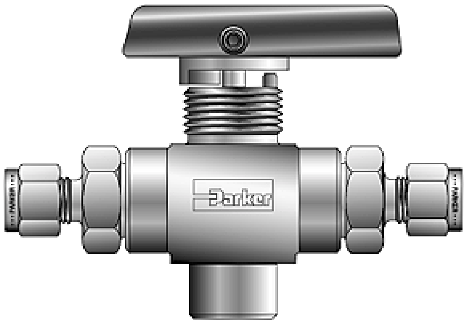
Engineering Performance Report

EPR 4103.1 Revision -

Valve Pressure / Temperature Ratings



Abstract

Recognized ASME valve design and pressure rating standards are not applicable to small instrumentation valves. Instrumentation valves are typically used based upon the manufacturer's recommended pressure-temperature ratings. This report reviews existing national standards and how they relate to instrumentation valves. Information on the design, rating, and testing of Parker instrumentation valves to applicable national standards is also presented.

National Standards

All Parker instrumentation valves are pressure rated in accordance with MSS SP-99 *Instrument Valves*. The Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) published this standard to specifically address these unique valves.

MSS SP-99 applies to small valves and manifolds developed for and primarily used in instrument, control and sampling piping systems. It addresses steel and alloy valves of one inch nominal pipe size and smaller. The standard requires all pressure boundary components to be manufactured from materials identified in it. In addition, material certifications, identifying chemical analyses and mechanical properties, must be obtained for all pressure boundary parts.

The design requirements in *MSS SP-99* deal principally with end connection standards. Familiar ASME standards for pipe threads, pipe socket welds and pipe buttwelds are incorporated by reference. Socket weld and butt weld connections for instrumentation tubing are based on sound welding practices since there are no national standards.

Valves manufactured in accordance with this standard have Cold Working Pressure (abbreviated CWP) ratings established by hydrostatic burst qualification tests. The CWP rating of an instrumentation valve is determined based upon 1/4 of the lowest burst pressure recorded for three production test valves, factored by the ratio of specified to actual tensile strengths of the pressure boundary materials.

The industrial valve standard, ASME B16.34 *Valves - Flanged, Threaded, and Welding End* was written for process system valves and only applies to the types of valves listed in the title. The standard states, in the Introductory Notes, that B16.34 may not be considered appropriate for "...valves used in instrument systems...". This standard does not address the use of compression ports, such as A-Lok® or CPI™, found on many instrumentation valves.

Another widely recognized standard, the ASME B31 Code for Pressure Piping, consists of a number of individually published sections for piping installations. The Code sets forth engineering requirements deemed necessary for safe design and construction of pressure piping, including valves. ASME B31.1 *Power Piping* deals with piping components typically found in power generating stations, industrial and institutional plants, geothermal heating systems, and central and distinct heating and cooling systems.

ASME B31.3 *Process Piping* deals with piping components found in petroleum refineries, chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants, plus related processing plants and terminals. Each standard has unique requirements for design, construction, inspection and testing of piping and ancillary components.

Instrumentation Valve Design and Testing

Product performance historically has not been addressed in national standards. Valve performance has been based upon the user's application and performance expectations. Parker engineers often seek out customer's expectations for our products and design valves to fill those needs. Extensive laboratory tests are used to qualify valve designs prior to production.

Strict quality programs, under the general requirements of ISO 9001, control procurement and use of all materials at Parker Instrumentation Valve Division. Valve pressure boundary components are manufactured using only those materials permitted by ASME B16.34 and/or MSS SP-99. Instrumentation valves manufactured from brass are also available from Parker, but brass is not a recognized material in either B16.34 or SP-99.

There are no national standards for end-to-end dimensions for instrumentation valves. While ASME B16.34 requires valves meet the dimensions presented in ASME B16.10 *Face-to-Face and End-to-End Dimensions of Valves*, a review of this standard for information in this regard provides little guidance for valves of one inch nominal pipe size or smaller.

Wall thicknesses to insure adequate pressure boundary factors of safety for Parker instrumentation valves are derived by analyses and by conducting validation burst tests in accordance with MSS SP-99. Valve pressure class ratings and associated wall thickness requirements in ASME B16.34 are not used since these are not intended for instrumentation valves.

ASME B16.34 requires all production valves be subjected to a shell test at 1.5 times the valves rated pressure and a seat/closure member test at 1.1 times the valves rated pressure using water or other suitable fluid. This requirement is also an option in MSS SP-99 when using liquid as a test fluid. Parker employs the gas test methods outlined in MSS SP-99 for shell and seat leakage on every production valve. A liquid shell test in accordance with ASME B16.34 is available for most Parker valves on special order.

Pressure-Temperature Ratings

ASME B16.34 groups valves into eight pressure classes based solely on metal strength properties. This standard further states that "pressure-temperature ratings for the valve may be limited by construction details or material considerations". An instrumentation valve's pressure-temperature performance is often controlled by the non-metallic components used in the valve. Common non-metallic components are elastomers, thermoplastics and lubricants. The strength and load-carrying capacities of all materials decrease with temperature, but this decrease is more dramatic in valve designs employing plastics and elastomers.

Parker subjects every product to rigorous pressure-temperature tests, upon which conservative ratings are generated. The pressure-temperature performance of Parker instrumentation valves is included in the product catalog for each respective product.

Relating to National Standards

Parker engineers are often asked if instrumentation valves meet the requirements specified in ASME B31.1 *Power Piping* or ASME B31.3 *Process Piping.*

Paragraph 122.3 of B31.1 discusses requirements for instrumentation piping systems. The paragraph reviews design and materials of construction. ASME B31.1 further states in paragraph 107, valves complying to ASME B16.34 may be used within the specified pressure-temperature ratings. As previously mentioned, B16.34 is not intended to be a design guide for instrumentation valves. The Parker Swing-out Ball Valve is the only product line conforming to B16.34 as a Class 600 valve, and exceptions include brass and three-way versions of this product line.

B31.1 requires valves not in compliance with ASME B16.34 be used only in accordance with the rules of paragraph 102.2.2 of the standard. ASME B31.1 states in paragraph 102.2.2 that components not covered by the standards listed in Table 126.1 have to be rated as required by paragraph 104.

Paragraph 104.7.2 states that components may be used ... “if the pressure design was based on calculations consistent with this code”. Paragraph 104.7.2 (B) states...“A proof test conducted in accordance with the ASME B&PVC Section I, A - 22 may be used to verify acceptability”. Paragraph A - 22 contains essentially the same formula as in MSS SP-99 for computing CWP when a burst test is used. However, paragraph A - 22 requires a 5:1 safety factor versus MSS SP-99, which requires a 4:1 safety factor.

Similarly, paragraph 322.3 of ASME B31.3 describes the requirements for instrumentation piping. ASME B31.3 further states in paragraph 307, valves complying to a standard listed in Table 326.1 may be used within the specified pressure-temperature ratings. It states “unlisted” valves may be used only in accordance with paragraph 302.2.3 of the code. ASME B31.3 states in paragraph 302.2.3 that components not listed in Table 326.1, but which conform to a published specification or standard (such as MSS SP-99), may be used within the following limitations:

1) The designer (purchaser) shall be satisfied that composition, mechanical properties, method of manufacture, and quality control are comparable to the corresponding characteristics of listed components.
2) Pressure design shall be verified in accordance with paragraph 304 of ASME B31.3.

Paragraph 304.7.2 (Unlisted Components) states: The pressure design of unlisted components... “shall be based on calculations by one or more of the means in (a), (b), (c), and (d)”. Here, paragraph (c) states ...”proof test in accordance with ASME B&PVC Section VIII, Division 1, UG-101”. Section VIII, Division 1, UG-101 contains essentially the same formula in MSS SP-99 for computing CWP when a burst test is used. Here again, paragraph UG-101 (M) requires a 5:1 safety factor.

