PIPING DESIGN ENGINEERING

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PIPING
DESIGN ENGINEERING

This is a consolidated document which provides a basic knowledge in some of the criteria's involved in Piping Design Engineering

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CHAPTER: 1

INTRODUCTION

DEFINITION:

Piping engineering is all about designing, fabricating and constructing lines for conveying fluids.

IMPORTANCE OF PIPING ENGINEERING:

- ✓ To maintain pressure difference (Δp)
- ✓ To maintain temperature difference (Δt)
- ✓ To maintain flow rate (Δq)

APPLICATIONS:

- ✓ 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 etc,
- ✓ 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.
- ✓ The fire protection piping networks in residential, commercial, industrial, and other buildings carry fire suppression fluids, such as water, gases, and chemicals to provide protection of life and property.
- ✓ The piping systems in thermal power plants convey high-pressure and high-temperature steam to generate electricity. Other piping systems in a power plant transport high- and low-pressure water, chemicals, low-pressure steam, and condensate.
- ✓ Sophisticated piping systems are used to process and carry hazardous and toxic substances.
- ✓ The piping systems in laboratories carry gases, chemicals, vapors, and other fluids that are critical for conducting research and development.

DEFINE PIPING

Piping is an assembly of pipe, fittings, valves, instruments and specialty components.

Piping is divided into three major categories:

- ✓ **Large bore pipe** generally includes piping which is greater than two inches in diameter.
- ✓ **Small bore pipe** generally includes piping which is two inches and smaller in diameter.
- ✓ **Tubing** is supplied in sizes up to four inches in diameter but has a wall thickness less than that of either large bore or small bore piping and is typically joined by compression fittings.

Piping system includes:

- ✓ Pipe
- ✓ Fittings (e.g. elbows, reducers, branch connections, etc.)
- ✓ Flanges, gaskets, bolting
- ✓ Valves
- ✓ Pipe supports

ASSOCIATION INVOLVED IN GENERATING CODES FOR PIPING DESIGN ENGINEERING:

- ➢ **ASME**

  -American Society of Mechanical Engineers

- ➢ **ANSI**

  -American National Standardization Institute

These standards give technical recommendations for designing piping system for power plants and chemical plants

- ✓ They contain formulas to calculate the minimum thickness of pipelines
- ✓ They contain formulas to calculate the extra thickness that a pipe must have when a branch is cut into it.
- ✓ They contain regulations for stress analysis
- ✓ They contain tables that give maximum allowable stress for metallic materials accepted by ANSI for pipeline construction depending on temperatures.

PIPING CODES:

ASME B31.1	-	Power Piping
ASME B31.2	-	Fuel Gas .Piping
ASME B31.3	-	Process Piping
ASME B31.4	-	Liquid Piping
ASME B31.5	-	Refrigeration Piping
ASME B31.8	-	Gas Distribution and Transportation
ASME B31.9	-	Building Service Piping
ASME B31.11	-	Slurry Piping

ASSOCIATION INVOLVED IN GENERATING MATERIAL SPECIFICATION FOR PIPING:

ASTM

-American Society for Testing Materials

- ✓ ASTM developed a collection of documents called material specifications for standardising materials of large use in the industry. Specifications starting with "a" are for steel. Specifications starting with "b" are for non-ferrous alloys (bronze, brass, copper nickel alloys, aluminium alloys and so on). Specifications starting with "d" are for plastic material, as PVC.
- ✓ An ASTM specification does not only specify the basic chemical composition of material, but also the process through which the material is shaped into the final product.
- ✓ This is why for a given base material seamless pipe have a specification, welded pipe have another specification wrought fittings have another specification, forged fittings have another specification, large valve bodies (normally cast) have another specification

API

-American Petroleum Institute

- ✓ Rules, practices and standards for oil and gas industry are issued by this institute and followed by almost all oil and gas companies in the world.
- ✓ Among the many standards issued by the institute there is also a standard for design of pipelines: API STANDARD 5l
- ✓ Within this standard materials for oil and gas transportation pipelines are specified, with denomination API 5l
- ✓ This is a family of carbon steels almost equivalent to ASTM A53 / A106.

CHAPTER 2

PIPE

INTRODUCTION:

- ✓ A pressure tight cylinder used to convey fluids under pressure through materials of commercially available designation.
- ✓ Pipe is always designated through nominal bore size(NBS) also called as nominal pipe size(NPS)
  - ✓ A pipeline conveys a fluid from one given point of the plant usually called inlet point of the line, to another part of the plant usually called outlet point of the line.

NOMINAL PIPE SIZE (NPS):

Pipe size is specified with two non-dimensional numbers: a Nominal Pipe Size (NPS) and a schedule (SCH). The relationship of these numbers to the actual pipe dimensions is a bit strange. The NPS is very loosely related to the inside diameter in inches, but only for NPS 1/8 to NPS 12. For NPS 14 and larger, the NPS is equal to the outside diameter (OD) in inches. For a given NPS, the OD stays constant and the wall thickness increases with larger SCH. For a given SCH, the OD increases with increasing NPS while the wall thickness increases or stays constant.

NOMINAL DIAMETER (DN):

It is same as nominal pipe size, but in mm.

SCHEDULE (WALL THICKNESS):

Schedule:

Carbon steel : 5, 10, 20, 30, 40, 60, 80, 100, 120, 160.

Stainless steel : 5S, 10S, 20S, 30S, 40S, 60S, 80S.

Weight series:

STD : Standard

XS : Extra Strong

XXS : Double Extra Strong

Wall thickness is designated by schedule number or descriptive classification, rather than the actual wall thickness. The original thicknesses were referred to as standard (STD), extra strong (XS) and double extra strong (XXS).

Wall thickness for the schedule 40 and STD are same for sizes ⅛ to 10”.schedule 80 and XS also have the same wall thickness for ⅛ to 8” diameter pipe.

CODES:

- **ASME B36.10 - CARBON STEEL**

- **ASME B36.19 - STAINLESS STEEL**

MATERIAL:

- **Carbon steel:**

Steel is basically a solution of carbon (C) into iron (Fe). The presences of carbon into the crystal structure of the iron improve very much the mechanical characteristics of the iron alone. Carbon steel is a conventional denomination for steel that has almost no other metallic elements added into it.

Carbon steel material specification **ASTM A106** is available in grades A, B and C. These refer to the tensile strength of the steel, with grade C having the highest strength. Common practice is to manufacture the pipe as A106 grade B

ASTM A53 is also commonly specified for galvanized or lined pipe or as an alternate to A106.the testing requirement for A53 are less stringent(rigorous or tight) than for A106. Three types of carbon steel pipe are covered by A53. These are type E or Electric resistance welded, type F or Furnace-butt welded, and type S or Seamless. Type E and S are available in grade A and B, comparable to grades A and B of A106.

- **Stainless steel:**

Austenitic stainless steel pipe commonly referred to as "Stainless Steel" is virtually non-magnetic. Stainless steel is manufactured in accordance with **ASTM A312** when 8" or smaller sizes are needed. There are eighteen different grades, of which type 304L is the most widely used.

Grade 316L has high resistance to chemical and salt water corrosion and is best suited for welding. Large sizes (8" and up) of stainless steel pipe are covered by **ASTM A358.** Extra light wall thickness (schedule 5S) and light wall thickness (schedule 10S) stainless steel pipe is covered by **ASTM A409.**

PIPE MANUFACTURING METHOD:

- Seamless

  Hot rolled, cold drawn etc

- Electric resistance welding

  No material is added during welding process

- Electric fusion welding

  Filler material is added during welding process

CHARACTERISTICS OF A PIPELINE:

- Nominal pipe size(NPS)
- Wall thickness
- Type of joint between pieces

- Welded joints
  - ✓ Butt welded
  - ✓ Socket welded
- Threaded joints
- Flanged joints

- External finishing
  - Painting
- Insulation

OTHER CHARACTERISTICS OF A PIPELINE:

Routing:

✓ The routing is how the Pipeline is developed into the space.

✓ There are rules and regulations to route a Pipeline according the "Good Engineering Practice"

✓ Cold Pipelines connecting static objects (something that does not move like Tanks, Vessels, other Pipelines, and Headers) can be straightly routed between the inlet and the outlet point.

✓ Cold Pipelines connecting machines that vibrate or rotate may need a flexible part between the inlet and the outlet point.

✓ Hot Pipelines must be flexible enough to adsorb the thermal expansion of the Pipeline from cold to hot condition

- **Supporting System:**

✓ Every Pipeline must be supported. Not all Pipelines are supported in the same way

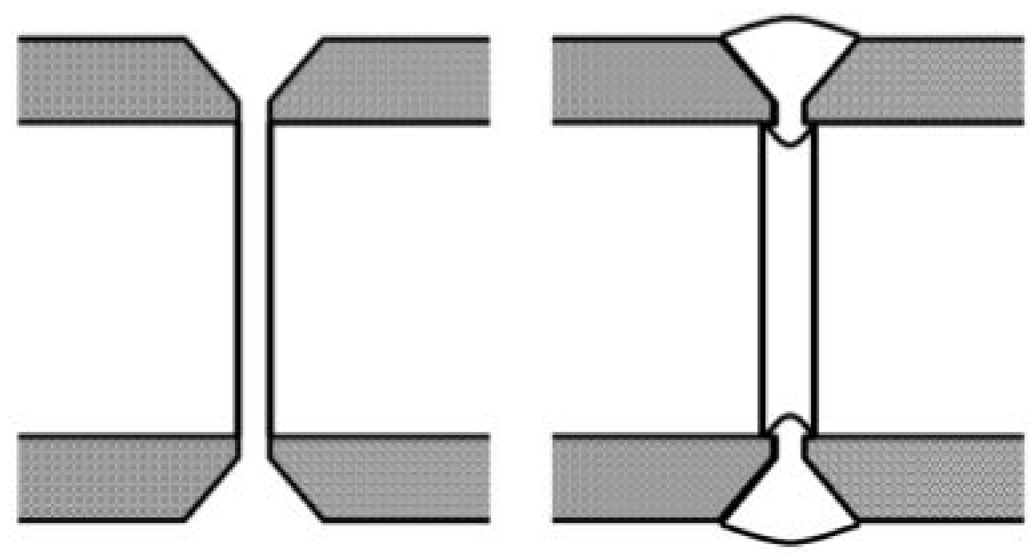
✓ Cold Pipelines can be supported everywhere with fixed points

✓ Hot Pipelines cannot be supported only with fixed points, but certain points must be only guided, meaning that in those points the Pipeline retains a certain numbers of degree of freedom in certain directions, while are constrained in certain other directions

TYPE OF JOINT BETWEEN PIECES:

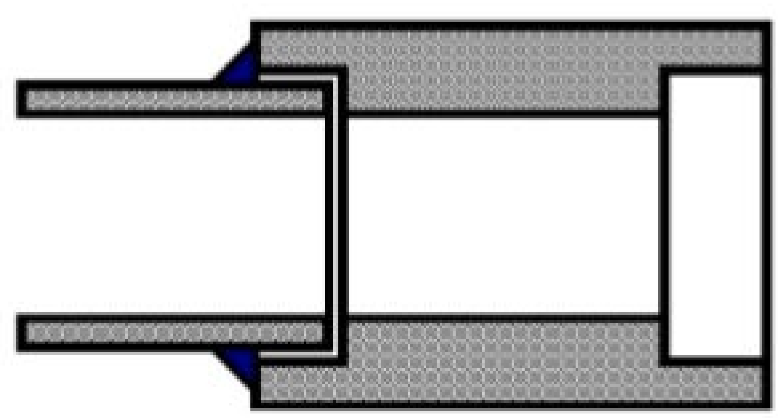
1. Butt welded joint:

The end is machined to allow head to head full penetrating welding



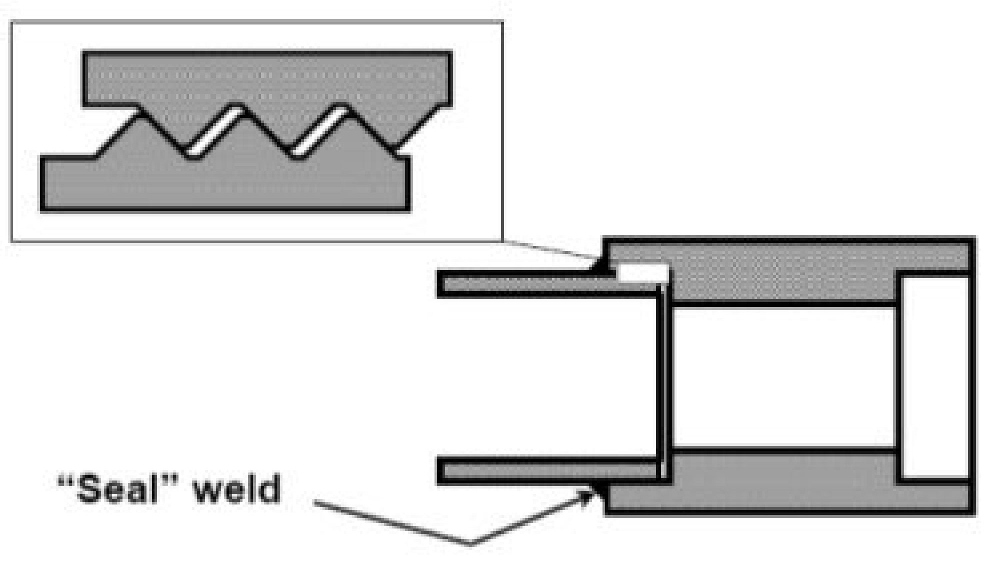
2. Socket welded joint:

A socket is provided where pipe can be inserted



3. Threaded joint:

Parts to be connected are threaded.



PIPE ENDS:

Pipe may be obtained with

- **Plain ends** are cut square and reamed to remove burns. This type of end is needed when being joined by mechanical couplings, socket weld fittings, or slip-on flange.
- **Beveled ends** are required for most butt weld application.
- **Threaded ends** are used with screwed joints and are ordered noting threaded on both ends or one end.

Various combination of pipe end:

POE: Plain one end

PBE: Plain both end

BOE: Beveled one end

BBE: Beveled both end

TOE: Threaded one end

TBE: Threaded both end

PIPE REPRESENTATION:

Up to 12 inch

Above 14 inch

SPECIFICATION OF A PIPE:

Example:

Size	:	NPS 12”
Diameter	:	DN 300
Wall thickness	:	Sch. 40
Material	:	ASTM A106 Gr. B

CHAPTER 3

FLUID

INTRODUCTION:

It can be

- ✓ A gas
- ✓ A liquid
- ✓ A mixture of gas or liquid
- ✓ A suspension of small solid particles inside a liquid.

BASIC PROPERTIES OF CONVEYED FLUIDS:

- ➢ Fluid type
- ➢ Flow rate
- ➢ Pressure
- ➢ Temperature

FACTORS DEPENDING UPON FLUID TYPE:

1. MATERIAL:

a. **Non corrosive fluids**: Services where impurities are accepted

Example:

Industrial water lines (cooling water)

Steam

Lube oil return / before filter lines

Air lines

Vents and drains

Material:

Carbon Steel

Low Alloy Steel (High T)

b. **Corrosive fluids**: Services where impurities are not accepted

Example:

Demineralized water

Lube oil after filters

Fuel gas / oil

Sea water (water containing Chlorine)

Material:

Stainless Steel

No Iron (Fe)

Copper/Nickel Alloys (Cu-Ni)

c. Aggressive Chemicals

Example

Strong Acids / Bases

Material:

Plastic: PVC – TEFLON – PE

Rubber: NBR, Viton

Composites: RESIN GLASS

2. CORROSION ALLOWANCES:

Thickness of the pipe increases with respect to corrosion. Typical corrosion allowance for water is 3mm.

3. TYPE OF JOINT:

Dangerous fluids are conveyed in fully welded pipes, were leaks are not accepted.

4. TESTING AND EXAMINATION:

For Dangerous Fluids 100% of joints are likely to be X-Ray examined

FACTORS DEPENDING UPON FLOWRATE:

1. DIAMETER:

For a given flow rate:

Small diameter means higher velocity of the conveyed fluid.

Big diameter means slower velocity of the conveyed fluid.

Velocity of fluids in pipelines affects:

Pressure losses along the pipeline.

Pressure losses are proportional to the square velocity (v2).

Vibration of the pipeline.

Usual velocities of fluids inside pipelines are:

Gas: 20 m/s - max. 40 / 50 m/sec.

Liquid: 2 to 4 m/s - max. 10 m/sec.

FACTORS DEPENDING UPON PRESSURE:

1. WALL THICKNESS CALCULATION

2. TYPE OF JOINT

Low pressure pipelines can be threaded or socket welded

High Pressure pipelines are Butt Welded

3. TESTING AND EXAMINATION:

Non process Pipelines (For Example Vents and drain lines) may even have no tests at all

Low Pressure Pipelines can undergo only the Hydraulic Test

For intermediate pressures a 10% to 50% of joints must be examined with X-rays

High Pressure Pipelines are usually 100% X-ray examined.

FACTORS DEPENDING UPON TEMPERATURE:

1. MATERIAL:

Steel for High Temperature (Low Alloy Steel Creep Resistant)

2. WALL THICKNESS CALCULATION

3. THERMAL INSULATION:

T>60°C Insulation for Personnel Protection is mandatory for all pipeline parts that can be reached by hands.

4. STRESS ANALYSIS:

Hot Lines must be routed properly. Provisions shall be taken so that when temperature rises from ambient to Operating Temperature the thermal expansion of Pipelines does not generate stresses too high for the pipes to withstand.

FLUID SERVICE CATEGORIES:

B31.3 recognizes the following fluid service categories and a special design consideration based on pressure. It is the owner's responsibility to specify the fluid service category for each piping system. With the fluid service category known, then the designer can make material and component selection, as well as employ the code required fabrication and inspection requirements based on the selected fluid category. These fluid categories and pressure concern are:

1. Normal fluid service
2. Category D fluid service
3. Category M fluid service
4. High pressure piping
5. Severe cyclic conditions

Category D Fluid Service is defined as all fluid services that are:

- Nonflammable
- Nontoxic
- Not damaging to human tissues
- The design gage pressure does not exceed 150 psig
- The design temperature is from -20° f to 366° f is the saturated temperature of steam at 150psig

Category M Fluid Service is defined as a service in which a single exposure to a very small quantity of toxic fluid can produce serious irreversible harm to person on breathing or bodily contact, even when prompt restorative are taken.

The Normal Fluid Service is defined as all other fluid services that are not category D and category M

High Pressure Piping Service is defined as that in which the pressure is in excess of that allowed by the ASME B16.5 2500 flange class ratings.

PIPING SYSTEM CORROSION:

General or Uniform Corrosion:

Uniform metal loss.

May be combined with erosion if high velocity fluids, or moving fluids containing abrasives.

Pitting Corrosion:

Localized metal loss randomly located on material surface.

Occurs most often in stagnant areas or areas of low flow velocity.

Galvanic Corrosion:

Occurs when two dissimilar metals contacts each other in corrosive electrolytic environment.

Concentration Cell Corrosion:

Occurs when different concentration of either a corrosive fluid or dissolved oxygen contacts areas of same metal.

Crevice Corrosion:

Localized corrosion similar to pitting.

Occurs at places such as gaskets, lap joint, and bolts where crevice exists.

Graphitic Corrosion:

Occurs in cast iron exposed to salt water or weak acids.

Reduces iron in cast iron and leaves graphite in place resulting in extremely soft material with no metal loss.

