PDHonline Course M414 (5 PDH)

Valves – Standard and Automatic Process Control

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2020

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VALVES – STANDARD AND AUTOMATIC PROCESS CONTROL

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I – INTRODUCTION:

The objective of this manual is to describe some of the most important control valves either manual operated or controlled automatically utilized in general **industrial processes** such as, water piping, refineries, oil & gas and petrochemical installations as gate, plug, globe, ball, butterfly, needle, diaphragm, safety, control, relief, pressure reducing, check, fire and sanitary valves.

The main focus is the didactic comprehension of standard and special **control valves, actuators, positioners, fieldbus systems and specifications** mentioned in a general way, since these subjects fall in a vast field. Then, many typical details as seals, gaskets, threads, fasteners, flanges, plastic materials and specific models are not completely covered.

Valves and fittings are subject to numerous standards and specifications issued by many supporting organizations. Today, the valve standards have dynamic specifications that reflect sound engineering practice changes in market demands and changes in technology and manufacturing procedures.

Early in this century when water piping, petrochemical, refining and general industries were in their infancy, pipe, valves & fittings manufacturers, as well as final users, had no standards to improve their processes. This lack of interchangeability with other products and parameters resulted in some technical institutions interested in addressing the standardization issues.

The Manufacturers Standardization **Society of the Valve & Fitting Industry (MSS)**, issued its first standard **in 1924**, and is still today at the forefront of valve standards activities.

Over the years many MSS documents have been the basis for **ASME** and **American Petroleum Institute (API)** standards. The **American Standards Association (ASA)** published their first document covering standardized flanges and flanged fittings in **1927**.

As the steam powered industrial revolution churned across the United States during the first quarter of this century, concern over **Boiler and Pressure** vessel design increased as some catastrophic disasters involving pressure vessels resulted in great loss of life and property. This situation led to the creation of the **"Boiler Code"**, which forever altered the future of all pressure containing components, including valves.

The **"Boiler Code"**, officially known as the **American Society of Mechanical Engineers (ASME)** Boiler & Pressure Vessel Code (B&PVC), laid the groundwork for many specifications and published the first edition of the Code in 1915. It is still published and yearly updated by ASME.

Over the years **the Code** has come to assure manufacturers, designers and the public, of the safety and reliability of pressure equipment.

During the World War II the fevered steps of **Oil & Chemical** production, dictated the creation of additional valve standards. The advent of pressure seal bonnet technology also required a new basis for determining pressure ratings of valves that led to standards such as **MSS SP-66**, **"Pressure Ratings for Steel Buttwelding End Valves"**.

The **Nuclear Power** industry of the 50's & 60's forced the creation of even more standards and specifications affecting the valve manufacturers and end-users. Today, the increased concern for the environment, plant worker safety and the general public, has created other valve standards that are technologically extensive and in many cases also legally driven.

All aspects of valve design, functionality, inspection and testing are covered in dozens of **ASME, API and MSS** documents. This dizzying amount of codes, types and specifications made this subject a job for only a few **valve engineering experts**. Unfortunately, retirement has drastically reduced experienced professionals and valve trained personnel familiarized with the valve standards.

II – STANDARD MANUFACTURING VALVES:

Many standards play an important role in the design and production of forged steel valves, fittings, flanges and accessories. These standards cover material, dimension, design, procedure and safety.

The actual **ASME/ANSI** (American Society of Mechanical Engineers & American National Standards Institute) is composed of users and producer groups, serves as the issuing agency for the majority of product standards related to the valve and fittings industry.

Generally, product standards are commonly issued by individual users and producer agencies, such as the American Petroleum Institute **(API)** and the Manufacturers' Standardization Society of the Valve & Fittings Industry **(MSS)**. Material standards and application processes are also sponsored by organizations as the American Society for Testing and Materials **(ASTM)**, the American Iron & Steel Institute **(AISI)**, and the Society of Automotive Engineers **(SAE)**.

1. ASME/ANSI STANDARDS:

ASME/ANSI B16.1: **Cast Iron Pipe Flanges and Flanged Fittings**. This standard covers pressure-temperature ratings, sizes, marking, and requirements for materials, dimensions and tolerances, bolt, nut, and gasket dimensions and tests for Classes 150, 300, 600, 900, 1500, and 2500.

ASME/ANSI B16.3: **Malleable Iron Threaded Fittings**. This standard covers pressure-temperature ratings, sizes, marking, dimensions, threading and coatings for Classes 150 and 300.

ASME/ANSI B16.4: **Cast Iron Threaded Fittings**. This standard covers pressure-temperature ratings, sizes, marking, dimensions and tolerances, threading and coatings for Classes 125 and 250.

ASME/ANSI B16.5: **Pipe Flanges and Flanged Fittings**. This standard covers pressure-temperature ratings, dimensions, tolerances, marking, testing, cast or forged materials, blind flanges, reducing flanges made from plate materials, recommendations regarding bolting, gaskets, joints and methods of designating openings for pipe flanges and flanged fittings.

Obs.: The standard includes flanges with rating class 150, 300, 400, 600, 900, 1500, and 2500 in sizes NPS 1/2 through NPS 24, with requirements given in both Metric and U.S units.

ASME/ANSI B16.9: **Factory-Made Wrought Steel Buttwelding Fittings**. This standard covers overall dimensions, tolerances, ratings, testing, and markings for wrought factory-made buttwelding fittings in sizes NPS 1/2 through 48 (DN 15 through 1200).

ASME/ANSI B16.10: Face-to-Face and End-to-End Dimensions of Valves. This standard covers face-to-face and end-to-end dimensions of straightway valves, and center-to face and center-to-end dimensions of angle valves. Its purpose is to assure installation interchangeability for valves of a given material, type size, rating class, and end connection.

ASME/ANSI B16.11: Forged Steel Fittings, Socket-Welding and Threaded. This standard covers ratings, dimensions, tolerances, marking and material requirements for forged fittings, both socket-welding and threaded.

ASME/ANSI B16.12: Cast Iron Threaded Drainage Fittings. This standard covers materials, sizes, dimensions and tolerances, threading, ribs, coatings, face bevel discharge nozzles, input shafts, base plates, and foundation bolt holes.

ASME/ANSI B16.14: Ferrous Pipe Plugs, Bushings and Locknuts with Pipe Threads. This standard covers pressure-temperature ratings, sizes, marking, materials, dimensions and tolerances, threading and pattern taper.

ASME/ANSI B16.15: Cast Bronze Threaded Fittings. This standard covers pressure-temperature ratings, sizes, marking, minimum requirements for casting quality and materials, dimensions, threading and tolerances in U.S. customary and metric (SI) units Cast Classes 125 and Class 250 and requirements pertaining to wrought or cast plugs, bushings, couplings, and caps.

ASME/ANSI B16.18: Cast Copper Alloy Solder Joint Pressure Fittings. This standard establishes requirements for pressure-temperature ratings, end connections, sizes, marking, materials, dimensions and tolerances and tests Cast copper alloy solder joint pressure fittings designed for use with copper water tube.

ASME/ANSI B16.20: Metallic Gaskets for Pipe Flanges-Ring-Joint, Spiral-Wound, and Jacketed. This standard covers materials, dimensions, tolerances, and markings for metal ring-joint gaskets, spiral-wound metal gaskets, and metal jacketed gaskets and filler material for use with flanges ASME/ANSI B16.5, ASME B16.47 and API-6A. This standard **replaces API-601**.

ASME/ANSI B16.21: Nonmetallic Flat Gaskets for Pipe Flanges. This standard includes types and sizes, materials, dimensions and allowable tolerances.

ASME/ANSI B16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings. This standard covers specifications for use with seamless copper tube conforming to ASTM B 88 (water and general plumbing systems), ASTM B 280 (air conditioning and refrigeration service), ASTM B 819 (medical gas systems), fittings assembled with soldering materials conforming to ASTM B 32, brazing materials conforming to AWS A5.8, as well as tapered pipe thread conforming to ASME B1.20.1.

Obs.: Allied with **ASME B16.18**, covers **cast copper alloy pressure fittings** and provide requirements for fitting ends suitable for soldering. Covers pressure temperature ratings, end connections, sizes, marking, material, dimension, tolerances and tests.

ASME/ANSI B16.23: Cast Copper Alloy Solder Joint Drainage Fittings (DWV). This standard is indicated for use in drain, waste and vent (DWV) systems for use with seamless copper tube conforming to ASTM B 306, Copper Drainage Tube (DWV). The fittings may be assembled with soldering materials conforming to ASTM B 32, as well as tapered pipe thread ASME B1.20.1.

ASME/ANSI B16.24: Cast Copper Alloy Pipe Flanges and Flanged Fittings. Covers pressure, temperature ratings, sizes, marking, requirements for materials, dimensions, tolerances, bolt, nut, and gasket dimensions, and tests for Classes 25, 125, 250, and 800.

ASME/ANSI B16.25: Buttwelding Ends. This standard covers the preparation of butt welding ends of piping components to be joined into a piping system by welding. It includes requirements for welding bevels, for external and internal shaping of heavy-wall components, and for preparation of internal ends (including dimensions and tolerances).

Obs.: Coverage includes non-backing rings, split or non-continuous backing rings, solid or continuous backing rings, consumable insert rings, gas tungsten are welding (GTAW) of the root pass. Details of preparation for any backing ring must be specified in ordering the component.

ASME/ANSI B16.26: Cast Copper Alloy Fittings for Flared Copper Tubes. This standard covers pressure rating, material, sizes, threading, marking.

ASME/ANSI B16.28: Wrought Steel Buttwelding Short Radius Elbows and Returns. This standard covers ratings, overall dimensions, testing, tolerances, and markings for wrought carbon and alloy steel buttwelding short radius elbows and returns. The term wrought denotes fittings made of pipe, tubing, plate, or forgings.

ASME/ANSI B16.29: Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings (DWV). This standard covers wrought copper and wrought copper alloy solder joint drainage fittings, designed for use with copper drainage tube, covers description, pitch (slope), end connections, sizes, marking, materials, dimensions and tolerances.

Obs.: ASME B16.29, Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings (DWV) provide requirements for fitting ends suitable for soldering. This standard covers description, pitch (slope), end connections, sizes, marking, materials, dimensions and tolerances.

ASME/ANSI B16.33: Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psig. This standard covers requirements for manually operated metallic valves sizes NPS 1.2 through NPS 2, for outdoor installation as gas shut-off valves at the end of the gas service line and before the gas regulator and meter where the designated gauge pressure of the gas piping system does not exceed 125 psi (8.6 bar).

ASME/ANSI B16.34: Valves - Flanged, Threaded, and Welding End. This standard applies to new valve construction and covers pressure-temperature ratings, dimensions, tolerances, materials, nondestructive examination requirements, testing, marking for cast, forged, fabricated flanged, threaded, welding end, wafer or flangeless steel valves, nickel-base alloys and other alloys.

Obs.: Wafer or flangeless valves, bolted or through-bolt types are installed between flanges or against a flange shall be treated as flanged end valves.

ASME/ANSI B16.36: Orifice Flanges. This standard covers flanges (similar to those covered in ASME B16.5) that have orifice pressure differential connections. Coverage is limited to Welding Neck flanges Classes 300, 400, 600, 900, 1500, and 2500, Slip-on and threaded Class 300, Orifice, Nozzle and Venturi Flow Rate Meters.

ASME/ANSI B16.38: Large Metallic Valves for Gas Distribution. This standard covers only manually operated metallic valves in nominal pipe sizes 2 1/2 through 12 having the inlet and outlet on a common center line, which are suitable for controlling the flow of gas from open to fully closed.

Obs.: Provide requirements for use in distribution and service lines where the maximum gage pressure at which such distribution piping systems may be operated in accordance with the code of federal regulations, transportation of natural and other gas by pipeline; minimum safety standard, does not exceed 125 psi (8.6 bar). Valve seats, seals and stem packing may be nonmetallic.

ASME/ANSI B16.39: Malleable Iron Threaded Pipe Unions. This standard provides requirements design, pressure-temperature ratings, sizes, marking, materials, joints and seats, threads, hydrostatic strength, tensile strength, air pressure test, sampling, coatings, dimensions for threaded malleable iron unions, classes 150, 250, and 300.

ASME/ANSI B16.40: Manually Operated Thermoplastic Gas. This standard covers valves with nominal sizes 1.2 through 6 for use below ground in thermoplastic distribution mains and service lines. Minimum Safety Standards, for temperature ranges of 20 °F to 100°F (0.29°C to 38°C).

Obs.: This Standard sets requirements for newly manufactured **valves for use in below ground piping systems** for natural gas [includes synthetic natural gas (SNG)], and liquefied petroleum (LP) gases (distributed as a vapor, with or without the admixture of air) or mixtures.

ASME/ANSI B16.42: Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300. This standard covers minimum requirements for pressure-temperature ratings, sizes, marking, materials, dimensions, tolerances, bolts, nuts, and gaskets and tests.

ASME/ANSIB16.44: Manually Operated Metallic Gas Valves for Use in House Piping Systems. Applies to new valve construction and covers quarter turn manually operated metallic valves in sizes NPS 1/2-2 which are intended for indoor installation as gas shut-off valves when installed in indoor gas piping between a gas meter outlet & the inlet connection to a gas appliance.

ASME/ANSI B16.45: Cast Iron Fittings for Solvent Drainage Systems. This standard covers description, sizes, marking, materials, pitch, design, dimensions, tolerances and tests.

ASME/ANSI B16.47: Large Diameter Steel Flanges: NPS 26 through NPS 60. This standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking, and testing for pipe flanges in ratings Classes 75, 150, 300, 400, 600, and 900. Flanges may be cast, forged, or plate (for blind flanges only) materials. Include requirements and procedures regarding bolting and gaskets.

ASME/ANSI B16.48: Steel Line Blanks. This standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking, and testing for operating lines in sizes NPS 1/2 through NPS 24 for installation between ASME B16.5 flanges in the 150, 300, 600, 900, 1500, and 2500 classes.

ASME/ANSI B16.49: Factory-Made Wrought Steel Buttwelding Induction Bends for Transportation and Distribution Systems. This standard covers design, material, manufacturing, testing, marking, and inspection requirements for pipeline bends of carbon steel materials having controlled chemistry and mechanical properties, produced by induction process, with or without tangents.

Obs.: This standard also covers induction bends for transportation and distribution piping applications **(ASME B31.4, B31.8, and B31.11)** Process and Power Piping have differing requirements and materials that may not be appropriate for the restrictions and examinations described herein, and therefore are not included in this Standard.

ANSI/ASME B31.3: "Chemical Plant and Petroleum Refinery Piping". This standard details the fabrication, assembly and nondestructive testing of piping systems, which include valves.

ANSI/ASME B31.3: Utilized by several valve manufacturers for fabrication procedures. The other code is **Section VIII, "Rules For the Construction of Pressure Vessels - Division 1"**.

ASME Section IX: Welding & Brazing Qualifications. This document addresses welding procedures, welding procedure qualifications and welder certifications. Most, if not all, pressure vessel welding codes specify Section IX as part of their processes.

Note: General application standards apply to valves operated in a temperature environment between **20°F and 150°F (0.29°C and 66°C)** and set forth the minimum capabilities, characteristics, and properties, which a valve at the time of manufacture must possess, in order to be considered suitable for use in gas piping systems.

2. ESSENTIAL API STANDARDS:

API 526: Flanged Steel Pressure Relief Valves. Are basic requirements given for direct spring-loaded pressure relief valves and pilot-operated pressure relief valves as follows: orifice designation and area; valve size and pressure rating, inlet and outlet; materials; pressure-temperature limits; and center-to-face dimensions, inlet and outlet.

API 527: Seat Tightness of Pressure Relief Valves. This standard describes methods of determining the seat tightness of metal- and soft-seated pressure relief valves, including those of conventional, bellows, and pilot-operated designs.

API 594: Check Valves Flanged, Lug, Wafer and Butt-welding. This standard covers design, material, face-to-face dimensions, pressure-temperature ratings, and examination, inspection, and test requirements for two types of check valves.

API 599: Metal Plug Valves Flanged, Threaded and Welding Ends. This standard covers requirements for metal plug valves with flanged or butt-welding ends, and ductile iron plug valves with flanged ends, in sizes NPS 1 to NPS 24, which correspond to nominal pipe sizes in **ASME B36.10M**.

Obs.: Valve bodies conforming to **ASME B16.34** may have flanged end and one butt-welding end. It also covers both lubricated and nonlubricated valves that have two-way coaxial ports, and includes requirements for valves fitted with internal body, plug, or port linings or applied hard facings on the body, body ports, plug, or plug port.

API 600: Steel Valves Flanged & Buttwelding Ends: Valve design and construction criteria are detailed, as well as materials and trim designations. This specification covers the same details small forged gate valves. API 602 further gives dimensions for extended body valves. API 600 differs from ANSI B16.34 is minimum wall thickness.

API 602: Compact Steel Gate Valves- Flanged, Threaded, Welding and Extended-Body Ends: API 602 is the 4" & smaller forged steel gate valve purchase specification. Small carbon steel gate valves such as the forged 150#, 300#, 600#, 800# & 1500# class valves manufactured by several companies worldwide are covered by API 602.

API 603: Class 150, Cast, Corrosion-Resistant, Flanged-End Gate Valves: This standard covers light walled gate valves in sizes NPS 1/2" through 24", in classes 150, 300 & 600. These valves are used in applications where the thicker API 600 casting is not needed.

API 608: Metal Ball Valves-Flanged and Butt-Welding Ends: Valve design and construction criteria are detailed and are the purchase specification for class 150 and class 300 metal ball valves. Important Note- ball valve working pressures should be based on seat material, not valve class.

API 609: Butterfly Valves, Lug-Type and Wafer Type: This standard covers butterfly valves with lug-type and wafer-type configurations, designed for installations between ANSI B16 flanges, through Class 600 and is also has purchase specifications.

API 598: Valve Inspection & Testing: This standard covers the testing and inspection requirements for gate, globe, check, ball, plug & butterfly valves. Steel valve pressure ratings found in ASME/ANSI B16.34 are required to determine API 598 test pressures for steel valves.

Obs.: The test specification according to **API 598 "Valve Inspection & Test"**, first drafted in 1974, lists all of the **test parameters** and procedures to be followed for production testing of valves. Most metallic seated valves larger than ANSI 2" size have an allowable leakage rate. As an example, valve testing specifications **rated with working pressures** (800 psi WOG - means 800 psi working pressure for water, oil or gas service.

API 6D: Specification for Pipeline Valves (Gate, Plug, Ball and Check Valves): The API 6D is the **primary** standard for valves used in pipeline service, including gate, plug, ball and check valves.

Obs.: Occasionally refinery and petrochemical purchasers reference other more **stringent testing requirements** than API 6D. However, it is important that the valve may have built under API 600, 602, 608 or 609 design criteria.

API RP 621: Recommended Practice 621, **"Reconditioning of Metallic Gate, Globe and Check Valves"**. Provides guidelines for reconditioning heavy wall (API 600 type) carbon steel, ferritic alloy (up to 9% Cr), stainless steel, and nickel alloy gate, globe, and check valves for ASME pressure classes 150, 300, 400, 600, 900, 1500, and 2500. Guidelines contained in this RP apply to flanged and butt weld cast or forged valves.

In 2001, the **American Petroleum Institute (API)** Refining Committee published a common valve **reconditioning standard**. The standard was conceived to eliminate the vast number of similar valve repair standards that each end-user had. The new standard is more stringent than most end-user repair documents, and also more stringent than most valve shops are using to working with. The result will be **higher quality reconditioned valves** for all the end-users that adopt this standard.

3. ESSENTIAL MSS SP STANDARDS:

MSS SP-55: Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components: This specification is listed as part of the procedure under API 598.

MSS SP-67: **Butterfly Valves**. This standard covers manufacturing and testing requirements, including pressure and temperature ratings. Primary body materials, such as nickel alloys, bronze, cast steel and ductile iron.

MSS SP-68: **High Pressure Butterfly Valves with Offset Design Valve**. This standard covers design, manufacturing and testing requirements, including pressure and temperature ratings. The primary body materials must be according to ASME B16.34.

MSS SP-70: **Cast Iron Gate Valves, Flanged and Threaded Ends Valve**. This standard covers design, manufacturing, testing requirements, pressure and temperature ratings. The primary body materials are: ASTM A126 Class B (Cast Iron), ASTM A536 (Ductile Iron), ASTM A395 (Ductile Iron).

MSS SP-71: **Gray Iron Swing Check Valves, Flanged and Threaded Ends Valve**. This standard covers design, manufacturing and testing requirements, including pressure and temperature ratings. Primary body material: ASTM A126 Class B (Cast Iron).

MSS SP-80: **Bronze Gate, Globe, Angle and Check Valves Valve**. This standard covers design, manufacturing, testing requirements, pressure and temperature ratings. The primary body materials are: ASTM B61 (Pressure Class 125, 150), ASTM B62 (Pressure Classes 200 and higher).

MSS SP-85: **Gray Iron Globe and Angle Valves, Flanged and Threaded Ends Valve**. This standard covers design, manufacturing and testing requirements, including pressure and temperature ratings. Primary body material: ASTM A126 Class B (Cast Iron).

MSS SP-110: **Ball Valves, Threaded, Socket Welding, Solder Joint, Grooved and Flared Ends Valve**. This standard covers design, manufacturing and testing requirements, including pressure and temperature ratings Primary body materials: nickel alloys, bronze, cast steel and ductile iron.

MSS SP-61: **Pressure Testing of Steel Valves**. This standard covers some valve types, such as bronze gate, globe & check valves not tested per **API 598,** normally tested per **MSS SP-61**.

MSS SP-25: **Standard Marking System for Valves, Fittings, Flanges and Unions**.

4. OTHER INTERNATIONAL STANDARDS:

Other organizations also publish valve standards, including the British Standards Institute **(BSI)**, International Standards Organization **(ISO)**, the Canadian Standards Organization **(CSA)** and the National Association of Corrosion Engineers **(NACE).**

BS 1873: **Steel Globe Stop and Check Valves For The Petroleum, Petrochemical and Allied Industries.** British standard for the Petroleum, Petrochemical other industries.

BS 5352: **Steel Wedge Gate, Globe and Check Valves 50mm (2") and Smaller.** Great Britain's British Standards Institute does have two standards that address globe valves.

NACE MR-0175: **Requirements for Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment**. This standard has procedures for materials used in "sour" and corrosion environments found in piping systems in many refineries. **MR-0175** is **not a standard**, but a **recom-**

mended practice. However, **NACE** (National Association of Corrosion Engineers) specification is treated as a standard in several industries. It lists materials, mechanical properties and heat treatments for metals used in **Hydrogen Sulfide (H2S)** bearing hydrocarbon service. **MR-0175** was defined to lessen the **H2S** induced cracking. The **"NACE"** is specified for use in high corrosion refinery processes. The most common corrosion resistant materials used in valve construction are 316S, Monel and Stellite. **H2S** is a flammable, extremely hazardous gas with a "rotten egg" smell.

BS 1873, BS 5352 & BS 6364: **Cryogenic Valves**. **BS 1868 & BS 5352**: **Steel Check Valves**. BSI published several standards covering areas that U.S. valve standards have ignored, such as globe valves. These documents are excellent starting points for professional guidance in these subjects.

ISO Standard 10434: Is essentially the **same as API 600**, only published in the ISO format. An appendix contains information pertaining to pressure seal valves. During the past years there has been a huge **cooperation** between the International Standards Organization (ISO) and US valve standards makers.

III – COMMON STANDARD VALVES:

Because of the diversity of the types of systems, fluids, and environments in which valves must operate, a vast array of valve types have been developed. The most common types are the **gate, globe, ball, plug, butterfly, diaphragm, reducing, check, pinch needle and safety valves**.

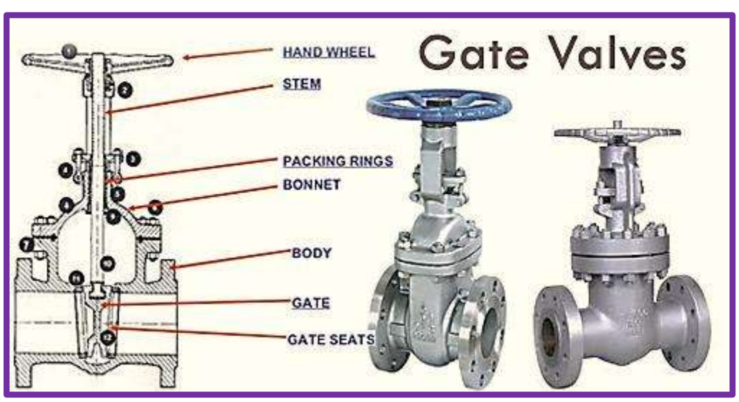
Some valves are capable of throttling flow, others can only stop flow, others for corrosive systems and some handle high pressure fluids. Understanding these differences and how they affect the valve's application or operation is necessary for the successful operation of a facility.

Although all valves have almost the same basic components and functions to control fluid flows, the method of controlling may vary in several application aspects. In general, basically there are four methods of controlling flow through a valve:

1. Move a disc or plug into or against an orifice (globe or needle type valve);
2. Slide a flat, cylindrical, or spherical device across an orifice (gate and plug valves);
3. Rotate a round disc across the diameter of an orifice (a butterfly or ball valve);
4. Move a spring device into the flow passage (diaphragm and pinch valves).

1. Gate Valves:

Gate valves are by far the most widely used in industrial piping. That's because most valves are needed as stop valves - **to fully shut off or fully turn on flow** - the only job for which gate valves are recommended. Gate valves are not suitable for **throttling** purposes since the control of flow would be difficult due to valve design and since the flow of fluid slapping against a partially open gate can cause extensive damage to the valve.



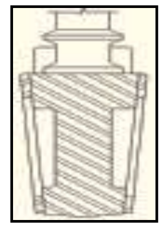
Gate Valves are designed to operate **fully open or fully closed**. Gate valves provide optimum performance in conditions where high flow efficiency, tight shut off and long service is required. Because they operate slowly they prevent **fluid hammer**, which is detrimental to piping systems. There is very little pressure loss through a gate valve. In the fully closed position, gate valves provide a positive seal under pressure.

A gate valve usually requires more turns - more work - **to open** it fully. Also, unlike many globe valves, the volume of flow through the valve is not in direct relation to number of turns of handwheel. Repeated movement of disc near point of closure under high-pressure flow may gall or score seating surfaces on downstream side. Slightly opened disc in turbulent flow may cause troublesome vibration and chattering. In a slightly opened position high-velocity flow will cause erosion of seating surfaces in gate valves.

1.1. Disk Designs:

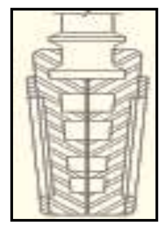
Gate valves are available with a variety of disks. Classification of gate valves is usually made by the type disk used: **solid wedge, flexible wedge, split wedge, or parallel disk**. Solid wedges, flexible wedges, and split wedges are used in valves having inclined seats. Parallel disks are used in valves having parallel seats. Regardless of the style of wedge or disk used, the disk is usually replaceable. In services where solids or high velocity may cause rapid erosion of the seat or disk, these components should have a high surface hardness and should have replacement seats as well as disks.

