Pipelines & Fittings

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Main Topics

1. Piping difination and types.
2. Piping size and wall thickness.
3. Piping classification.
4. piping componemts.
5. Piping expansion.
6. Piping support.
7. Pipe anchor and gauides.

Main Topics

8. **Pipeline introduction and terms.**
9. **Pipeline layout.**
10. **Pipeline design.**
11. **Pipeline pressure drop calculation.**
12. **Pipieline corrosion types and protection.**
13. **Pipeline pigging.**

Introduction

- Piping systems are like arteries and veins. hey carry the lifeblood of modern civilization. In a modern city they transport water from the sources of water supply to the points of distribution; convey waste from residential and commercial buildings and other civic facilities to the treatment facility or the point of discharge. Similarly, pipelines carry crude oil from oil wells to tank farms for storage or to refineries for processing. The natural gas transportation and distribution lines convey natural gas from the source and storage tank forms to points of utilization, such as power plants, industrial facilities, and commercial and residential communities. In chemical plants, paper mills, food processing plants, and other similar industrial establishments, the piping systems are utilized to carry liquids, chemicals, mixtures, gases, vapors, and solids from one location to another.

- **Pipe definition:**
- Pipe is a tube with round cross section conforming to the dimensional requirements of:
- ✓ ASME B36.10 M Welded and Seamless - Wrought Steel Pipe.
- ✓ ASME B36.19 M Stainless Steel Pipe.

- **Piping types according to the fabrication materials:**

A. **Metallic piping:** like the carbon steel, stainless steel, cast iron, malleable iron, brass, copper, cast steel, forged steel, and wrought steel.
B. **Non metallic pipes:** like the plastic piping, ceramic piping, fiber glass piping, Asbestos- cement piping, PVC.

- Metallic piping types according to manufacturing method:

1. **Seamless pipe:**

- Pipe produced by piercing a billet followed by rolling or drawing, or both.

2. Spiral welded pipe:

- Pipe having a helical seam with either a butt, lap, or lock-seam joint which is welded using either an electrical resistance, electric fusion or double-submerged arc welding process.

❑Non metallic flow lines advantages:

- Corrosion resistance.
- Reduction of paraffin and scale build up.
- Less resistance to flow.

❑Non metallic flow lines disadvantages:

- Temperature effecting thermal expansion.

- **Pipe size:**
- The systems describing the pipe size:

1. Iron pipe size (IPS):

- It is a system was established to designate the pipe size.
- The size represented the approximate inside diameter of the pipe in inches so an IPS 6 pipe is one whose inside diameter is approximately 6 inches.
- Each pipe size was produced to have one thickness, which later was termed as standard (STD) or standard weight (STD. WT.) and The outside diameter of the pipe was standardized.
- As the industrial requirements demanded the handling of higher-pressure fluids, pipes were produced having thicker walls, which came to be known as extra strong (XS) or extra heavy (XH), double extra strong (XXS) or double extra heavy (XXH) walls while the standardized outside diameters are unchanged.

2. Nominal Pipe Size (NPS):

- It is a dimensionless designator of pipe size which indicates standard pipe size when followed by the specific size designation number without an inch symbol.
- The nominal pipe size (NPS) replaced IPS, and the term schedule (SCH) was invented to specify the nominal wall thickness of pipe, for example, NPS 2 indicates a pipe whose outside diameter is 2.375 inch.
- The NPS 12 and smaller pipe has outside diameter greater than the nominal diameter .
- The NPS 14 and larger pipe ,here the outside diameter is the same of nominal diameter, for example, NPS 14 pipe has an outside diameter equal to 14 inches.
- The inside diameter will depend upon the pipe wall thickness specified by the schedule number.

3. Diameter nominal (DN):

- It is a dimensionless designator of pipe size in the metric unit system, developed by the International Standards Organization (ISO) which indicates standard pipe size when followed by the specific size designation number.

TABLE A1.1 Pipe Size Designators: NPS and DN

NPS	DN	NPS	DN	NPS	DN	NPS	DN
⅛	6	3½	90	22	550	44	1100
¼	8	4	100	24	600	48	1200
¾	10	5	125	26	650	52	1300
½	15	6	150	28	700	56	1400
¾	20	8	200	30	750	60	1500
1	25	10	250	32	800	64	1600
1¼	32	12	300	34	850	68	1700
1½	40	14	350	36	900	72	1800
2	50	16	400	38	950	76	1900
2½	65	18	450	40	1000	80	2000
3	80	20	500	42	1050	—	—

Notes:

1. For sizes larger than NPS 80, determine the DN equivalent by multiplying NPS size designation number by 25.

without a millimeter symbol. For example, DN 50 is the equivalent designation of NPS 2. Refer to Table A1.1 for NPS and DN pipe size equivalents.

➢ **Pipe wall thickness:**

- Schedule is expressed in numbers (5, 5S, 10, 10S, 20, 20S, 30, 40, 40S, 60, 80, 80S, 100, 120, 140, 160).
- A schedule number indicates the approximate value of the expression 1000 P/S, where P is the service pressure and S is the allowable stress, both expressed in pounds per square inch (psi).
- The higher the schedule number, the thicker the pipe is.
- The outside diameter of each pipe size is standardized. Therefore, a particular nominal pipe size will have a different inside diameter depending upon the schedule number specified.

Nominal Bore 1/2 inch (DN 15 mm), Outside Diameter 21.34 mm

Schedule	Sch. 5	Sch. 10	STD	XS	Sch. 160	XXS
Wall Thickness (mm)	1.65	2.11	2.77	3.73	4.78	7.47
Internal Diameter (mm)	18.04	17.12	15.80	13.90	11.78	6.40

Schedule 40 has same dimensions as STD. Schedule 80 has same dimensions as XS.

- The nominal wall thickness of NPS 10 and smaller schedule 40 pipe is same as that of STD. WT. pipe. Also, NPS 8 and smaller schedule 80 pipe has the same wall thickness as XS pipe.
- The schedule numbers followed by the letter S are per ASME B36.19M, and they are primarily intended for use with stainless steel pipe.
- The pipe wall thickness specified by a schedule number followed by the letter S may or may not be the same as that specified by a schedule number without the letter S.

➢ Piping classification:

- It is usual industry practice to classify the pipe in accordance with **the pressure - temperature** rating system used for classifying flanges.

TABLE A1.2 Piping Class Ratings Based on ASME B16.5 and Corresponding PN Designators

Class	150	300	400	600	900	1500	2500
PN	20	50	68	110	150	260	420

Notes:

1. Pressure-temperature ratings of different classes vary with the temperature and the material of construction.

2 For pressure-temperature ratings, refer to tables in ASME B16.5, or ASME B16.34.

- However, it is not essential that piping be classified as Class 150, 300, 400, 600, 900, 1500, and 2500.
- The piping rating must be governed by the pressure-temperature rating of the weakest pressure containing item in the piping.
- The weakest item in a piping system may be a fitting made of weaker material or rated lower due to design and other considerations.

Pressure nominal(PN):

- Pression nominal (PN) is the rating designator followed by a designation number, which indicates the approximate pressure rating in bars.

TABLE A2.4 Pressure-Temperature Rating for Classes 125 and 250 Cast-Bronze Threaded Fittings (ANSI/ASME B16.15-1985)*

Temperature (°F)	Class 125 (psi)	Class 250 (psi)
−20 to 150	200	400
200	190	385
250	180	365
300	165	335
350	150	300
400	125	250

* Ratings are independent of the contained fluid.

- **Piping components:**
- Designed and manufactured in accordance several industry standards including API, ASTM, ANSI/ASME and Manufacturer’s Standardization Society (MSS)which used for large-diameter pipeline fittings/flanges).

1. Tees.
2. Elbows.
3. Reducers.
4. Laterals.
5. Cross.
6. Couplings.
7. Caps.
8. Flanges.
9. Gaskets.
10. Bolting.
11. Valves.

1. **Tees:**

Straight Tee

Reducing Outlet Tee

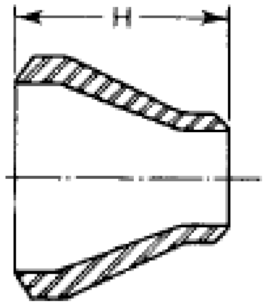
2. **Elbows:**

45 ° Long Radius

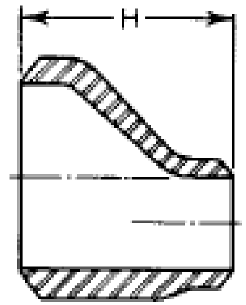
90 ° Long Radius

Return elbow

3. Reducers:

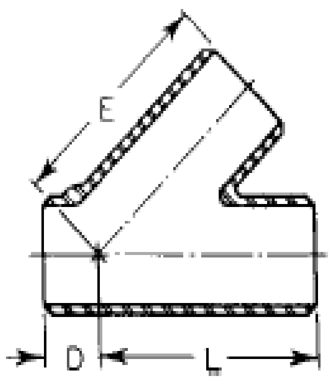


Concentric



Eccentric

4. Laterals:



5. Flanges:

➢ Definition:

- Flanges are fittings required for bolted pipe connections.

➢ Types and applications:

1. loose-type.
2. Integral-type.
3. Optional-type.

1. Loose type :

- They covers those designs in which the flange has no direct connection to the nozzle neck or the vessel or pipe wall and those designs where the method of attachment is not considered to give the mechanical strength equivalent of integral attachment.
- Used for low pressure application only.

2. Integral-Type Flanges:

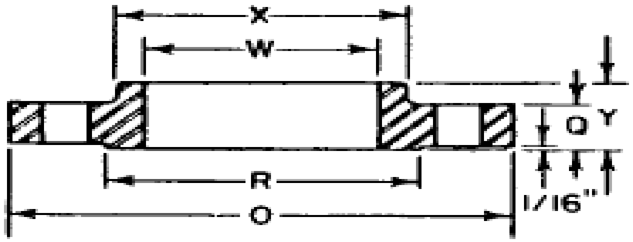
- This type covers designs in which the flange is cast or forged integrally with the nozzle neck or the vessel or pipe wall, butt-welded thereto, or attached by other forms of arc or gas welding of such a nature that the flange and nozzle neck or vessel or pipe wall is considered to be the equivalent of an integral structure. In welded construction, the nozzle neck or the vessel or pipe wall is considered to act as a hub.

3. Optional-Type Flanges:

- This type covers designs where the attachment of the flange to the nozzle neck or the vessel or pipe wall is such that the assembly is considered to act as a unit, which shall be calculated as an integral flange, except that for simplicity the designer may calculate the construction as a loose-type flange, provided that stipulated load values are not exceeded.

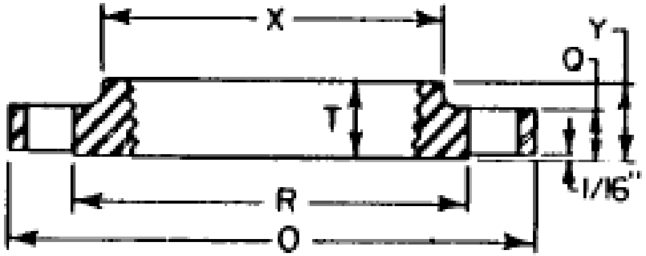
1. Slip-on:

- This flange is slipped over the pipe and then fillet welded. Slip-on flanges are easy to use in fabricated applications.



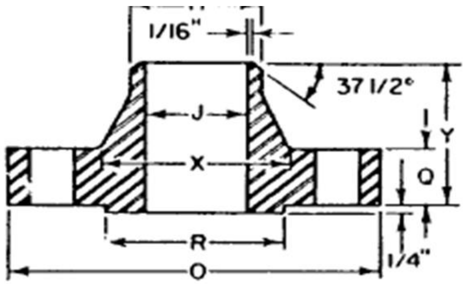
2. Threaded neck:

- This flange is referred to as either threaded or screwed. It is used to connect other threaded components in low pressure, non-critical applications. No welding is required.



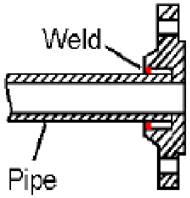
3. Weld neck:

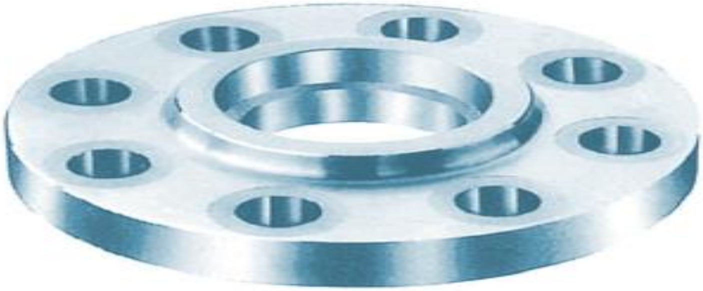
- Weld-neck flanges are typically better in the higher-pressure oil and gas and pipeline applications.



4. Socket weld:

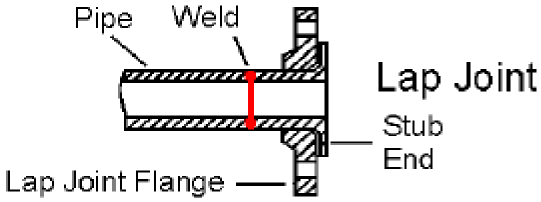
- This flange is counter bored to accept the pipe before being fillet welded. The bore of the pipe and flange are both the same therefore giving good flow characteristics.





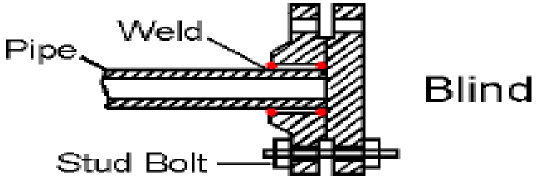
5. Lap joint flange:

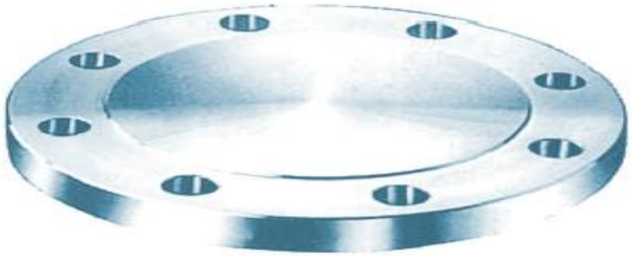
- These flanges are always used with either a stub end or taft which is butt welded to the pipe with the flange loose behind it.
- Used for low pressure applications.



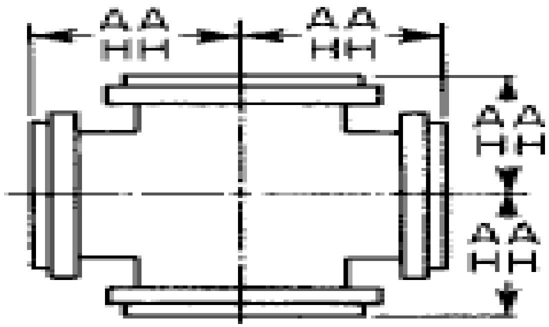
6. Blind flange:

- This flange is used to blank off pipelines, valves and pumps, it can also be used as an inspection cover. It is sometimes referred to as a blanking flange.

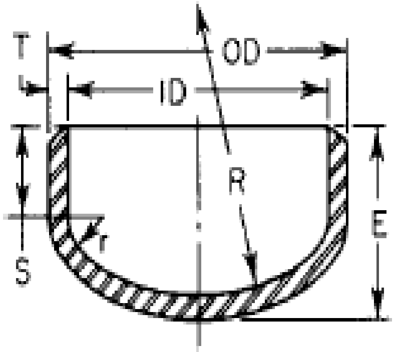




6. Cross:



7. Caps:



8. Gaskets:

- On normal process applications, three basic gasket types are used, sheet, spiral wound and solid metal.

1. Sheet Gaskets:

- Are normally limited to utility service type duties and low pressure hydrocarbon service (ANS class 150, sometimes class 300).

2. Spiral Wound Gaskets:

- Are the main gaskets used for piping class 300 and over.
- They are made up from chevron shaped steel (normally stainless steel) strip which is wound spirally, with CAF or graphite as a filler material, the whole secured by an outer (and sometimes an inner) steel guide ring.
- Spiral wound gaskets are flexible, while the fluid pressure assists in the sealing performance.

3. Solid Metal Ring Joint Gaskets:

- Are used on the wellhead and subsea piping applications.
- They are very rugged, reliable and tolerant to misalignment and localized minor damage.
- Their use in process facilities is often limited by the difficulty of removing or replacing equipment, due to the large separation distances required to extract the gaskets.