CHAPTER 4

FITTINGS

CODES:

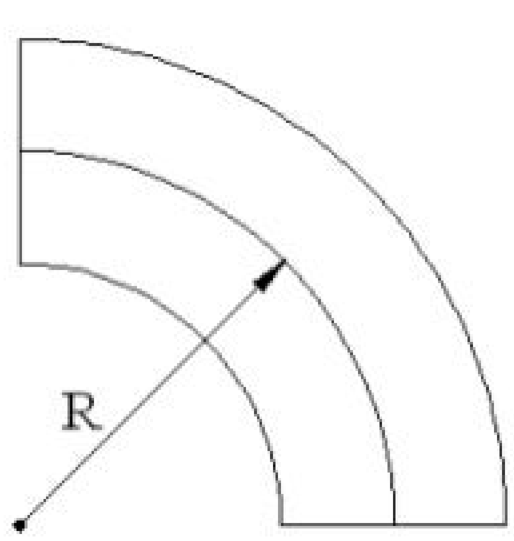
ASME B16.9	:	**Butt Welded Fittings**
ASME B16.11	:	**Socket Welded and Threaded Fittings**

TYPES OF FITTINGS:

1. Elbow and Return
2. Tee and Cross
3. Reducer
4. Coupling
5. Union
6. Caps
7. Stub ends
8. Olets
9. Bellows
10. Strainers
11. Nipple
12. Plug

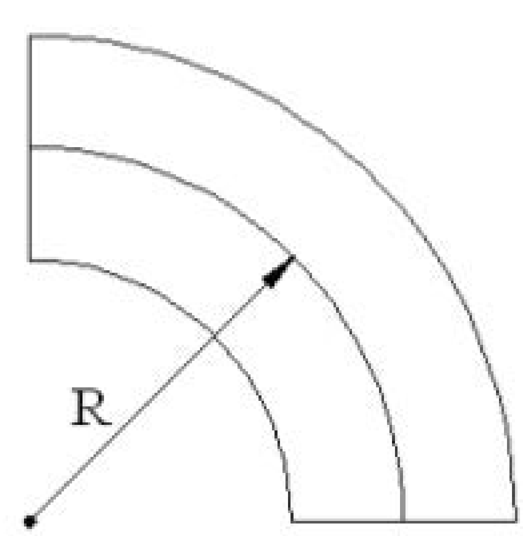
ELBOW AND RETURN:

1. Long radius elbow
2. Short radius elbow



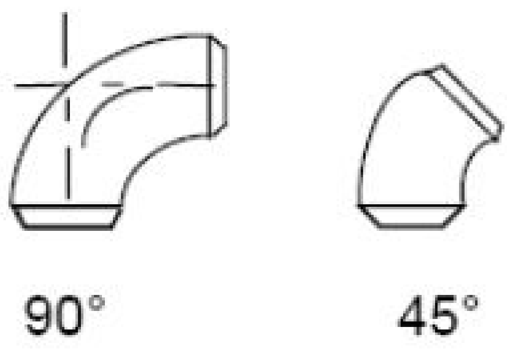
R=1D

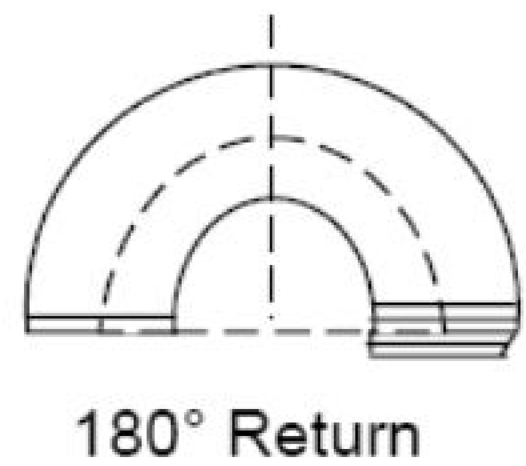
SHORT RADIUS



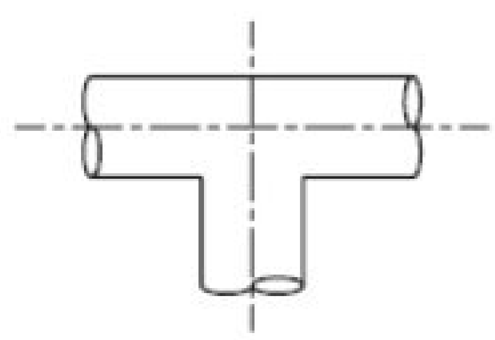
R=1.5 D

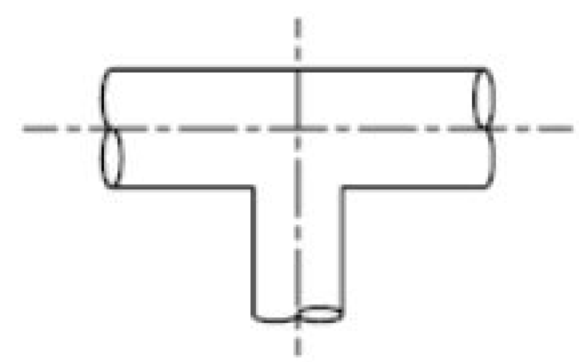
LONG RADIUS



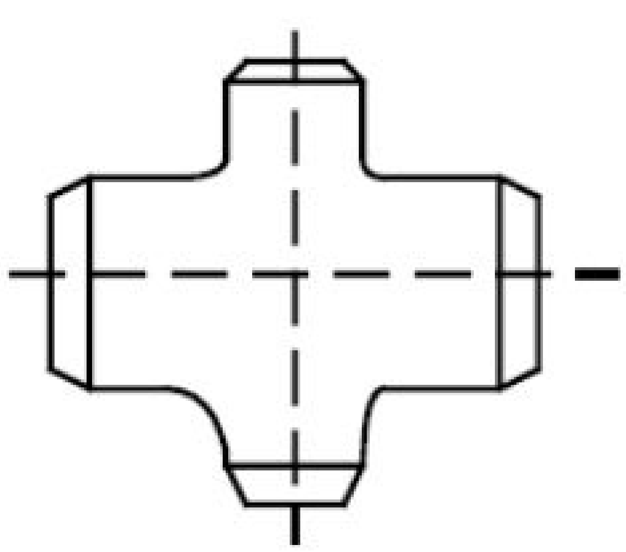


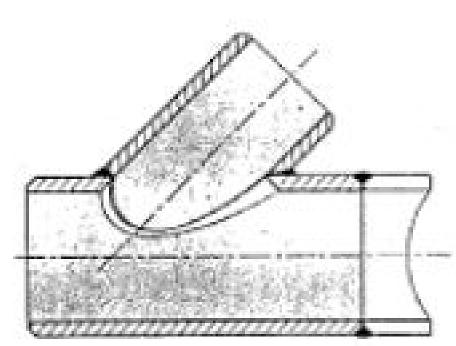
TEE AND CROSS:





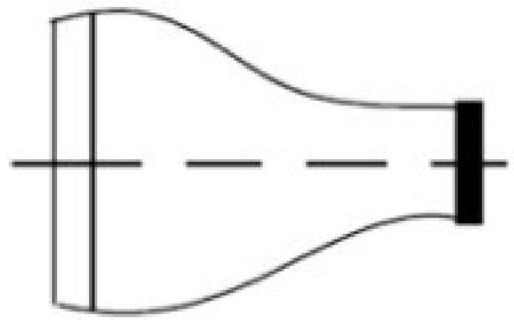
STRAIGHT TEE **REDUCING TEE**



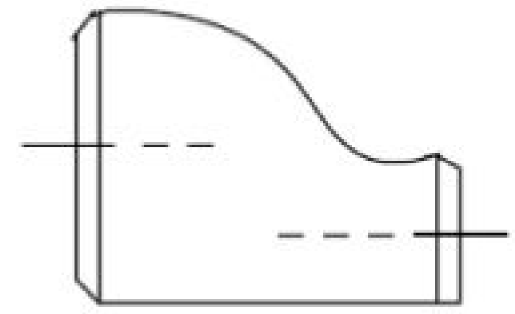


CROSS **LATERAL**

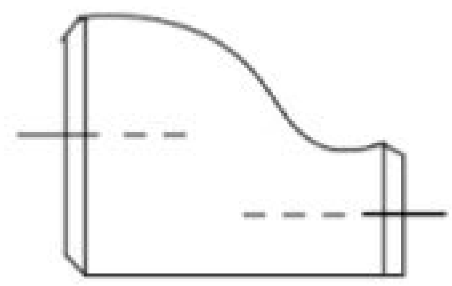
REDUCER:



CONCENTRIC

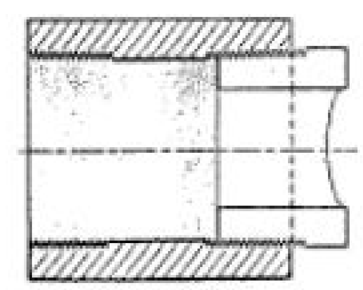


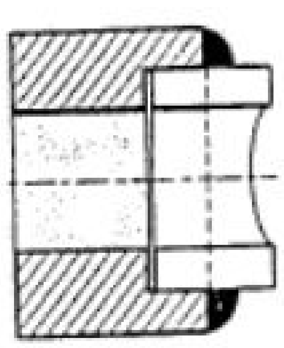
ECCENTRIC (FSD)



ECCENTRIC

COUPLING:

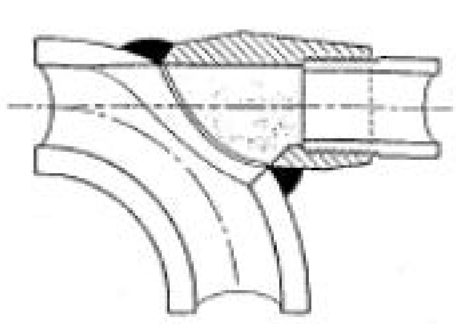




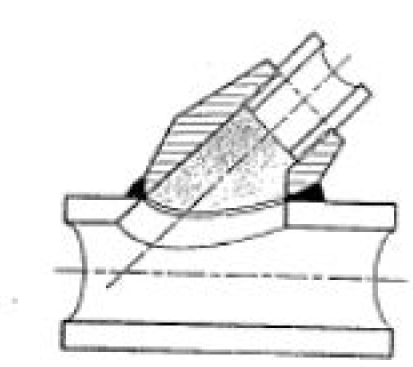
HALF COUPLING (SW)

FULL COUPLING (TH)

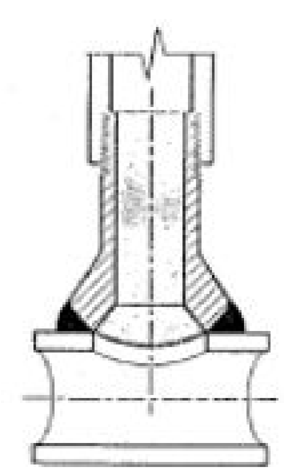
OLETS:



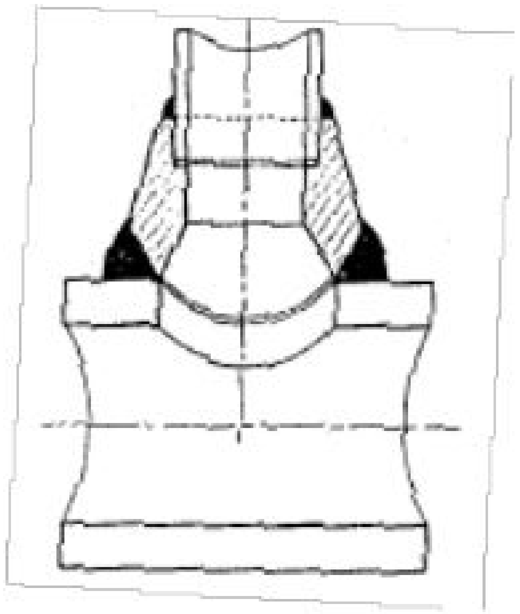
ELBOLET



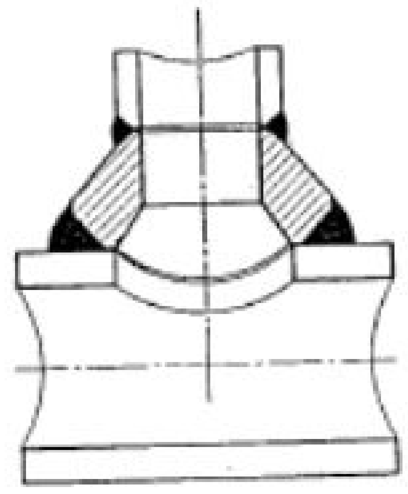
LATROLET



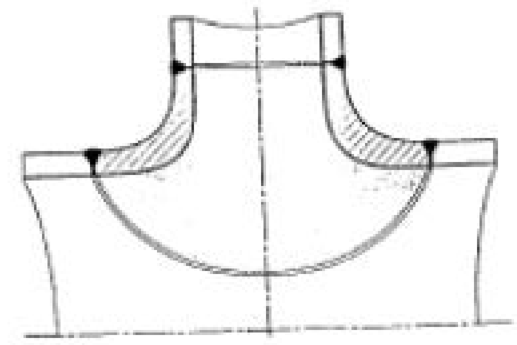
NIPPOLET



SOCKOLET

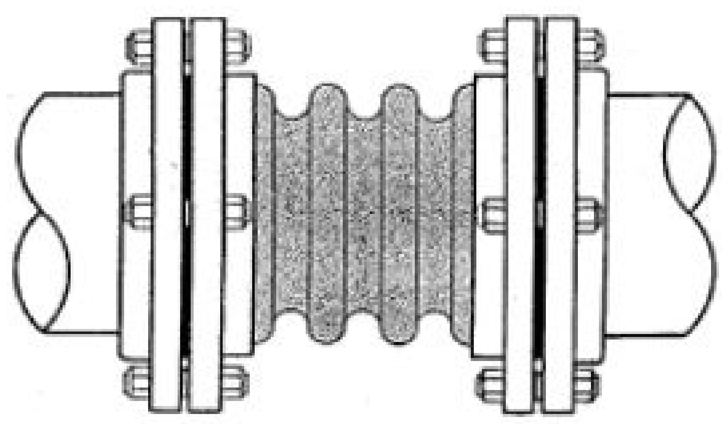


WELDOLET

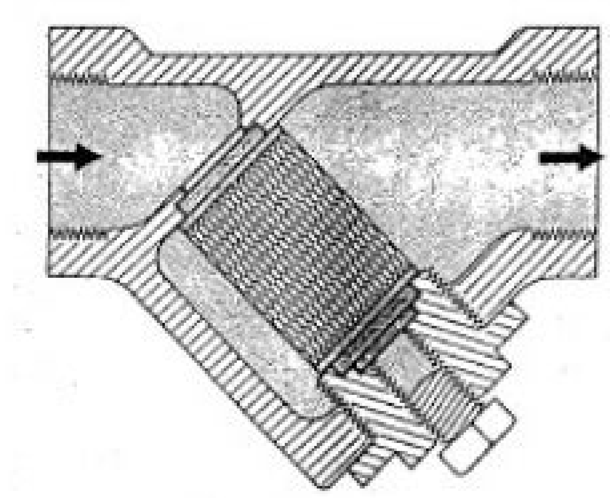


SWEEPOLET

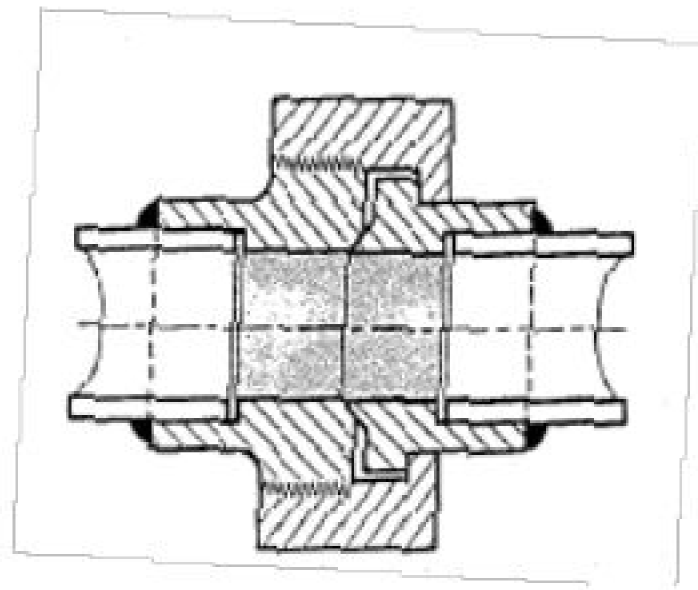
BELLOWS:



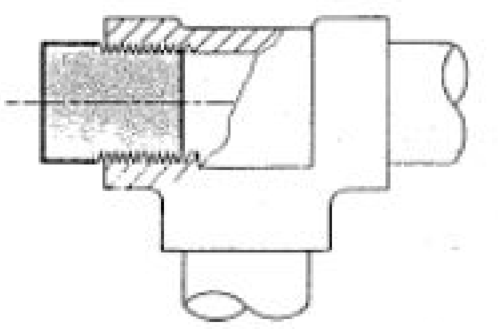
STRAINER:



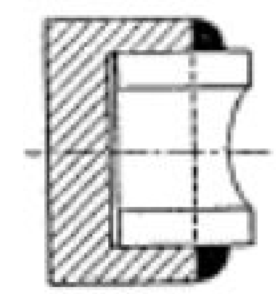
UNION: (SW)



PLUG: (TH)



CAP: (SW)



CHAPTER 5

FLANGES

CODES:

ASME B16.5	**- UPTO 24" SIZE**
ASME B16.47	**- ABOVE 24" SIZE**
ASME B16.36	**- ORIFICE FLANGE**

MATERIAL:

ASTM A105

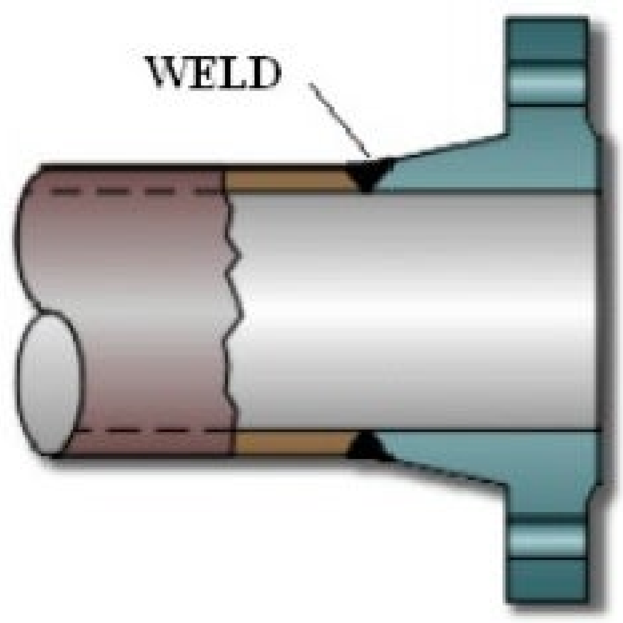
FLANGE RATING CLASS (ASME B16.5):

Ratings are maximum allowable working gage pressure at the various temperatures for the applicable material and rating. The common rating classes are **150#, 300#, 400#, 600#, 1500# and 2500#.**

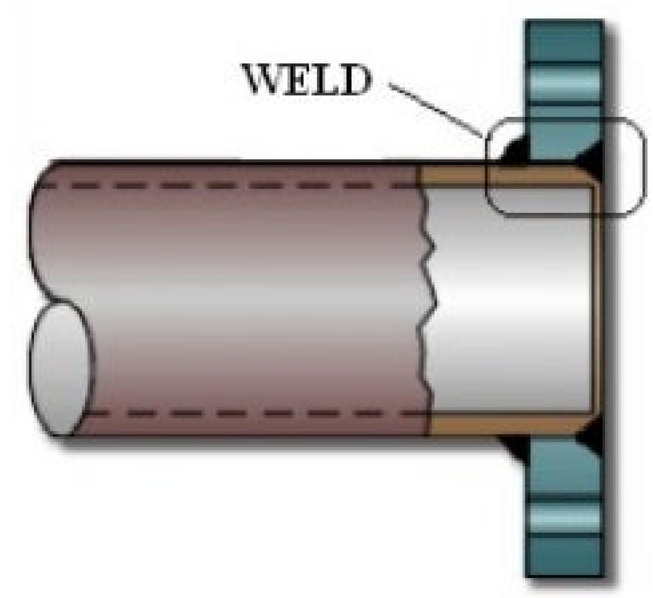
FLANGE TYPES:

SLIP-ON FLANGE:

The flange is slipped over the pipe and welded (usually both inside and outside) to provide strength and prevent leakage. These flanges are at low cost end of the scale, and do not require high accuracy when cutting the pipe to length. They do not allow full penetration weld, so that they are use for low ratings (usually 150# only) and unsevere applications.



