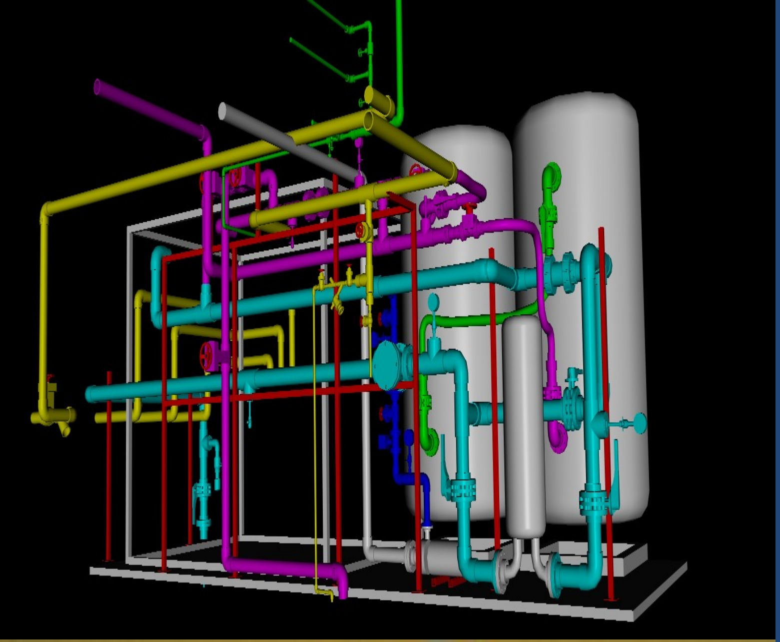


PIPING & INSTRUMENTATION DIAGRAM

21st Oct 2015

Presented by : Muhammad Afzal Kayani

Objective

The aim of this course is to develop a basic understanding of analyzing/interpreting P & I Diagrams and its utilization

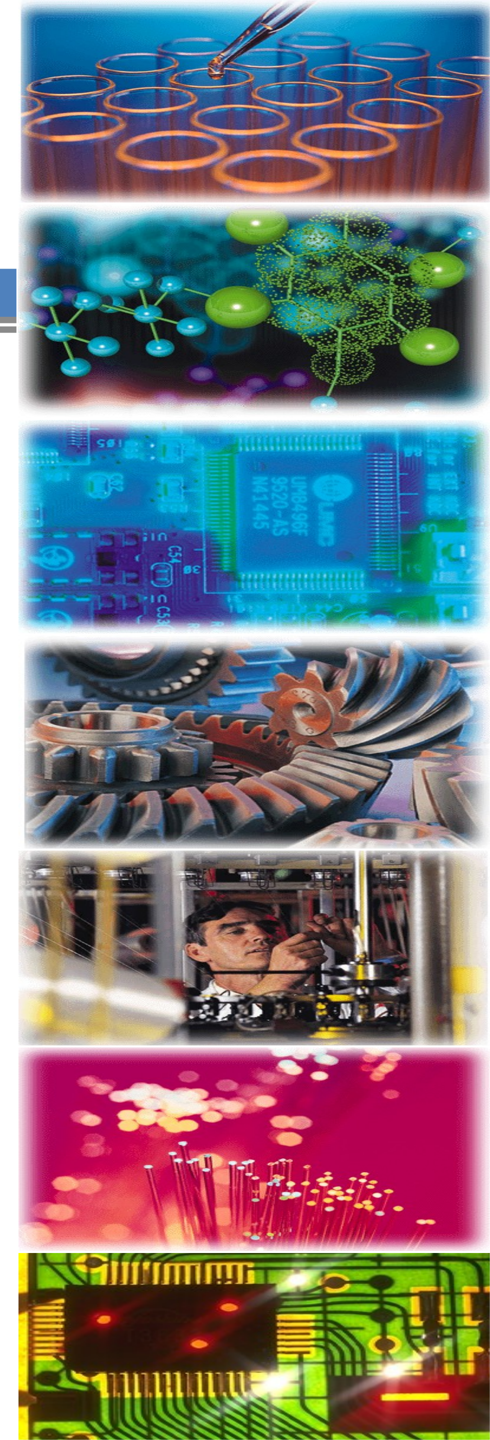


TABLE OF CON-TENTS

P & ID

TABLE OF CON- TENTS

P & ID

Introduction

WHY skill is necessary for chemical plant personnel in analyzing & interpreting Process Flow Diagrams ?

Introduction

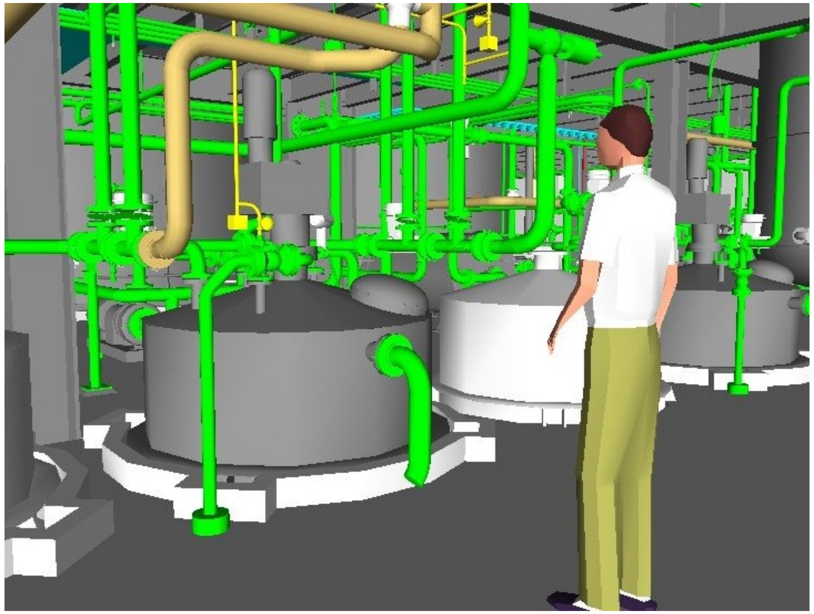
Flow Diagrams communicate information about a process in the most effective way.

- ❑ Complex chemical processes
- ❑ High temperature, pressure, energy
- ❑ High reactivity & toxicity of chemicals
- ❑ Serious consequences in case of missed communication
- ❑ Appropriate process diagrams are required for clear visual information

Introduction

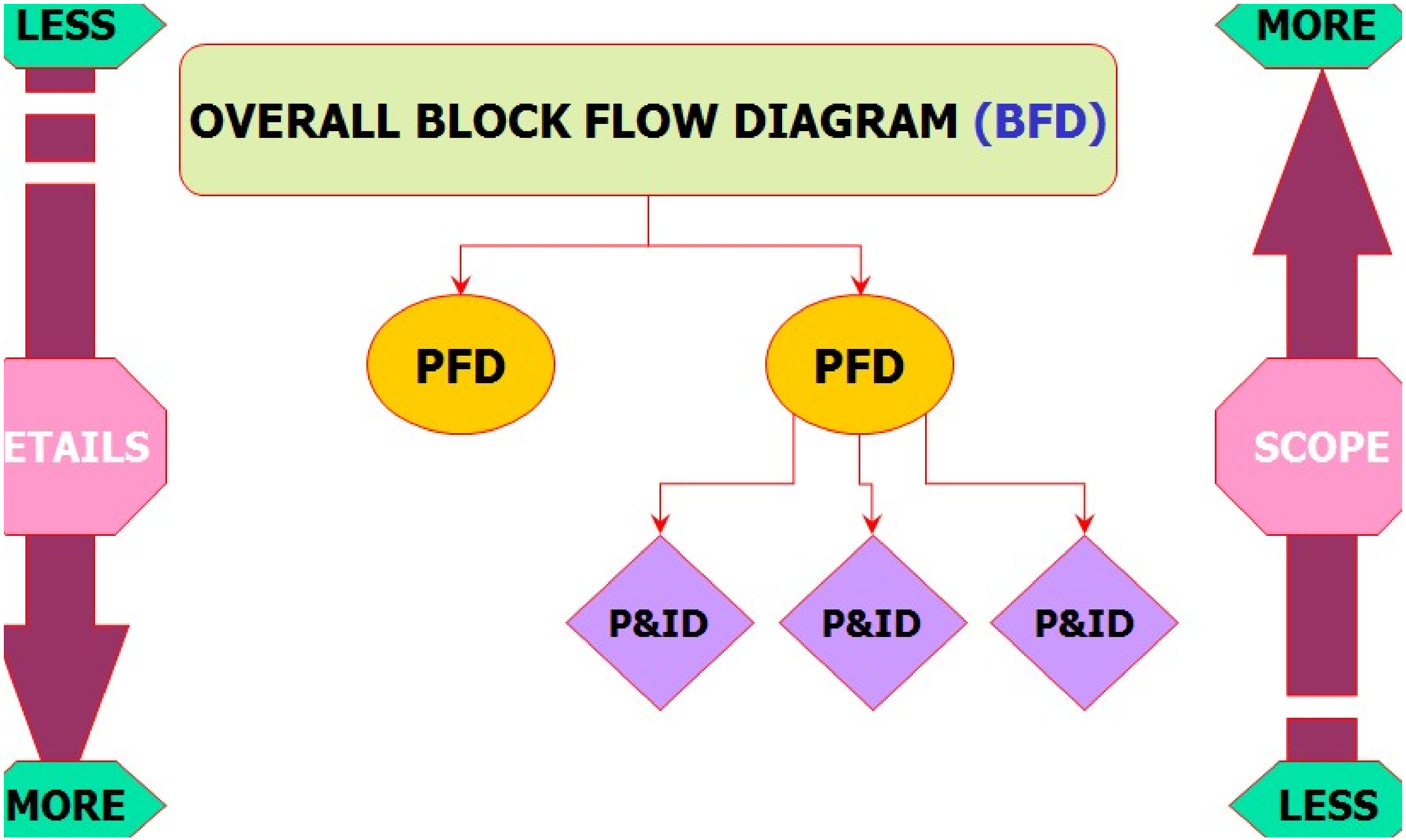
3 Levels of Diagram are generally applied in process industry.

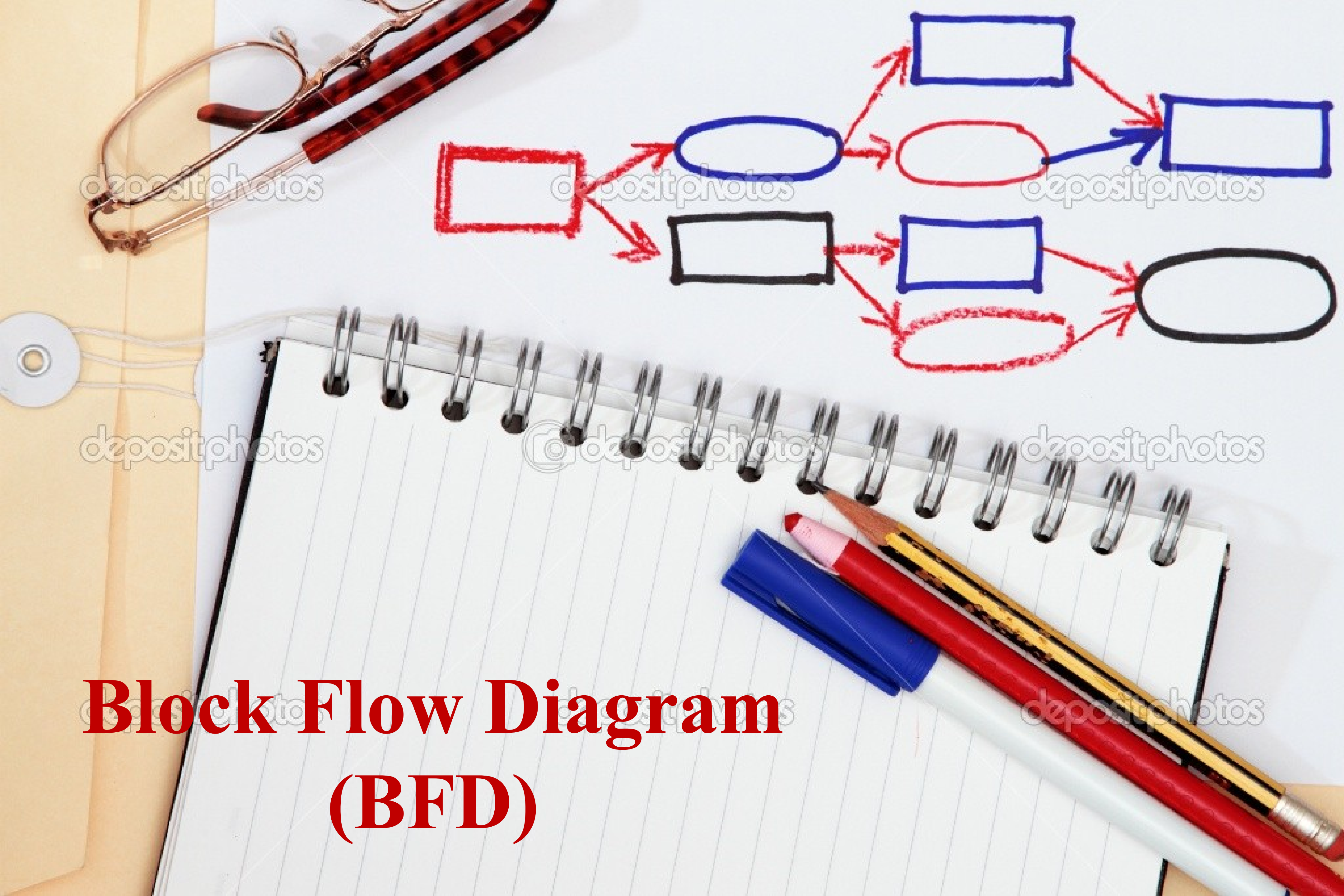
- ❑ Block Flow Diagram (BFD)
- ❑ Process Flow Diagram (PFD)
- ❑ Piping and Instrumentation Diagram (P&ID) – often referred to as Mechanical Flow Diagram



Introduction

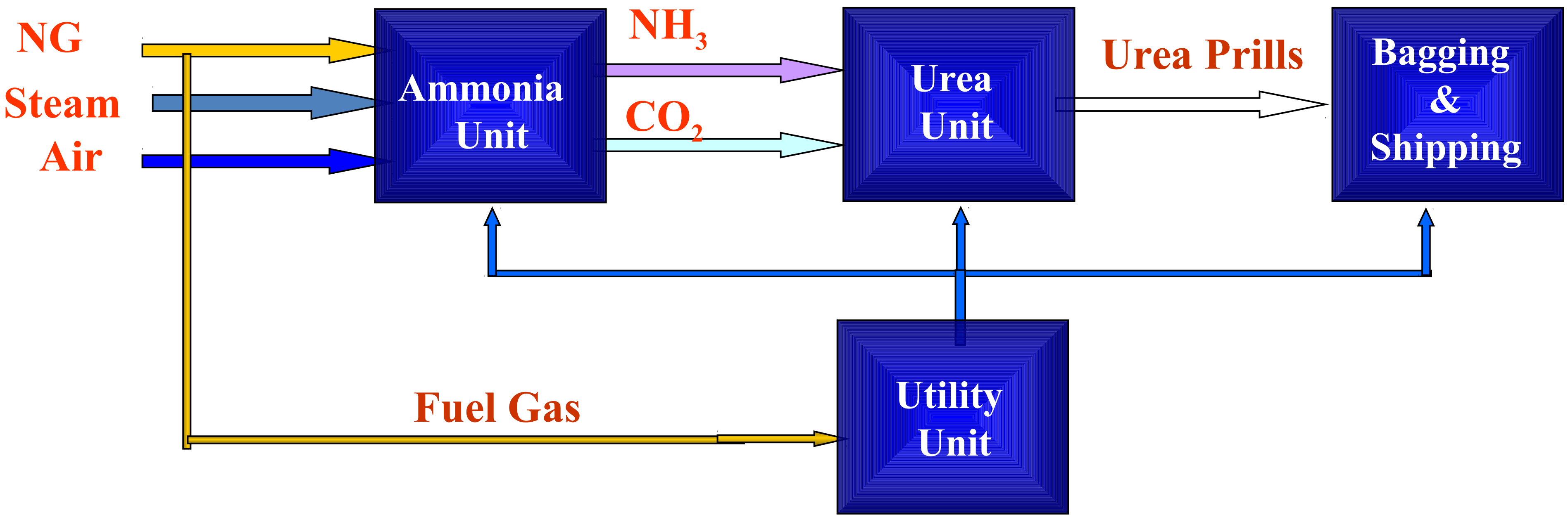
Each step shows additional information.




Block Flow Diagram
(BFD)

Block Flow Diagram (BFD)

- BFD shows overall processing picture of a chemical complex & is useful as an orientation tool.
  - Chemical process can be broken down into basic areas or blocks.
  - Diagram consists of a series of blocks representing different equipments or unit operations that are connected with input & output streams.



