I. INTRODUCTION

The Parker Instrumentation Valve Technical Guide will help you select the best valve for your instrumentation system application. Selecting the proper valve requires careful consideration of many factors. These factors include, but are not limited to, service pressure and temperature, flow rate, pressure drop, the flow media's fluid and chemical properties, packing design, seat design, actuation alternatives, special cleaning, compliance with technical standards, and integration within your instrumentation system.

Flow analysis is an important aspect in selecting the proper valve. Accordingly, the Parker Instrumentation Technical Guide presents engineering formulae for flow analysis of gases and liquids.

It is historically reported the first control valve was a bamboo plug valve made in China about 2000 B.C. Today, valves serve five primary functions: to start and stop flow, to regulate and throttle flow, to prevent backflow, to regulate pressure, and to relieve excessive pressure.

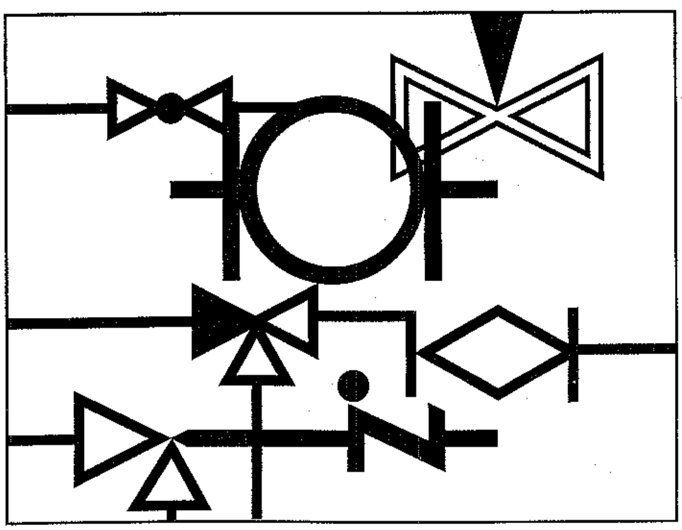
Every industrial plant, power plant or research facility requires not only the large valves and piping that carry the main flow of fluids, but also a maze of small valves for the purpose of linking the primary flows with instruments and controls. Instrumentation valves have functional counterparts with larger general service valves. However, owing to their size, details of design and applications are unique.

This section reviews the fundamental factors to be considered in selecting an instrumentation valve. Some of the most important criteria required for valve selection are listed below. The relative importance of each factor will change for each valve application.

- Flow Media
- Pressure and Temperature Considerations
- Seat Designs
- Stem Packing Designs
- Actuator Designs
- Cleaning Requirements and Options
- Codes and Standards
- Flow Calculations and Valve Sizing

One must clearly recognize that failure, improper selection or improper use of any valve or instrumentation product can cause personal injury and property damage. Furthermore, while this Valve Technical Guide seeks to help you select the best valve for your instrumentation system application, the information presented by this Valve Technical Guide may not be complete for your specific valve selection.

It is important that you analyze all aspects of your application and review the information concerning the instrumentation products in their current respective product catalog. Due to the variety of operating conditions and applications for Parker Hannifin instrumentation valves, 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 and safety requirements of the application are satisfied.



ON THE COVER:

Seven valve symbols often used in engineering schematics are shown on the cover of IVD's Technical Guide. Starting from the top right hand corner and moving down and around in a clockwise direction they are:

- Needle Valves
- Plug Valves
- Check Valves
- Angle Valves
- 3-Way Valves
- Ball Valves
- Globe Valves

II. FLOW MEDIA

A) Flow Characteristics

Flow media characteristics are an important factor in valve selection analysis. The principle aspects include fluid properties, chemical reactivity or toxicity and abrasiveness. Valves can often dramatically change the flow, not only directly within the valve, but also quite a distance downstream of the valve. Furthermore, changes in the fluid's properties caused by temperature or chemical changes may also dramatically alter the flow characteristics.

Pressure drop is a key criteria in valve selection. Increased pressure drop across a valve means higher costs for pressurizing the fluid system. Higher pressure drops decrease a valve's life expectancy, and may even damage the rest of the fluid system. High pressure drops across open valves should be avoided. Examples of the problems often caused by high pressure drops are discussed later. The geometry of a valve's internal flow path is the key factor in estimating its potential pressure drop. Straight (inline) internal flow paths create significantly less pressure drop than flow paths that change direction. For example, inline Ball and Plug valves have lower pressure drops than valves with angle bodies, such as Needle or Diaphragm valves. A measure of a valve's potential pressure drop is the C_v (flow coefficient) factor.

Flow rate and velocity are closely related to pressure drop. Increasing the flow rate or velocity to compensate for a low C_v carries the penalty of increased pressure drop and higher costs. This makes sense of course, because more power (i.e., energy or money) is required to push the extra fluid through the valve. The C_v value, by definition, is the flow rate a valve will allow, in gallons of water per minute at 60° F with a pressure drop of one psi.

Turbulence is another important factor in proper valve selection. The degree of turbulence depends upon the flow rate and velocity, as well as the fluid's viscosity, which in turn is controlled by the fluid temperature. It is important to remember as the temperature increases, the viscosities of all liquids decrease, while the viscosities of all gases increase. The classic Moody Diagram can be used to estimate turbulence in a fluid system. Viscosity will be discussed in greater detail later. Internal surface finish of pipe or tubing also affects turbulence. Most of the instrumentation and control lines utilize tubing rather than piping, with the natural advantages of dimensional accuracy and smooth internal surface finishes. As a general rule, tubing is more compatible than pipe with instrumentation valves and accessories. It offers better interior cleanup, and the special instrumentation connection methods offered for tubing result in less interior residue in the form of chips, weld slag, and so forth.