Summary

If an instrumentation valve’s maximum CWP rating was based upon metal strength and not the limitations of any plastic or elastomer, the valve’s maximum pressure rating could be reduced by 20 percent for use in both a B31.1 and B31.3 pressure piping application. In addition, owing to the numerous applications and valve designs available with instrumentation valves, each B31.1 or B31.3 installation has to be reviewed by both the purchaser and the valve manufacturer to determine the proper valve for permitted designs, materials, pressure-temperature ratings, and any other special operational or service categories discussed in these standards.

Definitions

Burst Pressure - The pressure at which the valve’s pressure boundary ruptures or the valve fails due to gross leakage.

Cold Working Pressure Rating - The maximum allowable working pressure of a valve at ambient conditions (-20 °F to 100 °F), abbreviated CWP. (MSS SP-99)

Control Piping - Piping used to interconnect pneumatically or hydraulically operated control apparatus, or to signal transmission systems. (MSS SP-99)

Factor of Safety - Typically defined as a number larger than one used to evaluate the relative safeness of a component. Typical industrial factors of safety for valves are 4 or 5.

Instrument Piping - Piping used to connect instruments to main piping or other instruments. (MSS SP-99)

Instrument Valves - Valves designed for use in instrument, control and sampling piping systems. (ASME B31.1, Article 122.3)

Manifold Valve - Two or more instrument valves fabricated into a single valve body. (MSS SP-99)

Pressure Boundary Components - For instrument valves, the following items are defined to be pressure boundary parts. Each item may not apply to all valve designs. a) Body, b) Packing Nut, c) Bonnet, d) Union Nut, e) Body to Bonnet Bolting, f) Body Bolting. (MSS SP-99)

Definitions - Continued

Proof Test - A general term applied to any number of tests used to establish the maximum allowable working pressure of a valve.

Seat/Closure Member Test - An internal pressure test of flow regulating elements (seats, seals, and closure members such as gate, disc, ball or plug). (MSS SP-82)

Shell Test - An internal pressure test of the pressure containing envelope. (MSS SP-82)

Tensile Strength - The stress required to reach the maximum strength of a material during a standard tensile test.

Referenced and Related Documents

ASME Standards[1]

ASME Boiler and Pressure Vessel Code
    Section I Power Boilers
    Section VIII Division 1 Pressure Vessels
ASME B1.20.1 Pipe Threads, General Purpose (inch)
ASME B16.10 Face-to-Face and End-to-End Dimensions of Valves
ASME B16.11 Forged Steel Fittings, Socket Welded and Threaded
ASME B16.25 Buttwelding Ends
ASME B16.34 Valves - Flanged, Threaded, and Welding End
ASME B31.1 Power Piping
ASME B31.3 Process Piping

MSS Standard Practices[2]

MSS SP-25 Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-82 Valve Pressure Testing Methods
MSS SP-99 Instrument Valves

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[1] *American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017*

[2] *Manufacturers Standardization Society of the Valve and Fitting Industry, Inc., 127 Park Street, N.E. Vienna, VA 22180-4602*

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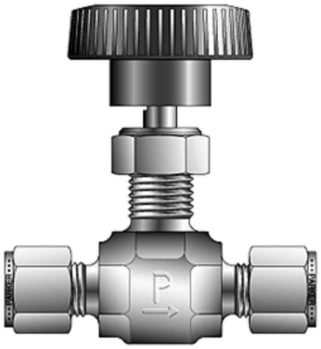
Parker Instrumentation

Engineering Performance Report

EPR 4103.2 Revision -

Cleaning for Oxygen Service



Abstract

Components and systems for gaseous or liquid oxygen service must be cleaned to minimize the presence of reactive contaminants. It is essential to remove organic deposits such as lint or particulate like metal fines from components being used in highly enriched oxygen environments. Hydrocarbon contamination is particularly undesirable in any oxygen system. The acceptance criteria in terms of maximum allowable hydrocarbon and particulate contamination varies considerably among published standards and papers. Oxygen service valves furnished by the Instrumentation Valve Division of Parker are cleaned, assembled and packaged to standards that are considered conservative, ultra high purity cleanliness goals for the majority of oxygen systems.

Scope

This report provides an introduction to the unique concerns that must be addressed in the handling of oxygen and the special cleaning and assembly methods used by Parker Instrumentation Valve Division for oxygen service valves. The majority of this report is extracted from ASTM G 128 *Standard Guide for Control of Hazards and Risks in Oxygen Enriched Systems*. Neither this ASTM standard nor Parker Hannifin purport to address all of the safety concerns associated with the handling of oxygen. Furthermore, it is important to know that most common industrial components, such as valves, are not designed for a specific application. They are versatile, general-purpose products that can be used in many types of applications and systems. Valves may be prepared for oxygen service by applying recognized practices for material selection, cleaning, assembly, and packaging.

Causes of Fires in Oxygen

Oxygen is the most abundant element, making up 21% of the air and 55% of the earth's crust. It supports plant and animal life. Despite its apparent innocence, oxygen is a serious fire hazard. It makes materials easier to ignite and their subsequent combustion more intense, more complete, and more explosive than in air. Typically, in an oxygen system, a small amount of energy ignites a material with a low ignition temperature or a particle with a large surface area and small mass. Once ignited, the material gives off enough heat to ignite bulk materials with higher ignition temperatures. This sequence, which began as a small event, grows into a fire and becomes self sustaining. Common ignition energy sources are: (1) mechanical impact, (2) particle impact, (3) friction, and (4) pneumatic impact or compression heating.

Mechanical Impact - When an object strikes another, as with a hammer blow, absorbed energy appears as heat.

Particle Impact - When the impact of a particle carried in the flow steam strikes a surface, such as a valve seat, the kinetic energy of the particle creates heat at the point of impact.

Friction - The rubbing of two solid materials results in the generation of heat.

Pneumatic Impact or Compression Heating - A common cause of ignition is the rapid pressurization of a system, resulting in near-adiabatic compression heating of the oxygen. The gas temperature can reach the auto-ignition point of organic contaminants or polymers, whose combustion can add enough heat to ignite metal and cause a fire. ASTM G 63 contains a technical discussion of these ignition mechanisms.

Fire Prevention

Combustion in air containing about 21% oxygen is a familiar hazard. Typical fire protection methods focus on separating the three elements needed to create a fire: (1) the oxidant, (2) the fuel, and (3) the ignition source. The separation of these three elements can not be applied to oxygen systems because: (1) the process fluid is the oxidant and can not be removed, (2) the materials used to build a system are flammable under at least some conditions, and (3) ignition sources exist within the system itself.

ASTM G 128 states that progressive stringent oxygen service practices are to be applied in the following order:

Cleaning
Compatible lubricants
Compatible polymers and other nonmetals
Compatible metals

When oxygen concentrations and pressures are low, the hazard is lowest and cleaning may be the only control necessary. As oxygen enrichment and pressure increase, careful cleaning is required and lubricants are selected more carefully. At higher pressures, careful cleaning, selection of lubricants, and selection of polymers and other nonmetals are all important. At the level of greatest severity, metal selection must be added to the preceding measures.

Recognizing, identifying, and controlling potential causes of fire is not simple. ASTM G 63, G 88, G93, and G94 describe many factors affecting oxygen or oxygen enriched systems and describe how to reduce the hazards associated with these systems. System design, component selection and operating procedures deserve the same attention as oxygen service practices.

System Design

Oxygen system design should not be undertaken casually. The first and most important rule is: Consult an expert! Oxygen system design should begin with the same principals as conventional air or gas system design and follow the same nationally recognized codes and standards. There are no special codes that mandate how to design oxygen systems.