TABLE A2.19 Selections of Gasket Materials for Different Services

Fluid	Application	Gasket material*
Steam (high pressure)	Temp up to 1000°F (538°C)	Spiral-wound comp. asbestos or graphite
	Temp up to 1000°F (538°C)	Steel, corrugated, or plain
	Temp up to 1000°F (538°C)	Monel, corrugated, or plain
	Temp up to 1000°F (538°C)	Hydrogen-annealed furniture iron
	Temp up to 1000°F (538°C)	Stainless steel 12 to 14 percent chromium, corrugated
	Temp up to 1000°F (538°C)	Ingot iron, special ring-type joint
	Temp up to 750°F (399°C)	Comp. asbestos, spiral-wound
	Temp up to 600°F (316°C)	Woven asbestos, metal asbestos
	Temp up to 600°F (316°C)	Copper, corrugated or plain
Steam (low pressure)	Temp up to 220°F (105°C)	Red rubber, wire inserted
Water	Hot, medium, and high pressures	Black rubber, red rubber, wire in-serted
	Hot, low pressures	Brown rubber, cloth inserted
	Hot	Comp. asbestos
Water	Cold	Red rubber, wire inserted
	Cold	Black rubber
	Cold	Soft rubber
	Cold	Asbestos
	Cold	Brown rubber, cloth inserted
Oils (hot)	Temp up to 750°F (399°C)	Comp. asbestos
	Temp up to 1000°F (538°C)	Ingot iron, special ring-type joint
Oils (cold)	Temp up to 212°F (100°C)	Cork or vegetable fiber
	Temp up to 300°F (149°C)	Neoprene comp. asbestos

Air	Temp up to 750°F (399°C)	Comp. asbestos
	Temp up to 220°F (105°C)	Red rubber
	Temp up to 1000°F (538°C)	Spiral-wound comp. asbestos
Gas	Temp up to 1000°F (538°C)	Asbestos, metallic
	Temp up to 750°F (399°C)	Comp. asbestos
	Temp up to 600°F (316°C)	Woven asbestos
	Temp up to 220°F (105°C)	Red rubber
Acids	(Varies; see section on corrosion)	Sheet lead or alloy steel
	Hot or cold mineral acids	Comp. blue asbestos
		Woven blue asbestos
Ammonia	Temp up to 1000°F (538°C)	Asbestos, metallic
	Temp up to 700°F (371°C)	Comp. asbestos
	Weak solutions	Red rubber
	Hot	Thin asbestos
	Cold	Sheet lead

* Several gasket manufacturers have introduced nonasbestos, nonmetallic gasket materials for use in high-temperature service. These materials are proprietary, and therefore the manufacturers should be consulted for specific applications.

9. Bolting & Bolts:

- The choice of bolting materials for flanged joints requires careful consideration.

- Parameters influencing the choice are strength over the design temperature range, thermal expansion, ductility (for low temperature applications), and galvanic attack between materials.

- Bolts and nuts should be protected from corrosion; current methods include cadmium plating, hot dip galvanizing and resin coating.

10.Valves:

- **Definition:**

- They are mechanical devices for the control, interruption or complete shut-off of the flow through pipe systems.
- They are available in a large variety of types and styles.

- **Classification:**

A. According to the function:

1. On-off service.
2. Throttling or flow control.
3. Prevention of reverse flow.
4. Directional flow control.
5. Pressure control.

B. According to mechanical motion:

1. Linear Motion Valves:

- The valves closure member moves in a straight line to allow, stop, or throttle the flow(Gate , Globe , Lift check valve, In-line check valve, Stop check valve, Pinch valve, Diaphragm valve, Safety valve, Relief valve).

2. Rotary Motion Valves:

- When the valve-closure member travels along an angular or circular path(Butterfly , Ball , Plug , Swing check valve, Stop check valve, Folding-disc check valve, Tilting-disc check valve).

3. Quarter Turn Valves:

- Some rotary motion valves require approximately a quarter turn, 0° through 90°, motion of the stem to go to fully open from a fully closed position or vice versa(Ball valve, Butterfly , Plug).

- **Valve components:**

A. Pressure Retaining Parts:

1. Body:

- The valve body houses the internal valve parts and provides the passage for fluid flow.

2. Bonnet or Cover:

- The bonnet or cover is fastened to the valve body to complete the pressure-retaining shell.

3. Disc:

- The disc is the part which allows, throttles, or stops flow, depending on its position.

4. Valve Trim:

- The removable and replaceable valve internal parts that come in contact with the flow medium.
- These parts include:
  1. Valve seat.
  2. Disc.
  3. Glands.
  4. Spacers.
  5. Guides.
  6. Bushings.
  7. internal springs.

B. Non-Pressure Retaining Parts:

1. Valve seat.
2. Stem.
3. Yoke.
4. Packing.
5. Gland bolting.
6. Bushings.
7. Hand wheel.
8. Valve actuators.

➢ Valve types ,Advantage and Disadvantages for each type:

1. Gate Valve:

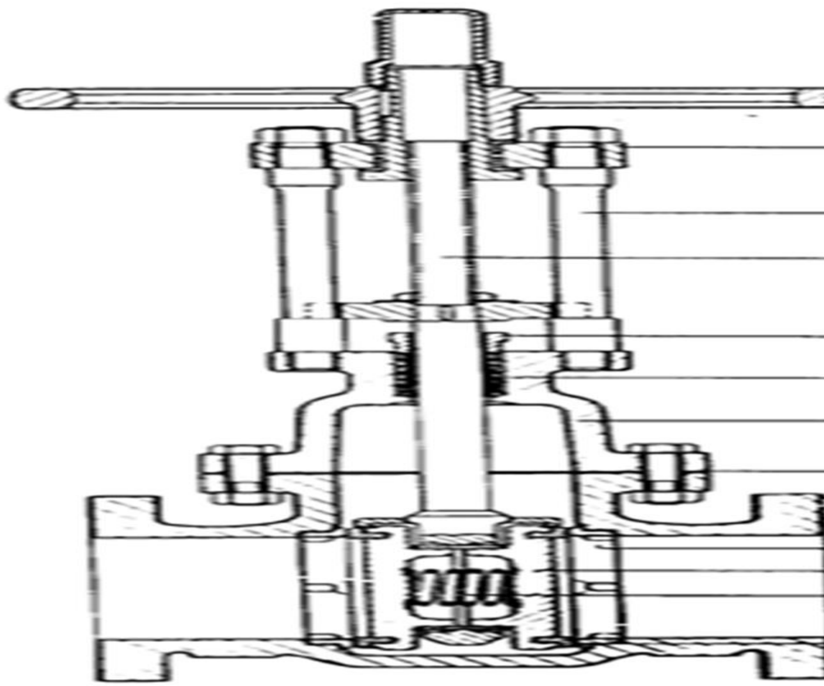
- *Function:*
- Used for isolation as they are either fully open or fully closed.
- *Advantages:*

1. They have good shutoff characteristics.
2. They are bidirectional.
3. The pressure loss through the valve is minimal.

- *Disadvantages:*

1. Gate valves are not quick opening or closing valves. Full-stem travel to open or close a gate valve requires many turns of its hand wheel or an actuator.
2. Gate valves require large space envelope for installation, operation, and maintenance.
3. The slow movement of the disc near the full-closed position results in high-fluid velocities, causing scoring of seating surfaces, referred to as wire drawing. It also causes galling of sliding parts.

4. Some designs of gate valves are susceptible to thermal or pressure binding, depending upon the application.
5. In systems experiencing high-temperature fluctuations, wedge-gate valves may have excessive leakage past the seats due to changes in the angular relationship between the wedge and the valve seats caused by piping loads on the valve ends.
6. Repair or machining of valve seats in place is difficult.



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- *Gate Valve Applications:*

1. Socket or butt-welding end-gate valves in air, fuel gas, feed water, steam, lube oil, and other systems are typical applications.
2. Threaded-end gate valves may be used in air, gaseous, or liquid systems.
3. Flanged gate valves used in low-pressure and low-temperature systems such as fire protection systems' water piping or water distribution pipelines.

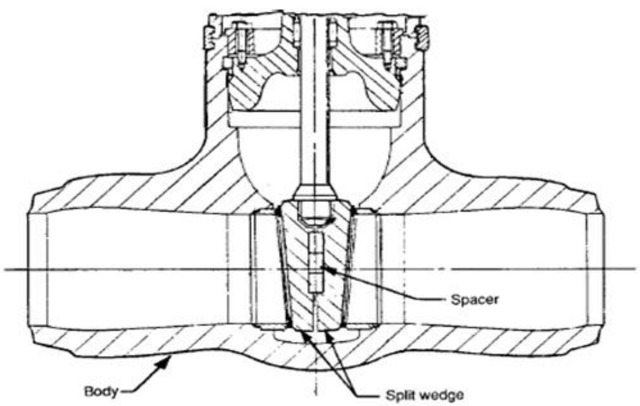


FIGURE A10.6 Split-wedge gate valve.

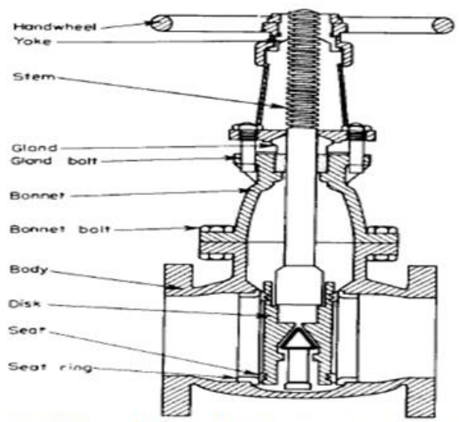


FIGURE A10.7a Double-disc rising-stem flanged-end gate valve for 150-psig service.

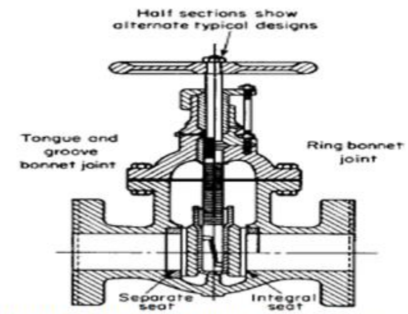


FIGURE A10.7b Double-disc nonrising-stem gate valve.

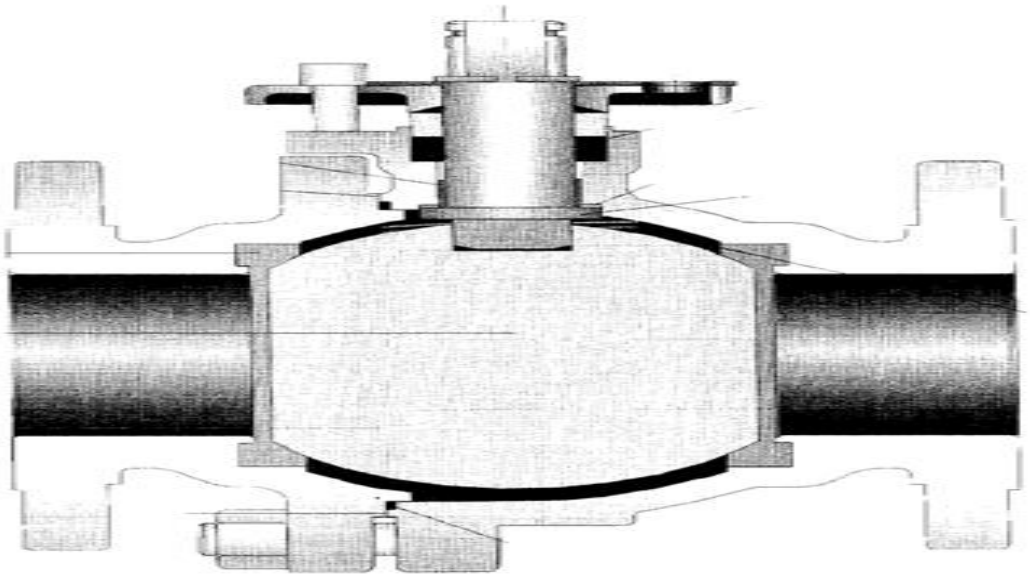
2. Ball Valves:

A. Floating Ball Valves:

- In this type of valve, the ball has some freedom to move along the axis of the valve while being prevented from rotating against the stem.

❖ *Function:*

- Isolation valves.

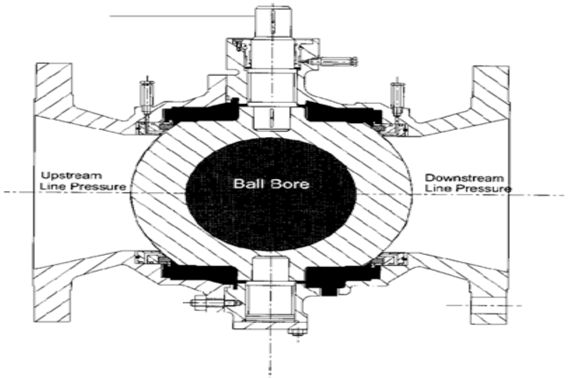


B. Trunnion Mounted Ball Valve:

- The ball is held in a fixed axial position by upper and lower stems (Trunnions) and can move a rotational mode.

❖ *Function:*

- Isolation valves.



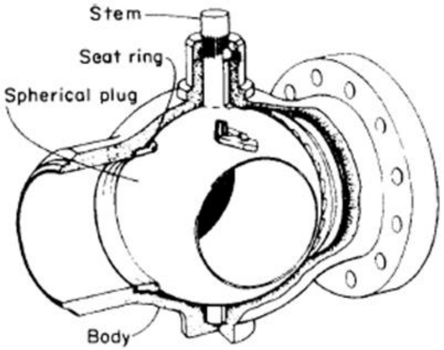


FIGURE A10.20 Ball valve in closed position.

❖ *Advantages of Ball Valves:*

1. Provides bubble-tight service.
2. Quick to open and close.
3. Smaller in size than a gate valve.
4. Lighter in weight than a gate valve.
5. Multiport design offers versatility not available with gate or globe valves. It reduces the number of valves required.
6. Several designs of ball valves offer flexibility of selection.

7. Can be used in clean and slurry applications.
8. High-quality ball valves provide reliable service in high-pressure and high-temperature applications.
9. Force required to actuate the valve is smaller than that required for a gate or a globe valve.

- *Disadvantages of Ball Valves:*

1. They are not suitable for sustained throttling applications.
2. In slurry or other applications, the suspended particles can settle and become trapped in body cavities causing wear, leakage, or valve failure.

- *Typical Applications of Ball Valves:*

1. Air, gaseous, and liquid applications requiring bubble-tight service.
2. Low-point drains and high-point vents in liquid, gaseous, and other fluid services.
3. Instrument root valves.
4. Cooling water and feed water systems.
5. Steam service.

3. Globe Valves:

- Functions:

1. Isolation.
2. Throttling.

- Types:

1. Tee Pattern.
2. Wye Pattern.
3. Angle Pattern.

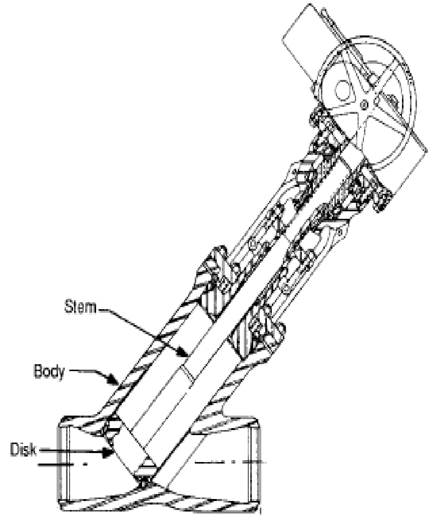


FIGURE A10.9 Large wye-pattern globe valve (with gear actuator).

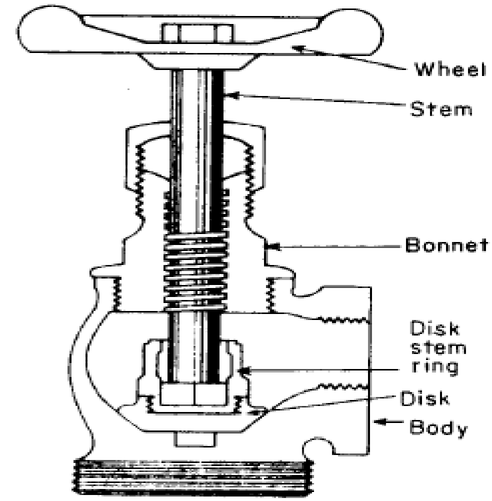
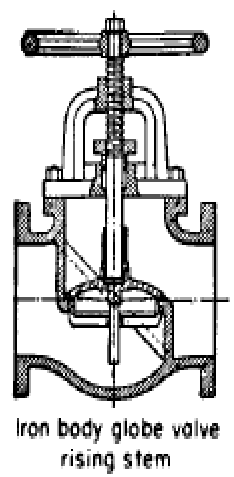


FIGURE A10.10 Angle globe valve with screwed ends.



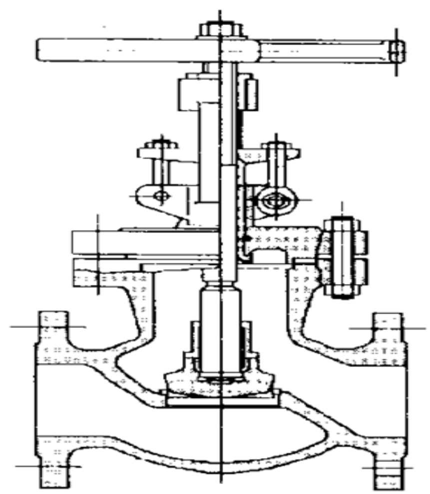


FIGURE A10.11 A typical large globe valve with flanged ends.