- **Solid Wedge:**



The solid wedge gate valve is the most commonly used disk because of its simplicity and strength. A valve with this type of wedge may be installed in any position and it is suitable for almost all fluids. It is practical for turbulent flow.

- **Flexible Wedge:**

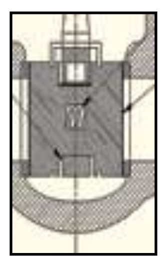


The flexible wedge gate valve, as shown, is a one-piece disk with a cut around the perimeter to improve the ability to match error or change in the angle between the seats. The cut varies in size, shape, and depth. A shallow, narrow cut gives little flexibility but retains strength. The reason for using a flexible gate is to prevent binding of the gate within the valve when the valve is in the closed position.

- **Split Wedge:**

Split wedge gate valves, as shown, are of the ball and socket design. These are self-adjusting and self-aligning to both seating surfaces. The disk is free to adjust itself to the seating surface if one-half of the disk is slightly out of alignment because of foreign matter lodged between the disk half and the seat ring. This type of wedge is suitable for handling noncondensing gases and liquids at normal temperatures, particularly corrosive liquids.

- **Parallel Disk**



The parallel disk gate is designed to prevent valve binding due to thermal transients. This design is used in both low and high pressure applications. The wedge surfaces between the parallel face disk halves are caused to press together under stem thrust and spread apart the disks to seal against the seats.

The tapered wedges may be part of the disk halves or they may be separate elements. The lower wedge may bottom out on a rib at the valve bottom so that the stem can develop seating force.

1.2. Stem Design:

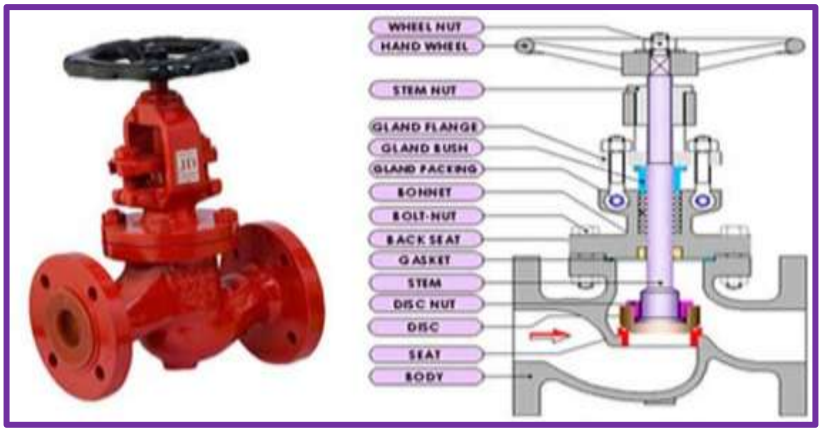
Gate valves are classified as either **rising stem or non-rising stem** valves. For the non-rising stem gate valve, the stem is threaded on the lower end into the gate. As the hand wheel on the stem is rotated, the gate travels up or down the stem on the threads while the stem remains vertically stationary.

1.3. Seat Design:

Seats for gate valves are either provided integral with the valve body or in a seat ring type of construction. Seat ring construction provides seats which are either threaded into position or are pressed into position and seal welded to the valve body. The latter form of construction is recommended for higher temperature service.

2. Globe Valves:

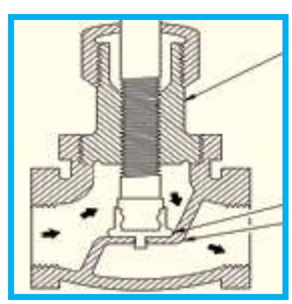
Globe Valves are very commonly used in general industry processes. The main service is for **regulating flow** in a pipeline. This type may be automated or manual handwheel opened with a movable plug that can be screwed to close (or shut) the valve. The plug is also called a disc or disk. Globe valves have a lot of advantages: they offer precise throttling control and have high-pressure limits, moreover considered to have a low coefficient of flow. Globe valves may be used also for on-off duty since the flow resistance from the tortuous flow passage of these valves can be accepted.



However, if the valve has to be opened and closed frequently, globe valves are ideally suited because of the short travel of the disc between the open and closed positions, and the inherent robustness of the seating to the opening and closing movements. Globe valves are also suited for controlling in situations where there are high pressure differences between the inlet and outlet.

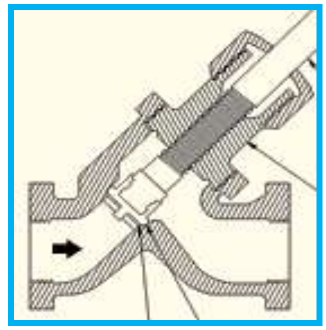
The winding path does not let it speed up too much and reduces the impact of the Bernoulli Effect that often damages ball valves. Commonly there are **3 styles** of globe valves: **Straight Pattern, Angle Pattern and Y-Pattern** determined by the geometry of the end connection and the stem. The three primary body designs for globe valves are **Z-Body, Y-Body and Angle Design**.

- **Z-Body Design**



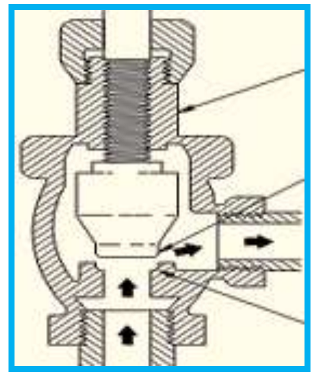
The simplest design and most common for water applications is the Z-body. The Z-shaped diaphragm or partition across the globular body contains the seat. The horizontal setting of the seat allows the stem and disk to travel at right angles to the pipe axis. The stem passes through the bonnet which is attached to a large opening at the top of the valve body. This provides a symmetrical form that simplifies manufacture, installation, and repair.

- **Y-Body Design:**



This design is a remedy for the high pressure drop inherent in globe valves. The seat and stem are angled at approximately 45°. The angle yields a straighter flow path (at full opening) and provides the stem, bonnet, and packing a relatively pressure resistant envelope. Y-body globe valves are best suited for high pressure and other severe services. In small sizes for intermittent flows, the pressure loss may not be as important as the other considerations favoring the Y-body design.

- **Angle Valve Design:**



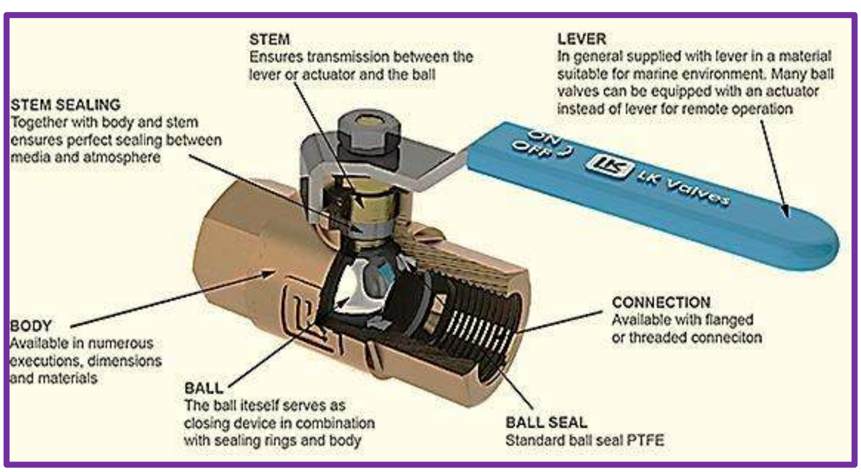
The angle body globe valve design is a simple modification of the basic globe valve. Having ends at right angles, the diaphragm can be a simple flat plate. Fluid is able to flow through with only a single 90° turn and discharge downward more symmetrically than the discharge from an ordinary globe.

A particular advantage of the angle body design is that it can function as both a valve and a piping elbow. Globe valves may therefore be used for most duties encountered in fluid handling systems. This wide range of duties has led to the development of numerous variations of globe valves designed to meet a particular duty at the lowest cost.

3. Ball Valves:

There are many models of Ball Valves. The design that gives the name has a hollow sphere, the main part of the valve which controls the fluid flow. Some ball valves contain a swing check located within the ball to give the valve a check valve feature. Ball valves are normally found in the following systems: clean water, seawater, sanitary, sewers, drain, air, hydraulic and oil transfer and are an excellent choice for **shut-off applications** often preferred to **replace globe valves** and **gate valves** for this purpose. They do not offer the **fine control** that may be necessary in **throttling applications**, but sometimes are used for this purpose.

The ball performs the same function as the plug in the globe valve. When the valve handwheel or lever is operated to open the valve, the ball rotates to a point where the hole through the ball is in line with the valve body inlet and outlet. When the valve is shut, which requires only a 90-degree rotation, the ball is rotated the way the hole becomes perpendicular to the flow openings and then the fluid flow is stopped. When the valve is closed, the hole is **perpendicular to the ends of the valve**, and flow is blocked.



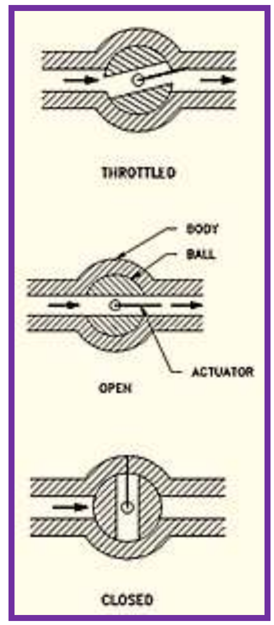
The handwheel or lever will be in line with the port position letting you "see" the valve's position. The ball valve, along with the butterfly valve and plug valve, are part of the family of quarter turn valves. Most ball valves are of the **quick-acting type** (requiring only a quick 90-degree turn to operate the valve either completely open or closed), but many are **planetary gear operated**. This type of gearing allows the use of a relatively small handwheel and operating force to operate a fairly large valve. The gearing increases the operating time for the valve.

Ball valves are **used extensively** in industrial applications because they are very versatile, supporting pressures up to **1000 bar** (14500 psi) and temperatures up to **482°F (250°C)**. Ball sizes typically range from **0.2 to 11.81 inches** (0.5 cm to 30 cm), very easy to repair and operate. The body of ball valves may be made of metal, plastic or metal with a ceramic center. The ball is often chrome plated to make it more durable.

3.1 - Models of Ball Valves:

There are **five** general body models of ball valves: single body, three piece body, split body, top entry and welded. The difference is based on how the pieces of the valve, especially the casing that contains the ball itself, are manufactured and assembled. The valve operation is the same in all models.

3.2 - Styles of Balls:



Full Port: Or more commonly known as **Full Bore Ball Valve** has an oversized ball so that the hole in the ball is the same size as the pipeline resulting in lower friction loss. The valve is larger and more expensive so this is only used where free flow is required, for example in pipelines which **require pigging** (internal pipeline inspection with a moving device).

Reduced Port: Commonly known as **Reduced Bore Ball Valves,** as the pipe size is smaller than the valve size. Thus, the flow area is smaller than the pipe.

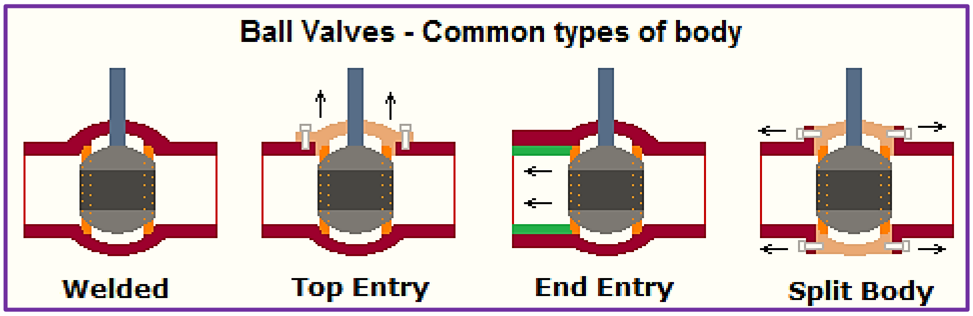
V Port: Has either a **"v" shaped ball or a "v" shaped seat**, to be opened and closed in a more controlled manner, closer to linear flow characteristic. When the valve is in the closed position and opening is starting, the small end of the "v" is opened, allowing a stable flow control.

Trunnion Ball Valve: Has a mechanical device, anchoring the ball at the top and the bottom, for larger and higher pressure valves (above 600 psig).

Cavity Filler Ball Valve: Avoids residues in the ball valve, mainly in food industries as residues may also be health hazard, and when the fluid changes from time to time, contamination of fluids may occur. To avoid trapped residues, the cavity has to be plugged, which can be done by extending the seats in such a manner that it is always in contact with the ball.

3. 3 - Types of Body:

- **Welded**: This type of ball body guarantees the absence of leakages along all valve's life, with no requirement for maintenance operations. This is a highly important requisite especially for ball valves installed either underground and submarine pipelines. It is also often chosen for hazardous fluids.
- **Top Entry**: The ball can be taken out removing the top cover. It can be repaired on site.
- **End Entry:** The body is one piece. The ball is entered from the axial entry.
- **Split Body**: There are two or three pieces, to allow easy maintenance of all internal parts.



3.4 - Three-way and Four-way Ball Valves:

3-way Ball Valves: Have an **L - or T - shaped hole** through the middle. It is easy to see that a T - valve can connect any pair of ports, or all three, but the 45 degree position which might disconnect all three leaves no margin for error. The L - valve can connect the center port to either side port, or disconnect all three, but it cannot connect the side ports together.

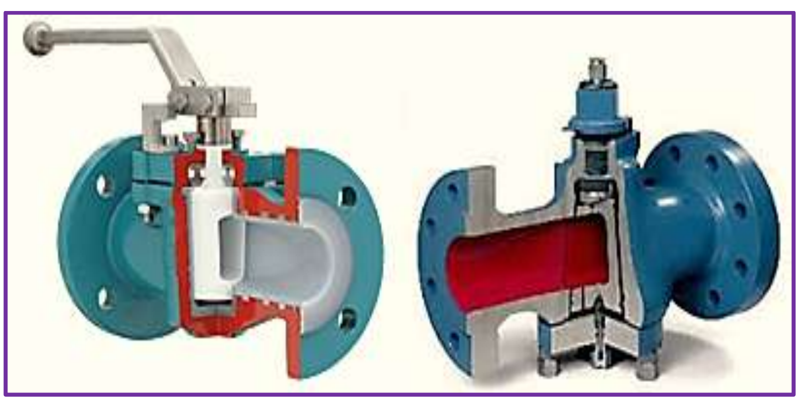
4-way Ball Valves: Are also commercially available, for special applications, such as **driving air-powered motors** from forward to reverse, the operation is performed by rotating a single lever four-way valve. The 4-way Ball Valve has two L - shaped ports in the ball that do not interconnect, sometimes referred to as an **"×"** port. Ball Valves **up to 2 inches** generally come in single piece, two or three piece designs. One piece ball valves are almost always reduced bore, are relatively inexpensive and generally are throw-away types.

Two Piece Ball Valves: Are generally slightly reduced (or standard) bore and can be either throw-away or repairable. **The 3-piece design** allows the ball, stem & seats to be easily removed from the pipeline. This facilitates **efficient cleaning** of deposited sediments, replacement of seats and gland packings, polishing out of small scratches on the ball without removing the pipes from the valve body. The design concept of a three piece valve is for to be repairable.

Manually Operated Ball Valves: Are the **most common ball valves**, but there is always a danger of water hammering. These ball valves may be also equipped with **pneumatic actuator** or motor operated, with a positioner which transforms the control signal to open or close the valve, accordingly. They can be used either for on/off or flow control.

4. Plug Valves:

Plug valves are rotational motion valves used **to stop or let** a dynamic path of the fluid flow. The name is derived from the shape of the disk, which resembles a plug. The simplest form of a plug valve is the petcock. The body of a plug valve is machined to receive the tapered or cylindrical plug. The disk is a solid plug with a bored passage at a right angle to the longitudinal axis of the plug.

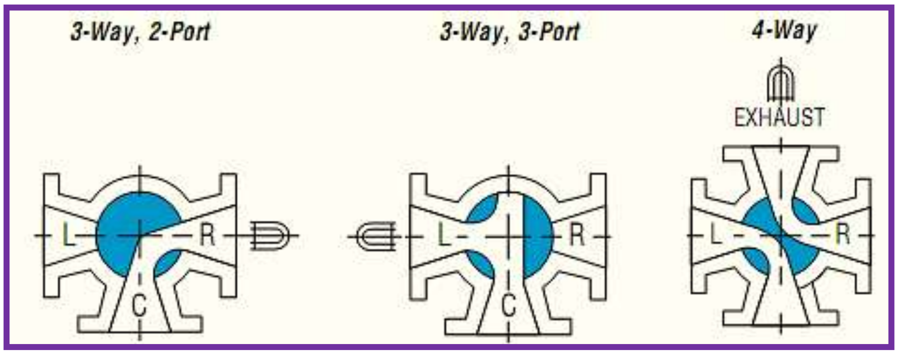


Plug valves are normally used in **non-throttling** and **on-off operations.** When frequent operations of the ball valves are necessary, like the gate valves, a high percentage of flow change occurs near the shutoff with at high velocity. However, a **diamond-shaped port** has been developed for **throttling** service.

4.1. Multiport Plug Valves:

The **multiport** construction and the installation simplify the pipelines, and provide a more convenient operation than multiple gate valves. They also eliminate pipe fittings, as well conventional shutoff valves. These valves are intended to divert the flow of one line while shutting off flow from the other lines. If complete shutoff of flow is a requirement.

It is necessary that a style of multiport valve be used that permits this, or a secondary valve, which should be installed on the main line ahead of the multiport valve to permit complete shutoff of flow. The advantage in the use of multiport valves is simplification of piping and operations. One **3-way or** a **4-way multiport** valve may be used in place of two; three or four straightway valves, and in most cases will also eliminate other fittings, such as tees and elbows.



4.2. Disks:

The plugs are either round or cylindrical with a taper and may have various types of port openings, each with a varying degree of area relative to the corresponding inside diameter of the pipe.

- **Rectangular Port Plug**: The most common port shape is the rectangular port. The rectangular port represents at least 70% of the corresponding pipe's cross-sectional area.
- **Round Port Plug**: Describes a valve that has a round opening through the plug. **Full port** is when the port is the same size or larger than the pipe's inside diameter. **Standard round** port is when the opening is smaller than the pipe's inside diameter.
- **Diamond Port Plug**: Has a diamond-shaped port through the plug. This design is for throttling service. All diamond port valves are venturi restricted flow type.

4.3. Lubricated Plug Valves:

Can be as large as 24 inches and have pressure capabilities up to 6000 psig. The plug can be cylindrical or tapered. The most common **fluids** controlled by plug valves are gases and liquid hydrocarbons. Grease lubricates the plug motion and seals the gap between plug and body, injected into a fitting at the top of the stem. The **lubricant** must be compatible with the temperature and nature of the fluid.

4.4 Non-lubricated Plug Valves:

Can also be as large as 24 inches and have pressure capabilities up to 6000 psig. There are two basic types of nonlubricated plug valves: **lift-type** and elastomer sleeve or **plug coated**.

- ✓ **Lift-type Valves:** Constructed with a mechanically lifting to slightly disengage it from the seating surface to permit easy rotation. The mechanical lifting can be accomplished with a cam or external lever.

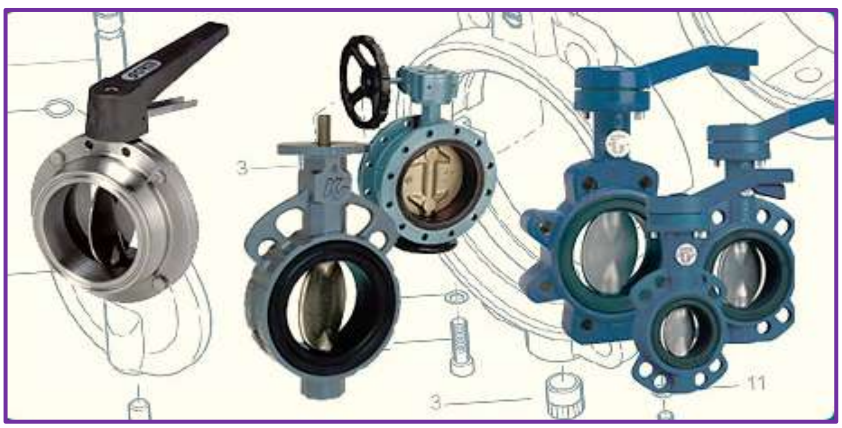
- ✓ **Elastomer Sleeve or Plug Coated:** The plug valve has a TFE lining completely surrounding the plug. This design results in a primary seal being maintained between the sleeve and the plug at all times regardless of position. It also has a low coefficient of friction and is, therefore, **self-lubricating**.

4.5. Plug Valve Glands:

The gland of the plug valve is equivalent to the bonnet of a gate or globe valve. The gland secures the stem assembly to the valve body. There are three general types of glands: **single gland, screwed gland, and bolted gland**. Gland adjustment should be kept tight enough to prevent the plug from becoming unseated and exposing the seating surfaces to the live fluid.

5. Butterfly Valves:

Butterfly Valves can be used for **isolating or regulating** flow. The closing mechanism is a disk type and the operation is similar to a ball valve for quick opening or shut off. The "butterfly" is a metal disc mounted on a rod. When the valve is closed, the disc is turned the way it **completely blocks off** the passage way. When the valve is **fully open**, the disc is rotated a **quarter turn**, so that it allows an almost unrestricted passage of the fluid.

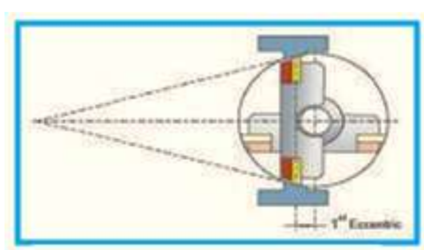


The valve may also be **opened incrementally to throttle flow**. Butterfly valves are easily and quickly operated because the **90° rotation** of the handle moves the disk from a fully closed to fully opened position. Larger butterfly valves are actuated by handwheels connected through gears that provide the mechanical movement of the stem.

Butterfly valves are especially well-suited for the handling of large flows of liquids or gases at relatively low pressures and for the handling of slurries or liquids with large amounts of suspended solids, as well on firefighting apparatus.

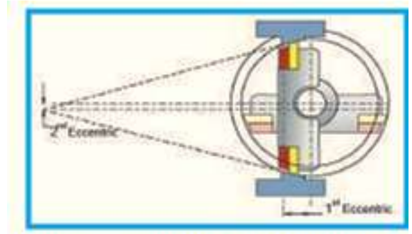
5.1. Types:

a. Concentric Butterfly Valves: This is the most common type of butterfly valve constructed with a resilient rubber seat and a metal disc. The seat and seal are designed conically and on centre. This design relies on a frictional interference seal and so is applicable only to soft seated valves.



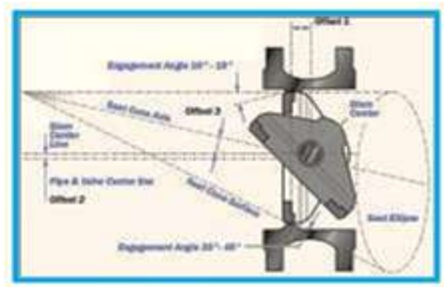
Concentric Butterfly Valves

b. Double Eccentric Butterfly Valves: This type is also referred as High Performance Butterfly Valves or Double Offset Butterfly Valves. The seat and seal design remains conical and on centre. This design again relies on a frictional, interference seal, but the friction is reduced, allowing a larger resistant seal materials used to prevent "jamming". This type has been widely adopted for crude oil valves, high-pressure and high flow-rate piping systems.



Double Eccentric Buterffly Valves

c. Triple Eccentric Butterfly Valves: This type is also commonly called Triple Offset Butterfly Valves. The center of the cone is rotated from the valve centerline resulting in an ellipsoidal profile and providing the third offset. The geometry allows the body seat to be used as the closed limit stop, aiding operator adjustment.



Triple Eccentric Butterfly Valves

The Triple Offset design is ideally suited to metal seated valves providing bubble-tight performance on high temperature, high pressure and firesafe applications. This type of valve is generally used in applications which require bi-directional tight shut-off in Oil & Gas, LNG/NPG terminal tanks, Chemical Factories, Ship-building. Widely used for dirty- heavy oil to prevent extrusion.

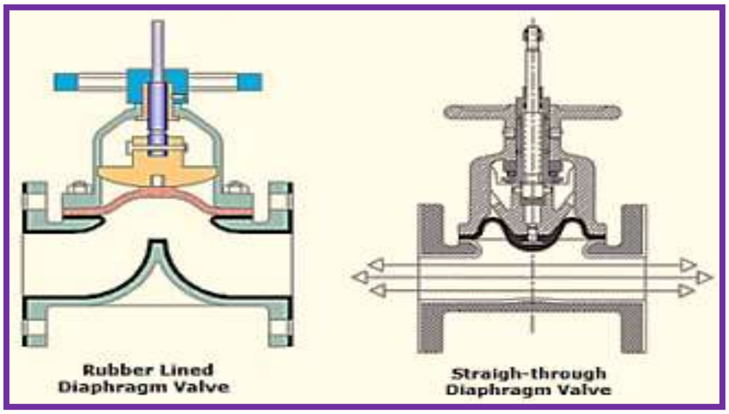
d. Wafer Butterfly Valves: Designed to maintain a seal against bi-directional pressure differential to prevent backflow in systems designed for unidirectional flow. It accomplishes this with a tightly fitting seal, i.e., gasket, o-ring, precision machined, and a flat valve face on the upstream and downstream sides of the valve.

e. Lug Butterfly Valves: Have threaded inserts at both sides of the valve body to be installed into a system using two sets of bolts and no nuts. The valve is installed between two flanges using a separate set of bolts for each flange. This setup permits either side of the piping system to be disconnected without disturbing the other side.

6. Diaphragm Valves:

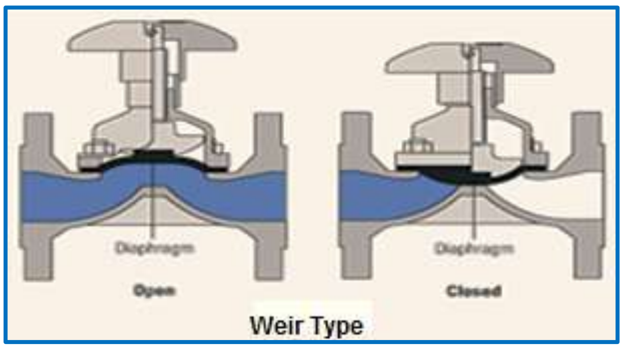
Diaphragm valves have a linear motion used to start, regulate, and stop fluid flow. The name is **derived from a flexible disk**, with a seat located at the top of the valve body. The stem of the valve is used to **push down a flexible diaphragm**, which in turn **blocks the path** of the fluid. The development of new diaphragm materials enables diaphragms to be used on most fluids. Their application is however limited by the temperature that the diaphragm can withstand - typically less **than 175°C**. Diaphragm valves are generally used on process fluid applications.