ASTM G 88, CGA G-4.4, NFPA 50 and 51, and many other referenced documents provide excellent guidelines for system design - but these references are not handbooks. These references review how the severity of system operating conditions influences the degree of system design. Praxair Publication L-5110N warns "...Remember that design of oxygen systems requires specialized knowledge. Liability problems associated with improperly designed systems can far outweigh the cost of professional services."

Valve Selection

Oxygen system designers and users must be sensitive to valve function, material compatibility, adequate ratings, and proper installation, operation, and maintenance. Valve selection requires special attention by the system designer, because valves are actuated routinely while the system is in use. Valve manufacturers in general have neither the experience nor expertise to select the most appropriate valve for a specific use, such as an oxygen system.

ASTM G 88, CGA G-4.4, and NFPA 51 unanimously emphasize that valves must be opened slowly. Opening speed is controlled by valve design, as well as by operating procedures. Ball and plug valves have a straight-through design, thereby providing a lower pressure drop than a needle valve. However, ball and plug valves are quick opening and create high velocities when opened, whereas needle valves are designed to open slowly.

Particular attention should be directed to valve pressure and temperature ratings, internal materials of construction. and how readily the valve can be cleaned and kept clean. Valves often are selected with higher ratings, greater wall thickness, and more fire-resistant materials than the rest of the system because they are exposed to more severe service conditions.

Valve Cleaning and Assembly

Initial cleanliness in oxygen systems must be established as components are built and the system is fabricated. ASTM G 93 states that manufactured products such as valves should be cleaned by the manufacturer prior to final assembly and test. Furthermore, the purchaser should approve the cleaning and packaging procedures to assure they satisfy the system requirements.

The Parker Instrumentation Valve Division has established perhaps the most rigorous cleaning and assembly practices in the industry for oxygen service valves. Parker Specification ES8003 identifies the minimum cleaning, handling and packaging requirements for components to be used in oxygen enriched environments. It is based upon the recommended practices in ASTM G 93 and CGA Pamphlet G-4.1 for cleaning, drying, inspection and packaging. Assembly and packaging operations are conducted in a vertical flow Class 100 Clean Room as defined by Federal Standard 209. All processes and inspection methods are monitored using Quality Assurance Instruction QAP-119 for compliance with the ES8003 specification.

Machined metallic components are pre-cleaned using caustic (detergent) methods to remove organic contamination such as hydrocarbon oils, grease and waxes, followed by thorough rinsing and hot air drying. Applicable acid cleaning treatments (such as passivation) are subsequently applied, followed by thorough rinsing in hot deionized (DI) water.

In the final cleaning stage, all valve components are cleaned appropriate for the component. Components that will be exposed in direct oxygen service are cleaned using multi-step processes involving alkaline soap soaks, ultrasonic agitation in DI water containing surfactants, rinsing, final ultrasonic agitation in DI water, and drying. Components not exposed to oxygen service and all polymers are immersed in DI water, ultrasonically agitated and dried.

The ES8003 cleaning process has been developed to meet the requirements of ASTM G 93 for both hydrocarbon and particulate levels Level C and Test 2, Level 500 for all products except HR Series Metering Valves. HR Series Metering Valves meet the G93 requirements for Level E and Level 500. The process is monitored periodically on valve assemblies using the solvent extraction test per ASTM F 331 for nonvolatile residue and ASTM F 312 for particle populations.

After assembly and testing, finished products are packaged appropriately to protect them from contamination until they are installed. Cleaned polyethylene caps are placed on assemblies to protect threads. Each assembly is heat-sealed in a 4 to 6 Mil (0.15mm) polyethylene bag. A high purity nitrogen purge is employed during the bagging operation. This bag is then heat-sealed in a second 4 to 6 Mil polyethylene bag. A label, printed on suitable non-shedding paper, is placed between the bags, identifying the component as cleaned in accordance with ASTM G 93. The bagged product is placed in a cardboard box and the box is shrink wrapped. The box is labeled with the component model number and packaging date code.

Notes on Compatible Lubricants, Polymers & Other Nonmetals, & Metals

Parker valves requiring lubrication for function are assembled only with perfluoroalkyl polyether grease meeting the requirements of ASTM G 93 and MIL-G-27617 for oxygen compatibility.

Both polytetrafluoroethylene (PTFE) and polychlorotrifluoroethylene (PCTFE) are listed by CGA G-4.4 as suitable polymers for oxygen service. Yet, even these materials begin to decompose at 200 to 300 °C (400 to 600 °F) and can ignite at higher temperatures. All nonmetals should be tested and evaluated carefully before being used in a particular oxygen system application. ASTM G 63 presents a systematic approach to selecting nonmetallic materials and includes a compilation of test data for many nonmetallic materials frequently used in oxygen service.

For common systems at oxygen concentrations up to about 40% and at pressures below 1MPa (150 psig), few special metals are required. NFPA 51 and CGA G-4.4 mention existing practices for the use of steel or stainless steel for oxygen systems, but only at 7 MPa (1000 psig) or less. Further, in regions of high velocities, such as valves, copper and nickel based alloys (brass and alloy 400) are recommended - except for low pressures to 1.4 MPa (200 psig) where selected stainless steels may be used. CGA G-4.4 recommends asking the oxygen supplier to provide specific guidance.

Referenced and Related Documents

ASTM Standards[1]

ASTM D 2512 Test Method for Compatibility of Materials with Oxygen (Impact Sensitivity and Pass-Fail Technique)
ASTM D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM D 4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
ASTM F 312 Methods for Microscopic Sizing and Counting Particles from Aerospace Fluids on Membrane Filters
ASTM F 331 Test Method for Nonvolatile Residue of Halogenated Solvent Extract from Aerospace Components (Using Rotary Flash Evaporator)
ASTM G 63 Guide for Evaluating Nonmetallic Materials for Oxygen Service
ASTM G 72 Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment
ASTM G 74 Test Method for Ignition Sensitivity of Materials to Gaseous Fluid Impact
ASTM G 86 Test Method for Determining Ignition Sensitivity of Materials to Mechanical Impact in Pressurized Oxygen Environments
ASTM G 88 Guide for Designing Systems for Oxygen Service
ASTM G 93 Practice for Cleaning Methods for Material and Equipment Used in Oxygen-Enriched Environments
ASTM G 94 Guide for Evaluating Metals for Oxygen Service
ASTM G 128 Guide for Control of Hazards and Risks in Oxygen Enriched Systems
ASTM G 114 Practice for Aging Oxygen-Service Materials Prior to Flammability Testing
ASTM G 124 Test Method for Determining the Combustion Behavior of Metallic Materials in Oxygen-Enriched Atmospheres
ASTM G 126 Terminology Relating to Compatibility and Sensitivity of Materials in Oxygen Enriched Environments
ASTM G 128 Guide for the Control of Hazards and Risks in Oxygen Enriched Systems
ASTM STP 1395 Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres

ANSI Standards[2]

ANSI B31.3 Chemical Plant and Petroleum Refinery Piping
ANSI Z49.1 Safety in Welding and Cutting

CGA Documents [3]

CGA Video AV-8 Characteristics and Safe Handling of Cryogenic Liquid Gaseous Oxygen
CGA E-2 Hose Line Check Valve Standards for Welding and Cutting
CGA G-4 Oxygen
CGA G-4.1 Cleaning Equipment for Oxygen Service
CGA G-4.3 Commodity Specification for Oxygen
CGA G-4.4 Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems
CGA P-2.5 Transfilling of High Pressure Gaseous Oxygen to be Used for Respiration
CGA P-14 Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres
CGA TB-3 Hose Line Flashback Arresters

Federal Standard [4]

FED-STD-209 Clean Room and Work Station Requirements, Controlled Environments

NFPA Standards [5]

