

SEMI F32-0998

TEST METHOD FOR DETERMINATION OF FLOW COEFFICIENT FOR HIGH PURITY SHUTOFF VALVES

1 Purpose

1.1 This test method describes how to determine two criteria used in selecting valves of appropriate size for gases and liquids.

1.2 Methods and equations are specified and/or referenced to assist in accurate calculation of pressure drops across valves tested by this method.

2 Scope

2.1 This method establishes the testing criteria for determination of two coefficients specified in ANSI/ISA-S75.02:

- Valve flow coefficient (C_v)
- Critical pressure drop ratio factor (x_T)

2.2 This method is to be used with ANSI/ISA-S75.02. This method applies to manual and actuated valves for use in both gas and liquid distribution systems used in semiconductor manufacturing facilities. It is a test method, where existing test methods are referenced and limitations are imposed on test conditions. Specific equations for calculating flow coefficients, choked flow parameters, and pressure drops are referenced to the appropriate ISA section.

3 Limitations

3.1 This method will limit the use and interpretation of ANSI/ISA-S75.02 for use by manufacturers and users of valves designed for the semiconductor industry.

3.2 This method is not intended to be used to determine flow coefficients for valves used in vacuum service.

4 Referenced Documents

NOTE: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4.1 ANSI Documents¹

ANSI/API 2530 — Part 2: Natural Gas Fluids Measurement - Concentric, Square-Edged Orifice Met

ANSI/ISA-S-75.01 — Flow Equations for Sizing Control Valves

ANSI/ISA-S75.02 — Control Valve Capacity Test Procedure

5 Terminology

5.1 Acronyms

5.1.1 ΔP — Pressure drop across valve, kPa (psi).

5.1.2 F_k — Ratio of specific heats factor, where:

$$F_k = \frac{k}{1.40}$$

5.1.3 F_L — Liquid pressure recovery factor

$$F_L = \frac{Q_{\max}}{0.0865 * C_v * \sqrt{\frac{P_1 - 0.96 * P_v}{S_f}}}$$

$$F_L = \frac{Q_{\max \text{ gpm}}}{1.00 * C_v * \sqrt{\frac{P_1 - 0.96 * P_v}{S_f}}}$$

5.1.4 gpm — Gallons per minute

5.1.5 k — Specific heat ratio

5.1.6 P_1 — Absolute pressure at upstream pressure tap, kPa (psi).

5.1.7 P_2 — Absolute pressure at downstream pressure tap, kPa (psi).

5.1.8 P_v — Absolute vapor pressure of liquid at inlet temperature, kPa (psi).

5.1.9 $psia$ — Pounds per square inch absolute

5.1.10 $psid$ — Pounds per square inch differential

5.1.11 Q — Volumetric flow rate

5.1.12 $Q_{\max}$ — Maximum flow rate (choked flow conditions) at a given upstream condition.

5.1.13 $scfh$ — Standard cubic feet per hour

5.1.14 S_f — Specific gravity of a liquid relative to water.

5.1.15 S_g — Specific gravity of a gas relative to air.

5.1.16 T — Absolute temperature of test gas or liquid, °K (°R).

¹ American National Standards Institute, 11 West 42nd St., New York, NY 10036, Telephone: 212.642.4900, Fax: 212.398.0023

5.1.17 x — Ratio of pressure drop to absolute inlet pressure, dimensionless, where:

$$x = \frac{\Delta P_{kPa}}{P_{1kPa}} \quad | \quad x = \frac{\Delta P_{psid}}{P_{1psia}}$$

5.1.18 x_T — Ratio of pressure drop to absolute inlet pressure ($\Delta p/p_1$) at choked flow condition, dimensionless.

5.1.19 Y — Expansion factor for compressible fluids, where:

$$Y = 1 - \frac{x}{3 \times F_k \times x_T}$$

5.2 Definitions

5.2.1 *flow coefficient* C_v — A numeric constant used to characterize the flow capacity of a valve.

5.2.2 *vapor pressure condensation point* — Pressure at which fluid phase changes from liquid to gas, for a given upstream condition.

5.2.3 *vena contracta* — Point in a duct where the diameter of the fluid stream is smaller than the diameter of the duct.

6 Test Fluids

6.1 *Incompressible (Liquid) Fluid* — Water is the standard liquid test fluid.

6.2 *Compressible (Gaseous) Fluid* — Nitrogen is the standard gaseous test fluid. When using Nitrogen, care should be taken to assure that the fluid does not approach the vapor pressure condensation point at the vena contracta.

7 Test Setup

7.1 Test Valve

7.1.1 The test valve can be any high purity valve, or a combination of valve with tube connections, fittings connection, or expanders which are normally attached as part of the valve assembly as purchased. It is important to note that the definition of the “test valve” is inclusive of all connections and fittings, as supplied by the manufacturer. This specifically differs from the ISA procedure, whereby a method is provided to differentiate the pressure drop contribution of the attached fittings. It is recognized that flow coefficients may vary slightly depending upon the end connection used. Examples of typical test valves are shown in Figure 1.

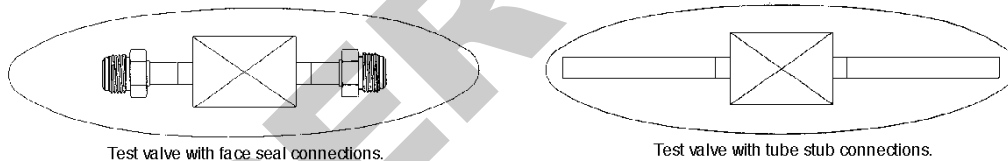


Figure 1
Test Valve with Various Connections