The valve assembly has only three major parts such as Body, Bonnet & Diaphragm. In the diaphragm valve, it's also very easy to replace the rubber diaphragm without dismantling body from the line. There are two different classifications based on the geometry of the valve body.

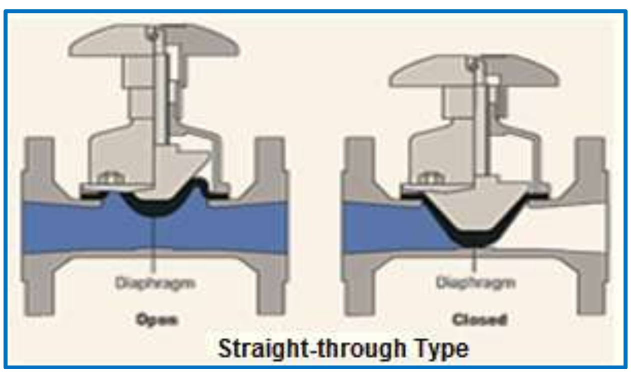


6.1. Types:

a. Weir Diaphragm Valves: Are the best **throttling valve**, but has a limited range. Its throttling characteristics are essential because of the large shutoff area along the seat, available to control small flows.

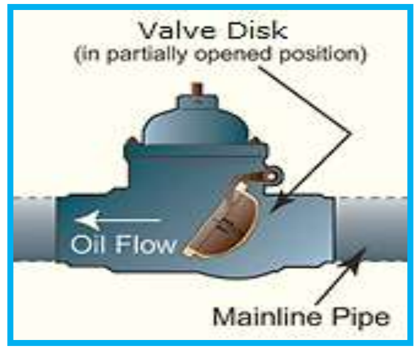


b. Straight-through Diaphragm Valves: The bore runs laterally through the body and a wedge shaped diaphragm is used to make the closure.



6.2. Diaphragm Construction:

Some elastomeric diaphragm materials may be unique in resistance to certain chemicals at high temperatures. However, the mechanical properties of any **elastomeric material will be lowered at the higher temperature** with possible destruction of the diaphragm at high pressure. All elastomeric materials **operate best below 150°F**. Flexible materials are available in Buna-N, Neoprene, Nordel, Hypalon, Viton, Tyon, Urethane, Butyl, Silicone or other available materials. Viton is subject to **lowered tensile strength** just as any other elastomeric material would be at elevated temperatures.

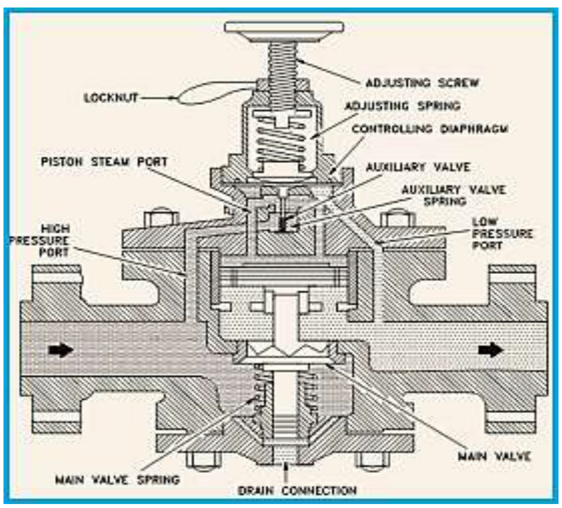


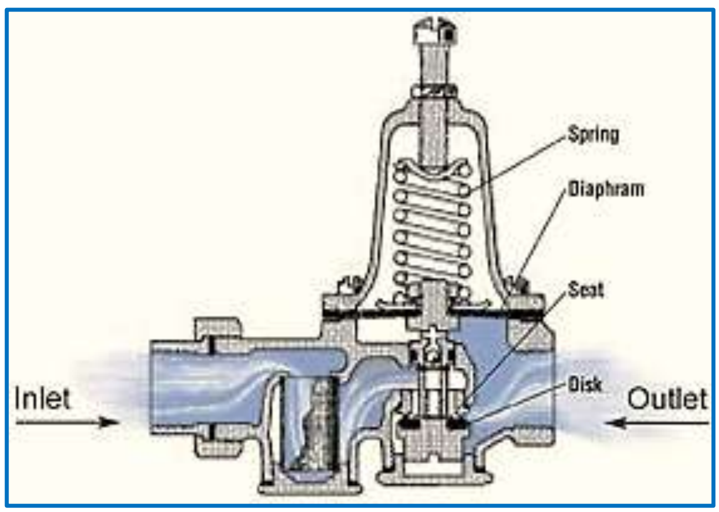
There are no packing glands to maintain and no possibility of stem leakage. There is a **wide choice** of available **diaphragm materials**. Diaphragm life depends upon the nature of the material handled, temperature, pressure, and frequency of operation.

7. Pressure Reducing Valves:

Pressure Reducing Valves, as the designation identifies, automatically reduce pressure to a preselected point since the supply is as high as the selected pressure. The main service of a Reducing Valve is to **control high pressure** at the valve inlet adjusting the screw on top of the valve assembly. The pressure entering assists the main valve spring in keeping the port closed, by pushing upward the main valve disk. There is also an auxiliary valve that controls the admission of high pressure to the piston on top of the main valve. The piston has a larger surface area than the main disk, resulting in a net downward force to open the Reducing Valve.

The auxiliary valve is controlled by diaphragm located directly over the auxiliary valve. The principal parts of the reducing valve are the main valve; an upward-seating valve that has a piston on top of its valve stem, an upward-seating auxiliary (or controlling) valve, a controlling diaphragm, and an adjusting spring and screw. The other type is designated as Non-variable Reducing Valve and its design replaces the adjusting spring and screw with a pre-pressurized dome over the diaphragm.



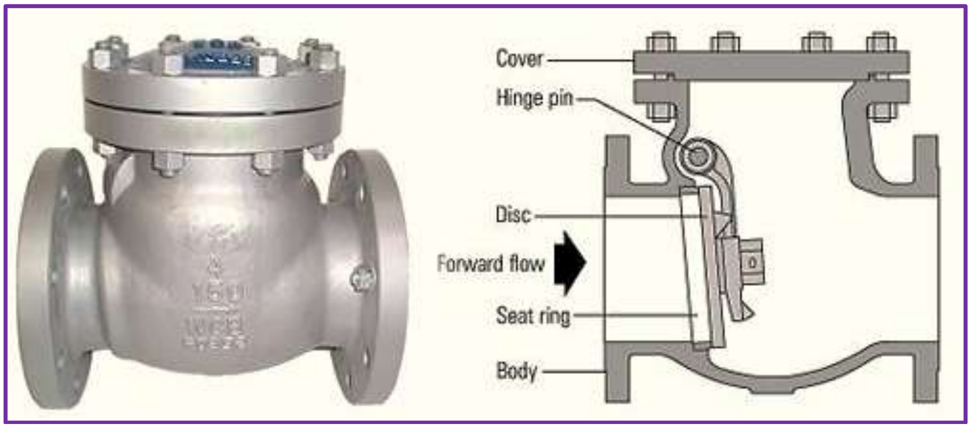


The valve stem is connected either directly or indirectly to the diaphragm. The valve spring below the diaphragm keeps the valve closed. As in the Reducing Valve the supply pressure is bled through an orifice to beneath the diaphragm to open the valve. Valve position is determined by the strength of the opposing forces of the downward force of the pre-pressurized dome versus the upward force of the outlet-reduced pressure.

8. Check Valves:

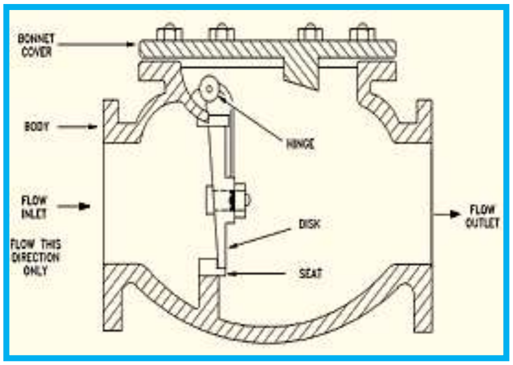
Check Valves are two-port valves, meaning they have two openings in the body, one for fluid to enter and the other for fluid to leave. These types **work automatically** and most are not controlled by a person or any external control and do not have any valve handle or stem. The bodies of most check valves are made of plastic or metal.

The check valves are **activated by the proper flowing material** in the pipeline. The pressure of the fluid passing through the system opens the valve, while any reversal of flow will close the valve. Closure is accomplished by the weight of the check mechanism, by back pressure, by a spring, or by a combination of these means. The most common types are **swing, tilting-disk, piston, butterfly, stop and ball valves**.



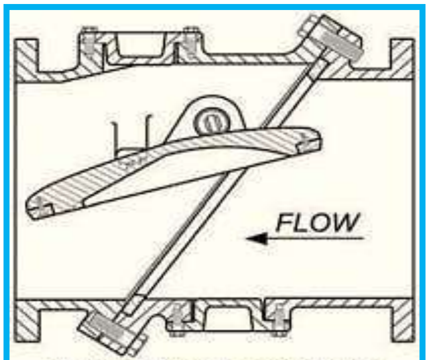
8.1. Types:

a. Swing Check Valves: The swing check valve, as shown below, is the most common, allows full, unobstructed flow and **automatically closes** as pressure decreases. These valves are fully closed when the flow reaches zero and prevent back flow. Turbulence and pressure drop within the valve are very low. This type is normally recommended for use in systems employing gate valves because of the low pressure drop across the valve. Swing Check valves are available in either **Y-Pattern or Straight Body** design.



Usually has replaceable seat rings. The seating surface is placed at a slight angle to permit easier opening at lower pressures, more positive sealing, and less shock when closing under higher pressures. In either style, the disk and hinge are suspended from the body by means of a hinge pin. Seating is either metal-to metal or metal seat to composition disk. Composition disks are usually recommended for services where dirt or other particles may be present in the fluid, where noise is objectionable, or where positive shutoff is required.

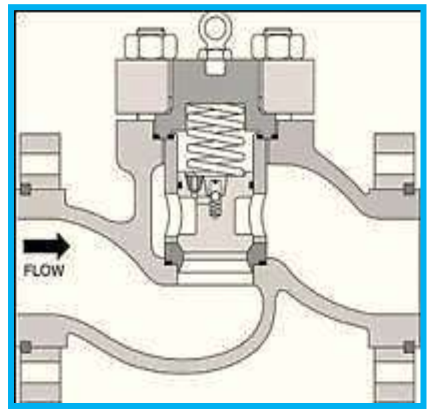
b. Tilting Disk Check Valves: The tilting disk check valve is similar to the swing check valve. The tilting disk type **keeps fluid resistance and turbulence low** because of its straight-through design. The disk lifts off of the seat to open the valve. The airfoil design of the disk allows it to "float" on the flow. Disk stops built into the body position the disk for optimum flow characteristics.



TILTED DISC CHECK VALVE

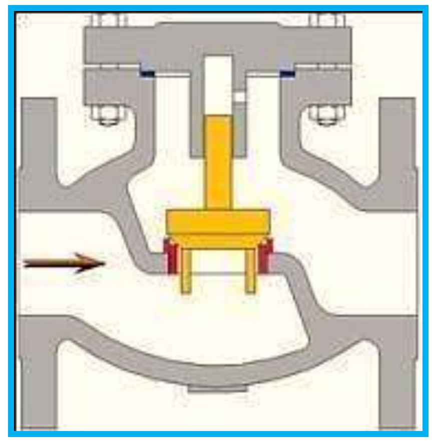
Backpressure against the disk moves it across the soft seal into the metal seat for tight shutoff without slamming. If the reverse flow pressure is insufficient to cause a tight seal, the valve may be fitted with an external lever and weight. These valves are available with a soft seal ring, metal seat seal, or a metal-to-metal seal. The latter is recommended for high temperature operation. The soft seal rings are replaceable, but the valve must be removed from the line to make the replacement.

c. Lift Check Valves: The lift check valve is commonly used in **piping systems** in which **globe valves** are being used **as a flow control valve**. They have similar seating arrangements as globe valves. These valves are suitable for installation in **horizontal or vertical lines with upward flow**. They are recommended for use with steam, air, gas, water, and on vapor lines with high flow velocities. These types are available in three body patterns: horizontal, angle, and vertical. The fluid flow must always enter below the seat.



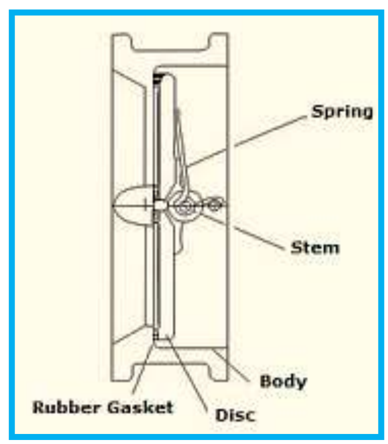
As the flow enters, the disk is raised within guides from the seat by the pressure of the upward flow. When the flow stops or reverses, the disk or ball is forced onto the seat of the valve by both the backflow and gravity. Some types may be installed horizontally. In this design, the disk is suspended by a system of guide ribs. This type of design is generally employed in plastic check valves. The seats of metallic body can be either integral with the body or contain renewable seat rings. The disk construction is similar to the disk of globe valves with either metal or composition disks.

d. Piston Check Valves: A Piston Check valve is essentially a Lift Check valve. It has a seat system consisting of a **piston and cylinder** that provides a cushioning effect during operation. The flow characteristics through a Piston Check valve are **essentially the same** as through the Lift Check valve. When the flow ceases or is reversed the piston closes slowly preventing pressure surges.



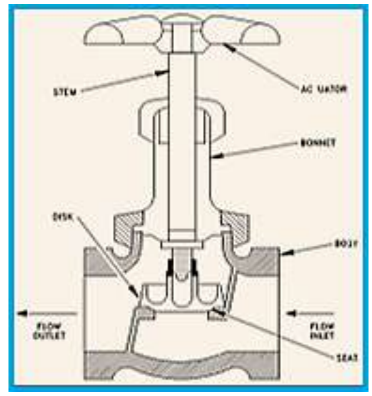
The **non-slam design is also effective** in dampening pulsating flow. Valves of this type are used on water, steam, and air systems. The installation and construction of the seats and disks are the same as for Lift Check valves used primarily in conjunction with globe and angle valves in piping systems, with frequent changes in flow direction.

e. Butterfly Check Valves: Butterfly check valves have an **arrangement similar** to butterfly valves and the **flow** characteristics are the **same**. Because of the relatively quiet operation, this type generally finds application in **heating, ventilation, and air conditioning** systems. Simplicity of design permits construction in large diameters, up to 72 inches. The wafer flange clamped.



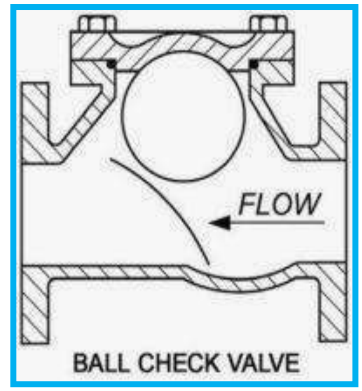
Butterfly check valves have **excellent retaining performance**, reliability and low flow resistance. It is also suitable for systems in the industries of petrochemical, food processing, medicine, textile and paper-making. These valves may be installed horizontally or vertically with the vertical flow either upward or downward. Flexible **sealing materials** are available in Buna-N, Neoprene, Nordel, Hypalon, Viton, Tyon, Urethane, Butyl, Silicone and TFE as standard, or other available materials when needed.

f. Stop Check Valves: The stop check valve looks very much like a lift check valve; however, the valve stem is very long. When it is screwed all the way down it holds the disk firmly against the seat, thus preventing any flow of fluid. A stop check valve is a **combination of a lift check valve and a globe valve**. It has a stem which, when closed, prevents the disk from coming off the seat and provides a tight seal (similar to a globe valve). When the stem is operated to the open position, the valve operates as a lift check valve.



During operation of a **stop check valve**, the stem is not connected to the disk to close the valve tightly in order to limit the travel of the valve disk in the open direction. The maximum lift of the disk is controlled by the position of the stem limiting the amount of fluid passing through the valve. These valves are widely used throughout process plants, in many drain lines and on the discharge side of pumps.

g. Ball Check Valves: The ball check valve is one of the few types of ball valves, which **works well in both water and wastewater applications**. Ball check valves are simple and commonly used on small pumps and in low head systems. A precision ball makes the most accurate and least expensive valve poppet available. Ideal for slurry applications or low flow rates.

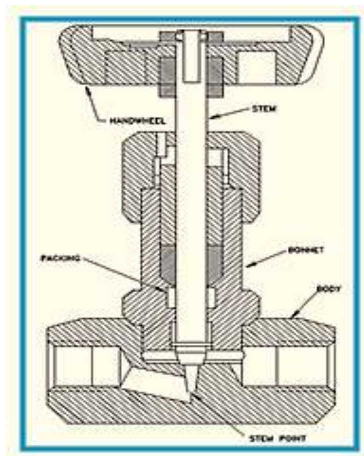


If the flow reverses, the gravity pulls the ball back into its seat, preventing backward flow through the valve. However, design care and process application should be taken. Ball Check valves have the **high tendency to slam**, due to the inertia stroke and when encounter high dynamic pressure, severe **seat slamming** may result.

The standard bearing ball materials are typically hard and wear resistant. In addition there are **standard precision balls available** in a number of corrosive resistant metals and several **plastics for special applications** or radioactive situations.

9. Needle Valves:

A needle valve, as shown below, **is used to regulate** and in consequence **create fine adjustments** in the amount of **fluid flow**. The distinguishing characteristic of a needle valve is the long, tapered, needlelike point on the end of the valve stem. This "needle" acts as a disk. Needle valves are often used as component parts of other, more complicated valves. For example, they are used in **some types of reducing valves**.



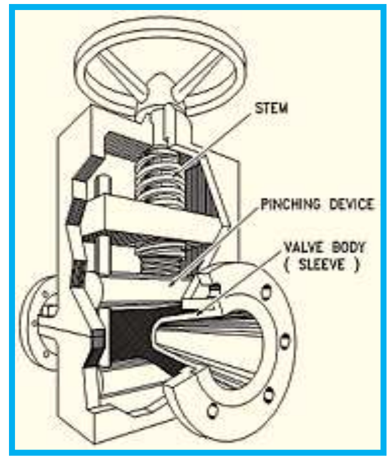
Pressure pump controls may have Needle Valves to minimize the effects of fluctuations in pump discharge pressure. Needle valves are also used in some components of **automatic combustion control** systems where very precise flow regulation is necessary. One type of body design for a Needle Valve is the machined bar stock body, common as globe types, using a ball swiveling in the stem top to provide the necessary manual rotation for seating the “needle” without damage.

Needle valves are frequently used as **metering valves** for extremely **fine flow control**. A typical metering valve has a stem with 40 threads per inch. Needle valves generally use one of two styles of stem packing: an O-ring with TFE backing rings or a TFE packing cylinder and are often equipped with replaceable seats for ease of maintenance.

10. Bar Stock Pinch Valves:

The relatively **inexpensive** pinch valve is the simplest in any valve design. It is the industrial version of the pinch cock used in the **laboratory to control** the flow of fluids through rubber tubing. Pinch valves, are suitable for **on-off and throttling services**. However, the effective throttling range is usually between 10% and 95% of the rated flow capacity. Pinch valves are ideally suited for the **handling of slurries**, **liquids with large amounts of suspended solids**, and systems that convey solids pneumatically.

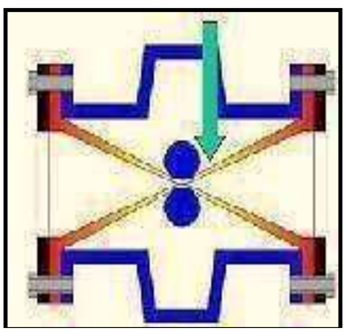
One type of body design for a pinch valve is the machined bar stock body, or manufactured of natural and synthetic rubbers and plastics which have good abrasion resistance properties. The pinch control valve consists of a **sleeve molded of rubber or other synthetic material and a pinching mechanism**. The sleeves are commonly available with extended hubs and clamps designed to slip over a pipe end, or with a flanged end having standard dimensions.



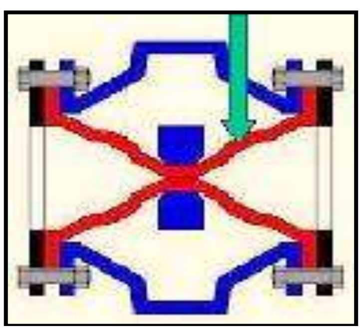
11. RF Pinch Valves:

The RF pinch valves use advanced technology **elastomer tubes** to **minimize abrasion and corrosion** with the highest standards for materials of construction and provide the longest sleeve life. Used for different applications such as, **slurries, viscous and corrosive** substances, suspended solids and other hard to handle medium, with rugged design and the best material available.

RF pinch valves meet the most rigorous service conditions, make it easy to maintain and minimize time for maintenance, allowing working pressure up to **600 psi** (40 bar) in the smaller sizes. Standard **face-to-face** dimensions are accepted by all engineering/design companies, lower cost in sle-eve replacement, zero leakage shut-off guaranteed not to seize or jam. The sketches below show how conventional **RF Pinch Valve works**:



It can be seen that 95% of sleeve wear occurs during the last 10% of closure when stress velocity and abrasion are the highest.



Elastomer tube folds prevent stretching and are the key to longer life.

Note: In 2008 ANSI (American National Standards Institute) and ISA (Instrument Society of America) published a new standard called ANSI/ISA 75.10.02 for RF Pinch Valves. This new control valve standard replaces the old standard ISA 75.08-1999 which has now ceased to exist.

12. Relief and Safety Valves:

These types of valves prevent equipment damage by relieving excess pressure in a fluid system. **Pressure relief valves** (PRV´s) are valves used to control or limit the pressure in a system. **Safety valves** are designed to open and relieve excess pressure from vessels or equipment. The main difference between a Relief valve and a Safety valve is the extent of opening at the **setpoint** pressure.

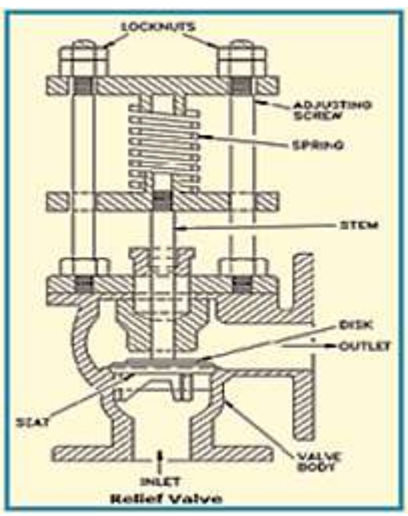
- **Relief Valves**: Open **gradually**, as the inlet pressure increases above the setpoint, and opens only the necessary to relieve the over-pressure condition.

- **Safety Valves**: Open **immediately**, as the pressure setting is reached, and stays fully open until the pressure drops below a reset point. Important to notice that the reset pressure, normally, is lower than the actuating pressure setpoint.

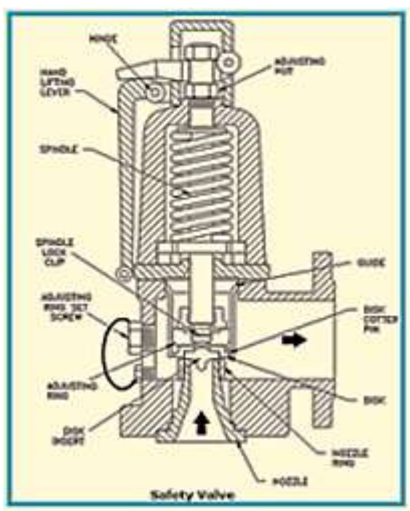
- **Pilot-Operated Valves**: Are designed to **maintain the pressure,** through a small passage at the top of a piston connected to the stem, the way that the system pressure closes the main relief valve. The Pilot-Operated valves **are typically solenoid-operated**, with the energizing signal originating from pressure measuring systems. When the **small pilot valve opens, pressure is relieved**; the system pressure opens the main relief valve.

The main difference between an actuating **pressure setpoint** and the pressure of resetting is called **blowdown**, expressed as a percentage of the actuating pressure setpoint. Determined by spring compression the system pressure overcomes spring pressure and the Safety or Relief Valve opens. The **pressure setpoint** is adjusted by turning the **adjusting nuts** on top of the yoke to increase or decrease the spring compression.

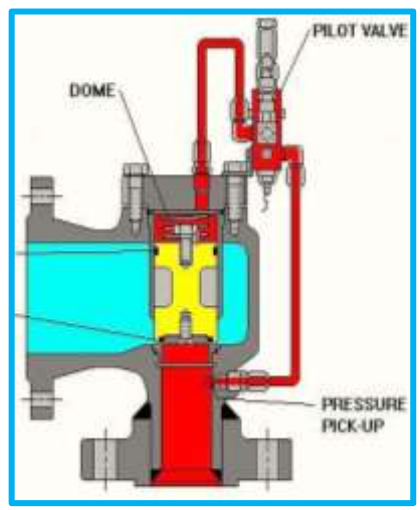
Obs.: Relief Valves are typically used for **incompressible fluids** such as water or oil. **Safety Valves** are typically used for **compressible fluids** such as steam or other gases and can often be distinguished by the presence of an external lever at the top of the valve body, which is used as an operational check.



Relief Valve



Safety Valve



Pilot-Operated Valve

13. Solenoid Valves:

A **solenoid** is a **coil wound** into a tightly packed helix. The term solenoid refers specifically to a **magnet** designed to produce a uniform magnetic field in a volume of space. The term solenoid may also refer to a variety of transducer devices that convert energy into linear motion. The solenoid is an integrated device which actuates either a **pneumatic or hydraulic valve**, which is a specific type of relay that internally uses an electromechanical coil wound to operate an electrical switch; for example, an automobile starter solenoid, or a linear process solenoid.

Solenoid valves are the most frequent devices **used for control in fluid flow**, to shut off, release, dose, distribute or mix fluids. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design. The **valve is controlled** by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. **Multiple** solenoid valves can be placed together on a manifold. A solenoid valve has two main parts: the solenoid and the valve. The solenoid **converts electrical energy into mechanical energy** which, in turn, opens or closes the valve mechanically.