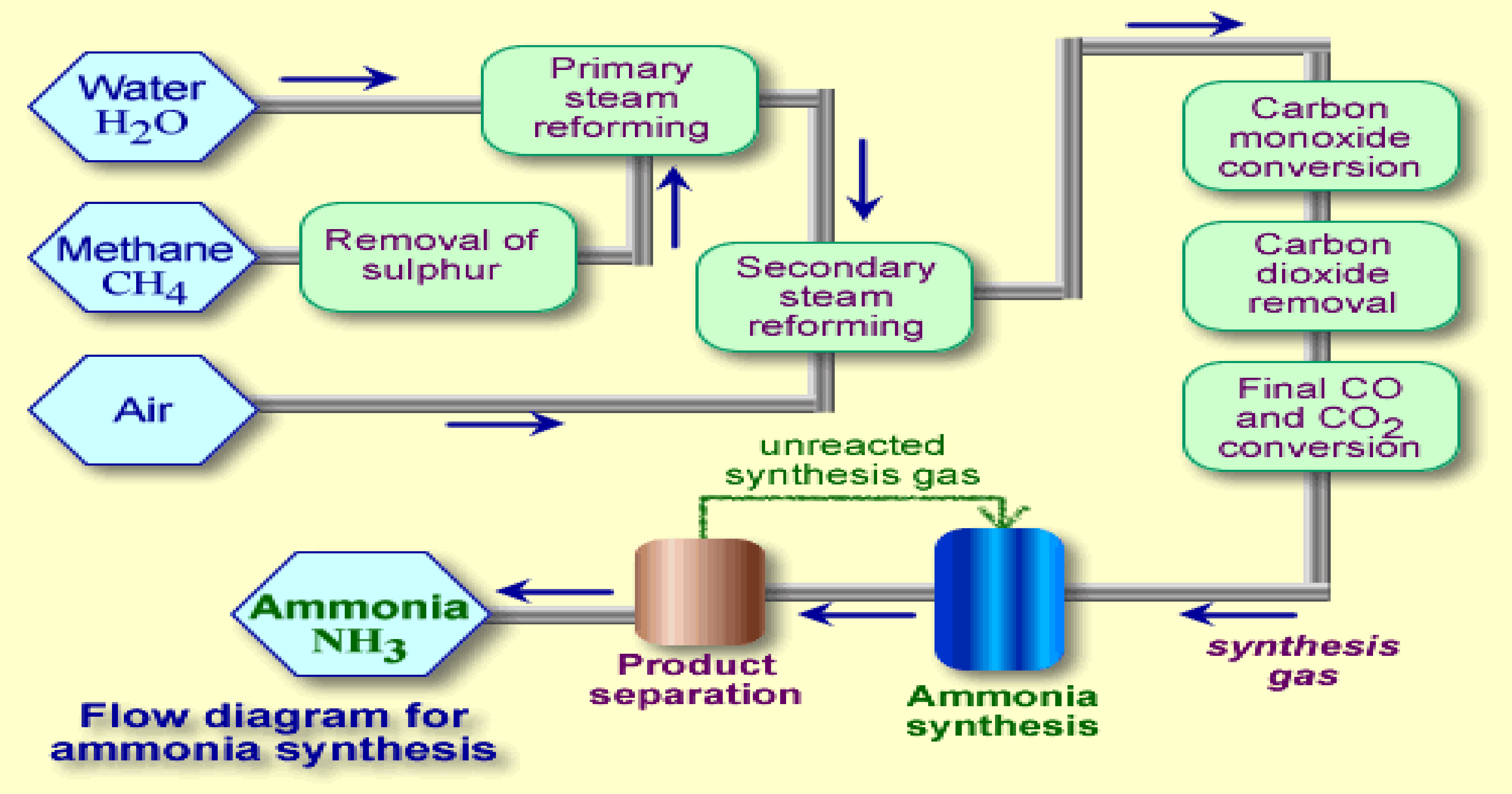
Block Flow Diagram (BFD)

Diagram is very useful for “getting a feel” for the process & is a starting point for developing a PFD.

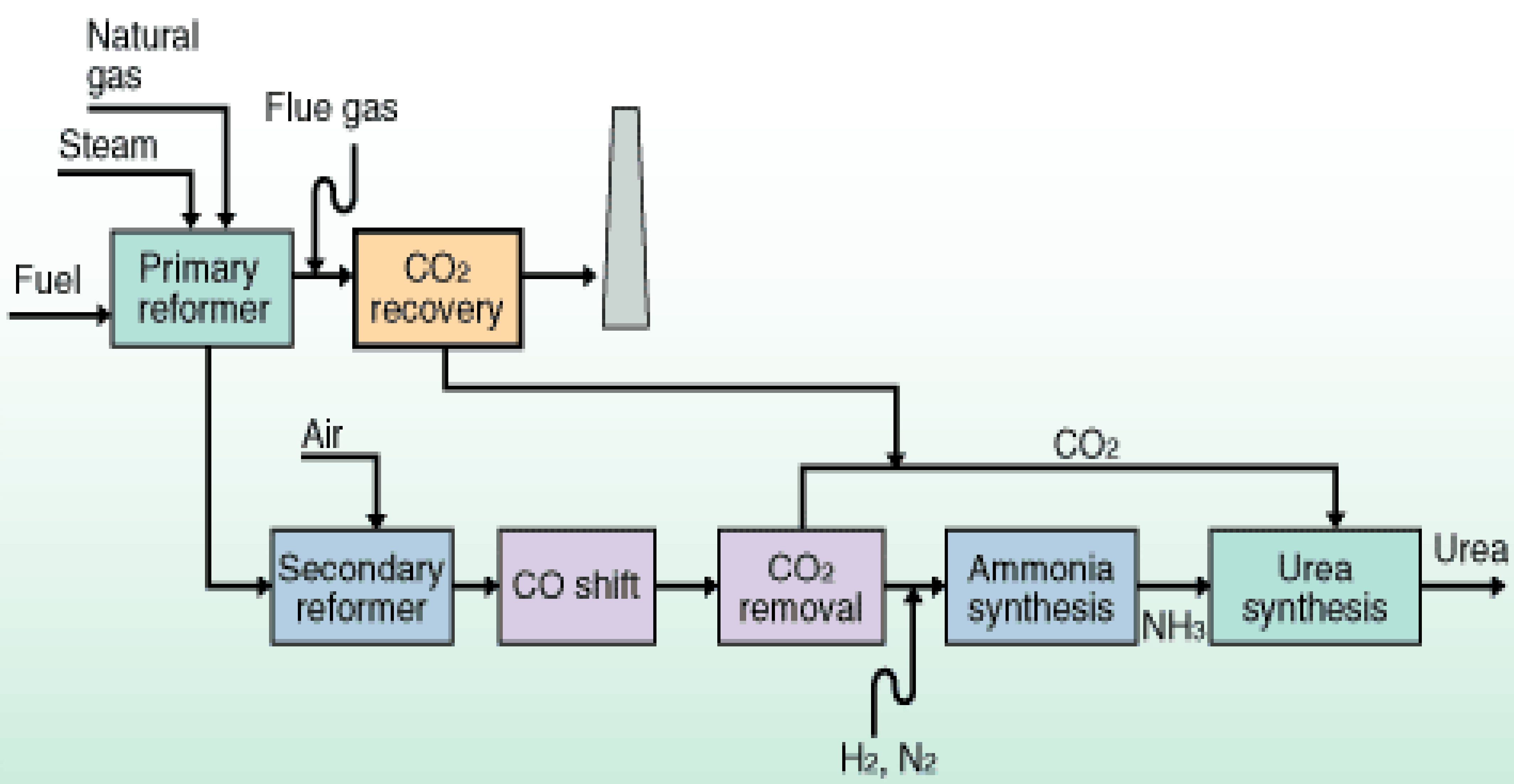
Following conventions are used,

- Only limited information is available about each process unit.
- Each block represents a process function which in reality may consist of several pieces of equipment.
- Major flow lines shown with arrows giving direction of flow.
- Flow goes from left to right whenever possible.
- Light streams (gases, vapors) move towards top and heavy streams (solid, liquid) go towards bottom.

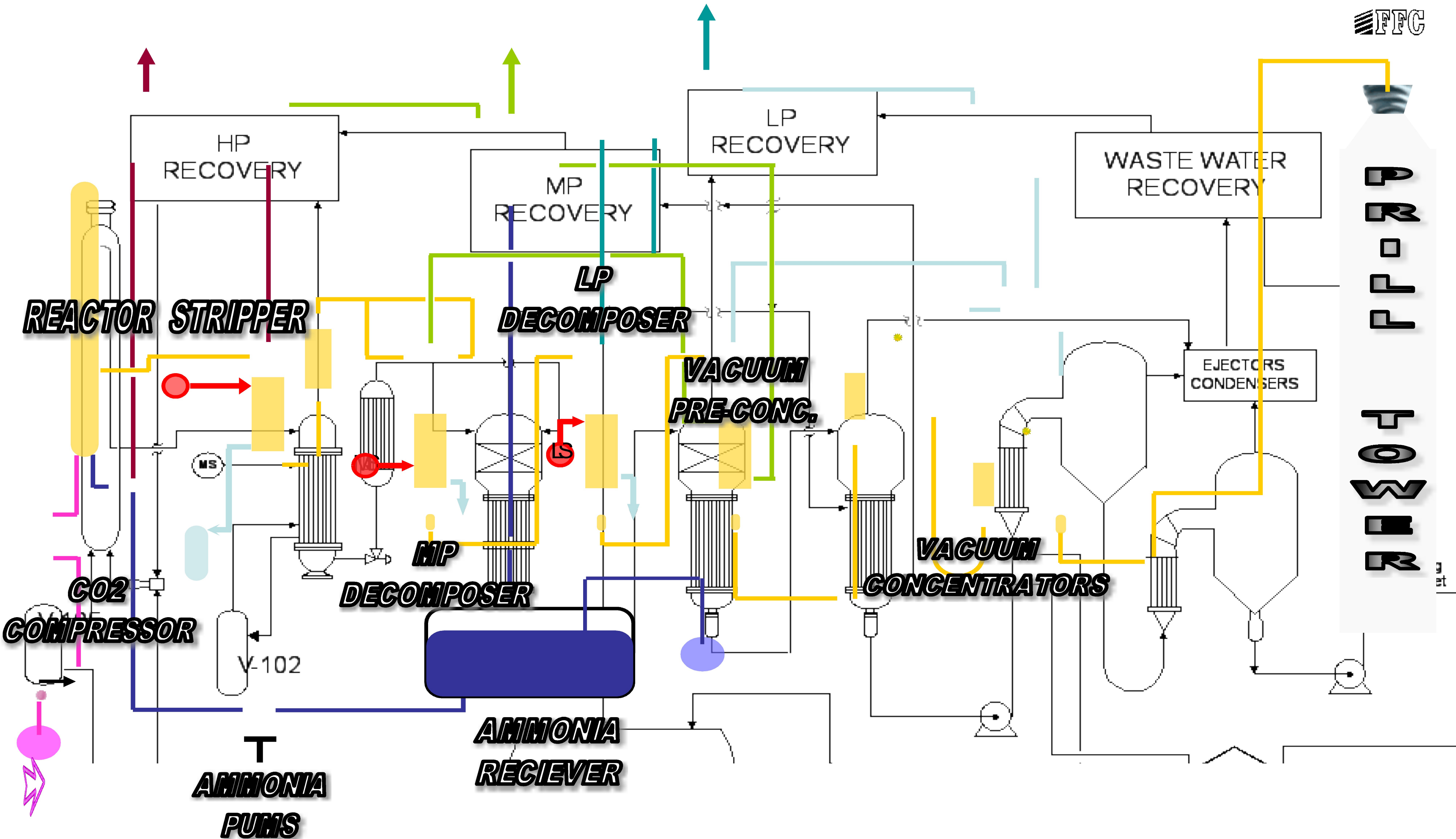
Block Flow Diagram (BFD)

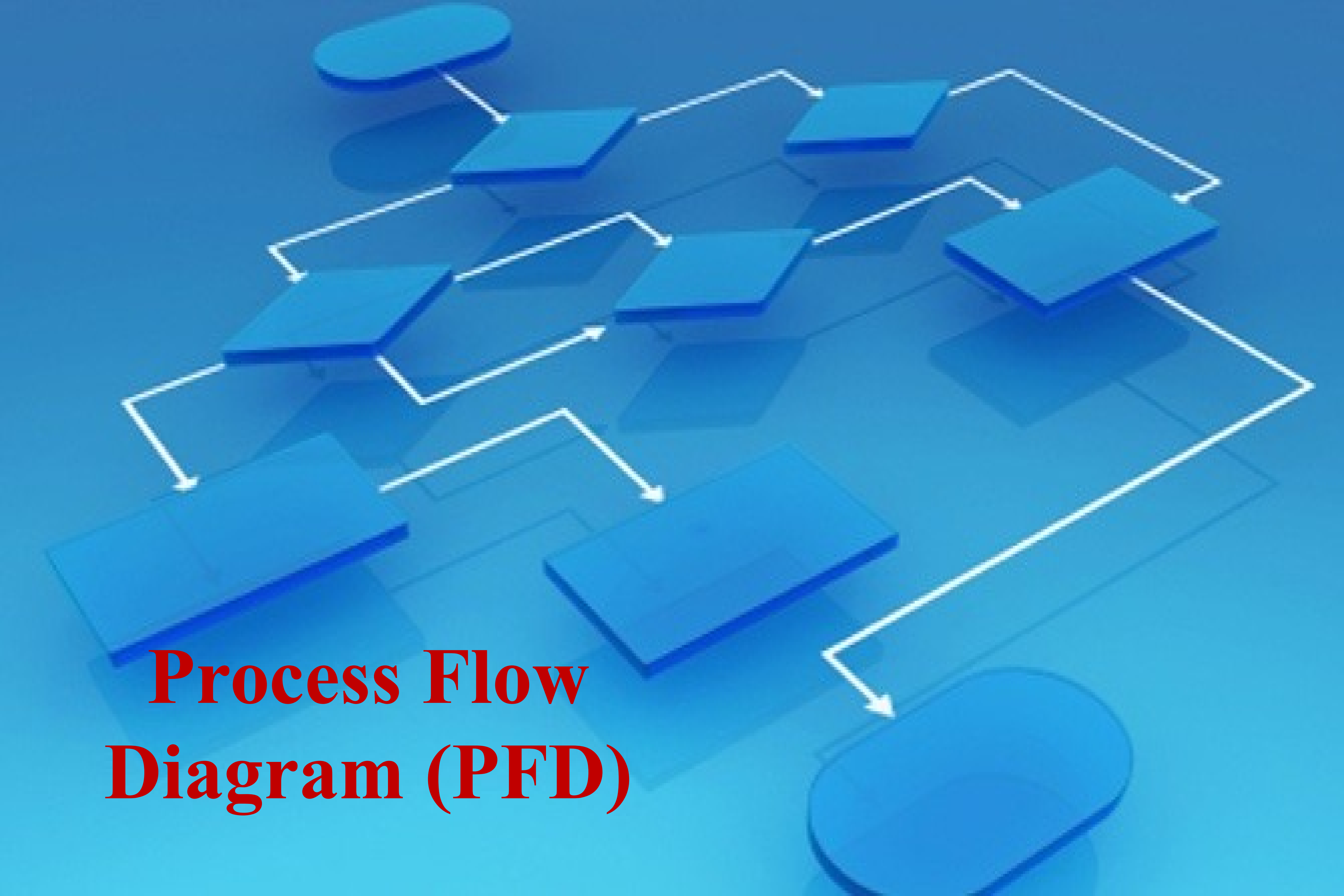


Block Flow Diagram (BFD)



UREA PLANT


HP RECOVERY
MP RECOVERY
LP RECOVERY
WASTE WATER RECOVERY
REACTOR
STRIPPER
LP DECOMPOSER
VACUUM PRE-CONC.
EJECTORS CONDENSERS
MS
LS
MP DECOMPOSER
VACUUM CONCENTRATORS
CO2 COMPRESSOR
V-102
AMMONIA RECIEVER
AMMONIA PUMS
PRILL TOWER



Process Flow Diagram (PFD)

Process Flow Diagram (PFD)

PFD provides basic information of the following,

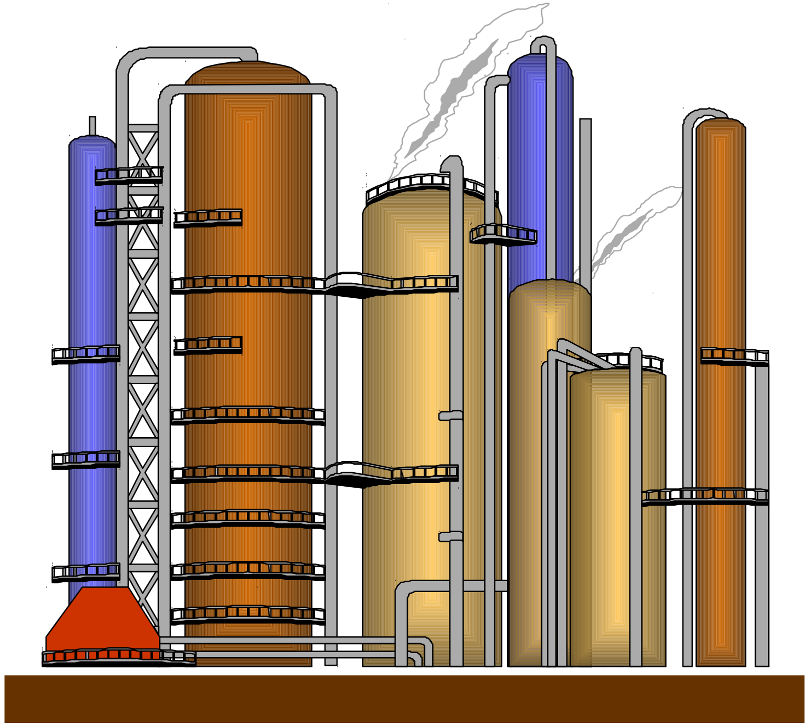
1. Process fundamental details

2. Process stream Information

3. Equipment information

Process Flow Diagram (PFD)

- Bulk of information about chemical process is available as compared to BFD.
- There are no universally accepted standards about contents of information.
- PFD information for same process may differ from one company to another company.