NFPA 50 Bulk Oxygen Systems at Consumer Sites
NFPA 51 Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes
NFPA 51B Fire Prevention in Use of Cutting and Welding Processes
NFPA 53 Fire Hazards in Oxygen-Enriched Atmospheres
NFPA 99 Health Care Facilities

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[1] *American Society for Testing and Materials, 100 Barr Harbor drive, West Conshohocken, PA 19428-2959*
[2] *American National Standards Institute, 11 West 42nd Street, New York, NY 10036*
[3] *Compressed Gas Association, Inc., 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202*
[4] *Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Avenue, Philadelphia, PA 19111-5094*
[5] *National Fire Protection Association, Inc., 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101*

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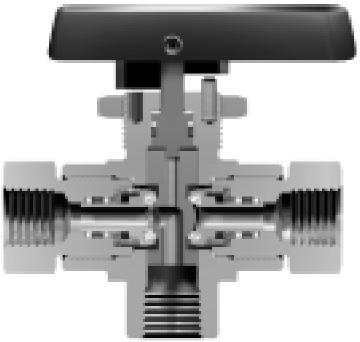
Parker Instrumentation

Engineering Performance Report

EPR 4103.3 Revision -

Modernizing The Sizing Of Valves For Determination Of Flow



The most common practice used in industry to determine the pressure drop or flow capacity of a valve is to obtain the valve flow coefficient C_v from the valve manufacturer and apply it to an appropriate formula. Today, most valve manufacturers publish flow coefficients, together with equations to predict flow versus pressure drop. Most manufacturers' equations for incompressible fluid (liquid) flow are correct. However, it is amazing how many different compressible fluid (gas) flow formulas are used, and worse still, they do not all provide the same answers. Incorrect valve selection can lead to inadequate flow or noise when undersized, and excessive cost when oversized.

Correct sizing for control valves has been a problem since they were invented. Originally, valve manufacturers avoided the use of valve flow coefficients and mathematical formulas by presenting graphs or nomographs for water, air, and steam flow for each valve size. This system was prevalent until mid 1942, when the current valve flow coefficient C_v, was introduced. The coefficient C_v is used in computations for both compressible and incompressible flow.

During the 1950's and 1960's, there was widespread disagreement between valve manufacturers as to which compressible fluid flow equation should be used. Some users in the process industries began to realize the compressible fluid flow formulas then in use gave results that were in disagreement, and could lead to serious sizing errors. The cause of the problem was that valves with the same C_v rating but with different shapes could have radically different gas flow characteristics. It became apparent that a single experimentally determined valve flow coefficient C_v was insufficient to describe both liquid and gas flow through valves over the full range of pressure drops.

The compressible fluid flow formula that became the Instrumentation Society of America (ISA) standard appeared in an article by Les Driskell in *Hydrocarbon Processing*, published in July 1969[1]. This was followed in 1970 by Driskell's article in *ISA Transactions*[2], and in 1983 with his textbook *Control Valve Selection and Sizing*. Driskell recognized flow through valves was very similar to flow through thin, sharp-edge flowmeter orifices. His work rested on a solid foundation of many years of research conducted on sharp-edged orifices for precise flow measurement.

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[1] Driskell LR, "New Approach to Control Valve Sizing" Hydrocabon Processing, July, p 131, 1969

[2] Driskell LR, "Sizing Valves for Gas Flow", ISA Transactions, Vol. 9, No. 4, 1970

Pressure drop across an orifice or valve causes a reduction in density because the gas reacts to the pressure drop by expanding. This is not the case with liquids because density can not change significantly. Mass flow rate (density x velocity x flow area) does not change along a flow path in steady flow, so an expanding gas must accelerate to higher velocities to maintain the mass flow rate.

The orifice meter flow equation for compressible fluids is the same as for incompressible fluid flow, except for using the gas density at the inlet conditions, and correcting for the effects of compressibility by means of the Y "expansion factor". The expansion factor is the ratio of flow coefficient for a gas to that of a liquid.

For orifice meters, the expansion factor is given by an empirical formula. For valves, the expansion factor accounts for the change in density of a fluid as it passes from the valve inlet to the vena contracta and for the change in area of the vena contracta as the pressure drop is varied. The expansion factor formula for valves requires the experimentally determined critical pressure drop ratio factor x_T.

Existing Valve Sizing Methods

Most valve manufacturers publish various equations in an attempt to simplify the ISA compressible fluid formulas by not utilizing the x_T coefficient. Most of the formulas in widespread use will not predict compressible fluid flow accurately for all types of valves over the full range of pressure drops.

Of three valve manufacturer's formulas reviewed, the first simplifies the ISA equation by assuming $x_T = 0.50$ for every valve. The second uses the "downstream density" equation - an equation reinvented many times since the early 19th century, which approximates the textbook-derived equation for the flow of a compressible fluid through an ideal nozzle. Another manufacturer uses the "mean density" equation, but truncates it at $p_2 / p_1 = 0.528$ (based on the critical pressure drop ratio of an ideal nozzle). All of these formulas have the potential to predict compressible fluid flows well in excess of actual values.

ISA standard S75.01 *Flow Equations for Sizing Control Valves* provides excellent valve sizing equations for both compressible and incompressible fluids. When the equations are applied, reliable results over the full range of pressure drops are obtained regardless of the media or valve type.

The calculation example in Figure 1 illustrates the accuracy of the ISA compressible fluid formula to actual flow, and the significant error that can occur when using a simplified form of the ISA equation.

So why doesn't everyone use the ISA standard compressible fluid formula? First, the testing and data reduction required to obtain the experimentally determined capacity factors is substantially more complex than traditional procedures, and manufacturers

Determining C_v and x_T

ISA standard S75.02 *Control Valve Capacity Test Procedure* provides two methods for determining the valve flow coefficient C_v and critical pressure drop ratio factor x_T. The first involves finding the maximum flowrate q_{max} (referred to as choked or sonic flow) of the valve, and the second, or alternative test procedure, obtains the information through linear curve fitting of test data.

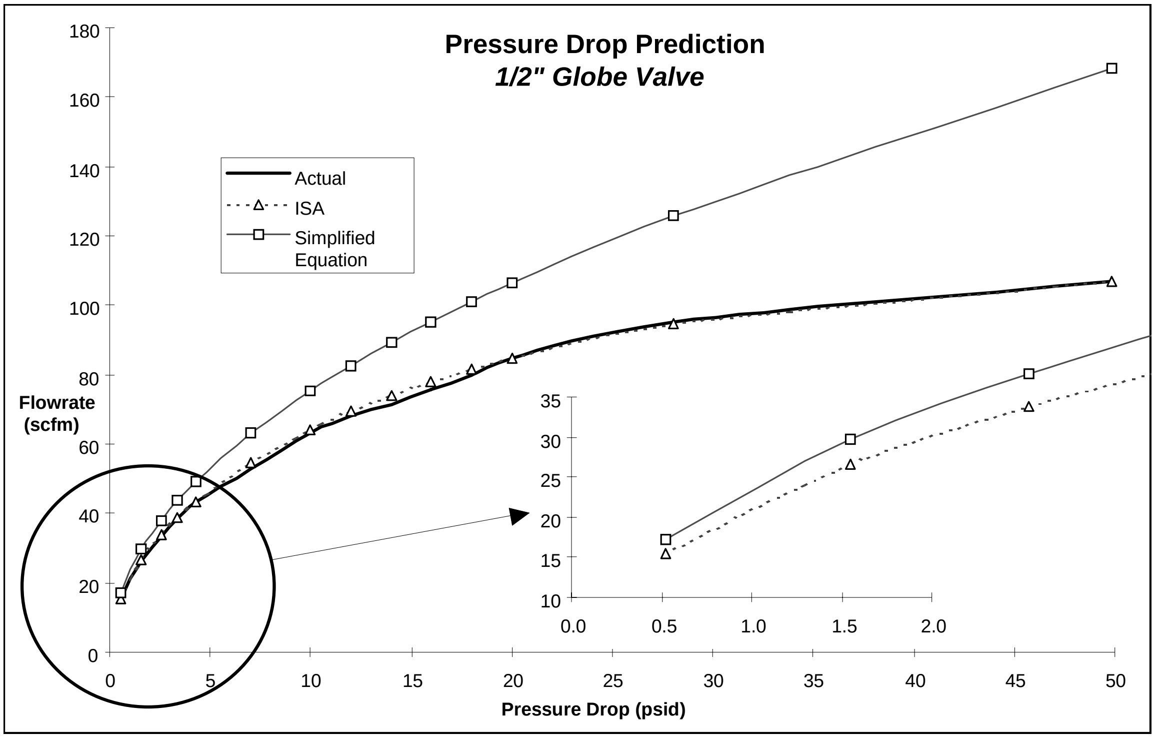

Figure 1: The ISA equation for compressible fluid pressure drop prediction versus a typical simplified equation.