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- Advantages of a Globe Valve:

1. Good shutoff capability.
2. Moderate to good throttling capability.
3. Shorter stroke (compared to a gate valve).
4. Available in tee, wye, and angle patterns, each offering unique capabilities.
5. Easy to machine or resurface the seats.
6. With disc not attached to the stem, valve can be used as a stop-check valve.

- Disadvantages of a Globe Valve:

1. Higher pressure drop (compared to a gate valve).
2. Requires greater force or a larger actuator to seat the valve (with pressure under the seat).
3. Throttling flow under the seat and shutoff flow over the seat.

- Typical Applications of Globe Valves:

1. Cooling water systems where flow needs to be regulated.
2. Fuel oil system where flow is regulated and leak tightness is of importance.
3. High-point vents and low-point drains when leak tightness and safety are major considerations.
4. Feed water, chemical feed, condenser air extraction, and extraction drain systems.
5. Boiler vents and drains, main steam vents and drains, and heater drains.
6. Turbine seals and drains.
7. Turbine lube oil system and others.

4. Needle Valves:

❑ Function:

- Needle valves generally are used for instrument, gauge, and meter line service.

❑ Advantage:

- Very accurate throttling is possible with needle valves and, therefore, they are extensively used in applications that involve high pressures and/or high temperatures.

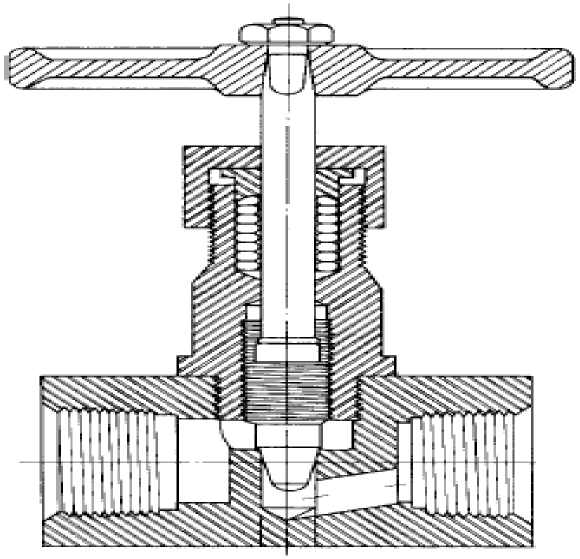


FIGURE A10.12 Needle valve for accurate throttling of flow.

5. Check Valves:

❑ Function:

- Check valves are designed to pass the flow in one direction with minimum resistance & prevent the backflow with minimal leakage.

❑ Types:

1. Tee-pattern lift check.
2. Wye-pattern lift check.
3. Swing check.
4. Tilting-disc check.
5. Folding Disc Check Valves.
6. Vertical or In-Line Check Valve.
7. Stop Check Valve.
8. Ball check.

❑ Advantages of Check Valves:

- They are self-actuated and require no external means to actuate the valve either to open or close. They are fast acting.

❑ Disadvantages of Check Valves:

1. Since all moving parts are enclosed, it is difficult to determine whether the valve is open or closed. Furthermore, the condition of internal parts cannot be assessed.
2. Each type of check valve has limitations on its installation configurations.
3. Valve disc can stick in open position.

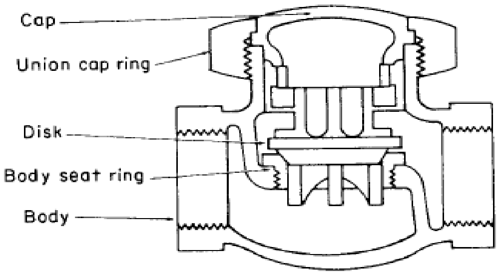


FIGURE A10.13 Lift check valve.

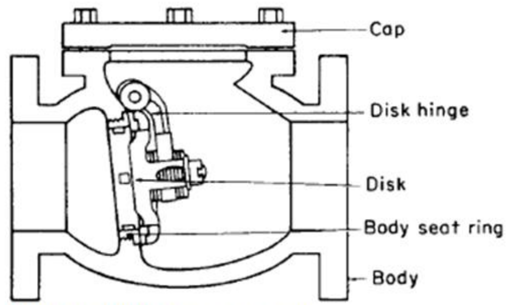


FIGURE A10.14 Swing check valve.

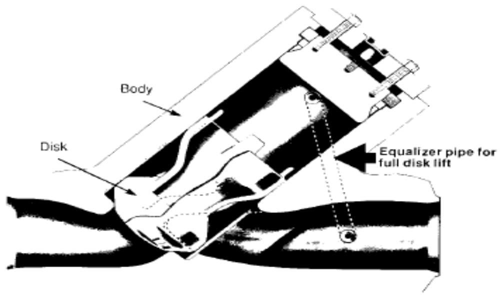


FIGURE A10.16 Wye-pattern lift check valve. (*Courtesy, BTR Inc./ Edward Valve*)

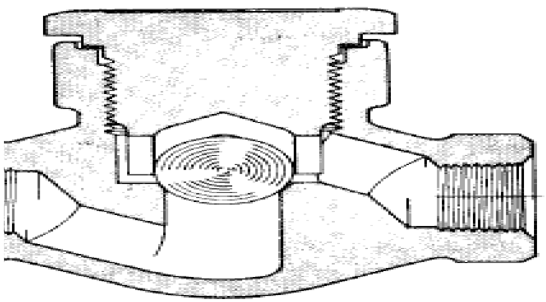


FIGURE A10.17 Ball check valve.

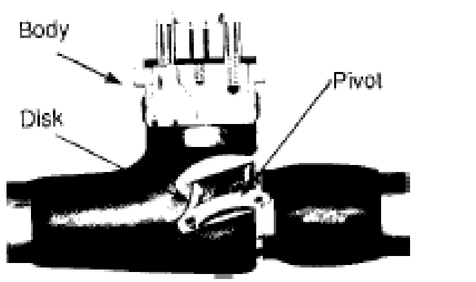


FIGURE A10.15 Tilting-disc check valve. (*Courtesy BTR Inc./Edward Valve*)

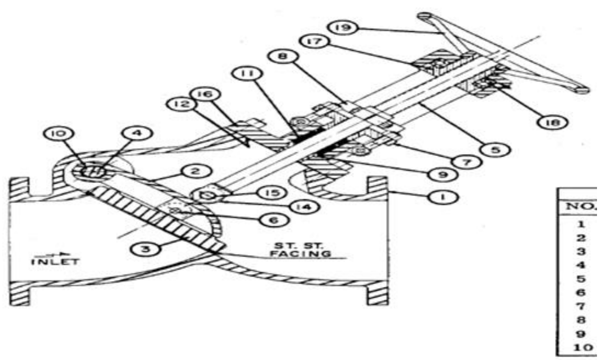


FIGURE A10.19a Swing-disc stop check.

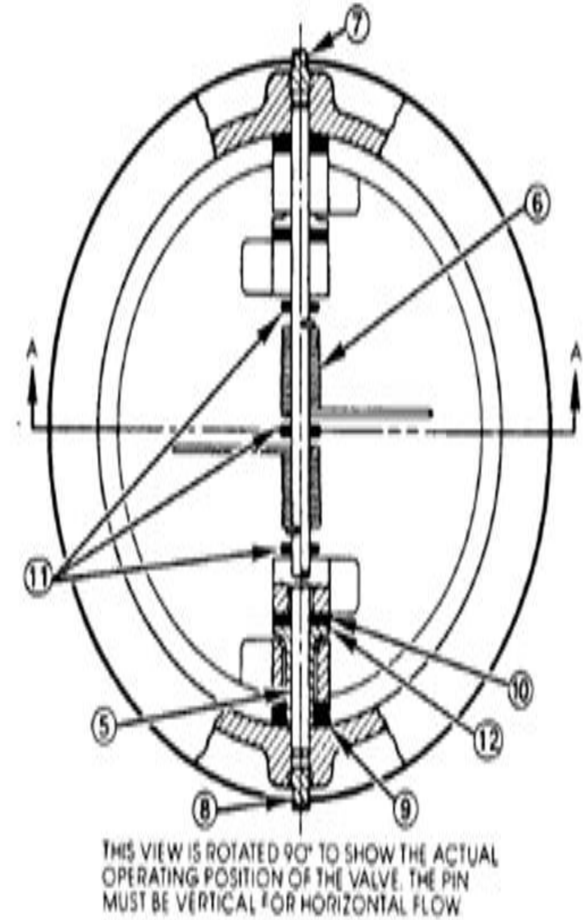
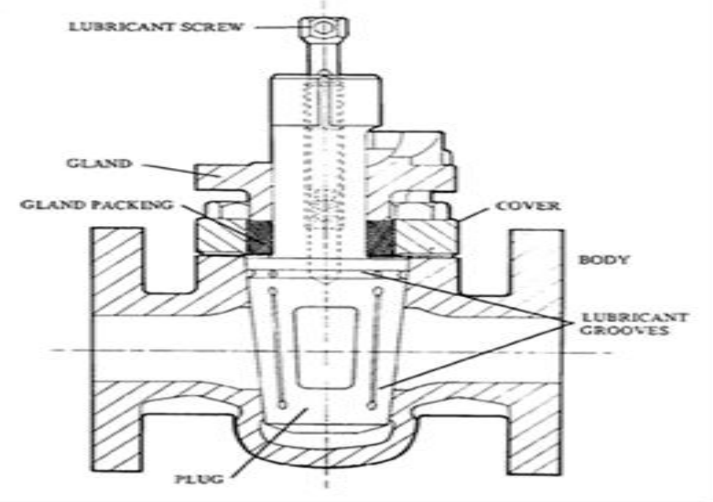


FIGURE A10.18 Folding-disc check valve.

6. Plug Valve(Cocks):

- Functions:

• Normally used for open and shut operation.
• Throttling is possible on some low flow applications.



- Advantages of Plug Valves:

1. Simple design with few parts.
2. Quick to open or close.
3. Can be serviced in place.
4. Offers minimal resistance to flow.
5. Provides reliable leak tight service. Seal can be maintained by injection of sealant or by replacement of sleeve, in addition to utilizing the wedging action of a tapered plug.
6. Multiple port design helps reduce number of valves needed and permits change in flow direction.

❑ Disadvantages of Plug Valves:

1. Requires greater force to actuate, due to high friction.
2. NPS 4 (DN 100) and larger valves require use of actuators.
3. Reduced port, due to tapered plug.
4. Typically, plug valves may cost more than ball valves.

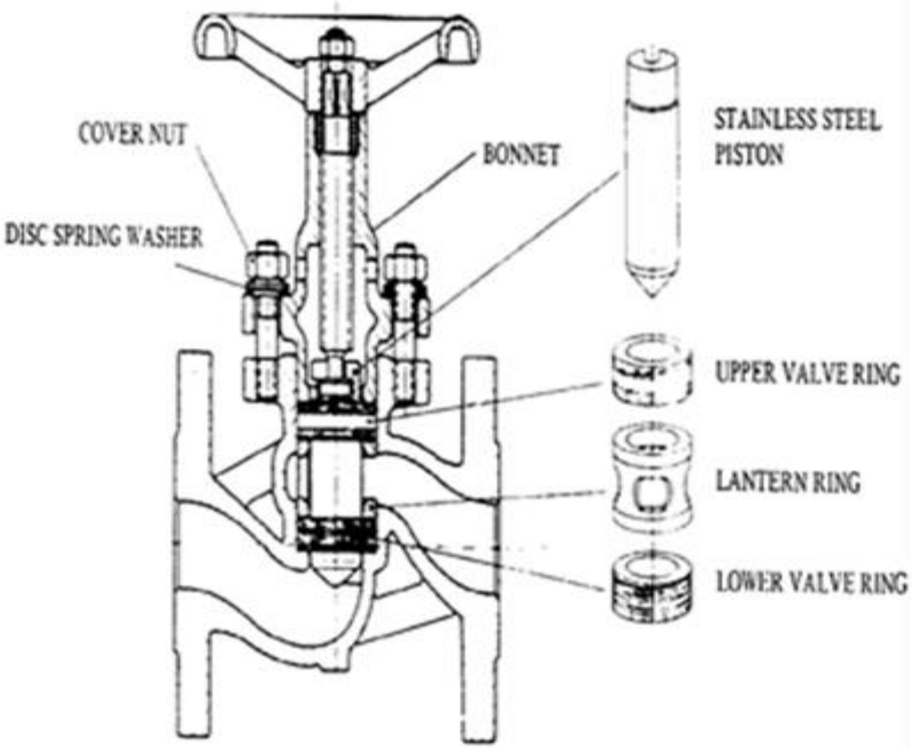
❑ Typical Applications of Plug Valves:

1. Air, gaseous, and vapor services.
2. Natural gas piping systems.
3. Coal slurries, mineral ores, mud, and sewage applications.
4. Oil piping systems.
5. Vacuum to high-pressure applications.

7. Piston Valve:

- Function:

- The valve is intended for open and shut operation, but can be shaped by a specially shaped piston and lantern ring for close control of flow.



8.Diaphragm valve:

- Function:
  - All diaphragm valves are bidirectional. They can be used as on-off and throttling valves.
- Types:

1. Weir-Type Diaphragm Valves.
2. Straight-Through Diaphragm Valves.

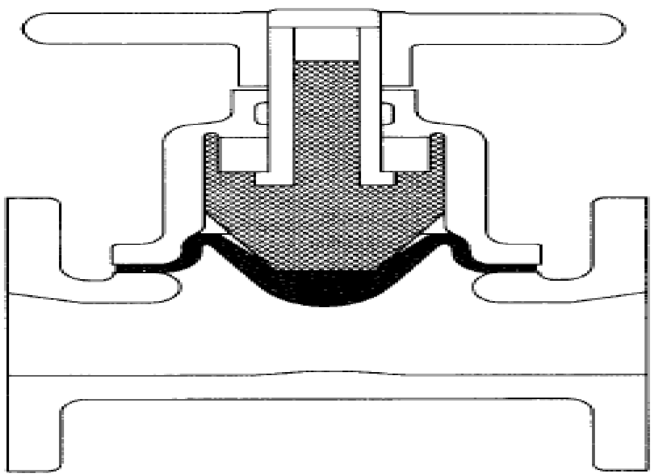


FIGURE A10.27 Straightway-type diaphragm valve.

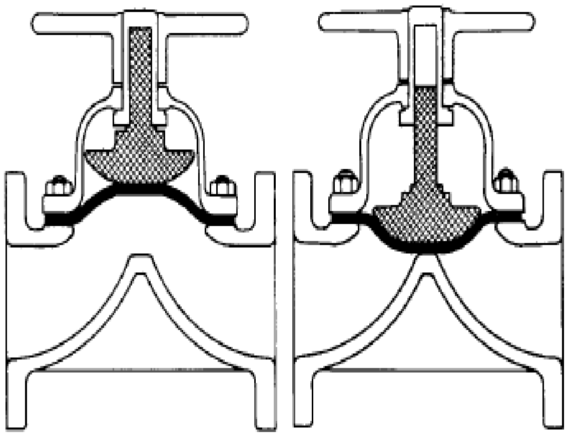


FIGURE A10.26 Sketch of a weir-type of diaphragm valve in open and closed positions.

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❑ Advantages:

1. Can be used as on-off and throttling service valves.
2. Offer good chemical resistance due to variety of linings available.
3. Stem leakage is eliminated.
4. Provides bubble-tight service.
5. Does not have pockets to trap solids, slurries, and other impurities. It is suitable for slurries and viscous fluids.
6. These valves are particularly suitable for hazardous chemicals and radio active fluids.
7. These valves do not permit contamination of flow medium, thus they are used extensively in food processing, pharmaceutical, brewing, and other applications which cannot tolerate valve illustrating passage of ball-brush cleaner any contamination.

❑ Disadvantages:

1. The weir may prevent full drainage of piping.
2. Working temperatures and pressures are limited by the diaphragm material. Generally the pressures are limited to 200 psi (1380 KPA) and temperatures up to 400°F (204°C).
3. The diaphragm may also limit the hydrostatic pressure.
4. The diaphragm may experience erosion when used extensively in severe throttling service containing impurities.
5. Diaphragm valves are available in limited sizes, usually NPS ½ to 12 (DN 15 to 300).

❑ Typical Applications of Diaphragm Valves:

1. Clean or dirty water and air service applications.
2. Demineralized water systems.
3. Corrosive applications.
4. Radwaste systems in nuclear facilities.
5. Vacuum service.
6. 6 Food processing, pharmaceutical, and brewing systems.

9. Butterfly valve:

- ❑ Function:

- Used to control and regulate or throttle the flow.
- Suitable for low-pressure and low-temperature applications as well as high-pressure and high-temperature applications.

- ❑ Types:

1. Low-pressure &low temperature ⇒ Concentric butterfly valves.
2. High-pressure & high temperature ⇒ Eccentric butterfly valves.