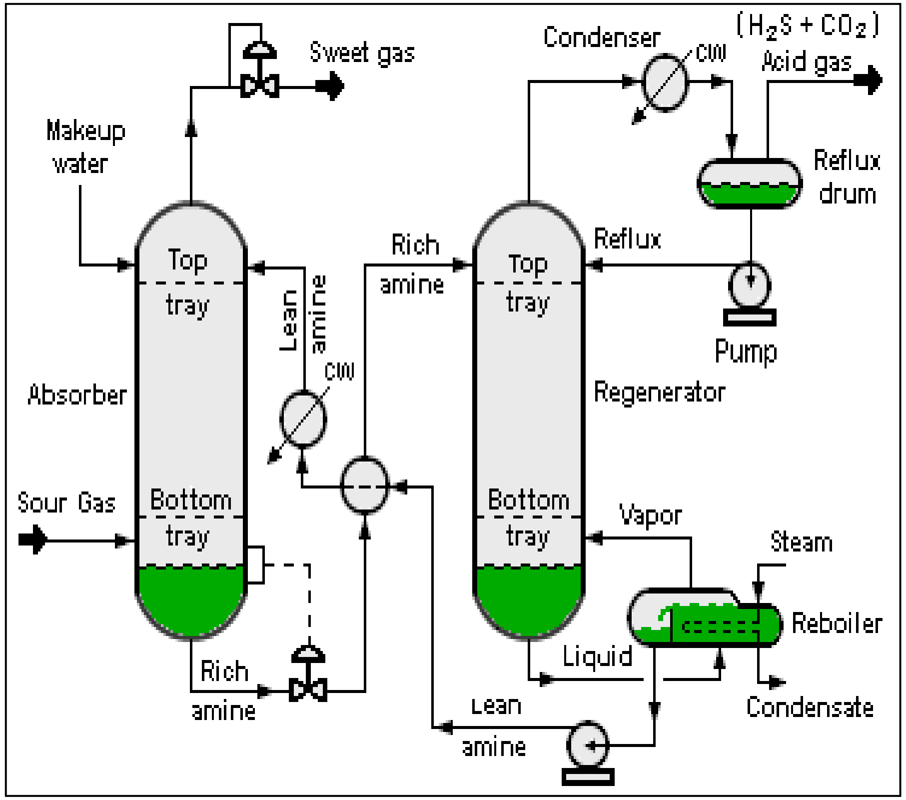


Process Flow Diagram (PFD)

Showing the connectivity & flow relationship between major equipments of plant

<u>It normally includes</u>,

- All Major Equipments with a descriptive name & unique equipment number
- Process condition & chemical composition of each stream
- Bypass & Re-circulation Streams
- Flow & equipment summary table
- Basic control loops, illustrating the control strategy used to operate the process during normal operation

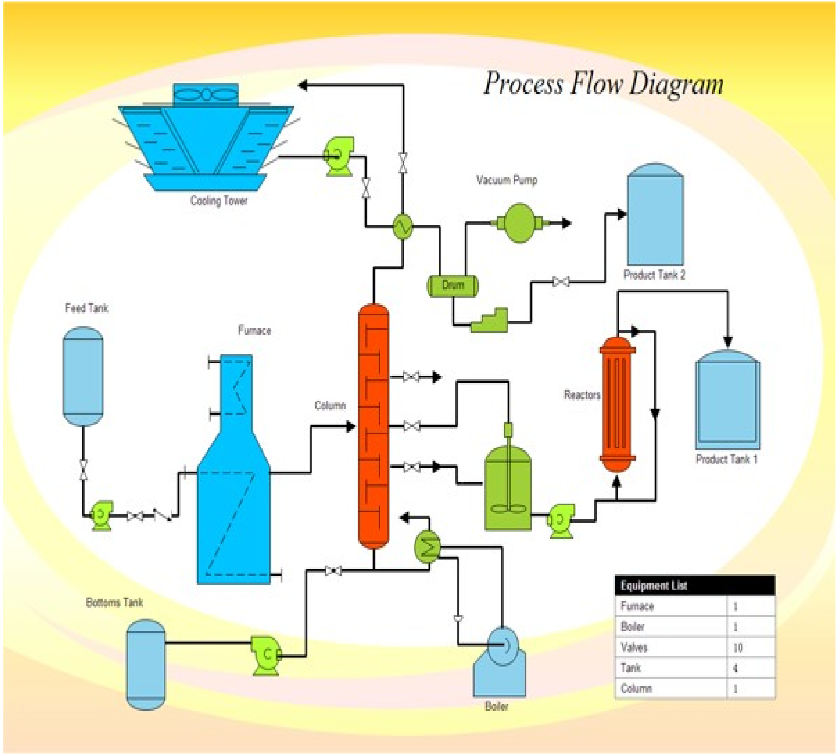


Process Flow Diagram (PFD)

Displays the flow relationship between major equipments of plant

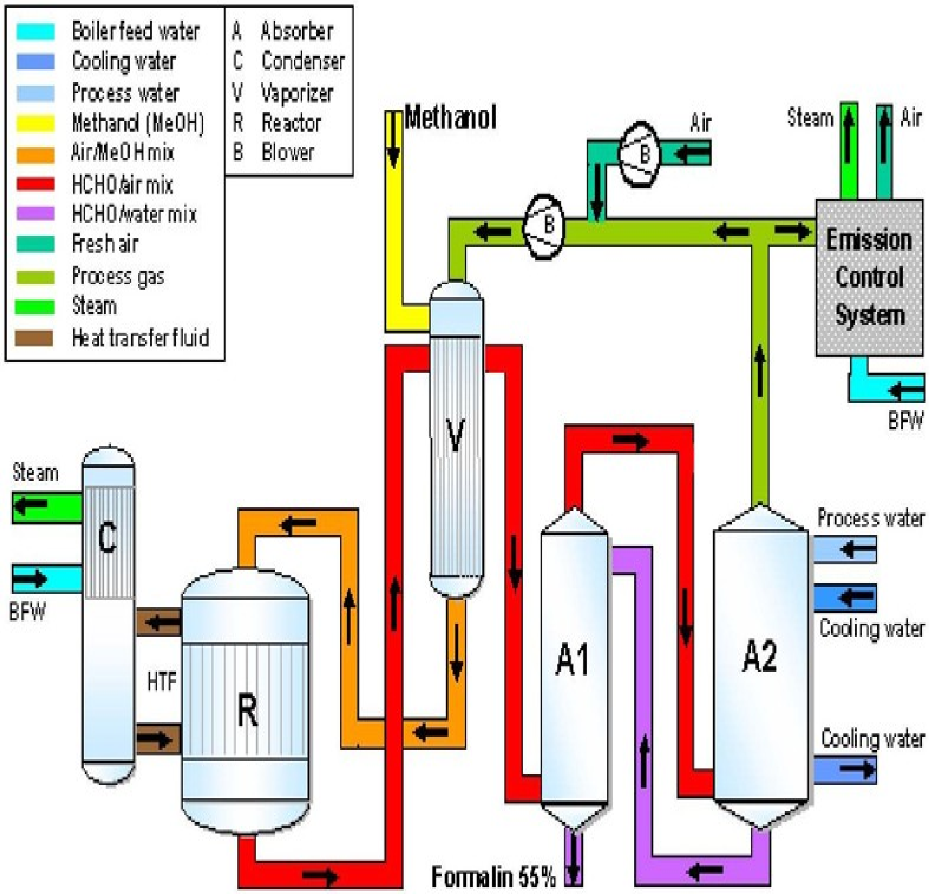
<u>It does not include</u>,

- ❑ Minor piping details (Piping line #, piping class)
- ❑ Manual isolation & shut-off valves
- ❑ Flanges
- ❑ Vents & drains
- ❑ Instrumentation
- ❑ Safety relief valves



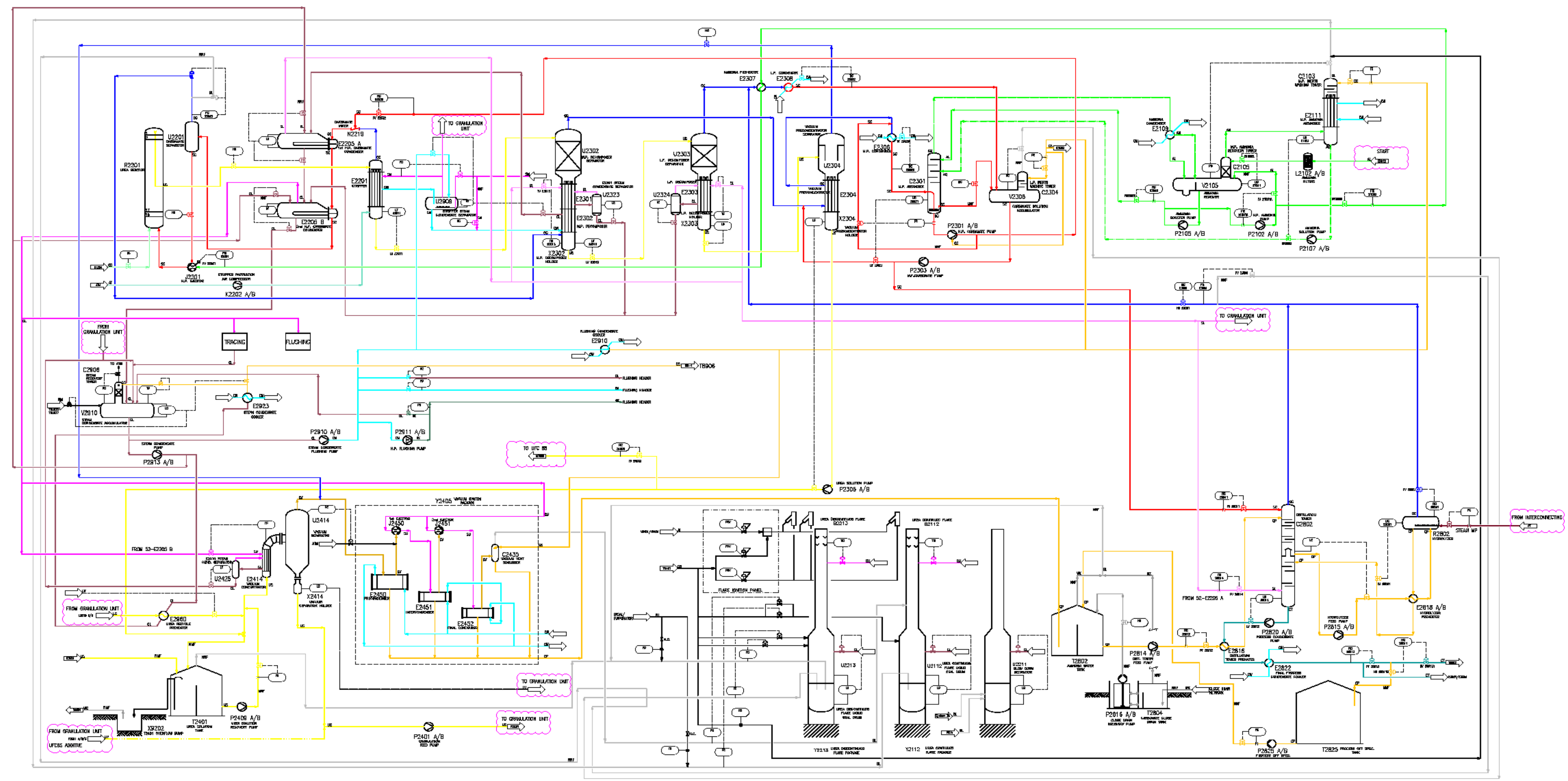
Introduction to Process Flow Diagram (PFD)

- Computer generated with the help of process simulators
- CAD Package
- Standard symbols / icons are used
- Arrows show the flow of chemicals
- Produced on large sheet of paper



Process Flow Diagram (PFD)

- PFD are produced by drafting department working with process engineering.
- A well-known engineering & construction firm (consultant) may be hired for above task.
- PFD & PIDs are approved after completion.
- The value of the PFD does not end with the construction of plant.
- It remains the document that best describes the process, and is used in the training of operators and new engineers.
- It is consulted regularly to diagnose operating problems that arise and to predict the effects of changes on the process.



AL (AMMONIA LIQUID)
AM (AMMONIA VAPOUR)
AQ (AMMONIA WATER)
AT (TREATED AIR)
CD (CARBON DIOXIDE)
CL (STEAM CONDENSATE LP)
CM (STEAM CONDENSATE MEDIUM PRESSURE)
CP (PROCESS CONDENSATE)
CS (STEAM CONDENSATE)
CT (PURIFIED PROCESS CONDENSATE)
CW (COOLING WATER)
CX (STEAM CONDENSATE HP)
GC (CARBAMATE GAS)
SC (CARBAMATE SOLUTION)
SL (STEAM LP)
SM (STEAM MP)
SU (STEAM LP)
SV (VAPOUR CONTAMINATED STEAM)
UF (UREA FORMALDEHYDE)
US (UREA SOLUTION)
WX (CLOSE DRAIN)

03	4/10/10	H	ISSUED FOR CONSTRUCTION	C. CARLAPPI		C. CARLAPPI
REV.	DATE	STATUS	DESCRIPTION	PREPARED	CHECKED	APPROVED

QAFCO 5 Project

QAFCO QATAR FERTILISER COMPANY

eni saipem

HYUNDAI ENGINEERING & CONSTRUCTION CO., LTD.

DOCUMENT ID CODE	CAT. CODE	ACC. CODE
	1	1

CONTRACTOR DWG No.

TITLE: PROCESS FLOW DIAGRAM
UREA PLANT

JOB No. 317300 SH 1 OF 1

SCALE | SIZE

AREA 52 | SYSTEM | ITEM | FILE NAME

Conventions used for identifying Process Streams & Equipment

Process Equipment Identification

T – Turbine

K - Compressor

E - Heat Exchanger

V - Vessel

P - Pump

R - Reactor

C – Column / Tower

T - Storage Tank

F - Fired Heater

Process Streams

PG : Process Gas

AL : Liquid Ammonia

US : Urea Solution

Utility Streams

CW : Cooling Water

NG : Natural Gas

UN : Utility Nitrogen

IA : Instrument Air

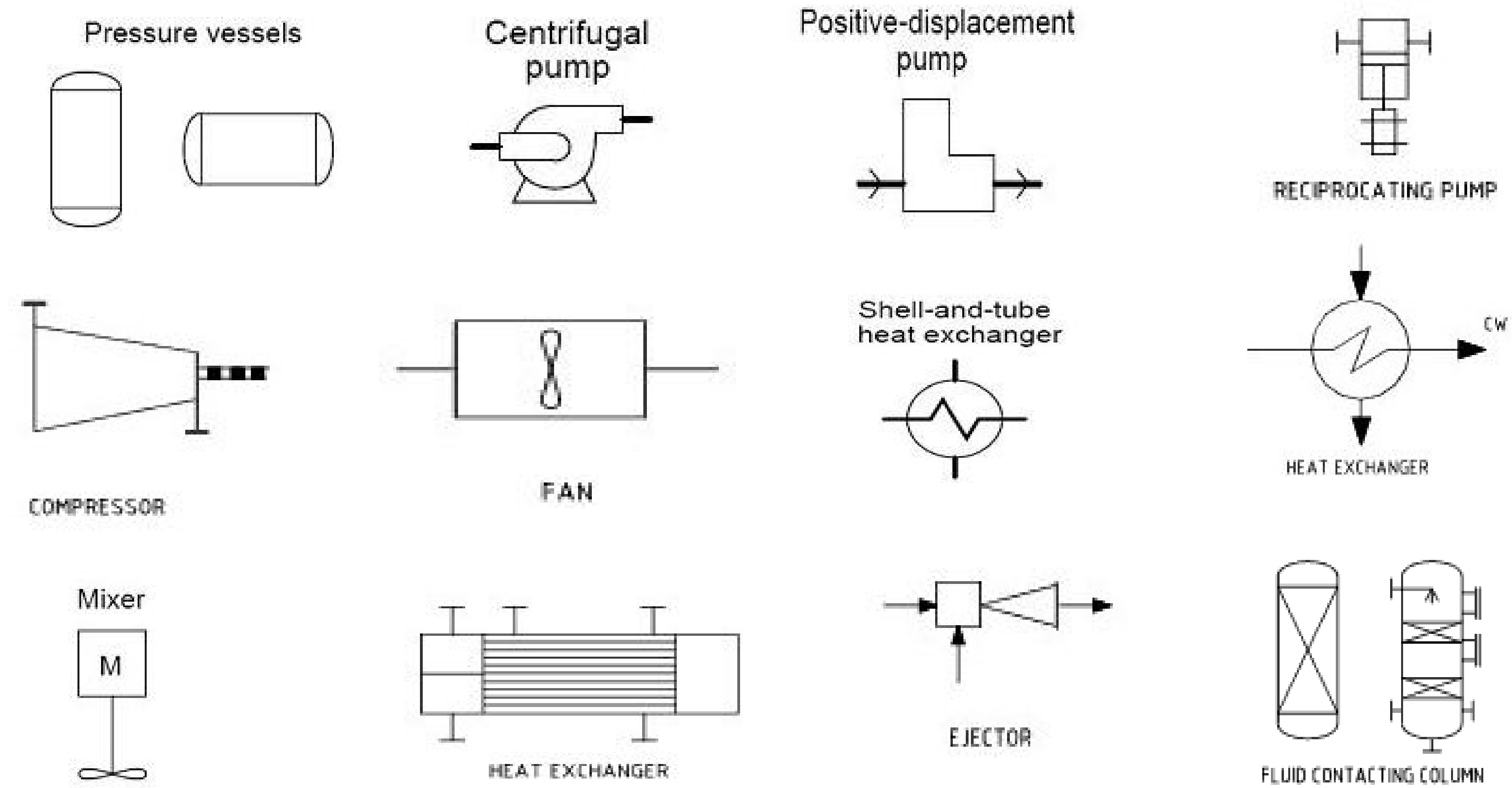
HS : High Pressure Steam

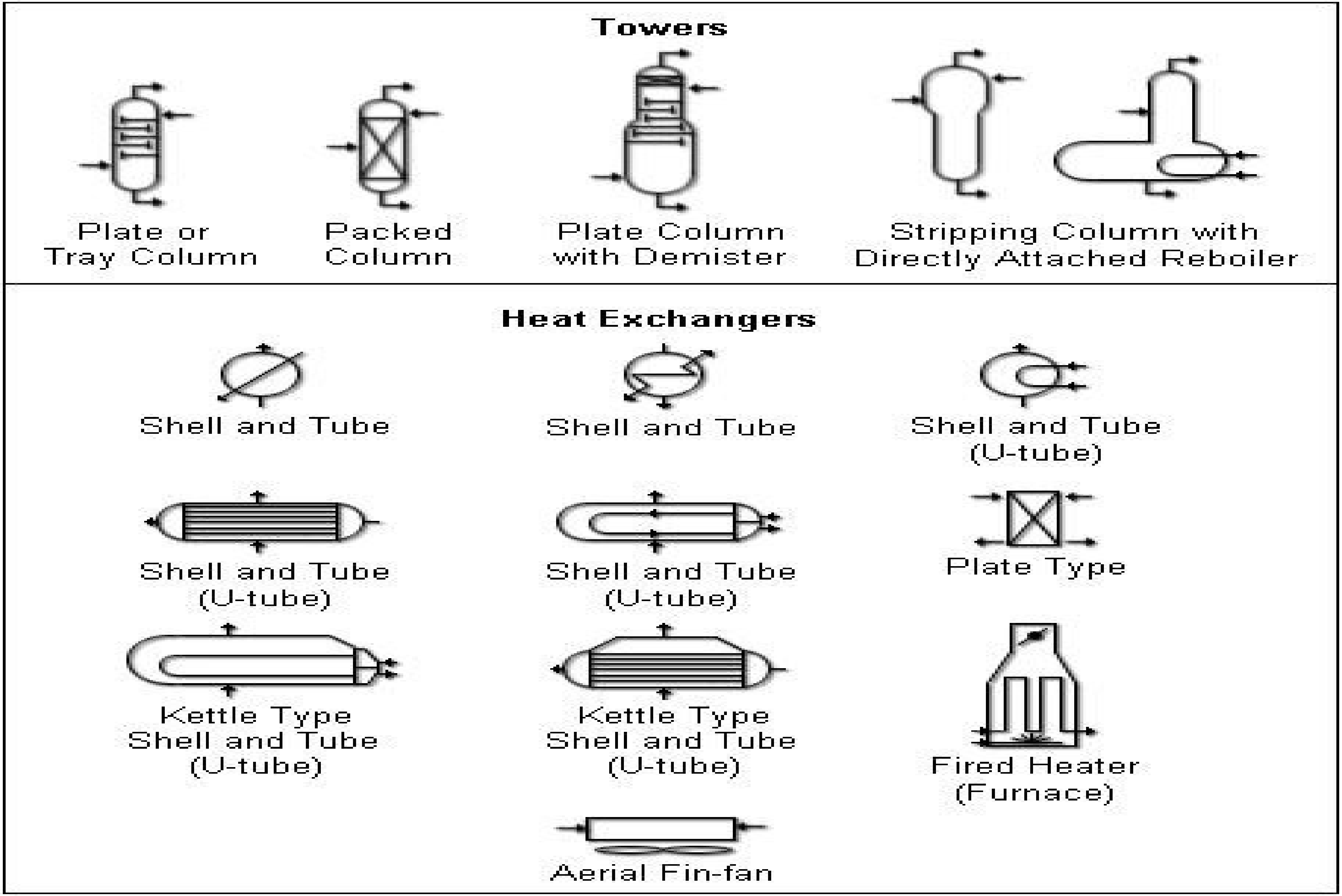
FG : Fuel Gas

DMW : De-mineralized Water

FW : Fire Water

PFD Drawing Symbols




Towers
Plate or
Tray Column
Packed
Column
Plate Column
with Demister
Stripping Column with
Directly Attached Reboiler
Heat Exchangers
Shell and Tube
Shell and Tube
Shell and Tube
(U-tube)
Shell and Tube
(U-tube)
Shell and Tube
(U-tube)
Plate Type
Kettle Type
Shell and Tube
(U-tube)
Kettle Type
Shell and Tube
(U-tube)
Fired Heater
(Furnace)
Aerial Fin-fan