With the first test procedure, C_v is determined at pressure drop ratios ($x = \Delta p / p_1$) less than 0.02. A separate test to determine x_T requires the valve be tested at it's maximum flowrate, which is defined by ISA as "the flowrate at which, for a given upstream pressure, a decrease in downstream pressure will not produce an increase in flowrate". This test requires a large volume of gas, and becomes a significant problem for larger high flow valves, such as ball and butterfly valves. Employing the ISA alternative test procedure eliminates this high flow test difficulty.

It has been determined the expansion factor Y is a linear function of the pressure drop ratio x. At a fixed stem travel C_v is constant, but the expansion factor Y changes with x. As x approaches zero (no expansion), Y approaches 1.0 in value. With the ISA alternate test procedure, both C_v and x_T are determined by testing the valve at a minimum of five widely spaced pressure differentials, measured at a constant upstream pressure. From these data points, values of YC_v are calculated using the equation:

$$YC_v = \frac{Q_{scfh}}{1360 \times P_{1\,psia}} \sqrt{\frac{G_g \times T_{\circ R}}{x}}$$

The test points are then plotted as YC_v versus x, and a linear curve is fitted to the data as shown in Figure 2. The value of C_v for the test specimen is taken from the curve at $x = 0$ and $Y = 1$. Since Y is linear with x, it can be shown that that the flow rate reaches a maximum when $Y = 2/3$. Therefore, the value of x_T for the test specimen is taken from the curve at $YC_v = 0.667C_v$. This method has the obvious advantage of determining the critical pressure drop ratio factor without having to achieve choked flow.

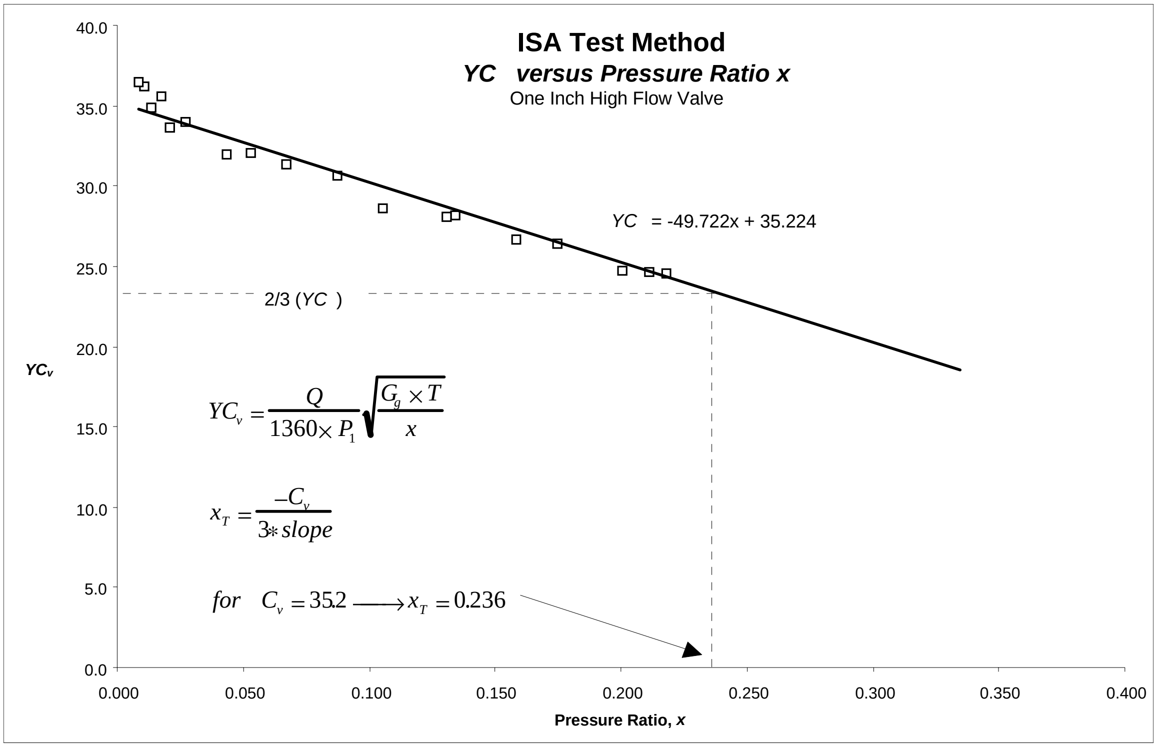

Figure 2: An example of the ISA Flow Coefficient alternative test method plot of expansion factor Y times flow coefficient C_V versus pressure drop ratio x.

ISA Equation

The ISA equation for compressible fluid flowrate is a function of the pressure drop ratio x, the inlet pressure p, temperature T, flow coefficient C_V, critical pressure drop ratio factor x_T, gas specific gravity G_g, and expansion factor Y:

$$Q_{scfh} = 1360 \times C_v \times p_{1\,psia} \times Y\sqrt{\frac{x}{G_g \times T_{\circ R}}}$$; where,

$$Y = 1 - \frac{x}{3F_k X_T}$$ (Limits 1.0 > Y > 0.67)

The expansion factor Y also includes the effect of the specific heat ratio F_k of the compressible fluid on the flow rate. For air, both F_k and G_g are equal to 1.0 at moderate temperatures and pressures.

The flow predicted by the above equation, assuming a constant inlet pressure and temperature, rises to a maximum until $x = x_T$ at which point $Y = 2/3$. Flow conditions where the value of x exceeds x_T are known as choked flow. Choking occurs when the jet stream at the valve's vena contracta attains its maximum cross-sectional area at sonic velocity. No further increase in flowrate can occur regardless of decreases in downstream pressures after this point.

The above ISA equation is modified when choked flow occurs to:

$$Q_{scfh} = 1360 \times C_v \times p_{1\,psia} \times Y \sqrt{\frac{X_T}{G_g \times T_{^\circ R}}}$$; where,

$$Y = 1 - \frac{1}{3F_k}$$

Impact of x_T on Flow

Valves with different flow paths have distinctly different critical pressure drop ratio factors. Valve geometries with complicated or circuitous flow paths tend to have numerically higher x_T values than valves with smooth, unobstructed flow paths. Therefore, two valves with identical flow coefficients C_v but with different x_T values will produce remarkably different flowrates.

For example, compare a full open ball valve with a C_v of 1.0 and an x_T of 0.14 with a needle globe valve with the same C_v but having an x_T of 0.84. Assume the upstream pressure is maintained at 100 psia and 70 °F. Flow rates will be the same at low values of x. As x increases, the flows become quite different. The ball valve will reach maximum flow at $x = 0.14$, while the needle valve will reach maximum flow at $x = 0.84$. The needle valve will have a flowrate at choked flow of almost twice that of the ball valve!