- ❑ Advantages:

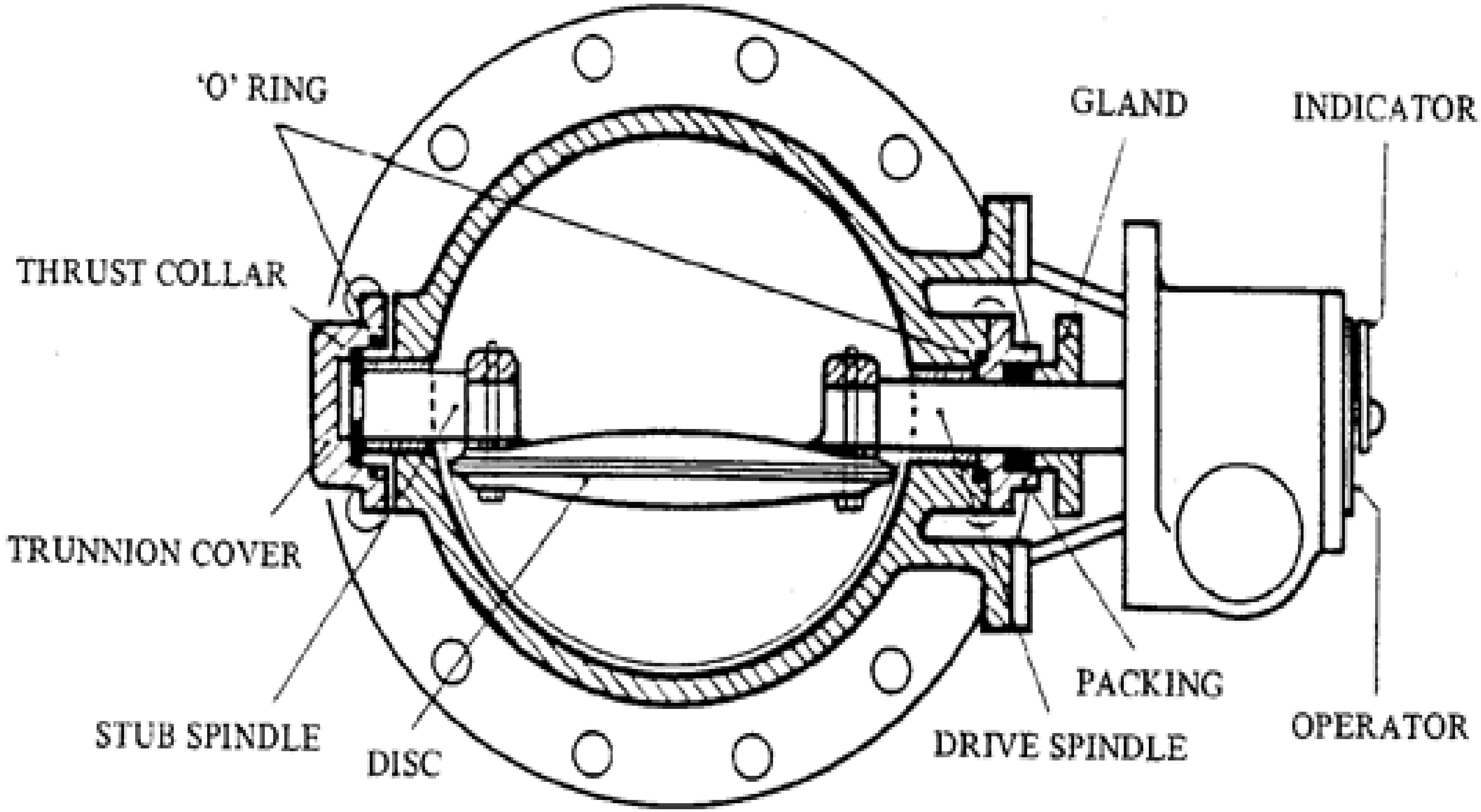
1. The compact design requires considerably less space, compared to gate, globe, or other valves.
2. Light in weight.
3. Quick acting; as a quarter-turn valve, it requires less time to open or close.
4. It is available in large sizes, ranging from NPS 1½ (DN 40) to over NPS 200 (DN 5000).
5. They have low-pressure drop and high-pressure recovery.
6. Provide bubble-tight service.

- **Disadvantages:**

1. Throttling service is limited to low differential pressure.
2. Throttling is restricted to a 30- to 80-degree disc opening. Location of valve, pipe routing, free, and closed discharge are to be considered while using a butterfly valve in a throttling application.
3. Cavitation and choked flow are two potential concerns.
4. The disc movement is unguided and affected by flow turbulence.

- **Applications:**

1. Cooling water, air, gases, and other similar applications, such as fire protection, circulating water, et cetera.
2. Corrosive services requiring lined valves.
3. Food processing, chemical, and pharmaceutical services.
4. Slurry and similar services.
5. High-pressure and high-temperature water and steam services.
6. Throttling service involving low differential pressures, as in cooling water or air supply systems.
7. Vacuum service.


'O' RING
THRUST COLLAR
TRUNNION COVER
STUB SPINDLE
DISC
GLAND
INDICATOR
PACKING
DRIVE SPINDLE
OPERATOR

11.Safety valve - Pressure relieve valve:

- ➢ Function:
- Used for overpressure protection of piping and equipment.
- ➢ Types:

1. Direct acting:

- The most commonly used and are suitable for the majority of applications.
- The set pressure is applied by means of a spring which acts on the valve disc, mating it with the valve seat in the valve body.

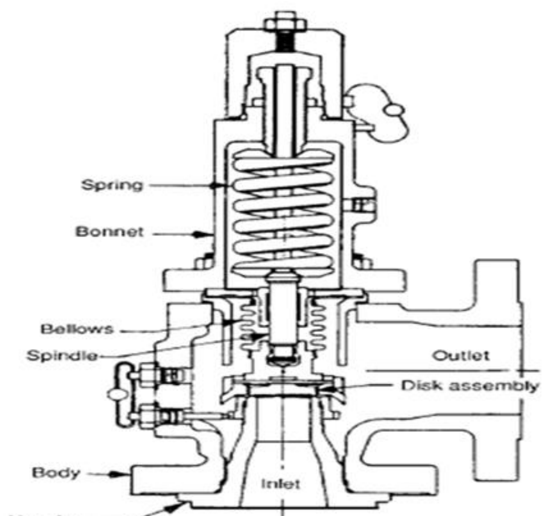


FIGURE A10.32 Safety valve.

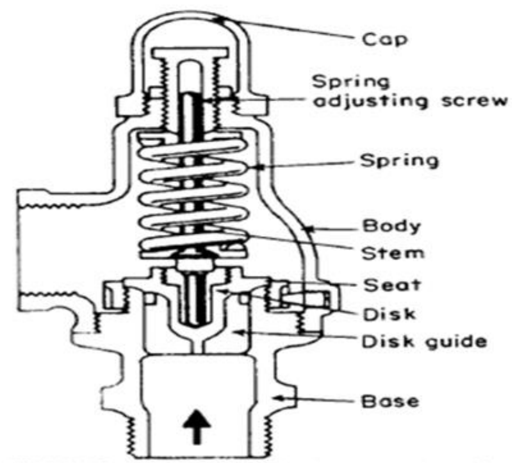


FIGURE A10.33 Relief valve opens when line pressure exceeds preset loading on the spring.

2. Pilot operated:

- Have a main valve and a pilot valve, through which the flow pressure loads the main valve.
- The pilot valve is in itself a safety and relief valve.
- When a predetermined pressure is reached, the pilot valve relieves the pressure loading on the main valve which allows it to open.
- Pilot operated valves are used where direct valves are unsuitable.

- ❑ Safety valve application:
- Generally used in gas or vapor service because their opening and reseating characteristics are commensurate with the properties and potential hazards of compressible fluids.
- ❑ Pressure relieve valve:
- Are used primarily in liquid service

TABLE A10.11 Valve Types and Typical Applications

Valve type	Service/Function			
	Isolation or stop	Throttling	Pressure relief	Directional change
Gate	yes	no	no	no
Globe	yes	yes	no	yes (note 1)
Check	note 2	no	no	no
Stop check	yes	no	no	no
Butterfly	yes	yes	no	no
Ball	yes	note 3	no	yes (note 4)
Plug	yes	note 3	no	yes (note 4)
Diaphragm	yes	no	no	no
Safety/relief	no	no	yes	no

Notes:

1. Only angle-globe valves can be used for a 90-degree change in direction of flow.
2. Check valves (other than the stop-check valves) stop flow only in one (reverse) direction. Stop-check valves can be and are used as stop, block, or isolation valves, in addition to being used as a check valve.
3. Some designs of ball-and-plug valves (contact the valve manufacturer) are suitable for throttling service.
4. Multiport ball-and-plug valves are used for changing the direction of flow and mixing flows.

➢ Pipe expansion:

- Steel piping systems are subject to movement because of thermal expansion/ contraction and mechanical forces.

- Piping systems subjected to temperature changes greater than 50°F or temperature changes greater than **75°F**, where the distance between piping turns is greater than **12 times** the pipe diameter, may require expansion loops.

- In the majority of oil and gas facility and pipeline applications, pipe expansion is not critical, as normal piping arrangements contain the numerous elbows and changes of direction.

- These make the piping system relatively flexible and allow the pipe to absorb the expansion; however, if the flowing temperatures are high or there is a significant variation in temperature, the normal piping configuration may not be adequate to handle the expansion and contraction of the piping systems.

➢ **Pipe Supports & Restraints:**

❑ Supports functions:

1. Absorb system weight.
2. Reduce:
   - Longitudinal pipe stress.
   - Pipe sag.
   - End point reaction loads.

❑ Restraints functions:

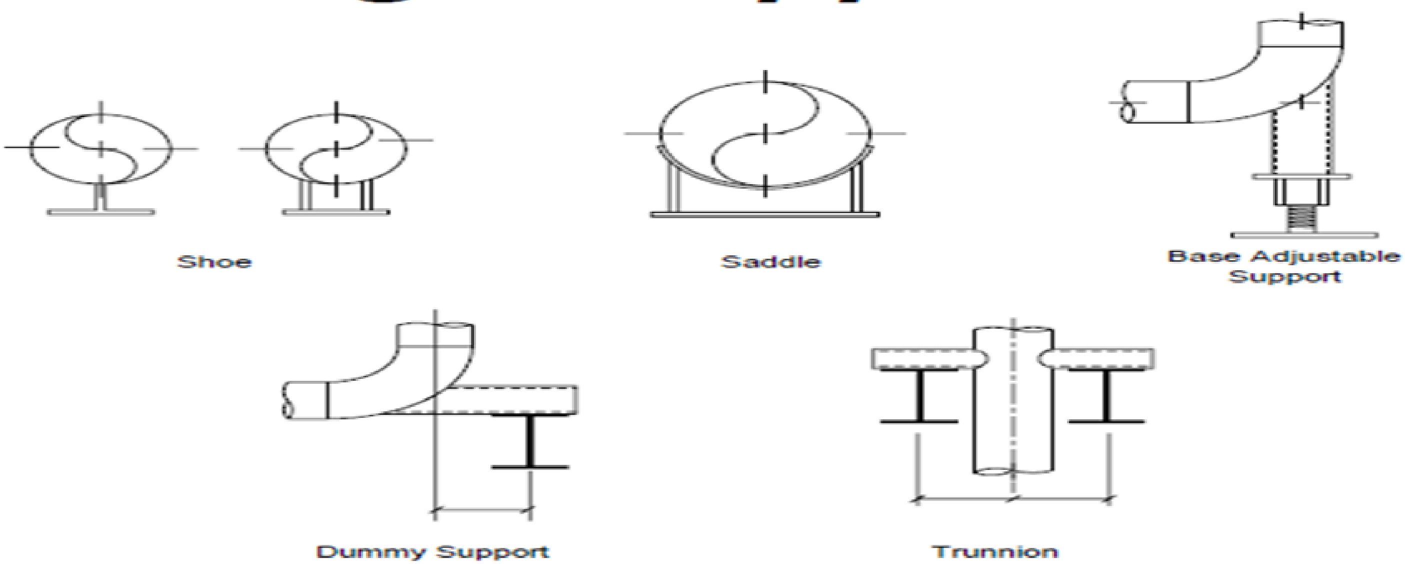
I. Control, limit, redirect thermal movement:
   - Reduce thermal stress.
   - Reduce loads on equipment connections.

II. Absorb imposed loads:
   - Wind.
   - Earthquake.
   - Slug flow.
   - Water hammer.
   - Flow induced-vibration.

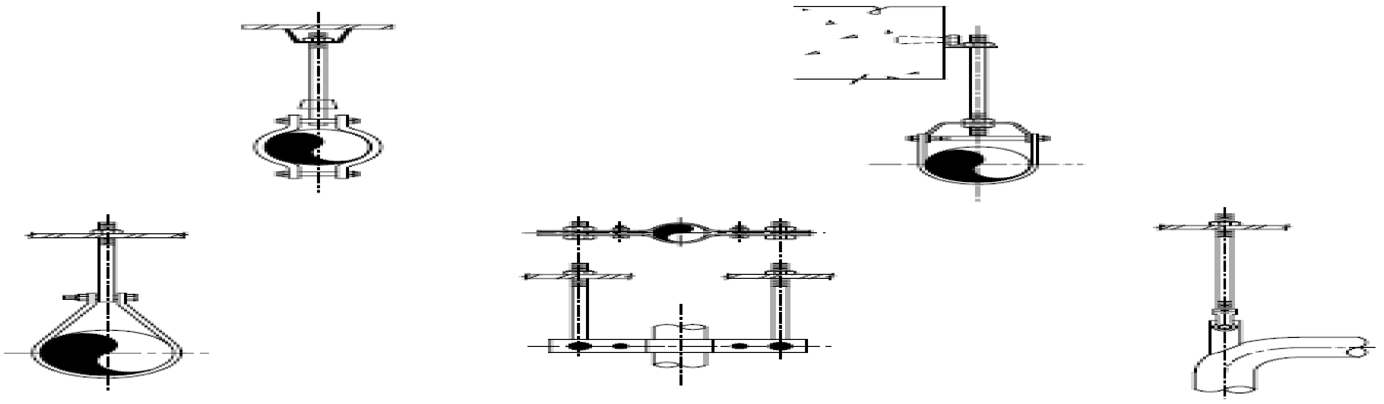
❑ Selection factors:

- Weight load.
- Available attachment clearance.
- Availability of structural steel.
- Direction of loads and/or movement.
- Design temperature.
- Vertical thermal movement at supports.

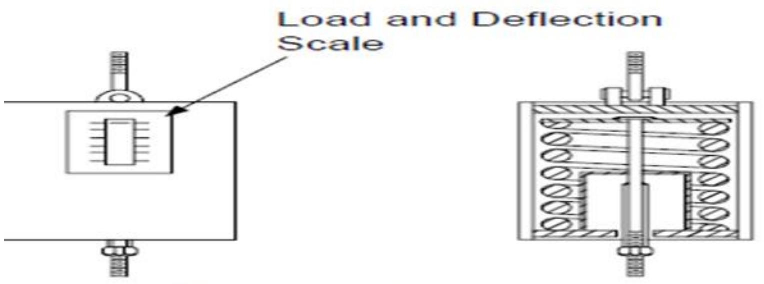
Rigid Supports



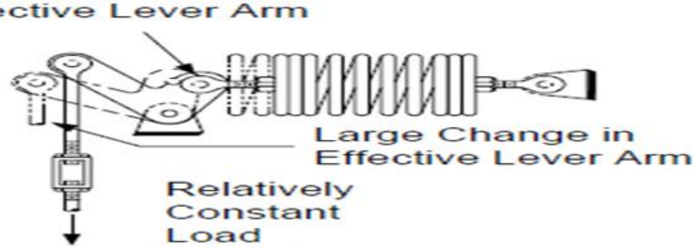
Hangers



Flexible Supports



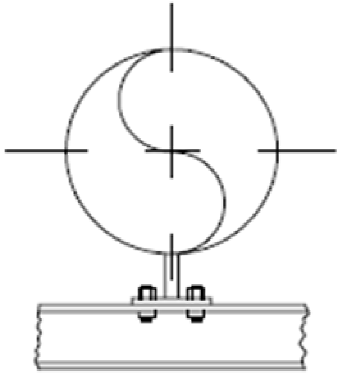
Typical Variable-Load Spring Support



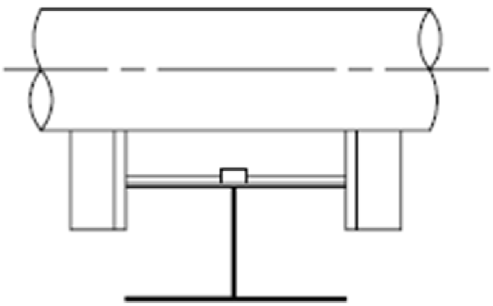
Typical Constant-Load Spring Support Mechanism

- **Anchors & guides:**

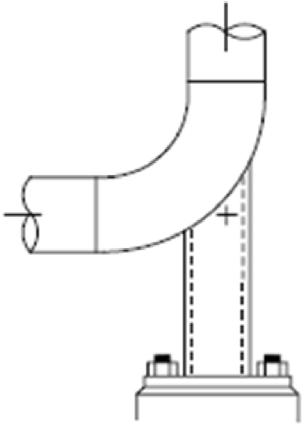
- Anchor functions:
  - Full fixation.
  - Permits very limited (if any) translation or rotation.
- Guide functions:
  - Permits movement along pipe axis.
  - Prevents lateral movement.
  - May permit pipe rotation.



