

# Oil and Gas Pipeline Design, Maintenance and Repair

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## Part 4: Pipeline Components

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# METALLIC PIPES

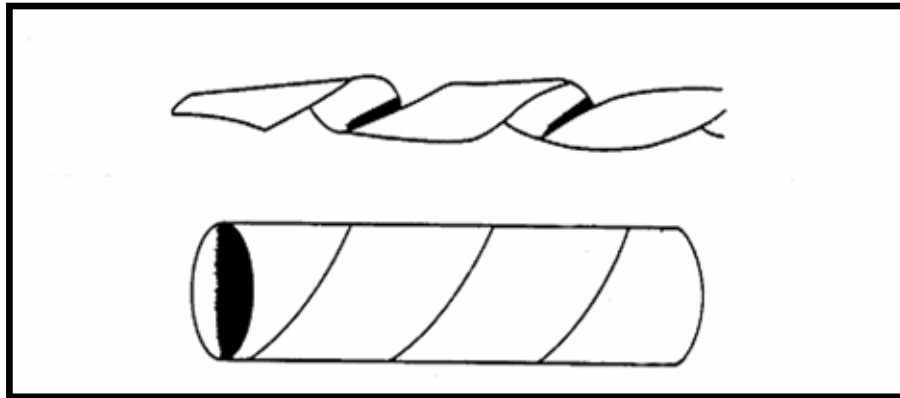
- Most metallic pipes are stronger and harder to break
- They are more conductive to heat and electricity and less corrosive-resistant than nonmetallic pipes.
- Commercially available metallic pipes are discussed in the following



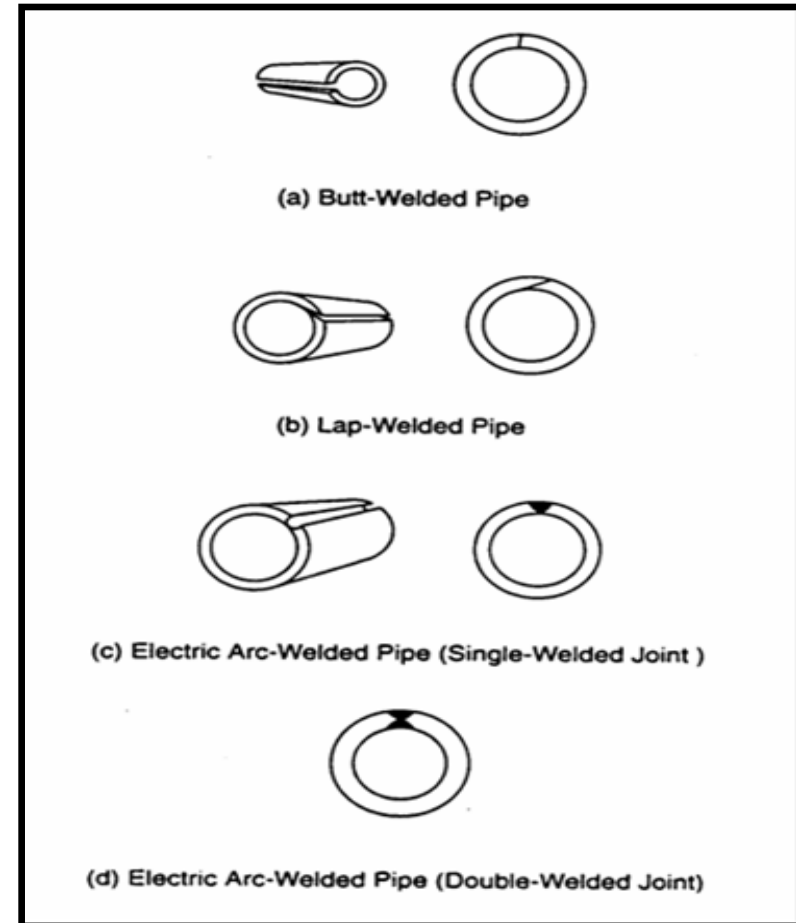
# Ordinary Steel Pipe

- Made of wrought (carbon) steel
- Seamless or seamed (welded)
- Seamed made of steel sheets or steel plates rolled or press formed into circular shape, with the edge (scam) of each pipe closed by welding
- Four types of welding
  - A. Butt weld,
  - B. Lap weld,
  - C. Electric arc weld (single-welded joint)
  - D. Electric arc weld (double welded joint)