WELD NECK FLANGE



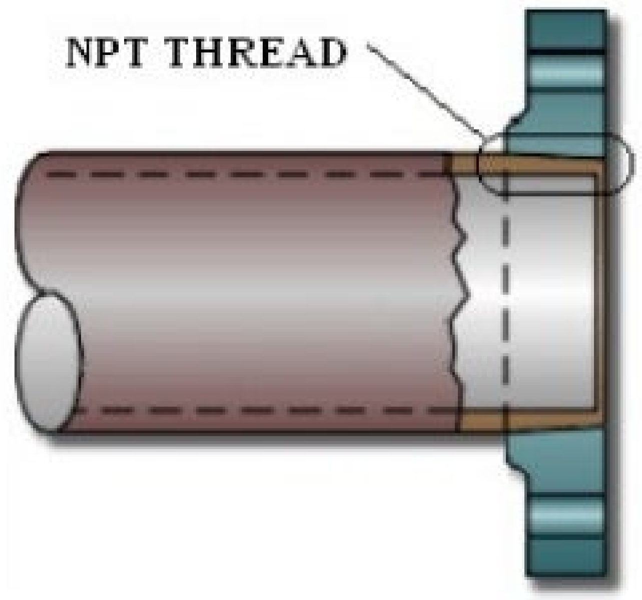
SLIP-ON FLANGE

WELD NECK FLANGE:

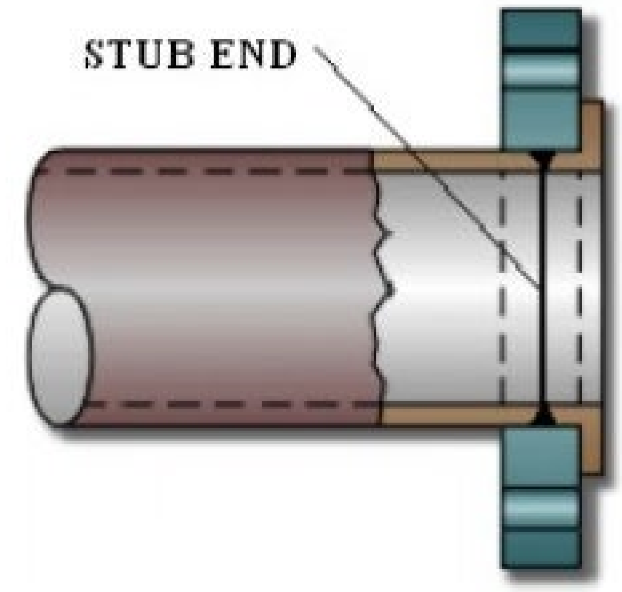
This flange is designed to be joined to a piping system by butt welding. It is relatively expensive because of its long neck, but is preferred for high stress applications. This does not come free of cost, since the shape of the flange obliges to start from a heavy forging and waste a lot of material from machining. the neck, or hub, transmits stresses to the pipe, reducing stress concentration at the base of the flange. The gradual transition of thickness from the base of the hub to the wall thickness at the butt weld provides important reinforcement of the flange. The bore of the flange matches the bore of the pipe, reducing turbulence and erosion.

THREADED FLANGE

This is similar to a slip on flange in outline, but the bore is threaded, thus enabling assembly without welding. This obviously limits its application to relatively low pressure piping systems. The flange may be welded around the joint after assembly, but this is not considered as satisfactory method of increasing its pressure applications.



THREADED FLANGE



LAP JOINT FLANGE

LAP JOINT FLANGE:

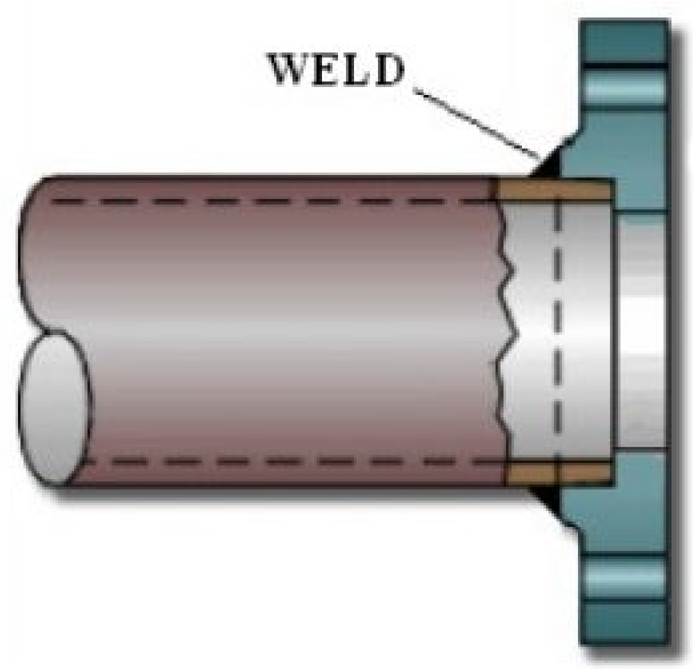
This is similar to a slip on flange, but it has a radius at the intersection of the bore and the flange face, and no raised face, to accommodate a lap joint stub end. The face on the end forms the gasket face of the flange. This type of flange is used in application where section of piping systems need to be dismantled quickly and easily for inspection or replacement, because the stub end is welded to the pipe, not the flange. This solution is used for Stainless Steel lines at low pressure, since the heavy flange does not come in contact with the conveyed fluid and can be provided in much cheaper Carbon Steel material. Moreover no weld is required, also a good thing for Stainless Steel lines.

BLIND FLANGE:

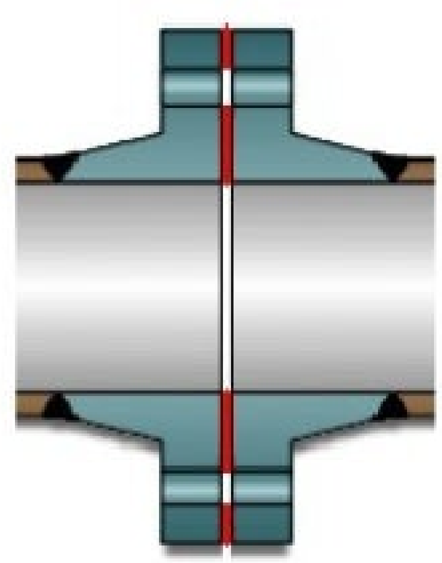
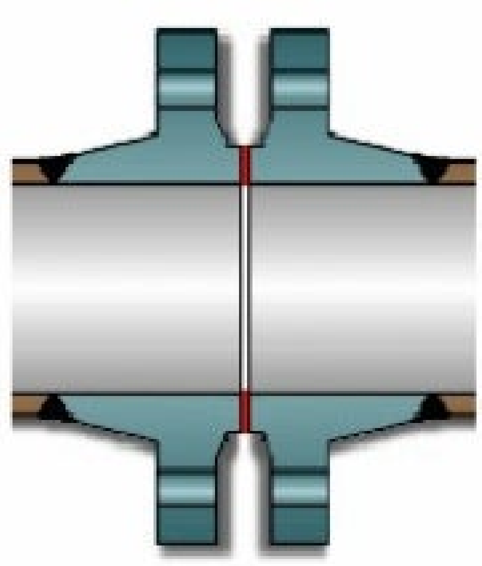
This is a flange without a bore and is used to shut off a piping system or vessel opening. It also permits easy access to vessels or piping systems for inspection purposes.

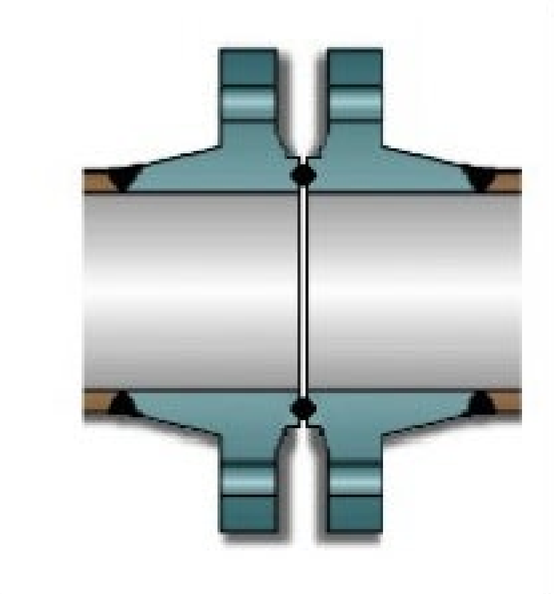
SOCKET WELD FLANGE:

This is similar to a slip on flange in outline, but the bore is counter-bored to accept pipe. The diameter of the remaining bore is same as the inside diameter of the pipe. The flange is attached to the pipe by a fillet weld around the hub of the flange. An optional internal weld may be applied in high stress application. Its biggest use is in high pressure systems such as hydraulic and steam lines.



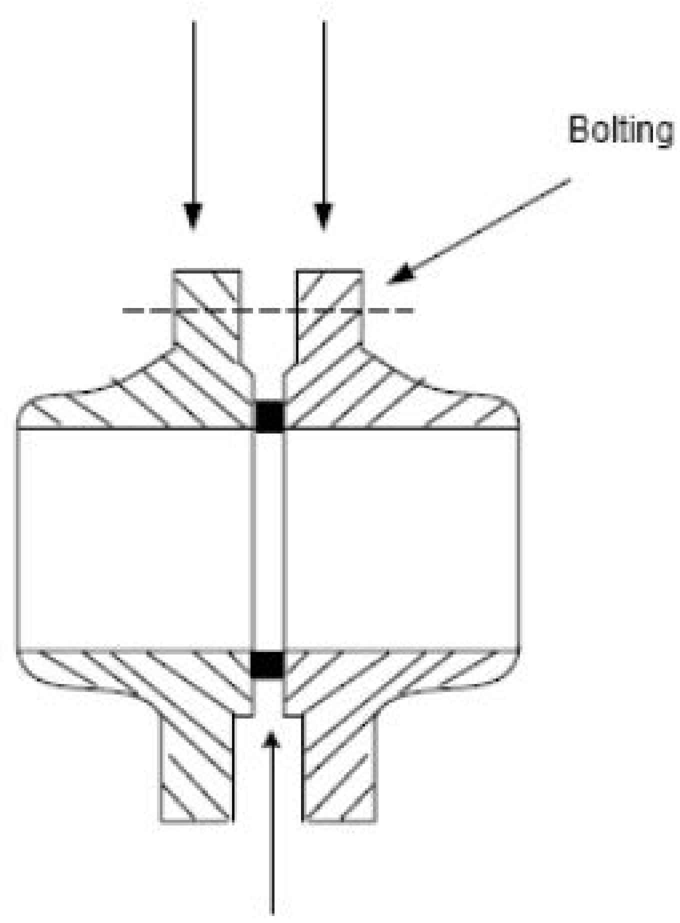
FLANGE FACES:

	**FLAT FACE:** **GASKET:** **Full Face Flat** It covers the entire surface of the flange
	**RAISED FACE** **GASKET:** **Flat** It covers the raised surface of the flange **Spiral Wound** Also known as Spirometallic,or Spirotallic, its a wounded spiral of Stainless Steel and Graphite to withstand high temperatures or severely aggressive fluids

<table>
<tr>
<td></td>
<td>RING JOINT

GASKET:
Metallic Ring
It is normally made up of Steel. It deforms inside the ring joint grooves assuring sealing at very high pressures.</td>
</tr>
</table>

TYPICAL FLANGE ASSEMBLY:



GASKETS:

- ✓ Resilient material
- ✓ Inserted between flanges
- ✓ Compressed by bolts to create seal
- ✓ Commonly used types
  - Sheet
  - Spiral wound
  - Solid metal ring

BOLTS AND NUTS:

Two types of bolting are available for joining the flanges. They are viz., stud bolt with two nuts and the machine bolt using one nut. Stud bolts have largely displaced the regular bolts for bolting the flanged piping joints.

The major advantages of the stud bolt are

1. It can be easily removed if corroded and

2. Stud bolts in less frequently used sizes and materials can be readily made from round stock.

BOLTING CODES:

ASME B18.2.1	Square and Hex bolts and screws, inch series including hex Cap screws and lag screws
ASME B18.2.2	Square and Hex nuts (inch series)

BOLTING MATERIALS:

A193	AS & SS bolting materials for high temperature services
A194	CS & AS nuts for bolts for high temperature & high pressure service
A320	AS bolting materials for low temperature services

CHAPTER 6

VALVES

FUNCTIONS:

- Block flow
- Throttle flow
- Prevent flow reversal

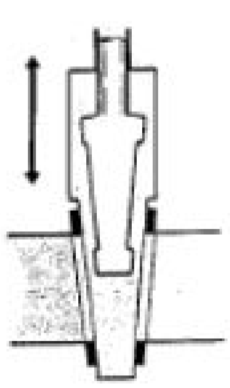
VALVE SELECTION:

1. Identify design information including pressure and temperature, valve function, material, etc.

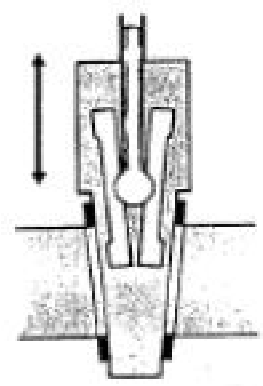
2. Identify potentially appropriate valve types and components based on application and function (i.e., block, throttle, or reverse flow prevention).
3. Determine valve application requirements (i.e., design or service limitations).
4. Finalize valve selection. Check factors to consider if two or more valves are suitable.
5. Provide full technical description specifying type, material, flange rating, etc.

OPERATED VALVES:

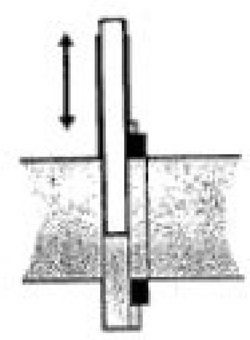
GATE TYPE:



SOLID WEDGE GATE VALVE

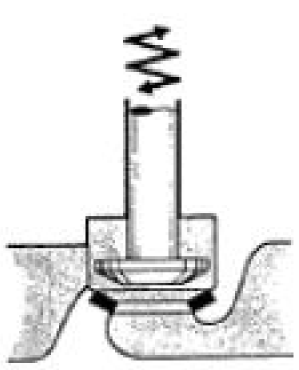


SPLIT WEDGE GATE VALVE

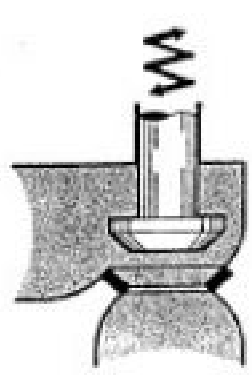


SINGLE DISC SINGLE SEAT

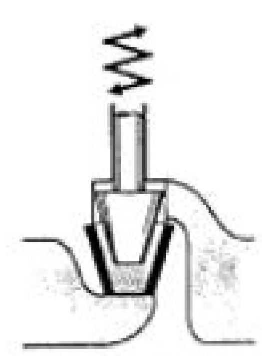
GLOBE TYPE:



GLOBE VALVE

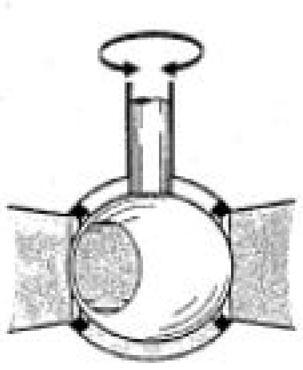


ANGLE VALVE

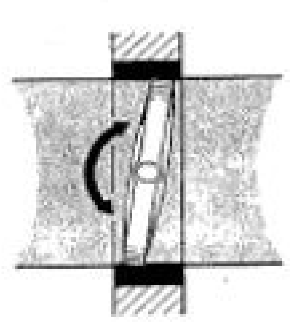


NEEDLE VALVE

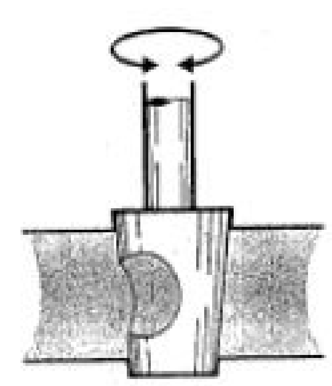
ROTARY TYPE:



ROTARY VALVE

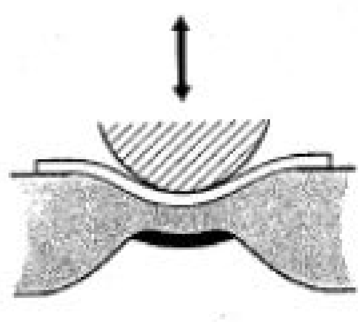


BUTTERFLY VALLVE

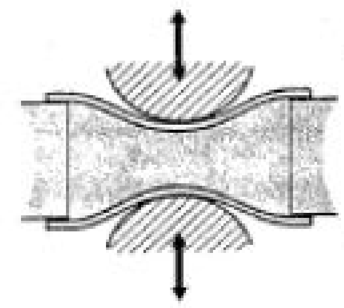


PLUG VALVE

DIAPHRAGM TYPE:



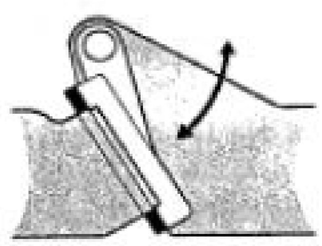
DIAPHRAGM VALVE



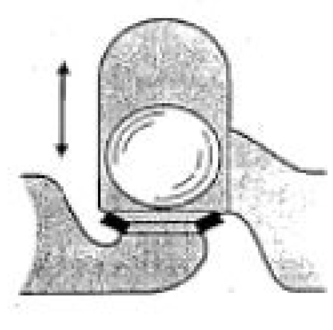
PINCH VALVE

SELF OPERATED VALVES:

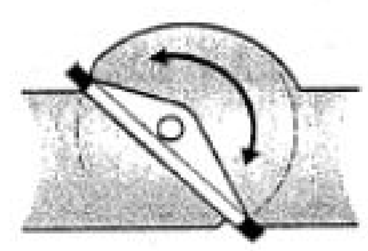
CHECK TYPE:



SWING CHECK

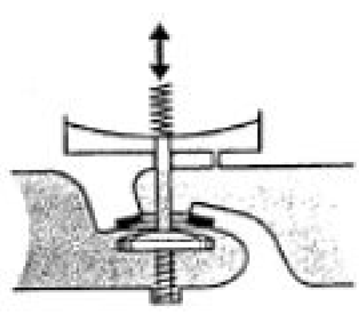


BALL CHECK

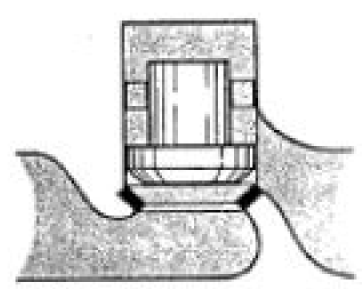


TILTING DISC CHECK

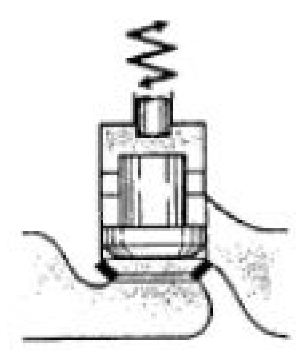
REGULATING TYPE:



