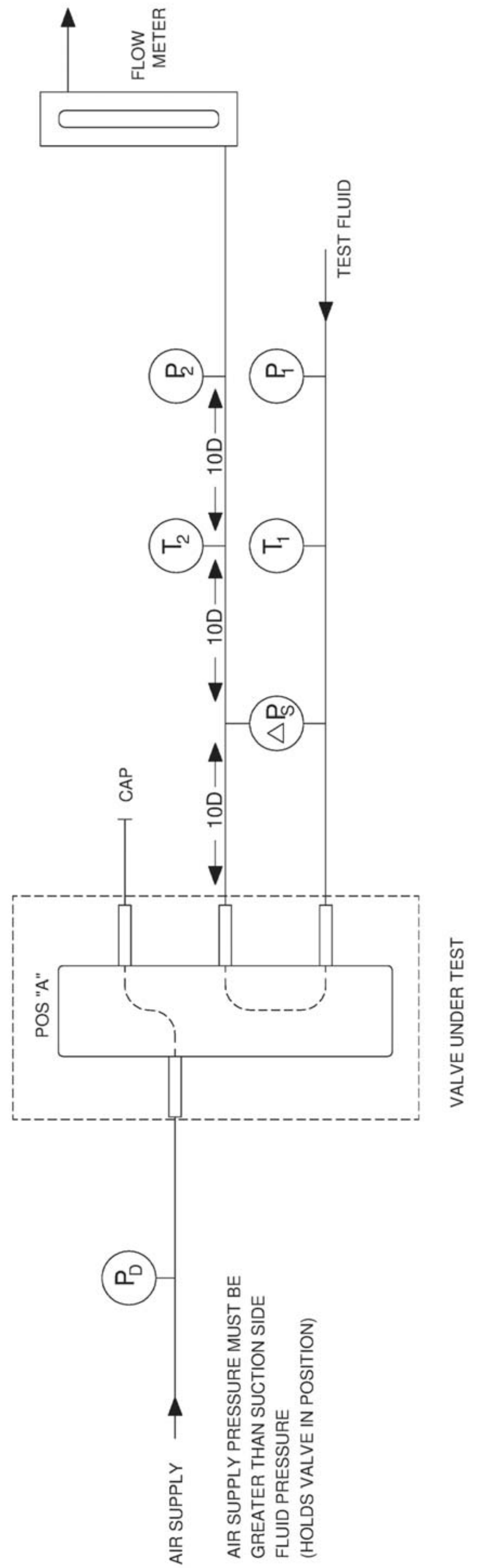

FIGURE 1 Suction pressure drop—position A.

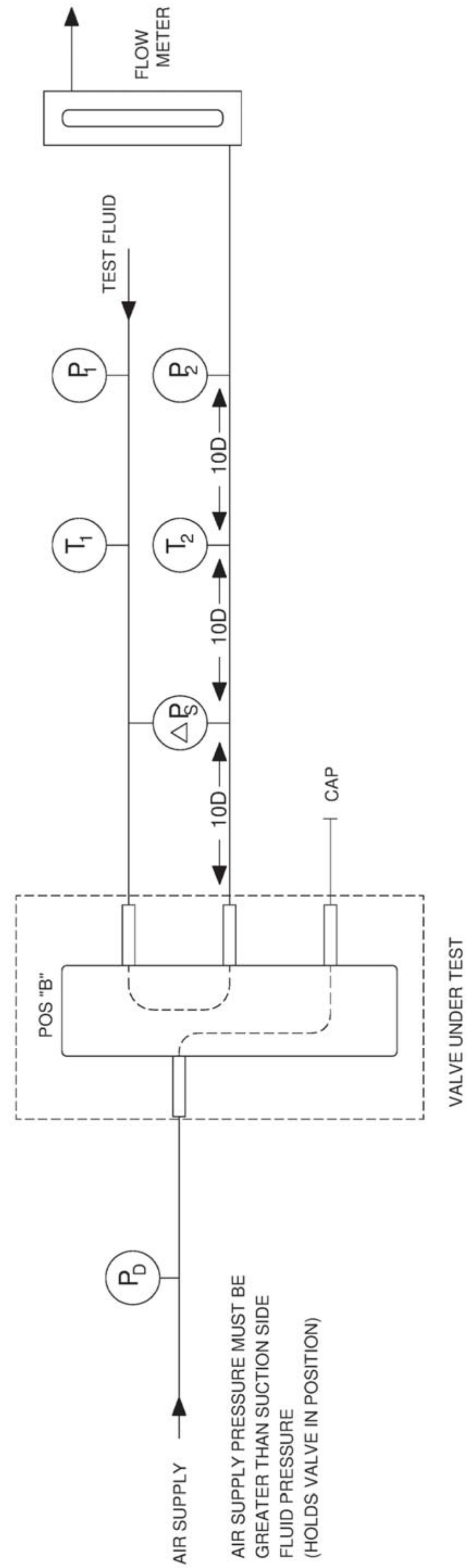

FIGURE 2 Discharge pressure drop—position B.