13.1. Types:

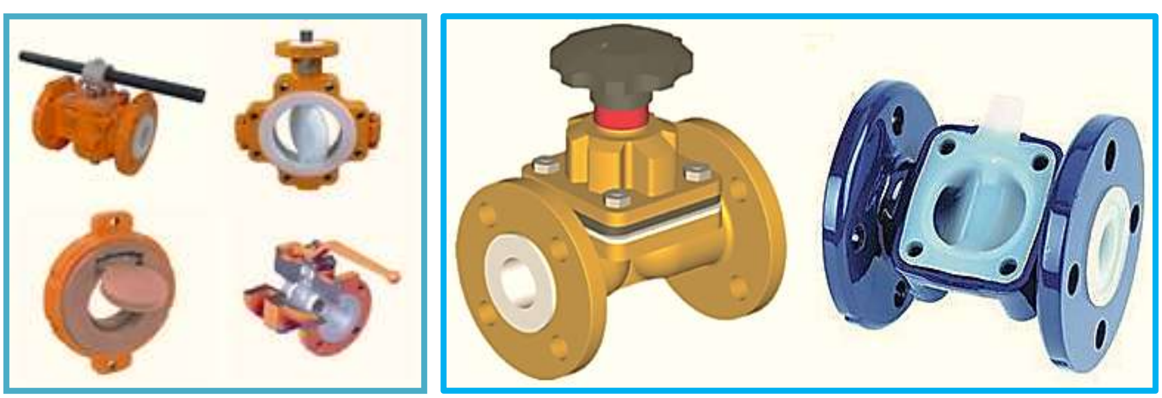
a. Rotary Solenoid Valves: The **rotary solenoid** is an electromechanical device used to **rotate a ratcheting mechanism** when power is applied. These were used in the 1950s for rotary snap-switch automation in electromechanical controls.

b. Pneumatic Solenoid Valves: A **pneumatic solenoid** valve is a switch for **routing air to any pneumatic device**, usually an actuator, allowing a relatively small signal to control a large device. It is also the interface between electronic controllers and pneumatic systems.

c. Hydraulic Solenoid Valves: Hydraulic solenoid valves are in general **similar to pneumatic** solenoid valves except that they control the flow of hydraulic fluid, often at **around 3000 psi**. Generally metal-to-metal seating surfaces or soft-seating with **PTFE** or other composition materials to seal designs are used.

14. Plastic Lined Valves:

Plastic lined valves were **developed to handle a wide variety of corrosives**, at temperatures from -20°F to 350°F (-28°C to 149°C). That includes acids, caustics, oxidants, reducing agents, waste fluids, salt solutions, slurries and many other fluids, particularly when sudden **leakage or spillage of dangerous** or toxic fluids can cause **environmental damage** or injure operating personnel.



Lined valves **use fluorocarbons** such as **PTFE** or Teflon (Polytetra-fluoroethylene), **PFA** (Perfluoroalkoxy), **FEP** (Fluorinated Ethylene Propylene), **PVDF** (Polyvinylidene Fluoride) and **UHMW** (Ultra High Molecular Weight) and many other upon customer request. Application for highly engineered fluid handling products including: sleeved plug valves, lined valves, high performance butterfly valves, aseptic and industrial diaphragm valves, actuation, lined pipe, fittings and hoses, air operated diaphragm and peristaltic pumps.

15. Knife Valves:

There are many types of Knife Valves **for common and special applications** also available for automatic process. Fabricated construction allows to use carbon steel, stainless steel, Hastelloy, titanium or other costly alloys for the interior of the valve.

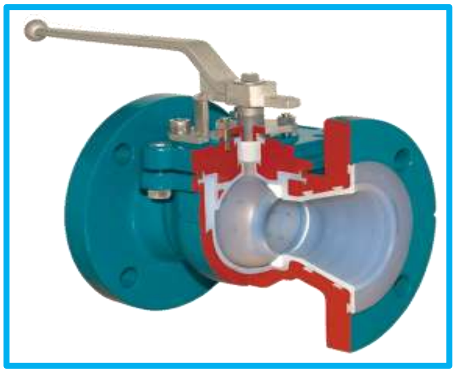
16. RF Slurry Knife Gate Valves:

Generally the Heavy Slurry Knife Gate valves are formed by **two heavy duty elastomer sleeves**, one on either side of the gate integrally molded with a stiffener ring, not only to maintain the shape of the sleeve, but also **acts as scraper,** while the **gate is being opened**. These sleeves shall be compressed between the piping flanges once installed.

Application for **bi-directional flow and shut-off**, **with zero downstream leakage**, pressure rating 150 psi (10 bar), no metal parts in contact with the flowing media when the valve is in the fully open position, no seat cavity for solids preventing full gate closure.

17. Ceramic Lined Valves:

The Ceramic Lined Valve (CLV) is a recent innovation **designed specifically for mining application as slurry and suspended solids**, eliminating short wear life and leakage problems. Valve inlets are commonly lined with 1/2"-thick **high abrasion-resistant ceramic sleeves** for longest wear resistance and maximum durability.



18. Rubber Lined Valves:

Commonly applied for slurry and suspended solids, used on **severe abrasion-resistant** fluid applications. It has a vulcanized rubber, which incorporates a liner **chemically bonded** to the valve body, giving a higher **pressure of up to 20 bar** and up to 8 meters per second (dependent on valve size).

- **Natural Rubber**: Natural Rubber Polyisoprene/ISBR (-20 to 70°C);
- **White Natural Rubber**: Natural Rubber Polyisoprene/SBR - (-10 to 80°C);
- **EPDM**: Ethylene Propylene Diene WPM - (-30 to 130°C);
- **Nitrile**: Butadiene Acrylonitrile – (-10 80°C);
- **Neoprene**: Polychloroprene – (-25 to 95°C);
- **Hypalon**: Chlorosuphonated polyethylene – (-15 to 90°C);
- **Viton**: Vinyl-idenefluoride-hexafluoro propyleneco-polymer – (-5 to 150°C).

19. Refractory Lined Valves:

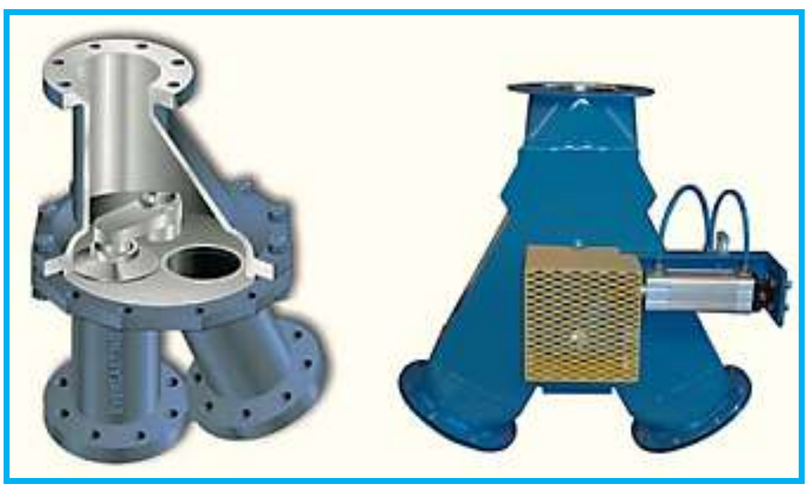
These valves are **lined with a heat-resistant refractory material as FCCU** (Fluid Catalytic Cracking Units), generally for high temperatures **up to 1200°C**.

20. Diverter Valves:

The **2-Way or 3-Way** Diverter Valves is **designed for use in gravity flow applications** where material can be **diverted from one source to other destinations**. Commonly applied for Powder, Pellets and Granular transport for Plastics, Chemicals, Foods, Mining and Textiles. The Diverter Valve, as shown below, is commonly designed with removable access doors for replacement of blade and shaft seals. All internal ledges are eliminated to promote cleanliness.

21. Control Diverter Valves:

Are pneumatic Control Diverter Valves derived from simple 2 and 3-way valves that can be equipped with single cylinders for **two-way or 3-way positions**, commonly used to converge two or more transport material systems. These valves are generally fabricated in carbon steel with stainless diverter blades, including full width access doors for blades replacement. These Control Diverter Valves can also be **equipped with IP-65 limit switches** for opening/closing positions confirmation, for flows from 50 TPH to 800 TPH.

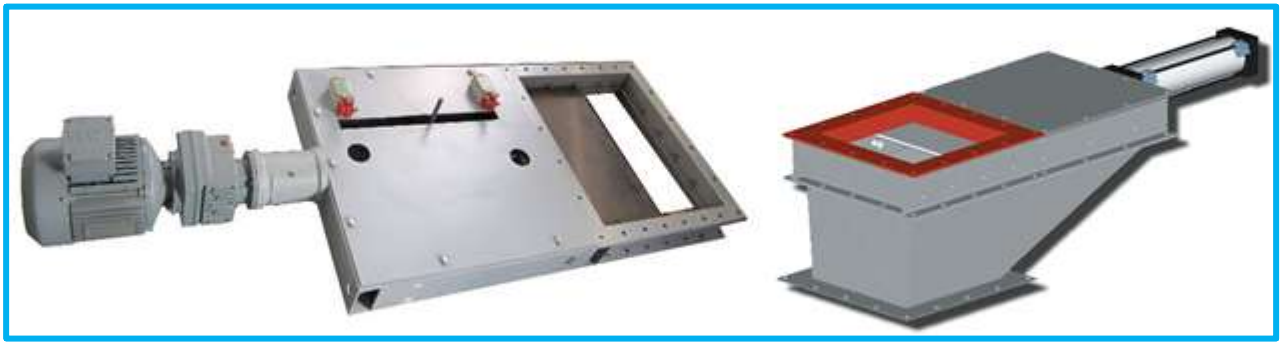


22. Iris Valves:

The **patented Iris valves** were designed specifically to **handle dry bulk solids in gravity discharge** of free-flowing material **from bins, bulk bags, chutes, and hoppers**, commonly fabricated in stainless steel with control rings and metal trigger locks.

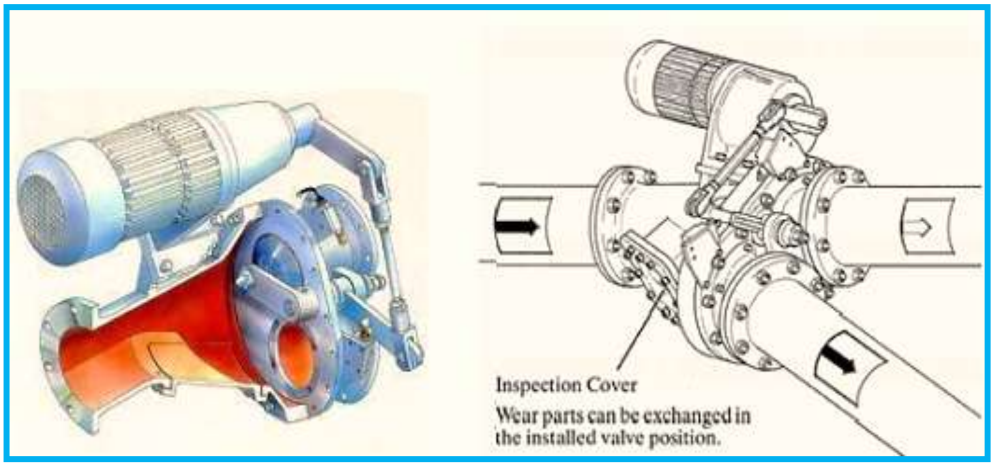
23. Gate Sliding Valves:

The Gate Sliding Valves are generally **used in vacuum applications** where material needs to be **converged from** one or **two sources** to an **unique destination**. Easy "in-line" installation, 2" to 8" sizes, **may be pneumatically operated.** The fabrication includes cylinder, 5/2-way-solenoid-valve with auxiliary hand operation and two proximity switches. Slide plate runs on ball bearings in a U-frame, **and closes** when the **electric supply** is cut. **Application**: Shutting off of **bulk transported materials** without over-pressure.



24. Pneumatic Transport 2-Way Valves:

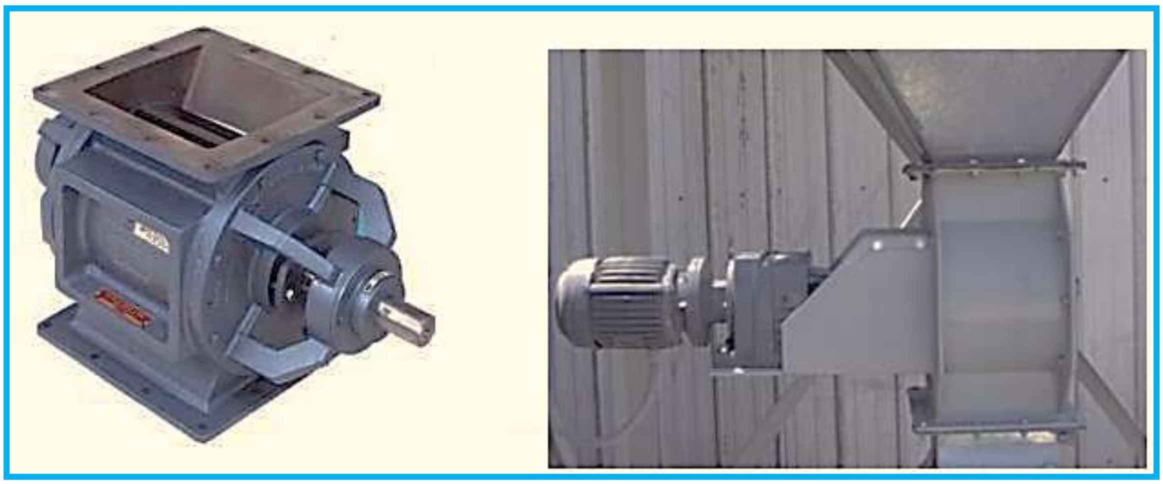
These 2-Way Valves are used for changing the direction of **flow in pneumatic conveying lines** and systems for transporting **powdery bulk materials** as cement, raw meal, lime, fly ash and so on. The principle **is simple and similar to described above**.



In these valves, one of the discharge spouts is always closed by a disc while the other one is opened for the selected way. The valve disc is **spring loaded** but can also be **switched manually** or by a **pneumatic piston** or an **electric motor actuator**. Remotely controlled valves can be also equipped with **limit switches** or proximity switch types. Application includes the Chemical, Mining, Oil Sands, Pulp & Paper, Water Treatment, Pollution Control, Food & Beverage, Process and General Industries.

25. Rotary Valves:

Rotary Valves or Rotary Airlock Valves are used in a wide range of transport material applications. The material **enters from the top and exits from the bottom flange** of the Rotary Valve. Rotary Airlock is also known as Rotary Valve, Rotary Feeder or Airlock Feeder. Rotary Airlocks are important components for **pneumatic conveying, bulk solids handling and batching** systems. The main function of a Rotary Airlock is **to control flow of bulk solids from silo, mixer, cyclone or hopper under gravity**. Airlocks can work on pressure and vacuum applications.

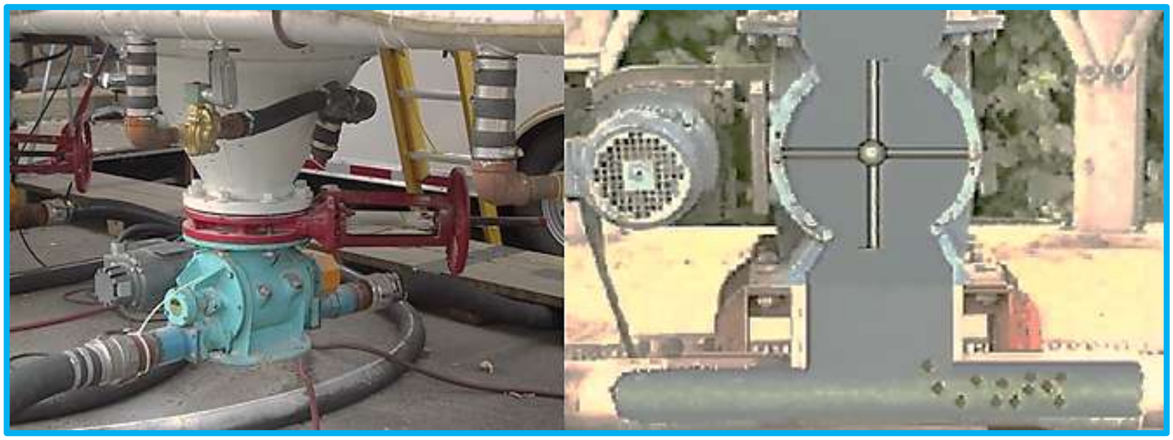


26. Special Rotary Valves:

The **MSRT** (tapered bore rotary valves types) are designed for use under gravity, pressure and vacuum conditions, suitable **for metering a wide range** of dry solids, granular, pelleted and powdered type materials from the outlets of silos, hopper, cyclones, mixers, weighers, etc. The **MSRP** (parallel bore rotary valves types) are designed so that the maximum number of blades remain in contact with body, without affecting throughput **with a minimum clearance at rotor tips and body side**. Substantial throat opening at valve entry, allows high filling efficiency.

27. Dilute Phase Rotary Valves:

Dilute Phase Rotary Valves are used to **airlock and metering of bulk materials both powder and pellets**, into a low velocity or dense phase high pressure convey line. The equipment are used to **control the high pressure air or gas loss** between two different pressure zones in a **dense phase conveyor** while allowing dry solids material to pass from one pressure zone to the other.



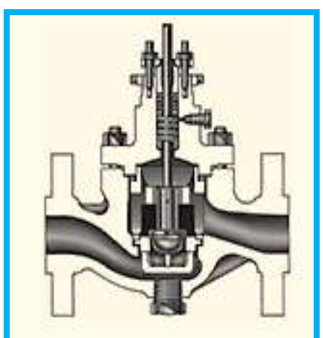
The dilute transport phase is carried in systems in which the **solids are fed into the air stream**. Solids **are fed from a hopper** at a controlled rate **through a Rotary Airlock Valve**. The system may be positive or negative pressure or employ a combination of both. **Positive pressure** systems are usually limited to a maximum pressure of **1 bar gauge. Negative pressure** systems to a **vacuum** of about **0.4 bar,** and blowers and exhausters are used.

IV – OIL & GAS AND REFINERY CONTROL VALVES:

Control valves **regulate the rate of fluid flow** as the position of the valve plug or disk is changed by force from the actuator. To do this, the valve must; contain the fluid without external leakage; have adequate capacity for the service; withstand the erosive, corrosive, and temperature influences of the process; incorporate end connections to actuator attachments; permit transmission of actuator thrust to the valve plug stem or rotary shaft. The following summary describes some special control valves:

1. Single-Ported Globe Valves:

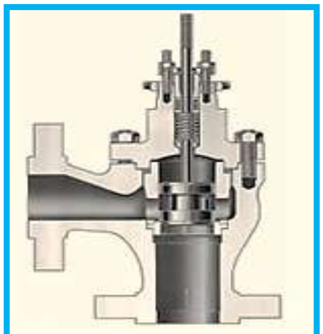
Single port is the most common valve body style. Single-port valves are available in various forms, such as **globe, angle, bar stock, forged, and split constructions** and can handle most service requirements and often can be used in 4-inch to 8-inch sizes with high-thrust actuators, specified for applications with **stringent shut-off** requirements.



Single-Ported Globe-Style Valve

2. Single-Ported Angle Valves:

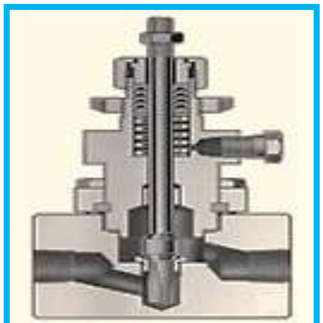
Angle valves are nearly **always single-ported**, commonly used in **boiler feedwater, heater drain service** and piping schemes where these types can also serve as elbows. The valve shown, has cage-style construction or may have screwed-in seat rings, expanded outlet connections, restricted trim, and outlet liners for reduction of erosion damage.



Single-Ported Angle Valve

3. Bar Stock Valves:

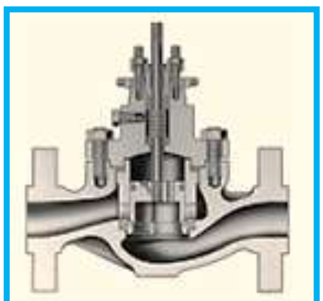
Bar-Stock Valves are often specified for **corrosive applications** in chemical industries from any metallic bar-stock material and some plastics. When exotic metal alloys are required for **corrosion resistance**, a bar-stock body is normally **less expensive** than a valve body produced from a casting.



Bar Stock Valve

4. Balanced-Plug Cage-Style Valves:

The Balanced-Plug Valve style, also **single-ported**, provides the advantages of a balanced valve plug often associated only with double-ported valve bodies. Generally only one seat ring is used.

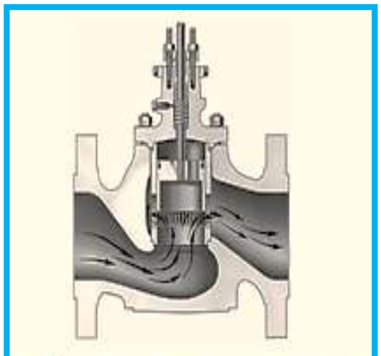


Balanced-Plug Cage-Style Valve

The cage-style trim provides a valve plug guiding, seat ring retention, sliding piston ring-type seal between the upper parts of the valve plug. The wall of the cage cylinder type **can virtually eliminate leakage** of the upstream high pressure fluid into the lower pressure downstream system.

5. High Capacity Cage-Suppress Noise Valves:

The High Capacity Cage-Guided valve was designed to **suppress noise applications such as high pressure gas reducing** stations where sonic gas velocities are often encountered at the outlet of conventional valves. The design incorporates oversize end connections with a streamlined flow path and the ease of trim maintenance inherent with cage-style constructions. Use of **noise abatement trim** reduces overall noise levels by as much as **35 decibels**.



High Capacity Cage-Suppress Valve

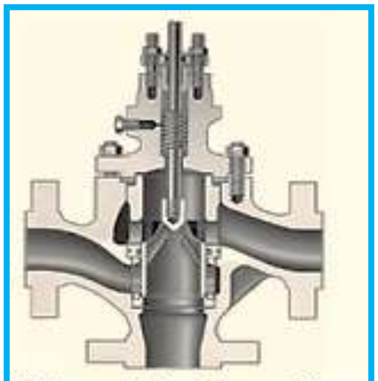
6. Double-Ported Globe Valves:

Double-Port Globe guided valve plugs are often used for **on-off** or **low-pressure throttling service**. Top-and-bottom-guided valve plugs furnish stable operation for severe service conditions. Reduced **dynamic forces** acting on plug, permit choosing a smaller actuator than would be necessary for a single-ported valve body with similar capacity.

Double-Ported Globe Valve

7. Balanced Plug Three-Way Valves:

Balanced Plug Three-Way valves, are manufactured with cylindrical valve plug in the **down position** to **open the bottom common port** to the right-hand port and shuts off the left-hand port. The application is for use with **three pipeline connections** providing general **converging (flow-mixing) or diverging (flow-splitting)** service. Actuator selection demands careful consideration, particularly for constructions with unbalanced valve plug.



Balanced Plug Three-Way Valve

8. High-Performance Butterfly Valves:

These valves require **high-output or large actuators** if the valve is big and **the pressure drop is high**, so, operating torques may be quite large, used for throttling service or for **on-off control**. The control range for this style of valve is approximately one third as large as a ball or globe style valves. Commonly offer effective throttling control and provide linear flow characteristic through **90°** of disk rotation. Standard pneumatic diaphragm or piston rotary actuators are used.

High-Performance Butterfly Valve

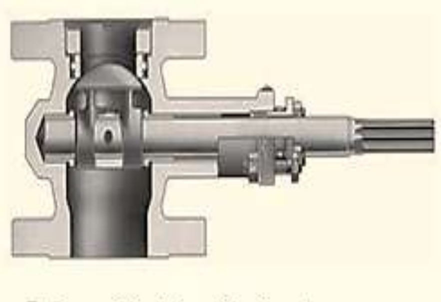
9. Eccentric-Disk Control Valves:

Eccentric Disk rotary shaft control valves are intended for **general service applications** not requiring **precision throttling control,** frequently applied in applications requiring **large sizes** and **high temperatures**.

Eccentric-Plug Control Valve

10. Eccentric-Plug Control Valves:

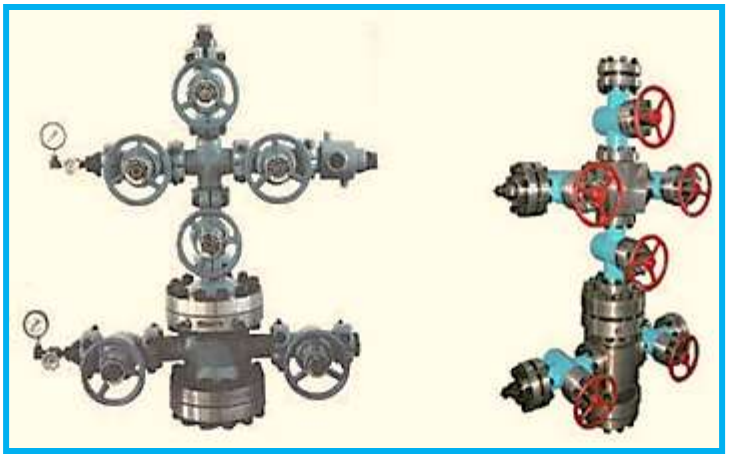
These valves are applied for **erosive, coking and other hard-to-handle fluids**, providing either **throttling or on-off operation** for dependable service in slurry applications. Mining, petroleum refining, power, and pulp and paper industries use these valves. The rugged body and trim design handle **temperatures** up to **800 °F (427 °C)** and **shut-off** at **1500 psi (103 bar)**. Seat ring and rugged plug allow forward or reverse flow with **tight shutoff** in either direction, including ceramics, for selection of erosion resistance.


Eccentric-Plug Control Valve

11. Christmas Tree Valves:

Christmas trees are special valves used on both **surface and subsea wells,** also identified as **"subsea tree**" or **"surface tree"**. The primary **function of a tree is to control the flow**, **usually oil or gas**. Christmas Trees may also be used to **control the injection of gas or water** into a non-producing well in order to enhance production rates of oil from other wells. When the well and facilities are ready **to produce and receive oil or gas**, tree valves are opened and the formation fluids are allowed to go through a flow line.

The oil & gas flow are led to processing **facilities** storages on the surface of the sea and afterwards a pipeline transports to a refinery or distribution center (gas). Flow lines in subsea wells usually lead to a **fixed or floating production platform,** to a **storage ship** or barge, known as a Floating Storage Offloading **(FSO)**, Floating Processing Unit **(FPU)**, or Floating Production and Offloading **(FPSO)**.



The wellheads and Christmas Trees are under the quality standards of **API Specification 6A**. Wide pressure range for **application from 2,000 psi up to 20,000 psi** and their specification levels is PSL3, high-pressure bearing, no spillage and reliable quality, especially the anticorrosion to H2S CO2. The Offshore Wellhead is made of high strength and anti-corrosion materials. The maximum working pressure depends on the connection methods of the product.