The degree of turbulence in a system depends upon the velocity profile of the flow stream. Figure 1 illustrates the velocity profile of laminar and turbulent flow. Laminar flow is characterized by a parabolic profile, where the relatively large viscous forces cause the fluid to slow as it passes near the pipe walls. In turbulent flow, the inertial forces are large in relation to the viscous forces. Therefore, turbulent flow exhibits a more uniform velocity profile. Flow analysts use the Reynolds number (N_R) to describe fluid turbulence. This dimensionless number is the ratio of the fluid's momentum to the opposing drag (friction) forces in the fluid system.

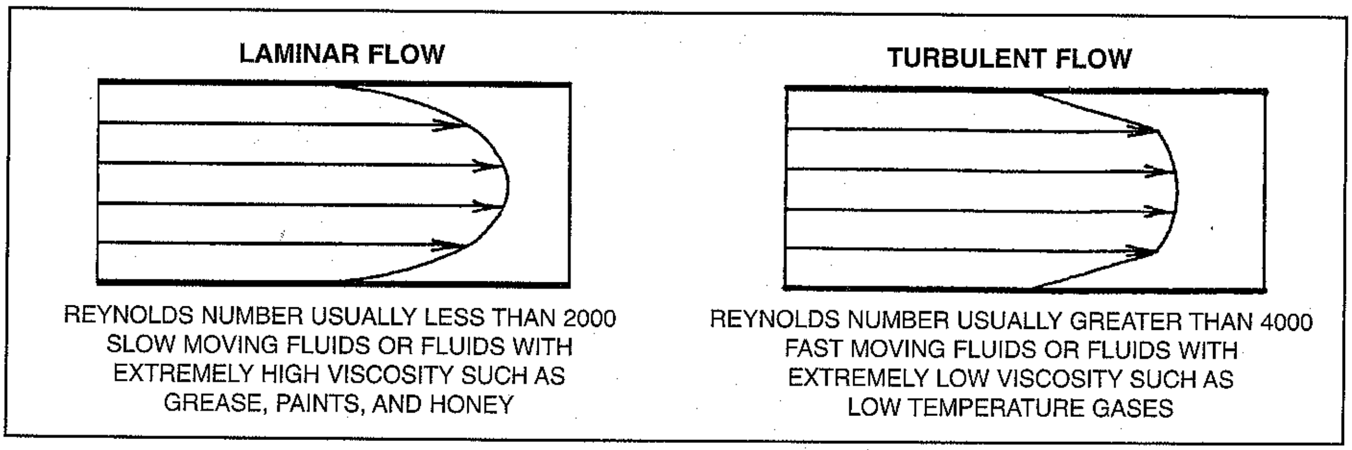


Figure 1 Laminar and Turbulent Flow
Reynolds number (N_R) above 4,000 may indicate turbulent flow

Noise is generated by all fluid systems. Valves are a natural source for noise in fluid systems, since noise is generated by flow restrictions, and most valves inherently restrict flow. Many factors affect the noise generated by a valve. These include the type of valve, how far the valve is open, flow characteristics, size and length of pipe or tubing adjacent to the valve, fluid system materials of construction, presence of thermal pipe insulation, how many and what types of surfaces the sound might be reflected from, and whether the fluid is a liquid or gas. The OSHA Act of 1970 limits the noise that people may be exposed to. Remedies for excessive noise include changing the flow characteristics (i.e., reducing flow rates and/or pressure drops), placing valves in series or parallel configurations to reduce the pressure drop experienced by any single valve, or limiting the actual transmission or reflection of sound waves. However, excessive noise in a fluid system is frequently a symptom of dangerous flow conditions. Therefore, it is important to investigate all potential causes of the noise before considering noise abatement devices to muffle the sound.

Waterhammer derives its name from the hammering sound which happens when a shock wave encounters a flow restriction in a liquid flow system. This phenomena can cause severe damage to pumps, turbines, instruments and even piping supports. Proper valve selection can minimize the generation of waterhammer. The key is to avoid quick opening and closing of the valve in systems with either high flow velocities or differential pressures. The use of Ball or Plug valves with automatic actuators (i.e., electric or pneumatic) must be cautiously reviewed in these applications. Prudence is demanded since Ball and Plug valves can potentially generate powerful shock waves because of their quick opening characteristics, even when used with manual actuators (i.e., handles). Using automatic actuators with Ball or Plug valves increases the risk that dangerous shock waves will be generated by the valve's accelerated opening or closing.

Flashing and cavitation merit special consideration in valve selection. Both phenomena may damage fluid systems, and valves often contribute to this problem. Evidence of these include vibration, an intermittent ticking, hiss, roar, or the worst case of a churning gravel sound. Cavitation is especially dangerous if the liquid flow stream contains sand or metallic particles. Decreasing the pressure drop or the inlet pressure sometimes reduces the potential of flashing or cavitation.

Flashing and cavitation are associated with gas bubbles in a liquid flow stream. They occur in high-speed liquid flow when bubbles form around the valve's seat area. An energy balance exists between the liquid velocity and pressure in the flow stream. If the velocity increases, the pressure usually decreases. The velocity increase reduces the available energy required to maintain the flow pressure. Subsequently, the flow pressure drops as it is starved of energy. Bubbles form if the flow pressure falls below the liquid's vapor pressure, literally causing the liquid to boil. Flashing and cavitation often occur immediately downstream of a valve's seat area. The reduction in flow area sharply increases the speed of the liquid flow stream, which reduces the pressure and causes bubbles to form as the liquid boils.