Equipment Numbering System

Pump

Pump # 01

P – 101 A/B

01 Area

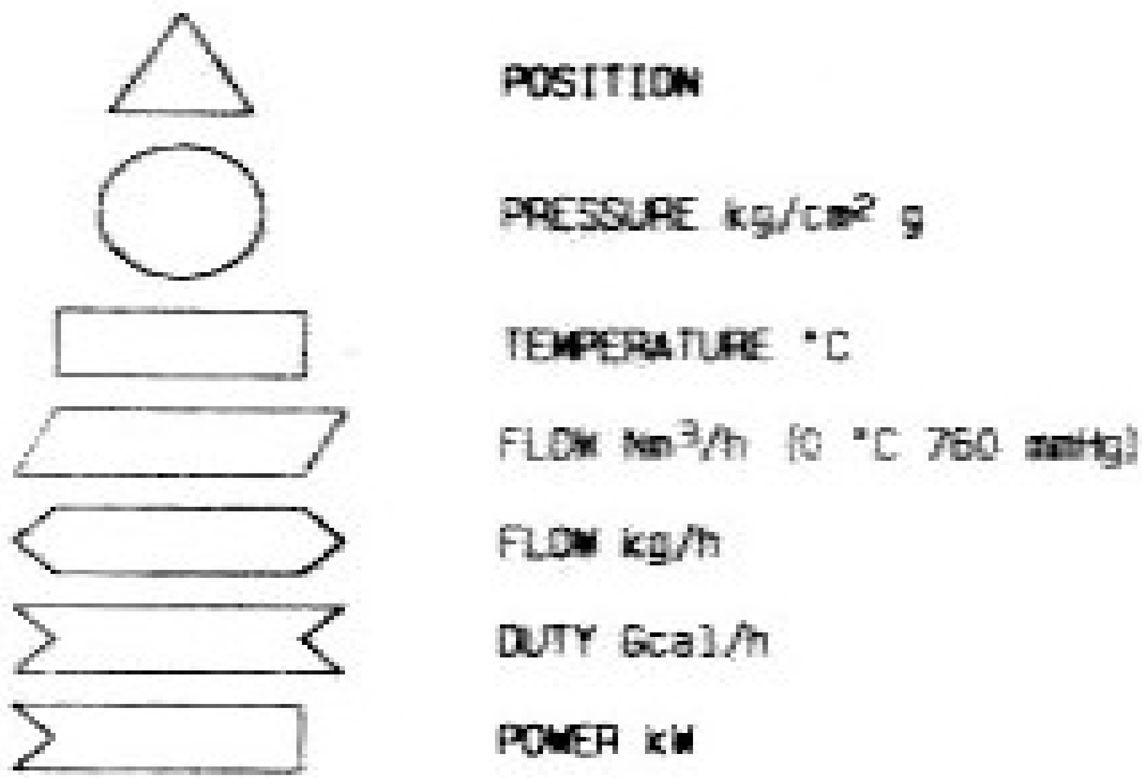
Back up pump is available

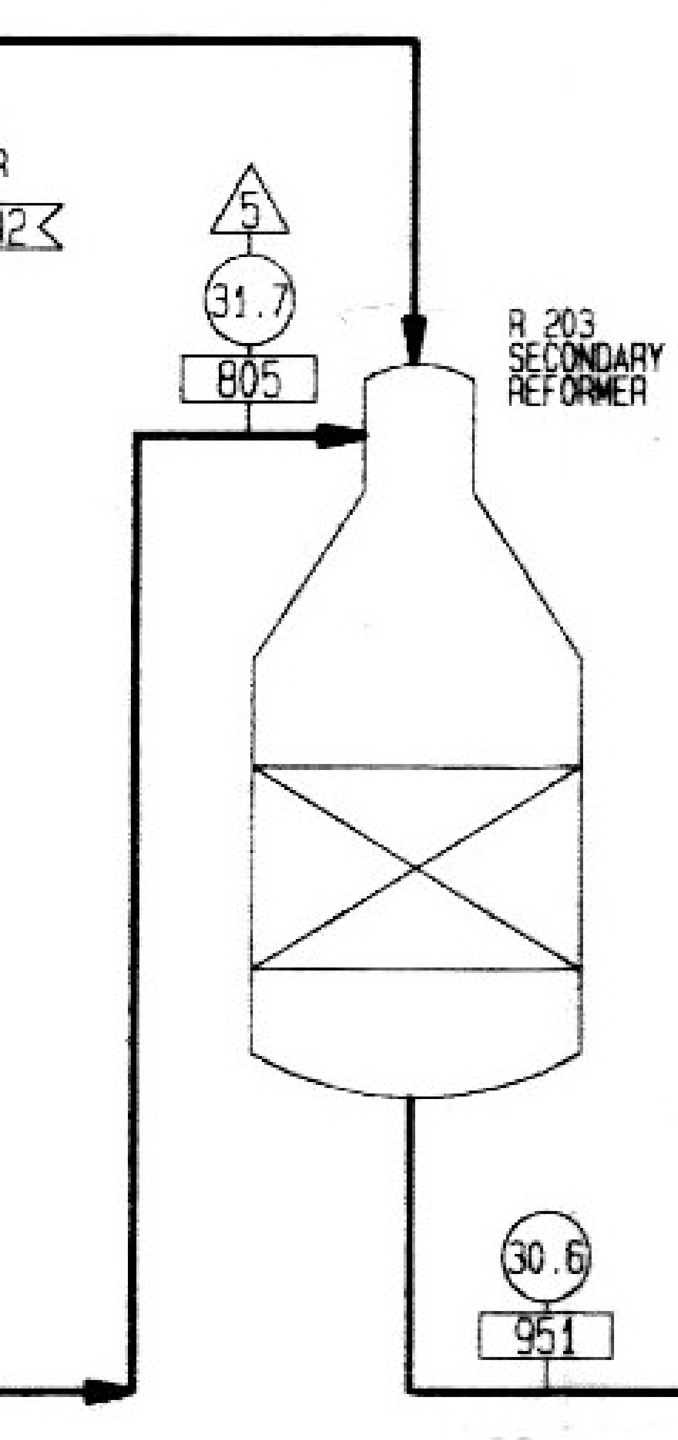
Information Flags

- Not all process information is of equal importance.
- Information critical to the safety & operation of the plant is included.
- This includes temperature pressure & flow rates of feed & product streams.
- The information provided on the flags is also included in the flow summary table. Therefore flags are useful in reducing size of flow summary table.

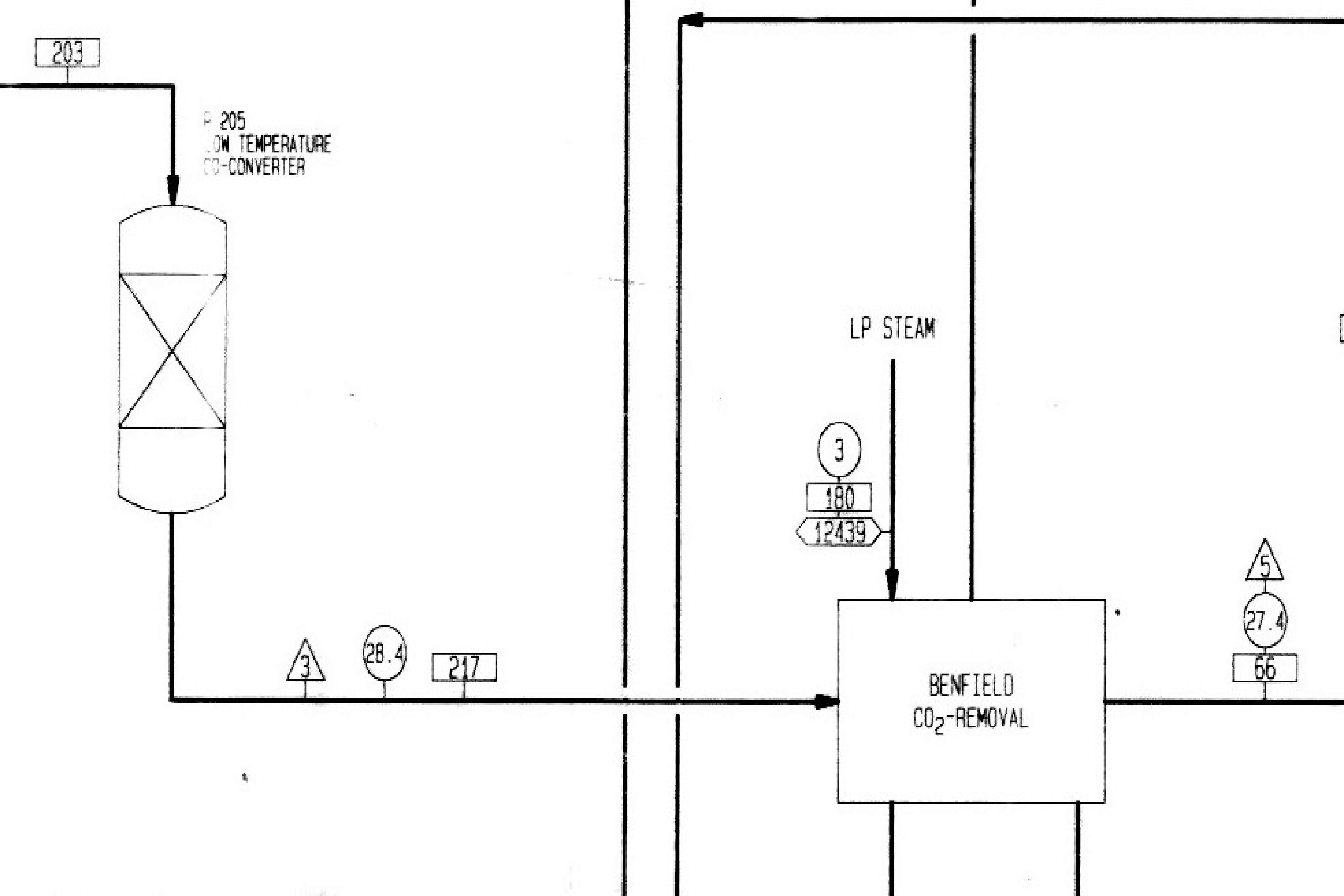
Information Flags For Stream Identification

Stream information is added to the diagram by attaching " information flags"





POS.	1		2		3		4		5	
COMP.	Nm^3/h	MOL %	Nm^3/h	MOL %	Nm^3/h	MOL %	Nm^3/h	MOL %	Nm^3/h	MOL %
O_2					7410	20.99				
H_2			1914	74.23			1914	4.30	80288	65.29
N_2	7548	18.00	639	24.76	27549	78.04	8186	18.39	8186	6.66
CO									11518	9.37
CO_2	3354	8.00			11	0.03	3365	7.54	14330	11.65
Ar			5	0.21	332	0.94	5	0.01	5	
CH_4	30946	73.80	21	0.80			30966	69.57	8640	7.03
C_2H_6	84	0.20					84	0.19		
H_2O			1		191		129332		95862	
Σ DRY	41932	100.00	2579	100.00	35302	100.00	44510	100.00	122967	100.00
TOTAL	41932		2580		35493		173842		218829	
MW		20.46		8.65		28.91		18.47		14.67


203
P 205
LOW TEMPERATURE
CO-CONVERTER
LP STEAM
3
180
12439
5
27.4
66
3
28.4
217
BENFIELD
CO2-REMOVAL

Piping & Instrumentation Diagram

Introduction to P & ID

- Principal or core document in a process industry
- Overall document used to define a process
- Provides information to begin planning for construction of plant
- The P & ID includes every mechanical aspect of the plant except stream flows, pipe routing, pipe lengths, pipe fittings, supports, structure & foundations
- Sets of symbols are used to depict mechanical equipment, piping, piping components, valves, drivers and instrumentation and controls.
- There is no universal, national, international standard that specifies what information should be included on a P&ID
- Some changes will probably be included when the revision is issued
- Reflect process improvements and additions, as well as changing control technology

Development of a P & ID

- P & IDs develop in steps

- Lay out a conceptual pass at showing vessels, equipment and major piping

- The instrumentation and controls are typically added next

- Specialists fill in the information regarding the equipment: size, rating, throughput, and utility usage (horsepower)

- P & IDs are controlled documents formally issued at various stages. Control means changes to the drawings are identified and documented.

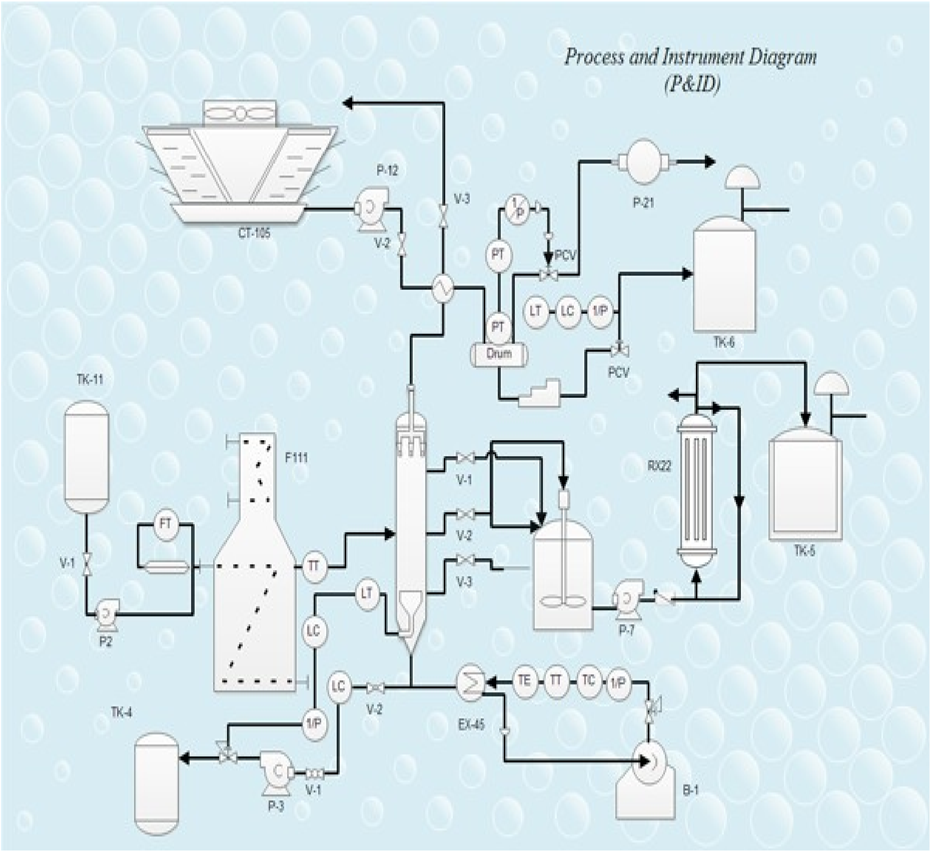
- Formal issue process occurs several times in the course of a