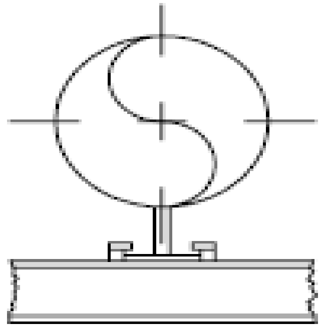
Anchor



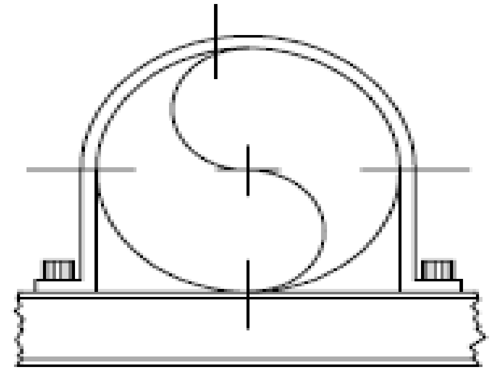
Anchor



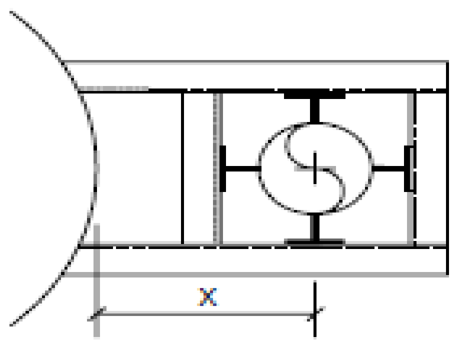
Partial Anchor



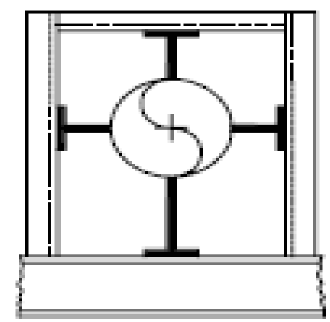
Guide



Guide



Vertical Guide



Guide

PIPELINES

➢ Introduction:

- Once oil and gas are located and the well is successfully drilled and completed, the product must be transported to a facility where it can be produced/treated, stored, processed, refined, or transferred for eventual sale.
- The piping and pipeline systems typically associated with producing wells include, but are not limited to, the well flowline, interconnecting equipment piping within the production "battery," the gathering or sales pipeline, and the transmission pipeline.

➢ Terms:

⚠ Well Flowline:

- It is the first pipeline system connected to the wellhead & carries total produced fluids (e.g., oil, gas, and produced water) from the well to the first piece in the treatment plant which typically is the production manifold or the production separator.

⚠ Interconnecting Piping:

- Includes the piping between the various pieces of production/treating equipment such as production separators, line heaters, oil heaters, pump units, storage tanks, and gas dehydrators.
- The piping systems may also include headers, fuel systems, other utility piping, and pressure-relief/flare systems.

⚠ Gathering Pipeline(sales pipeline):

- The pipe that delivers the well production to some intermediate or terminal location.
- The gathering pipeline literally gathers the production from producing wells and conveys the production to a collection system, a processing facility, custody-transfer (sales) point, or other.

⚠ Transmission Pipeline:

- The transmission pipeline is a "cross-country" pipeline that is specifically designed to transport petroleum products long distances.
- The transmission pipeline collects the specific petroleum products from many supply sources along the pipeline (such as gathering pipelines) and delivers the product to one or more end users.

❑ Transmission pipelines categories:

1. Natural gas:

- Natural-gas transmission pipelines carry only natural gas.

2. Product:

- Product pipelines may carry a number of processed or refined petroleum products such as processed natural-gas liquids (e.g., butane and propane), gasoline, diesel, and refined fuel oils.

3. Crude oil:

- Crude-oil pipelines convey unrefined crude oil from producing areas to large storage areas or directly to refineries.

➢ Pipeline layout:

❑ Factors affecting the flowline layout:

I. Type of reservoir.

II. The shape of the reservoir.

III. The way in which the land over the reservoir is being used.

IV. The shape of the field.

V. The anticipated future development for the field.

VI. The available and permissible flow rate.

VII. The flowing and shut-in pressure and temperature.

VIII. The climate.

IX. The location topography.

X. The primary destination of the oil or gas.

XI. System reliability.

XII. Economic.

Pipeline design:

- Data required for design:

1. Maximum operating condition.
2. Type of line.
3. Length of line.
4. Amount of pressure drop.
5. Volume.
6. Geographic and soil condition.
7. Estimated service life required.

N.B:

- By all of these data it will be possible to select the size, weight, grade and type of pipe.

➢ **Pipeline operating problems:**

- Corrosion.
- Paraffin and scale deposits.
- Freezing of hydrates in gas wells flow line.
- Pulsation and vibration resulting.
- Thermal expansion.

➢ Pipeline gathering systems:

❑ Gathering system definition:

- Transport of the hydrocarbon stream from its source to the processing facility.

❑ Gathering system content:

- Gathering systems consist of several lines, perhaps interconnected, often of relatively **small diameter** (2 to 8 inches) and **low pressure** (0- 500 psia).
- Of course there are exceptions, such as high-pressure gas wells.

❑ Gathering system location:

- The smaller gathering lines may be aboveground or buried, whereas larger lines are always buried.
- Aboveground lines are much easier to maintain but are exposed to the atmosphere which leads to corrosion problems.

- Pipeline gathering system types:

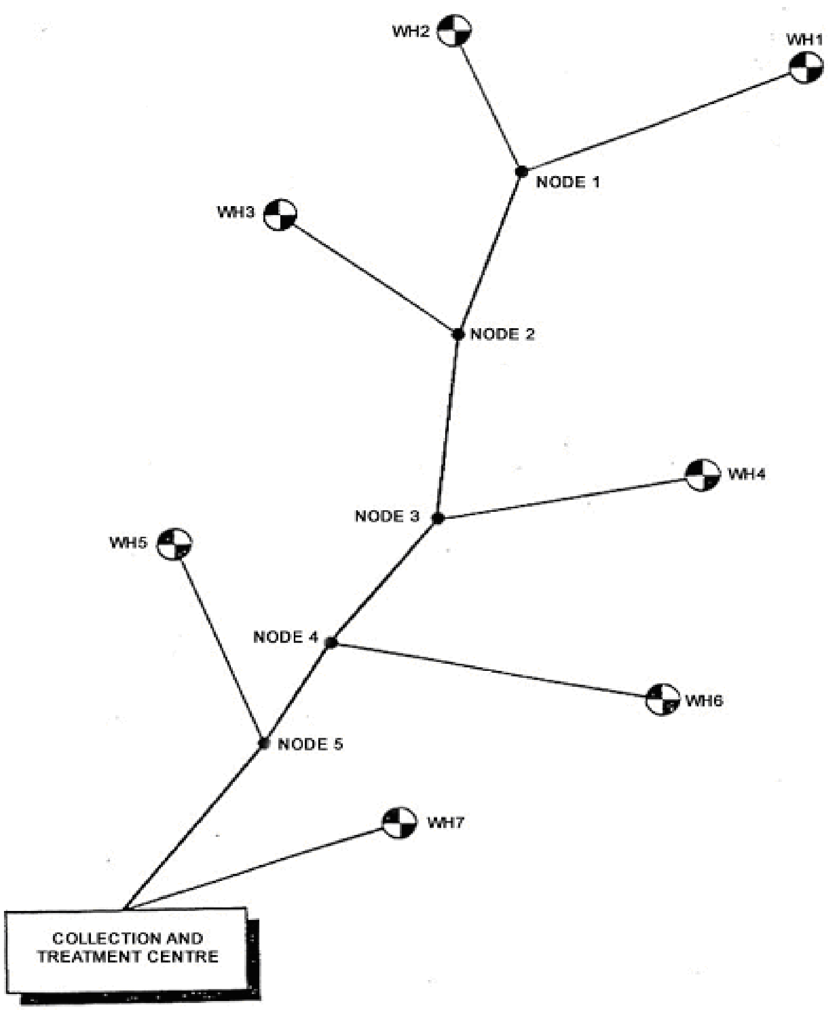
A. First classification:

1. **Loop Gathering System**.
   - Advantage: High degree of reliability.
   - Disadvantage: Not economic.
2. **Radial Gathering System.**
   - This type is most generally application.
3. **Main Gathering System**.
   - Advantage: Min. cost installation.
   - Disadvantage: Not reliable.

B. The second classification:

1. Single-trunk systems with “lateral” lines from each well production facility.
2. Loop systems in which the main line is in the shape of a loop around the field.
3. The multiple-trunk system, in which there are several main lines extending from a central point.
4. Combinations of Categories 1 through 3.

- Pipeline gathering system structures:
  1. Branched structure:



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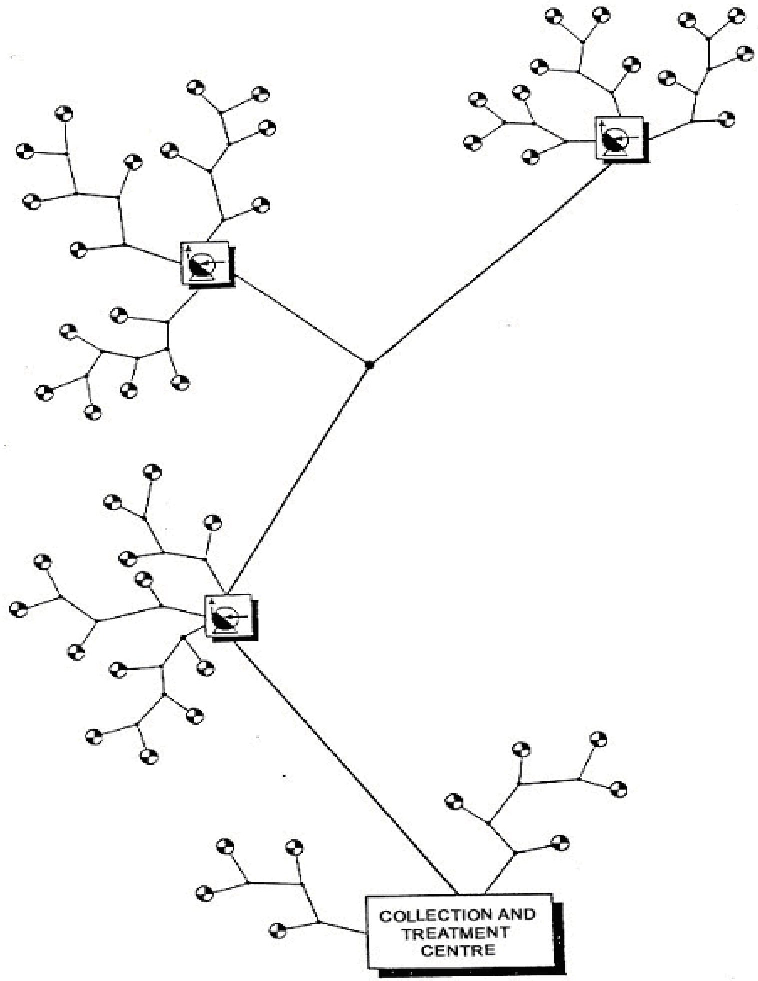
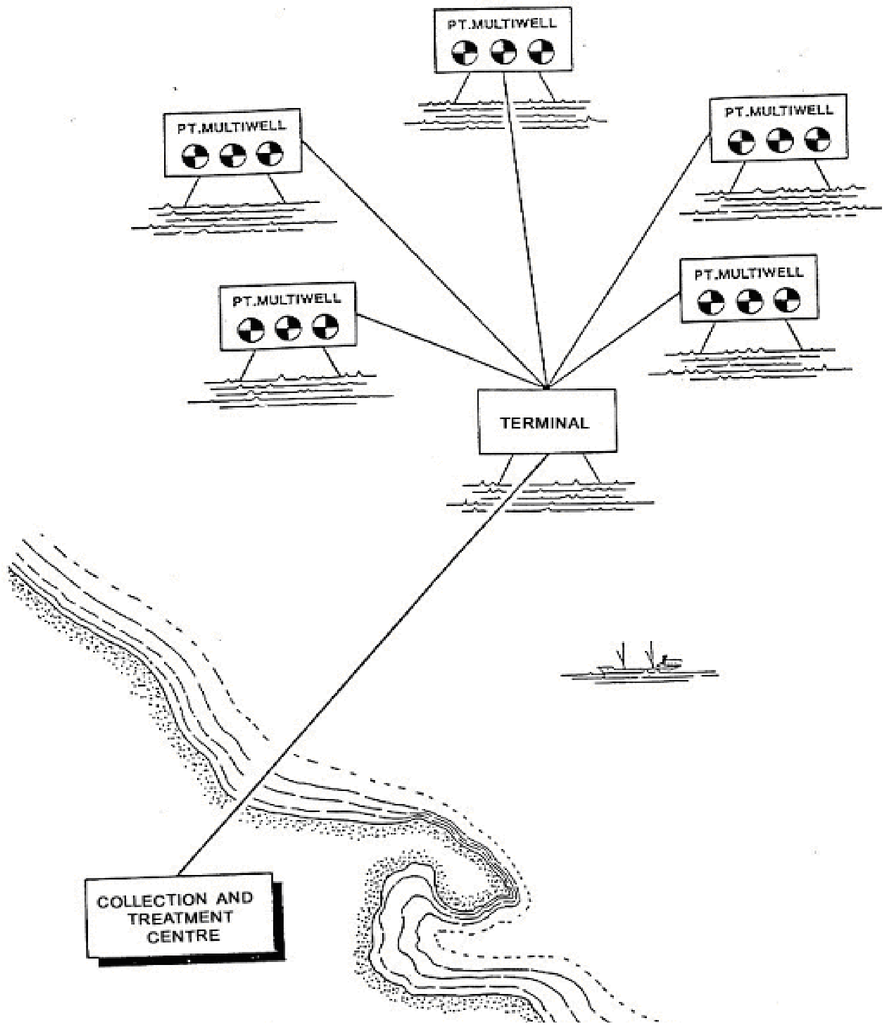
2. Star structure:



3. Integrated structure:



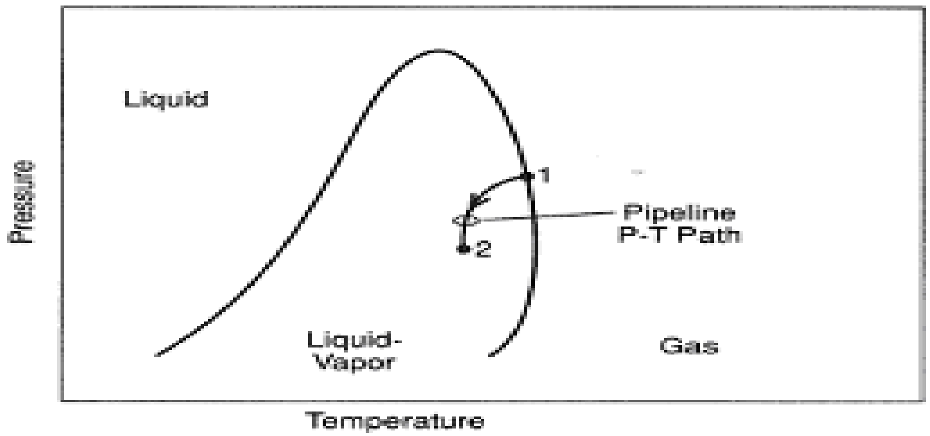
❑ Flow type in gathering systems:

- Depending on well effluent type and field processing, gathering lines may have to handle ***single phase or two-phase streams.***

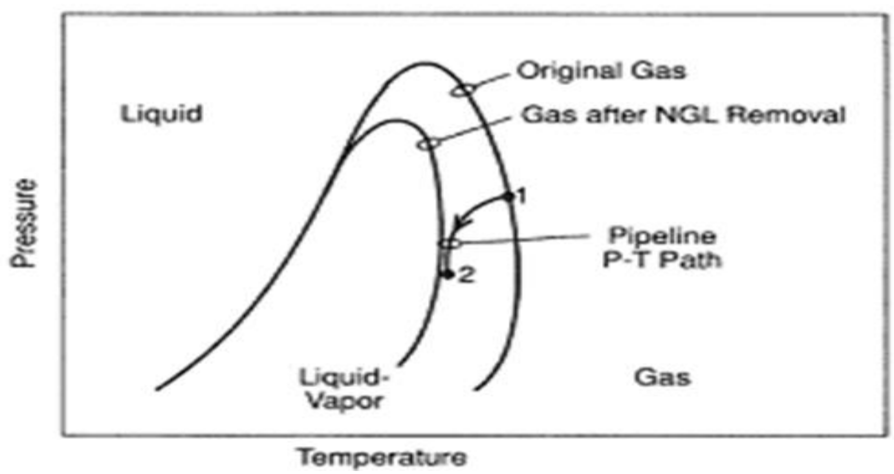
- Gas from dry-gas fields is transported in single phase gas lines.