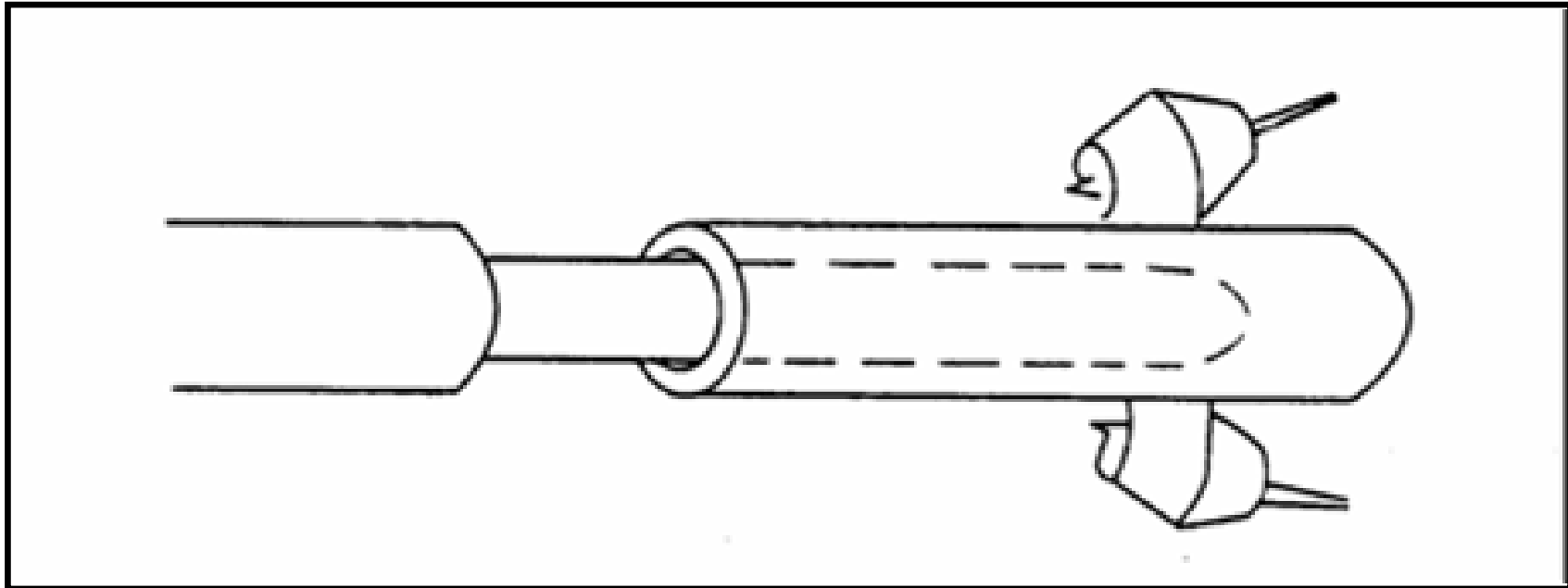
# Different Types of Welding For Seamed Steel Pipe



Spiral welded pipe



# Seamless Pipe



Formation seamless pipe

# Corrugated Steel Pipe

- Thin-wall, large-diameter pipes made of galvanized steel sheets having either helical or annular corrugations
- Used extensively in sewer and drainage systems where both the internal pressure (water pressure) and the external pressure (soil pressure) are low and where leakage will not cause serious problems.
- Some come with perforations to allow drainage into them
- The water in a large diameter corrugated pipe is often gravity flow (open channel flow) rather than pressure flow (pipe flow).
- Come in a great range of sizes, and have a large variety of fittings.
- Some are fabricated to have a pecan-shaped (arched) instead of circular cross section

# Cast-Iron Pipe

- Two types: the ordinary or gray cast-iron pipe, and the ductile-iron pipe.
- The ordinary cast-iron pipe made of iron containing 3 to 4% of carbon in the form of graphite flakes
- Gray cast-iron pipe has relatively strong corrosion-resistance ability and long life
- Two strength designations for cast-iron pipes: 18/40 and 21/45. In the first designation
- The number 18 means that the minimum bursting tensile strength is 18,000 psi, and the number 40 means that the minimum modulus of rupture (i.e., the tensile stress that causes failure due to bending) is 40,000 psi
- The meaning of the 21/45 designation is similar.



# Ductile-Iron Pipe

- Made of iron containing approximately 3.5% of carbon in spheroidal or nodular form, and a magnesium alloy
- Have the advantages of gray cast-iron pipe (corrosion-resistance and long life) and steel pipe (ductility).
- Often lined and/or coated with cement mortar, Like the gray cast-iron pipe
- Strength designation is 60/42/10.
  - 60 means a minimum tensile strength of 60,000 psi
  - 42 means a minimum yield strength of 42,000 psi
  - 10 means 10% minimum elongation.

# Stainless Steel Pipe

- 300 series such as SS304 or SS316, the most used stainless steel pipes
- Steel contains chrome-nickel alloys, and corrosion resistant
- High price, used only in special applications such as:
  - when the fluid, or environment is rather corrosive,
  - when no rusting of pipe can be tolerated such as in pharmaceutical or food industries.

# Aluminum Pipe

- Corrosion resistant
- Used in certain food plants and chemical plants
- 1100 and 6000 series of aluminum are used for making pipes,.
- Aluminum 1100 is low in strength but easy to weld.
- 3000 or 6000 series is High-number aluminums are stronger mechanically and more corrosion-resistant, and hard to weld.
- Pipes formed by a drawing or extrusion process; they are seamless.

# Copper Pipe

- Corrosion-resistant but expensive
- Used only for small pipes such as those used in plumbing.
- Pipes can be formed by cold drawing
- Note that many of the stainless steel, aluminum and copper pipes are actually tubing rather than pipes.