Introduction to P & ID

Defines a process – Equipment, piping and all monitoring & control components

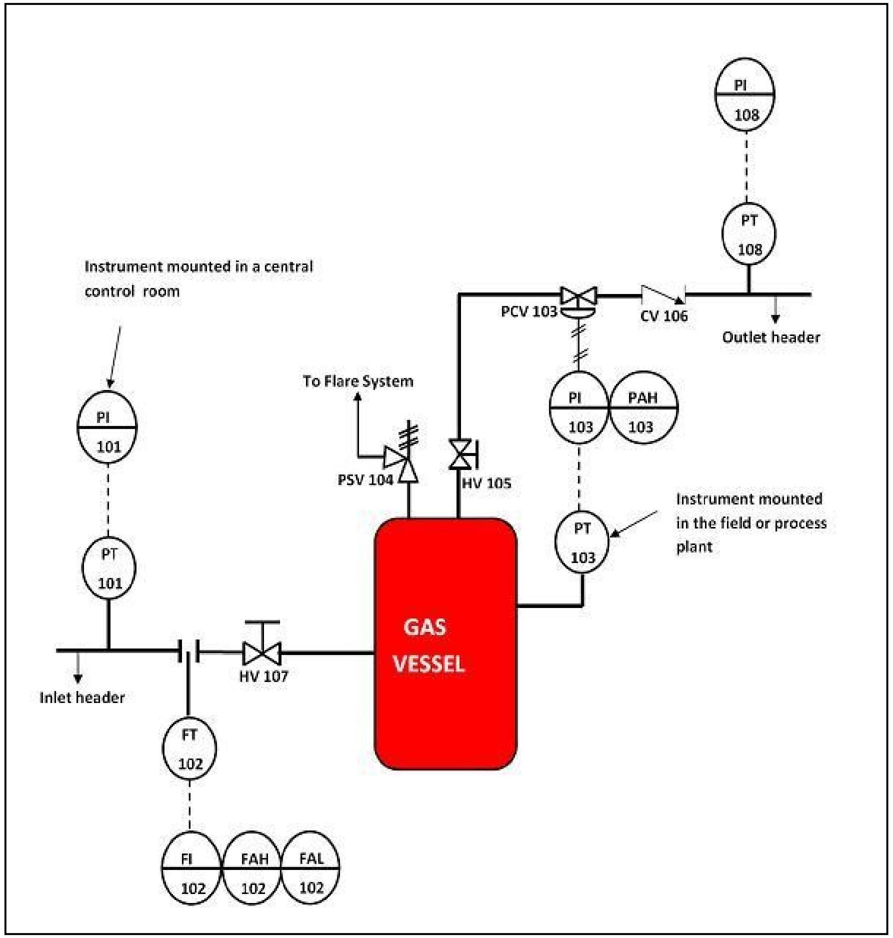
<u>It includes</u>,

- ❑ Basic operational & startup information
- ❑ Equipment capacity & rating
- ❑ Piping details (Piping line #, piping class)
- ❑ All isolation valves with identification
- ❑ Startup & flushing lines
- ❑ Interconnections
- ❑ Vents & drains
- ❑ Safety relief valves
- ❑ Control loops & Instrumentation
- ❑ DCS Inputs
- ❑ Interlocks

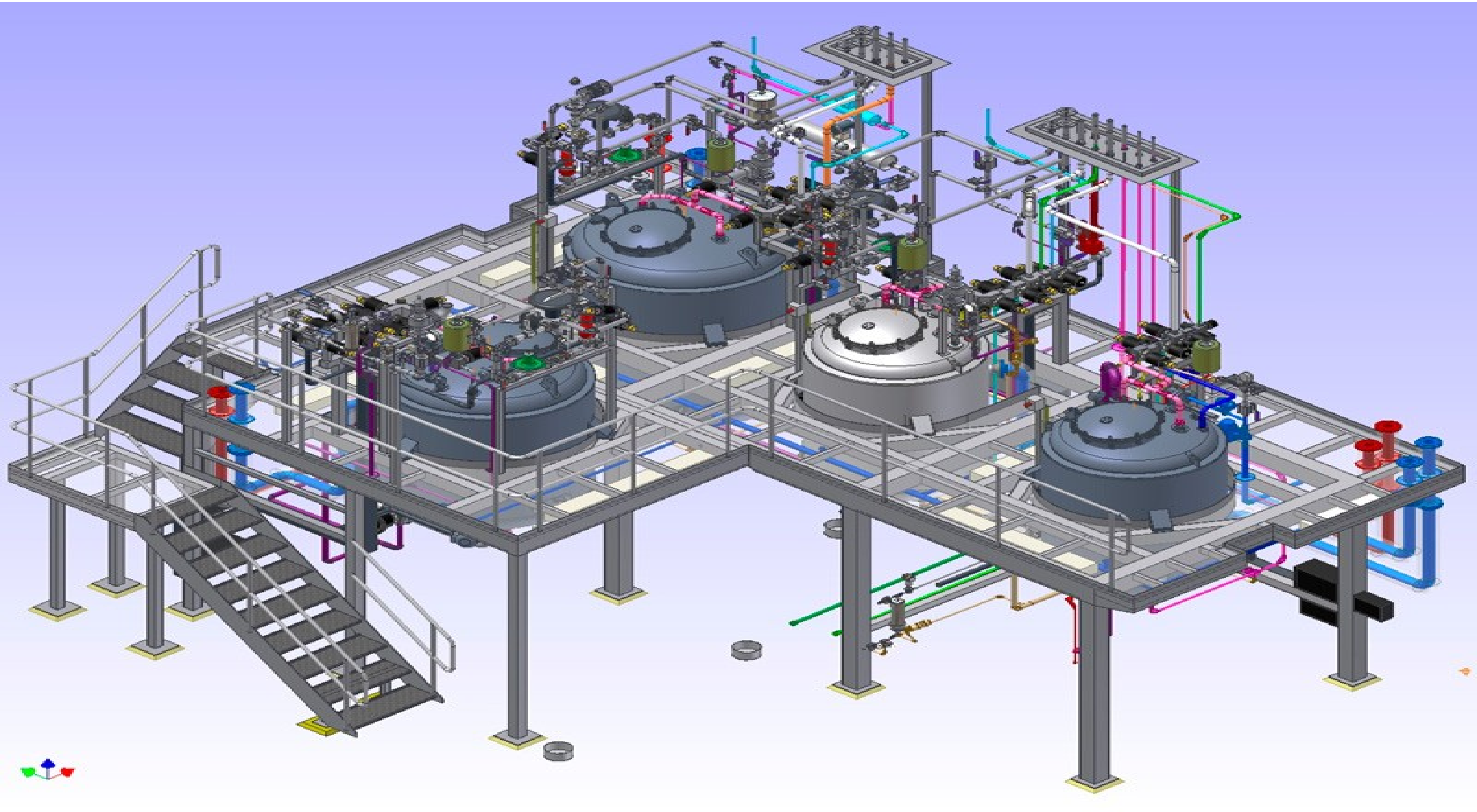


Piping & Instrumentation Diagram (P & ID)

- Used for planning & construction of plant
- Used to operate the process
- Used for maintenance & modification of process
- Used by mechanical technicians & safety personal
- Used for HAZOP study of plant
- Controlled document formally issued at various stages of project



P & ID Symbology & Abbreviation



P & ID Symbols - Abbreviations

PRESSURE

PC = Controller

PI = Indicator

PIC = Indicator-controller

PR = Recorder

TEMPERATURE

TE = Temperature sensing element

Th = Thermometer Indicator

TRC = Recorder-controller

TR = Recorder

LEVEL

LC = Controller

LG = Glass

LI = Indicator

LR = Recorder

FLOW

FC = Controller

FE = Test orifice plate

FI = Indicator

FR = Recorder

P & ID Symbols - Abbreviations

SELF OPERATED CONTROL VALVES

FCV = Flow

LCV = Level

PCV = Pressure

TCV = Temperature

MISCELLANEOUS

SG = Sight Glass

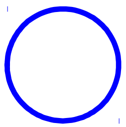
FV = Straightening Vains

HC = Hand Control

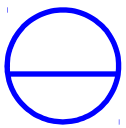
PSD = Pressure Safety Device

PSV = Pressure safety valve

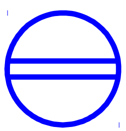
Location Of Instrument



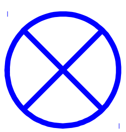
Locally Mounted



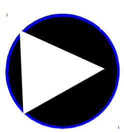
Mounted on panel board in control room



Mounted on local panel board



Local Transmitter



Electric – Pneumatic Converter

Process Control Loop

Simple instruments permit direct reading of a process variable in the field. These devices include pressure gauges, thermometers, level gauges and rotameters.

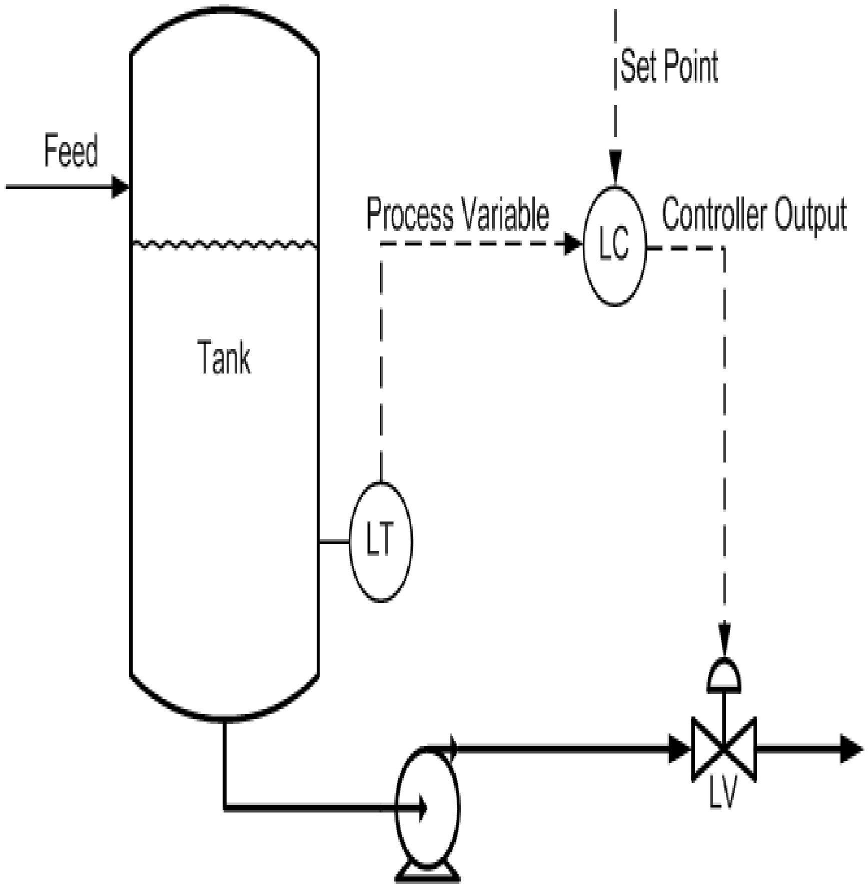
Automatic Control Loop

It consists of three parts

- Sensing
- Comparing
- Correcting

Process Control Loop

In automatic control, the three devices – the **transmitter** that senses, the **controller** that compares, and the **control valve** that corrects – are interconnected to form a control loop. The interconnection may be pneumatic, electronic, digital, or a combination of all three. The pneumatic component is typically a 3-15 psig (pounds per square inch gauge) instrument air signal. If the interconnection is electronic, a 4-20 mA (mill amperes) signal is usually used.



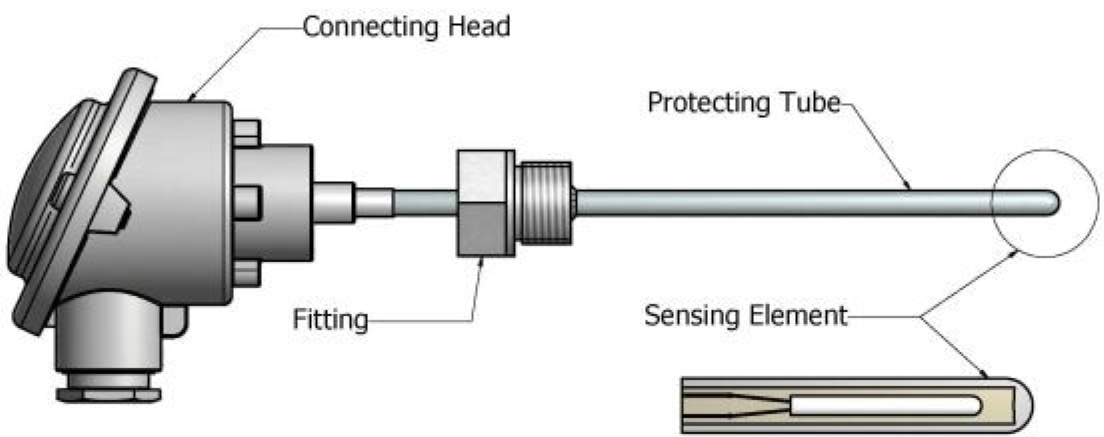
Process Control Loop

Sensing : To measure / sense a process variable

- ❑ Flow of fluid in a pipe
- ❑ Level of a liquid in a tank
- ❑ Temperature of a fluid in a vessel
- ❑ Pressure of gas in a pipe

Normally these process variables are measured continuously. A transmitter measures the process in some way and transmits the information to a central location (sends an electrical signal) where the comparison takes place. The central location is usually a control room where plant operators monitor the process, or, the rack room where the process control computer is located that performs the comparison.

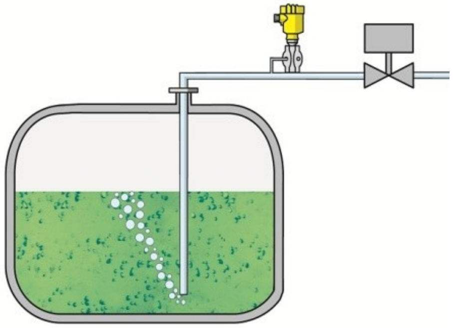
Process Control Loop: Temperature Sensing



Thermocouple

RTD

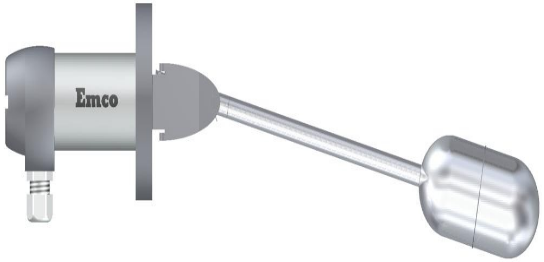
Process Control Loop : Level Sensing



Bubbler Type

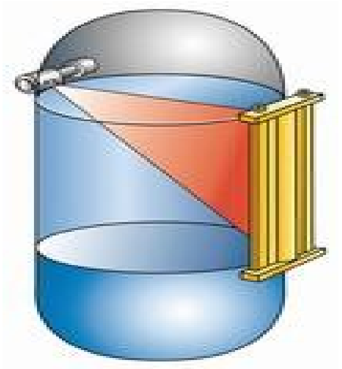
Differential pressure Type

Radar Type



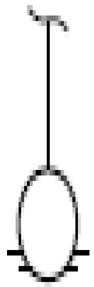
Float Type

Capacitance Type

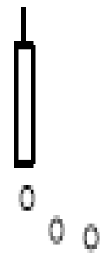


Radioactive

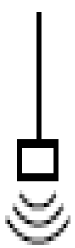
Level Measurement



LEVEL (FLOAT)



BUBBLER



LEVEL (ULTRASONIC)

Process Control Loop : Flow Sensing

Orifice Type

Venturi Type

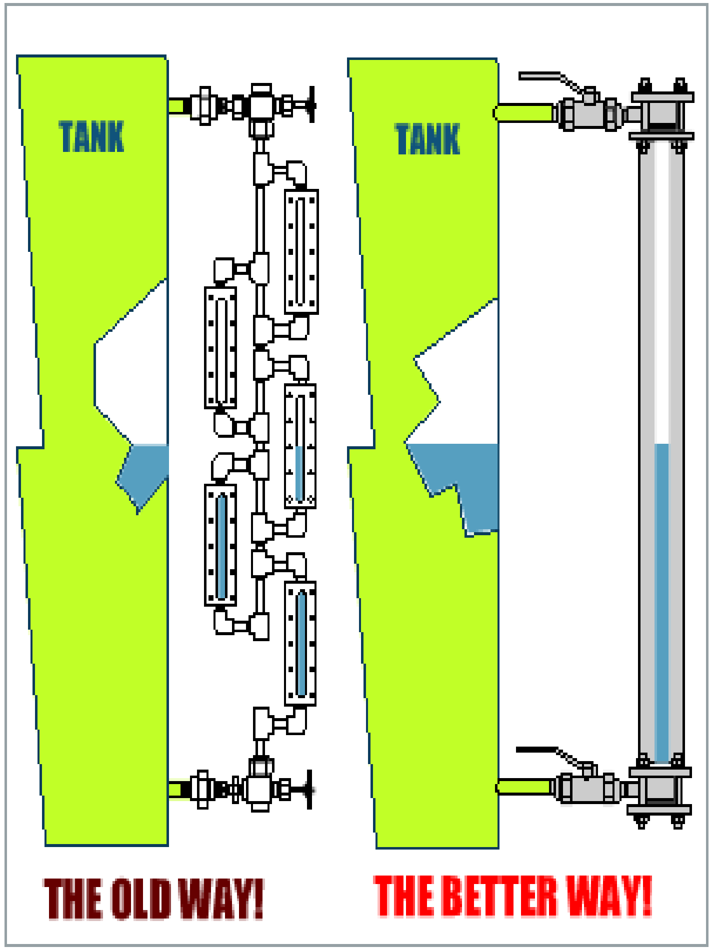
Vortex Type

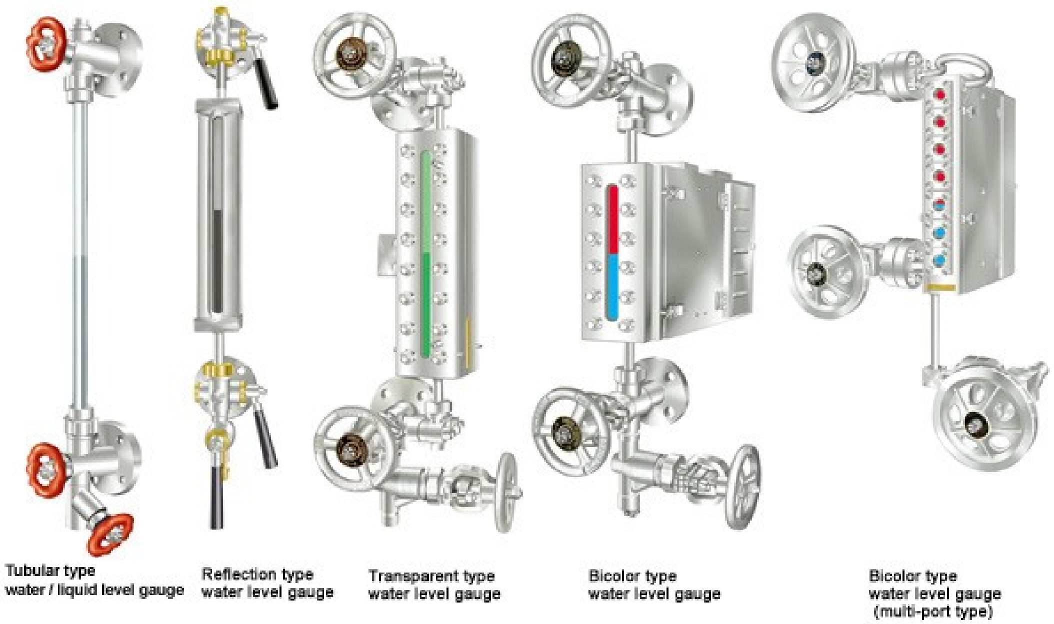
Magnetic Type

Flow Totalizer

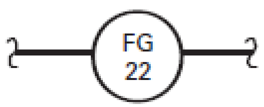
Sight Glass

Level Glass

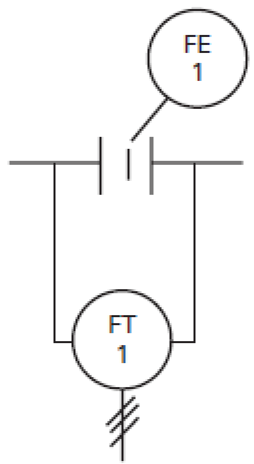

TANK
TANK
THE OLD WAY!
THE BETTER WAY!