12. Blowout Preventers Valves (Bops):

Blowout Preventers valves (BOPs) **are safety devices** used to "prevent" the uncontrolled **flow of liquids and gases during well drilling** operations that are capable of being **remotely** controlled. When the driller closes the valve, a pressure-tight seal is formed at the top of the well, preventing the fluids from escaping. The two major types are Annular (also known as Spherical) and RAM.

13. Mission Drill Pipe Float Valves:

These drill pipe float valves **provide blowout protection at the bottom of the drill string**, to prevent flowback and bit plugging, keeping cuttings out of the drill pipe while making connections.

14. Plug Valves:

Flanged Plug Valves are used for portable **Flowline Oil Drilling Equipment** can be supplied according to API 6A specification, suitable for Temperature Classification **P** through to **U** as standard or **K, L or X**, to client order. The Plug Valve is also available with hammer pressure ratings, and hydraulically balanced for the Oil & Gas application.

15. Reset Relief Valves:

Reset Relief Valves also known as NOV valves, Shear Relief Valves or Float Valves are **the top** of the line, used to protect the **oil well drilling** equipment. Patented Reset Relief Valves were designed to protect pumps from high pressure spikes and automatically snaps to a full open position when the **set pressure** is reached. Commonly is equipped with a position release button that indicates, at a glance, whether the valve is open or closed. It is easy to adjust set pressure and reset, and allows pressure limitations to be increased while under pressure.

16. High Capacity Control Valves:

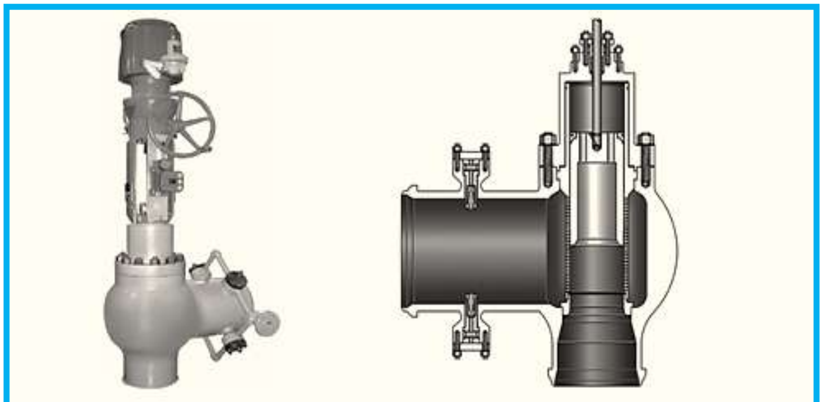
Generally, **globe valves** larger than 12-inches, **ball valves** over 24-inches and **butterfly valves** larger than 48-inches fall in the **special valves category**. As valve sizes increase arithmetically, static **pressure loads at shut-off** increases geometrically. Generally the maximum **allowable pressure drop** is reduced on **larger valves** to reduce fluid velocity, noise and actuator requirements within reasonable limits, as well, lowered working pressure ratings.

Large Flow Valve for Noise Atenuation Service

17. Steam Conditioning Valves:

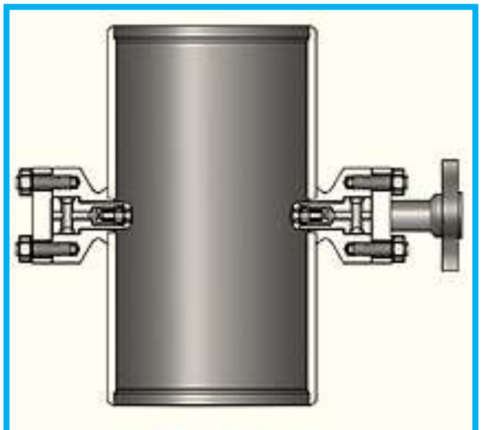
Steam conditioning valves are used for the simultaneous **reduction of steam pressure and temperature** to the level required for a given application. Frequently, these applications deal with high inlet pressures and temperatures and require significant reductions of both properties. Forged materials permit higher design stresses and improved grain structure, which also allows the manufacturer to provide up to Class 4500, and intermediate class ratings, with greater ease versus cast valve bodies.

The steam conditioning valve **incorporates a spray water manifold** downstream for its pressure reduction stage. The manifold features various geometries. The backpressure activates spray nozzles that maximize mixing and quick vaporization of the spray water. The steam conditioning valve **injects the spray water towards the center of the pipeline** and away from the pipe wall. The number of injection points varies by application, arranged around the circumference of an outlet manifold for a more complete distribution of the spray water.


Steam Conditioning Valve Cross-Section of Steam Conditioning Valve

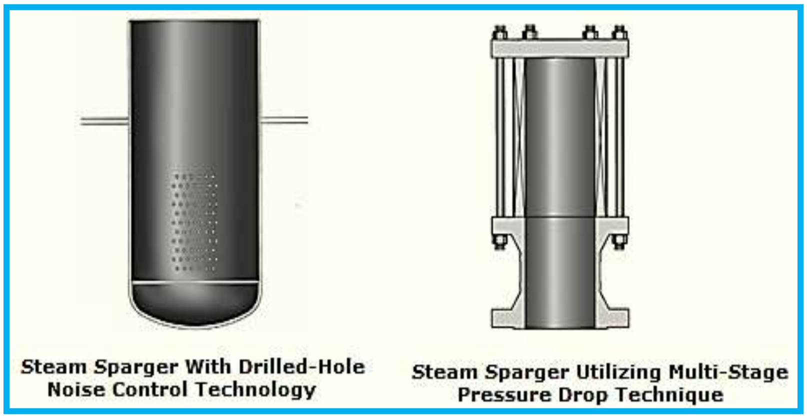
18. Steam Coolers:

Steam coolers are used when an application requires separation of the **pressure reduction** and **desuperheating** functions. Steam coolers are equipped with a **water supply manifold** to provide cooling water flowing to a number of individual spray nozzles installed in the pipe wall. The result is a fine spray injected radially into the high **turbulence** of the **axial steam** flow. The combination of large surface area contact of the water and high turbulence in the steam make for very efficient mixing and rapid vaporization.


Steam Cooler

19. Steam Spargers:

Steam spargers are **pressure-reducing** devices used to **safely discharge steam** into a condenser or turbine exhaust duct to provide backpressure to the **turbine bypass valve**, to limit steam velocity and allow reduced pipe size between the bypass valves. The spargers design and installation are both key elements when considering total noise of the processes.



V – SPECIAL DESIGN & SANITARY VALVES:

Sanitary valves are designed to meet the stringent demands of today's facilities, to ensure an efficient cleaning and sanitizing in sewer piping and processing environment.

1. Backflow Valves or Flood Shut-off Valves:

Sewer Backwater valves are designed to **block backflow of sewage** into the home. In certain situations, flooding can bring wastewater from sewer lines into houses through drain pipes, causing costly to repair and some serious health concerns. The option for avoiding backups is to **install shut-off valves** that prevent sewage and water from back flowing onto the property.

2. Sanitary Rotary Valves:

Sanitary rotary valves work as product feeders and have bearings only on one side like **monoblock pumps.** The side cover can be opened and rotor can be dismantled. This type of feeder is ideal for food and chemicals industries where frequent material change takes place, better washing performance is necessary and also needs high sealing performance.

3. Sewage Air Release Valves:

The Sewage Air Release Valve is applied in releasing **entrapped air and protecting the pipeline from damages** due to vacuum or surge while increasing pipeline flow.

4. Lightweight Air Release Valves:

The Lightweight Air Release Valve is specially developed for **wastewater** and the **irrigation** market.

VI – FIRE CONTROL VALVES:

There are several valve types for **firefighting application**. The most known types are: Right Angled, Bib Nose, Straight, Oblique, Turndown Flanged and Double Outlet. The manufacturers´ patterns fit to requirements and specifications of local governments and Fire Fighting Defense Services, extending to the requirements of Industries, Shopping Malls, Refinery, Steel, Fertilizer, Petrochemical, Power Generation and other Plants.

1. Fire Fighting Double Headed Hydrant Valves:

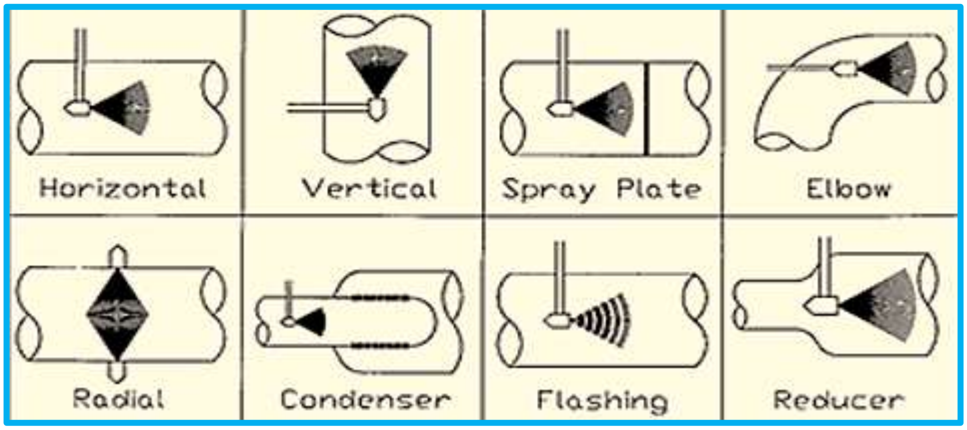
The firefighting double headed **hydrant valves are the most acknowledged product**. It has 2 delivery ends and a hand wheel to open/shut the water supply. The valve also has a flange, which is attached to branch of hydrant post that carries the water under pressure. The manufacturing range of hydrant valves can be **specially developed and customized** according to the user specifications.

2. Pressure Control Deluge Valves:

The Deluge Valve combines **deluge and pressure control** functions in the same valve. Pressure control is typically associated with a large system, where the fire pump is designed for capacity of several deluge systems. When only **one part** of the deluge system is operated, the delivery pressure to each system should be reduced to meet the components' pressure rating and to prevent flooding by use of excess flow. When **several deluge systems** operate simultaneously, the pressure control Deluge Valves **ensure balancing of the water pressure** and efficient use of the overall capacity.

VII - DESUPERHEATING:

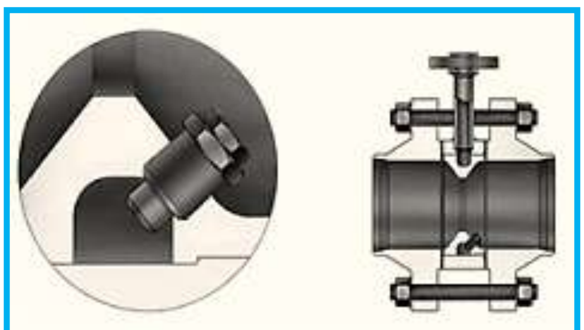
The method to reduce temperature is the **installation of a desuperheater**. Precise **temperature control** is needed to improve heating efficiency or to protect downstream product and/or equipment from heat related damage. A desuperheater injects a controlled, predetermined **amount of water into a steam flow to lower the temperature** of the steam. Desuperheaters must integrate with a wide variety of complex thermal and flow dynamic variables to be effective. Desuperheaters come in all shapes and sizes and use various energy transfer and mechanical techniques to achieve the desired performance within the limits of the system environment, as shown below:

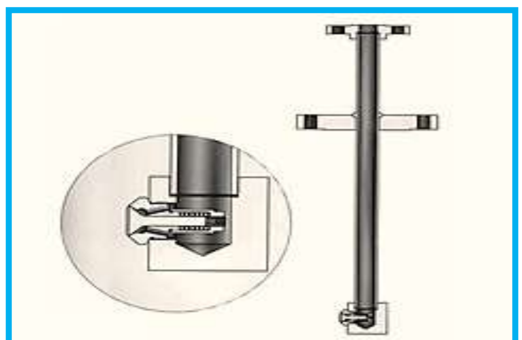


Typical Desuperheater Designs:

Reduced diameter **throat venturis** allow spraying of water to multiple points through drilled holes or small nozzles. The venturi **increases** steam velocities to approximately **10 ft/s** (3 m/s) under optimum conditions, to enhance atomization in steam flows. It handles applications over moderate loads change (up to 20:1) and can be installed in **pipelines** sizes of **1-inch through 24-inches**.

This design requires an external water control valve **to meter water flow** based on a **signal from** a temperature sensor in the downstream steam line. Standard installation is a **flanged branch connection tee** on an 8-inch or larger steam pipe line requiring an **external water control valve to meter water flow** based on a signal from a temperature sensor in the downstream steam line.


Geometry-Assisted Wafer Design

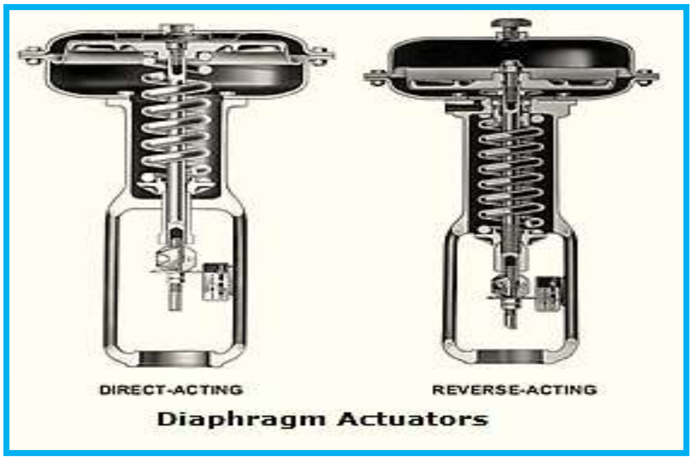

Variable Geometry Nozzle Design

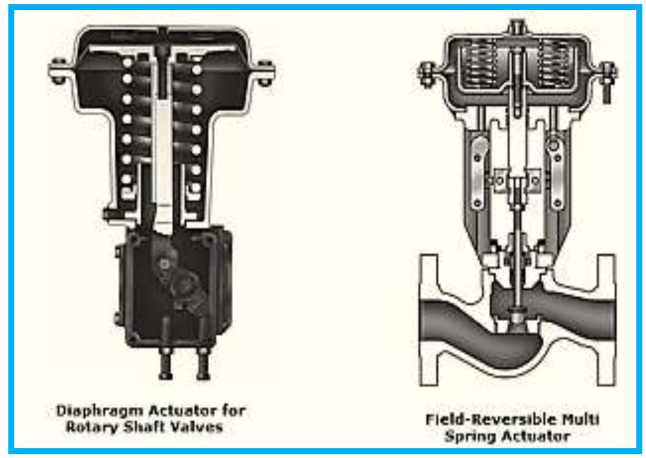
VIII - ACTUATORS:

Pneumatically operated control valve actuators are the most popular type in use, but **electric, hydraulic and manual actuators** are also widely used. The spring-and-diaphragm pneumatic actuator is most commonly specified due to its dependability and simplicity of design. **Electric and electro-hydraulic actuators** are more complex and more expensive than pneumatic actuators used where **air supply** source is not available or low ambient temperatures could freeze condensed water in pneumatic supply lines and when unusually large stem forces are needed.

1. Diaphragm Actuators:

Pneumatically operated diaphragm actuators use **air supply** from controller, positioner or any other source. Net output thrust is the difference between diaphragm force and opposing spring force. Diaphragm actuators are simple, dependable, and economical. All types may **either open or close the valve**, depending on orientation of the actuator lever on the valve shaft. **Diaphragm styles** include: direct acting (increasing air pressure pushes down diaphragm and extends actuator stem; reverse-acting (increasing air pressure pushes up diaphragm and retracts actuator stem; reversible (actuators that can be assembled for either direct or reverse action; direct-acting unit for rotary valves (increasing air pressure pushes down on diaphragm).





2. Piston Actuators:

Piston actuators are **pneumatically operated** using high-pressure plant air to 150 psig, often eliminating the need for supply pressure regulator. Applications supply; piston actuators furnish maximum thrust output and fast stroking speeds; piston actuators are double acting to give maximum force in both directions; spring return to provide fail-open or fail-closed operation.

3. Electrohydraulic Actuators:

Electrohydraulic actuators are ideal for **isolated locations** where pneumatic **supply pressure is not available** but where precise control of valve plug position is needed. Require only electrical power to the motor and an electrical input signal from the controller. Electrohydraulic actuators units are **normally reversible** for minor adjustments and might be self-contained, including **motor, pump, and double-acting hydraulically operated piston** within a weather-proof or explosion-proof casing.

Double-Acting Electrohydraulic Actuator and Handwheel

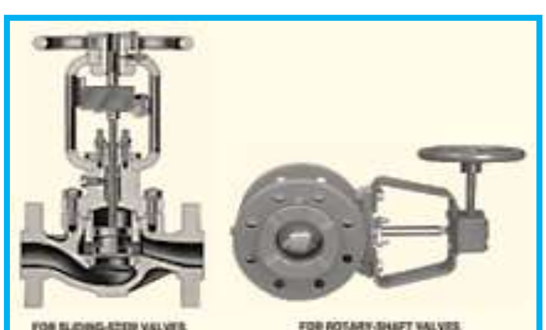
4. Electric Actuators:

Electric actuator designs **use an electric motor** and some form of **gear reduction** to move the valve and these mechanisms have been used for continuous control with varying degrees of success. **Electric actuators have been much more expensive** than pneumatic for the same performance levels. However, this is an area of rapid technological change, and **future designs** may cause a shift towards greater use of electric actuators.

Electric Actuator and Gear Reduction

5. Rack and Pinion Actuators:

Rack and pinion designs provide a **compact and economical solution for rotary shaft valves**, typically used for on-off applications or where process variability is not a concern.



Typical Manual Actuators

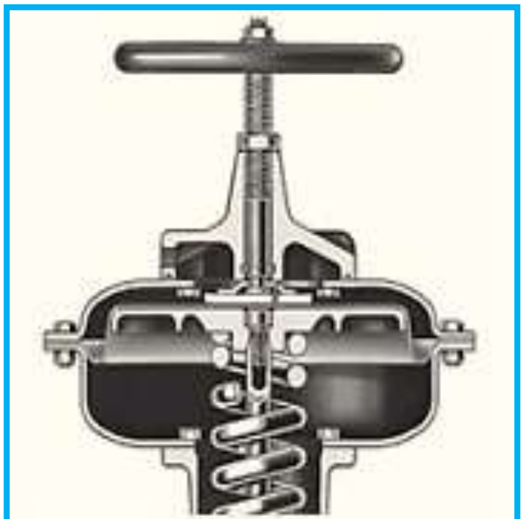
Typical Rack and Pinion Actuator

6. Manual Actuators:

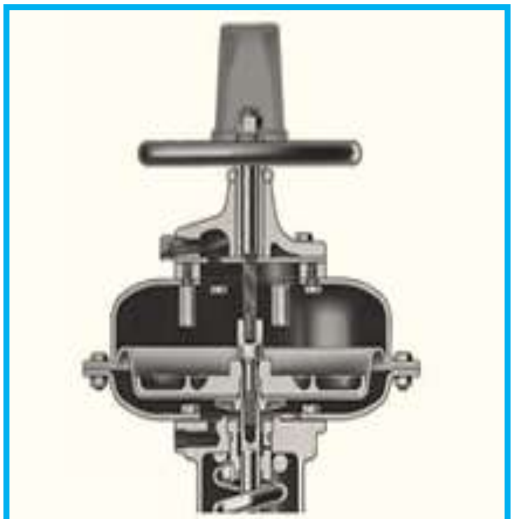
Manual actuators are useful when **automatic process control** is not required, ease of operation and good manual control is still necessary. They are often used to **bypass** a valve in a three-valve loop around control valves during maintenance or shutdown the automatic system. Manual actuators are available in various sizes for all models to permit accurate repositioning of the valve plug or disk. Manual actuators are much less expensive than automatic actuators.

7. Direct-Acting Diaphragm Actuator and Reverse-Acting Diaphragm Actuator:

These valves types are diaphragm types designed to provide control or on/off action for the various control valves. These actuators operate smoothly and accurately when supplied with the appropriate pneumatic signal from controllers or the output from valve positioners. The units shown below, can be used as an adjustable travel stop to limit travel in the upward direction or to manually close push-down-to-close valves.



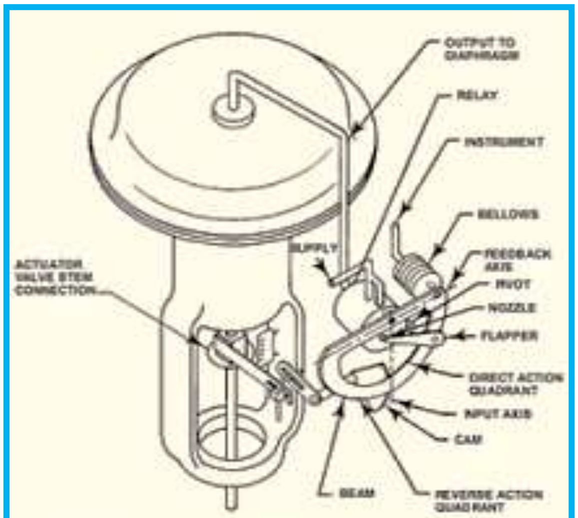
Hand-wheel for Direct-Acting Diaphragm Actuator



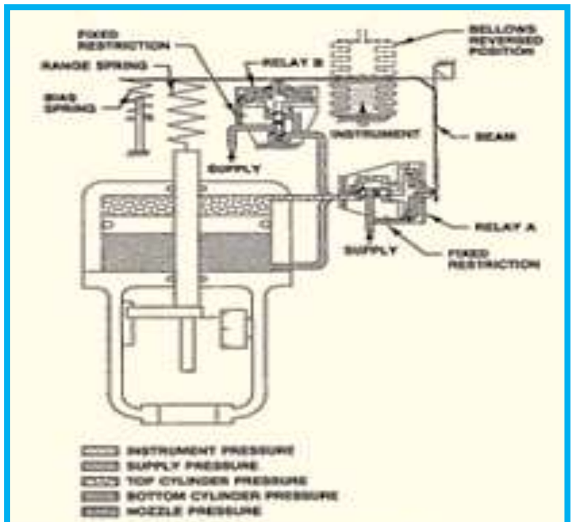
Hand-wheel for Reverse-Acting Diaphragm Actuator

IX - POSITIONERS:

Pneumatically operated valves **depend on a positioner to receive an input signal** (usually 4-20 mA) from a process controller and convert it to manage the **valve opening or closing**. These instruments are available in three configurations:



Positioner for Diaphragm Actuator



Positioner for Piston Actuator

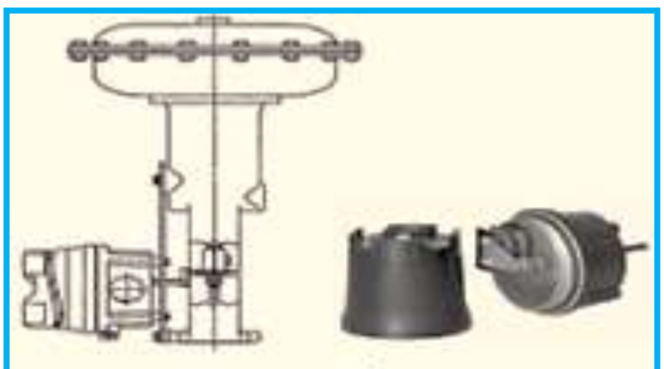
- **Pneumatic Positioners**: Has a pneumatic signal **(usually 3-15 psig)** is supplied to the positioner of a valve with the required air pressure to move the valve to the correct position.

- **Analog I/P Positioner:** This positioner performs the same function as the one above, but uses **electrical current** (**usually 4-20 mA**) instead of air as the input signal.

- **Digital Controller**: As the Analog I/P described above, the difference is that the electronic signal conversion is **digital rather than analog**. The digital products cover three categories.

1. Limit Switches:

Limit switches operate discrete inputs to a distributed control system, signal lights, small solenoid valves, electric relays, or alarms. The cam-operated type is typically used with two to four individual switches operated by movement of the valve stem. An assembly that mounts on the side of the actuator houses the switches. Each switch adjusts individually and can be supplied for either alternating current or direct current systems. Other styles of valve-mounted limit switches are also available.



Cam Operated Limit Switches

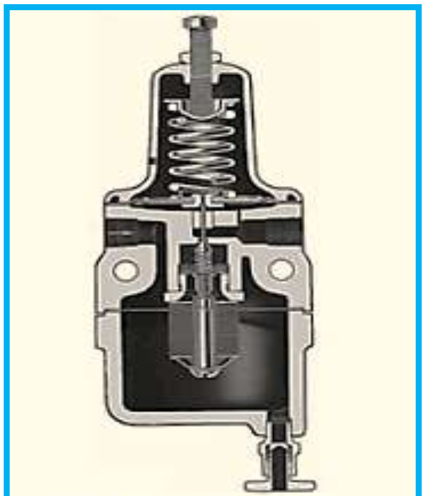
2. Solenoid Valves:

The solenoid valve is an electromechanical device used for controlling liquid or gas flow, which can be controlled by electrical current, running through a coil. When the coil is energized, a magnetic field is created, causing a plunger inside the coil to move. When electrical current is removed from the coil, the valve will return to its de-energized state. In direct-acting solenoid valves, the plunger directly opens and closes an orifice inside the valve. In pilot-operated valves (also called the servo-type), the plunger opens and closes a pilot orifice.

The most common solenoid valve has two ports: an inlet port and an outlet port. The inlet line pressure led through the pilot orifice, opens and closes the valve seal. The actuator type and the desired failsafe operation determine the selection of the proper solenoid valve. The solenoids can be used on **double-acting pistons** or single-acting **diaphragm actuators**. Solenoid valves make automation of fluid and gas control possible. Modern solenoid valves offer fast operation, high reliability, long service life, and compact design.

3. Supply Pressure Regulator:

Supply pressure regulators, commonly also **called air sets reduce plant air supply** to valve positioners and other control equipment. Common reduced-air-supply **pressures** are **20, 35 and 60 psig**. The regulator mounts integrally to the positioner, or nipple-mounts or bolts to the actuator.



Supply Pressure Regulator with Filter and Moisture Trap

4. Electro-Pneumatic Transducers:

The transducer receives a **direct current input signal** and uses a torque motor, nozzle-flapper or a pneumatic relay to **convert the electric signal to a pneumatic output signal**. The nozzle pressure operates the relay and is piped to the torque motor bellows to provide a **comparison between input signal and nozzle pressure**.