# Other Metal Pipes

- Many other metal pipes are available.
- Made from different alloys and are used for different purposes, such as corrosion resistance to a particular fluid, high-temperature, low-temperature resistance, etc.
- Some examples are listed in table

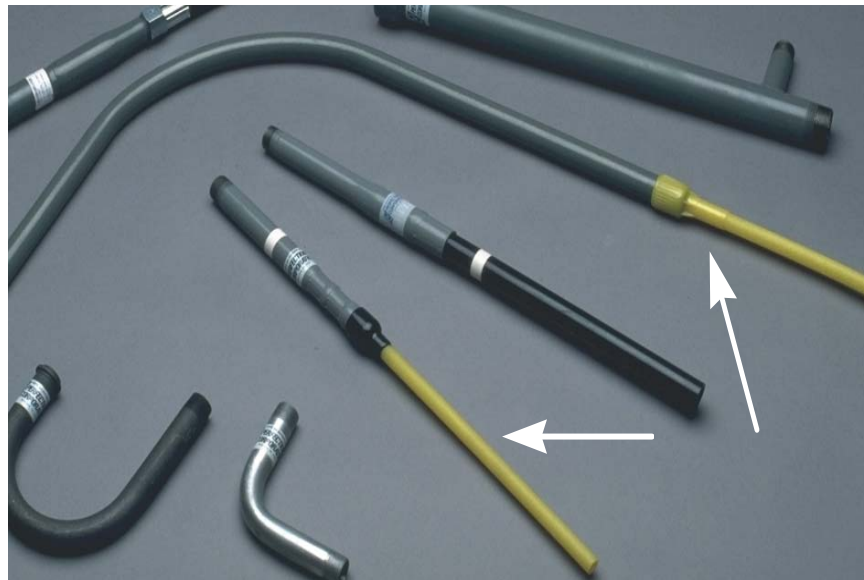
# Some Metal Pipes for Special Applications

Type	Applications
Admiralty metal	Resistant to corrosive water, including saltwater
Aluminum 1100	Most weldable type of aluminum, low strength, and resistant to formaldehyde, ammonia, phenol, and hydrogen sulfide; used in food plants
Aluminum 3003	Superior mechanical properties; contains manganese; used in chemical plants
Aluminum 6061 or 6063	Contains silicon and magnesium; highly corrosion resistant
Brass and silicon	Resistant to corrosive waters, including brines. sugar water and organic acids
Copper	Resistant to corrosive water
Cast iron	Corrosion resistant; used for water and gas distribution. and sewage systems
Ductile iron	Similar corrosion-resistant properties as cast iron. but is more ductile

# Some Metal Pipes for Special Applications

Type	Applications
Ductile iron	Similar corrosion-resistant properties as cast iron. but is more ductile
Monel	Nickel-based alloy; high strength; corrosion resistant to alkaline solutions and air free acids; used only when copper contamination is not a problem
Nickel	Highly corrosion resistant
Stainless steel (type 304)	Corrosion resistant; commonly used in processing food and medicine; extra low carbon (ELC) grade provides good weldability
Stainless steel (types 316.321. or 347)	Also available in ELC grades; good corrosion resistance at elevated temperatures and pressures; available in ELC grade for good weldability
Tantalum	Resistant to nitric and other acids
Titanium	Highly resistant to corrosion in oxidizing media: resistant to sulfuric acid and perchlorites: resistant to abrasion and cavitation

# NONMETALLIC PIPES





# NONMETALLIC PIPES

- Not be as strong as metallic pipes
- Lighter in weight.
- More economical
- Have certain other advantages such as being more corrosion resistant.
- There different types of nonmetallic pipes
- The one which used in oil and gas industry is plastic pipes

# Plastic Pipes

- Three types of plastic pipes commonly used.
  - PVC (polyvinyl chloride)
  - PE (polyethylene)
  - PP (polypropylene)
- Used for
  - Water,
  - Waste water
  - Natural gas
  - Other fluids that do not dissolve or chemically interact with plastics

# Plastic Pipes

- Users must know that
  - Plastic pipes are usually not strong as metal pipes,
  - Deform easily
  - Expand five times as much as steel pipe as a result of temperature,
  - Become brittle in very cold weather.
- Besides, not enough data have been accumulated about plastic pipes to know their long term performance

# PVC

- Currently very popular for answers of relatively small diameter- up to 24 inches (610 mm)
- Used for water supply and indoor plumbing.
- Relatively hard (as compared to PE pipes)
- Highly abrasive (wear resistance)
- Corrosion resistant to a number of chemicals
- Will not deteriorate under the attack of bacteria and other microorganisms, macroorganisms, or fungi.
- Suited for use as-sewers.
- Soluble solids such as calcium carbonate cannot accumulate and attach to the interior surface (smooth & hard)

# PVC

- Free from the tuberculation problem that often exists in water works using steel or other metal pipes.
- Weakness: deteriorate when exposed to ultraviolet light.
- Not to be exposed to direct sunlight (used or stored over extended time).
- Suited for underground pipelines.
- Come in segments 40 ft (12.2 m) each, often 20 ft (11.1 m) or less.
- Joined together by using solvent-cement, or gaskets.
- Solvent-cement for flat ends of pipes such as those due to cuts
- Gaskets for full lengths of pipes with bell and spigot ends.
- Gasketed joints allow for thermal expansion.

# PE

- Very flexible, coiled for compactness in storage and transportation.
- Hundreds of feet, up to 6-inch (152 mm), can be rolled around a single spool.
- This reduces the number of joints, and facilitates transportation and laying of pipe.
- Can be easily laid on surface or underground without having joints over a long distance - several hundred feet or meters.
- Flexibility allows the pipe to follow the curvature of topography easily.
- Joining is usually done by thermal fusing - heating and melting the pipe ends while holding them together.

# PE

- Widely used for natural gas distribution lines up to 10-inch (254 mm) diameter
- Used for water lines and other applications.
- Classified according to their density (or specific gravity)
- Low density (LDPE), Sp. Gr. (0.910 to 0.925)
- Medium density (MDPE), Sp. Gr. (0.926 to 0.940)
- High density (HDPE), Sp. Gr. ( 0.941 to 0.965)
- All PE pipes are highly corrosion resistant and abrasion resistant.
- Weakness: material deteriorates under exposure to sunlight.