PRESSURE REGULATING



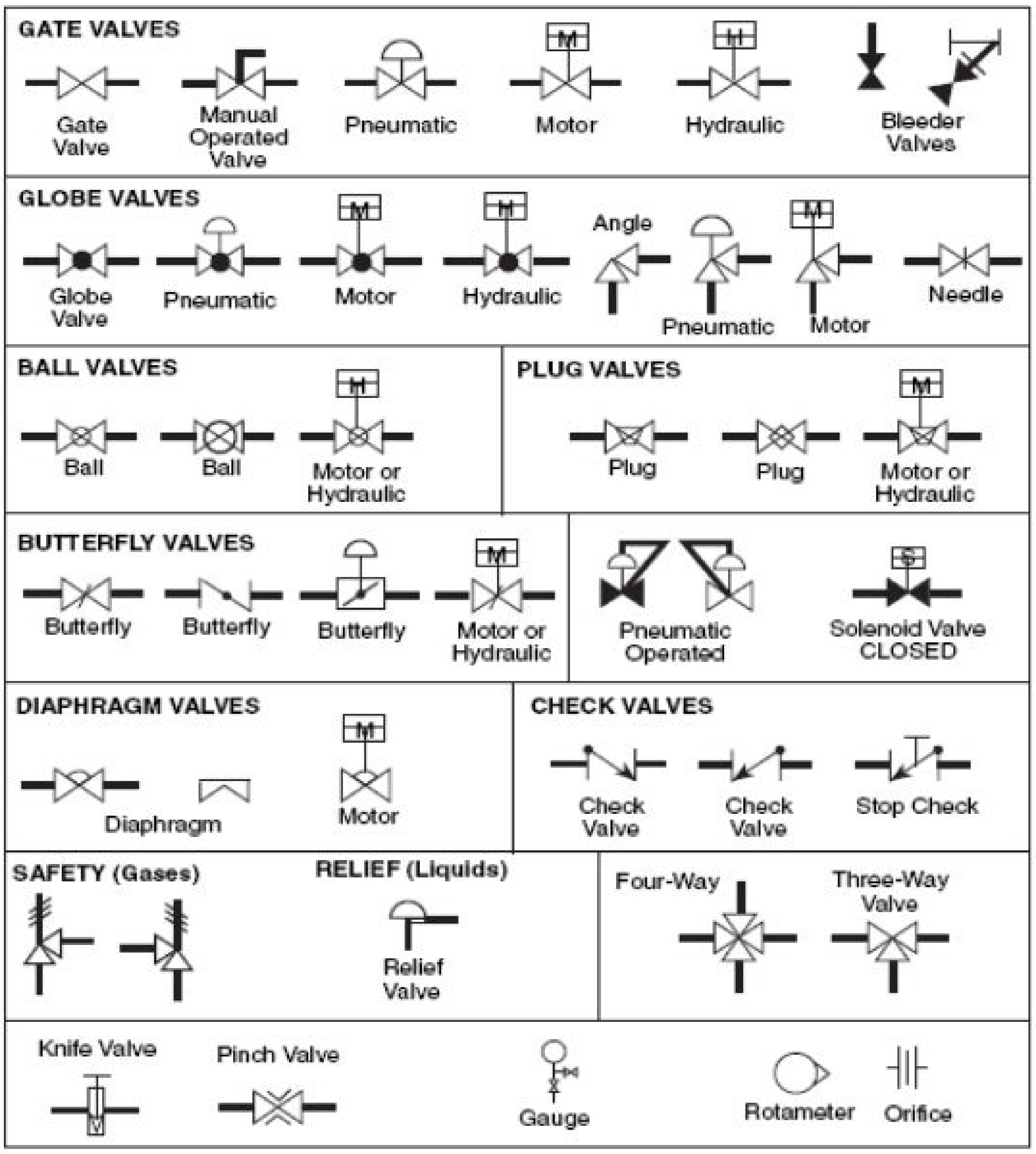
PISTON CHECK



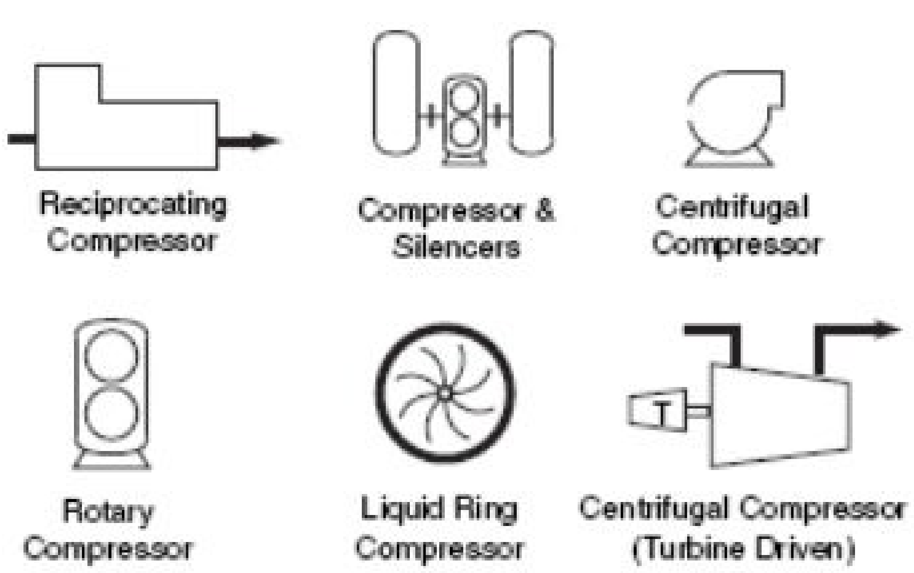
STOP CHECK

CHAPTER 7

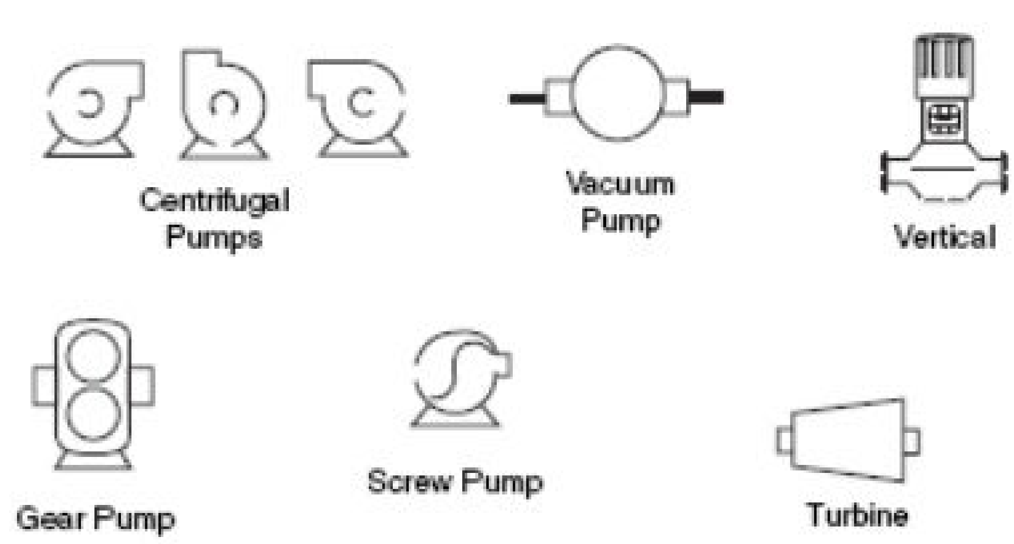
PIPING SYMBOLS



COMPRESSOR:

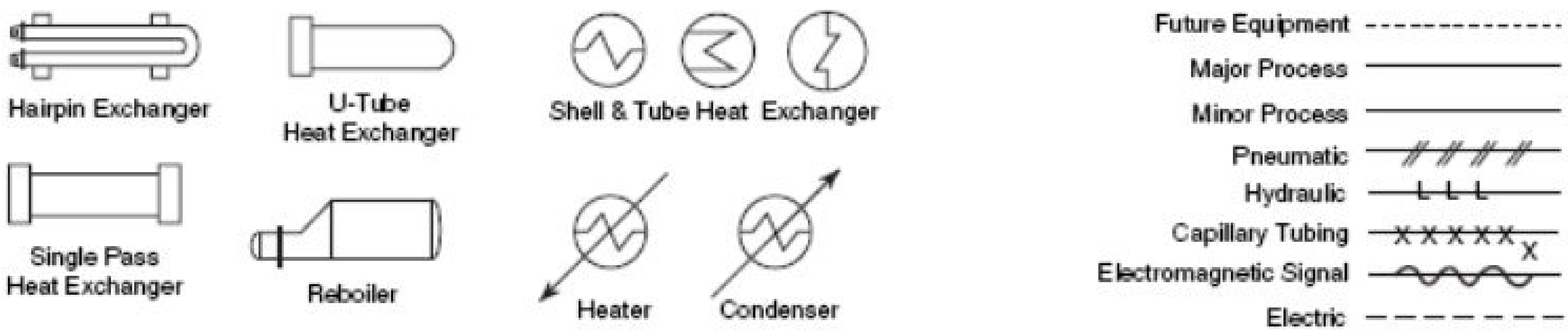


PUMP:

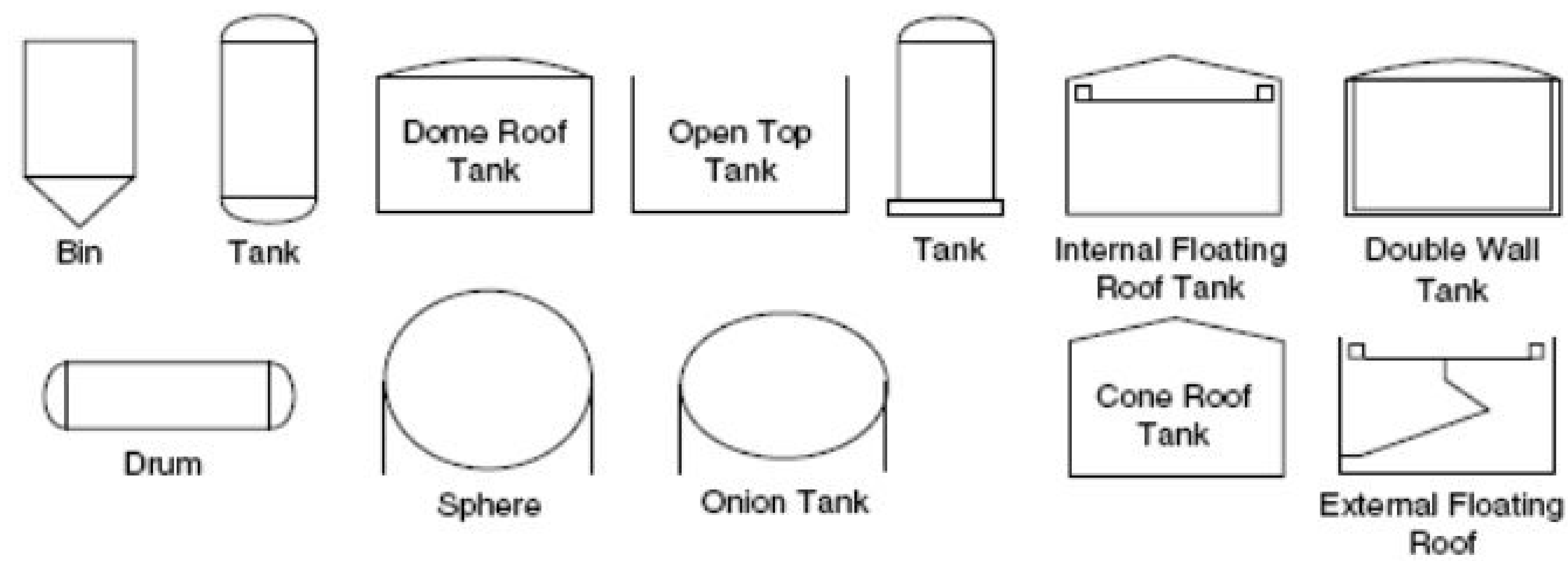


HEAT EXCHANGERS:

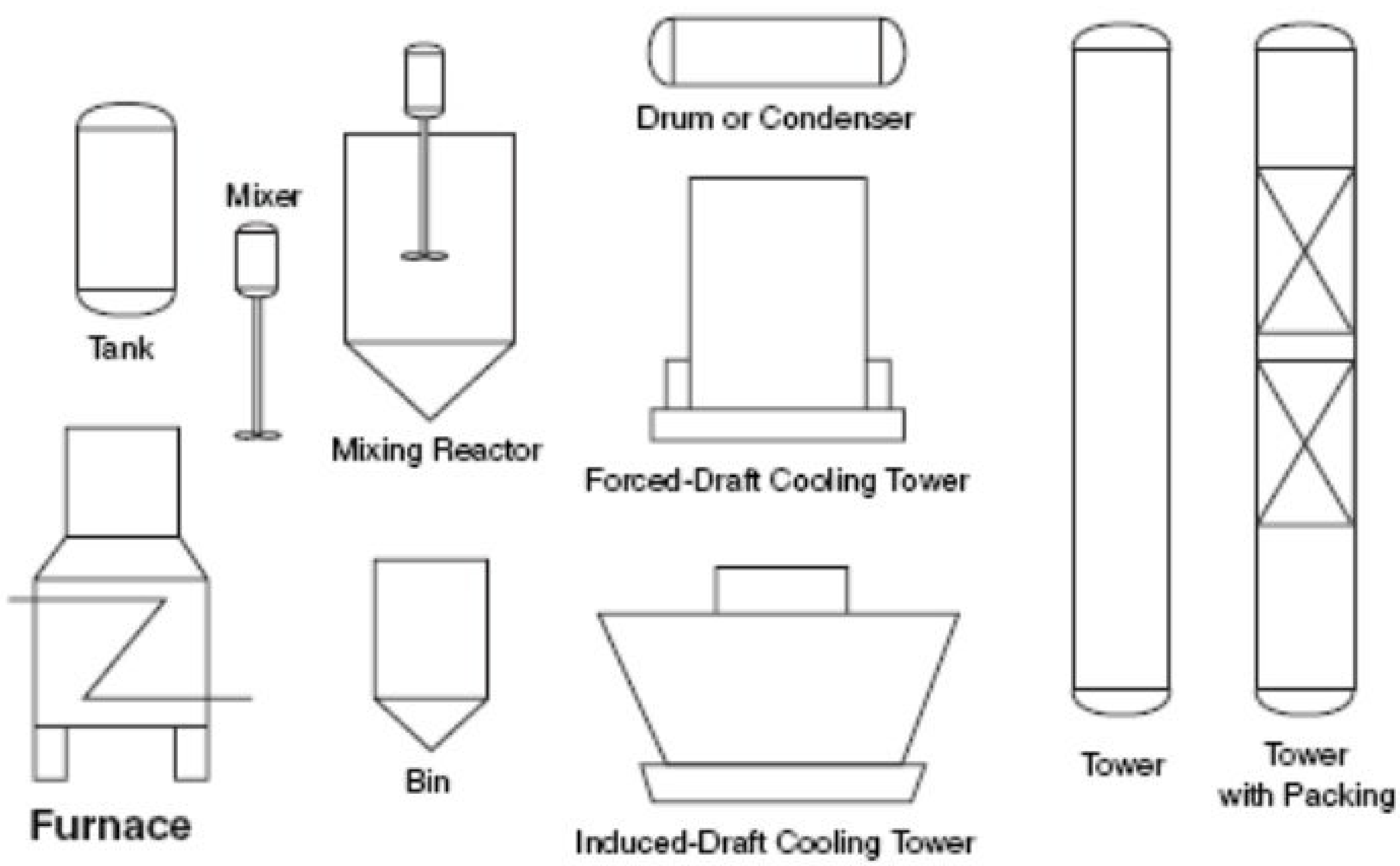
LINE SYMBOLS:



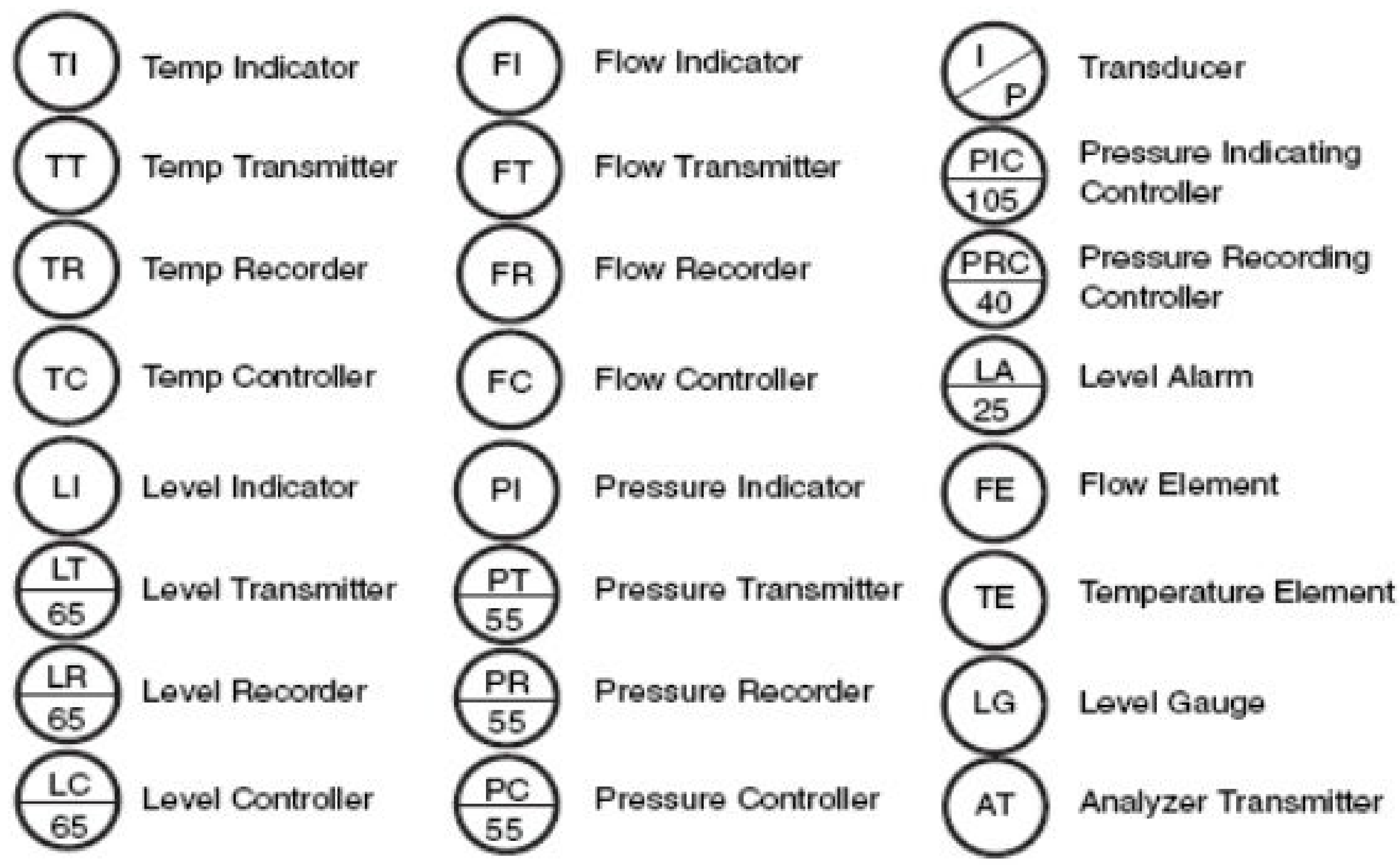
STORAGE SYMBOLS:

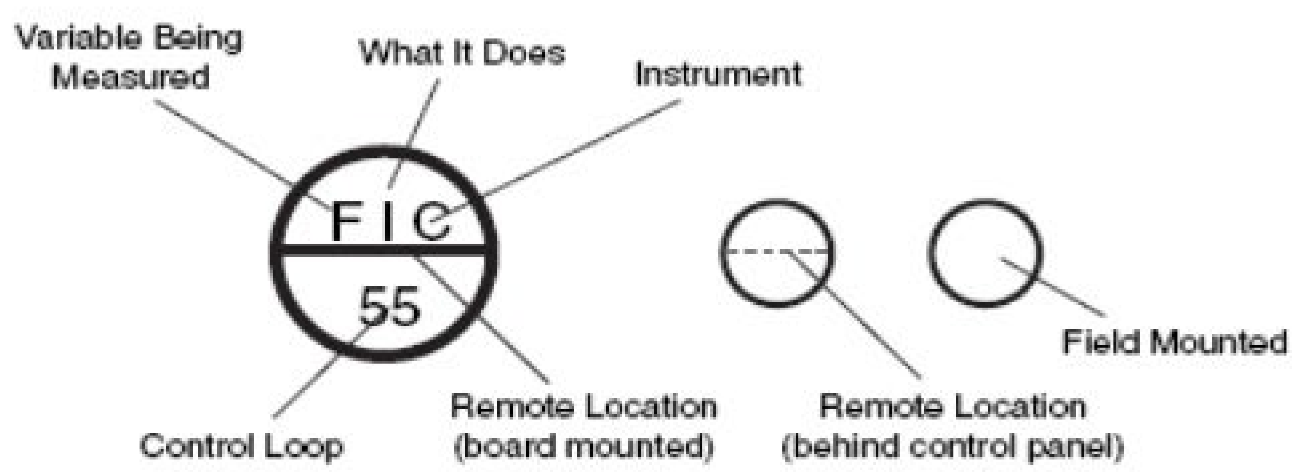


VESSELS:

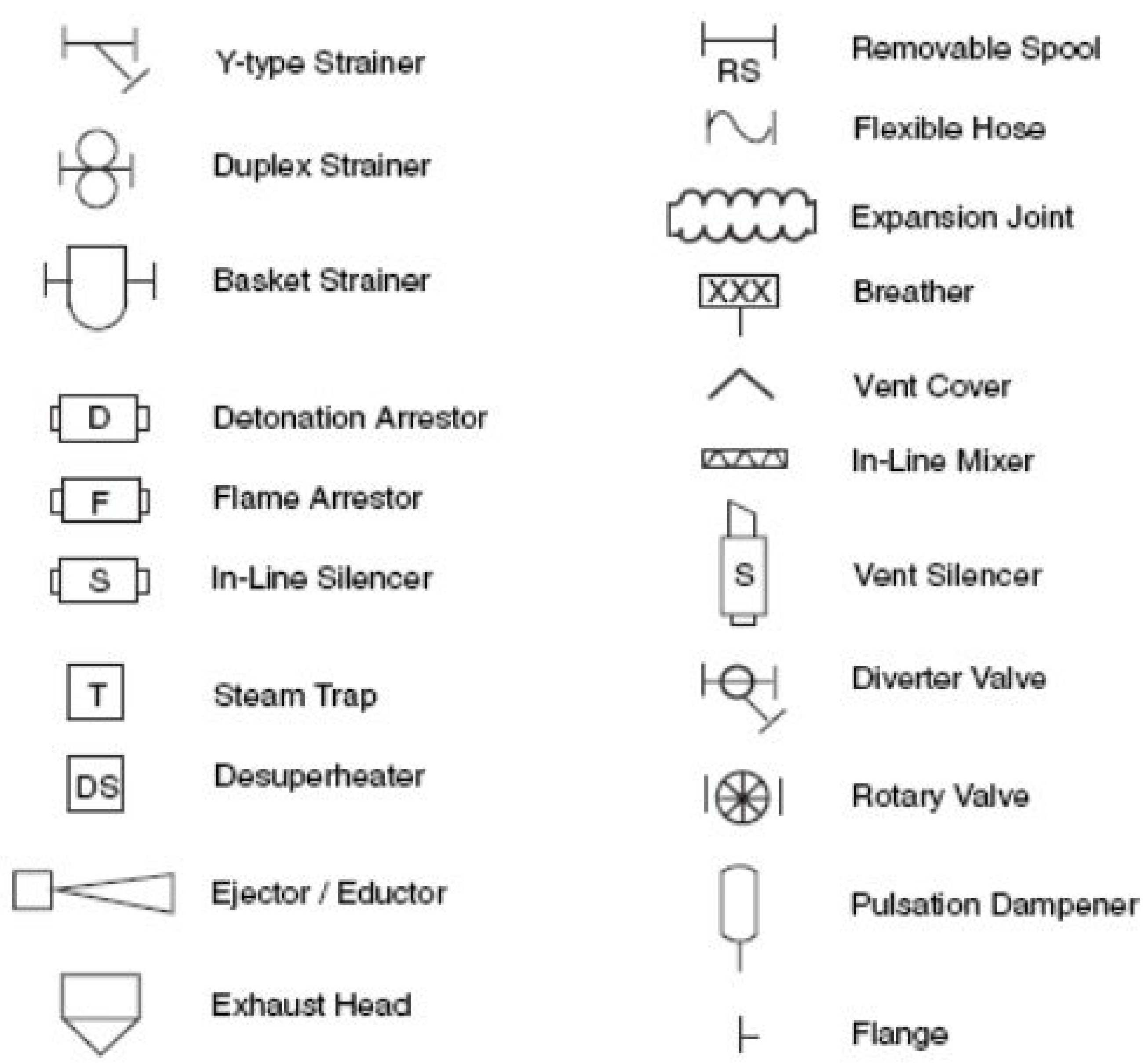


INSTRUMENTS:





MISCELLANEOUS:



PREFIXES:

CW	**Cooling Water**
MU	**Makeup**
FW	**Feed Water**
SE	**Sewer**
RX	**Reactor**
UT	**Utilities**
CA	**Chemical Addition**
IA	**Instrument Air**

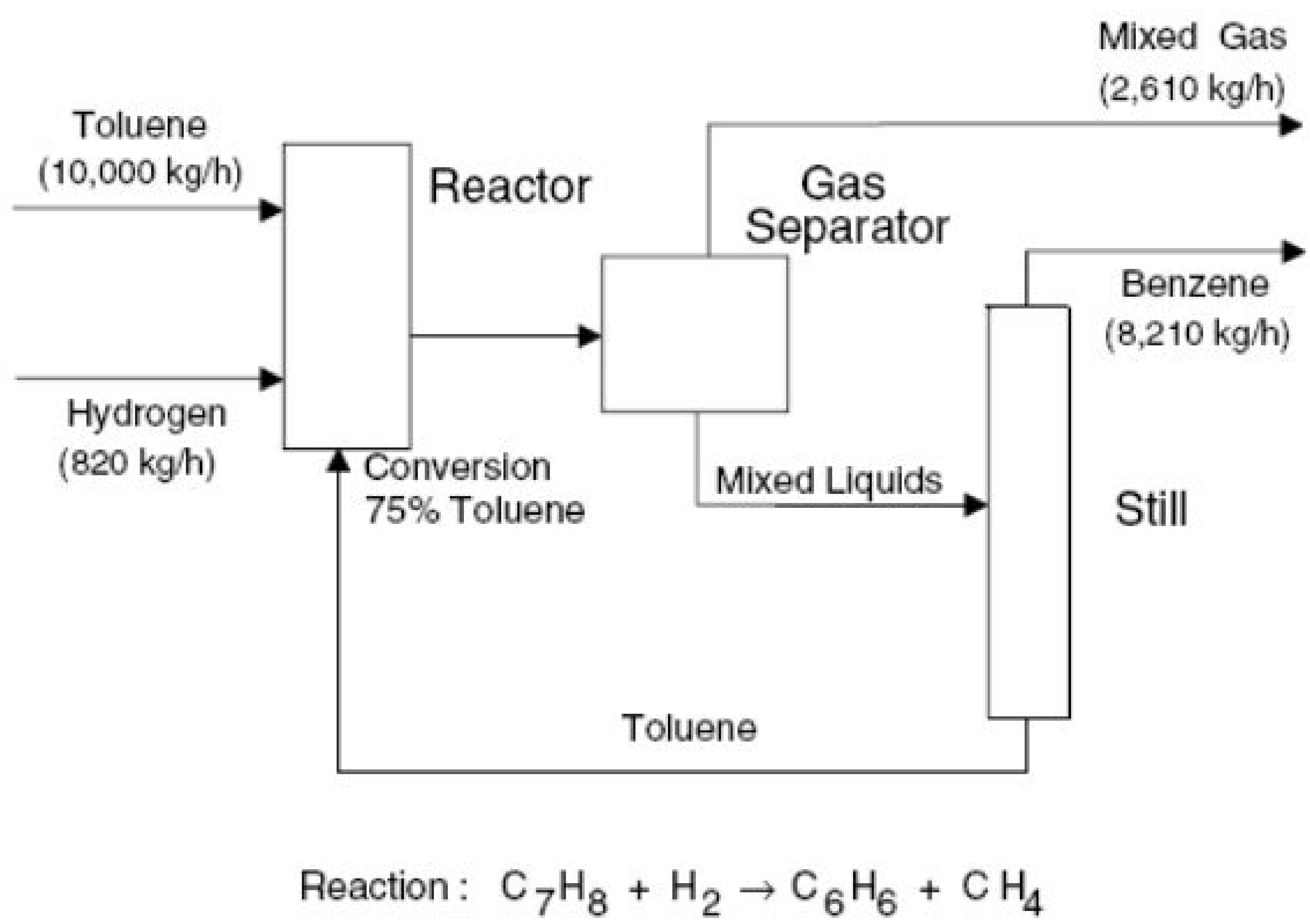
ABBREVIATION:

D	**Drum**
C	**Column**
CT	**Cooling Tower**
TK	**Tank**
F	**Furnace**
EX	**Exchanger**
P	**Pump**
V	**valve**

CHAPTER 8

BLOCK FLOW DIAGRAM

This diagram was a series of blocks connected with input and output flow streams. It included operating conditions (temperature and pressure) and other important information such as conversion and recovery, given in the problem statement. It did not provide details regarding what was involved within the blocks, but concentrated on the main flow of streams through the process. The block flow diagram can take one of two forms. First, a block flow diagram may be drawn for a single process. Alternatively, a block flow diagram may be drawn for a complete chemical complex involving many different chemical processes. We differentiate between these two types of diagram by calling the first a block flow process diagram and the second a block flow plant diagram.



BFD FOR THE PRODUCTION OF BENZENE

Conventions and Format Recommended for Laying Out a Block Flow Process Diagram:

1. Operations shown by blocks.
2. Major flow lines shown with arrows giving direction of flow.
3. Flow goes from left to right whenever possible.
4. Light stream (gases) toward top with heavy stream (liquids and solids) toward bottom.
5. Critical information unique to process supplied.
6. If lines cross, then the horizontal line is continuous and the vertical line is broken.
7. Simplified material balance provided.

CHAPTER 9

PROCESS FLOW DIAGRAM

The process flow diagram (PFD) represents a quantum step up from the BFD in terms of the amount of information that it contains. The PFD contains the bulk of the chemical engineering data necessary for the design of a chemical process. The PFD from one company will probably contain slightly different information than the PFD for the same process from another company. Having made this point, it is fair to say that most PFDs convey very similar information.

A typical commercial PFD will contain the following information:

1. All the major pieces of equipment in the process will be represented on the diagram along with a description of the equipment. Each piece of equipment will have assigned a unique equipment number and a descriptive name.

2. All process flow streams will be shown and identified by a number. A description of the process conditions and chemical composition of each stream will be included. These data will be displayed either directly on the PFD or included in an accompanying flow summary table.

3. All utility streams supplied to major equipment that provides a process function will be shown.

4. Basic control loops, illustrating the control strategy used to operate the process during normal operations, will be shown.

The basic information provided by a PFD can be categorized into one of the following:

1. Process topology
2. Stream information
3. Equipment information

PROCESS TOPOLOGY:

The location of and interaction between equipment and process streams is referred to as the process topology. Equipment is represented symbolically by "icons" that identify specific unit
operations each major piece of process equipment is identified by a number on the diagram. A list of the equipment numbers along with a brief descriptive name for the equipment is printed along the top of the diagram. The location of these equipment numbers and names roughly corresponds to the horizontal location of the corresponding piece of equipment. consider the unit operation P-101A/B and what each number or letter means.

P-101A/B identifies the equipment as a pump

P-**1**01A/B indicates that the pump is located in area 100 of the plant

P-1**01**A/B indicates that this specific pump is number 01 in unit 100.

P-101**A/B** indicates that a back-up pump is installed. Thus, there are two identical pumps P-101A and P-101B. One pump will be operating while the other is idle.

Conventions Used for Identifying Process Equipment.

General Format XX-YZZ A/B

XX are the identification letters for the equipment classification

C - Compressor or Turbine

E - Heat Exchanger

H - Fired Heater

P - Pump

R - Reactor

T - Tower

TK - Storage Tank

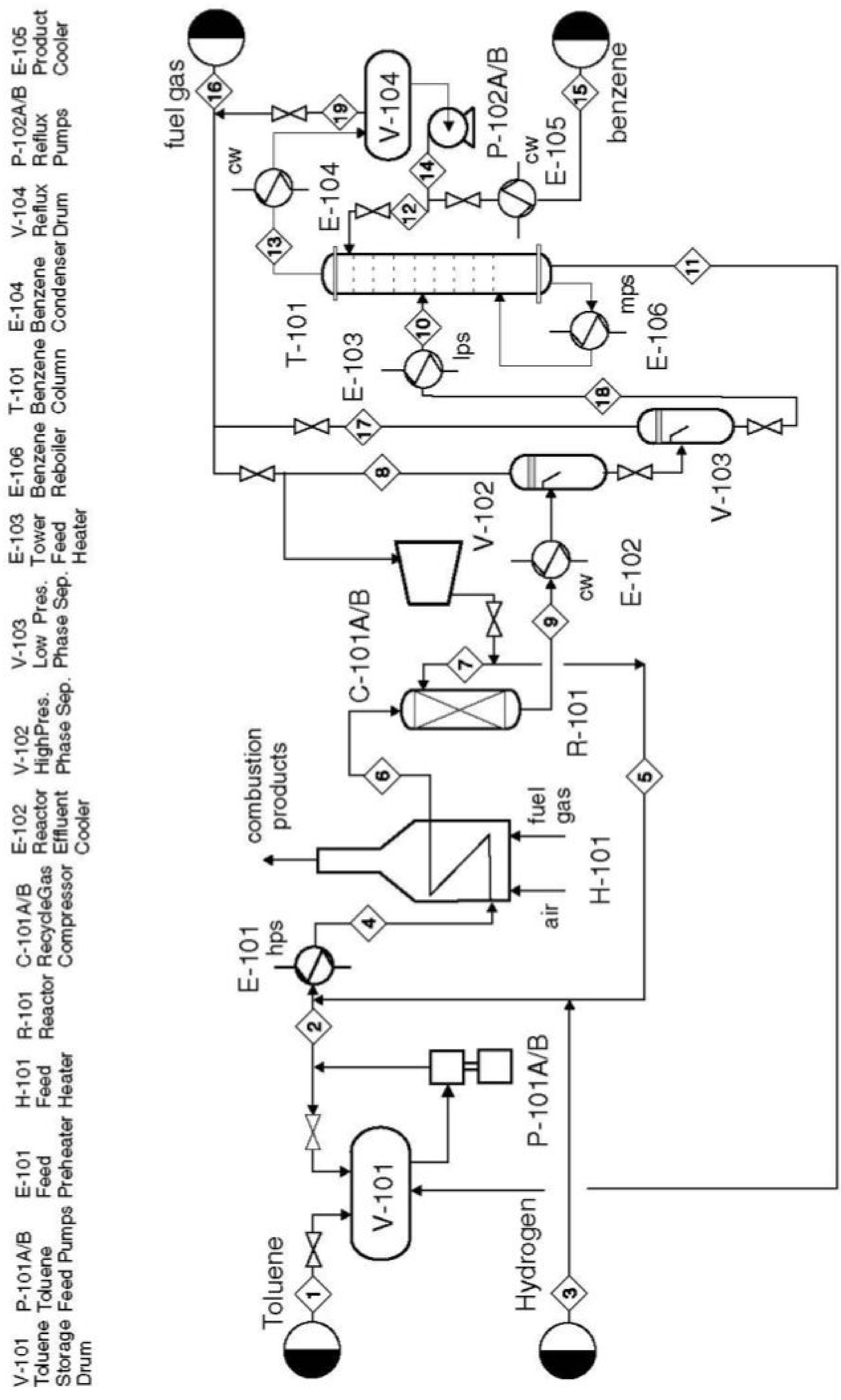
V - Vessel

Y designates an area within the plant

ZZ is the number designation for each item in an equipment class

A/B identifies parallel units or backup units not shown on a PFD

Supplemental Information Additional description of equipment given on top of PFD


V-101 Toluene Storage Drum
P-101A/B Toluene Feed Pumps
E-101 Feed Preheater
H-101 Feed Heater
R-101 Reactor
C-101A/B RecycleGas Compressor
E-102 Reactor Effluent Cooler
V-102 HighPres. Phase Sep.
V-103 Low Pres. Phase Sep.
E-103 Tower Feed Heater
E-106 Benzene Reboiler
T-101 Benzene Column
E-104 Benzene Condenser
V-104 Reflux Drum
P-102A/B Reflux Pumps
E-105 Product Cooler
Toluene
Hydrogen
V-101
P-101A/B
E-101
hps
air
H-101
fuel gas
combustion products
R-101
C-101A/B
E-102
cw
V-102
V-103
E-103
lps
T-101
E-106
mps
E-104
cw
V-104
P-102A/B
cw
E-105
fuel gas
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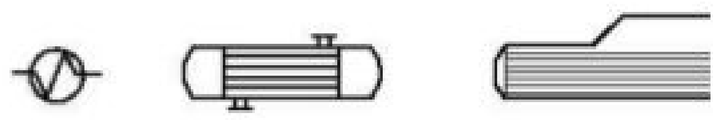
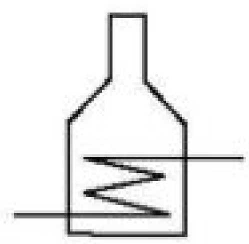
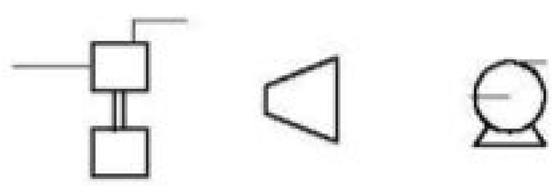


HEAT EXCHANGERS

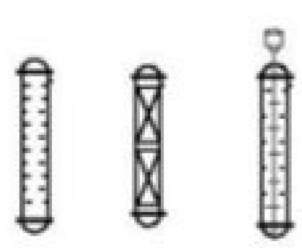


FIRED HEATER

STORAGE TANKS

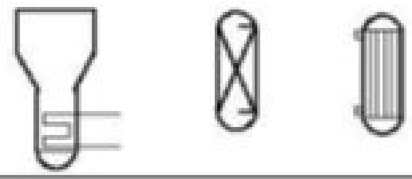


PUMPS, TURBINES,
COMPRESSORS

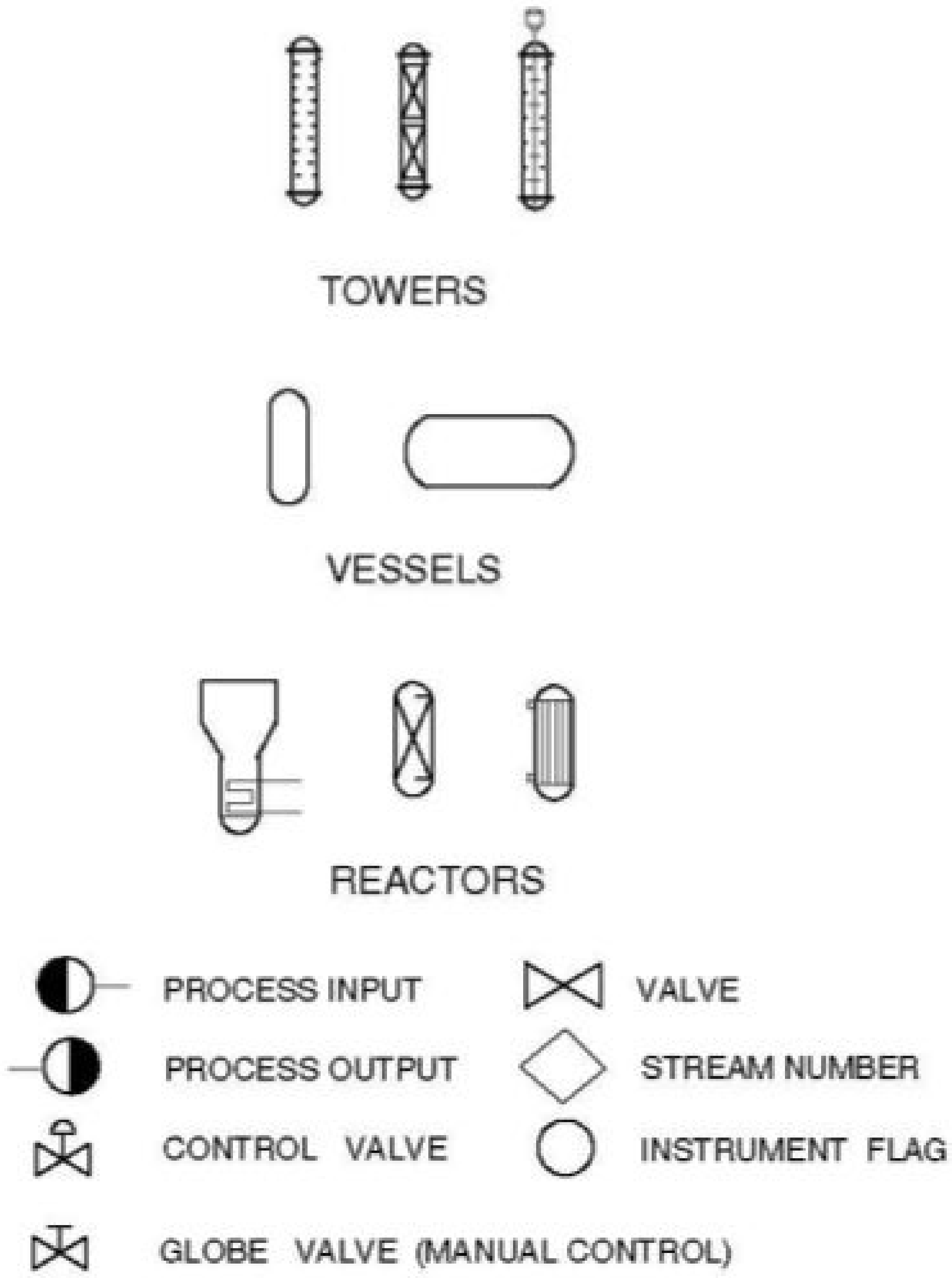


TOWERS

VESSELS



REACTORS



Symbols for drawing process flow diagrams.

Conventions For Identifying Process And Utility Streams:

Process Streams:

Diamond symbol located in flow lines.

Numerical identification (unique for that stream) inserted in diamond.

Flow direction shown by arrows on flow lines.

Utility Streams:

lps	Low-pressure Steam: 3–5 barg (sat) ‡
mps	Medium-pressure Steam: 10–15 barg (sat) ‡
hps	High-pressure Steam: 40–50 barg (sat) ‡
htm	Heat Transfer Media (Organic): to 400°C
cw	Cooling Water: From cooling tower 30°C returned at less than 45°C†
wr	River Water: From river 25°C returned at less than 35°C

rw	Refrigerated Water: In at 5°C returned at less than 15°C
rb	Refrigerated Brine: In at −45°C returned at less than 0°C
cs	Chemical Waste Water with high COD
ss	Sanitary Waste Water with high BOD, etc.
el	Electric Heat (specify 220, 440, 660V service)
ng	Natural Gas
fg	Fuel Gas
fo	Fuel Oil
fw	Fire Water

STREAM INFORMATION:

The characteristics of the streams such as temperatures, pressures, compositions, and flow rates can be shown directly on the figure, adjacent to the stream. This is not practical for a more complex diagram. In this case, only the stream number is provided on the diagram. This indexes the stream to information on a flow summary or stream table, which is often provided below the process flow diagram.