Electro-Pneumatic Transducer Mounted in a Diaphragm-Actuated Control Valve

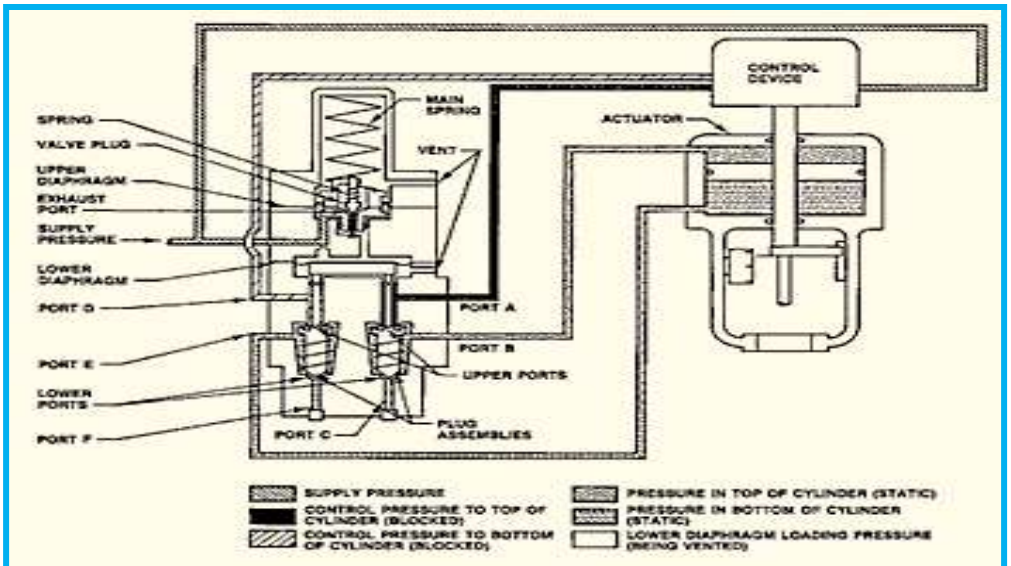
5. Electro-Pneumatic Valve Positioners:

These positioners are used in **electronic control loops to operate pneumatic diaphragm** control valve actuators. The positioner receives a **4 to 20 mA DC input signal** and uses an I/P converter, nozzle-flapper or pneumatic relay to convert the input signal to a pneumatic output signal. The output signal is **applied directly to the actuator diaphragm**, producing valve plug position proportional to the input signal. The valve plug is mechanically fed back to the torque comparison of plug position and input signal.

Electro-Pneumatic Positioner on Diaphragm Actuator

6. Pneumatic Lock-Up Systems:

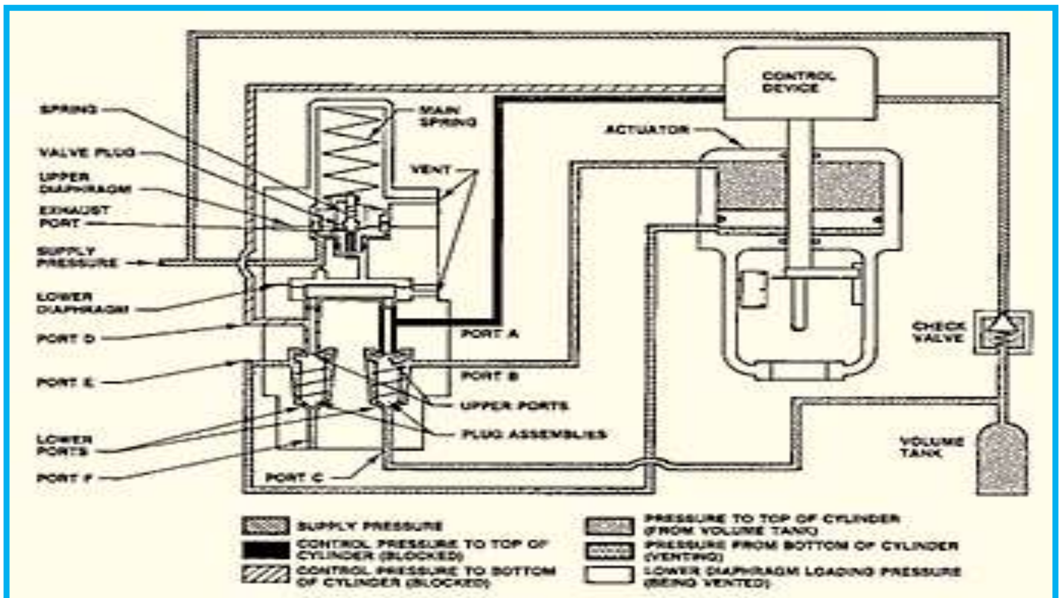
Pneumatic **lock-up systems** are used with control valves **to lock an existing actuator** in the event of supply **pressure failure**. These devices can be used with **volume tanks** to move the valve to fully open or closed position on loss of pneumatic air supply. **Similar arrangements** are available for control valves **using diaphragm actuators**.



Lock-Up System for Piston Actuator

7. Fail-Safe Systems for Piston Actuators:

In these systems, the **actuator piston** moves to the **top or bottom** of the cylinder when **supply pressure falls** below a pre-determined value. The **volume tank**, provides loading pressure for the actuator piston **when supply pressure fails**, moving the piston to the desired position. Automatic operation resumes, and the **volume tank is recharged** when supply pressure is restored to **normal**.



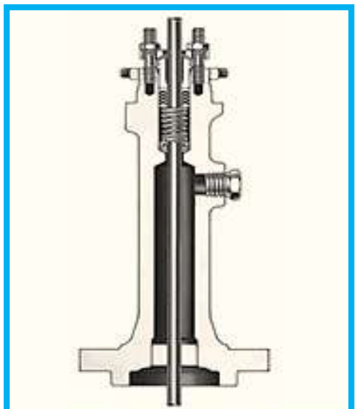
Schematic for a "Fail-Safe" System

X – STANDARD AND SPECIAL CONTROL VALVES:

Standard control valves applications can be defined as being encompassed by: atmospheric pressure up to 6,000 psig (414 bar), temperature from -150 °F (-101 °C) to 450 °F (232 °C), flow coefficient C values from 1.0 to 25,000, and the limits imposed by common industrial standards. Corrosiveness and viscosity, leakage rates, and many other factors demand consideration for standard applications.

1. High-Temperature Control Valves:

Standard Control valves for services at temperatures **above 450 °F** (232 °C), commonly applied in **boiler feedwater** systems and **superheater** bypass systems. Plastics, elastomers, and standard gaskets **are unsuitable** and are replaced by metal-to-metal seating materials, as well, semi-metallic, laminated flexible graphite packing materials and spiral-wound stainless steel and flexible graphite gaskets. Extension bonnets, as shown below, help **protect packing box** parts from **high temperatures** and typical trim materials using Alloy 6, 316 with alloy 6 hard facing and 422 SST.


Tipical Extension Bonnet

Note: Valve body castings Cr-Mo steels are often used for **temperatures above** 1000 °F (538 °C). ASTM A217 Grade WC9 is used up to 1100 °F (593 °C). For **temperatures on up to** 1500 °F (816 °C) the materials usually selected are types 316 or 317 stainless steel. For temperatures between 1000 °F (538 °C) and 1500 °F (816 °C), the **carbon content must be controlled** to the upper the range, 0.04 to 0.08%. The 9%Cr-1%Mo-V materials, such as ASTM A217 grade C12A castings and ASTM A182 grade F91 are used at temperatures up to 1200 °F (650 °C).

2. Cryogenic Control Valves:

Cryogenics is the science dealing with **materials and processes at temperatures below -150 °F (-101 °C)**. For control valve applications in cryogenic services, many of the same issues need consideration as with high temperature control valves. Plastic and elastomeric components often cease to function appropriately at temperatures below **0 °F (-18 °C)**. In these temperature ranges, components such as packing and plug seals require special consideration.

Packing is a concern, in cryogenic applications, because of the frost and moisture condensation on colder surfaces that may form on valves. Ice forms on the bonnet and stem areas of control valves and as the stem is stroked by the actuator, causing tears and thus loss of seal. Materials of construction for cryogenic applications are generally **CF8M** body and bonnet material with 300 series stainless steel trim material. In flashing applications may be required to combat erosion.

3. Nuclear Control Valves:

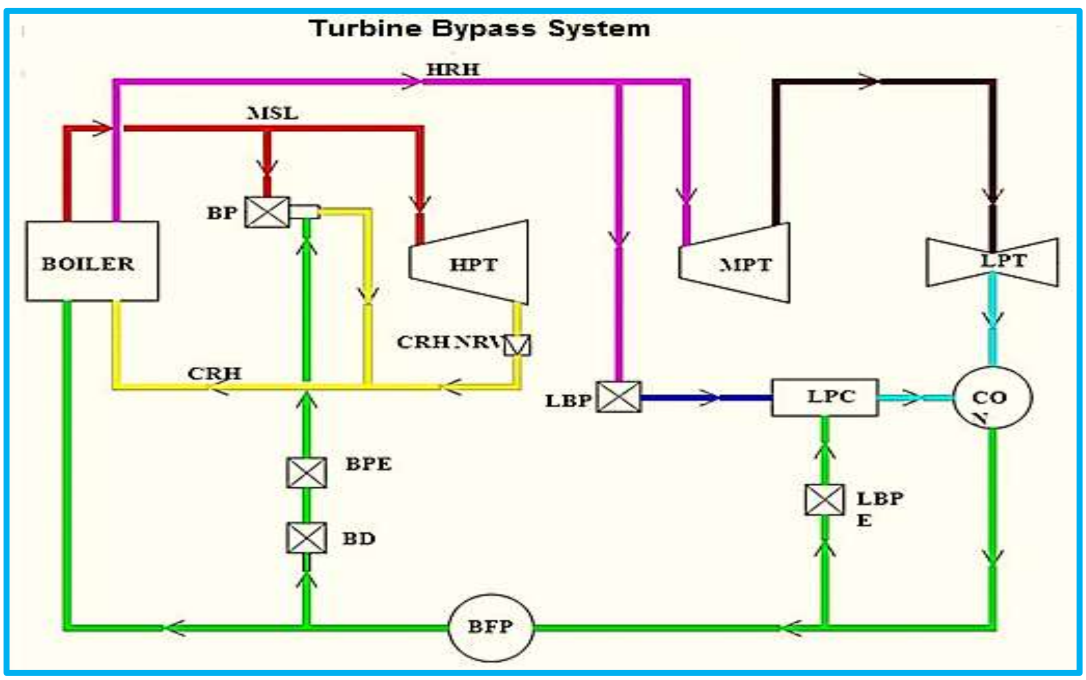
Since 1970, U.S. manufacturers and suppliers of components for nuclear power plants have been subject to the requirements of Appendix B, Title 10, Part 50 of the **Code of Federal Regulations** entitled **Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants**. In keeping with the requirements of the Code of Federal Regulations, most nuclear power plant components are specified in accordance with **Section III of the ASME Boiler and Pressure Vessel Code**, entitled Nuclear Power Plant Components.

Valves manufactured in accordance with **Section III** requirements receive an **ASME code** nameplate and an **"N" stamp** symbolizing service acceptability in nuclear power plant applications. The ASME Section III is **revised** by means of semi-annual addenda, which may be used after date of issue, and which become mandatory six months after date of issue.

4. Turbine Bypass Control Valves:

Turbine bypass valves are usually the same manifold design steam conditioning valves for low-pressure or high-pressure applications. These valves are required to **control the flow of the water to the turbine bypass valves**. Due to equipment protection requirements, it is imperative that these valves provide **tight shutoff**. The turbine bypass valves **allow operation of the boiler independent of the turbine**. The turbine bypass not only supplies an alternate flow path for steam.

The **turbine bypass system protects** the turbine, boiler, and condenser from damage that may occur from thermal and pressure excursions. For this reason, **turbine bypass valves** require extremely **rapid open/close response** times for maximum equipment protection. This is accomplished with an electrohydraulic actuation system that provides both the forces and controls for such operation. The **major elements** of a turbine bypass system, as shown below, are **turbine bypass valves**, with water control valves and the electro-hydraulic system.



5. Valves Subject to Sulfide Stress Cracking:

NACE is responsible for a large number of standards, but by far the most influential and well known is **MR0175**, formerly entitled **"Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment"**, issued in 1975 to provide guidelines for the selection of materials that are resistant to failure in hydrogen sulfide containing oil and gas production environments.

This procedure was modified significantly in a 2003 revision to cover chloride stress corrosion cracking in addition to sulfide stress cracking, reformatted and released as a joint NACE/ISO document called

NACE MR0175/ISO 15156, **"Petroleum and Natural Gas Industries - Materials for Use in H2S Containing Environments in Oil and Gas Production".**

Carbon and low-alloy steels must be **properly heat treated** to provide resistance to sulfide stress cracking (SSC) with a maximum hardness limit of **HRC 22**. Austenitic stainless steels are most resistant to SSC in the annealed condition, acceptable up to **35 HRC**. Copper-base and nickel alloys generally **provide the best resistance** to SSC. Some precipitation nickel alloys are acceptable for use in applications requiring high strength and/or hardness up to **40 HRC**.

Surface lining even using chromium, nickel or other types of plating **offer no protection** against SSC. Their use is allowed in sour applications for wear resistance, but they cannot be used in an attempt to protect a non-resistant base material from SSC. Weld repairs and **fabrication welds** on carbon and low-alloy steels must be **properly processed** to ensure that they meet the **22 HRC** maximum hardness requirement in the base metal, heat-affected zone (HAZ), and weld deposit.

Alloy and carbon steels require post-weld heat treatment. NACE MR0175/ISO 15156 introduced significant changes to the standard. However, many end users continue to specify NACE MR0175-2002. The most significant changes include:

- The 17-4PH H1150 DBL **bolting** that was previously used for full-rated **exposed bolting** in a Class 600 globe valve **is no longer allowed**.

- **NACE MR0103** imposes welding controls on carbon steels that are more rigorous than those imposed by MR0175-2002.

This procedure requires that carbon steels be welded per another NACE document called RP0472 **"Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments"**, to ensure both the weld deposit and heat affected zone (HAZ) in a weldment will be soft enough to resist sulfide stress cracking.

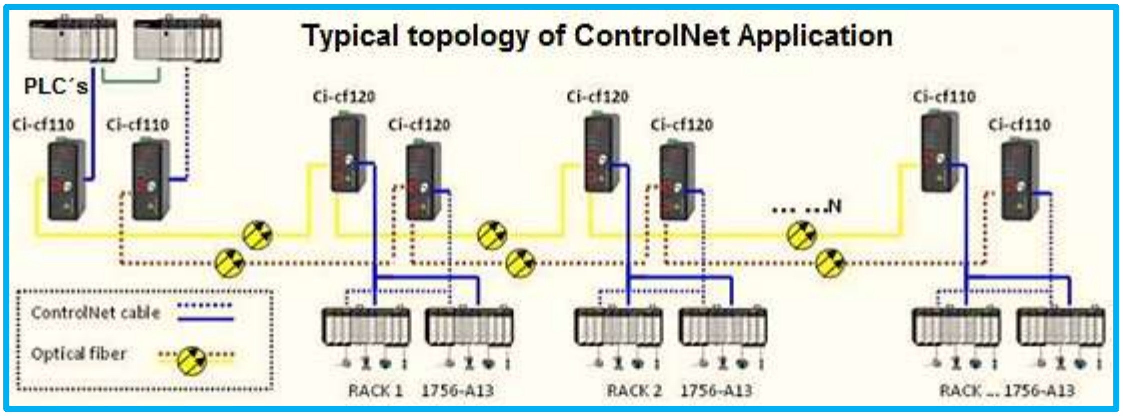
XI – CONTROL AND FIELDBUS TECHNIQUES:

Control and Fieldbus techniques offer flexible and easy automation solutions that industrial users utilize to drive network gateways. Fieldbus is the name of a family of industrial computer network protocols used for real-time distributed control, standardized as **IEC 61158**. A complex automated industrial system, such as manufacturing assembly lines, usually needs an organized hierarchy of controlling to work well. In this hierarchy, there are usually Human Machine Interfaces (HMI´s) at the top, where operators can monitor or operate full production processes.

Fieldbus is a way to connect instruments in a production plant and requires only one communication point at the controller level to allow multiple of analog and digital points to be connected at the same time. This is typically linked to a middle layer of Programmable Logic Controllers (PLC´s) via a worldwide communications system (e.g. Ethernet). At the bottom of the control chain is the **Fieldbus**, which links PLCs to all components that actually do the automated work, such as sensors, actuators, electric motors, console lights, switches, valves and contactors. Thus, there is a wide **array of communications options available** for all types of applications, as basically described below:

1. ControlNet:

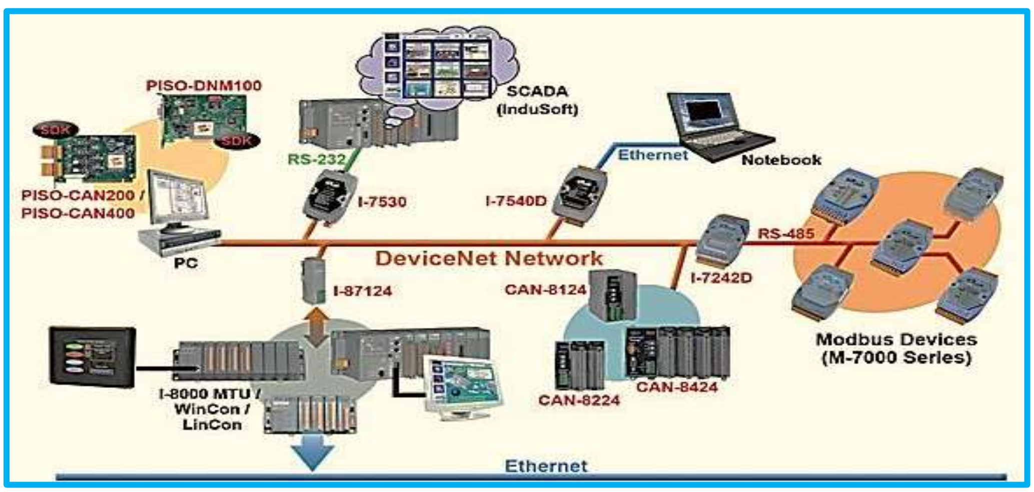
ControlNet was developed by **Rockwell Automation** and actually is managed by the ControlNet International User organization. ControlNet is a member of the CIP (Common Industrial Protocol) network family. ControlNet offers good real-time capabilities **providing high-speed** deterministic transmission for time-critical I/O data and messaging data. ControlNet usually uses **coax cables** and a transmission with a high **speed of 5 Mbit/s**. The configuration process is based on electronic device data sheets (EDS-Files) provided by the device manufacturers and contain relevant communication parameters for the ControlNet system.



2. DeviceNet:

DeviceNet was also originally developed by **Rockwell Automation** and actually is managed by the Open Devicenet User organization (ODVA). Devicenet is among the **world leading device** for industrial automation. DeviceNet is a **very popular network** for time critical applications. DeviceNet is a digital, multi-drop network that serves as a communication network between industrial controllers offering a **single point of connection for configuration** by supporting both I/O and explicit messaging and uses the Common Industrial Protocol, called CIP, for its upper protocol layers.

The DeviceNet network provides open, device-level control and information networking for simple industrial devices. It supports communication between sensors and actuators and higher-level devices such as Programmable Logic Controllers (PLC´s) and computers. With power and signal in a single cable, it offers simple and cost-effective wiring options. DeviceNet **uses a trunk-line/drop-line topology** that provides separate wire pairs for both signal and power distribution. Selectable communication rate: **125, 250 e 500 kbps**.



3. Hart Protocol:

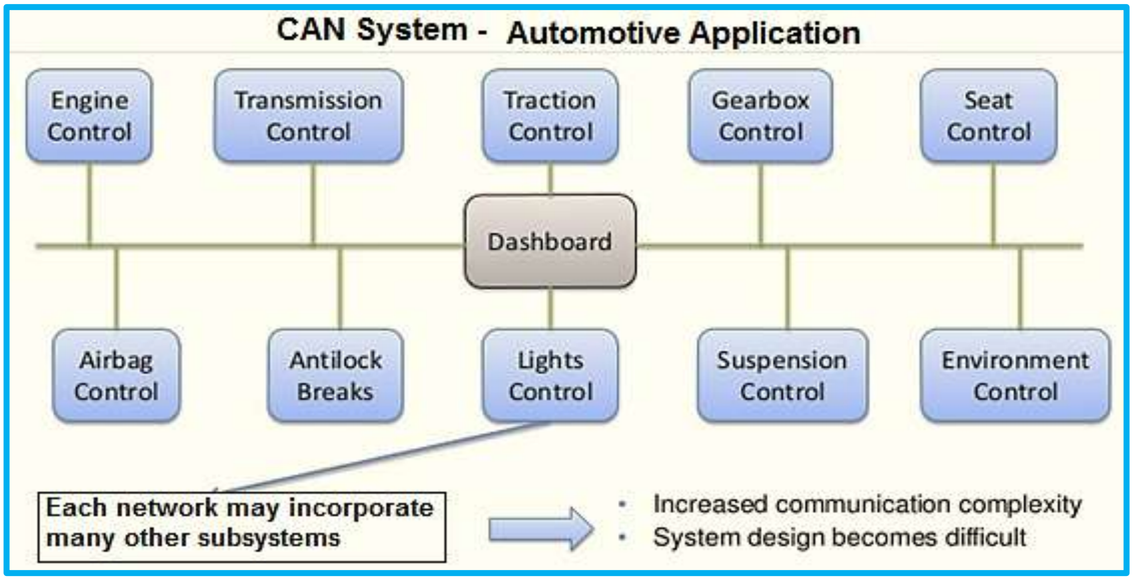
The HART Protocol was **developed in the mid-1980s by Rosemount Inc.** for use with a range of smart measuring instruments. Originally proprietary, the protocol was soon published for free use by anyone. In 1993, the registered trademark and all rights in the protocol were transferred to the HART Communication Foundation (HCF). The protocol remains open and free for all to use without royalties.

“Hart” is an acronym for **Highway Addressable Remote Transducer**. The Hart Protocol makes use of the Bell 202 Frequency Shift Keying (FSK) standard to superimpose **digital communication signals** at a low level on top of the **4-20mA**.

4. Controller Area Network (CAN):

A Controller Area Network (CAN bus) is a vehicle bus standard designed to allow micro-controllers and devices to communicate with each other in applications without a host computer. The Controller Area Network (CAN) was **developed by Bosch in the 1980s** to provide simple, highly reliable, prioritized communication between intelligent devices, sensors and actuators in automotive applications. Today, CAN is used a variety of applications. As a result:

- Large number of different chips and vendors support CAN;
- The total chip volume is huge;
- The parts cost is small (less than $1 USD).



5. Foundation Fieldbus:

In 1994, for technical and political reasons, the French ISP (Interoperable Systems Project) and the World FIP (Flux Information Processus) **merged to form the Fieldbus Foundation**. The aim was to create a single, international fieldbus standard for **hazardous environments** which will find wide-spread use as IEC (International Electrotechnical Committee) standardized fieldbus. Foundation Fieldbus is an all-digital, serial, two-way communications system that serves as the base-level network in a plant or factory automation environment. It is an open architecture, developed and administered by the Fieldbus Foundation.

Foundation Fieldbus was originally intended as a replacement for the **4-20 mA** standards, but today it coexists alongside other technologies such as **Modbus, Profibus, and Industrial Ethernet**. Foundation Fieldbus actually keeps a growing installed base in many heavy process applications such as refining, petrochemicals, power generation, and even food and beverage, pharmaceuticals, and nuclear applications. This fieldbus system can also be used as a **Local Area Network (LAN)** for automation devices and process automation. The Fieldbus technology is continuously replacing the 4-20mA technology. There are two main systems:

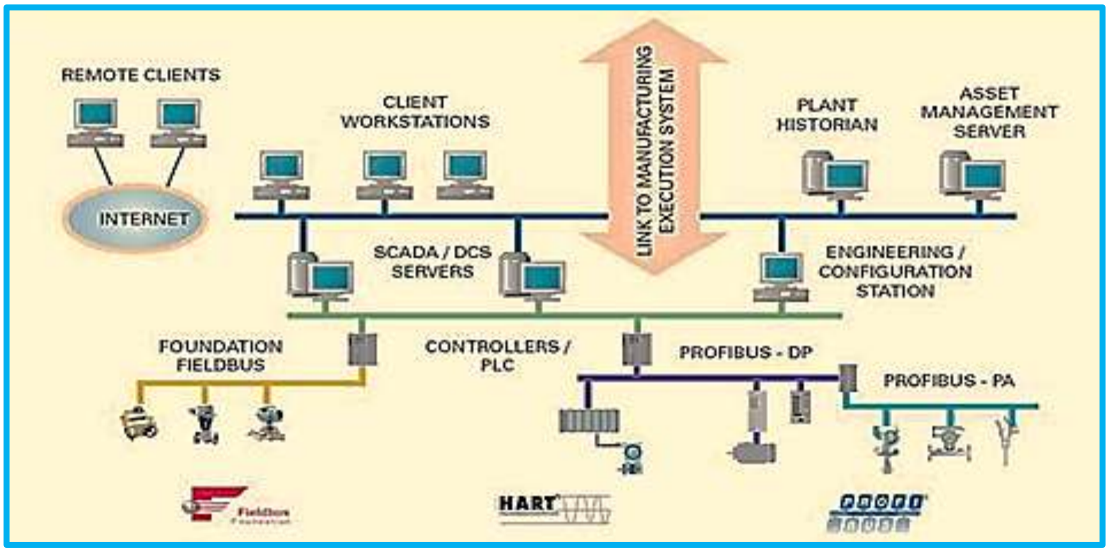
- ✓ **H1 (Lower Speed Ethernet)**: Communication that runs at **31.25 kbit/s,** providing an open and interoperable solution for most field instruments including intrinsically safe networks.

- ✓ **HSE (High Speed Ethernet)**: Communication that runs at **100 Mbit/s** with high speed connection between various H1 and host systems including the PLCs with a "backbone" network.

The ability to **embed software** commands into the memory of the device represents the real difference between **digital and analog I/P segments**. Fieldbus networks exchange data have **two methods**. **Cyclic or Acyclic data**:

- ✓ **Cyclic Data**: Are pre-configured information to pass from one device to another at a known rate. Cyclic data is the sender and the receiver end of the message. Therefore if this cyclic data is not delivered with the proper timing, faults will occur on the network to be monitored for reliability assurance.

- ✓ **Acyclic Data**: Are messages sent and received at any time as they are generated by the sender and generally have a lower priority than cyclic messages. The system incorporates a "request" and "response" communications scheme where the message sender waits to receive a response from the target before generating another message.



6. Profibus:

Profibus or PROFIBUS is the abbreviation for **Process Field Bus** and is the standard for **field bus communication** in automation technology. The Profibus communication protocol was **created in 1989** by a consortium of companies and institutions and promoted by the BMBF (German department of education and research). Profibus devices can also participate in self-diagnosis and connection diagnosis. Devices on the system connect to a central line and communicate information in an efficient manner, but can go beyond automation messages. The initial version of PROFIBUS was PROFIBUS FMS, Fieldbus Message Specification. PROFIBUS FMS was designed to communicate between Programmable Controllers and PCs. Profibus is divided into two main variations:

- **DP (Decentralized Peripheral)** version. Is the more commonly used that replaced the first complex communication protocol version FMS (Fieldbus Message Specification) in 1993;

- **PA (Process Automation)** protocol version. Is the less commonly used.

Profibus DP: Is the high speed solution of Profibus. It has been designed and optimized especially for communication between automation systems and decentralized devices. It **can operate at data** rates of up to **12 Mbit/s** over **twisted pair cables or fiber optic** links.