# PIPE DESIGNATION

- A common designation of pipe size in the U.S. is the nominal pipe size (NPS)
- Nominal diameter of pipes is given in inches.
- The weight (or thickness) of the pipe is given in
  - schedule number (steel, stainless steel, and PVC),
  - or class number (for cast iron or ductile iron pipes )
- Table 4.2 gives the designations for steel pipe
  - Class numbers:
    - STD (standard),
    - XS (extra strong)
    - XXS (double extra strong).
- Schedule number (from 10 to 160)



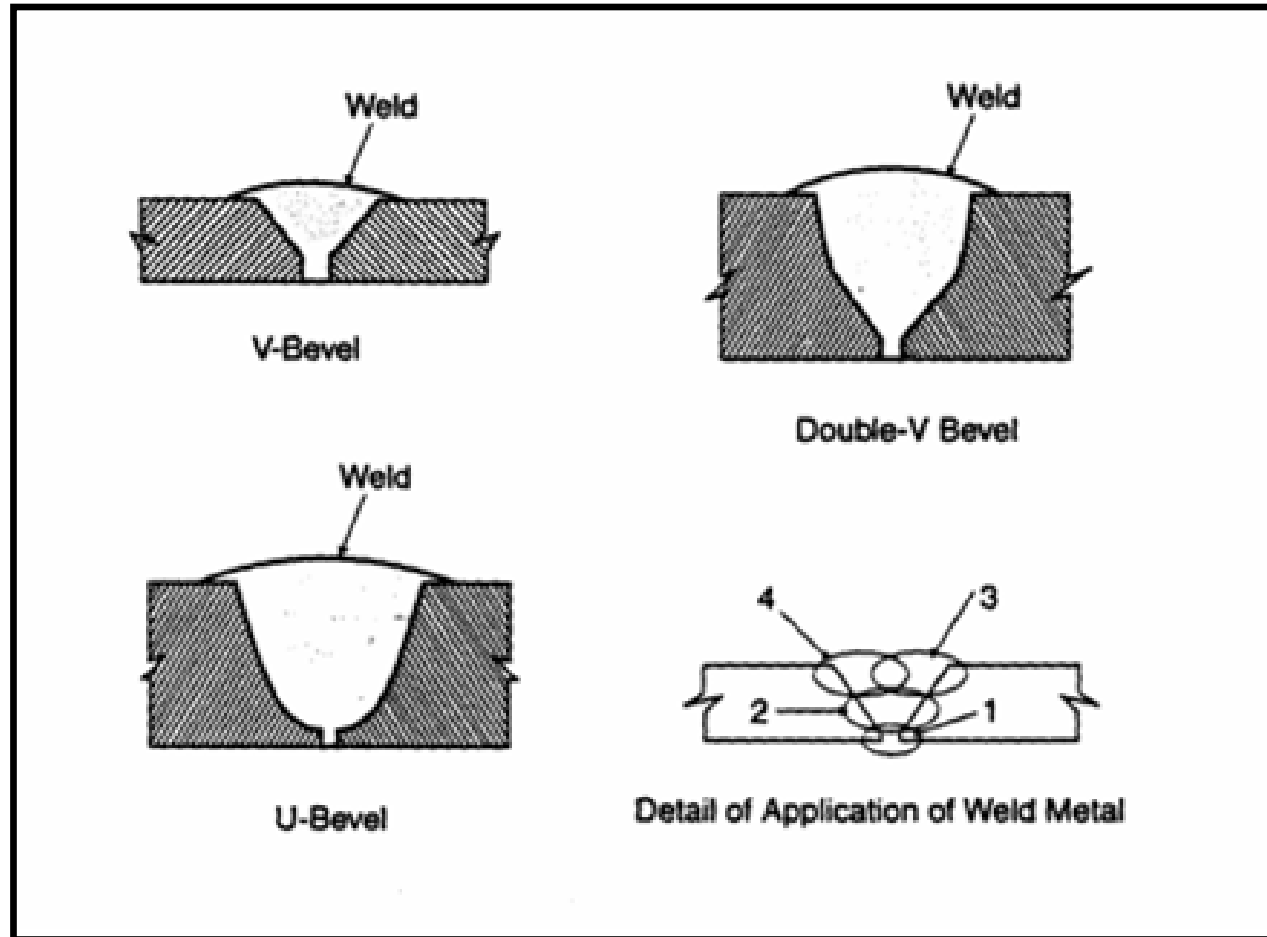
# PIPE DESIGNATION

- An exception to the foregoing designation system for steel pipes is light-gauge piping such as the spiral-welded pipe.
- Sizes from 1 inch to 12 inches, the wall thickness of spiral-welded pipes is the same as schedule 10S (S stands for stainless steel), and for sizes from 14 to 24 inches, it is the same as schedule 10.