Information Provided in a Flow Summary:

Essential Information

Stream Number

Temperature (°C)

Pressure (bar)

Vapor Fraction

Total Mass Flowrate (kg/h)

Total Mole Flowrate (kmol/h)

Individual Component Flowrates (kmol/h)

Optional Information

Component Mole Fractions

Component Mass Fractions

Individual Component Flowrates (kg/h)

Volumetric Flowrates (m3/h)

Significant Physical Properties

Density, velocity

Other

Thermodynamic Data

Heat Capacity

Stream Enthalpy

K-values

Stream Name

EQUIPMENT INFORMATION:

The final element of the PFD is the equipment summary. This summary provides the information necessary to estimate the costs of equipment and furnish the basis for the detailed design of equipment.

Equipment Descriptions for PFD and P &IDs:

Equipment Type:

Description of Equipment

Towers

Size (height and diameter), Pressure, Temperature

Number and Type of Trays

Height and Type of Packing

Materials of Construction

Heat Exchangers:

Type: Gas-Gas, Gas-Liquid, Liquid-Liquid, Condenser, Vaporizer

Process: Duty, Area, Temperature, and Pressure for both streams

No. of Shell and Tube Passes

Materials of Construction: Tubes and Shell

Tanks:

See vessels

Vessels:

Height, Diameter, Orientation, Pressure, Temperature, Materials of Construction

Pumps:

Flow, Discharge Pressure, Temperature, _P, Driver Type, Shaft Power, Materials of Construction

Compressors:

Actual Inlet Flow Rate, Temperature, Pressure, Driver Type, Shaft Power, Materials of Construction

Heaters (Fired):

Type, Tube Pressure, Tube Temperature, Duty, Fuel, Material of Construction

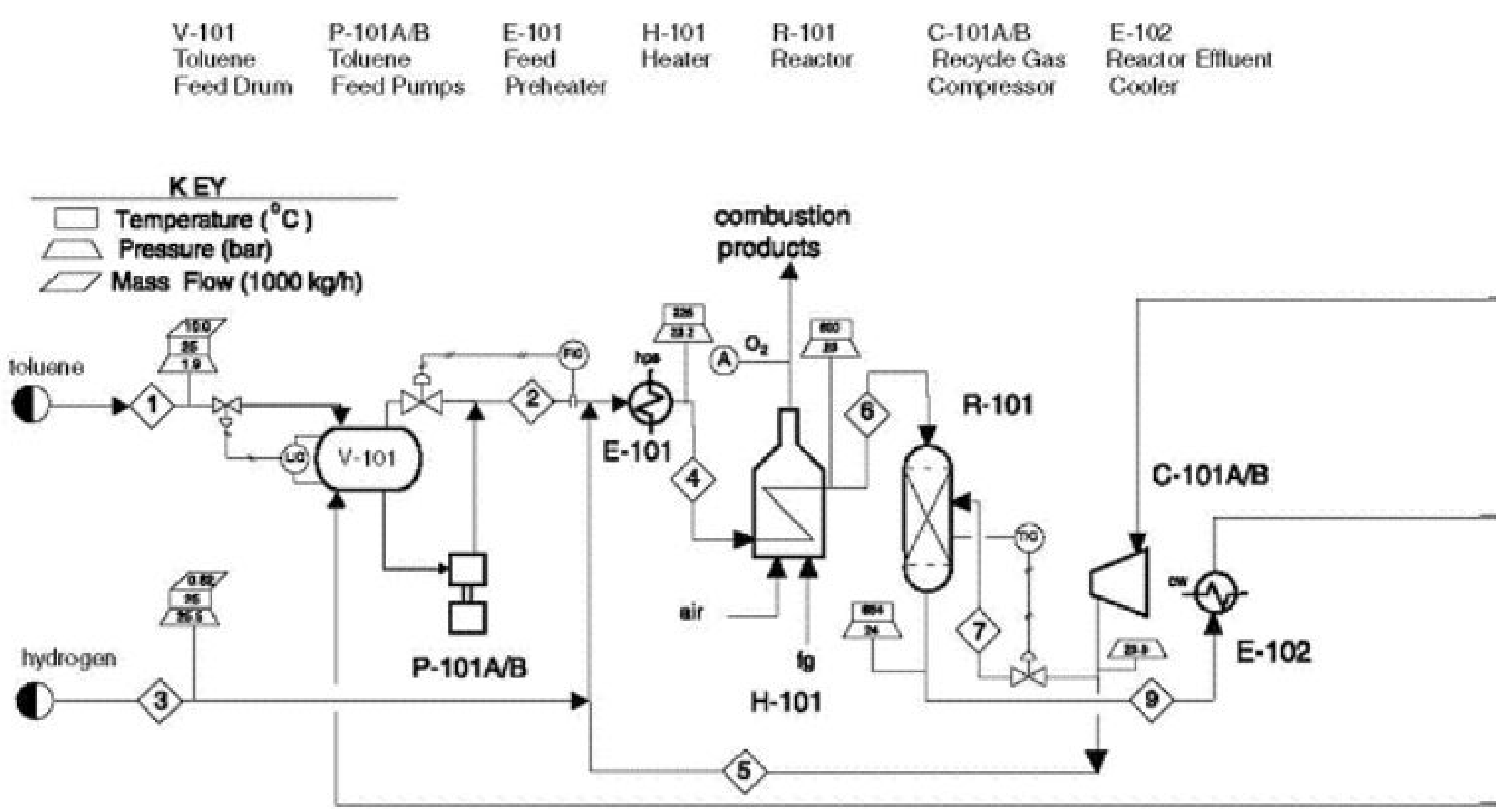
Others:

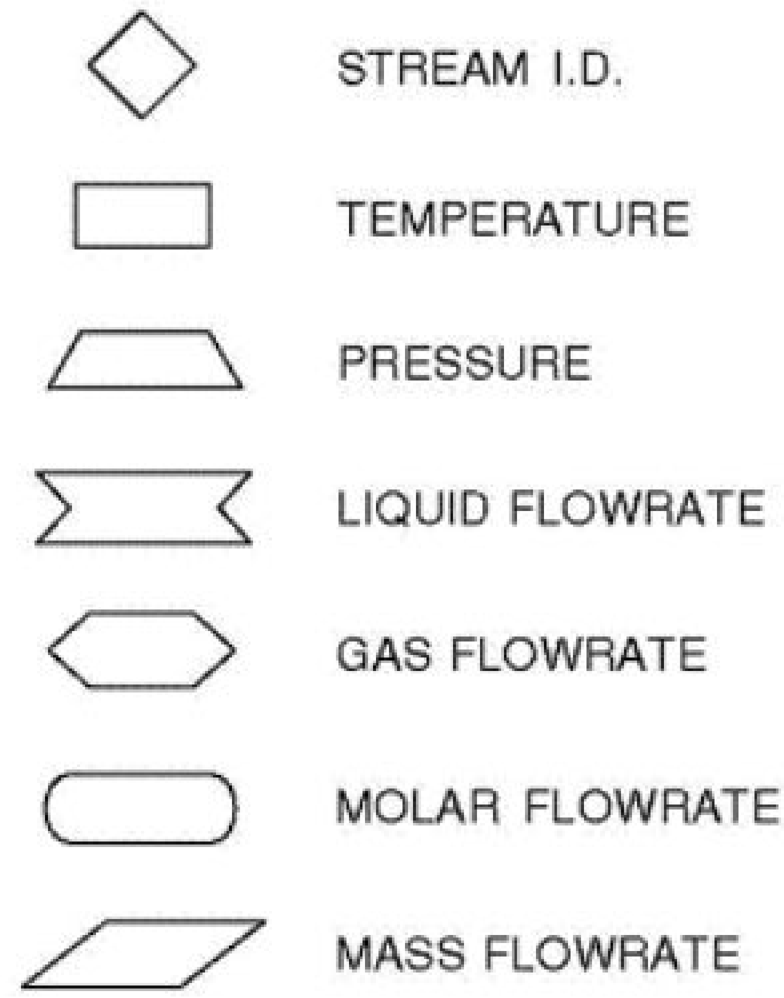
Provide Critical Information

COMBINING TOPOLOGY, STREAM DATA, AND CONTROL STRATEGY TO GIVE A PFD:

Stream information is added to the diagram by attaching "information flags." The shape of the flags indicates the specific information provided on the flag. These information flags play a dual role. They provide information needed in the plant design leading to plant construction and in the analysis of operating problems during the life of the plant. Flags are mounted on a staff connected to the appropriate process stream.

More than one flag may be mounted on a staff.





Symbols for steam information

CHAPTER 10

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

The piping and instrumentation diagram (P&ID) or mechanical flow diagram (MFD) provides information needed by engineers to begin planning for the construction of the plant. The P&ID includes every mechanical aspect of the plant except the information. Each PFD will require many P&IDs to provide the necessary data. The P&ID provides information on the piping, included as part of the diagram. As an alternative, each pipe can be numbered, and the specifics of every line can be provided in a separate table accompanying the diagram.

Exclusions from Piping and Instrumentation Diagram

1. Operating conditions *T, P*
2. Stream flows
3. Equipment locations
4. Pipe routing
    a. Pipe lengths
    b. Pipe fittings
5. Supports, structures, and foundations

Conventions in Constructing Piping and Instrumentation Diagrams

For Equipment—Show Every Piece Including

Spare units

Parallel units

Summary details of each unit

For Piping—Include All Lines Including Drains, Sample Connections and Specify

Size (use standard sizes)

Schedule (thickness)

Materials of construction

Insulation (thickness and type)

For Instruments—Identify

Indicators

Recorders

Controllers

Show instrument lines

For Utilities—Identify

Entrance utilities

Exit utilities

Exit to waste treatment facilities

Utility connections are identified by a numbered box in the P&ID. The number within the box identifies the specific utility. All process information that can be measured in the plant is shown on the P&ID by circular flags. This includes the information to be recorded and used in process control loops. The circular flags on the diagram indicate where the information is obtained in the process and identifies the measurements taken and how the information is dealt with.

Conventions Used for Identifying Instrumentation on P&IDs

Meanings of Identification Letters XYY

	First Letter (X)	Second or Third Letter (Y)
A	Analysis	Alarm
B	Burner flame	
C	Conductivity	Control
D	Density or Differential	
E	Voltage	Element
F	Flowrate	
H	Hand (manually initiated)	High
I	Current	Indicate
J	Power	
K	Time or time schedule	Control station/Close
L	Level	Light or low
M	Moisture or humidity	Middle or intermediate

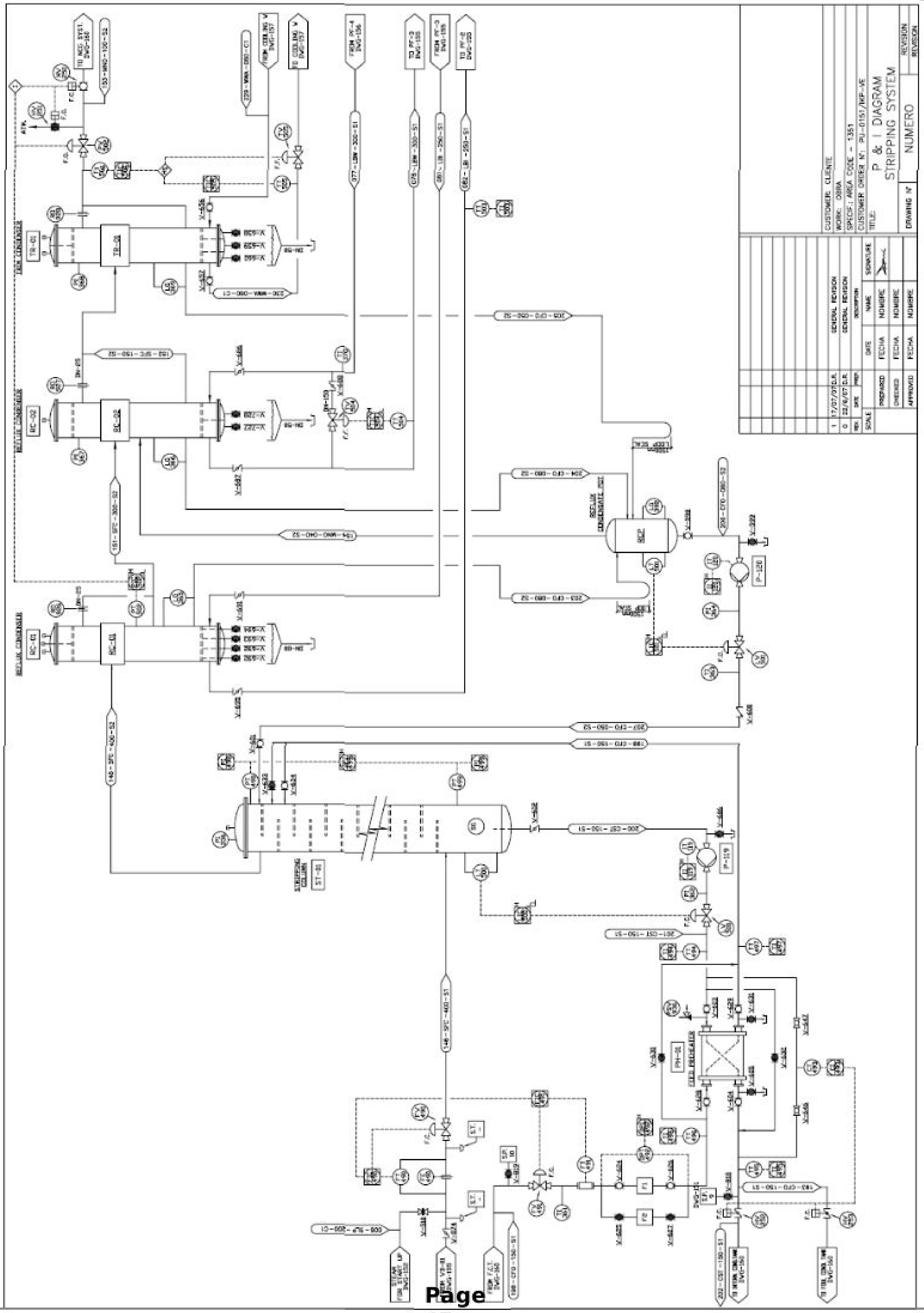
O		Orifice/Open
P	Pressure or vacuum	Point
Q	Quantity or event	
R	Radioactivity or ratio	Record or print
S	Speed or frequency	Switch
T	Temperature	Transmit
V	Viscosity	Valve, damper, or louver
W	Weight	Well
Y		Relay or compute
Z	Position	Drive

The P&ID is the last stage of process design and serves as a guide by those who will be responsible for the final design and construction. Based on this diagram:

1. Mechanical engineers and civil engineers will design and install pieces of equipment.
2. Instrument engineers will specify, install, and check control systems.
3. Piping engineers will develop plant layout and elevation drawings.
4. Project engineers will develop plant and construction schedules.

ADDITIONAL DIAGRAMS:

A utility flowsheet may be provided which shows all the headers for utility inputs and outputs available along with the connections needed to the process. It provides information on the flows and characteristics of the utilities used by the plant. Vessel sketches, logic ladder diagrams, wiring diagrams, site plans, structural support diagrams, and many other drawings are routinely used but add little to our understanding of the basic chemical processes that take place. Additional drawings are necessary to locate all of the equipment in the plant. Plot plans and elevation diagrams are provided that locate the placement and elevation of all of the major pieces of equipment such as towers, vessels, pumps, heat exchangers, and so on. When constructing these drawings, it is necessary to consider and to provide for access for repairing equipment, removing tube bundles from heat exchangers, replacement of units, and so on.


P & I DIAGRAM
STRIPPING SYSTEM
NUMERO
REVISION

CHAPTER 11

PLOT PLAN

Plot plans are considered key documents to projects and are normally initiated in the pre-contract, conceptual and development stages of a proposal. After the contract is awarded for engineering, plot plans are developed at a rather rapid pace with very limited information. This early stage plot plan usually is very limited in detail, containing only enough dimensional data to define the outer limits of the available property selected for plant development. Located within the boundaries of the available property, rough equipment sizes and shapes are pictorially positioned. along with anticipated pipe rack configurations, structure shape and rough sizes. The plot plan at this level of detail is then used for constructability evaluation and is normally submitted to the client for approval.

Once approved by the client, almost every group including Engineering, Scheduling, Construction, Operations, Cost Control, Estimating and Material Control use the plot plan as a pictorial reference for their work. At this point, the plot plan becomes a universal document used by all groups to interface with one another and the client.

Development of the plot plan in the very early stages is usually accomplished through the use of preliminary project design data, approximate equipment sizes and a process flow diagram to establish rough sketches. These sketches are used to determine structure configuration and relative equipment positioning.

PURPOSE:

Construction:

The plot plan is used to schedule the erection sequence of all plant equipment.

Estimating:

The plot plan is used to estimate the overall cost of the plant.

Client use:

The plot plan is used for safety, operator, and maintenance review and to develop an as-built record of the plant arrangement.

The plot plan is a dynamic document, evolving through the life of a job. Some of the more common names and descriptions used during this evolution process are as follows:

Proposal Plot Plan –

Used to establish the basis of bid work.

Approval Plot Plan

Offered to the client for his concurrence of available space, perimeter roads, adjacent inhabited areas and interface points with the remainder of the complex.

Overall Plot Plan

A small scale depiction of utility, storage, and loading facilities as associated with the process plant.

Sectional Plot Plans

The overall plot plan broken into manageable size drawings.

Planning Plot Plan

An agreed-upon arrangement which usually starts the work of most groups that rely on equipment positioning.

Production Plot Plan

An update of the planning plot plan after enough study work has been completed to establish firm location of equipment. This plot plan is the basis for beginning detailed design work.

Construction Plot Plan

Releases the constructor to begin activities related to equipment location, such as roads, pile driving, underground piping, foundations, etc. It is the single document containing all equipment, structure and road locations.

Final or "As Built" Plot Plan –

A plot plan normally provided by the responsible engineering company that reflects the completed project as constructed. This plot plan is maintained by the client for future expansion work requirements or other business needs.

MAJOR ROLES OF A PLOT PLAN

- Plot plans are essential for obtaining permits and determining environmental and personnel safety. They are the key documents used in assessing fire protection.
- During the engineering and construction phases of a job, many owners use the plot plan as a basis for evaluating the level of completeness of agreed upon work. The document thus becomes a measuring device for progress payments.

- Prevailing winds and tower and structure heights must be considered in developing a plot plan. Although wind direction is never constant, prevailing wind is used as a basis to evaluate safety within the client's complex, as well as the safety of neighbors should a spill, release or fire occur. Tower and structure height and their positioning are major considerations, especially when units are located near airports or in flight paths.
- Climatic considerations also play a major role in plot plan development. Extreme sun exposure in desert areas or near the equator may require shelters to protect operators and maintenance personnel from high temperatures. Conversely, special considerations must be given to plants located where extreme cold, ice or snow may be prevalent. Under the most extreme conditions, many equipment items requiring frequent visits by personnel are enclosed by heated shelters. These shelters are sometimes connected by tunnels suitable for human passage. In many cases, plant utilities are run within the confines of these tunnels to guard against freeze-up and to conserve energy for producing utilities streams

ESSENTIAL DATA:

- Direction.
- Overall boundary of the plot with dimension.
- Scale and Symbols.
- Equipment No.
- Pipe Rack.
- Location of Process/ Utility plants/ Buildings/ Tank farm/Non-plant buildings w.r.to direction
- Boundary of all the buildings and plant.(i.e dimension)
- Proposed constructions.
- Roads & access ways
- Stairways & platforms
- Main access road

- Entry point of trucks / trains and other product loading / raw material unloading
- Wind direction
- Effluent drains
- Main power cable entry

CHAPTER 12

EQUIPMENT LAYOUT

KEY FACTORS:

- Pumps (NPSH, suction line, motor location)
- Instrumentation(CVs accessible)
- Heat exchangers (bundles)
- Flares(radiation levels)
- Solids(use gravity flow)
- Expensive piping(run length)
- Reactors(catalyst dump)
- Maintenance(access, removal)

SAFETY ISSUES:

- Accident containment and avoidance of "domino effect".
- High hazard operations.
- Segregation of different risks.
- Exposure to possible explosion overpressure.
- Exposure to fire radiation.
- Minimizing vulnerable piping.
- Drainage and grade sloping.
- Prevailing wind direction.
- Provision for future expansion.