Solving the Testing Problem

Despite the merits of the ISA S75.02 test procedure, there is the problem of the costs of testing. Parker Hannifin's Instrumentation Valve Division has solved this problem by developing an automated test facility that reduces test time and eliminates manual data reduction. Data on C_v and x_T is obtained rapidly, reduced immediately and automatically, and checked for test errors before proceeding to the next test specimen. Results are archived in a database for permanent reference. Users are assured of reliable data taken under standardized conditions.

At Parker, a PC running Windows® NT controls the test and reduces the test data. Rather than wasting time manually adjusting the flow and pressure drop, a servo-operated throttling valve is used. The valve is actuated by a Parker Compumotor digital motion control system, supervised by the PC. The throttling valve has enough flow capacity for testing two inch high flow valves, but can be repositioned well below 0.0001 inch when testing smaller instrumentation valves.

A bank of four thermal mass flowmeters is used to cover a 10,000:1 flow range. The appropriate flowmeter is selected via computer control, and the PC checks that readings are within the calibrated flow range for the selected meter, before accepting the data.

Test specimen inlet pressure and differential pressure are measured with digital output transducers. Again, the computer will reject values too low to measure accurately.

Test data is reduced as the test is being performed, and the results plotted live on the monitor in the form required by ISA S75.02. A straight line is fitted to the data by a least square curve fit, with the curve updated whenever a new data point is acquired. The PC automatically calculates C_v and x_T from the equation of the least squares curve fit, and displays these values on the screen. The operator reviews the graph to be sure there are no anomalies before accepting the data.

It takes only a few minutes to flow test a specimen with the Parker test stand, and there is a high degree of assurance of accurate results. A set of standard test specimens is maintained, and retested periodically to verify repeatability. Instruments, of course, are calibrated periodically under the supervision of the Quality Assurance department.

Representative x_T Examples

Representative x_T values are provided in ISA S75.01, but the standard cautions the user to obtain the manufacturer's x_T values. Testing of Parker valves using the ISA S75.02 alternative method has provided a great deal of knowledge about the flow characteristics of different types of valves. Although the x_T values obtained support the fact that numerically lower x_T values are found in valves with smooth, unobstructed flow paths, there is no substitute for obtaining correct x_T values from the manufacturer for proper flow calculations.

Instrumentation valves have functional counterparts with larger general service valves. However, owing to their size, details of design and applications are unique. C_V and x_T values of representative Parker instrumentation valves follow. Comparisons are made between valves of the same size to demonstrate the significant effect flow path and design has on the capacity factors.

The valve illustrated in Figure 3 is typical of a FNPT ported needle or globe valve design with a regulating stem type, where the flow enters under the valve seat and exits the valve after making several dramatic turns. The flow in the FNPT ported ball valve in Figure 4 does not have to undergo any change in direction. These valves have identical orifice sizes of 0.188", but the C_V and x_T for the needle valve are 0.58 and 0.83, while the C_V and x_T for the ball valve are 1.02 And 0.42.

It is well known stem designs produce different C_V's, but they also produce different x_T's. The valve illustrated in Figure 3 is available with both a blunt and regulating stem. The blunt stem option will increase the C_V and reduce the x_T.

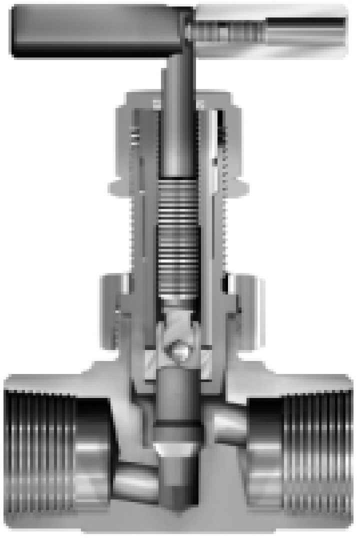

Figure 2
Needle Valve Cross Section

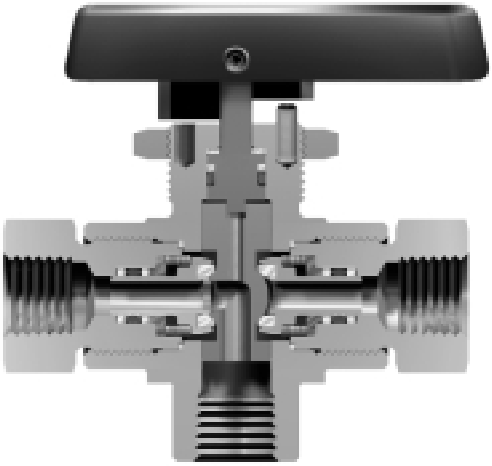

Figure 3
Ball Valve Cross Section

Ball valves with the same orifice size can produce different C_v and x_T values, but the differences are typically small. The two ball valves illustrated in Figures 5 and 6 are both compression ported ball valves with 0.188” orifices, but are two different designs. The C_v and x_T values for the design in Figure 5 are 1.04 and 0.42, while the C_v and x_T values for the valve illustrated in Figure 6 are 1.08 and 0.36. The non-changing flow area in the MB Series Ball Valve contributes to a higher C_v and a lower x_T.

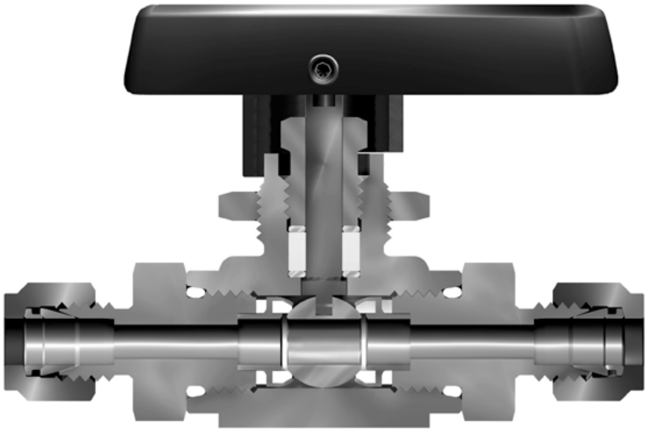

Figure 5
B Series Ball Valve Cross Section

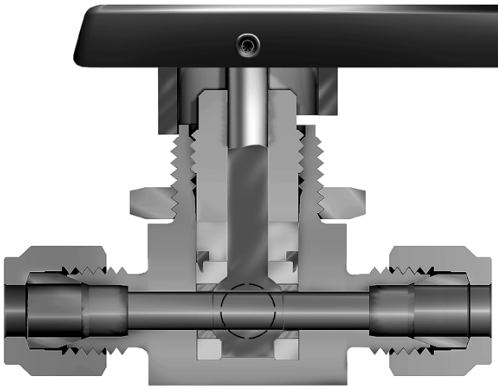

Figure 6
MB Series Ball Valve Cross Section

The effect of flow path on the two capacity factors is well represented in the design of the two check valves illustrated in Figures 7 and 8. Here again, the two valves have identical 1/4” face seal ports and identical 0.188” orifices. The C_v and x_T values for the C Series Check Valve are 0.75 and 0.53 because the flow path is not as tortuous as with the CO Series Check Valve, which has C_v and x_T values of 0.62 and 0.73.