# Table 4.2 Dimensions and weights of welded wrought steel pipe

NPS in	OD in	Pipe Thickness						Schedule Number					
		STD		XS		XXS		10		20		30	
		Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.
1/8	0.405	0.068	0.24	0.095	0.31								
1/4	0.540	0.088	0.42	0.119	0.54								
3/8	0.675	0.091	0.57	0.126	0.74								
1/2	0.840	0.109	0.85	0.147	1.09	0.297	1.71						
3/4	1.050	0.113	1.13	0.154	1.47	0.308	2.44						
1	1.315	0.133	1.68	0.179	2.17	0.358	3.66						
1-1/4	1.660	0.140	2.27	0.191	3.00	0.382	5.21						
1-1/2	1.900	0.145	2.72	0.200	3.63	0.400	6.41						
2	2.375	0.154	3.65	0.218	5.02	0.436	9.03						
2-1/2	2.875	0.203	5.79	0.276	7.66	0.552	13.70						
3	3.500	0.216	7.58	0.300	10.25	0.600	18.58						
3-1/2	4.000	0.226	9.11	0.318	12.51								
4	4.500	0.237	10.79	0.337	14.98	0.674	27.54						
4	5.863	0.258	14.62	0.375	20.78	0.750	38.55						
6	6.625	0.280	18.97	0.432	28.57	0.864	53.16						
8	8.625	0.322	28.55	0.500	43.39	0.875	72.42			0.250	22.36	0.277	24.70
10	10.750	0.365	40.48	0.500	54.74	1.000	104.13			0.250	28.04	0.307	34..24
12	12.750	0.375	49.56	0.500	65.42	1.000	125.49			0.250	33.38	0.330	43.77
14	14.000	0.375	54.57	0.500	72.09			0.250	36.71	0.312	45.61	0.375	54.57
16	16.000	0.375	62.58	0.500	82.77			0.250	42.05	0.312	52.27	0.375	62.58
18	18.000	0.375	70.59	0.500	93.45			0.250	47.39	0.312	58.94	0.438	82.15

# CONNECTIONS (JOINTS)



# CONNECTIONS (JOINTS)

- **Bonded (welded) joints** - Include welding for steel pipe, brazing or soldering for brass, copper and lead pipes, and fusing of plastic pipes.
- **Threaded joints** - Connecting threaded pipe sections together, or connecting a threaded pipe to a threaded coupling or fitting.
- **Flanges** - Flanges most common way to provide a strong joint without permanently joining the pipe sections together as done in welding. used for steel pipes at both the inlet and the outlet of pumps, valves, flow meters, and other fittings. Allows easily installation and disconnection from the pipe.

# CONNECTIONS (JOINTS)

- **Mechanical joints** - Various mechanical connectors exist for ease in assembly/disassembly.
- **Bell-and-spigot joints** - See Figure 4.4 for those used in pressure concrete pipes. Other pipes, including glass pipes and plastic pipes, also use bell-and-spigot joints.
- **Push-on joints** - can be connected together simply by pushing two pipe sections (segments) against each other. Likewise, the sections can be disconnected simply by pulling them apart.

# FITTINGS

Fittings Type	Purpose
Bushing	connect a threaded small pipe to a large one
Cap	seal the end of a pipe
Coupling	connect two threaded pipes of the same size together
Half coupling	one end threaded, and the other plain. The plain end can be welded to, for example, a tank to from a pipe entrance
Cross	connect a pipe to three others
Elbow	change flow direction
Nipples	tap a pipe (small tap)

# FITTINGS

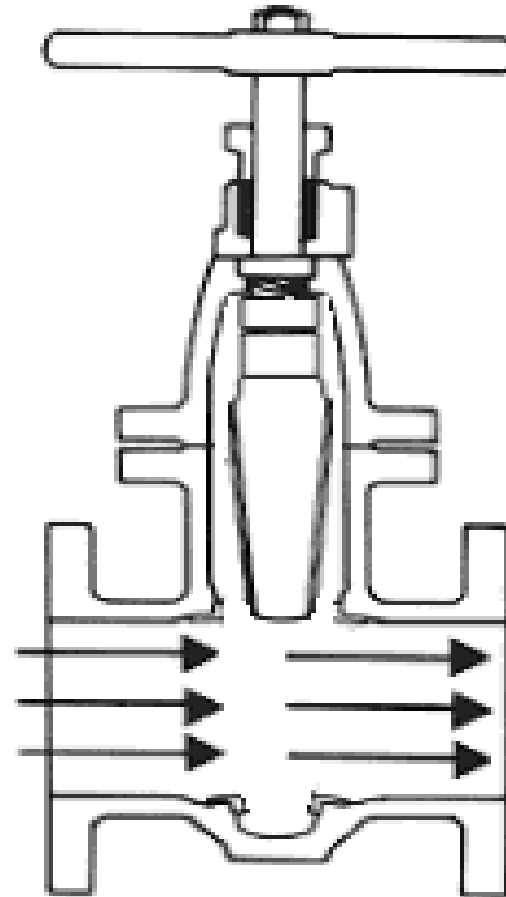
Fittings Type	Purpose
Plug	seal the end of a threaded pipe
Reducer	change (reduce or enlarge) pipe diameter
Saddle	tap a pipe
Sleeve	connect two pipes together
Tee	connect a 90° branch
Union	connect two threaded pipes of the same size together without having to turn the pipes-just turn the union
Y	connect two pipes to one pipe in the shape of a Y