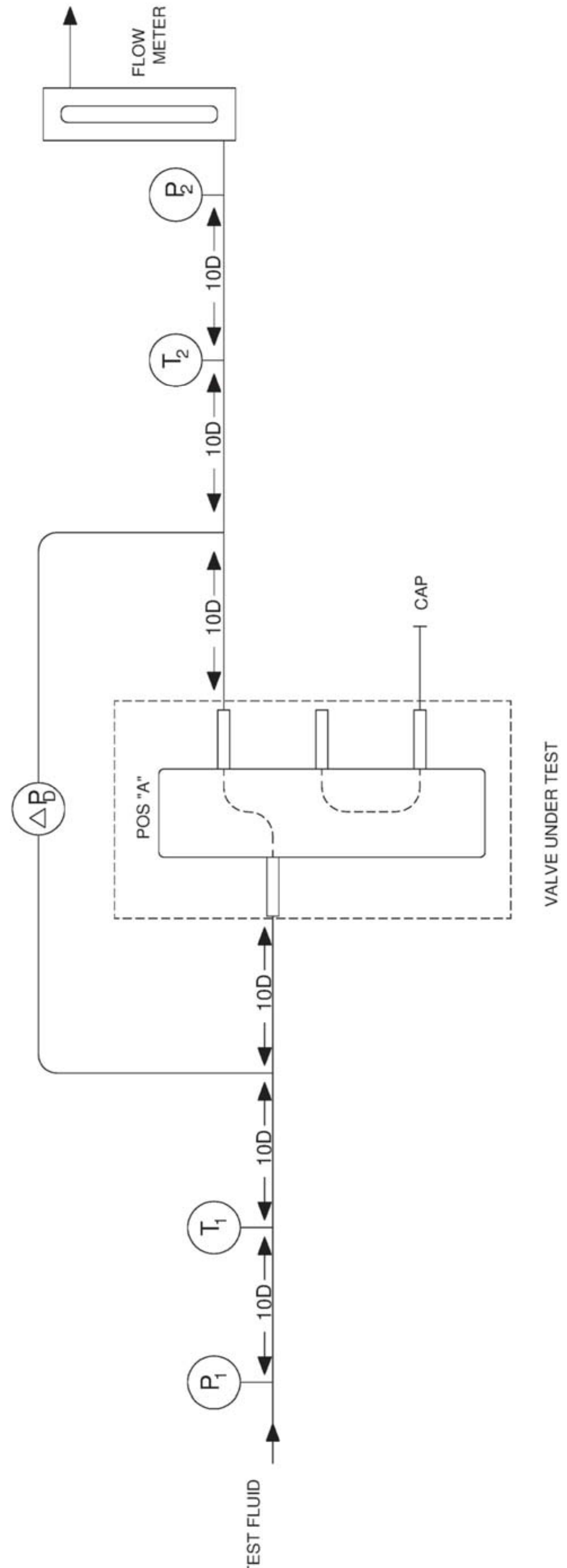

FIGURE 3 Discharge pressure drop—position A.