EQUIPMENT ARRANGEMENT:

- Equipment must be grouped within common process areas to suit independent operation and shutdown.
- Equipment within process and off-site areas must be arranged to accommodate operational and maintenance access and to meet the safety requirements.
- Process units, buildings, and group of off-site areas (e.g., tank) are serviced by auxiliary roads for maintenance and fire fighting.

- Equipment location must facilitate in-place maintenance by mobile equipment.
- Process equipment must be enclosed in shelters only when required by extreme climatic condition or client preferences.
- Piping, instrument and power cables are to be carried on overhead pipe racks in process units and utility plants and in grade sleepers in off-site areas.

ACCESS:

- Operator access is the space required between components or pairs of components to permit walking, operating valves, viewing instruments, climbing ladders or stairs, and safety exiting the unit in an emergency.
- Maintenance access is the space required to service equipment in place or to remove the unit equipment or portion of the equipment for off-sit repair.

EQUIPMENT ELEVATION:

- Equipment should be generally be elevated a minimum height from grade to suit process, operational, and maintenance requirement.
- Horizontal drums, shell and tube exchangers, and furnaces must be supported from grade by concrete piers.
- Vertical vessels (e.g., towers and reactors with attached skirts) and base plate equipment with pumps should be supported at grade by concrete foundation.
- Large vacuum or crude towers with swaged bottom section and compressors that are to be elevated for operational needs must be supported from concrete structures.
- Equipment that must be elevated for process requirements (e.g., shell and tube overhead condensers) must be supported in structures.

PLATFORM, LADDERS AND STAIRS:

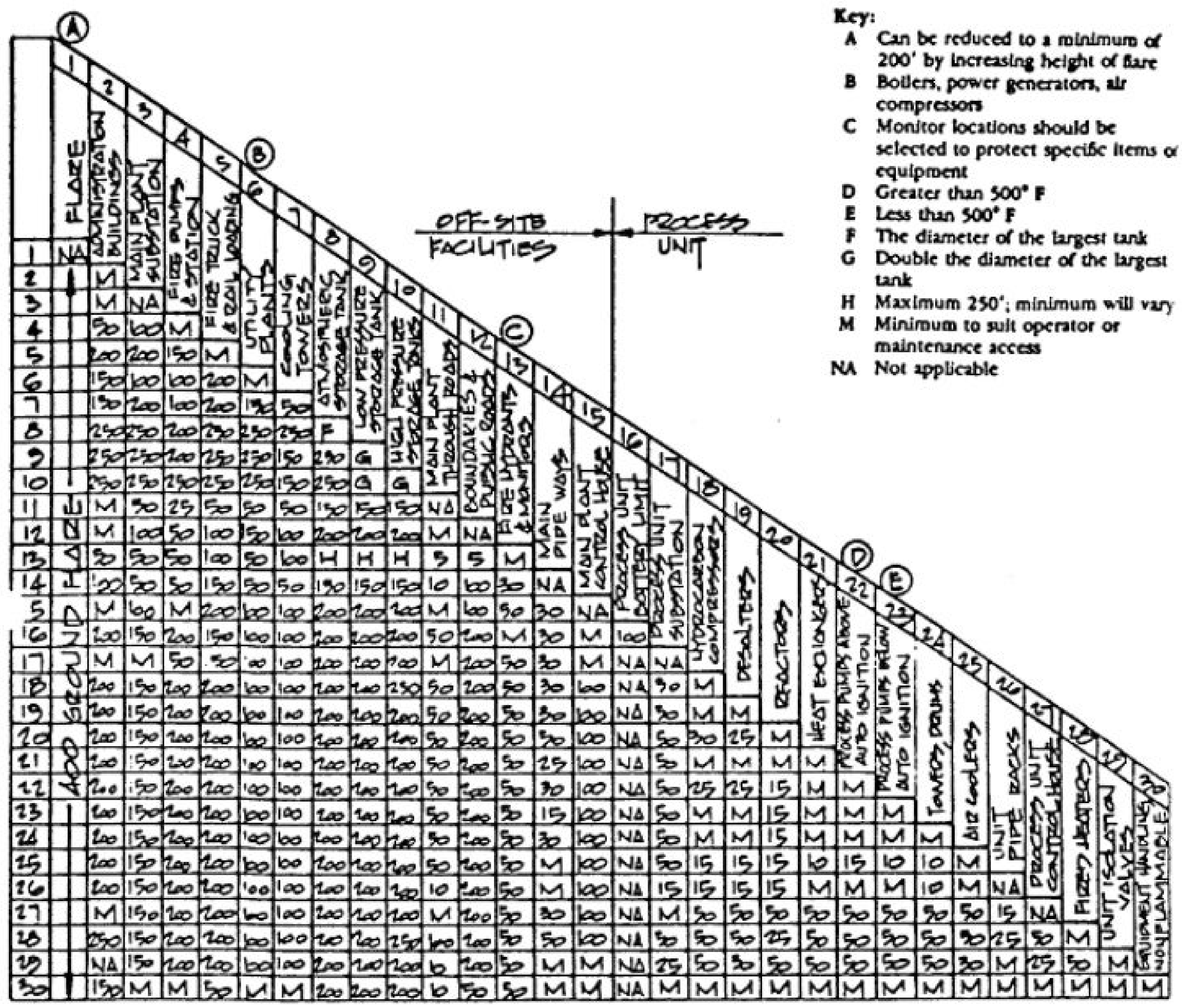
- Platforms are to be provided at all elevated equipment and at control that are beyond reach from grade for manual operation and maintenance.
- Stairways must be provided to lead to service levels in structures, buildings, compressor house decks, and furnace that require frequent access by plant operations personnel.
- Storage tank larger than 15 ft in dia and higher than 20 ft also require stair for access.
- Ladders must be provided for vessel platforms, secondary service levels in structures and furnace and at storage tanks with the dimensions.

- Escape ladders must also be provided from service levels so that no point on the platform is horizontally more than 75 ft in walking distance from a main or secondary exit.
- Ladders that extend more than 20 ft above grade must have safety cages. Self closing gates at ladder openings on all platforms are also required.

PURPOSE:

This document will be a guide for erection of equipment and input for other departments for planning the installation of their components

EQUIPMENT SPACING CHART:



Notes:

highlights the recommended safety distances between equipment associated with refinery, chemical, and petrochemical plants.

This exhibit should be read in conjunction with national and local codes and regulations. Exceptions to this exhibit should be by client specification only.

…mensions shown are to the face of equipment and are …nimum.

Fixed fire water sprays should be provided over equipment that handles flammable materials and operates at temperatures greater than 500° F (260° C) and over equipment that handles light hydrocarbons with a vapor pressure greater than 65 psi (3.5 kg/cm) at 100° F (38° C) or a discharge pressure greater than 500 psi (35 kg/cm) that is located directly beneath air-cooled exchangers.

ESSENTIAL DATA:

The general arrangement drawing shall indicate and locate various equipment viz. Coolers, Heat exchangers, Pumps, Vessels, Columns, Heaters, Compressors, Reactors, Flare stack, Package system, etc.

- All equipment shall be located in the sequence and at levels as recommended by process department with unique equipment number and dimension.
- Dimensions shall be given with respect to centre line/tangent line of the equipment to the nearest building column or to adjacent equipment.
- Access platform for equipment, ladders, and stairways shall be indicted.
- Maintenance spaces and drop out area for equipment shall be clearly indicted
- Further equipment if any shall be indicated in dotted line.

CHAPTER 13

PIPING LAYOUT:

Piping arrangement drawing shall include equipment fixed with nozzles, platforms, ladders, stairways, etc suitably located as per engineering practice. Piping routing shall be drawn legibly in accordance with P & I diagram taking into account the requirement for stress, supports, accessibility for instruments and valves, manual movement and other statutory regulations if any.

Purpose:

This document is used for erection of piping and other components.

PIPING ISOMETRICS:

Piping isometrics is a representation of 3D view of piping layout. It shall include pipes, pipefitting, valves, instruments, piping specialties, flanges and other accessories as indicted in P & I diagram. Support location & type shall be marked as suggested by stress department. A statement-indicating bill of materials shall also be drawn on the same drawing. Generally one isometric drawing is produced for one line.

Purpose

This document is used for pre fabrication of piping and withdrawal of materials required for fabrication from stores.

PIPE RACK:

Pipe rack shall include location of various Piping systems, Electrical trays, Instrument cable trays, platform, ladders etc. This has to be developed based on equipment locations, P&IDs, line list, stress, supports, operation requirements, maintenance requirements etc. This could be either concrete or steel. The concrete pipe racks have high initial cost but no subsequent maintenance costs, where as the steel pipe racks, though initially cheaper and have lesser construction time, require regular painting due to corrosion, especially in coastal areas.

General Engineering Practice for tier concept

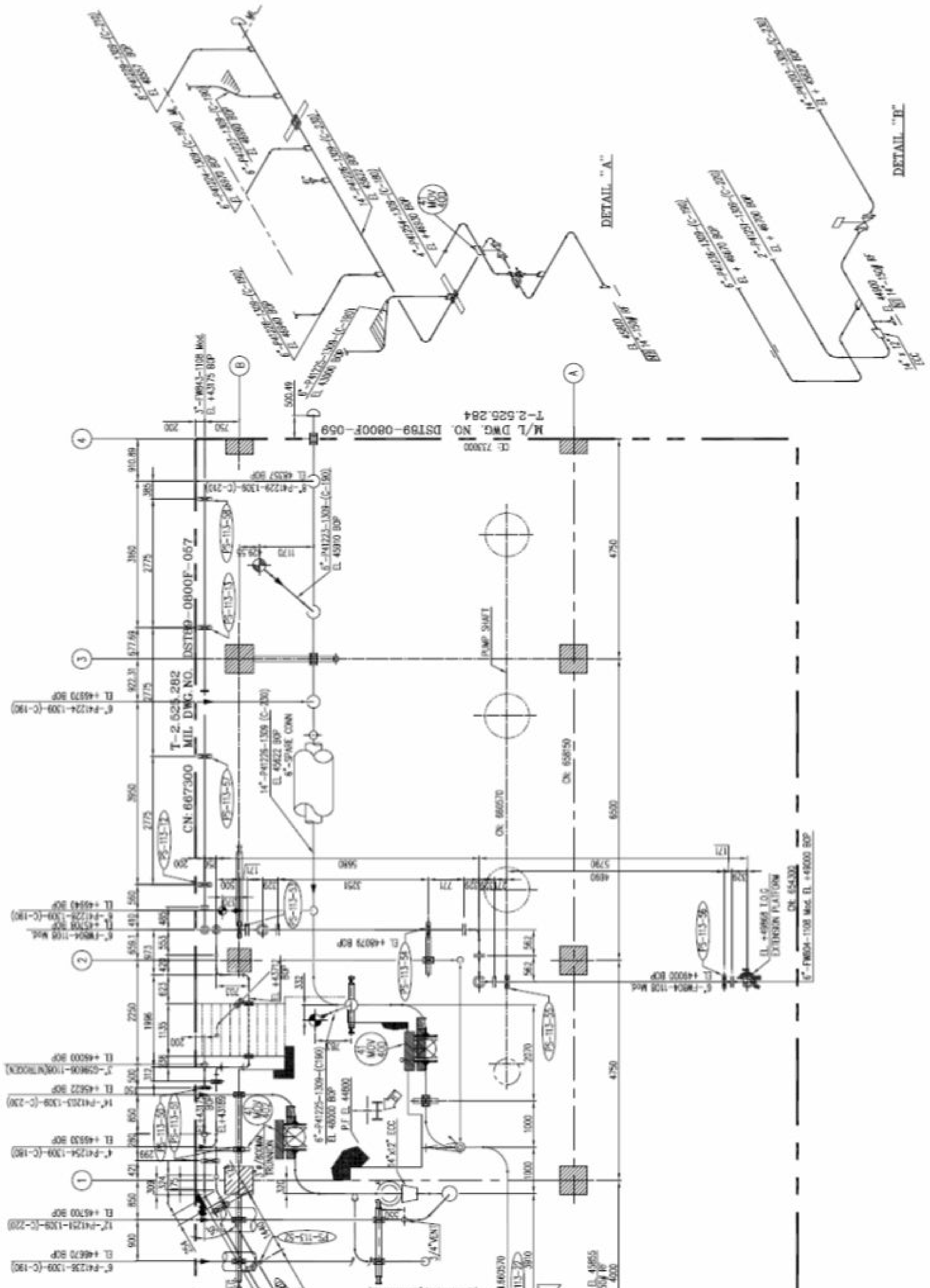
Process lines shall be kept in bottom most tiers

Utility lines shall be kept in the middle tier.

Flare, Electrical cable trays and Instrument cable trays shall be kept in top most tiers.

Purpose

This document is used for installation of piping systems.


DETAIL "A"
DETAIL "B"

CHAPTER 14

PIPE SUPPORTS

PURPOSE:

- Absorbs system weight.
- Reduce:
    - Longitudinal pipe stress.
    - Pipe sag.
    - End point reaction loads.
- Control or direct thermal movement due to:
    - Thermal expansion.
    - Imposed loads.

SELECTION FACTORS:

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

DEFINITIONS:

Anchor:

A device which restrains the pipe from movement and rotation in all direction, the member to which an anchor is fixed.

Base support or pipe stanchion:

A dummy pipe with base plate welded to the pipe. The pipe dummy will rest on the supporting structure and so support the pipe. When considering site adjusting is required, the pipe stanchion may be of 2-piece type, welded together after adjustment.

Clamp or clip:

A device bolted around a pipe or, for cold insulation, around the insulation. Clamps form an integral part of hangers and clamped cradles or pipe shoes.

Constant load support:

A spring loaded support assembly or device designed such that the supporting effort is constant over the total travel of the support. Constant load supports are meanly used in pipes connected to strain sensitive equipment or for critical system with large movement.

Dummy leg:

A dummy leg welded to the pipe. The pipe dummy will rest on the supporting structure and so support the pipe.

Goal post support:

Frame type support for situation where heavy loads may be expected

Guide:

A device controlling the direction of movement of piping/supports

Guided support:

A support allowed moving along a predetermined axis, controlled by guides

Hanger:

A support suspended from concrete floors or columns, allowing supports and hangers to be bolted

Pipe shoe or cradle:

A pipe support welded or clamped to a pipe

Pipe stop:

A device preventing the pipe from displacement in one direction may be applied in combination with a guide in another direction

Pivot:

An element similar to a base support, but which allows the pipe to rotate around and to move along the longitudinal axis of that pivot. These supports are usually used as a sort of base support but they allow vertical movement and rotation while preventing lateral movement. Downward movement can be restricted with this type of support

Rest support:

Location where a pipe is resting with or without the application of a pipe shoe on the supporting structure

Reinforcing Pad or Saddle:

A plate welded to the pipe in order to reinforce thin-walled pipe to prevent the pipe from being damaged

Shear Lug:

A welded attachment to the pipe at one or both side of a clamped cradle or pipe shoe, preventing the pipe from slipping through the pipe support

Snubber:

A shock absorbing device, allowing the pipe to freely and slowly move while absorbing sudden shocks. It may be of the hydraulic, spring loaded...

Sway Brace:

An adjustable spring or friction loaded device, usually applied for controlling vibration, absorbing shock loading, guiding or restraining the movement of the pipe and bracing against sway

Sway Strut:

An adjustable device, usually applied for restraining movement of piping in one direction while providing movement in another direction

Spring Hanger:

A suspended spring loaded support

Spring Support:

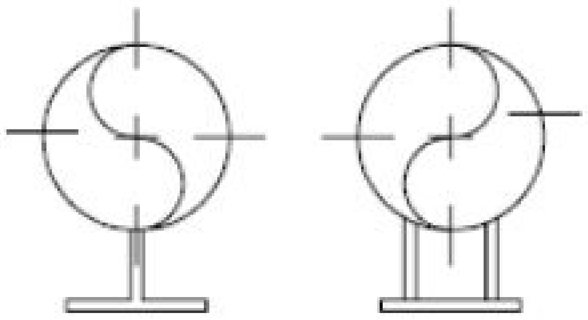
A spring loaded assembly or device supporting the pipe from underneath

Trunnion:

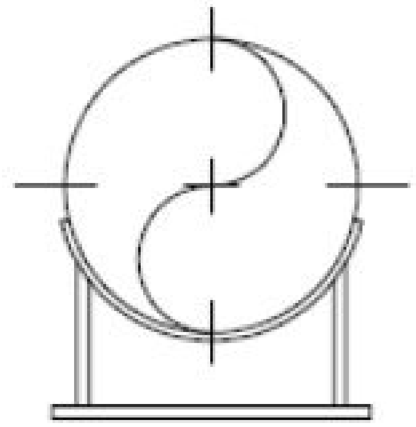
A tubular supporting device, branching-off horizontally from a vertical line and resting on, or suspended from the supporting structure

U-bolt:

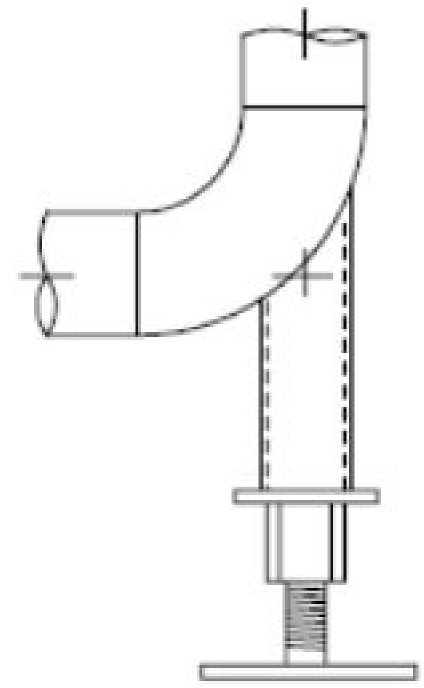
A light duty fixture, u-shaped with both ends threaded and provided with nuts. These supports can be used for both semi-fixed and guiding points



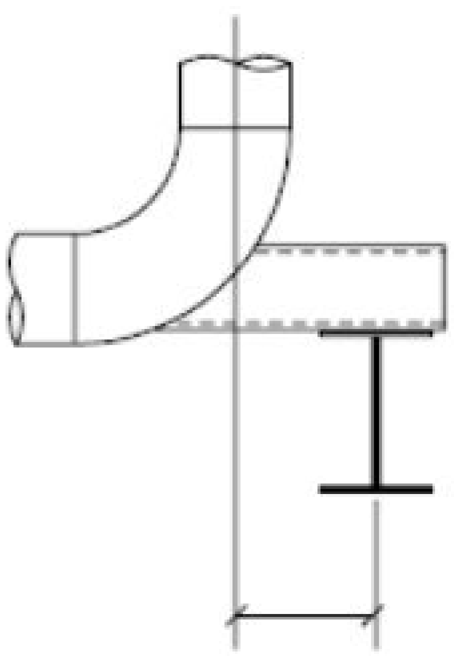
SHOE



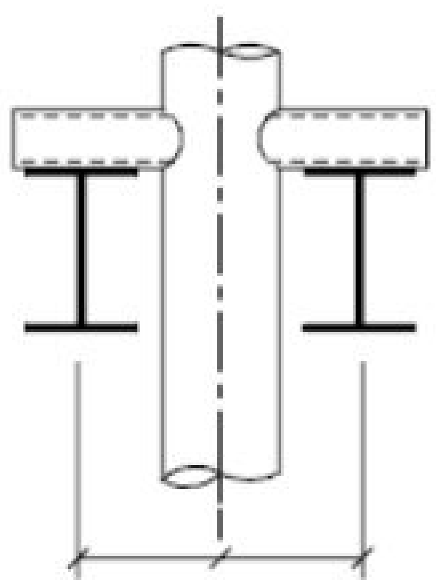
SADDLE



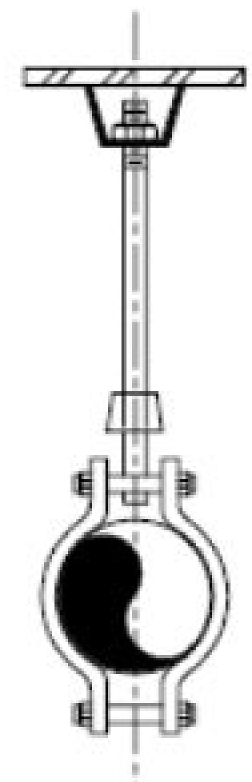
BASE ADJUSTABLE SUPPORT.