# VALVES

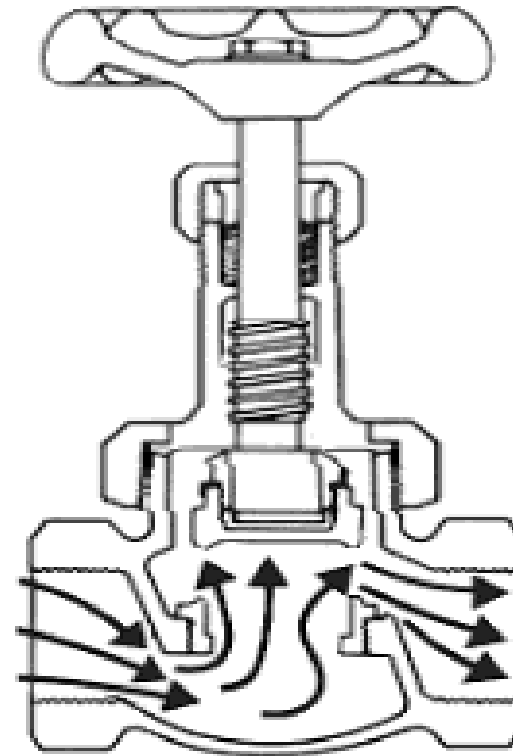
- **Gate valve –**
  - Closed and opened by turning the handle connected to it, which raises or lowers a stem (shaft) connected to the gate.
  - Takes many turns to completely open or close a gate valve.
  - Headloss of the valve is small when the gate is fully open.
  - May be a wedge or a disk (for nonslurry), or a knife (for slurry).
  - Used in oil or natural gas pipelines has a conduit with a full round bore for smooth passage of pigs or scrapers.
  - called conduit gate, valves or full-bore gate valves.
- **Globe valve –**
  - Outside is globe shaped.
  - Flow changes direction as it goes through the valve.
  - Large head loss is generated even when the valve is fully open.
  - Gives better control of flow than gate valves - good for flow throttling.



# Gate Valves



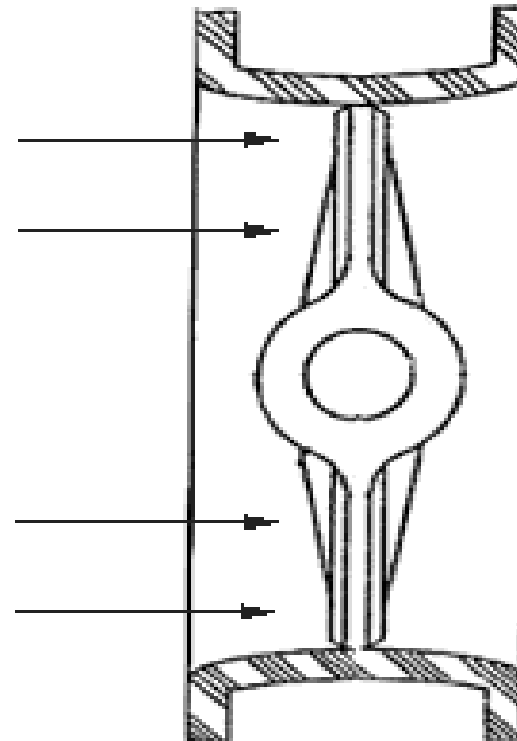
# Globe Valve



# VALVES

- **Angle valve**
  - Except that the flow direction is changed by  $90^\circ$  as the flow leaves the valve.
  - Used in locations of  $90^\circ$  bends and is good for flow throttling.
- **Ball valve**
  - A large bead (i.e., a large sphere having a central piercing).
  - Turned from a completely closed to a fully open position in  $90^\circ$ .
  - When fully open, it causes little blockage to the flow and hence has little headloss.
  - Used mainly for on-off operations.