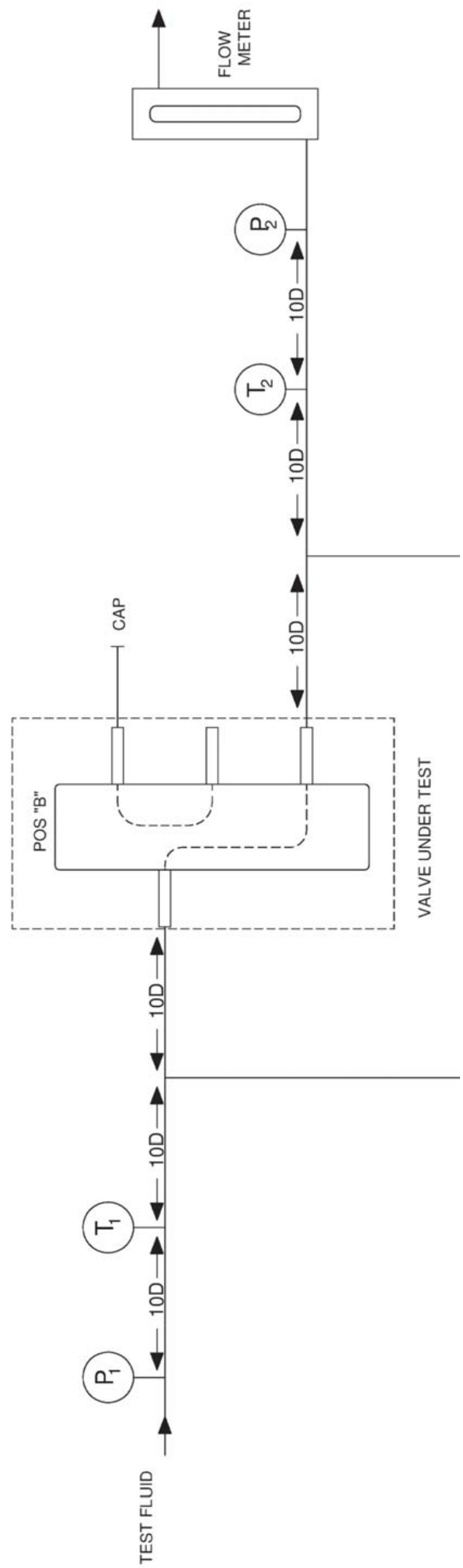

FIGURE 4 Discharge pressure drop—position B.

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INFORMATIVE APPENDIX A
EXAMPLE DATA SHEET AND GRAPH FOR
FOUR-WAY REVERSING VALVE MASS FLOW CAPACITY

The following is an example data sheet for reporting the data. Provide data and a graph for each flow path in each valve position. Add rows to the table as needed to accommodate additional data.

Observer: C. Brown **Test Date:** 02/07/2009 **Ambient Air Temperature:** 11.3°C (78°F) **Barometric Pressure:** 101.352kPa (14.7 psi)

Valve Manufacturer: XYZ Valve Co. **Model:** ABC123 **Serial Number:** 123456

Connection Type: Sweat **Connection Size:** 3/8 TO 5/8 in. ODF

Valve Orientation (see Note 2): T **Test Fluid:** Water

End-Use Refrigerant.: R-410A **Thermophysical Properties Source:** ASHRAE Handbook

Valve Flow Path: Low Pressure					**Valve in Test: Nominal 3 ton**					**Valve Position A**
Row No.	**Barometric Pressure**	**Inlet Gage Press**	**Inlet Temp.**	**Inlet Density**	**ΔP**	**$\rho \cdot \Delta P$**	**$(\rho \cdot \Delta P)^{1/2}$**	**Mass Flow**	**Temp. Out**	**Remarks**
	kPa	**kPa**	**°C**	**kg/m^3**	**kPa**	**kg^2/(m$^4 \cdot$s^2)**	**kg/(m$^2 \cdot$s)**	**kg/s**	**°C**	
1	101.35	13.8	21	998	13.8	13772400	3711.1	0.47	21	Water
2	101.35	3.45	21	998	3.45	3443100	1855.6	0.23	21	Water

Valve Flow Path: High Pressure					**Valve in Test: Nominal 3 ton**					**Valve Position A**
Row No.	**Barometric Pressure**	**Inlet Gage Press**	**Inlet Temp.**	**Inlet Density**	**ΔP**	**$\rho \cdot \Delta P$**	**$(\rho \cdot \Delta P)^{1/2}$**	**Mass Flow**	**Temp. Out**	**Remarks**
	kPa	**kPa**	**°C**	**kg/m^3**	**kPa**	**kg^2/(m$^4 \cdot$s^2)**	**kg/(m$^2 \cdot$s)**	**kg/s**	**°C**	
1	101.35	6.9	21	998	6.9	6886200	2624.2	0.47	21	Water
2	101.35	1.52	21	998	1.52	1516960	1231.6	0.23	21	Water

Note 1: Dimensions must be consistent and shall be Inch-Pound (I-P) or Standard International Metric (SI). Flow rates are reported as pounds per minute (lb/min) in the I-P system and kilogram per second (kg/s) in the SI system of units.
Note 2: Orientation shall be described by designating the location of the high-pressure inlet tube, i.e., Top (T), Bottom (B), Horizontal (H).
Note 3: Values shown in this table are arbitrary and are for example purposes only. Although water is selected for this example, many other working fluids may be employed.