Profibus AP: Is used to monitor measuring equipment via a process control system. The disadvantage of this protocol is its **slow data rate** of only **31.25 kbit/s**. Weak current flow through the bus lines makes it intrinsically safe and ideal for use in explosion-hazardous areas.

XII – INSTRUMENT DIAGNOSTICS:

Digital valve controllers incorporate predefined instrument and **valve diagnostics within firmware** to provide alerts if there are problems with instruments, electronics, hardwares and valve performances. Utilizing Distributed Control System (DCS), PC software tools, or handheld communicators, process professionals can diagnose the health of the valve while it is in the line.

1. HART-based Handheld Field Communicators:

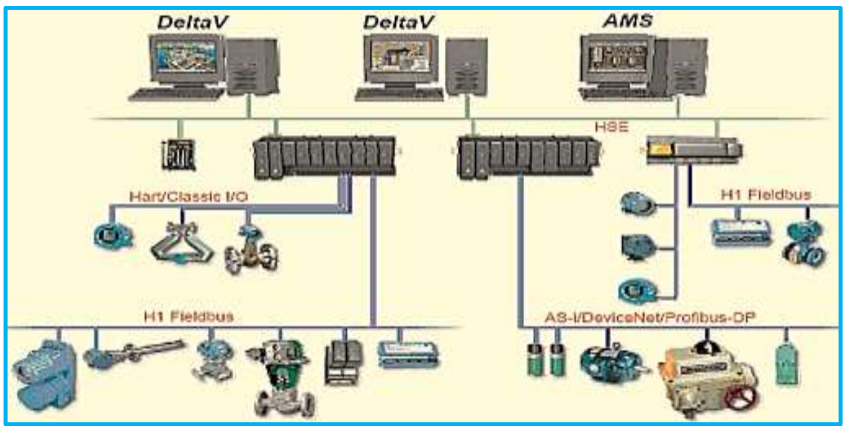
When connected to the digital valve controllers it enables user-configured **alerts and alarms**. These warnings provide notification of current status and potential **valve and instrument problems**, including travel deviation, travel limit, cycle count and travel accumulation.

2. AMS ValveLink Software:

Control valve can be evaluated while the valve **is fully operational** before failure, without disrupting the process. Allows tests that identify problems with the **entire control valve assembly**, using the valve stem travel feedback, the actuator pressure sensor and other sensors.

3. DeltaV System:

The DeltaV SIS is a system developed **to protect and improve plant performance**. The safety integrity is provided by continuously monitoring sensors, logic solvers and final elements, and every process fault is diagnosed before the process fails.



4. Flow Scanner:

Can diagnose the health of a valve through a series of off-line tests. The Flow Scanner system consists of a portable, ruggedized computer and pressure sensors. The sensors are connected to the valve to **enable diagnostic tests**, which are conducted with the **valve off-line**. A skilled technician can determine whether to leave the valve in the line or to remove the valve for repair. Digital instruments allow an extension of this service with added enhancements:

- Sensors are part of the instrument and tests can be run easily at appropriate times.
- It is possible to diagnose the health of a valve remotely via HART or Foundation fieldbus.
- On-line diagnostics enable predictive maintenance without disrupting the process.

5. Fieldvue Instruments:

Enable new diagnostic capabilities that can be accessed remotely. This single element requires a look at the potential impact of the technology as it applies to control valves.

XIII – CHARACTERISTICS OF PROCESS CONTROL VALVES:

Automatic process control valves normally respond to signals generated by independent devices such as flow meters or temperature gauges. These valves are normally fitted with actuators and positioners and can work with **pneumatic or hydraulic actuators** (also known as hydraulic pilots). Pneumatic or hydraulic actuators are **programmed** to respond to signals sent by Programmable Controllers. These programmed signals received by an electric or hydraulic positioner have the capacity to **open or close** the control valves. These types of valves control: Pressure Reducing, Flow Control, Back-pressure Sustaining, Altitude (controls the level of a tank) and Relief Valves.

- **Globe and Diaphragm Valves** are widely used for **control purposes** in many industries, although **quarter-turn types** such as Ball, Gate and Butterfly valves are also used.

- **Automatic process control valves** have the ability to reduce process variability depends upon many factors. Some of the most important design considerations include; dead band, actuator-positioner design; valve response time, valve type and characterization; valve type and sizing, as described below:

a. Dead Band:

Dead band is a **general phenomenon** where a range or band of controller output (CO) values **fails to produce** a change in the measured process variable (PV) when the input signal reverses direction and the process variable (PV) deviates from the set point. **Friction** is a major cause of dead band in control valves. Rotary valves are often very susceptible to friction caused by poor drive train stiffness. As a result, the valve shaft winds up and does not translate motion to the control element that clearly has a detrimental effect on process variability.

b. Actuator-Positioner Design:

Actuator and positioner design must be considered together. Positioners allow for precise positioning accuracy and faster response to process upsets when used with a conventional digital control system. These microprocessor-based positioners provide dynamic performance equal to the best conventional two-stage pneumatic positioners.

c. Valve Response Time:

For optimum control of many processes, it is important that the valve reach a specific position quickly. A quick response to small signal changes (1% or less) is one of the most important factors in providing optimum process control.

d. Valve Type and Characterization:

The main characteristic is the relationship between the valve flow capacity and the valve travel when there is a differential pressure drop across the valve to be held constant. Proper selection of a control valve designed to produce a reasonably linear installed flow characteristic over the operating range of the system is a critical step in ensuring optimum process performance. The **I/P positioner input signal** ahead of the positioner loop to recalibrate the input signal by taking the linear **4-20 mA controller** using a pre-programmed table to produce the desired valve characteristic.

e. Valve Type and Sizing:

Oversizing of valves sometimes occurs when trying to optimize process performance through a reduction of process variability. When the valve is oversized, the valve tends to reach system capacity at relatively low travel, making the flow curve flatten out at higher valve travels. Valve travels **above 50 degrees is ineffective** for control purposes because the process gain is approaching zero and the valve has wide changes with very little resulting changes in flow. When selecting a valve, it is important to consider the valve style, inherent characteristic, and valve size that will provide the broadest possible control range for the application.

Obs.: With Control Techniques, it is **recognized the importance** of simplicity in fieldbus communications. The higher level information systems include **SCADA** (Supervisory, Control and Data Access), **MRP** (Manufacturing Resource Planning), **ERP** (Enterprise Resource Planning) and a **lot of other** high technology systems and developed solutions for process automation.

XIV – VALVES MATERIAL SELECTION:

Control valves handle all kinds of fluids from cryogenic temperature range to over 1000 °F (538 °C). Manufacturers are **dedicated to helping select** the most appropriate valves for service conditions. Since there are several possible correct choices for an application, sometimes it is important that all the following information be provided:

- Type of fluid to be controlled;
- Temperature of fluid;
- Viscosity of fluid;
- Specific gravity of fluid;
- Flow capacity required (maximum and minimum);
- Inlet pressure at valve (maximum and minimum);
- Outlet pressure (maximum and minimum);
- Pressure drop during normal flowing conditions;
- Pressure drop at shutoff;
- Maximum permissible noise level, if pertinent;.
- Degrees of superheat or existence of flashing, if known;
- Inlet and outlet pipeline size and schedule;
- Special tagging information required;
- Body Material (ASTM A216 grade WCC, ASTM A217 grade WC9, ASTM A351 CF8M, etc.);
- End connections and valve rating (screwed, RF flanged, RTJ flanges, etc.);
- Action desired on air failure (valve to open, close, or retain last controlled position);
- Instrument air supply available;
- Instrument signal (3 to 15 psig, 4 to 20 mA, Hart, etc.).

In addition, the following information will be required according to the agreement of the user and the manufacturer depending on the application and engineering practices:

- Valve size and type number;
- Valve body construction (angle, double-port, butterfly, etc.);
- Valve plug guiding (cage-style, port-guided, etc.);
- Valve plug action (push-down-to-close or push-down-to-open);
- Port size (full or restricted);
- Valve trim materials required;
- Flow action (flow tends to open valve or flow tends to close valve);
- Actuator size required;
- Bonnet style (plain, extension, bellows seal, etc.);
- Packing material (PTFE V-ring, laminated graphite, environmental sealing systems, etc.);

a. Valve Body Materials:

Body material selection is usually based on the **pressure, temperature**, corrosive properties and erosive properties of the flow media. Some service conditions require use of exotic alloys and metals to withstand particular corrosive properties of the flowing fluid, for highly corrosion resistance. The specifications include foundry qualification, pattern equipment, alloy qualification, weldability, casting integrity, visual inspection, weld repairs, heat treatment and non-destructive testing.

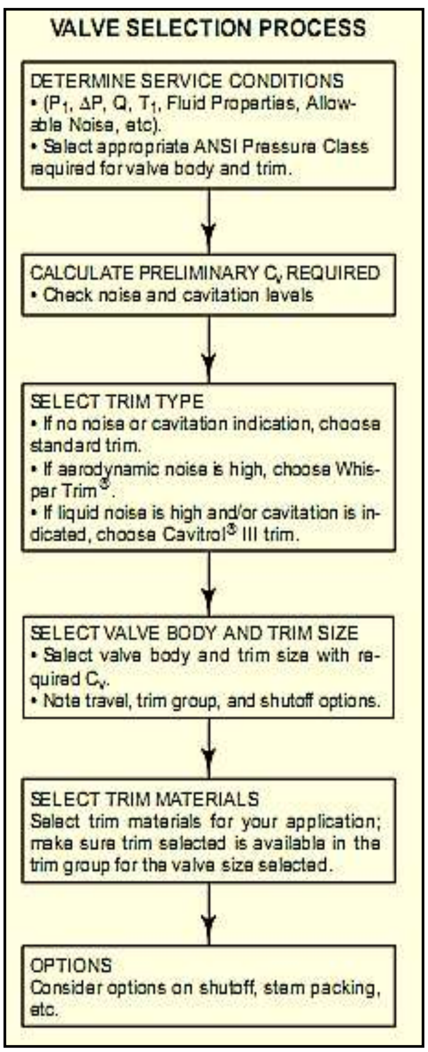
- **Cast Carbon Steel**: (ASTM A216 Grade WCB and WCC) are the most popular steel material used for valve bodies in **moderate services** such as air, saturated or superheated steam, non-corrosive liquids and gases. However, this type of material **cannot be used** above **800 °F (427 °C)** as the carbon rich phase might be converted to graphite.

- **Cast Chromium-Molybdenum Steel**: (ASTM A217 Grade WC9) is the standard Cr-Mo grade. The WC9 **has replaced C5** as the standard because of superior casting and welding properties, especially in steam and boiler feedwater service. The **chromium and molybdenum** provide **erosion-corrosion and creep resistance**, making it useful to **1100 °F (593 °C)**. The grade WC9 **requires preheating** before welding and heat treatment after welding.

- **Cast Type 304L**: Stainless Steel (ASTM A351 Grade CF3) is a good material offering for chemical service valves and is the best material for nitric acid and certain other chemical service applications. Optimum corrosion resistance is retained even in the as-welded condition.

- **Cast Type 316**: (S31600) Stainless Steel (ASTM A351 Grade CF8M) is the industry standard stainless steel body material. The addition of molybdenum gives Type 316 greater resistance to corrosion, pitting, creep and oxidizing fluids compared to 304.

- **Cast Type 317**: Stainless Steel (ASTM A479 Grade UNS S31700) **is essentially S31600** with nickel and molybdenum contents increased 1% each. This affords greater resistance to pitting and general corrosion than is obtained with S31600.



Designations for the High Nickel Alloys

Casting Designations	Equivalent Wrought Tradenames	Generic Designations	UNS Numbers for Wrought Equivalents
CF3		304L	S30403
CF8		304	S30400
CF3M		316L	S31603
CF8M		316	S31600
CG8M		317	S31700
CK3MCuN	Avesta 254 SMO[1]	Alloy 254	S31254
CN7M	Carpenter 20Cb3[2]	Alloy 20	N08020
CU5MCuC	Incoloy 825[3]	Alloy 825	N08825
CW12MW	Obsolete Hastelloy C[4]	Alloy C	N10002
CW2M	New Hastelloy C[4]	Alloy C276	N10276
CX2MW	Hastelloy C22[4]	Alloy C22	N06022
CW6MC	Inconel 625[3]	Alloy 625	N06625
CY40	Inconel 600[3]	Alloy 600	N06600
CZ100	Nickel 200	Alloy 200	N02200
LCB		LCB	J03003
LCC		LCC	J02505
M25S	S-Monel[3]	Alloy S	
M35-1	Monel 400[3]	Alloy 400	N04400
N12MV	Obsolete Hastelloy B[4]	Alloy B	N10001
N7M	Hastelloy B2[4]	Alloy B2	N10665
WCB		WCB	J03002
WCC		WCC	J02503

1. Trademark of Avesta AB
2. Tradenames of Carpenter Technology
3. Tradenames of Special Metals Corp.
4. Tradename of Haynes International

Pressure-Temperature Ratings for Standard Class ASTM A216 Grade WCC Valves (in accordance with ASME B16.34)

TEMPERATURE, °F	WORKING PRESSURES BY CLASS, PSIG				
	150	300	600	900	1500
	Psig				
-20 to 100	290	750	1,500	2,250	3,750
200	260	750	1,500	2,250	3,750
300	230	730	1,455	2,185	3,640
400	200	705	1,410	2,115	3,530
500	170	665	1,330	1,995	3,325
600	140	605	1,210	1,815	3,025
650	125	590	1,175	1,765	2,940
700	110	570	1,135	1,705	2,840
750	95	505	1,010	1,510	2,520
800	80	410	825	1,235	2,060
°C	Bar				
-29 to 38	20	52	103	155	259
93	18	52	103	155	259
149	16	50	100	151	251
204	14	49	97	146	243
260	12	46	92	138	229
316	10	42	83	125	209
343	9	41	81	122	203
371	8	39	78	118	196
399	7	35	70	104	174
427	6	28	57	85	142

Pressure-Temperature Ratings for Standard Class ASTM A217 Grade WC9 Valves (in accordance with ASME B16.34)

TEMPERATURE, °F	WORKING PRESSURES BY CLASS, PSIG				
	150	300	600	900	1500
-20 to 100	290	750	1,500	2,250	3,750
200	260	750	1,500	2,250	3,750
300	230	730	1,455	2,185	3,640
400	200	705	1,410	2,115	3,530
500	170	665	1,330	1,995	3,325
600	140	605	1,210	1,815	3,025
650	125	590	1,175	1,765	2,940
700	110	570	1,135	1,705	2,840
750	95	530	1,065	1,595	2,660
800	80	510	1,015	1,525	2,540
850	65	485	975	1,460	2,435
900	50	450	900	1,350	2,245
950	35	375	755	1,130	1,885
1000	20	260	520	780	1,305
1050	20(1)	175	350	525	875
1100	20(1)	110	220	330	550

Pressure-Temperature Ratings for Standard Class ASTM A351 Grade CF3 Valves (in accordance with ASME B16.34)					
TEMPERATURE	WORKING PRESSURES BY CLASS				
	150	300	600	900	1500
°F	Psig				
-20 to 100	275	720	1,440	2,160	3,600
200	230	600	1,200	1,800	3,000
300	205	540	1,080	1,620	2,700
400	190	495	995	1,490	2,485
500	170	465	930	1,395	2,330
600	140	435	875	1,310	2,185
650	125	430	860	1,290	2,150
700	110	425	850	1,275	2,125
750	95	415	830	1,245	2,075
800	80	405	805	1,210	2,015
850	65	395	790	1,190	1,980
900	50	390	780	1,165	1,945
950	35	380	765	1,145	1,910
1000	20	320	640	965	1,605
1050	20[1]	310	615	925	1,545
1100	20[1]	255	515	770	1,285
1150	20[1]	200	400	595	995
1200	20[1]	155	310	465	770
1250	20[1]	115	225	340	565
1300	20[1]	85	170	255	430
1350	20[1]	60	125	185	310
1400	20[1]	50	95	145	240
1450	15[1]	35	70	105	170
1500	10[1]	25	55	80	135

Pressure-Temperature Ratings for Standard Class ASTM A351 Grades CF8M and CG8M[1] Valves (in accordance with ASME B16.34)					
TEMPERATURE	WORKING PRESSURES BY CLASS				
	150	300	600	900	1500
°F	Psig				
-20 to 100	275	720	1,440	2160	3,600
200	235	620	1,240	1,860	3,095
300	215	560	1,120	1,680	2,795
400	195	515	1,025	1,540	2,570
500	170	480	955	1,435	2,390
600	140	450	900	1,355	2,255
650	125	445	890	1,330	2,220
700	110	430	870	1,305	2,170
750	95	425	855	1,280	2,135
800	80	420	845	1,265	2,110
850	65	420	835	1,255	2,090
900	50	415	830	1,245	2,075
950	35	385	775	1,160	1,930
1000	20	350	700	1,050	1,750
1050	20[2]	345	685	1,030	1,720
1100	20[2]	305	610	915	1,525
1150	20[2]	235	475	710	1,185
1200	20[2]	185	370	555	925
1250	20[2]	145	295	440	735
1300	20[2]	115	235	350	585
1350	20[2]	95	190	290	480
1400	20[2]	75	150	225	380
1450	20[2]	60	115	175	290
1500	20[2]	40	85	125	205

Notes: The alloy S31700 (ASTM A479) is completely austenitic and non-magnetic. CG8M (ASTM A351 CG8M) is the similar austenitic version and therefore is also partially strongly magnetic. Both material specifications indicate excellent resistance to digester liquor, dry chlorine dioxide and many other pulp and paper environments. **Cast Iron** (ASTM A216) is an inexpensive, **non-ductile material** used for valve bodies controlling steam, water, gas and non-corrosive fluids.

Pressure-Temperature Ratings for ASTM A216 Cast Iron Valves
(in accordance with ASME/ANSI B16.1)

TEMPERATURE	CLASS 125			CLASS 250		
	ASTM A 216			ASTM A 216		
	Class A	Class B		Class A	Class B	
	NPS 1-12	NPS 1-12	NPS 14-24	NPS 1-12	NPS 1-12	NPS 14-24
°F	Psig					
-20 to 150	175	200	150	400	500	300
200	165	190	135	370	460	280
225	155	180	130	355	440	270
250	150	175	125	340	415	260
275	145	170	120	325	395	250
300	140	165	110	310	375	240
325	130	155	105	295	355	230
353	125	150	100	280	335	220
375	---	145	---	265	315	210
406	---	140	---	250	290	200
425	---	130	---	---	270	---
450	---	125	---	---	250	---

XV – SERVICE TEMPERATURE FOR ELASTOMERS:

Service Temperature Table**, for elastomers** show that **tear strength** and other physical properties decrease rapidly as service temperature increases with considered dynamic forces.

Service Temperature Limits for Non-Metallic Materials

ASTM Designations and Tradenames	Generic Description	Temperature Range
CR	Chloroprene	-40 to 180°F, -40 to 82°C
EPDM	Ethylene propylene terpolymer	-40 to 275°F, -40 to 135°C
FFKM, Kalrez[1], Chemraz[2]	Perfluoroelastomer	0 to 500°F, -18 to 260°C
FKM, Viton[1]	Fluoroelastomer	0 to 400°F, -18 to 204°C
FVMQ	Fluorosilicone	-100 to 300°F, -73 to 149°C
NBR	Nitrile	-65 to 180°F, -54 to 82°C
NR	Natural rubber	-20 to 200°F, -29 to 93°C
PUR	Polyurethane	-20 to 200°F, -29 to 93°C
VMQ	Silicone	-80 to 450°F, -62 to 232°C
PEEK	Polyetheretherketone	-100 to 480°F, -73 to 250°C
PTFE	Polytetrafluoroethylene	-100 to 400°F, -73 to 204°C
PTFE, Carbon Filled	Polytetrafluoroethylene, Carbon Filled	-100 to 450°F, -73 to 232°C
PTFE, Glass Filled	Polytetrafluoroethylene, Carbon Filled	-100 to 450°F, -73 to 232°C
TCM Plus[3]	Mineral and MoS2 filled PTFE	-100 to 450°F, -73 to 232°C
TCM Ultra[3]	PEEK and MoS2 filled PTFE	-100 to 500°F, -73 to 260°C
Composition Gasket		-60 to 300°F, -51 to 150°C
Flexible Graphite, Grafoil[4]		-300 to 1000°F, -185 to 540°C

XVI – CONTROL VALVE SIZING:

Control valve sizing can be traced back to the **early 1960's** when a trade association, the **Fluids Control Institute** published sizing equations for use with both **compressible and incompressible fluids**. In **1967**, the ISA established a committee to develop and publish standard equations, the **ANSI/ISA Standard S75.01** after harmonized with **IEC Standards 534-2-1 and 534-2-2**. To specify Cv or Kv inside the main variables required to size the valve as follows:

1. Flow Coefficient Cv (or Kv):

Literally, **Cv** means "coefficient of velocity" used to compare flows of valves. How higher the Cv, the greater the flow. Thus, **Cv** is numerically equal to the number of U.S. gallons of water at 60°F that will flow through the **valve in one minute** when the pressure differential across the valve is 1 lb/in^2 (one pound per square inch). When the valve is opened, most of the time, a valve should be selected with low head loss in order to save energy. Use the following equations:

- The **Volumetric flow rate** units:

$$C_v = \frac{q}{N_1 F_p \sqrt{\frac{P_1 - P_2}{G_f}}}$$

- The **Mass flow rate** units:

$$C_v = \frac{W}{N_6 F_p \sqrt{(P_1 - P_2)\gamma}}$$

Other formulas considering Cv are:

$$Q = Cv \times \sqrt{\frac{\Delta P \times 62.4}{\rho}}$$

$$Q = Kv \times \sqrt{\frac{\Delta P \times 1000}{\rho}}$$

Where:

Q = Flow rate in gallons per minute (GPM);
ΔP = Pressure drop across the valve psi - (62.4 = fluid conversion factor);
ρ = Density of fluids in lb/ft³ - (according to temperature).

Kv: Is the Flow Coefficient in **metric units**. It is defined as the flow rate in cubic meters per hour [m³/h] of water at a temperature of 16º Celsius with a pressure drop across the valve of 1 bar.

Cv: Is the Flow Coefficient in **imperial units**. It is defined as the flow rate in US Gallons per minute [gpm] of water at a temperature of 60º Fahrenheit with a pressure drop across the valve of 1 psi.

Kv = 0.865·Cv;
Cv = 1,156·Kv.

Flow Coefficient table: Select the valve size using the appropriate manufacturer's **Cv value**:

Representative Sizing Coefficients for Single-Ported Globe Style Valve Bodies

Valve Size (inches)	Valve Plug Style	Flow Characteristic	Port Dia. (in.)	Rated Travel (in.)	C_V	F_L	X_T	F_D
1/2	Post Guided	Equal Percentage	0.38	0.50	2.41	0.90	0.54	0.61
3/4	Post Guided	Equal Percentage	0.56	0.50	5.92	0.84	0.61	0.61
1	Micro Form™	Equal Percentage	3/8	3/4	3.07	0.89	0.66	0.72
			1/2	3/4	4.91	0.93	0.80	0.67
			3/4	3/4	8.84	0.97	0.92	0.62
	Cage Guided	Linear	1 5/16	3/4	20.6	0.84	0.64	0.34
		Equal Percentage	1 5/16	3/4	17.2	0.88	0.67	0.38
1 1/2	Micro-Form™	Equal Percentage	3/8	3/4	3.20	0.84	0.65	0.72
			1/2	3/4	5.18	0.91	0.71	0.67
			3/4	3/4	10.2	0.92	0.80	0.62
	Cage Guided	Linear	1 7/8	3/4	39.2	0.82	0.66	0.34
		Equal Percentage	1 7/8	3/4	35.8	0.84	0.68	0.38
2	Cage Guided	Linear	2 5/16	1 1/8	72.9	0.77	0.64	0.33
		Equal Percentage	2 5/16	1 1/8	59.7	0.85	0.69	0.31
3	Cage Guided	Linear	3 7/16	1 1/2	148	0.82	0.62	0.30
		Equal Percentage			136	0.82	0.68	0.32
4	Cage Guided	Linear	4 3/8	2	236	0.82	0.69	0.28
		Equal Percentage			224	0.82	0.72	0.28
6	Cage Guided	Linear	7	2	433	0.84	0.74	0.28
		Equal Percentage			394	0.85	0.78	0.26
8	Cage Guided	Linear	8	3	846	0.87	0.81	0.31
		Equal Percentage			818	0.86	0.81	0.26

Other **Flow Coefficients,** as shown, may **indicate different** numbers, at 100% travel:

GATE VALVE Cv's

CLASS 150

SIZE	2"	2-1/2"	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"
Cv	298	466	694	1,234	2,873	5,109	8,622	12,416	17,651	23,055	30,603	37,782	57,349

CLASS 300

SIZE	2"	2-1/2"	3"	4"	6"	8"	10"	12"
Cv	289	452	672	1,194	2,776	4,935	7,982	11,929

GLOBE VALVE Cv's

CLASS 150

SIZE	2"	2-1/2"	3"	4"	6"	8"	10"	12"
Cv	46	72	105	166	400	810	1,310	1,900

CLASS 300

SIZE	2"	2-1/2"	3"	4"	6"	8"	10"
Cv	46	84	104	165	436	692	1,120

SWING CHECK VALVE Cv's

CLASS 150

SIZE	2"	2-1/2"	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"
Cv	218		499	903	2,032	3,679	5,857	8,435	11,708	15,293	19,754	24,912

CLASS 300

SIZE	2"	2-1/2"	3"	4"	6"	8"	10"	12"
Cv	211	330	482	858	1,963	3,549	5,546	8,128

XVI – ACTUATOR FORCE CALCULATIONS:

Pneumatic diaphragm actuators provide a net force, using air pressure to compress the spring to close a valve, or decompression the spring to open a valve, calculated in psi of differential pressure.

Example: Suppose that **275 lbf** is required to close a valve using a piston with a net area **100 in²**. Air pressure with a minimum of **3 psi** is used to overcome the pre-compression, so the pre-compression force must be:

F = Pressure x Area = then, 3 lb/in^2 X 100 in^2 = **300 lbf**.

Note: This **exceeds the force** required and is an **adequate selection**. Piston actuators with springs are sized in the same manner and must be calculated as:

Available Thrust Force = (Piston Area) x (Minimum Supply Pressure) =

Obs.: The manufacturer normally takes responsibility for actuator sizing and should have methods documented to check for maximum stem loads. Manufacturers also publish data on actuator thrusts, effective diaphragm areas, and spring data.

XVII – VALVE INSPECTION AND TESTING:

The **API standard 598** and other standards cover inspection, examination, supplementary examinations, and pressure test requirements for resilient-seated, nonmetallic-seated (e.g., ceramic) and metal-to-metal-seated valves of the gate, globe, plug, ball, check, and butterfly types.