Tubular type
water / liquid level gauge
Reflection type
water level gauge
Transparent type
water level gauge
Bicolor type
water level gauge
Bicolor type
water level gauge
(multi-port type)

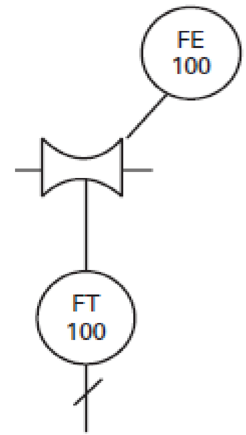
Flow Measurement



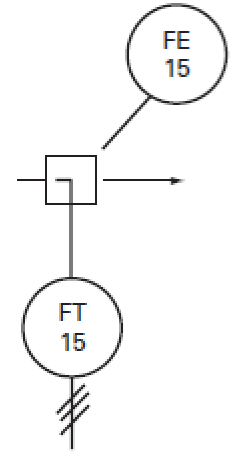
Flow Glass



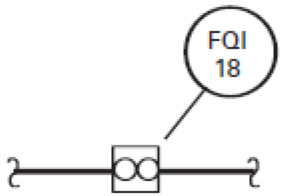
Orifice Plate



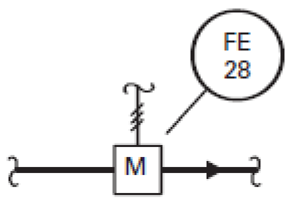
Venturi Tube



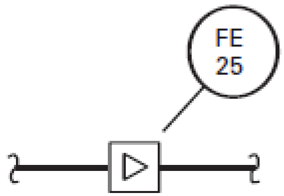
Pitot Tube



Flow Totalizer



Magnetic Flowmeter



Vortex Meter

Process Control Loop

Comparing :

The electronic **controller** is located in control room in the console and its face plate can be observed by the operator via a shared control system, such as a distributed control system (DCS) or a programmable logic controller (PLC). The value of the process variable is compared with the desired value (the set point), and action is taken to develop a signal to bring the two together. The control is automatic and

Process Control

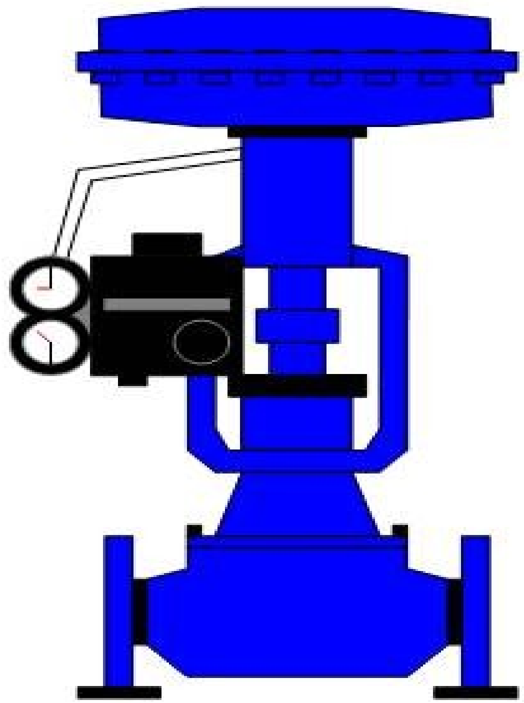
Correcting :

The control device then develops a signal to bring the process variable and the set point together. From the controller an electronic signal is sent to a device (E/P) in the field that computes the correct valve position & send a pneumatic signal to activate the final control element. This device is most often a **control valve** or a variable speed pump drive. Control valves usually are pneumatically actuated, often by a 3-15 psi signal & are supplied with a positioner to provide feedback of valve position.

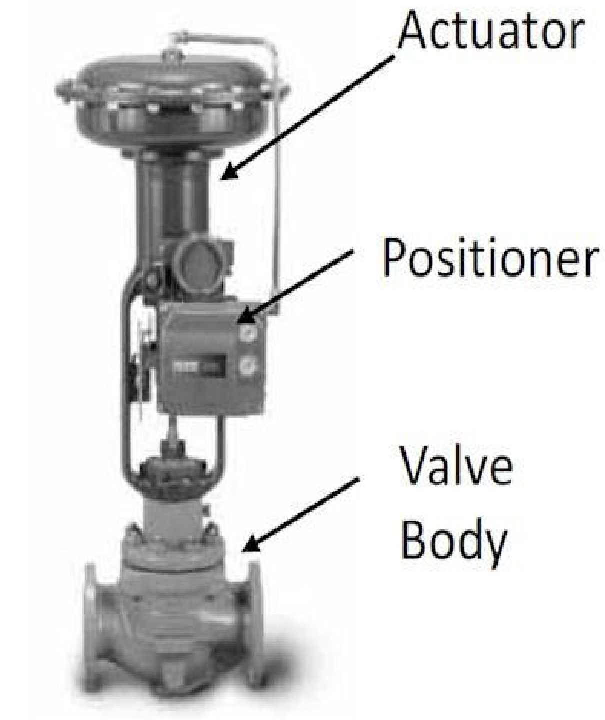
In order to warn operator about potential problems , high & low level alarms are provided , they receive the same

Final Control Element

Electronic to
Pneumatic Converter



Final Control
Element



Control Valve

Process Control Loop

Control Valve Action

The control action that finally takes place in the field is not describes explicitly in neither PFD nor P & ID. However is a simple matter to infer that if there is an increase in level of a vessel , the control valve will open slightly and the flow of liquid will increase, tending to lower the level in the vessel. For a decrease in the level of liquid, the valve will close slightly.

Control Loop Tuning Parameters

The response time of the system depends upon type of control action used.

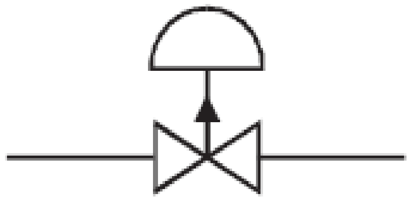
P - Proportional or gain – how far away the process variable is from the set point

I - Integral or reset – how long the process variable has been away from the set point

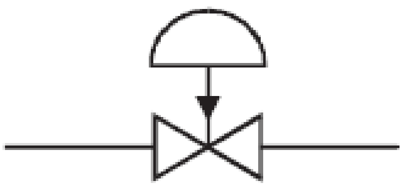
D - Derivative or rate – how fast the process variable is changing

Process Control Loop

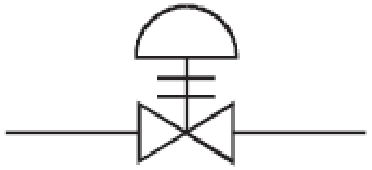
Control valves may fail in various positions – open, closed, locked. The position of a failed valve can have a significant impact on associated equipment, and, therefore, it is of interest to operations personnel. The fail positions may be identified on the P&ID using letters below the valve symbol: FO for Fail Open; FC for Fail Closed; FL for Fail Last or Locked.



TWO-WAY VALVE
FAIL OPEN

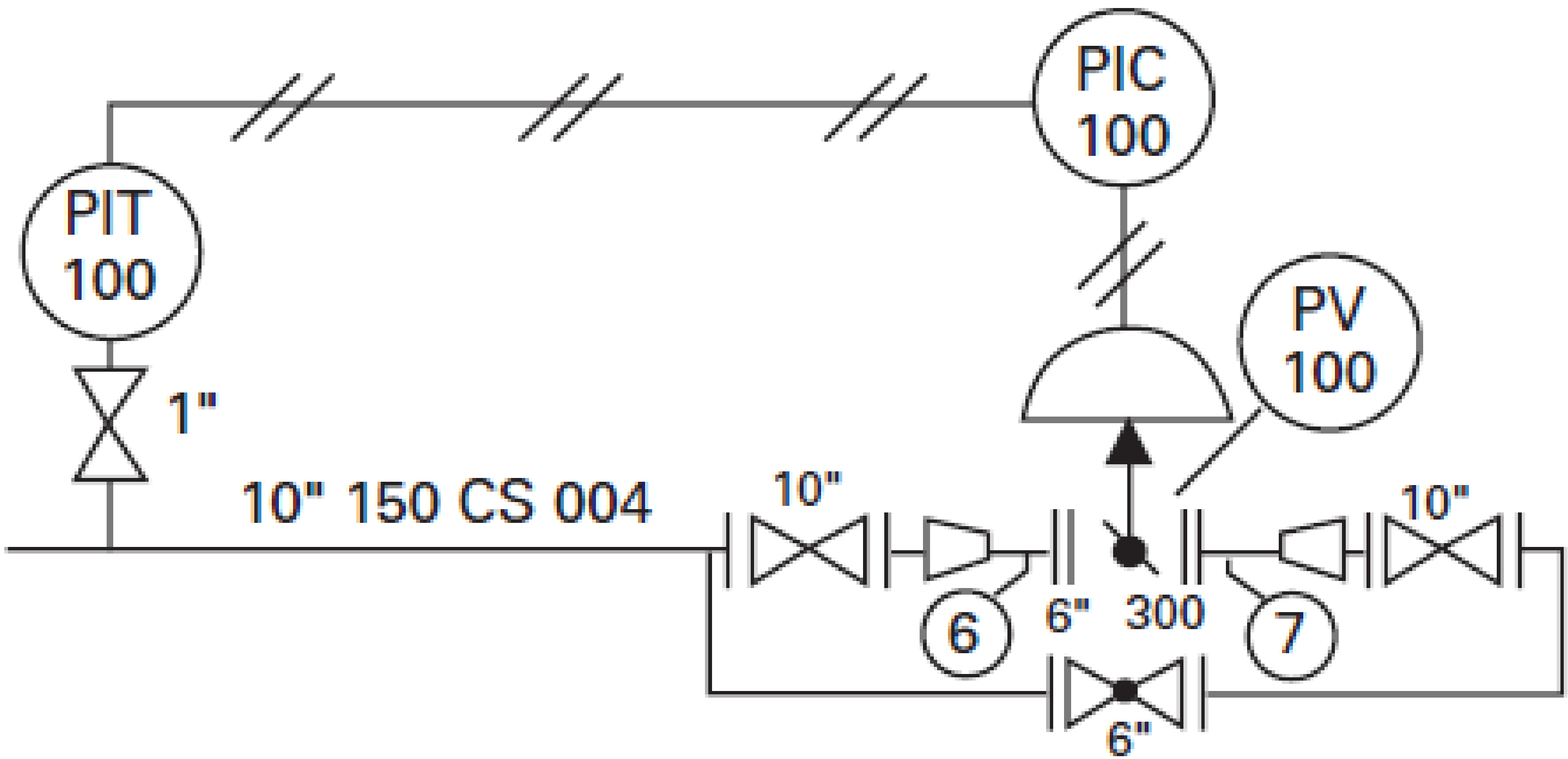


TWO-WAY VALVE
FAIL CLOSED

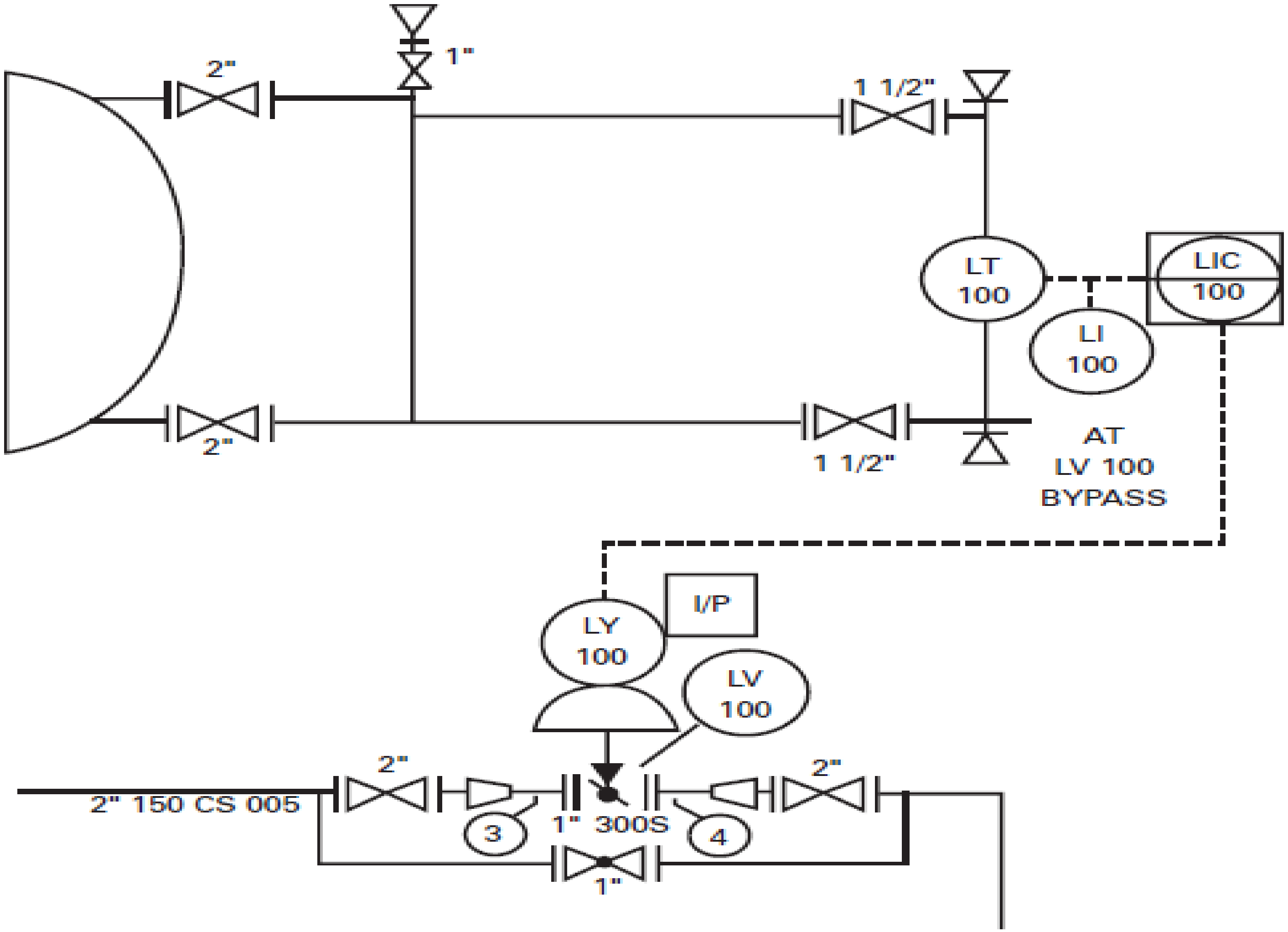


ANY VALVE
FAIL LOCKED
(POSITION DOES NOT CHANGE)

Pressure Loop

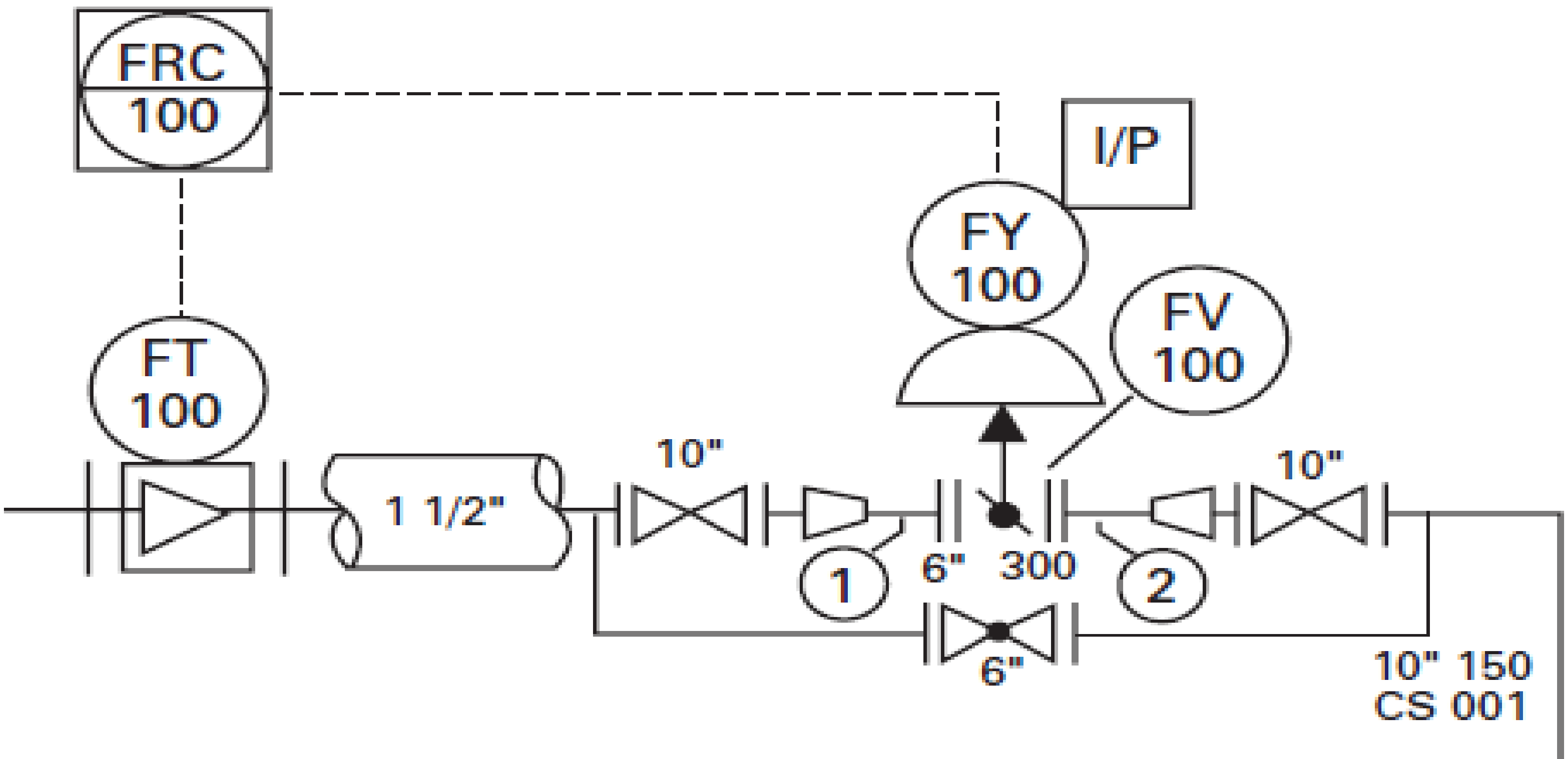


Level Loop



1"
2"
1 1/2"
LT
100
LIC
100
LI
100
2"
1 1/2"
AT
LV 100
BYPASS
I/P
LY
100
LV
100
2"
2"
2" 150 CS 005
3
1" 300S
4
1"