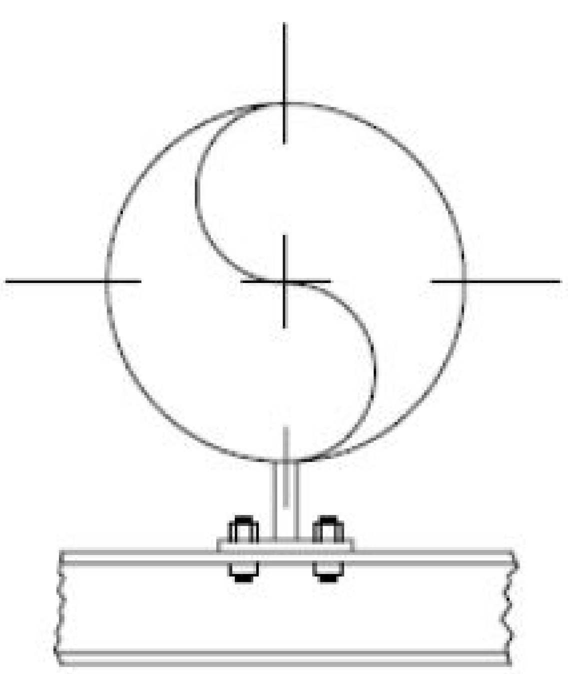
DUMMY SUPPORT

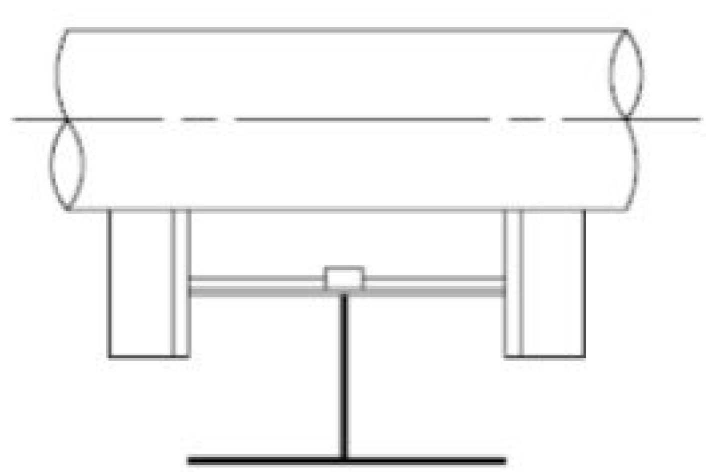


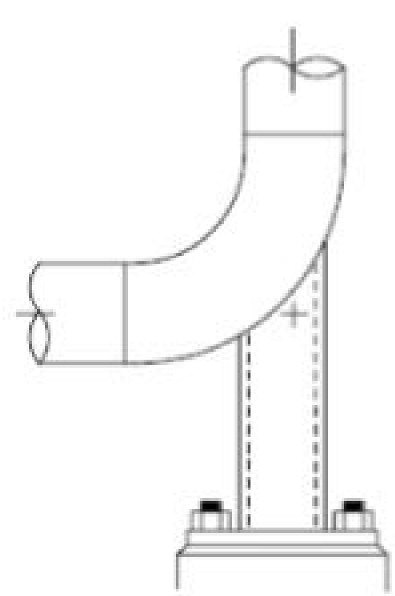
TRUNNION



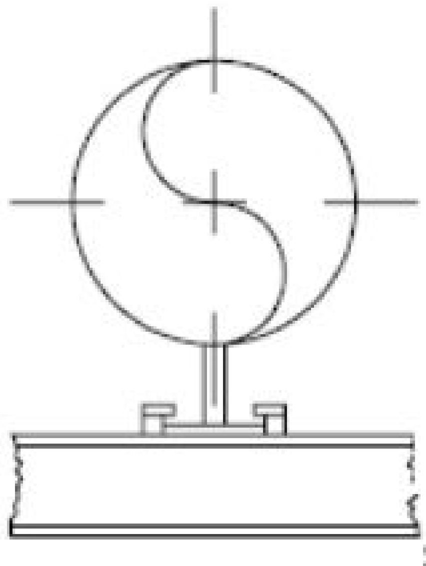
HANGERS

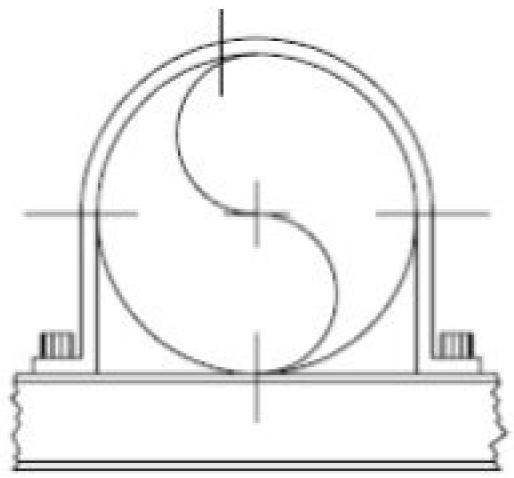


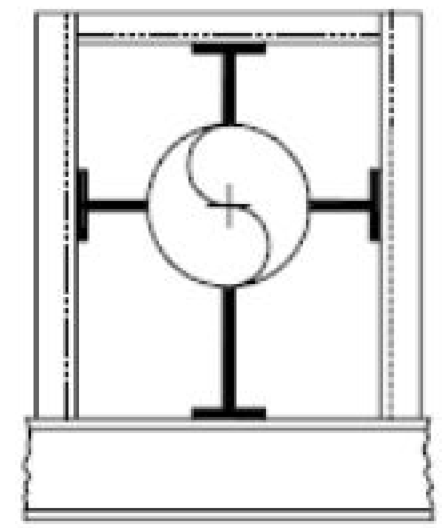




ANCHOR **ANCHOR** **PARTIAL ANCHOR**

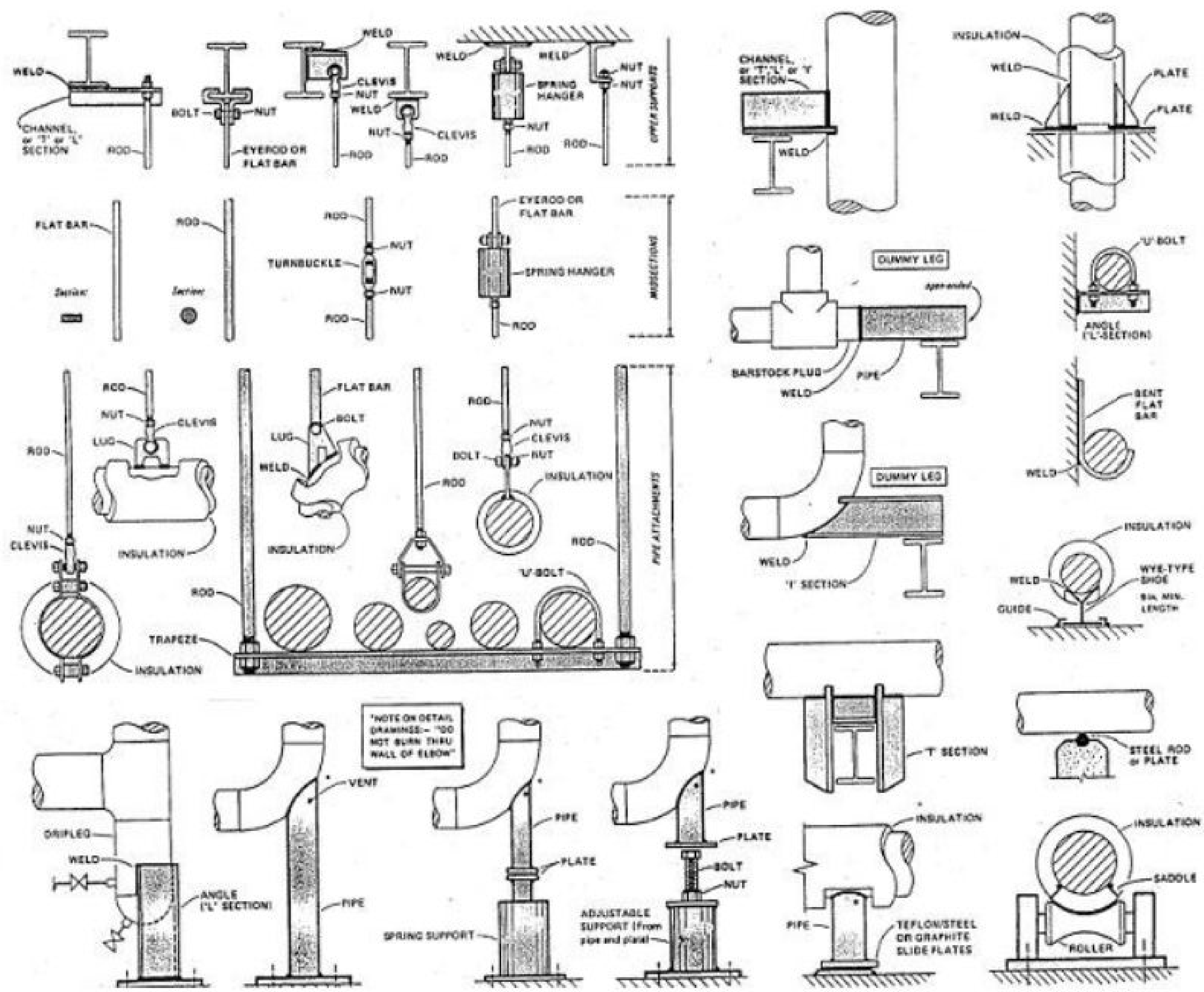




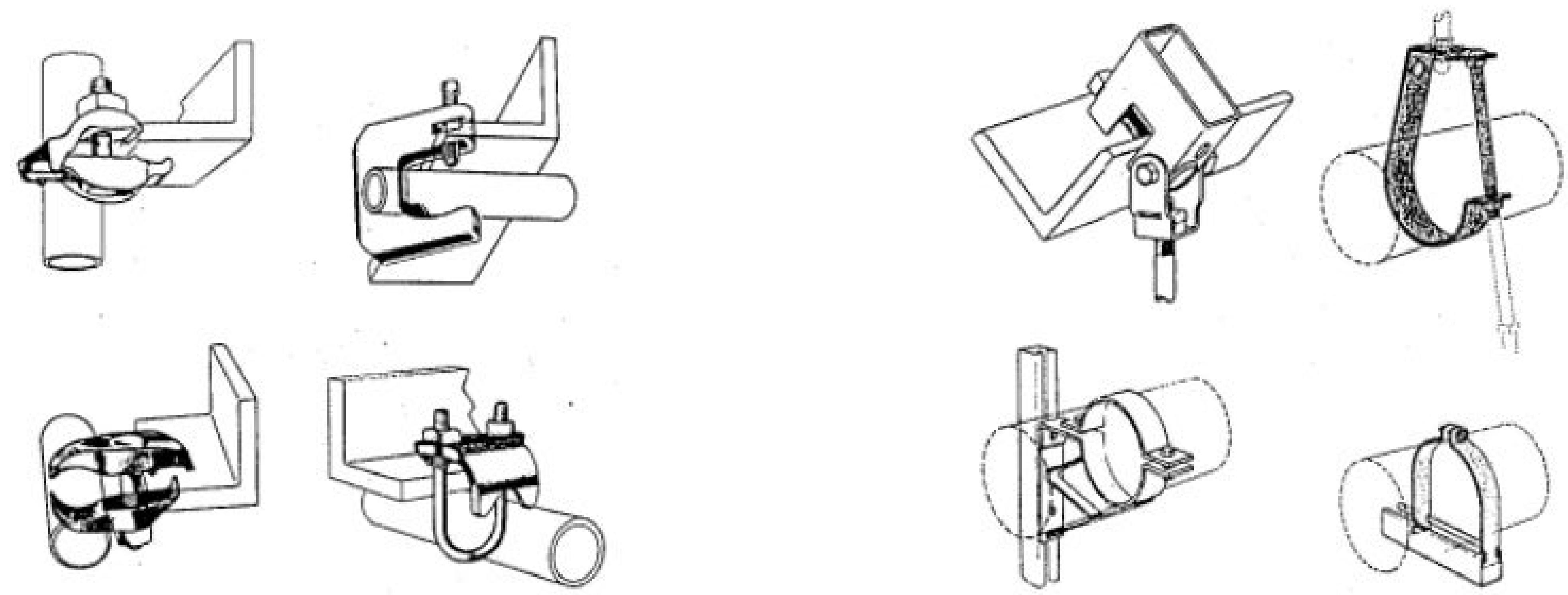


GUIDES

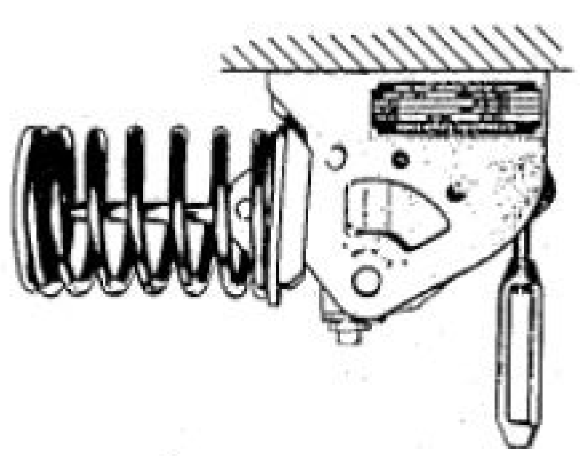
HANGERS AND SUPPORTS:

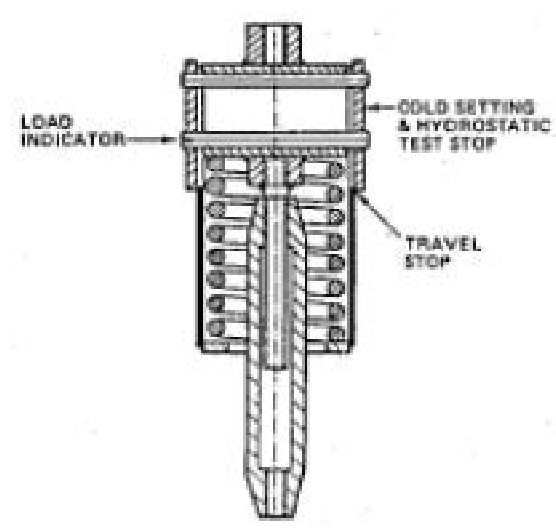


SUPPORTING PIPE CLOSE TO STRUCTURAL STEEL:



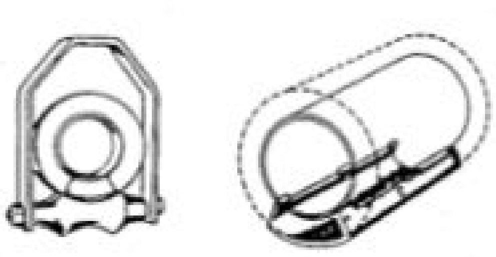
SPRING HANGERS:

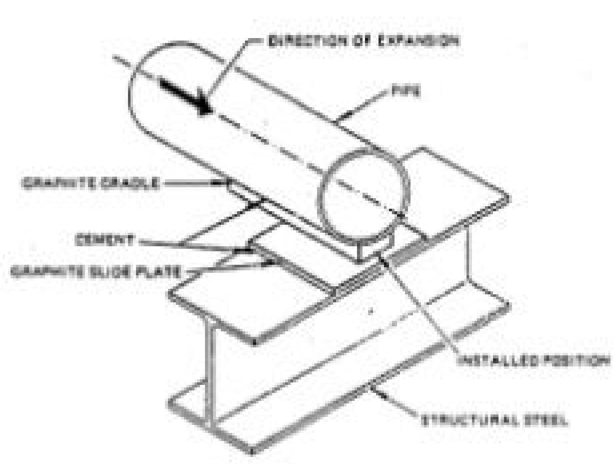


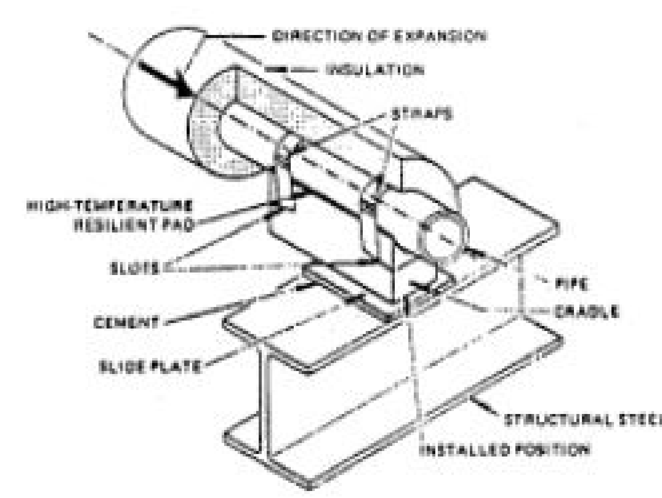


CONSTANT LOAD TYPE **VARIABLE LOAD TYPE**

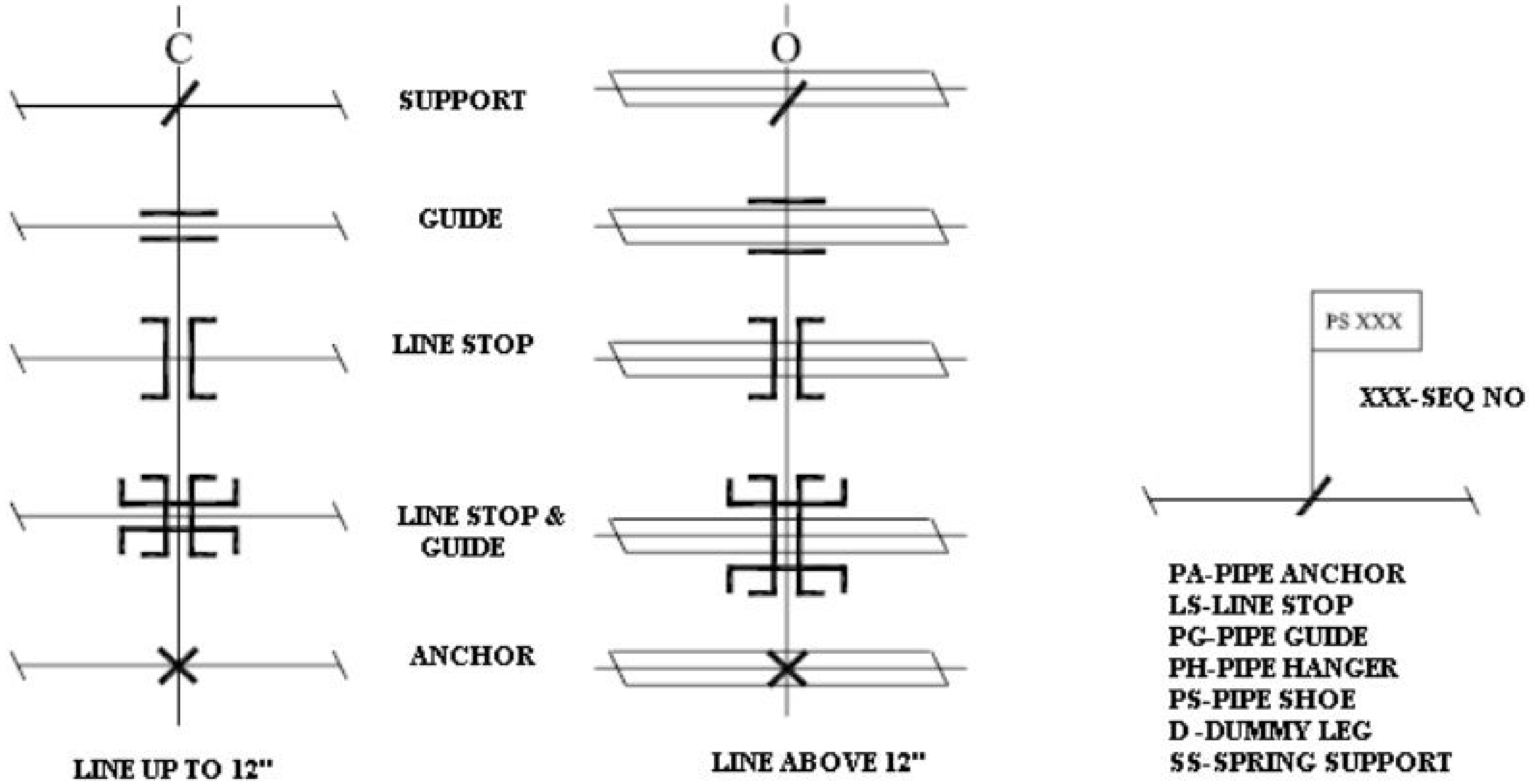
SUPPORTS ALLOWING FREE MOVEMENT OF PIPE:







SYMBLOIC REPRESENTATION:


C
O
SUPPORT
GUIDE
LINE STOP
LINE STOP &
GUIDE
ANCHOR
LINE UP TO 12"
LINE ABOVE 12"
PS XXX
XXX-SEQ NO
PA-PIPE ANCHOR
LS-LINE STOP
PG-PIPE GUIDE
PH-PIPE HANGER
PS-PIPE SHOE
D -DUMMY LEG
SS-SPRING SUPPORT