What ultimately happens to the bubbles determines if one is dealing with flashing or cavitation. Flashing means the bubbles simply drift downstream, causing minor erosion, noise or vibration in the fluid system. Cavitation is potentially more dangerous. The bubbles violently collapse after a short period of time. All of the energy stored in the bubbles' surface tension implodes to the bubbles' center, but is then reflected back in a powerful microjet of energy. These millions of destructive bubbles literally blast away pieces of the valve's components. Pitting and accelerated corrosion often accompany cavitation. Super-cavitation occurs when the downstream fluid line is almost filled with bubbles. Violent vibration may result when these bubbles explode downstream. Air aspiration (the introduction of atmospheric air into the flow stream) will not prevent cavitation, but sometimes reduces the bubbles' destructive explosion.

Wire drawing deserves special attention, especially with two-phase flow applications. Two-phase flow is simply liquids and gasses mixed together, such as wet stream or carbonated beverages. It is similar to flashing and cavitation, except that the gas bubbles never dissolve back into the liquid. What makes two-phase flow so potentially damaging is the perpetual presence of either gas bubbles or liquid droplets in the flow stream. These bubbles and/or droplets can rapidly cut flow channels through a valve's seating area. In fact, wire drawing gets its name from the thin linear flow channels around the valve's seat or stem that look like a wire was drawn or pulled through the valve's seat area.

Wire drawing is usually caused by high pressure two-phase flow. If a high pressure drop across a valve cannot be avoided, then the seat materials must be highly abrasion resistant. Wire drawing is amplified if the flow stream contains sand or metallic particles. Decreasing the pressure drop across a valve or the inlet pressure sometimes reduces the potential of wire drawing. Wire drawing can also be reduced by an ultra-tight seat seal. Selecting the right seat geometry can also reduce the potential of wire drawing. Evidence indicates that a conical seat geometry with a narrow sealing surface often provides very tight sealing.

B) Fluid properties

Compressibility is probably the most important fluid property. It determines whether the fluid behaves as a liquid or a gas. Flow equations for liquids and gases are radically different in most cases. Accordingly, the fluid's compressibility determines what flow equations should be used in the flow analysis.

Fluid type is of tremendous importance when dealing with liquids. Fluid types are divided into Newtonian and Non-Newtonian liquids. The distinction involves how a liquid's viscosity changes with temperature and pressure. Viscosities of Newtonian liquids change with temperature and with pressure. All other fluids are considered Non-Newtonian. Newtonian liquids are typically pure or low molecular weight liquids such as water, alcohol, oils, or cryogenic liquids. Non-Newtonian liquids include polymers, high molecular weight liquids, slurries, greases, drilling muds, printer's ink, foods such as ketchup and ice cream, crude oils at low temperature, paints and lacquers, and glue. Special flow equations must be used for Non-Newtonian liquids for accurate analysis results.

Chemical reactivity or toxicity often demands the highest attention in valve selection. The two factors that determine a valve's leak integrity are it's materials of construction and the valve's design. Unfortunately, all man-made valves leak, regardless of their materials of construction or design. It's merely a question of how soon a leak will occur, taking into account the leak rate, time in service, pressure, fluid properties, and so forth. This is the realistic view that all experienced valve design or application engineers have regarding the subject of valve leak integrity. Please note temperature and pressure can greatly increase the reactivity, corrosion potential, or toxicity of some chemicals – even those which are considered harmless at ambient temperature and pressure.

Instrumentation valve components are fabricated from a wide variety of materials including metals, thermoplastics, elastomers and ceramics. Moreover, scores of different lubricants or coatings are used to reduce friction and wear. Assembling the proper material defense against chemical attack is a challenging aspect of sound valve selection. Each material and lubricant must be chemically compatible with the flow media.

Abrasiveness of the flow media is usually a minor factor in valve selection. However, it can cause serious problems if not properly dealt with. Abrasion occurs when the flow media contains solid particles which are harder than the materials from which the valve is made. This type of flow media is commonly known as a slurry. The resultant damage depends upon the particles' velocity, size, impact angle, and relative hardness with respect to the valve's wetted components. Abrasion can also accelerate corrosion if the surface layer of a component part is damaged.

The best strategies against internal abrasion are to minimize turbulent flow, keeping the flow path as straight as possible, and decreasing the pressure drop across a valve. Decreasing the pressure drop or the inlet pressure sometimes reduces the potential of erosion. Low flow velocities, which reduce turbulent flow, also help to minimize erosion. Selecting the right seat geometry can also reduce the potential of erosion. Ball and Plug valves usually offer a reasonably straight internal flow path which reduces abrasive damage.

III. PRESSURE AND TEMPERATURE CONSIDERATIONS

The most commonly requested information about an instrumentation valve is its pressure and temperature rating (P/T) curve. Selecting the proper valve for a particular pressure and temperature is similar to selecting a valve for service with reactive or toxic chemicals. The materials of construction and lubricants determine how well a valve will perform. Temperature effects the point at which flashing and cavitation occur, the fluid's viscosity and density, the strength and performance of the many different types of materials from which the valve's components are made, and even the chemical reactivity or toxicity of the flow media.

Parker Hannifin IVD subjects every product to rigorous pressure/temperature tests, upon which conservative P/T curves are generated. The P/T performance of Parker Hannifin IVD valves is included in the product catalog for each respective product.