Flow Loop

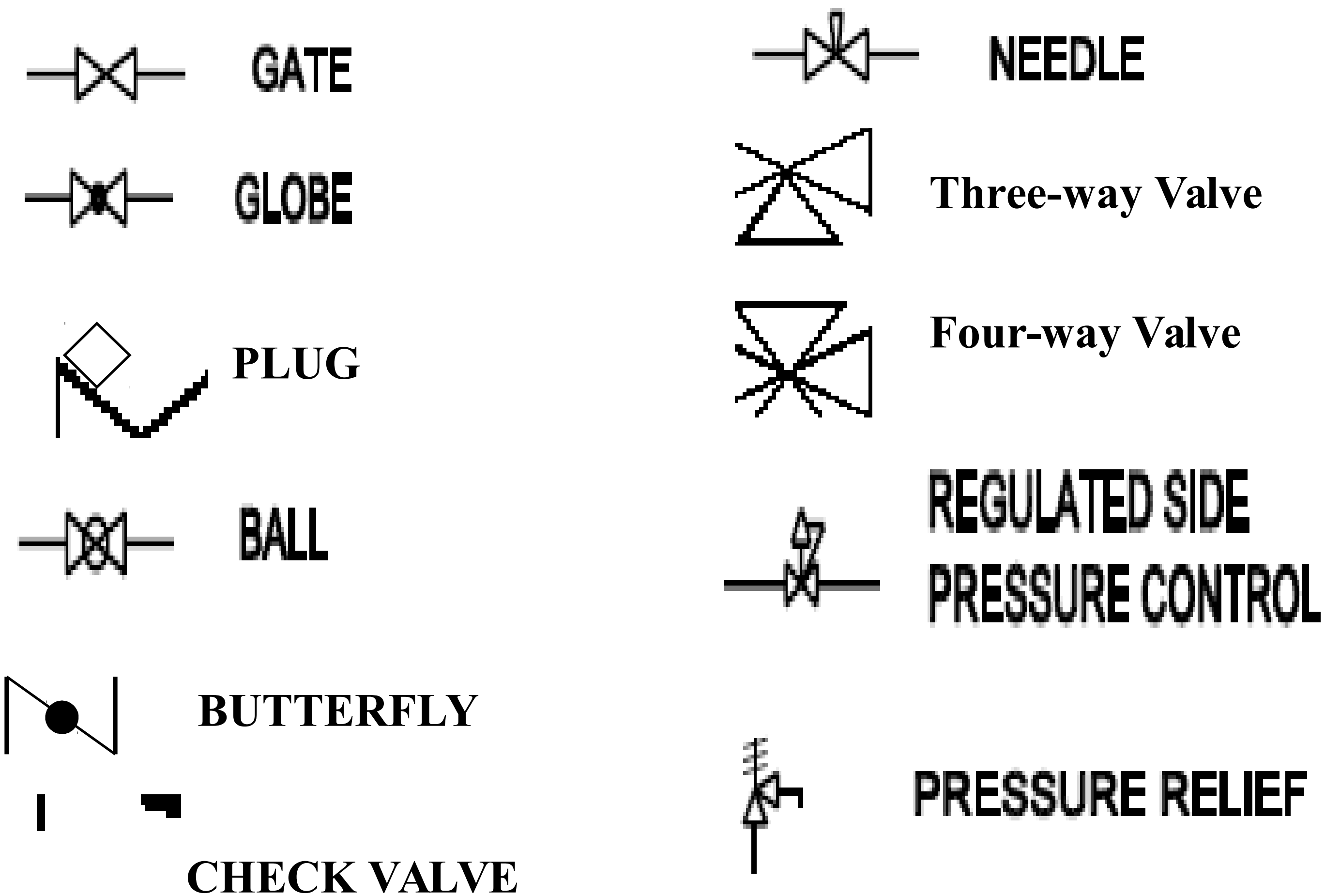


P & ID Symbology & Abbreviation

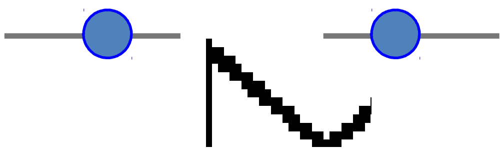
Valve type

VS → Gate Valve
VD → Globe, Needle or Angle Valve
VR → Plug Valve
VB → Ball or 3-way Plug Valve
VDR → Check Valve
VF → Butterfly Valve
VM → Diaphragm Valve
VP → Piston Valve

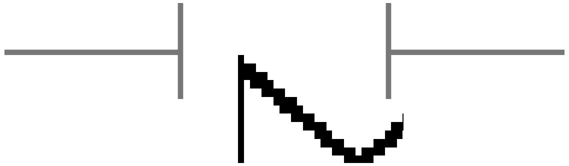
P & ID Symbology & Abbreviation



P & ID Symbology & Abbreviation

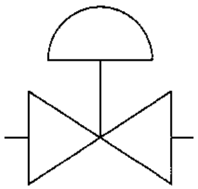


Welded Valve

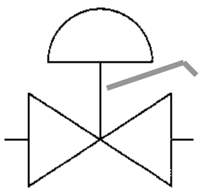


Flanged Valve

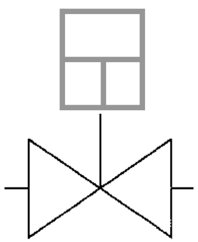
P & ID Symbology & Abbreviation



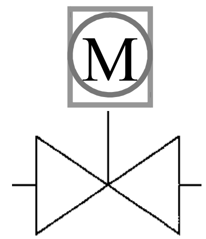
Diaphragm operated



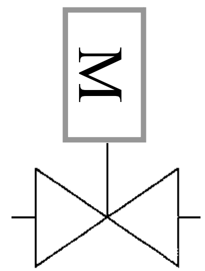
With Manual Hand wheel



Piston Operated



Motor Operated



Solenoid Operated

Line Symbols

Line symbols are used to define the ways information is transferred between the field devices and the central control location. The symbols describe how signals are transmitted between devices.

Instrument Connection to Process

Pneumatic Signal

Electric Signal

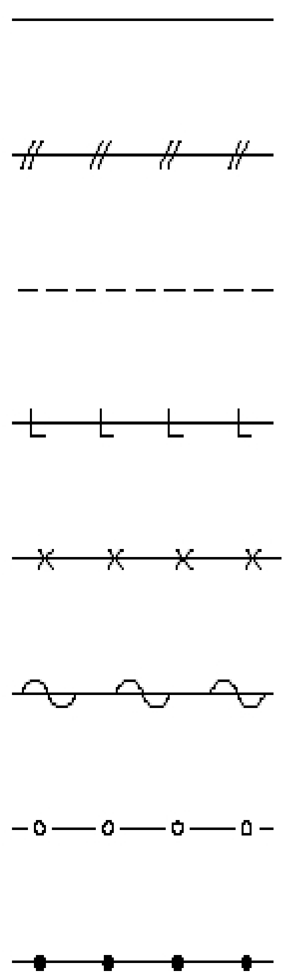
Hydraulic Signal

Capillary Tube

Electromagnetic Signal

Software Data Link

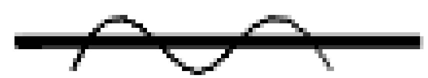
Mechanical Link



INSULATED

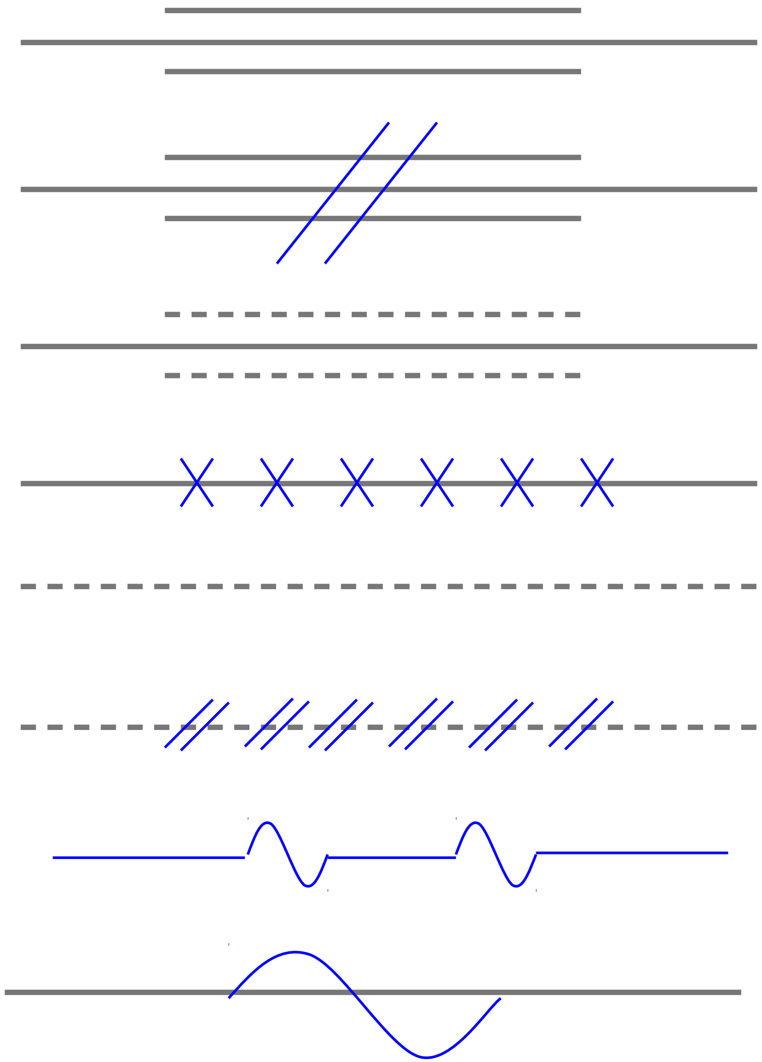
TRACE HEATED--SIMPLEST

JACKETED



ELECTICALLY HEATED

Line Symbols



Hot Insulated Line

Cold Insulated Line

Jacketed Line

Capillary Tube

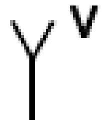
Electrical Transmission

Pneumatic Transmission

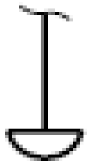
Process piping for Instrument

Insulated Line with external tracer

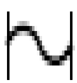
P & ID Symbology & Abbreviation



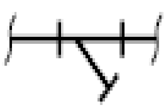
VENT TO
ATMOSPHERE



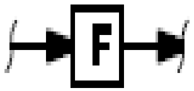
DRIP LEG



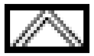
FLEXIBLE CONNECTION



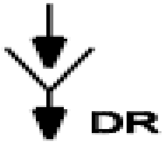
WYE STRAINER



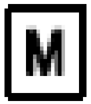
FLAME ARRESTER



RUPTURE DISK

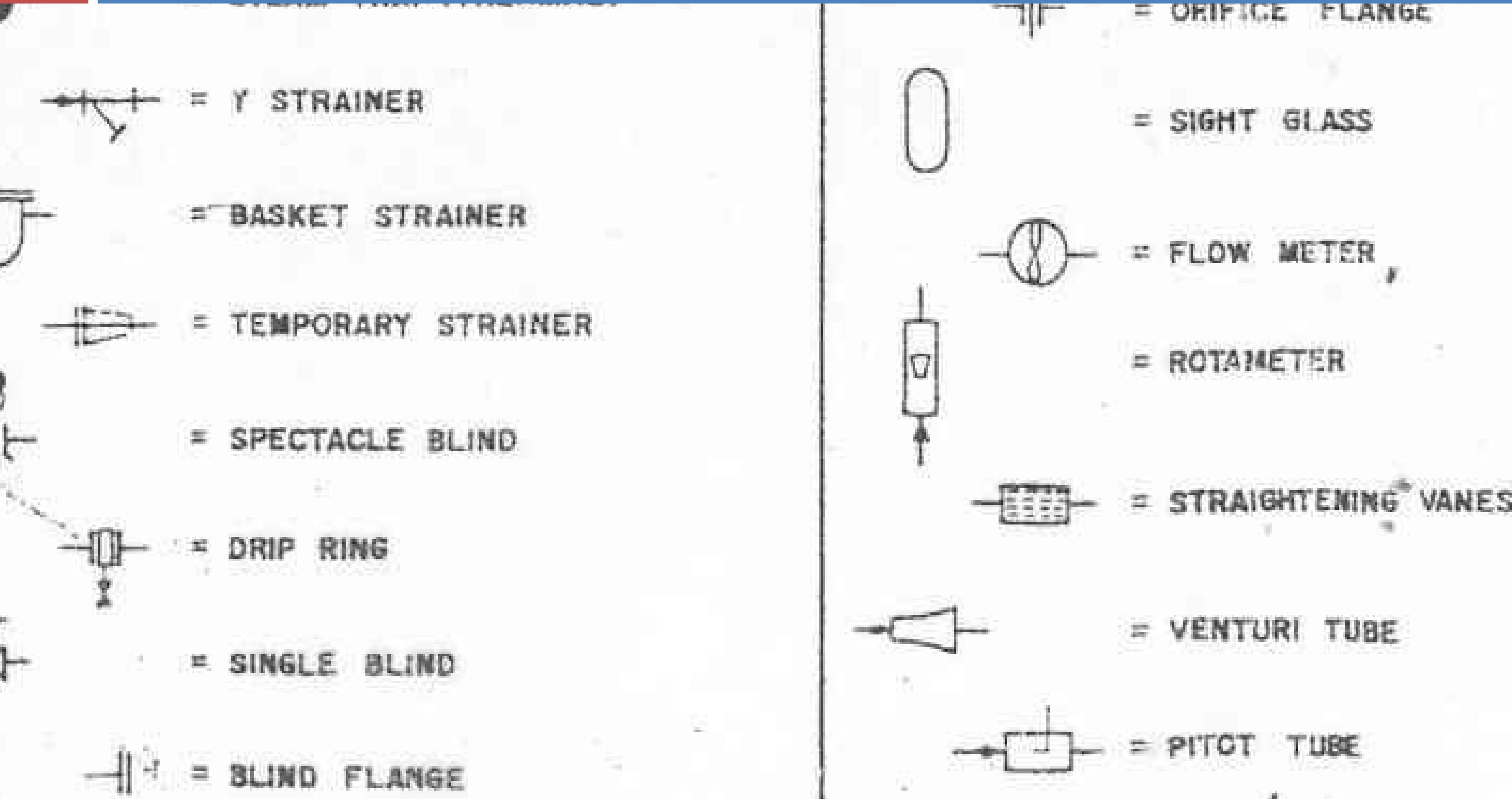


AIR GAP
DRAIN



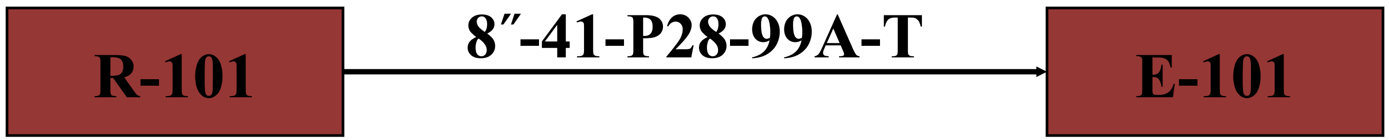
MOTOR

P & ID Symbology & Abbreviation



HOW TO READ A P&ID

Piping Specification & Decoding



It provides information about,

- ❑ Material of construction
- ❑ Design temperature & pressure
- ❑ Line size & thickness
- ❑ Valves & gaskets compatibility
- ❑ Used for any branching (off-take)