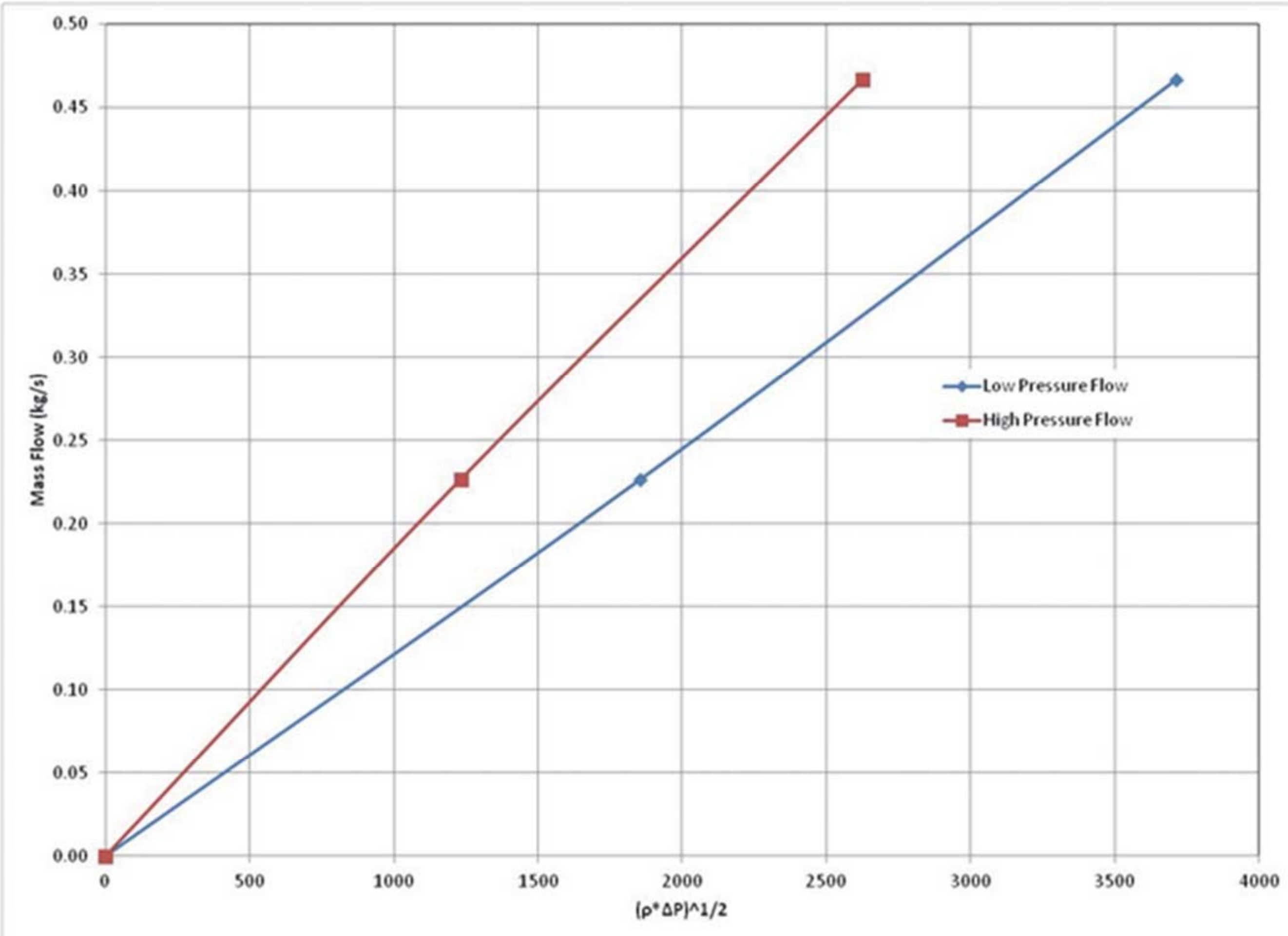

FIGURE A-1 Graph of valve flow rate—valve in position A.

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INFORMATIVE APPENDIX B
COMPUTATION OF FLOW CAPACITY IN TERMS OF REFRIGERATING EFFECT

The following thermodynamic equation relates the heat energy corresponding refrigerating effect to the mass flow rates of various refrigerants. Assuming that the refrigerant absorbs the heat associated with the phase change from saturated liquid to saturated vapor at the same rate as the mass flow rate through the valve, the equation may be used to express valve capacity in terms of refrigerating effect.

$Q = \dot{m}(h_g - h_f)$ (see note below)

where

Q = heat absorbed in the evaporator of the refrigerating system by the refrigerant flowing through the valve

$\dot{m}$ = mass flow rate of refrigerant through the valve.

h_g = specific enthalpy of the saturated refrigerant vapor exiting the evaporator

h_f = specific enthalpy of the refrigerant liquid entering the expansion device

Note: Dimensions must be consistent and shall be Standard International Metric (SI) or Inch-Pound (I-P). Refrigeration capacities are reported as watts (W) in the SI system and tons of refrigeration (TR) in the I-P system.