- Crude oil is transported in single phase liquid lines.

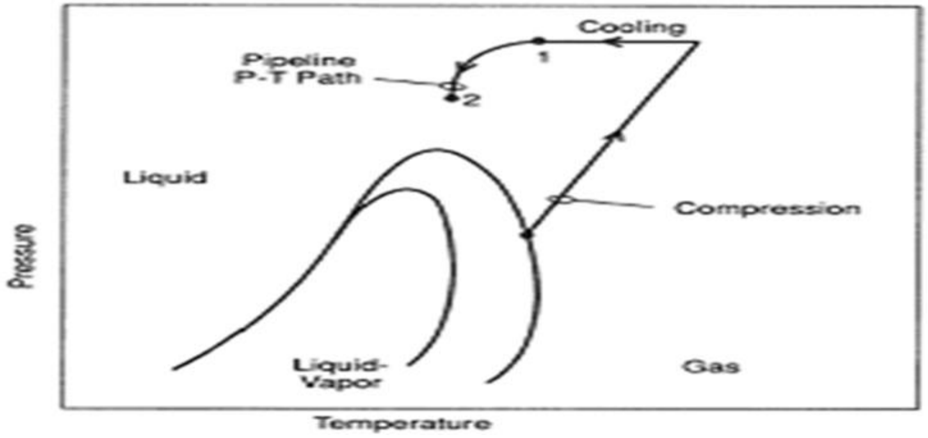
- When Wet Gas must be handled, different options arise:
  a) No condensate removal and transport in a two-phase line.
  b) Condensate removal and gas transport in single-phase line.
  c) No condensate removal and dense phase transport.


Liquid
Pressure
1
Pipeline
P-T Path
2
Liquid-
Vapor
Gas
Temperature

(a)


Original Gas
Liquid
Gas after NGL Removal
Pressure
1
Pipeline
P-T Path
2
Liquid-
Vapor
Gas
Temperature

(b)


Cooling
Pipeline
P-T Path
1
2
Liquid
Compression
Pressure
Liquid-
Vapor
Gas
Temperature

(c)

➢ Pipeline pressure drop calculation:

❑ Pressure drop in circular single phase pipes:

$$\Delta P = f \frac{L}{D} \frac{\rho}{2} V^2$$

$\Delta P = Pressure\ Drop$

$f = Pipe\ friction\ Coefficient$

$L = Length\ Pipe$

$D = Pipe\ Diameter$

$\rho = Density$

$V = Flow\ Velocity$

LP, pump suction	$CV^2 < 1000$
HP, pump discharge	$CV^2 < 4000$
Discontinuous	$CV^2 < 8000$
Blow-down	mach < 0.35

❑ Pressure drop in circular two phases pipes:

- Two-phase flow presents several design and operational difficulties not present in single phase (liquid or vapor) flow.

- Frictional pressure drops are much harder to calculate.

- In general, a larger pipe diameter is required.

- Firstly, flow regime must be determined

- Flow regime can be determined on 2D maps in V_{sg} V_s V_{sl} diagrams

  - V_{sg}: gas superficial velocity(Gas flow rate to the pipe cross section).
  - V_{sl}: liquid superficial velocity (Liquid flow rate to the pipe cross section).

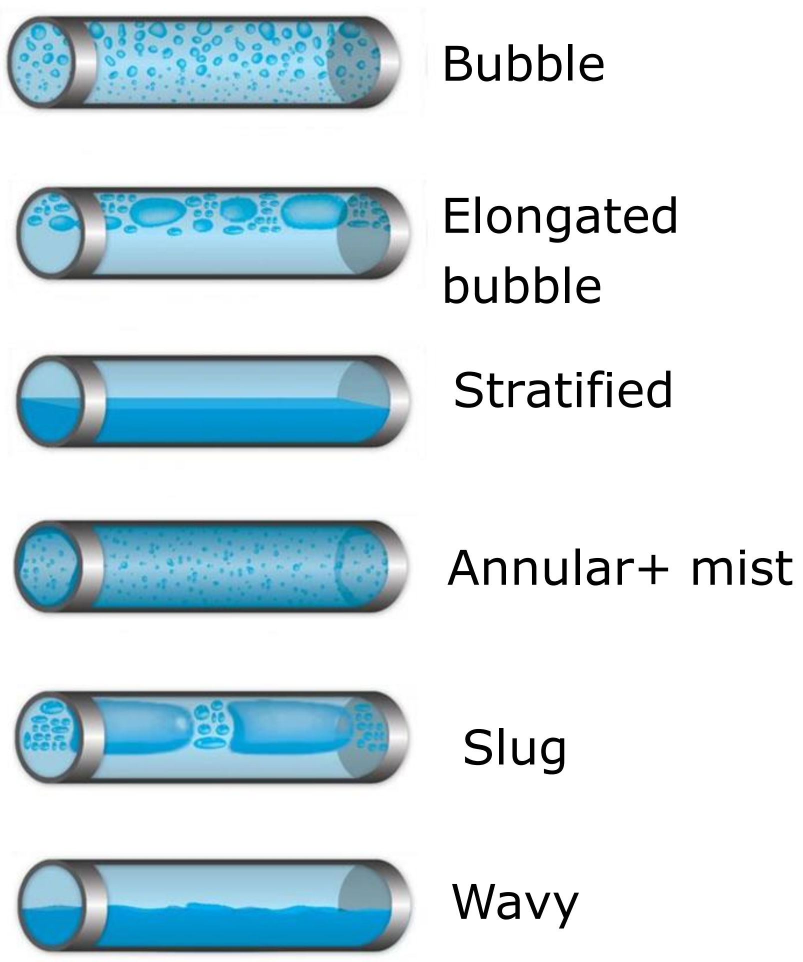
- Care should be taken in the interpretation of these flow maps as the regime boundaries are strongly affected by pipe inclination.

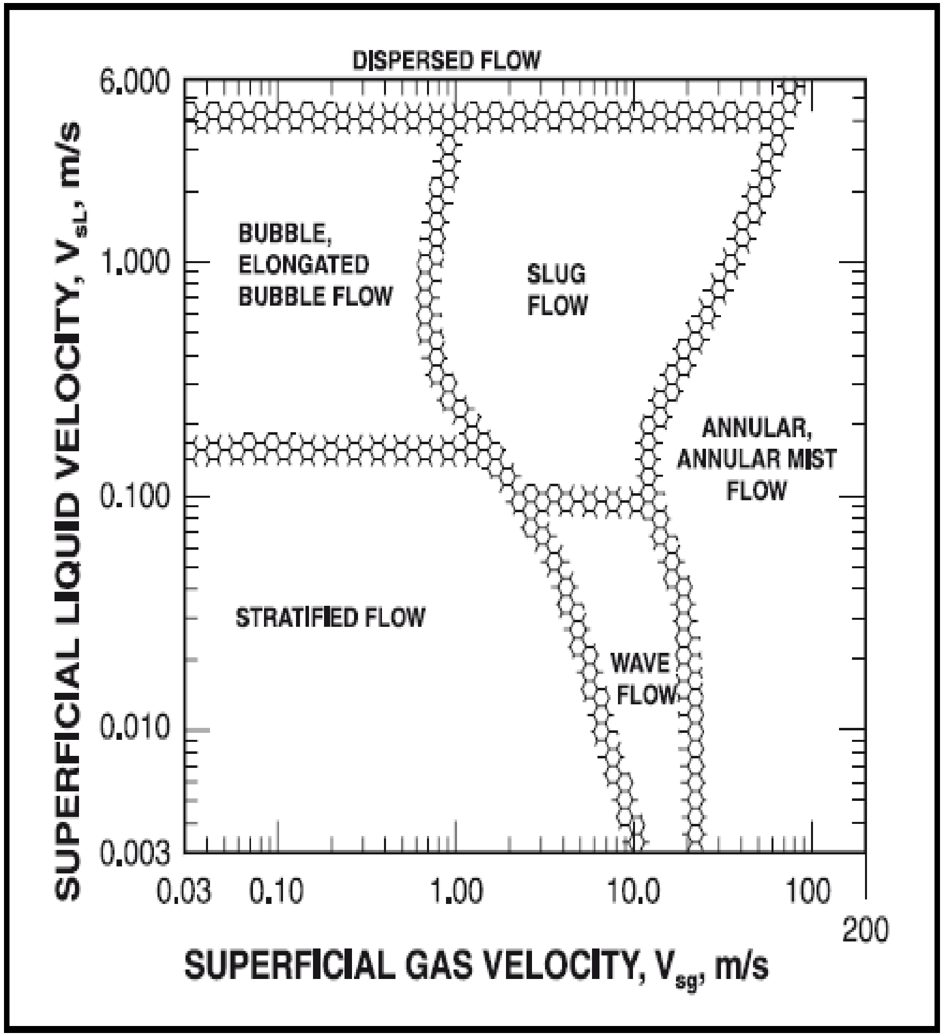
- Horizontal flow regime maps must not be used for vertical flow, and vice versa.

➢ **Superficial velocity**:

- Ratio of volumetric flowrate to pipe cross sectional area.

- ❑ Two-phase flow regimes in horizontal tubes:





➢ Pipeline corrosion:

1. Internal corrosion:

❑ Cause:

- The presence of CO_2, water, H_2S, chlorides (salt water), bacteria, completion fluids, or other substances in the produced hydrocarbon.
- Erosion or wear.

❑ Mechanism:

- When CO_2 or H_2S is mixed with oxygen and/or water, acids are formed that attack and destroy the steel. When CO_2 or H_2S is mixed with oxygen and/or saltwater, extreme corrosion occurs.
- Certain types of bacteria often found in producing formations can also attack and destroy the steel.

❑ Consequences:

  - Leaks.
  - Severe blowouts.

❑ Protection:

1. The removal of oxygen and water from the fluid.
2. Corrosion-inhibition chemicals.
3. Internal coatings.
4. Using corrosion-resistant materials.

2. External corrosion:

- ❑ Causes:

1. Buried pipe is subjected to cathodic actions and galvanic actions.
2. Aboveground pipe is subjected to atmospheric corrosion and galvanic actions.

- ❑ Mechanism:

- Cathodic actions occur when steel pipe is buried below ground.
- Ferric (steel) and soils, have small electrical potentials.
- In the natural process of converting metals back to their elemental or native state, electrolytic conduction takes place.
- Steel pipe becomes an anode (positively charged) and transfers material, by means of electrons, to the cathode (negatively charged) material, which is the soil.
- The pipe metal literally flows away by means of the electric current between the anode and cathode.
- Water contained in the soils and other media serves as the electrolyte to help promote the electron transfer.

❑ Protection:

1. The coating:

- It must provide an effective "insulation" against the environment but must be tough enough to withstand the operating temperatures, be resistant to the soil, and withstand physical handling.
    - Extruded systems (polyethylene or polypropylene over asphalt mastic or butyl adhesives).
    - Tape coats (polyethylene, polyvinyl, or coal tar over butyl mastic adhesive).
    - Fusion bonded epoxy (thin film)(the most popular).
    - Coal-tar epoxy.

- ✓ Fusion bonded epoxy advantages:
    - Excellent insulators.
    - They are hydrocarbon, acid, and alkali resistant.
    - They are unaffected by temperature.
    - They do not require a primer.
    - They can be applied over finished welds (field joint).

2. Cathodic protection for under ground pipe:

- Methods:
  - a) Impressed current .
  - b) Sacrificial anode.

- Mechanism:

- The normal case the steel pipe becomes an anode (positively charged) and transfers material, by means of electrons, to the cathode (negatively charged) material, which is the soil.

- Cathodic protection reverses the electron pass so the steel pipe which will accept electrons by the impressed current or sacrificial anode.

- Sacrificial anode method depending on using higher potential metal than the steel like the aluminum , magnesium or zinc which will be in contact with steel so the aluminum will be an anode and steel will be a cathode.

- **NB:**
- Onshore pipelines generally use magnesium, and offshore pipelines use zinc or aluminum anodes

- Sacrificial anode advantage:
- Sacrificial-anode systems are simpler and less expensive than impressed current systems.

- Impressed current disadvantage:
- Much more complex and require external power sources and AC/DC power inverters or rectifiers to provide the current to the pipe.

3. Galvanic corrosion:

❑ Cause:

- Corrosion is caused by the interface of dissimilar metals with different electrolytic potentials.

❑ Mechanism:

- The dissimilar metals will gain or lose electrons from or to each other resulting in one of the metals effectively flowing away and losing material.

- ❑ Examples:
- Steel pipe that undergoes abrupt changes in the medium will behave somewhat as dissimilar metals and cause galvanic actions.
- Pipe transitioning from below ground to above ground may experience galvanic-like corrosion.
- Mating materials such as carbon steel with stainless steel will cause the carbon steel to corrode.

- ❑ Protection:
- Using the insulation kit for flanges and joints.

4. Atmospheric corrosion:

❑ Cause:

- Exposing the steel pipe to moisture, salt, chemicals (pollution), heat, cold, or air (oxygen).

❑ Protection:

- Using anticorrosion coatings like epoxies paintings.
- Regular maintenance will normally provide adequate protection to the aboveground facilities.

5. Stress Corrosion Cracking (SCC).
6. Microbiologically Influenced Corrosion (MIC).

- **Corrosion monitoring:**
  - Laboratory Samples of Fluids.
  - Corrosion Coupons.
  - Electrical Readings at Specific Points along the Pipeline.
  - In Line Inspection Tools or Smart Pigs.

Pipeline pigging:

Definitions:

Pigging:

- It is the process of forcing a solid object through a pipeline and involves inserting the pig, via a pig launcher, into the pipelines and removing it by use of a pig receiver.

Pig:

- Defined as a device that moves through the inside of a pipeline, propelled by the flow of pipeline product, for the purpose of cleaning, separating, dimensioning or inspecting.

Pig Launcher:

- The device used to propel the pig into the pipeline (launch pig).

Pig Receiver:

- The device used to retrieve the pig from the pipeline (receive pig).

- Functions:
  - Provide a barrier between liquid products that use the same pipeline.
  - Check wall thickness and find damaged sections of lines.
  - Remove debris such as dirt and wax from lines.
  - Coat inner pipe walls with inhibitors.
  - Remove condensed hydrocarbon liquids and water in two phase pipelines.

❑ Pig types:

1. Wire Brush Foam Pigs:

- Used for cleaning lines with build-up or debris in new construction and routine maintenance.

2. Coated Foam Pigs:

- Used for regular wiping and general cleaning.

3. Foam Spheres:

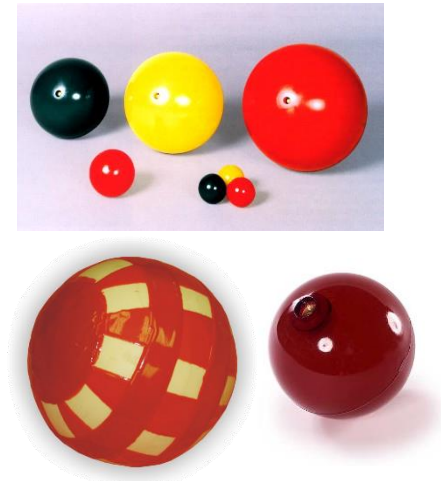
- Used as "sealing pigs" but there have been a limited number of spherical pigs designed for removing solids.

4. Steel Pigs:

- Made up of a central steel body to which are attached a number of sealing elements. fitted with various types of cleaning brushes ranging from carbon steel and stainless steel wire bristles to plastic bristles.

5. Intelligent Pigs:

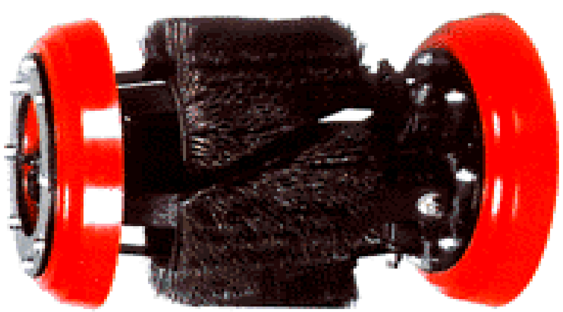
- More complicated and expensive item, used for monitoring purposes. They gathering data on the extent of corrosion inside pipelines.