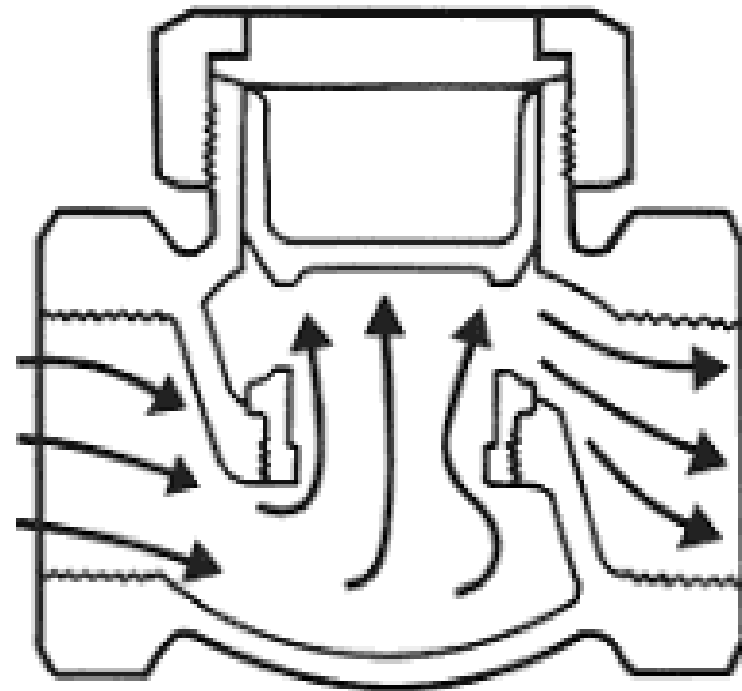
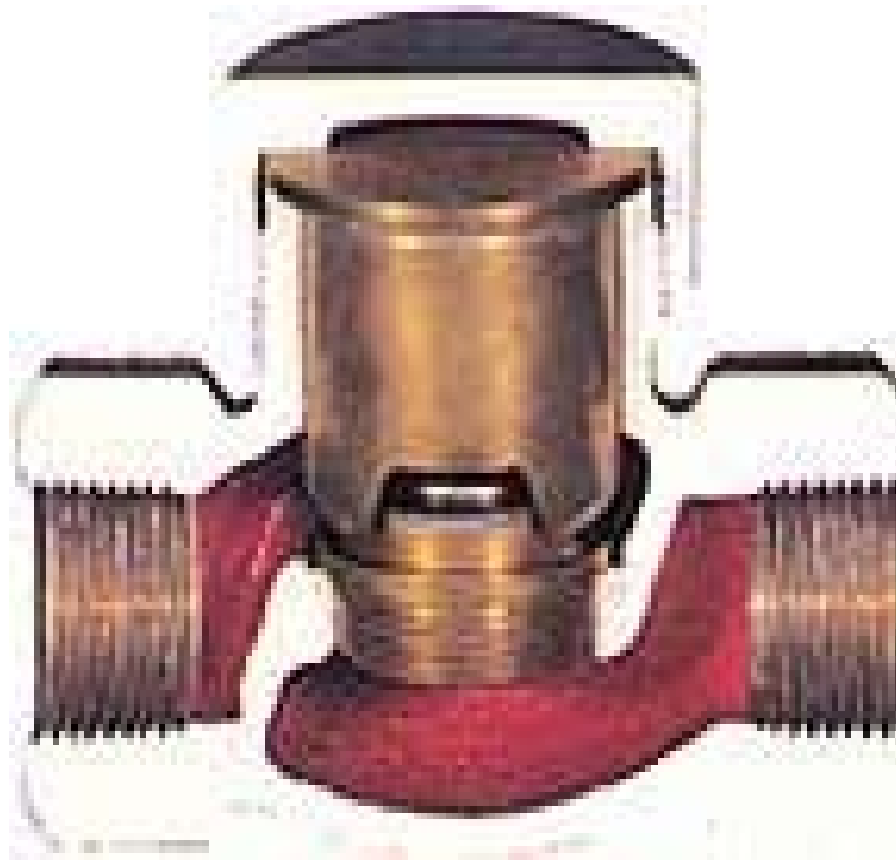
# Butterfly Valves



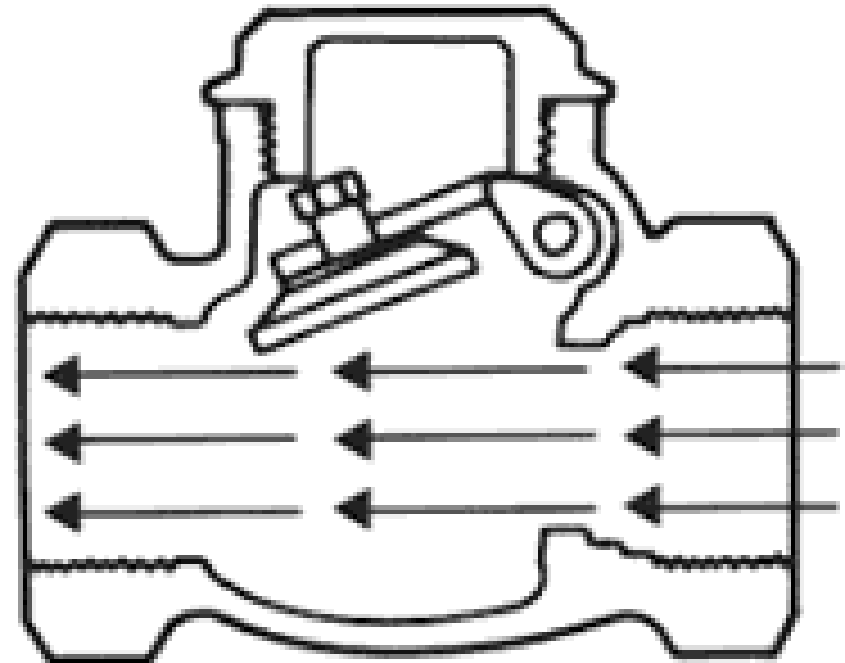
# VALVES

- **Check valve**
  - Flow cannot reverse through a check valve; the valve produces unidirectional flow
  - Three types of check valves are swing check valves (horizontal or vertical lift types), tilt disk check valve (does not slam), and ball check valve.
- **Foot valve**
  - A special vertical-lift type check valve embedded in the vertical end of a pipe connected to a reservoir below.
  - Used there to prevent the pump from losing priming when the flow is stopped