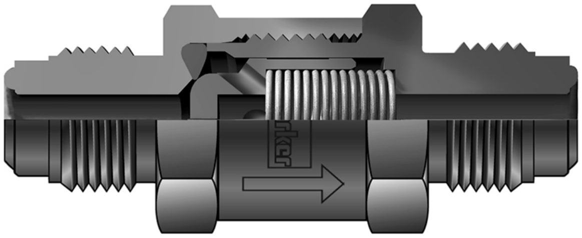

Figure 7
C Series Check Valve Cross Section

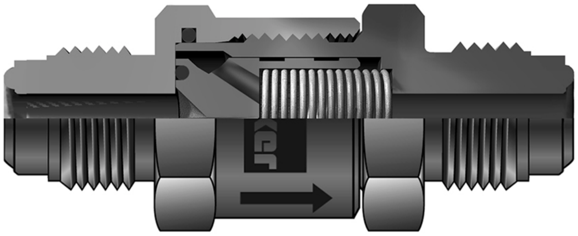

Figure 8
CO Series Check Valve Cross Section

inPHorm

Parker’s Instrumentation Valve Division has incorporated the valve capacity factors C_v and x_T and the ISA S75.01 flow equations into it’s Windows based product selection software inPHorm, so valve sizing becomes completely automatic. Users do not need to use the equations directly, or even look up C_v and x_T values.

A new era is dawning for compressible fluid valve selection, in which there will be no need to guess at required valve size because calculations are virtually effortless. There will not be any need to use flow capacity data taken many years ago to unknown or obsolete standards.

Parker Instrumentation

EPR 4103.3 Revision -

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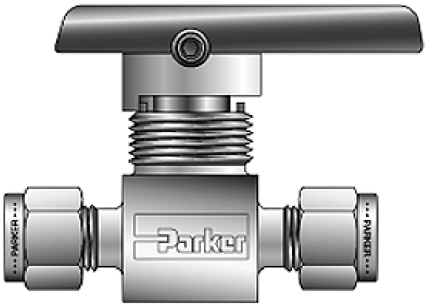
Engineering Performance Report

EPR 4121.1 Revision -

Miniature Ball Valve
One Piece Seat/Packing

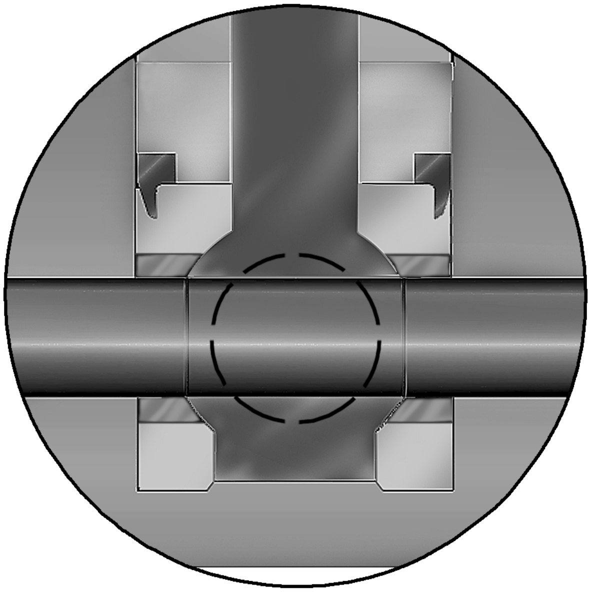


Abstract

Parker Instrumentation Engineers were asked to develop a miniature valve with better temperature performance when compared to valves currently available. Two Divisions within the Instrumentation Group combined resources to develop this product. Using expertise associated with injection molding Teflon® from Partek and the valve design and testing capabilities at the Instrumentation Valve Division, Parker developed and patented a product that extended the temperature range for this type of valve by a remarkable 265 °F (129 °C).

Patented Feature

The design advantage of the Parker Miniature Ball Valve is a unique one piece ball seat seal and stem packing. An injection molded grade of Teflon® perfluoroalkoxy (PFA) completely surrounds the entire ball area and a portion of the stem, creating a relationship that can not be achieved with separately made components. The one piece ball seat and seal is shown molded onto the lower portion of the stem in the figure below.



The advantage of the molded one piece PFA seal solved two weaknesses found in similar products. To understand the design advantage requires some explanation of similar conventional non-floating ball valve designs. Most designs use two machined TFE shells which meet along the valve centerline and surround the ball. These two components are squeezed together around the ball to effect a seal. In doing so, these valves have to overcome the potential tolerance gaps and associated leak paths which exist between the machined seals and the machined ball. In addition, the two TFE shells rely on squeeze to close their respective mating surfaces together, and seal the potential leak path.

These two potential leak paths are eliminated with the Parker Miniature Ball Valve. First, the injection molded PFA eliminates any dimensional differences between the ball and the seals. In essence, the surfaces of the ball and the seals are always perfectly matched. Second, the potential leak path associated with two TFE shells is completely eliminated.

It is well known extremes of temperature can create leak paths with plastic valve sealing mechanisms. When a valve has to overcome the design limitations associated with conventional two-piece TFE shell sealing mechanisms, temperature ranges must be limited to the range of approximately 50 to 150 °F (10 to 65 °C). The Parker Miniature Ball Valve performs remarkably well from -65 to 300 °F (-54 to 149 °C).

Other Design and Performance Features

The body is manufactured with patented vertical splines (thin channels) to provide a positive method of preventing the PFA from rotating with the ball at the rated temperatures. During assembly, the outer diameter of the PFA flows into several controlled splines and securely engages the PFA to the valve body.

The combination of these design advantages results in a valve with working pressures up to 3,000 psig (207 bar). Each valve is factory tested for leakage prior to shipment.

The Parker Miniature Ball Valve is currently available with US Customary port sizes from 1/8” to 3/8” and SI port sizes from 6mm to 8mm. They can be provided in two-way, three-way, and angle patterns. Additional sizes and options are under development.

Valves are manufactured in both ASTM A 479 stainless steel and ASTM B 16 copper alloy. These compact valves are panel mountable and feature fracture-resistant Nylon handles available in multiple colors. Pneumatic actuation is also an available option.

To obtain additional information on these or other Parker Instrumentation Valve products, contact the Parker Instrumentation Distributor in your area. If you need help in identifying your Distributor or information on over 500,000 motion control components, contact us at www.Parker.com or call Parker’s Product Information Center at 1-800-C-PARKER (1-800-272-7537).

Teflon - TM Dupont Co.

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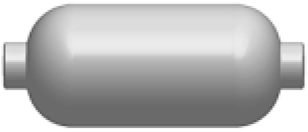
Parker Instrumentation

EPR 4121.1 Revision -

Engineering Performance Report

EPR 4160.1 Revision -

Sample Cylinders and Accessories Cylinder Design and Use



Abstract

Parker Stainless Steel and Aluminum Sample Cylinders are used in a variety of applications, ranging from gas chromatography to the transportation of hazardous chemicals. This report presents information on the design, testing and cleaning of Sample Cylinders. It also offers the user some important safety issues associated with the use of cylinders.

Cylinder Design and Production

The design, manufacture and testing of steel sample cylinders is regulated by the US government in 49 CFR, Paragraphs 178.36 *Specification 3A; seamless steel cylinders* and 178.42 *Specification 3E; seamless steel cylinders*[1]. Aluminum sample cylinders are governed by the same paragraphs, supplemented by Exemption DOT-E 7737. Specification 3A deals with cylinders not over 1,000 pounds water capacity and Specification 3E is for cylinders having an outside diameter no greater than 2 inches, with a length less than 2 feet. Service pressure is limited to 1,800 psi for Parker Sample Cylinders.

The above regulations control all aspects of the design and production of sample cylinders. Material physical properties and chemical characteristics are controlled. Each cylinder must be hydrostatically tested between 3,000 and 4,500 psi. In addition, one cylinder out of each lot of 500 or less must be subjected to a burst test and result in a safety factor on burst pressure of 3.3 minimum.

All cylinder tests must be inspected and verified by an independent inspection agency, and all test reports must be maintained for fifteen years. Each cylinder must also be marked and packaged in accordance with 49 CFR.