An instrumentation valve's pressure/temperature performance is usually controlled by the non-metallic components. These non-metallic components may include elastomeric or thermoplastic materials (such as a Viton® O-Ring or a Teflon® stem packing), or a lubricant's maximum service temperature. However, even metal components are limited to surprisingly low temperature limits, such as 400° F (204° C) for brass and 700° F (371° C) for 17-4 PH stainless steel. The strength and load-carrying capacities of all materials decrease with temperature, which is why the pressure limits for many plastics and elastomers (such as Teflon®, Kel-F® and Viton®) dramatically decrease around 350°F (176°C).

Degrees F to Degrees C Conversion Table

deg. F	deg. C	deg. F	deg. C	deg. F	deg. C	deg. F	deg. C	deg. F	deg. C	deg. F	deg. C
–70	= –57	30	= –1	130	= 54	275	= 135	550	= 288	800	= 427
–60	= –51	40	= 4	140	= 60	325	= 163	575	= 302	850	= 454
–50	= –46	50	= 10	150	= 66	350	= 177	600	= 316	900	= 482
–40	= –40	60	= 16	160	= 71	375	= 191	625	= 329	950	= 510
–30	= –34	70	= 21	170	= 77	400	= 204	650	= 343	1000	= 538
–20	= –29	80	= 27	180	= 82	425	= 218	675	= 357	1050	= 588
–10	= –23	90	= 32	190	= 88	450	= 232	700	= 371	1100	= 593
0	= –18	100	= 38	200	= 93	475	= 246	725	= 385	1150	= 621
10	= –12	110	= 43	225	= 107	500	= 260	750	= 399	1200	= 649
20	= –7	120	= 49	250	= 121	525	= 274	775	= 413	1250	= 677

Conversion Formulas: F = (1.8 x C) + 32 C = (F – 32) / 1.8

PSI to Bar Conversion Table

psi	bar	psi	bar	psi	bar	psi	bar	psi	bar	psi	bar
0 =	0	80 =	5.5	250 =	17.2	800 =	55.2	4000 =	275.8	8000 =	551.6
10 =	0.7	90 =	6.2	300 =	20.7	900 =	62.1	4500 =	310.3	8500 =	586.1
20 =	1.4	100 =	6.9	350 =	24.1	1000 =	69.0	5000 =	344.8	9000 =	620.6
30 =	2.1	125 =	8.6	400 =	27.6	1500 =	103.4	5500 =	379.2	9500 =	655.0
40 =	2.8	150 =	10.3	450 =	31.0	2000 =	137.9	6000 =	413.7	10000 =	689.5
50 =	3.4	175 =	12.1	500 =	34.5	2500 =	172.4	6500 =	448.2		
60 =	4.1	200 =	13.8	600 =	41.4	3000 =	206.9	7000 =	482.7		
70 =	4.8	225 =	15.5	700 =	48.3	3500 =	241.3	7500 =	517.1		

Conversion Formulas: bar = psi x .06895, psi = bar x 14.50377

IV. SEAT DESIGNS

Seat design and performance are crucial aspects of a valve. The seat is the primary flow control element whose performance can be tremendously affected by design factors such as geometry, surface finish, materials of construction, rigidity, and seating force. Flow media aspects such as velocity, flow rate, pressure drop, abrasiveness, chemical reactivity, and cavitation also influence how well a valve seat performs. A variety of seat designs have evolved to successfully handle a broad spectrum of application requirements.

With the simplest design, a rotating stem engages the seat, which most often is integral with the body. This concept is also used with throttling or metering valves. Another common seal combination features a two-piece stem design with an independent lower portion. Because the lower stem does not rotate upon actuation, the seating action is positive and consistent, thereby enhancing the chances for a repetitive tight seal.

As with many integral seat arrangements in instrumentation valves, the stem brinnels (crushes) the seat contact area slightly to accomplish a positive metal-to-metal seal. A certain amount of seat damage is tolerated, as long as it is not in excess of what a reseating and rebrinnelling can overcome. Metal-to-metal seats are required for high temperature service. Whether the stem design can be of the rotating or non-rotating type, depends on some extent on the media being handled. For non-lubricating fluids, such as gas or hot water, a non-rotating lower stem is advised. In the case of lube oil, a simple one piece stem will perform satisfactorily.

When fluid temperatures are below the upper limits for plastics such as Teflon®, an instrumentation valve can employ a plastic stem tip. Currently, the high temperature limits for plastic seated valves are between 300°F and 500°F (149°C and 260°C), depending on the severity of service and the specific design. Overall, plastic seated valves will outperform metal-to-metal seats in non-lubricating medias. In non-lubricating medias, such as dry gas, the plastic seat will deform and seal without excessive damage to the seat or the body that may occur in a dry metal-to-metal application. In lubricating medias, such as oil, the media will assist in minimizing the potential damage to the mating metal surfaces by providing low-friction wear conditions.

A) Ball and Plug Seats

Valves with a Ball or Plug type seat design are enormously popular in instrumentation valve applications. They can offer maximum flow capacity, excellent sealing integrity, seat wear compensation, and quick quarter or half-turn operation.

Several types of Ball and Plug type seats exist. The Parker Hannifin IVD B-Series Ball valve uses a floating ball design. The floating Ball design is considered to be the best design for overall performance due to the ability to respond to pressure fluctuations.

The four primary components in the Ball valve design are the ball, stem, seat and seat retainer. These features are illustrated in Figure 2. The most important aspect of the floating ball design is the linkage between the ball and stem. The top of the ball has a drive tang slot into which the stem's keyed end fits. It is designed so that the ball can be forced against the downstream seat by system pressure.