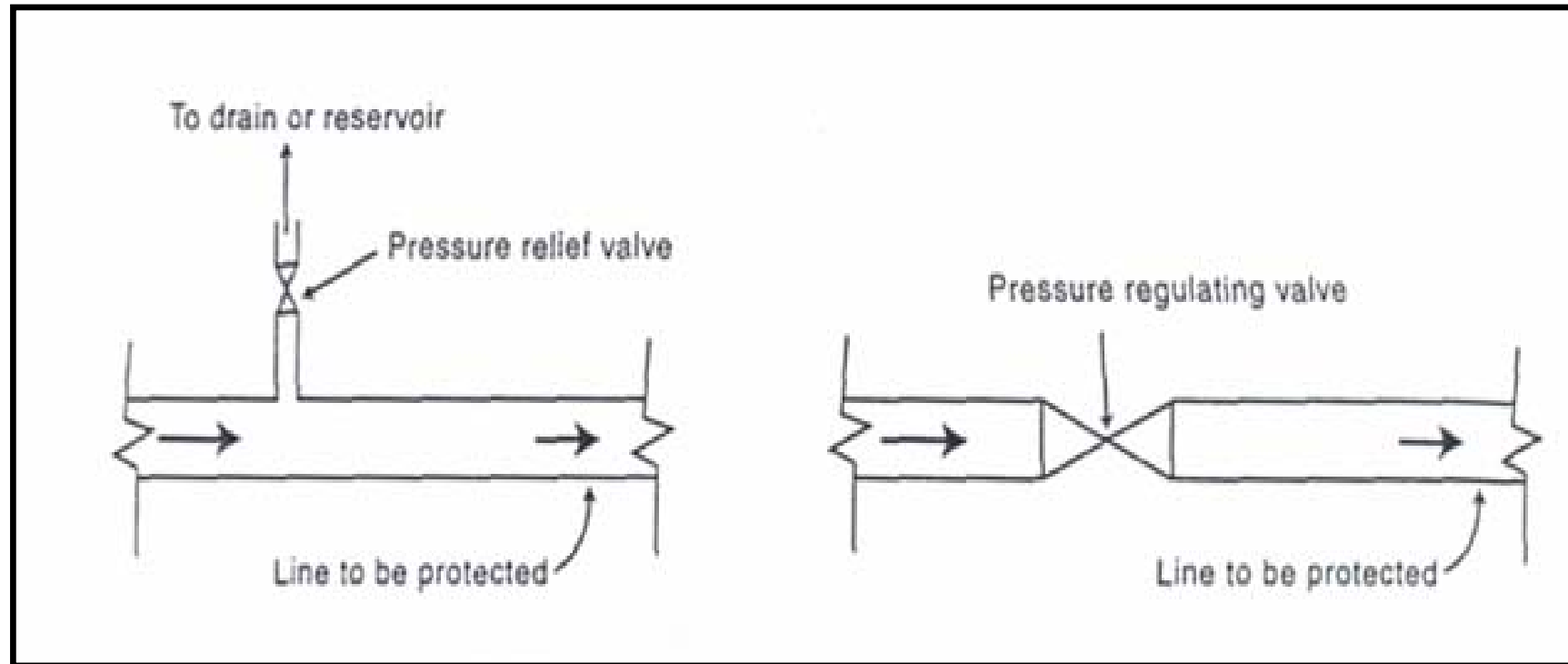
# Lift or Piston Check Valves



# Swing Check Valves



# PRESSURE RELIEF VALVES AND PRESSURE REGULATING VALVES

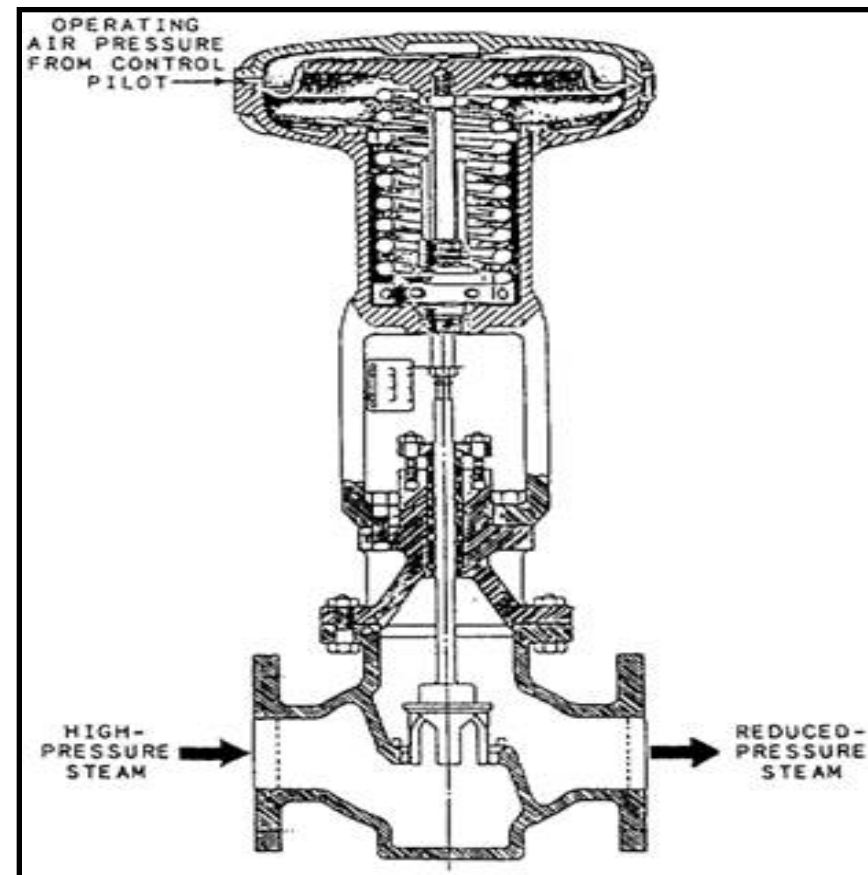




# PRESSURE RELIEF VALVES

There are two major groups of pressure relief valve:

1. Direct-acting pressure relief valves which are actuated directly by the pressure at the valve inlet
2. Pilot pressure relief valves in which a pilot mechanism opens and closes a main valve in response to the pressure in the pressure system



# Pressure Safety Valves