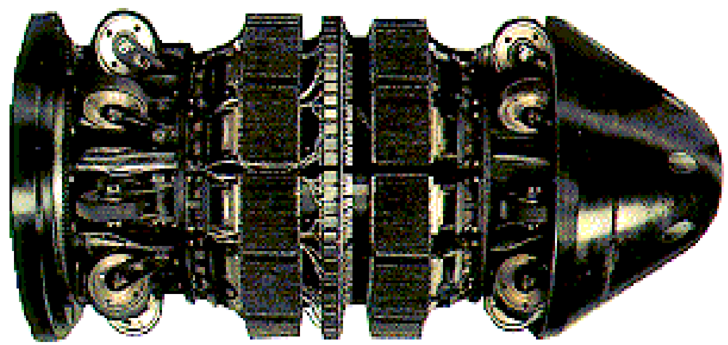


Wire Brush Foam Pigs

Coated Foam Pigs

Foam Spheres

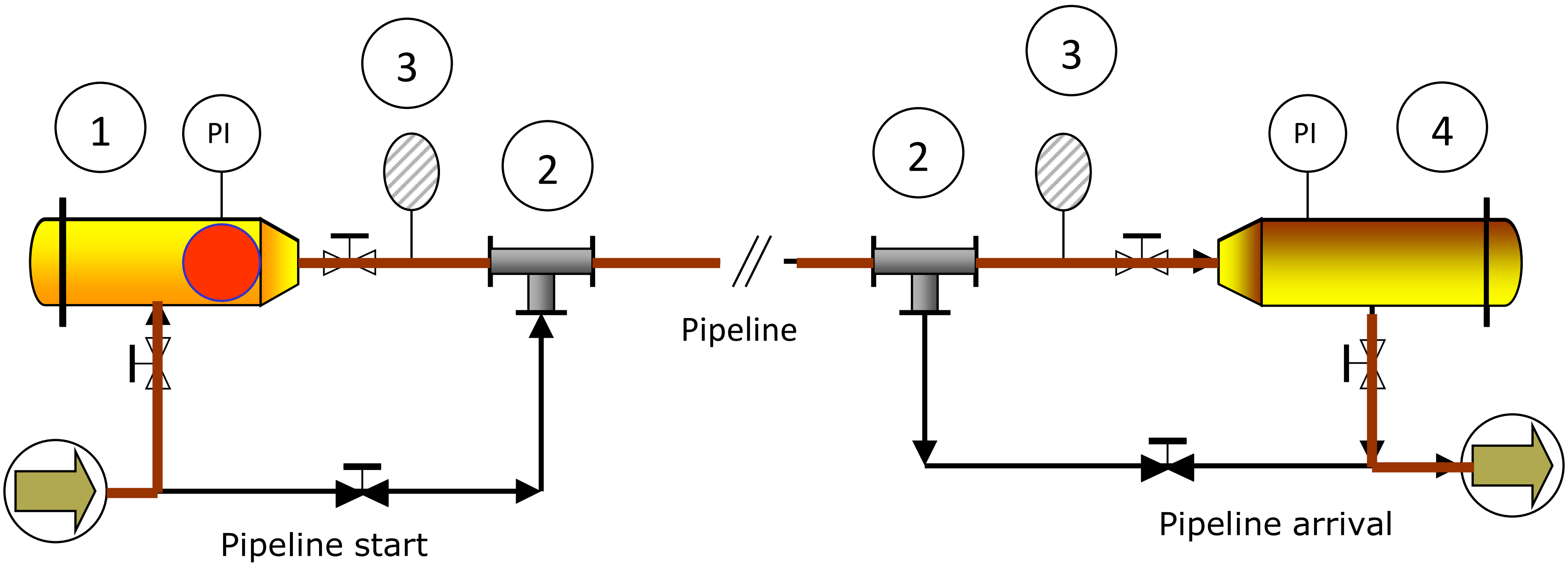




Intelligent Pigs

Steel Pig with Cleaning Brushes

- Pig launcher/pig receiver:



1 Launching Trap

2 Special T

3 Pig transit signaller

4 Receiving Trap

❖ Pig launcher and receiver closures types:

1. Clamp closures (yoke or double-yoke):

- Utilise two opposing clamps or yokes, to secure the door to the hub by means of inclined surfaces (the wedge effect).
- The sealing is achieved by compressing an O-Ring between the door and the hub.
- The correct operation of a clamp closure depends on:
  1. The gap between the door and hub (typically 0.25 inch or 6 mm).
  2. The torque values of the yoke bolts or clamping screws.

- Advantages:
  - Relatively simple construction and operation.
  - Require standard O-Rings or simple seals.
- Disadvantages:
  - The integrity of the closure depends on a single bolt and nut assembly.
  - The thread needs to be permanently lubricated – risk of corrosion and thread damage.
  - Limited choice of seal materials.
  - Very poor safety record.

2. Bayonet-type closures(Scholz closures):

- Operate by compressing a customary seal between the door and the hub using multiple inclined surfaces (wedges).

- Advantages:
  - Robust(strong).
  - Good safety record.
- Disadvantages:
  - Require a high level of cleanliness and maintenance.

3. Band lock closures:

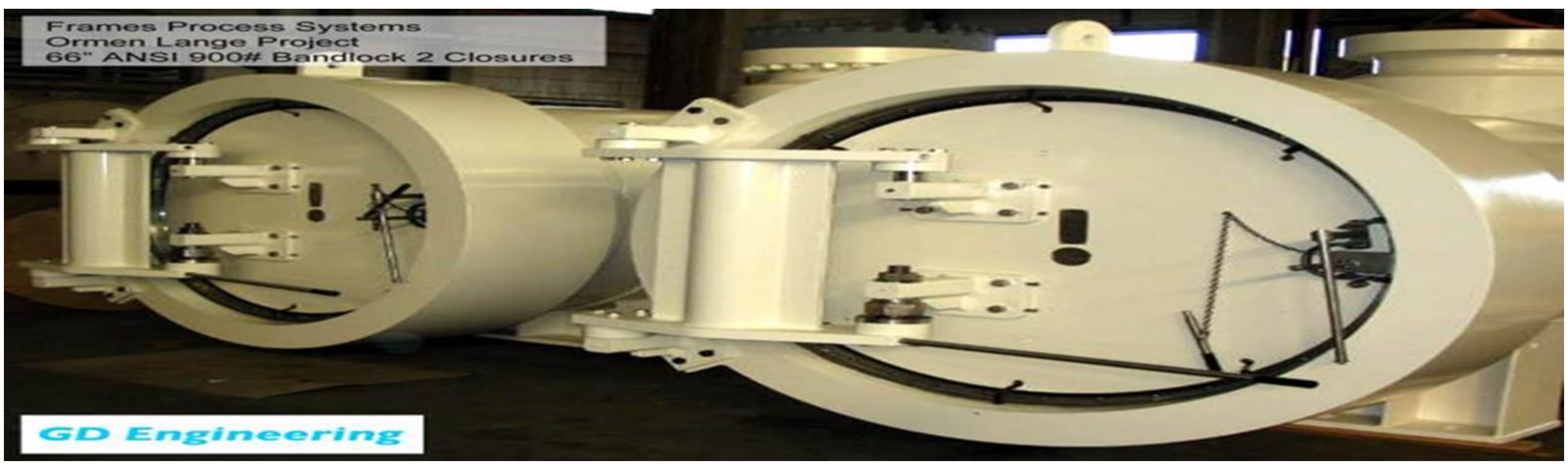
- Supplied from the UK by GD Engineering.
- Uses a locking band which expands into a groove machined inside a forged neck.
- Customary self-energising Band lock seals.

Advantages:

- Locking element always visible and always in compression.
- Excellent safety record.
- Easy to operate – can be opened in less than one minute even at very large sizes
- Available in sizes from 6 in up to 100 in.
- Suitable for pressures up to class 2500 (425 bar / 6170 psi) and beyond (10,000 psi).
- Band lock seals are self-energising and available in a wide range of materials, including Nitrile, Viton, Elast-O-Lion and EDR Elastomers.

- Disadvantages:

- Proper operation depends on good and regular maintenance.
- Spare seals are relatively expensive.



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❑ Pressure interlock / Warning device:

- Opening the door under pressure has disastrous consequences.
- Each closure must be provided with a pressure interlock or a pressure warning device.
- The operators should not be able to access the locking mechanism of the door unless there is positive confirmation that there is no residual internal pressure inside the pig trap.
- This function is usually achieved by mechanically incorporating a bleed valve or a bleed screw in the opening sequence of the door.

❑ Mechanical key interlocks:

❖ *Definition:*

- An additional mechanical lock is often fitted to the closure door in order to prevent vandalism, prohibit unauthorised access.

❖ *Types:*

  ✓ Smith Flow Control.

  ✓ Castell.

❖ *Usage:*

- Used to incorporate the opening of the closure door into a valve operating sequence.
- Key interlock systems – ensure that operations can only be carried out in a specified sequence.


SFC


GD Bandlock 2 Closure
with Smiths Interlock
GD Engineering

❑ Pig signallers:

❖ *Classification:*

1. Intrusive /Non-Intrusive.
2. Mechanical /Magnetic.
3. Local Indication (Visual) /Remote Indication (Electrical).
4. Valved (Removable under pressure) /Non-valved.
5. Extended (for mounting on buried pipelines) /Non-extended.

GD Engineering HI-T Pigalert Model MW
(Mechanical Welded)

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1. Non-intrusive pig signallers:

- Installed on live pipelines without any hot work.
- Used on risers before the main line isolation valve.
- Permanently mounted (secure locations – offshore of onshore plants) or Portable units.
- In order to detect the passage of pigs, non-intrusive pig signallers utilise various methods:
    - Magnetic.
    - Radio signal.
    - Sonic.
    - Ultrasonic.

TDW pig-signal non-intrusive pig indicator:

- Banded to the pipe externally.
- Detects the passage of pigs fitted with magnets or with radio transmitter.
- Passage time and date are displayed on a high-contrast LCD screen.

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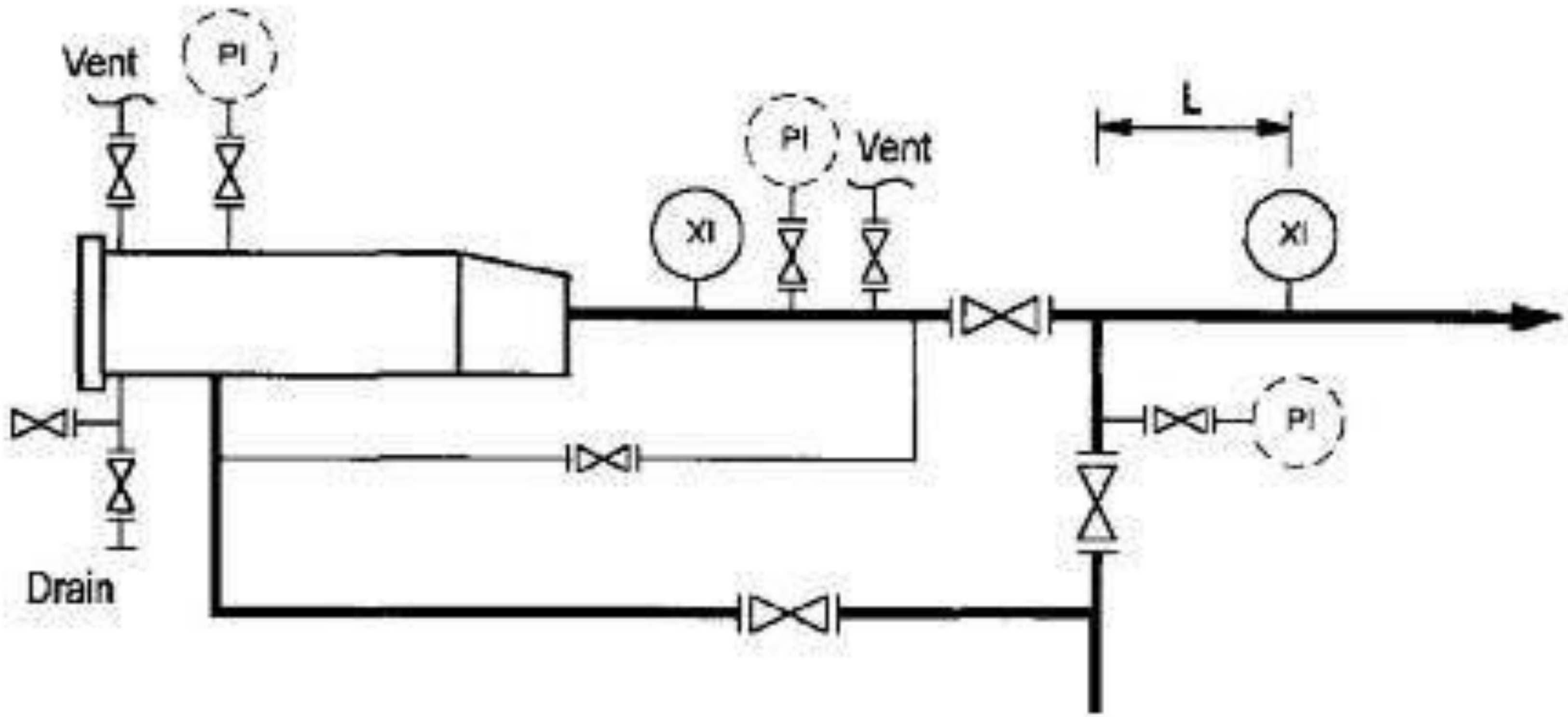
- GD Ultra Pig alert non-intrusive pig signallers:
- Use ultrasonic technology to detect the passage of standard pigs not fitted with magnets or radio-transmitters.

❑ Horizontal Pig Launcher Schematic:



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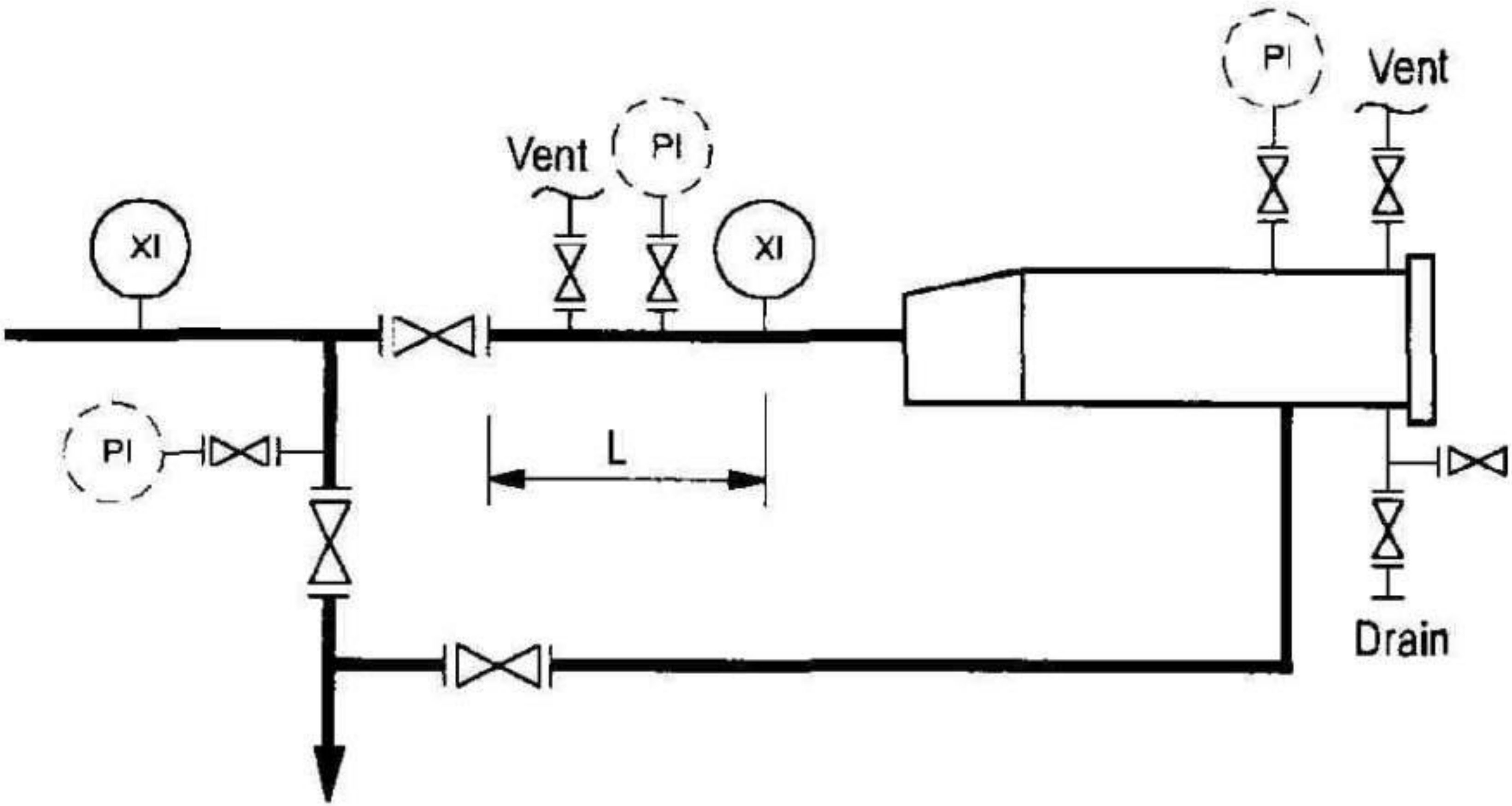
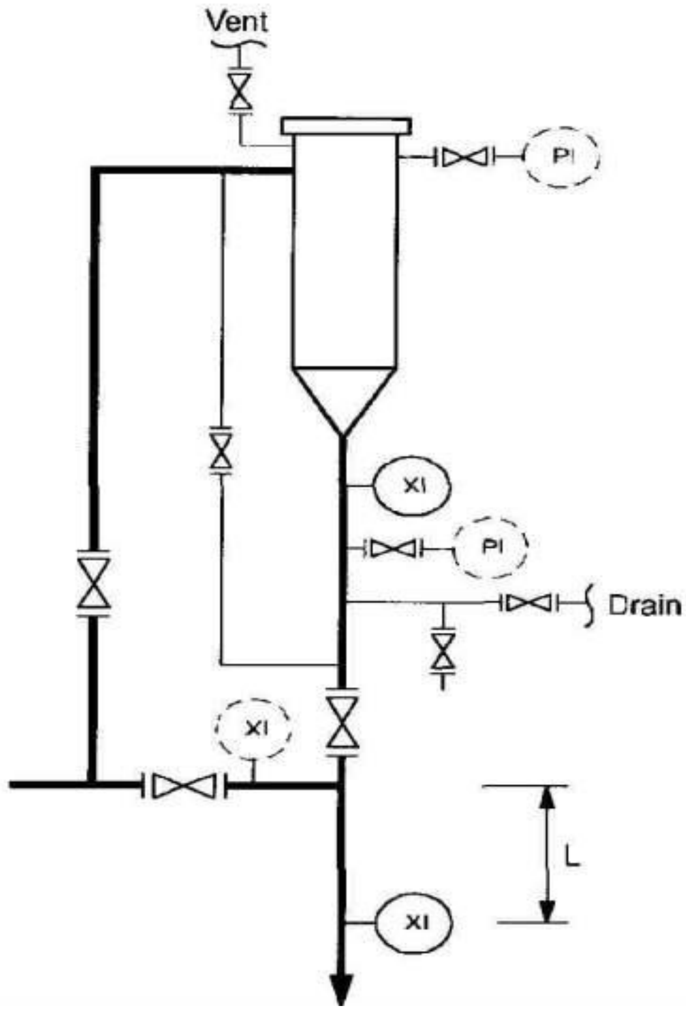
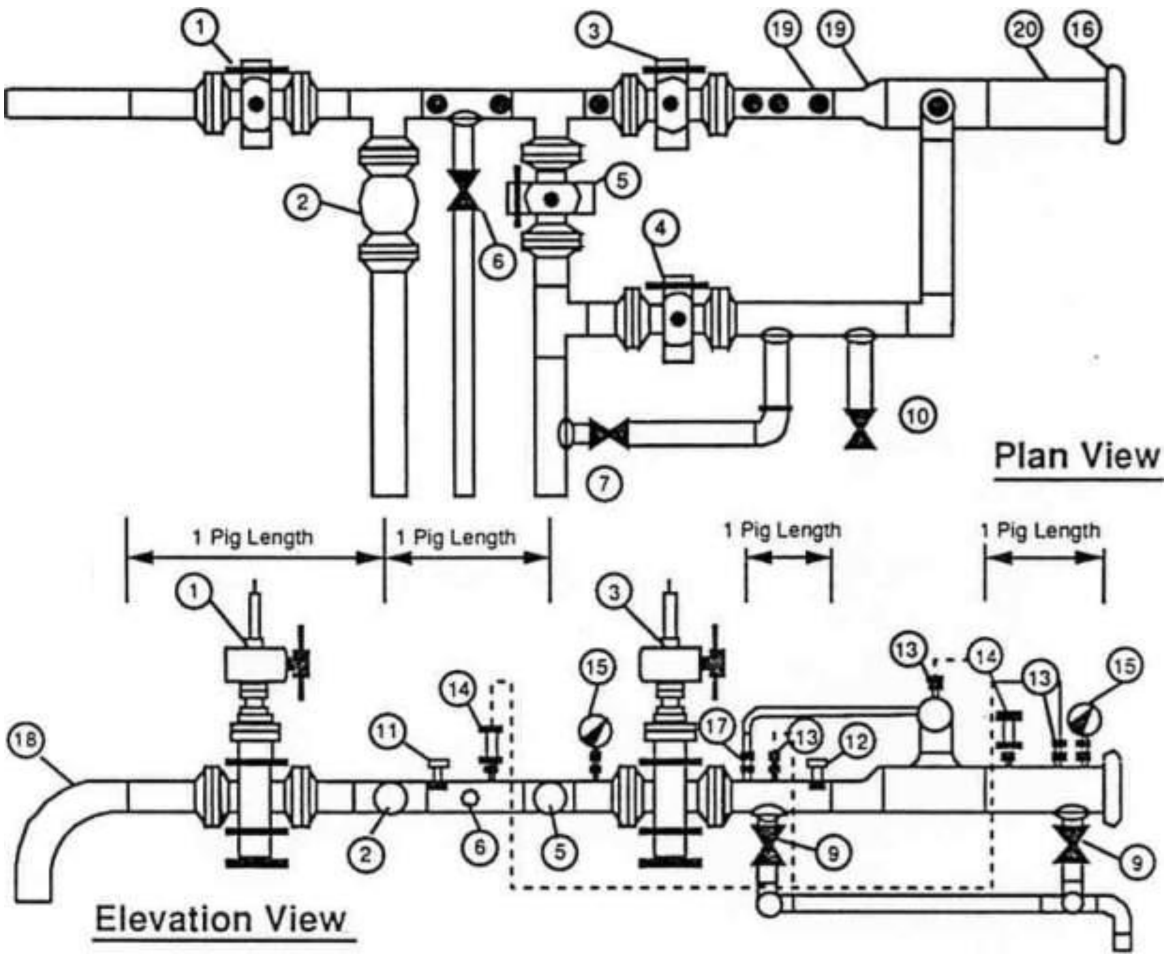
❑ Horizontal Pig Receiver Schematic:



❑ Vertical Pig Launcher Schematic:



❑ Pig launcher and pig receiver equipment:



1. Mainline Block Valve
2. Mainline Relief Valve
3. Pig Trap Isolation Valve
4. Kick-Out Line Valve
5. Bypass Line Valve
6. Chemical Injection Valve
7. Fill Line Valve
8. Eccentric Reducer
9. Pig Trap Drain Valves
10. Test Water & Purge Valve
11. Launch Pig Signaller
12. Receive Pig Signaller
13. Vapour Bleed Off Valve
14. Thermal Relief Valve
15. Pressure Gauge
16. Quick Opening End Closure
17. Equalizing Line
18. Fabricated Mainline Bend
19. Trap Minor Barrel
20. Trap Major Barrel

❑ Skid mounted pig traps:

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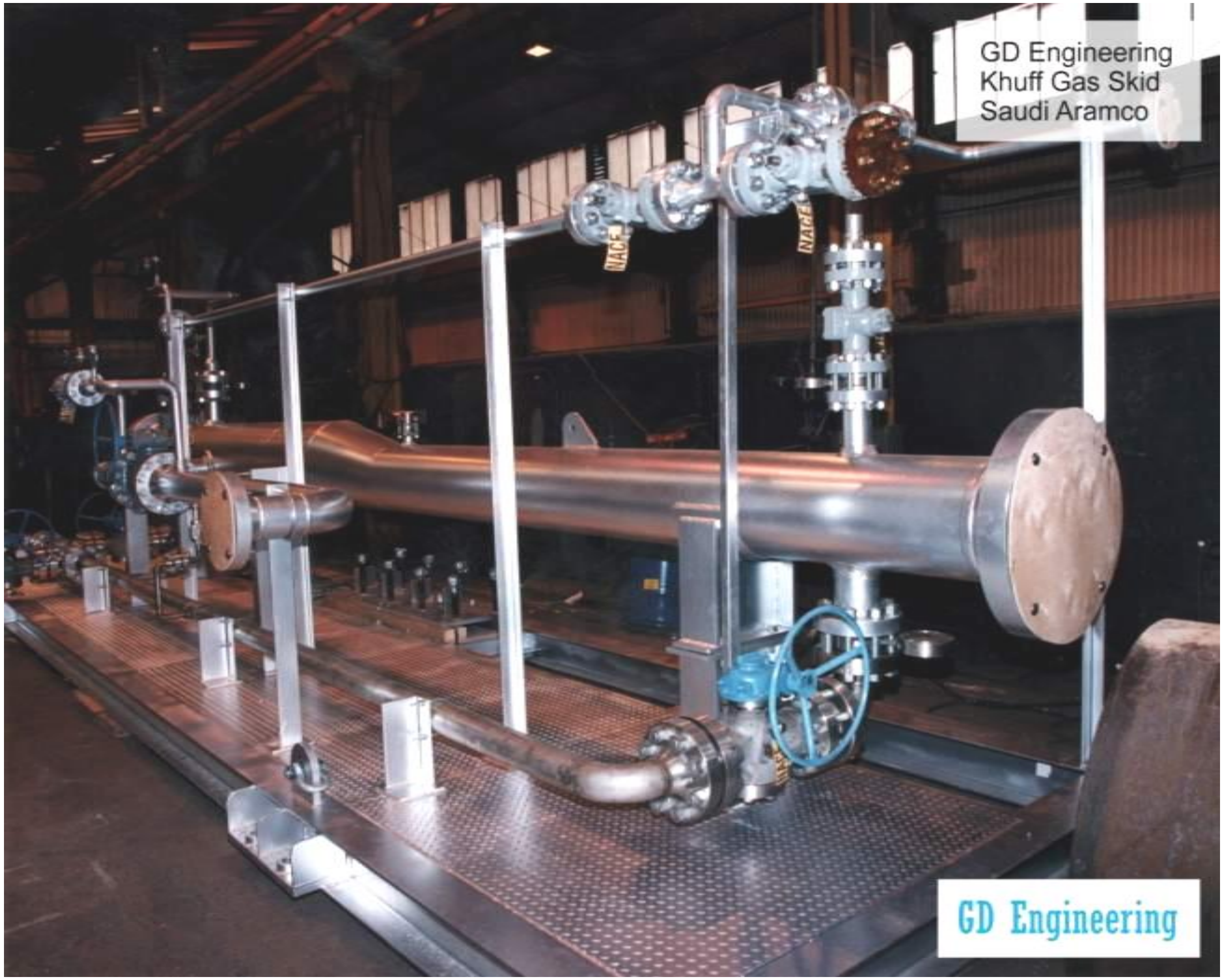

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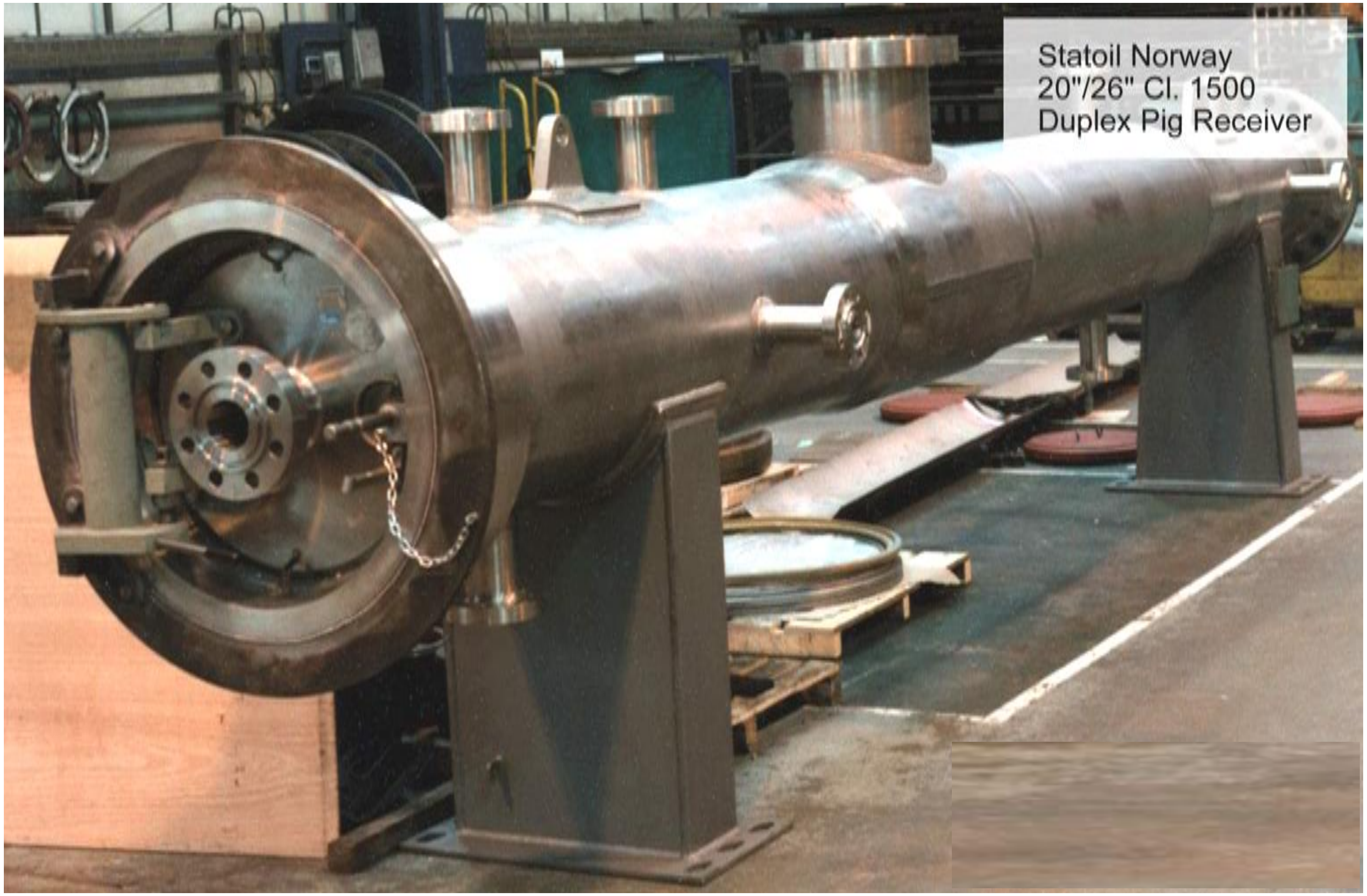
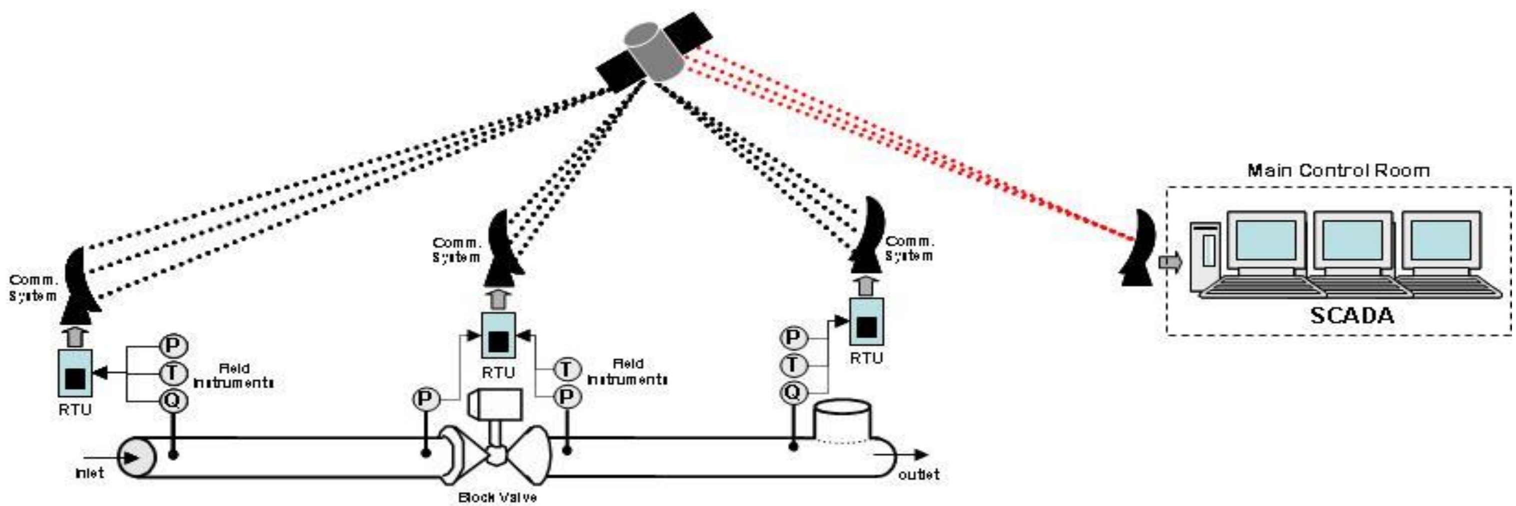

Statoil Norway
20"/26" Cl. 1500
Duplex Pig Receiver

EXAMPLE – PIGGING WAX DEPOSITS

❑ Pipeline control centers:

- Automatic control can be provided to produce safe operation in the face of unexpected upsets.
- Pipeline monitoring is accomplished through a computerized system known as a Supervisory Control and Data Acquisition (**SCADA**) System.
- Major transmission and distribution pipelines have an automated leak detection system that constantly checks the “line balance” and system pressures.



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