The seat is usually made of a thermoplastic such as Teflon®. The thermoplastic seat material is much softer than the ball, and the seat material has a tendency to permanently change shape (cold flow) when the ball seals against it. Cold flow is accelerated by either pressure or temperature. Increased pressure helps to crush the seat because the flow stream is pushing against the ball and seat with higher force. Increasing the service temperature also accelerates cold flow, since the thermoplastic's compressive strength is sharply reduced as the temperature increases.

Ball valve Seat materials include a variety of thermoplastics. Proper seat material selection requires careful consideration of temperature, pressure, abrasiveness, chemical reactivity, lubricity, and wear resistance. Parker Hannifin IVD offers a variety of high performance thermoplastics as seat materials in its B-Series Ball valve product line such as Kel-F®, Teflon® and Vespel®.

The seat retainer helps to preserve the seats' crucial sealing geometry. The seat retainer effectively protects the thermoplastic against excessive crushing and cold flow. The relatively soft thermoplastic seat, crimped inside the seat retainer, enables the ball seat to seal better as the pressure increases.

Valves with a Plug-type seat design are used extensively in instrumentation valve applications. This valve offers maximum flow capacity, good sealing integrity, minimal dead space, convenient maintenance, and quick quarter-turn operation.

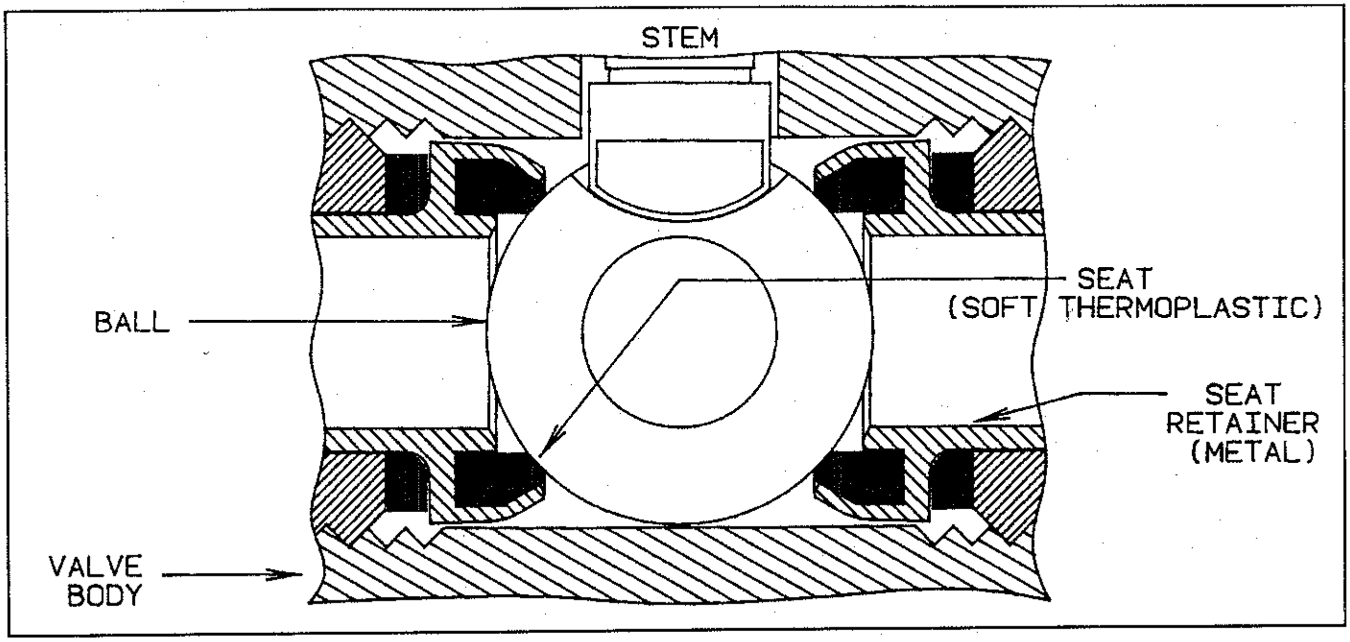


Figure 2 Floating Ball Valve Seat Design
This design features excellent seal integrity and seat wear compensation.

Plug valves are rotary type valves in which a plug-shaped element is rotated to engage or disengage a port hole in the valve body. The three primary components in the Parker Hannifin IVD Rotary Plug valve are the plug, seat, and atmosphere O-Ring seals, illustrated in Figure 3.