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INFORMATIVE APPENDIX C
SUGGESTED TEST APPARATUS IF TESTING WITH REFRIGERANT

C1. OVERVIEW

This annex describes a suggested test apparatus intended to facilitate four-way valve testing as required by this standard. The system described by this annex (See Figure C-1) is capable of testing with refrigerant according to the standard.

The benefits of the Annex C apparatus are as follows:

a. Allows testing with refrigerant.
b. Fluid flow is measured on the liquid side to simplify calibration.

C1.1 A variable-capacity compressor—may be variable speed or driven by a variable-speed belt drive.

C1.2 The reversing valve under test having appropriate gages or sensors—adaptors and connectors to accommodate various tube sizes may be needed. Refer to Figures 1 and 2 for details.

C1.3 A first heat-rejection heat exchanger having airflow control baffle or other method of adjusting heat removal.

C1.4 A sight glass to be used for a visual check to make certain single-phase liquid is flowing.

C1.5 A liquid flowmeter to measure refrigerant flow rate.

C1.6 An adjustable refrigerant-flow restrictor valve.

C1.7 A second heat-rejection heat exchanger having airflow control baffle or other method of adjusting heat removal.

C1.8 A sight glass to be used for observing that single-phase vapor flow is present.

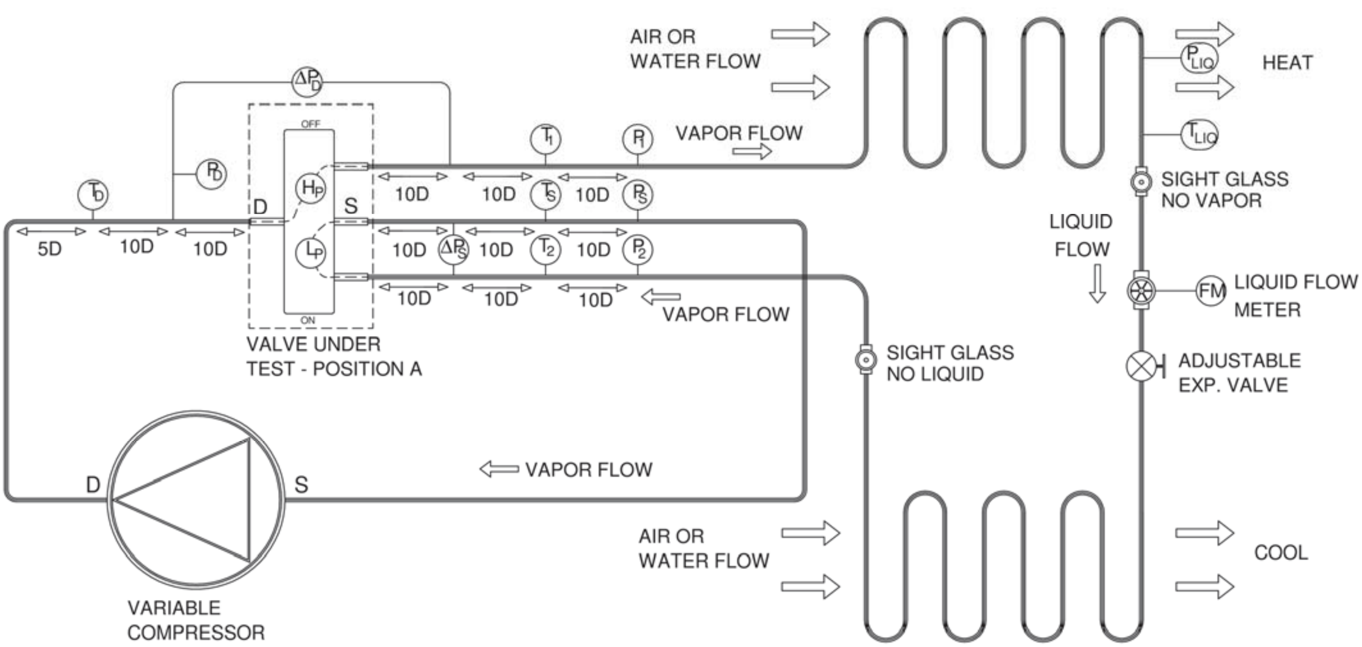

FIGURE C-1 Suggested test apparatus intended to facilitate four-way valve testing.

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