Cylinder Cleaning

After testing, Parker Sample Cylinders are prepared for delivery by performing the following steps on the internal surfaces of all cylinders:

Vapor Blast
Nitrogen Purge
Alkaline Clean
Water Rinse

---

[1] U.S. Government Printing Office, Mail Stop: SSOP, Washington, D.C. 20402-9328

Proper Use of Cylinders

- Cylinders must be filled only by properly trained personnel in accordance with CGA Pamphlets P.1 and G-6.3, available from the Compressed Gas Association[2].
- Numerous other publications are available from the Compressed Gas Association covering topics such as Visual Inspection, Service Life and Safe Disposal.
- Safety devices (Rupture Disc Units) must be used as required by 49 CFR Paragraphs 173.34 (d) and 173.301 (g) as well as CGA Pamphlet S-1.1. Rupture Disc Units are only designed for use with cylinders with volumes less than 3 gallons or 1-1/2 gallons for compressed gases and liquefied gases, respectively.
- Valves must be installed or removed only by trained personnel.
- Do not over pressurize.
- Do not alter cylinders in any way.

Precautions on the Use of Rupture Disc Units

- Ensure the minimum burst pressure rating of the Rupture Disc Unit is approximately 40% higher than the cylinder service (filling) pressure.
- Do not use Rupture Disc Units in a location where the release of the contents may cause death, personal injury and property damage. Rupture Disc Units are a CGA Type CG-1 pressure relief device and are designed to release the entire contents of the cylinder to atmosphere.
- Follow the minimum recommended practices for maintenance and inspection of pressure relief devices in CGA Pamphlet S-1.1.
- For additional information on Parker Rupture Disc Units, refer to any of the Maintenance and Installation Instructions for Rupture Discs and Combination Needle/Rupture Discs (INI-207, INI-219, MI-107, and MI-117).

Special Limitations for Aluminum Sample Cylinders

- Aluminum cylinders may not be charged with oxygen unless the cylinder threads are straight threads.
- Cylinders exposed to a fire or heated to temperatures in excess of 350°F should be condemned and/or hydrostatically tested prior to filing.
- Do not expose a pressurized aluminum cylinder to temperatures in excess of 130°F.
- Do not use caustic cleaners on aluminum cylinders.
- For additional information on the use of Parker Aluminum Sample Cylinders, refer to MI-109 packaged with each cylinder.

---

[2] Compressed Gas Association, Inc., 1725 Jefferson Davis Highway, Suite 1004, Arlington, Va 22202

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Parker Hannifin Corporation, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that you analyze all aspects of your application and review the information concerning the product or system in the current product catalog. Due to the variety of operating conditions and applications for these products or systems, the user, through its own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met.

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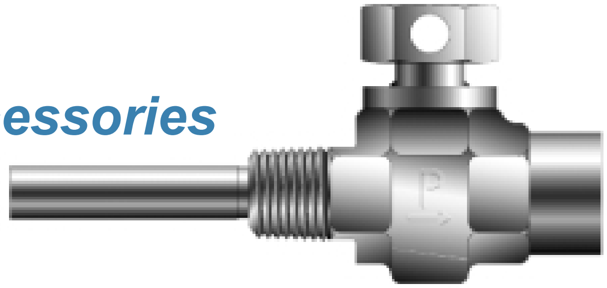
Engineering Performance Report

EPR 4160.2 Revision -

Sample Cylinders and Accessories Dip (Outage) Tubes



Abstract

Dip (Outage) tubes are used to provide a vapor space of desired volume in sample cylinders filled with liquids. The vapor space is used to permit the liquid in the cylinder to expand as the temperature of the liquid increases. Without this space, temperature increases may cause the pressure in the cylinder to increase enough to actuate the rupture disc unit.

The United States Department of Transportation (D.O.T.) and most state agencies have established maximum filling limits for cylinders containing liquids. Information on the subject is published in the US Code of Federal Regulations, Title 49 CFR[1] and the Bureau of Explosives, Tariff No. BOE 6000 Subpart D - Section 173.116 and Subpart F – Section 173.241. Use of the dip tube and sampling methods are provided in ASTM[2] D 1265, *Practice for Sampling Liquefied Petroleum (LP) Gases.*

It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of state and local regulatory agency requirements prior to use of any sample cylinder or accessory such as dip tubes.

Dip Tube Design

Parker dip tubes are available as standard options on Rupture Disc Units, Combination Rupture Disc / Needle Valves, and female-to-male NPT fittings. With both products, the tube is press-fit into the male end of the valve or fitting. In use, the male end of the valve or fitting is engaged into the female port of the sample cylinder. Both ¼" and ½" NPT port sizes are available. Dip tubes are manufactured from ASTM A 632 Grade TP 316L ¼ inch seamless austenitic stainless steel tubing.

Dip tubes on Rupture Disc Units and Valves provide a convenient assembly of two functional items. For flexibility, the Dip Tube Fitting permits the assembly of any male NPT ported valve to a dip tube. For further information on these and other products, refer to Parker Instrumentation Valve Division Catalog 4160-SC *Sample Cylinders and Accessories.*

Dip Tube Use

The cylinder is oriented vertically with the dip tube positioned in the top. The length of the dip tube controls the amount of vapor space. The dip tube length is measured from the end of the Dip Tube Fitting forging or Rupture Disc Unit forging.

The dip tube lengths listed in the Dip Tube Lengths table are approximations. Tolerances on cylinder volume, dimensions and thread engagement may alter the actual vapor space by as much as 25%. To obtain the exact outage, each cylinder assembly should be calibrated by suitable methods.

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[1] U.S. Government Printing Office, Mail Stop: SSOP, Washington, D.C. 20402-9328

[2] ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

Outage is the vapor space in a cylinder and is expressed as a percentage of the total volume of the cylinder; i.e.,

% Outage = (Vapor Space / Total Cylinder Volume) x 100

DIP TUBE LENGTHS – Stainless Steel Cylinders

Cylinder Model	Percent Outage				
	10	20	30	40	50
4F-SC75	1.0	1.3	1.7	2.0	2.3
4F-SC150	2.0	2.6	3.4	4.0	4.6
4F-SC300	1.6	2.3	3.0	3.7	4.3
4F-SC500	2.3	3.4	4.5	5.6	6.7
4F-SC1000	1.2	1.8	2.3	2.9	3.5
4F-SC2250	2.7	4.0	5.2	6.5	7.8
8F-SC1G	4.5	6.7	8.8	11.0	13.2

Dimensions in inches

DIP TUBE LENGTHS – Aluminum Cylinders (oriented with spherical end up)

Cylinder Model	Percent Outage				
	10	20	30	40	50
4F-SC150	1.2	1.5	1.9	2.2	2.5
4F-SC300	2.3	3.0	3.7	4.4	5.0
4F-SC500	3.8	5.0	6.2	7.3	8.3

Dimensions in inches

How to Order Dip Tubes with Sample Cylinder Valves and Rupture Disc Units

A 316 stainless steel dip tube will be supplied press fit to the Male NPT port of products when specified by adding the **dip tube length** to the end of the part number. The length is measured from the end of the forging.

Example 1: 4M4F-RV6L-18-SS-**4**. Describes a Rupture Disc Unit with a four inch (102mm) long dip tube.
Example 2: 4M4F-RV6LCK-18-SS-**2**. Describes a Combination Rupture Disc / Needle Valve with a two inch (51mm) long dip tube.

How to Order Dip Tube Fittings

A 316 stainless steel dip tube will be supplied press fit to the Male NPT port of Male x Female Pipe Adapters. They are available with 1/4” or 1/2” NPT threads. Specify the custom DT6L fitting by adding the **dip tube length** to the end of the part number. The length is measured from the end of the forging.

Example 1: 4M4F-DT6L-SS-**3**. Describes a 1/4” MNPT x 1/4” FNPT Fitting with a 3 inch (76mm) long dip tube.
Example 2: 8M8F-DT6L-SS-**2**. Describes a 1/2” MNPT x 1/2” FNPT Fitting with a 2 inch (51mm) long dip tube.

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