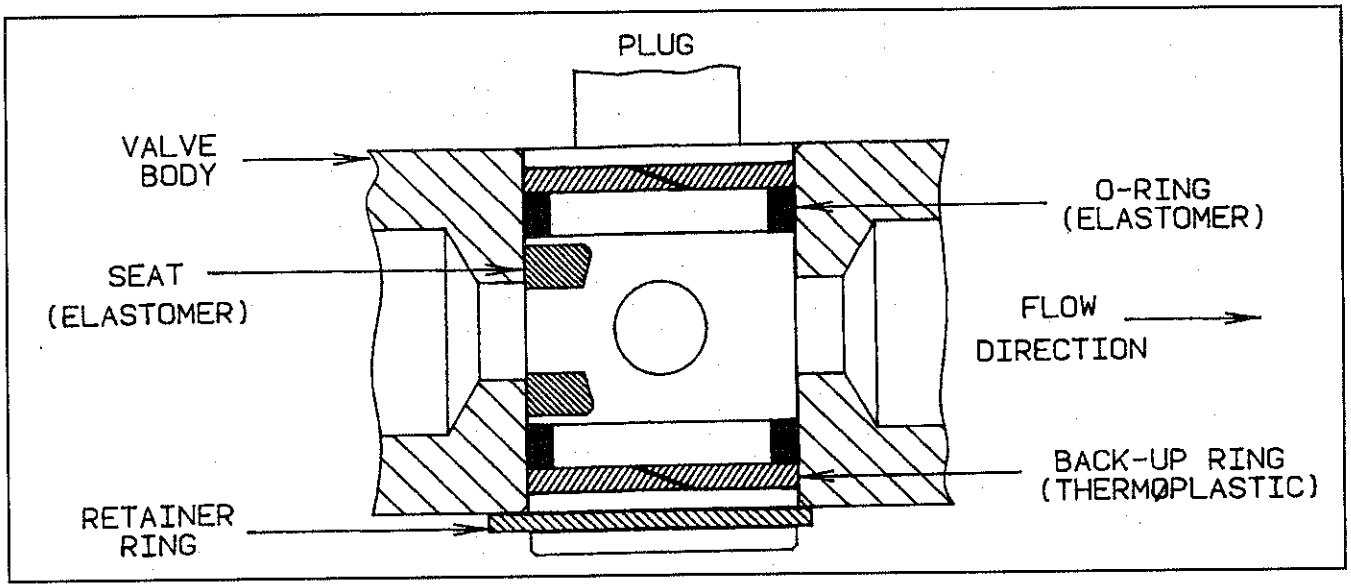


Figure 3 Plug Seat Design
This design offers good seal integrity and minimal dead volume.

Seal materials include a variety of elastomers. Proper seal material selection requires consideration of temperature, pressure, abrasiveness, chemical reactivity, lubricity, and wear resistance. Parker Hannifin IVD offers Viton®, Ethylene Propylene (EPR), and Nitrile elastomers as standard seal materials in its PR-Series Rotary Plug valve product line.

Ball and Plug type seats offer substantially higher flow rates than most other valves, particularly tapered stem (Needle) valves. However, Ball-type seats are usually not recommended for throttling service, where the valve is partially open or closed. Throttling exposes the valve and the downstream fluid system to several potentially dangerous conditions. These may include flashing, cavitation, erosion, noise, and severe mechanical vibration. The flow streams of a fully-open Ball or Plug valve, as well as a valve seat in the throttling position, are illustrated in Figure 4.

BALL IS IN THE FULL OPEN POSITION. FLOW REGIME MAY BE EITHER LAMINAR OR TURBULENT DEPENDING ON FLUID VELOCITY AND VISCOSITY.

THE PARTIALLY OPEN POSITION SHOULD BE AVOIDED. CAVITATION AND FLASHING PRODUCE MICRO-BUBBLES (*) WHICH MAY CAUSE SEVERE NOISE AND FLUID SYSTEM DAMAGE.

Figure 4 Flow characteristics of a Ball or Plug type Seat
Throttling may cause flashing, cavitation, erosion, noise, and severe mechanical vibration.

B) Tapered Stem Seats

The tapered stem seat is immensely popular in instrumentation valve applications. Of course, valves with a tapered stem are commonly known as Needle valves. Tapered stem valves offer excellent seal integrity for a variety of media applications such as gases, liquids, and slurries. They also function well in an extremely wide range of temperatures, and are available for a broad spectrum of reactive chemical environments. The tapered seat design consists of a valve stem whose downward travel decreases the fluid flowing through a valve's seat area.

Tapered stem designs may be fabricated from either metal or thermoplastic. Proper seat material selection requires careful consideration of temperature, pressure, abrasiveness, chemical reactivity, lubricity, and wear resistance. Thermoplastic tapered stem tips are superior to metal tapered stems for effectively sealing gases or low molecular weight liquids. However, metal stems are usually required for applications where high temperatures or pressures, reactive chemicals, or abrasive flow media are present.

Tapered stem valves offer higher flow resistance than Ball or Plug valves. Needle valves with tapered stem seats require valve bodies with angular internal flow passages. These non-linear flow paths increase the flow resistance and pressure drop across the valve, as compared to either a Ball or Plug valve. The difference in seat geometry makes tapered stem valves much more suited for throttling (adjustment) of flow streams than the Ball or Plug valve.

Several types of specialized tapered seat designs have evolved for instrumentation applications. They include the *Blunt, Regulating,* and *Metering* tapered stem designs. Each of the three basic tapered stem types are designed for a particular application. The Blunt Stem derives its name from the "V" shape of its tapered sealing end. The Blunt stem is tapered at 30 degrees which makes this design excellent for basic flow shut-off applications. The Regulating Stem combines the excellent shut-off characteristics of the Blunt stem with the ability to provide coarse regulation of the fluid flow stream. This is accomplished with a gradual taper at the stem end. The Metering Stem offers exceptional precision flow stream adjustment.

A tapered stem's performance can be enhanced by selecting either a metal or soft-seat stem tip design. The selection depends upon several flow media characteristics, including but not limited to, the temperature and corrosiveness, presence of hard particles (such as in a slurry), and whether the flow media is a liquid or gas. Metal stem tips are usually required for temperatures beyond 350°F (176°C), or if the flow media is highly abrasive. Soft-seat stem tips are often selected for use with gases, since the relatively soft thermoplastic tip can seal very tightly against the metal valve seat. Thermoplastics such as Kel-F® and Vespel® are used in such applications.