1. Shell Test (Hydrostatic Body Test):

Every valve shall be subjected to a **hydrostatic test** of the body shell at **1.5 times** the maximum permissible working pressure at 100 °F (38 °C), as specified in **Table 1**. The test **shall show no leakage**, **no wetting** of the external surfaces, and no permanent distortion under the full test pressure. The valve shall be set in the partially open position for this test, and completely filled with the test fluid. Any entrapped air should be vented from both ends and the body cavity.

All external surfaces should be dried and the pressure held for at least the minimum test duration. There shall be no visible leakage during the test duration specified in **Table 2**, provided the stem seals are capable of retaining pressure at least equal to the 100 °F (38 °C) without leakage. If leakage is found, corrective action may be taken to eliminate the leakage and the test repeated.

2. Backseat Test (Hydrostatic Seat Test):

When applicable (with exception of bellows seal valves), every valve must be **subjected** to a hydrostatic test of the backseat at **1.1 times** the maximum permissible working pressure at **100 °F** (38 °C), as specified in **Table 1**. The valve shall then be brought to the required test pressure. All external surfaces should be dried and the pressure held for at least the minimum test duration. There shall be no visible leakage during the test duration specified in **Table 2**.

Note: If **unacceptable leakage** is found, corrective action may be taken to eliminate the leakage and the test repeated. Every time the valve is disassembled to eliminate the leakage, all previous testing must be repeated upon re-assembly.

3. High-pressure Closure Test (Hydrostatic Seat Test):

Every valve shall be subjected to a **hydrostatic seat test** to **1.1 times** the maximum permissible working pressure at 100 °F (38 °C) as specified in **Table 1**. The test shall show no leakage through the disc, behind the seat rings or past the shaft seals. The allowable leakage of test fluid for the seat seal, shall be according to those listed in **Table 3**.

Note: If **unacceptable leakage** is found, corrective action may be taken to eliminate the leakage and the seat test repeated. If the valve is disassembled to eliminate the leakage, all previous testing must be repeated upon re-assembly.

4. Low-pressure Closure Test (Pneumatic Seat Test):

Every valve shall be subjected to an **air seat test** at a minimum gauge pressure differential from **4 to 7 bar (60-100 psig)** according to test duration specified in **Table 2**. The test shall show no leakage through the disc, behind the seat rings or past the shaft seals. The allowable leakage of test fluid from the seat seal shall be according to those listed in **Table 3**.

Check for leakage using either a **soap film solution** or an **inverted 'U' tube** with its outlet submerged under water. If the seat pressure is held successfully then the other seat shall be tested in the same manner where applicable. If **unacceptable leakage** is found, corrective action may be taken to eliminate the leakage and the seat test repeated. If the valve is disassembled to eliminate the leakage, all previous testing must be repeated upon re-assembly.

5. Liquid for Hydrostatic Test:

Hydrostatic tests shall be carried out with water at ambient temperatures, within the range of 41°F (5°C) and 122°F (50°C) and shall contain water-soluble oil or rust inhibitors. **Potable water** used for pressure test of **austenitic stainless steel** valves shall have a **chloride content less** than **30 ppm** and for **carbon steel** valves shall be **less** than **200 ppm**.

Test Certification: All tests should be always specified by the Purchaser. The manufacturer should **issue a test certificate** according to **API 598** confirming that the valves have been tested in accordance with the requirements of this specification. Working pressure at 100 °F (38 °C):

TABLE 1 – TEST PRESSURE (ASME B 16.34 & API Std. 602 for Class 800 Valves)

Class	150#			300#		
Description / Material	CWP	Shell	Seat	CWP	Shell	Seat
	psig	Kg/cm^2	Kg/cm^2	psig	Kg/cm^2	Kg/cm^2
A105, A350-LF2	285	32	23	740	80	59
A182-F5,F9,F11,F22	290	32	23	750	80	59
A182-F304,F316	275	30	23	720	78	57
A182-F304L, F316L	230	25	20	600	64	48
Class	**600#**			**800#**		
Description / Material	CWP	Shell	Seat	CWP	Shell	Seat
	psig	Kg/cm^2	Kg/cm^2	psig	Kg/cm^2	Kg/cm^2
A105, A350-LF2	1480	157	117	1975	210	153
A182-F5,F9,F11,F22	1500	159	117	2000	211	155
A182-F304,F316	1440	153	113	1920	204	150
A182-F304L, F316L	1200	127	94	1600	169	125

TABLE 2 – TEST DURATION

NOMINAL SIZE (NPS)	MINIMUM TEST DURATIONS (Seconds)			
	Hydro Shell Test	Backseat Test	Hydro Seat Test	Air Seat Test
≤ 2″	15	15	15	15
2 ½″ – 6″	60	60	60	60
8″ – 12″	120	60	120	120
≥ 14″	300	60	120	120

TABLE 3 – MAXIMUM ALLOWABLE LEAKAGE RATES

NOMINAL SIZE (NPS)	Gate & Globe Valves		Check Valves	
	Liquid Test[a] (Drops Per Minute)	Gas Test (Bubbles Per Minute)	Liquid Test	Gas Test
≤ 2″	0 [b]	0 [c]	3 scc x NPS / minute.	700 scc x NPS / minute
2 ½″ – 6″	12	24		
8″ – 12″	20	40		
≥ 14″	d	e		

a) For the liquid test, 1 milliliter is considered equivalent to 16 drops;
b) For the liquid test, 0 drops means no visible leakage per minimum duration of the test.
c) For the gas test, 0 bubbles means less than 1 bubble per minimum duration of the test.
d) For valves greater than or equal to 14″ (NPS 14), the maximum permissible leakage rate shall be 2 drops per minute per inch NPS size.
e) For valves greater than or equal to 14″ (NPS 14), the maximum permissible leakage rate shall be 4 bubbles per minute per inch NPS size.

6. Valve Test - API 6D / IS0 14313 Requirements:

6.1. Hydrostatic Shell Test:

Hydrostatic shell testing must be performed on the fully assembled valve prior to painting. The test pressure shall be **1.5 times** the pressure rating for material at **38 °C** (100 °F). No visible leakage is permitted during the hydrostatic shell test.

Valve size (inches)	Test duration (minutes)
1/2 to 4	2
6 to 10	5
12 to 18	15
>= 20	30

6.2. Stem Backseat Test:

The backseat must be closed and a minimum pressure of **1.1 times** the pressure rating for material at **38°C** (100 °F) as specified in Table below. No visible leakage is permitted at this test pressure.

Valve size (inches)	Test Duration (minutes)
<= 4	2
>= 6	5

6.3. Hydrostatic Seat Test:

High-pressure gas seat testing may be performed for all seat tests and shall not be less than **1.1 times** the pressure rating for material at **38 °C** (100 °F).

Valve size (inches)	Test duration (minutes)
1/2 to 4	2
>= 6	5

Note: Leakage for soft-seated valves and lubricated plug valves shall not exceed **IS0 5208** Rate A (no visible leakage). For metal-seated valves the leakage rate shall not exceed IS0 5208 Rate D, except that the leakage rate during the seat test in 10.4.5.5.2 shall not be more than two times IS0 5208 Rate D unless otherwise specified.

7. Valve Test - ASME B16.34 Requirements:

Each valve shall be given a shell test at a gage pressure no less than **1.5 times** the **100°F** rating, rounded off to next higher **25 psi** increment. Tests with **water** must contain a corrosion inhibitor, with kerosene or any other suitable fluid, with a viscosity not greater than water, temperature not above **125°F**. Visually detectable leakage through pressure boundary walls shall not be acceptable.

Valve size (inches)	Test time (seconds)
2 and smaller	15
2.5 to 8	60
10 and larger	180

7.1. Valve Closure Tests:

Each valve designed for shut-off or isolation service, such as a stop valve, and each valve designed for limiting flow reversal, such as a check valve, shall be given a closure test. The test pressure shall be not less than 110% of the 100°F rating except for a gas closure test. The closure test will follow the shell test except for valves 4-inches and smaller, ratings **Class 1500** and lower. The closure test may precede the shell test, when a gas closure test is used, not less than duration shown below.

Valve size (inches)	Test duration (Seconds)
2 and smaller	15
2 1/2 to 8	30
10 to 18	60
20 and larger	120

Note: Test with gage pressure not less than 80 psi may be substituted for valve sizes and pressure classes as shown below.

Valve Size	Pressure Class
12 and smaller	400 and lower
4 and smaller	All

XVIII – SEAT LEAKAGE CLASSIFICATIONS:

There are actually six different seat leakage classifications as defined by **ANSI/FCI 70-2** (European norm equivalent standard **IEC 60534-4**). The most common used are; CLASS IV and CLASS VI.

- **CLASS IV**: Is also known as metal to metal. Leakage rate with a metal plug and metal seat.
- **CLASS VI**: Is known as soft seat. Plug and seat are made from material as Teflon or similar.

1. Class I: Identical to Class II, III, and IV in construction and design, but no shop test is made, also known as dust tight and can refer to metal or resilient seated valves.

2. Class II: For double port or balanced single port valves with a metal piston ring seal and metal to metal seats.

- 0.5% leakage of full open valve capacity;
- Service dP or 50 psid (3.4 bar differential) whichever is lower at 50 to 125 °F;
- Test medium air at 45 to 60 psig is the test fluid.

Typical constructions: Balanced, single port, single graphite piston ring, metal seat, low seat load; Balanced, double port, metal seats, high seat load

3. Class III:

- 0.1% leakage of full open valve capacity.
- Service dP or 50 psid (3.4 bar differential) whichever is lower at 50 to 125 °F.
- Test medium air at 45 to 60 psig is the test fluid.
- For the same types of valves as in Class II.

Typical constructions: Balanced, double port, soft seats, low seat load; Balanced, single port, single graphite piston ring, lapped metal seats, medium seat load

4. Class IV:

- 0.01% leakage of full open valve capacity.
- Service dP or 50 psid (3.4 bar differential), whichever is lower at 50 to 125 ^{o}F.
- Test medium air at 45 to 60 psig is the test fluid.

Typical constructions: Class IV is also known as metal to metal; balanced, single port, Teflon piston ring, lapped metal seats, medium seat load; balanced, single port, multiple graphite piston rings, lapped metal seats; unbalanced, single port, lapped metal seats, medium seat load.

5. Class V:

- Leakage is limited to *5 x* 10 ml per minute per inch of orifice diameter per psi differential.
- The test fluid is water at 100 psig or operating pressure.
- Service dP at 50 to 125 ^{o}F.
- For the same types of valves as Class IV.

Typical constructions: Unbalanced, single port; lapped metal seat, high seat load; balanced, single port, Teflon piston rings, soft seats, low seat load; unbalanced, single port, soft metal seats.

6. Class VI:

Commonly known as a soft seat classification, where the seat or shut-off disc or both are made from some material such as Teflon. Intended for resilient seating valves.

- The **test** fluid is **air or nitrogen**.
- Pressure is lesser than 50 psig or operating pressure.
- Leakage depends on valve size, from 0.15 to 6.75 ml per minute, sizes from *1* to *8 inches*.

7. Leakage Classification and Test Procedures:

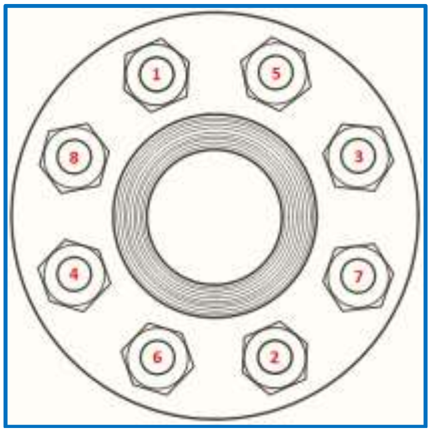
Leakage Class Designation	Maximum Leakage Allowable	Test Medium	Test Pressure	Testing Procedures Required for Establishing Rating
I	x	x	x	No test required
II	0.5% of rated capacity	Air or water at 50 - 125° F (10 - 52°C)	45 - 60 psig or maximum operating differential whichever is lower	45 - 60 psig or maximum operating differential whichever is lower
III	0.1% of rated capacity	As above	As above	As above
IV	0.01% of rated capacity	As above	As above	As above
V	0.0005 ml per minute of water per inch of port diameter per psi differential	Water at 50 to125°F (10 to 52°C)	Maximum service pressure drop across valve plug not to exceed ANSI body rating	Maximum service pressure drop across valve plug not to exceed ANSI body rating
VI	Not to exceed amounts shown in the table above	Air or nitrogen at 50 to 125° F (10 to 52°C)	50 psig or max rated differential pressure across valve plug whichever is lower	Actuator should be adjusted to operating conditions specified with full normal closing thrust applied to valve plug seat

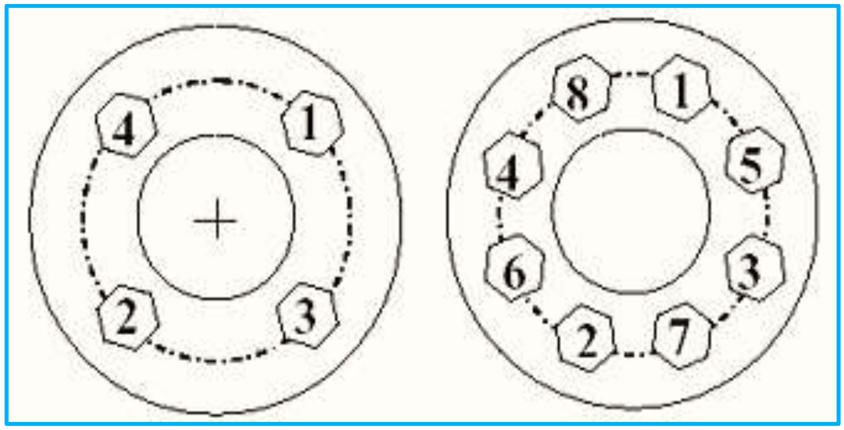
8. Bubble Shut-Off Test Procedure:

Port Diameter		Bubbles per minute	ml per minute
inches	**Millimeters**		
1	25	1	0.15
1 1/2	38	2	0.30
2	51	3	0.45
2 1/2	64	4	0.60
3	76	6	0.90
4	102	11	1.70
6	152	27	4.00
8	203	45	6.75
10	254	63	9
12	305	81	11.5

XIX – GOOD PIPING PRACTICES:

Ample space above and below the valve to permit easy removal of the actuator or valve plug for inspection and maintenance should be defined for all process procedures. Anyway, clearance distances are normally available from the valve manufacturer as certified dimension drawings. For **flanged** valve bodies, the flanges must be properly aligned to provide uniform contact of the gasket surfaces. Finish tightening them in a crisscross pattern, as indicated below. Proper flange tightening will avoid uneven gasket loading and will help prevent leaks.





1. Control Valve Maintenance

Three of the most basic approaches are:

- **Reactive** – Action is taken after an event has occurred. Wait for something to happen to a valve and then repair or replace it.
- **Preventive** – Action is taken on a timetable based on history; that is, try to prevent something bad from happening.
- **Predictive** – Action is taken based on field input using state-of-the-art, non-intrusive diagnostic test and evaluation devices or using smart instrumentation.

XX – DIAGNOSTIC DETECTION TYPES:

The advent of micro-processor based valve instruments in-service diagnostics capabilities has allowed companies to redesign their control valve maintenance work practices. More specifically, in-service diagnostics oversee:

1. Instrument Air Leakage: This diagnostic can detect both positive (supply) and negative (exhaust) air mass flow not only to detect leaks in the actuator or related tubing, but also much more difficult problems. For example, in piston actuators, the air mass flow diagnostic can detect leaking piston seals or damaged O-rings.

2. Supply Pressure: This in-service diagnostic will detect low and high supply pressure readings for adequate supply pressure to detect and quantify droop in the air supply during large travel excursions. This is particularly helpful in identifying supply line restrictions.

3. Travel Deviation and Relay Adjustment: The travel deviation diagnostic is used to monitor actuator pressure and travel deviation from setpoint and identify a stuck control valve, active interlocks, low supply pressure or shifts in travel calibration.

4. Instrument Air Quality: The I/P and relay monitoring diagnostic can identify problems such as plugging in the I/P primary or in the I/P nozzle, instrument diaphragm failures, I/P instrument O-ring failures, and I/P calibration shifts, as well, in identifying problems from contaminants in the air supply and from temperature extremes.

XXI – PROTECTION FOR INSTRUMENTS AND ELECTRIC MOTORS:

The types of protection commonly used for instruments are:

1. Dust Ignition-proof: A type of protection that excludes ignitable amounts of dust will not allow arcs, sparks or heat otherwise generated or liberated inside the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust.

2. Explosion-proof: A type of protection that utilizes an enclosure that is capable of withstanding an explosion of a gas or vapor within it and of preventing the ignition of an explosive gas or vapor that may surround it.

3. Intrinsically Safe: A type of protection in which the electrical equipment under normal or abnormal conditions is incapable of releasing sufficient electrical or thermal energy to cause ignition of a specific hazardous atmospheric mixture.

4. Non-Incendive: A type of protection in which the equipment is incapable, under normal conditions, of causing ignition of a specified flammable gas or vapor-in-air mixture due to arcing or thermal effect.

5. Hazardous Location Classification:

Hazardous areas procedures are classified by **class, division, and group**. The method was introduced into the **1996** edition of the **NEC** as an alternate method, but it is not yet in use. **Zone** method is common in Europe and most other countries.

1. Class: Defines the general nature of the hazardous material in the surrounding atmosphere.

a. Class I. Locations in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures.

b. Class II. Locations that are hazardous because of the presence of combustible dusts.

c. Class III. Locations in which easily ignitable fibers or flyings may be present but not likely to be in suspension in sufficient quantities to product ignitable mixtures.

2. Division: The Division defines the probability of hazardous material being present in an ignitable concentration in the surrounding atmosphere.

a. Division 1: Locations in which the probability of the atmosphere being hazardous is high due to flammable material being present continuously, intermittently, or periodically.

b. Division 2: Locations that are presumed to be hazardous only in an abnormal situation.

3. Group: The Group defines the hazardous material in the surrounding atmosphere.

The specific hazardous materials within each group and their automatic ignition temperatures can be found in Article 500 of the NEC and in NFPA 497M. Groups A, B, C and D apply to Class I, and Groups E, F and G apply to Class II locations. The following definitions are from NEC:

a. Group A: Atmospheres containing acetylene.

b. Group B: Atmospheres containing hydrogen, fuel and combustible process gases containing more than 30 percent hydrogen by volume, or gases or vapors of equivalent hazard such as butadiene, ethylene oxide, propylene oxide, and acrolein.

c. Group C: Atmospheres such as ethyl ether, ethylene, or gases or vapors of equivalent hazard.

d. Group D: Atmospheres such as acetone, ammonia, benzene, butane, cyclopropane, ethanol, gasoline, hexane, methanol, methane, natural gas, naphtha, propane, or gases or vapors of equivalent hazard.

e. Group E: Atmospheres containing combustible metal dusts, including aluminum, magnesium, and their commercial alloy, or other combustible dusts whose particle size, abrasiveness, and conductivity present similar hazards in the use of electrical equipment.

f. Group F: Atmospheres containing combustible carbonaceous dusts, including carbon black, charcoal, coal, or dusts that have been sensitized by other materials so that they present an explosion hazard.

g. Group G: Atmospheres containing combustible dusts not included in Group E or F, including flour, grain, wood, plastic, and chemicals.

6. Temperature Codes:

A mixture of hazardous gases and air may be ignited by coming into contact with a hot surface. The conditions under which a hot surface will ignite, depend on surface area, temperature and gas concentration. Tested equipment indicates the maximum surface temperature, as shown below:

Class 1	Division 1	Groups ABCD	T4
Hazard Type	Area Classification	Gas or Dust Group	Temperature Code

North American Temperature Codes

TEMPER-ATURE CODE	MAXIMUM SURFACE TEMPERATURE	
	°C	°F
T1	450	842
T2	300	572
T2A	280	536
T2B	260	500
T2C	230	446
T2D	215	419
T3	200	392
T3A	180	356
T3B	165	329
T3C	160	320
T4	135	275
T4A	120	248
T5	100	212
T6	85	185

Note: The **NEC** states that any equipment that does not exceed a maximum surface temperature of 100 °C (212 °F) is not required to be marked with the temperature code. Therefore, when a temperature **code is not specified**, it is assumed to be **T5**.

7. NEMA Enclosure Rating:

Enclosures may be tested to determine their ability to prevent the ingress of liquids and dusts. In the United States, equipment is tested to NEMA 250. Some of the more common enclosure ratings, defined in **NEMA 250**, are as follows.

a. Type 3R (Rain-proof, Ice-resistance, Outdoor enclosure): Intended for outdoor use primarily to provide a degree of protection against rain, sleet, and damage from external ice formation.

b. Type 3S (Dust-tight, Rain-tight, Ice-proof, Outdoor enclosure): Intended for outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust, and to provide for operation of external mechanisms, as ice.

c. Type 4 (Water-tight, Dust-tight, Ice-resistant, Indoor or outdoor enclosure): Intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.

d. Type 4X (Water-tight, Dust-tight, corrosion resistant, Indoor or outdoor enclosure): Intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water, and damage from external ice formation.

7.1 Hazardous Locations: Two of the four enclosure ratings for hazardous (classified) locations are described as follows in NEMA 250:

a. Type 7 (Class I, Division 1, Group A, B, C or D, Indoor hazardous location, Enclosure): For indoor use in locations classified as Class I, Division 1, Groups A, B, C or D as defined in the NEC and shall be marked to show class, division, and group. Capable of withstanding the pressures resulting from an internal explosion of specified gases.

b. Type 9 (Class II, Division 1, Groups E, F or G, Indoor hazardous location, Enclosure): Intended for use in indoor locations classified as Class II, Division 1, Groups E, F and G as defined in the NEC and shall be marked to show class, division, and group. Enclosures shall be capable of preventing the entrance of dust.

8. NEMA and IEC Enclosure Rating Comparison:

The following table provides an equivalent conversion from **NEMA** to **IEC IP** designations. The NEMA types meet or exceed the test requirements for the associated IEC classifications.

IEC Temperature Codes

TEMPERATURE CODE	MAXIMUM SURFACE TEMPERATURE	
	°C	°F
T1	450	842
T2	300	572
T3	200	392
T4	135	275
T5	100	212
T6	85	185

Conversion of NEMA Types to IEC IP Codes

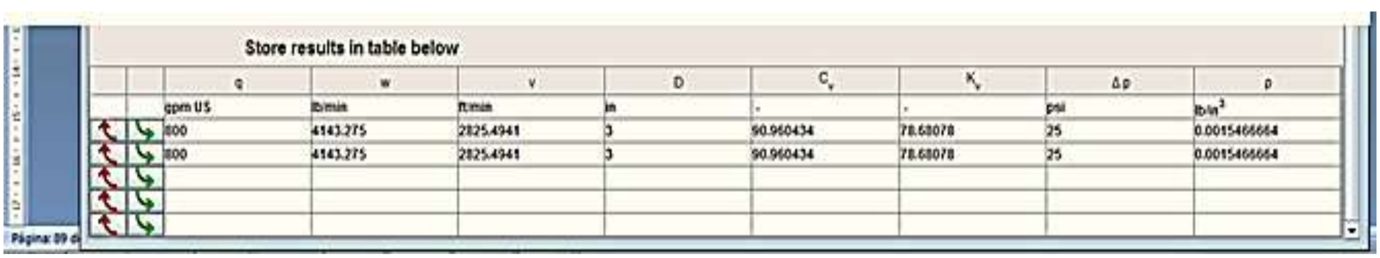
NEMA Type	IEC IP
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP65

Ingress Protection (IP) Codes

First Numeral Protection against solid bodies	Second Numeral Protection against liquid
0 No protection	0 No protection
1 Objects greater than 50 mm	1 Vertically dripping water
2 Objects greater than 12.5 mm	2 Angled dripping water (75° to 90°)
3 Objects greater than 2.5 mm	3 Sprayed water
4 Objects greater than 1.0 mm	4 Splashed water
5 Dust-protected	5 Jetting
6 Dust-tight	6 Powerful jetting
- -	7 Temporary immersion
- -	8 Permanent immersion

See the excellent page - **http://www.pipeflowcalculations.com/controlvalve** - shown as below, where the student can make a lot of training exercises:

The searched results are shown simply choosing the Report tab (above) or shown as table (below):


Store results in table below

q	w	v	D	C_v	K_v	Δp	ρ
gpm US	lb/min	ft/min	in	-	-	psi	lb/in³
800	4143.275	2825.4941	3	90.960434	78.68078	25	0.0015466664
800	4143.275	2825.4941	3	90.960434	78.68078	25	0.0015466664

Volume Equivalents

Note: Use Multiplier at Convergence of Row and Column	Cubic Deci-meters (Liters)	Cubic Inches	Cubic Feet	U.S. Quart	U.S. Gallon	Imperial Gallon	U.S. Barrel (Petro-leum)
Cubic Decimeters (Liters)	1	61.0234	0.03531	1.05668	0.264178	0.220083	0.00629
Cubic Inches	0.01639	1	5.787×10^{-4}	0.01732	0.004329	0.003606	0.000103
Cubic Feet	28.317	1728	1	29.9221	7.48055	6.22888	0.1781
U.S. Quart	0.94636	57.75	0.03342	1	0.25	0.2082	0.00595
U.S. Gallon	3.78543	231	0.13368	4	1	0.833	0.02381
Imperial Gallon	4.54374	277.274	0.16054	4.80128	1.20032	1	0.02877
U.S. Barrel (Petroleum)	158.98	9702	5.6146	168	42	34.973	1

1 cubic meter = 1,000,000 cubic centimeters.
1 liter = 1000 milliliters = 1000 cubic centimeters.

Volume Rate Equivalents

Note: Use Multiplier at Convergence of Row and Column	Liters Per Minute	Cubic Meters Per Hour	Cubic Feet Per Hour	Liters Per Hour	U.S. Gallon Per Minute.	U.S. Barrel Per Day
Liters Per Minute	1	0.06	2.1189	60	0.264178	9.057
Cubic Meters Per Hour	16.667	1	35.314	1000	4.403	151
Cubic Feet Per Hour	0.4719	0.028317	1	28.317	0.1247	4.2746
Liters Per Hour	0.016667	0.001	0.035314	1	0.004403	0.151
U.S. Gallon Per Minute	3.785	0.2273	8.0208	227.3	1	34.28
U.S. Barrel Per Day	0.1104	0.006624	0.23394	6.624	0.02917	1

References:

- Emerson Process Management, Control Valve Handbook, 4th Edition, 2005;
- Parcol S.p.A, Handbook for Control Valve Sizing, Bulletin 1-l, 2009;
- Dresser-Masoneilan, Control Valve Sizing Handbook, Bulletin OZ1000, 2004;
- ISA-75.01.01, Flow Equations for Sizing Control Valves, 2007;
- API 598, Valve Test Procedures;
- Enbridge Energy, Valve Specification EES105, 2006;
- Zatoni, Celio Carlos, Materiais para Tubulação, FATEC/SP, 2008
- www.pipeflowcalculations.com
- www.engineeringtoolbox.com