V. STEM PACKING DESIGNS

Packing design and performance play an important role in valve selection. Valves consist of a control element (such as a ball, plug, or tapered stem seat), and an actuation element. While the Seat is designed to directly control flow through the valve, the Packing limits the leakage between the Seat and Actuation elements. The Packing's performance can be tremendously affected by design factors such as geometry, surface finish, materials of construction, rigidity, and location on the valve stem.

The two fundamental Packing designs found in Parker Hannifin instrumentation valves are Packed and Packless valves. In general, Packed valves are usually quite suitable for most instrumentation applications, while Packless valves are preferred for service with expensive, toxic or reactive chemicals, or where any minute degree of leakage cannot be tolerated.

A) Packed Valves

Packed valves are used successfully in a vast array of instrumentation applications. These include most Needle and Ball valves. However, Packed valves are questionable for protecting against Stem area leaks of expensive, reactive, or toxic chemicals.

Packed valves rely upon the mechanical deformation (crushing) of a relatively soft packing material (Teflon®, Grafoil®, Viton®, etc.) against the valve stem. This squeezing of the relatively soft packing material eliminates all but microscopic gaps (leak paths) between the packing material and valve stem.

Critical factors such as hardness differences and surface finish limit the seal integrity of these packings. In fact, just the normal turning of the valve's Stem breaks the intimate bond between the Stem and Packing, which then may create new leak paths (although they may be extremely small). Accordingly, while Packed valves offer a reasonably high level of seal integrity for most applications, they are nevertheless susceptible to slight leakage under certain conditions, requiring packing nut adjustment.

The performance and capabilities of a Packed valve depends upon the location of the packing on the valve stem (with respect to the power threads), and the material from which the packing is fabricated. Packed valves are available in two basic configurations. These are known as "Packing above threads" (PAT) and "Packing below threads" (PBT). These configurations are illustrated in Figure 5.

The PAT *(Packing Above Thread)* design is suitable for service with most liquids and gases. It is available with the V-Series and SN-Series tapered-stem (Needle) valves offered by Parker Hannifin IVD.

The PBT *(Packing Below Thread)* design protects the flow stream from thread lubricant contamination or washout, keeps corrosive chemicals from damaging the stem's power threads, and allows a non-rotating lower stem design for superior sealing. It is available with the U-Series Union Bonnet and PBT-Series tapered-stem (Needle) valves, as well as the PV-Series Rising Stem Plug valve product lines offered by Parker Hannifin IVD.

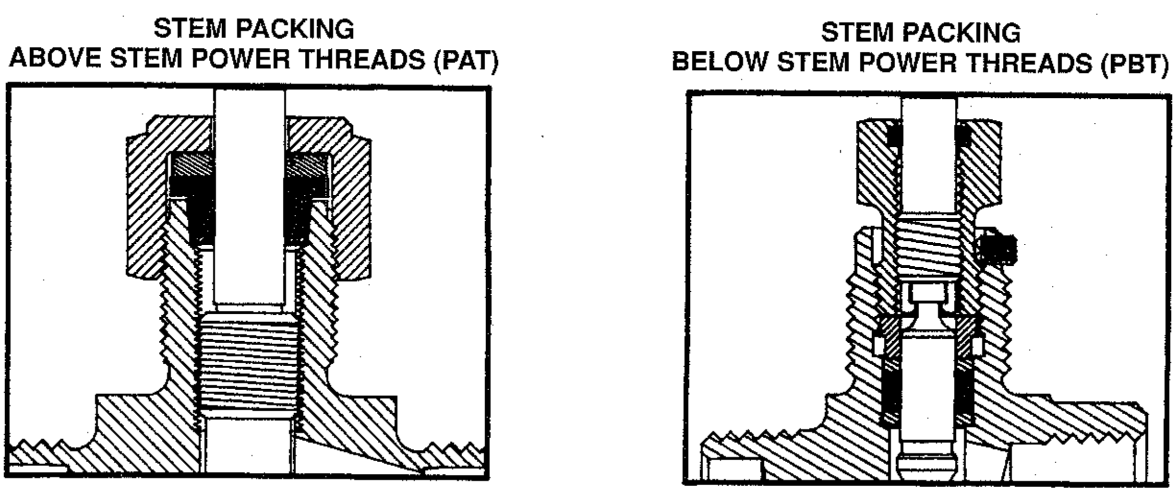


Figure 5 Packing Configurations (PAT and PBT)
The PAT (Packing Above Thread) design is suitable for service with most liquids and gases.

Of course, the performance and capabilities of a Packed valve depends upon the material from which the packing is fabricated as well as the location of the packing on the valve stem (PAT versus PBT). The three basic stem packing materials offered by Parker Hannifin IVD are plastics, elastomers and Grafoil®.

The type of valve application dictates what Packing material should be used. Three factors that demand prudent consideration are the temperature, chemical reactivity of the flow media and the actuation frequency.

Grafoil® is recommended for most high temperature applications. Furthermore, it is chemically resistant to attack from nearly all organic and inorganic fluids, with the exception of highly oxidizing acids and chemicals. This excellent chemical compatibility generally exists across Grafoil's® entire temperature range.

Thermoplastics and elastomers may be suitable for applications where service temperatures are less than 500°F (260°C). Parker Hannifin IVD offers Delrin®, PEEK® (virgin and carbon-filled), Rulon®, Teflon®, UHMWPE, Vespel® and other high-performance thermoplastics as Packing materials in its variety of product lines. Available elastomers include Nitrile, Ethylene Propylene (EPR), Fluorocarbon (Viton®), Kalrez® and other high-performance elastomers as O-Ring materials. It is important to remember that all materials have a chemical "Achilles heel", that is all are susceptible to accelerated chemical attack by at least one chemical compound. Increasing the service temperature may also weaken a material's ability to withstand reactive chemicals. Accordingly, prudent material selection of thermoplastics or elastomers is required in every valve selection analysis.

Most applications only require that the proper Packing material be selected. However, some applications demand that the valve's actuation frequency also be considered. In general, the applications requiring higher actuation frequencies require elastomeric Packing materials to minimize the frequency of stem packing adjustment. The underlying reason is the difference in the resiliency between elastomers, and the thermoplastic and Grafoil® materials. The valve stem and body cavity (in which the Packing is located) have microscopic surface scratches which are potential leak paths. However most thermoplastics, elastomers and Grafoil® are resilient enough such that their deformation can fill these microscopic gaps. The problem arises when the valve stem is actuated. This actuation causes the Packing and stem to slide against each other, which may cause leakage as the microscopic gaps are uncovered. Elastomers are able to refill the microscopic gaps much faster than either thermoplastics or Grafoil®. Accordingly, elastomers are generally superior for applications requiring high frequency actuation.

B) Packless Valves

Packless valves (Bellows and Diaphragm) are becoming increasingly popular in instrumentation valve applications. They are used when stem leakage cannot be tolerated, including such applications as toxic, corrosive, ultra-clean, flammable, or very expensive flow media. The Packless valve offers excellent sealing integrity and a variety of actuation options. Packless valves use a completely different stem sealing concept than the mechanical crushing method used by packed valves. The Packless concept calls for a hermetically-sealed barrier between the valve Seat and Stem mechanisms. Hermetic seals commonly achieve a seal integrity of 10^{-9} cc of helium per second or less.

Bellows and Diaphragm valves offer different performance features due to their respective designs. Bellows valves typically offer higher flow rates than Diaphragm valves, can better control flow, and are more adaptable to remote actuation in high pressure applications. A typical Bellows valve is illustrated in Figure 6.

The HP and P-Series Bellows valves offered by Parker Hannifin IVD are world-class quality products. Among the design features that elevate the P-Series Bellows valve product line are an externally-pressurized bellows, which allows faster purge times and reduces entrapment zones within the flow area, compared to an internally pressurized bellows design. Moreover, longer cycle life is obtained with an externally pressurized bellows because of a more uniform stress distribution in the bellows. These features make the HP and P-Series Bellows valves an excellent choice for applications that require a critical service Packless valve.

Diaphragm vales offer distinctly different features. These features include low internal volume, few entrapment zones, fast purge times and quarter-turn actuation. A typical Diaphragm valve is illustrated in Figure 7.

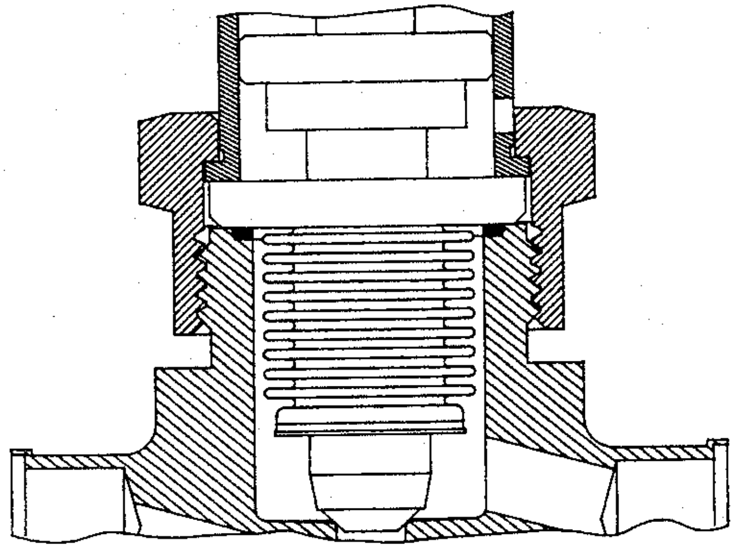


Figure 6 Bellows Valve Stem Seal Configuration

Bellows valves offers a variety of tapered stem designs for multi-turn, toggle, and remote actuation options.

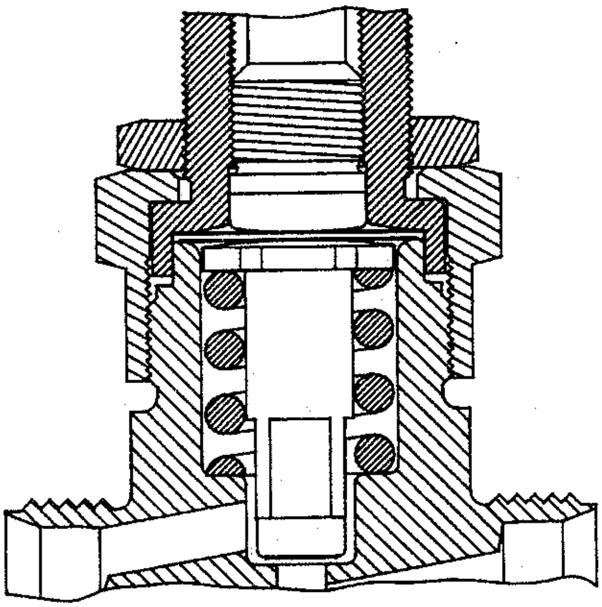


Figure 7 Diaphragm Valve Stem Seal Configuration

Diaphragm valves offer a variety of stem designs for quarter-turn and multi-turn options. These valves are ideal for applications requiring low particle generation and low internal volume.