Piping Specification & Decoding

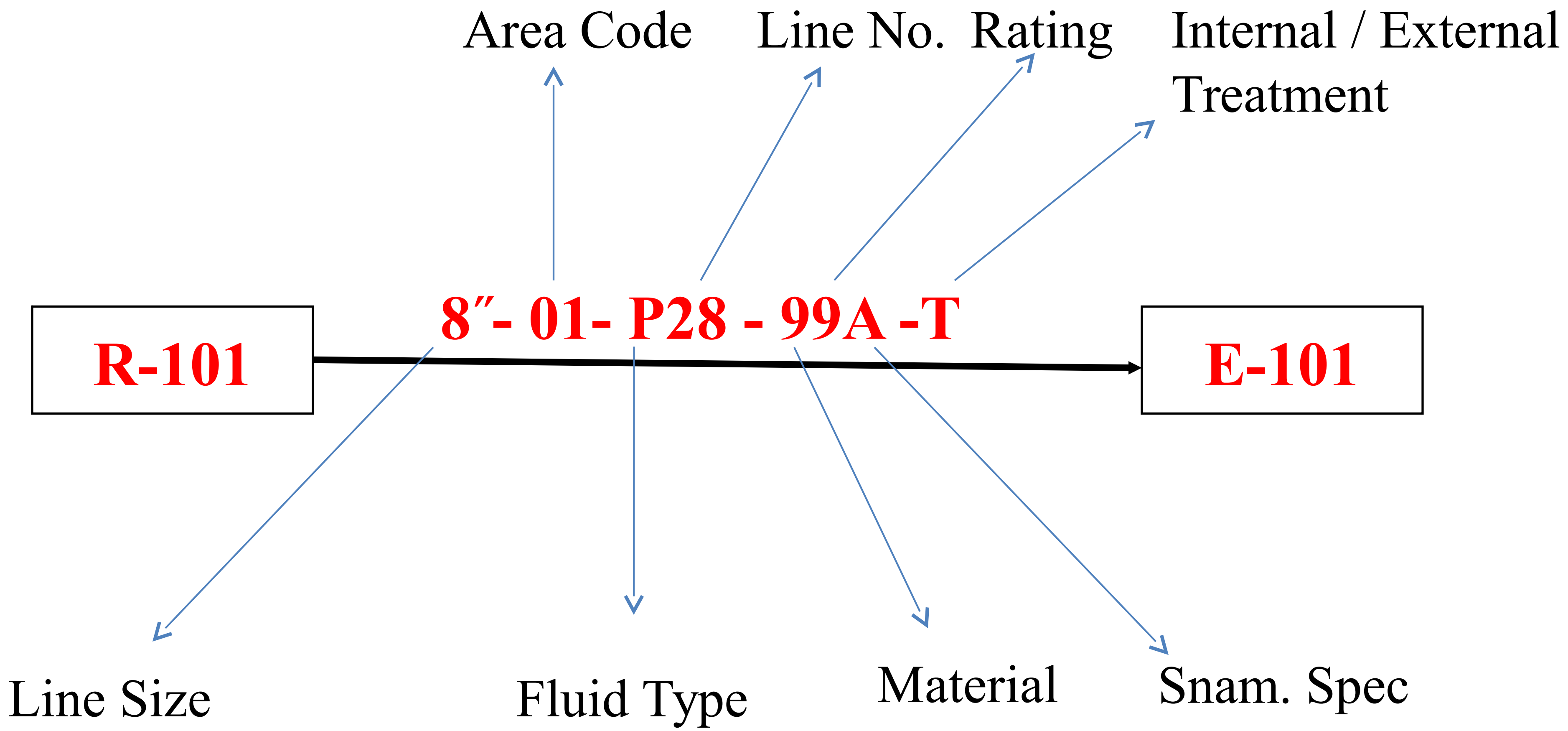
- Just like equipment, pipes on the flow diagram must be identified
- Pipe line symbol, is used in which to place this information
- In some instances the pipe specification symbol is located directly in the flow line

12″-30-**HS33**-55A-I

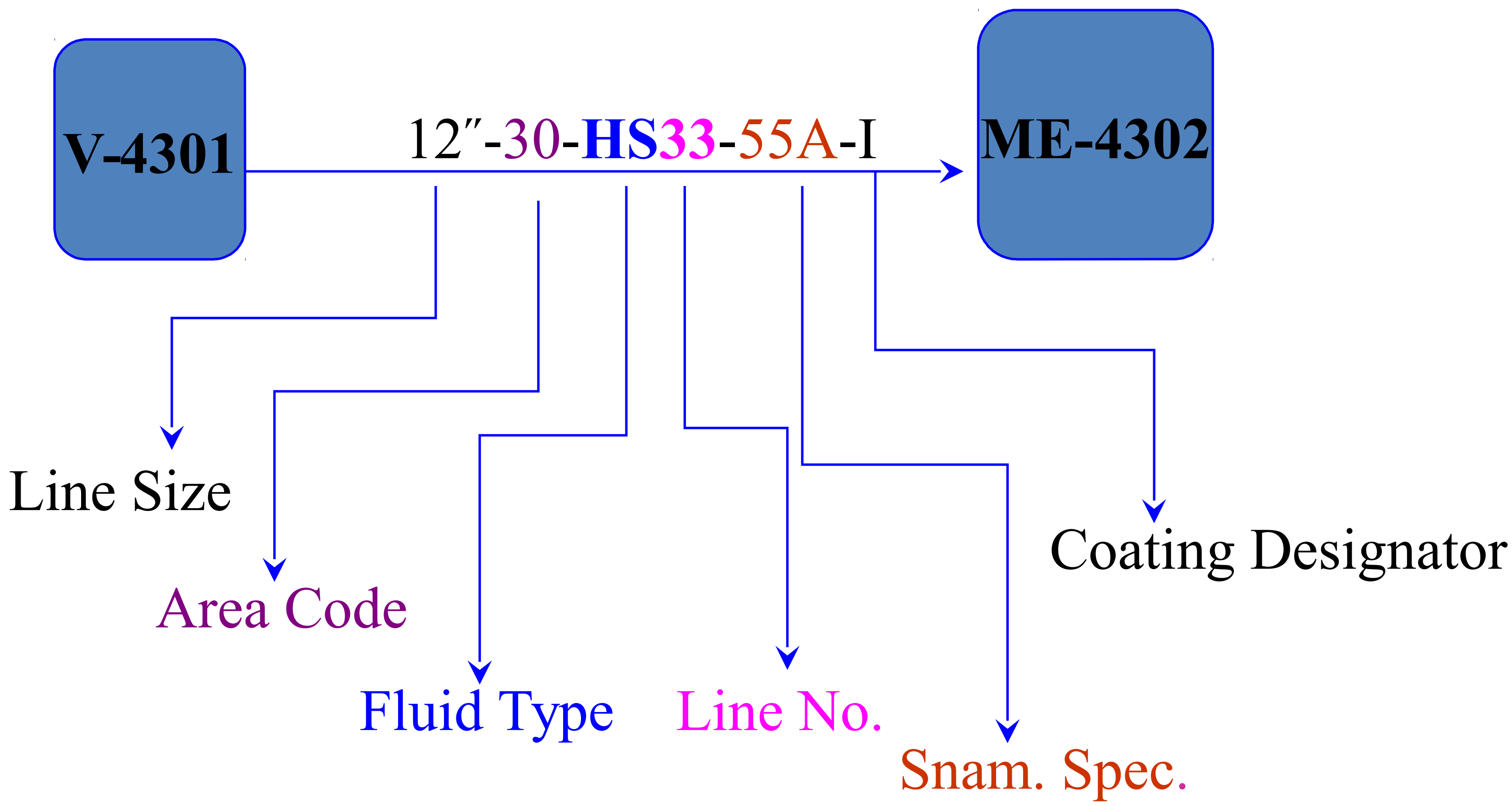
- In other instances the specification information is written above the line

12″-30-**HS33**-55A-I

Piping Specification & Decoding



Piping Specification & Decoding



System Code

Area Code

01 : Urea
02 : Reforming Section
03 : CO_2 absorption Section
04 : Synthesis gas compression
05 : Ammonia Synthesis
06 : Steam Generation
07 : Power Generation
08 : CW circulation

Fluid Type

12″-30-**HS**33-**55A**-I

- KS → Very High Pressure Steam
- **HS** → High Pressure Steam
- LS → Low Pressure Steam
- P → Process Fluid
- IA → Instrument Air
- UA → Utility Air
- UN → Utility Nitrogen

Material

55A

- 1 → Carbon Steel
- 3 → Austenitic Stainless Steel
- 4 → Reinforced Thermal Resin Pipe
- **5** → Si Killed Carbon Steel or CrMo steel
- 6 → Ferritic Alloy Steel
- 7 → Cast Steel
- 8 → Austenitic SS or Ferritic Alloy Steel
- 9 → Urea Grade SS

Material Rating

55A

1	150#
3	300#
5	600#
6	900#
7	1500#
8	2500#
9	Special

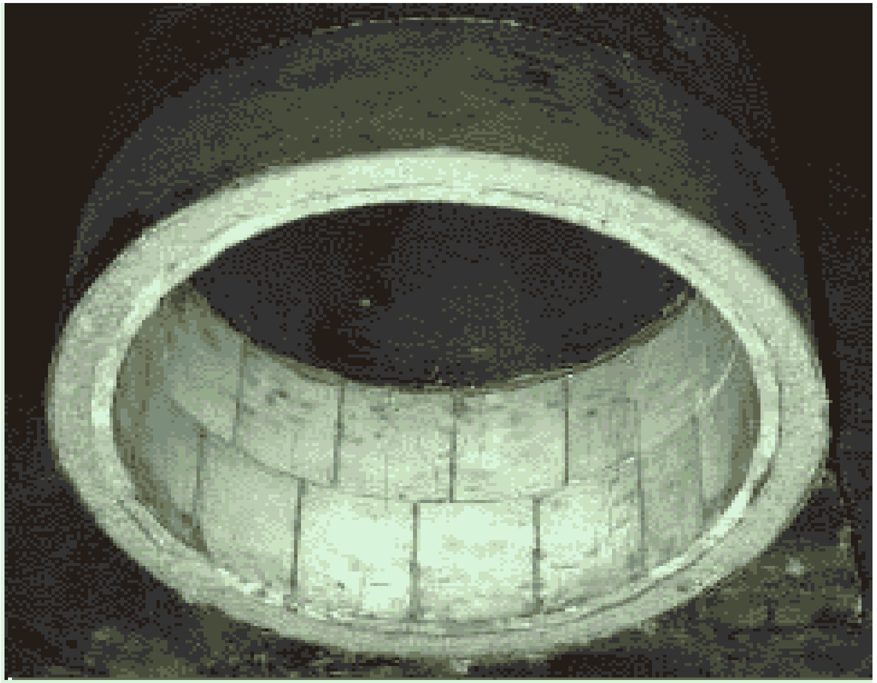
Insulation Specification

12″-30-**HS33**-**55A**-**I**

- A → Internal Treated, External coated
- B → External Coated
- E → Electric traced
- F → Cold Insulated
- **I** → Hot Insulated
- N → Not Painted /Insulated
- PP → Personnel Protected
- S → Internal Treated/External Painted
- T → Steam traced
- V → External painted
- W → Jacketed

PIPE COATING DESIGNATOR - A

A- Internal Treated, External coated

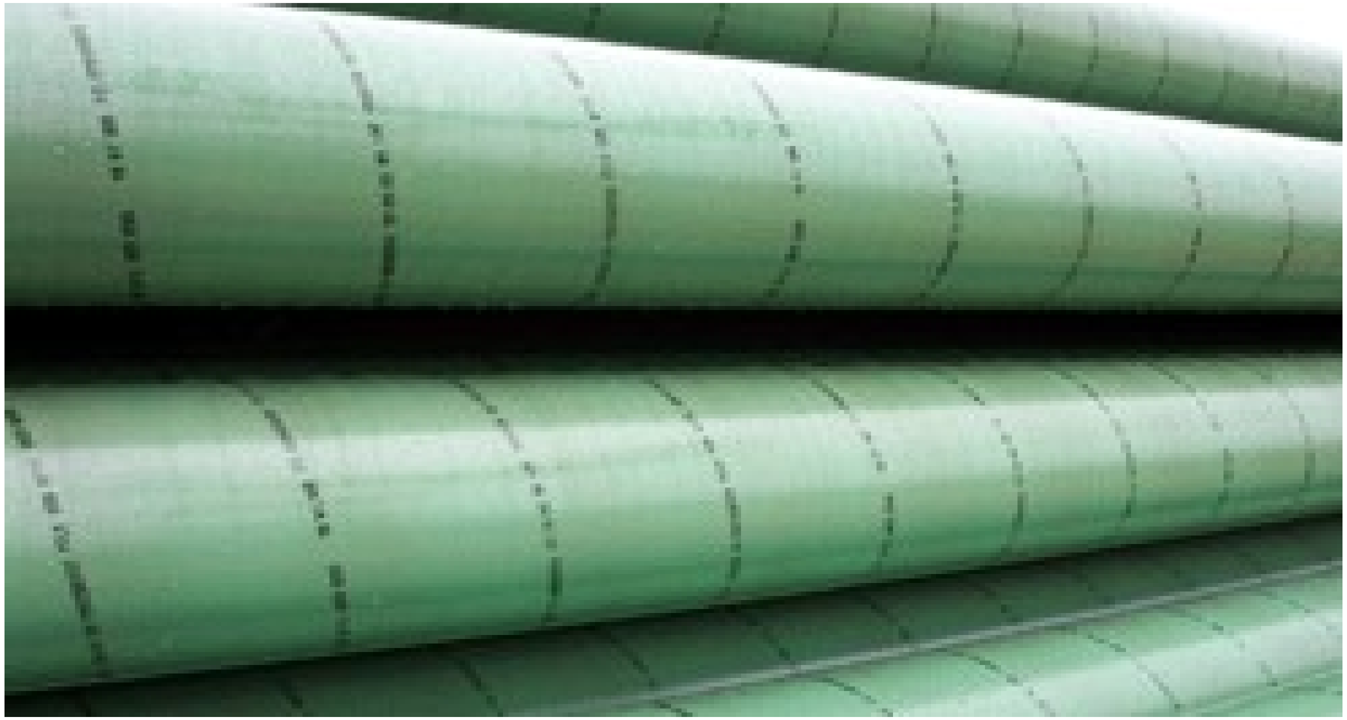


Ceramic Lined Pipe

Concrete Lined Pipe

PIPE COATING DESIGNATOR - B

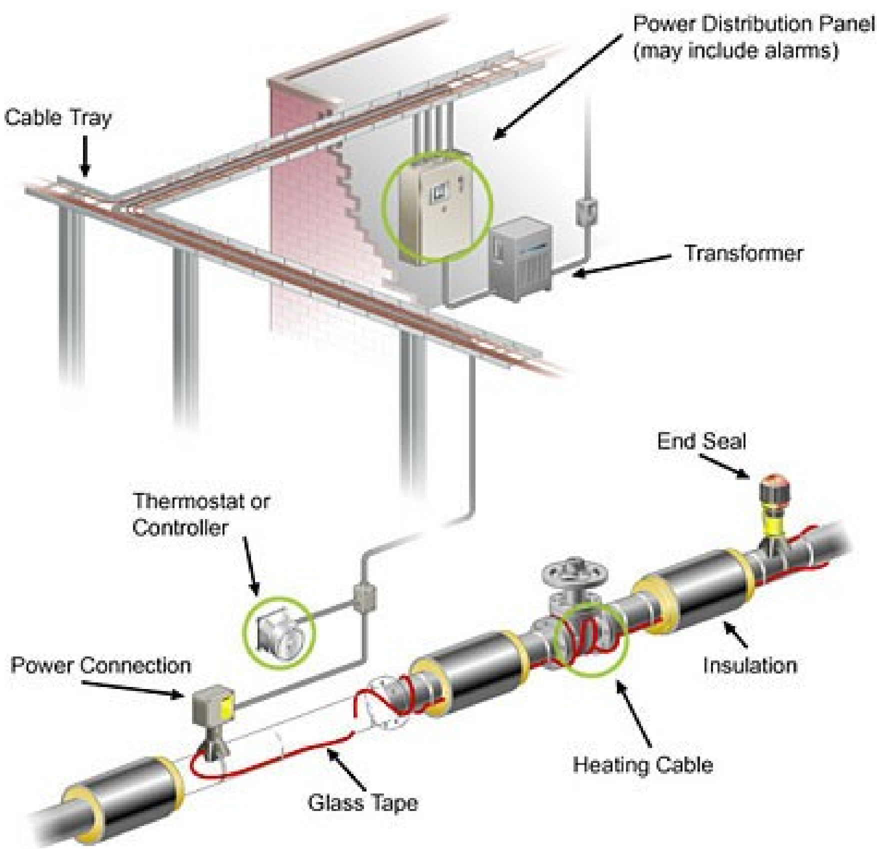
B- External coated



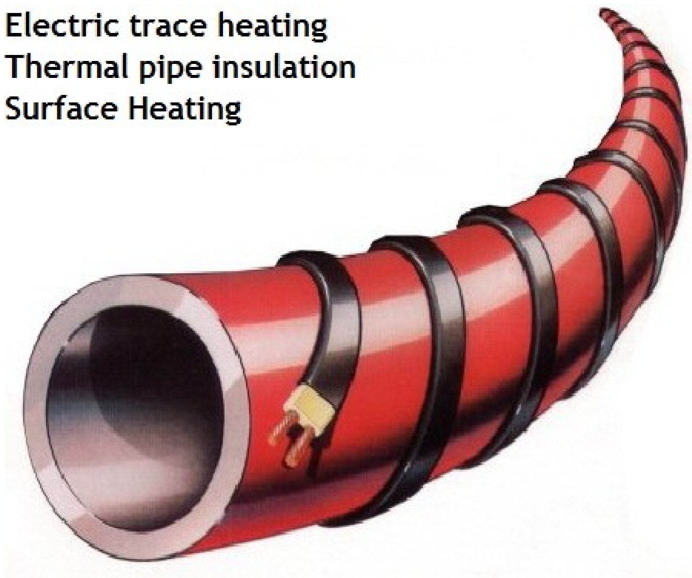
Coating and wrapping for underground installation

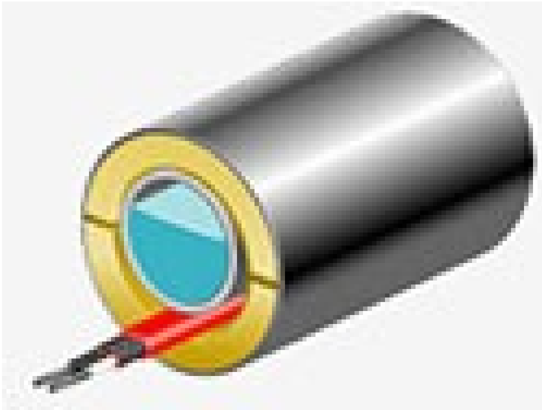
PIPE COATING DESIGNATOR - E

E- Electric Traced



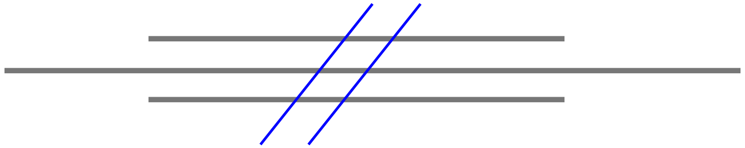
Electric trace heating
Thermal pipe insulation
Surface Heating





PIPE COATING DESIGNATOR - F

F- Cold Insulated



Cold Insulated pipe for low temperature service

PIPE COATING DESIGNATOR- I

I- Hot Insulated

Hot Insulated pipe for High temperature service

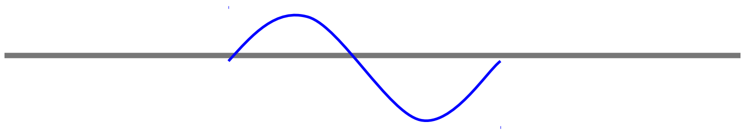
PIPE COATING DESIGNATOR - V

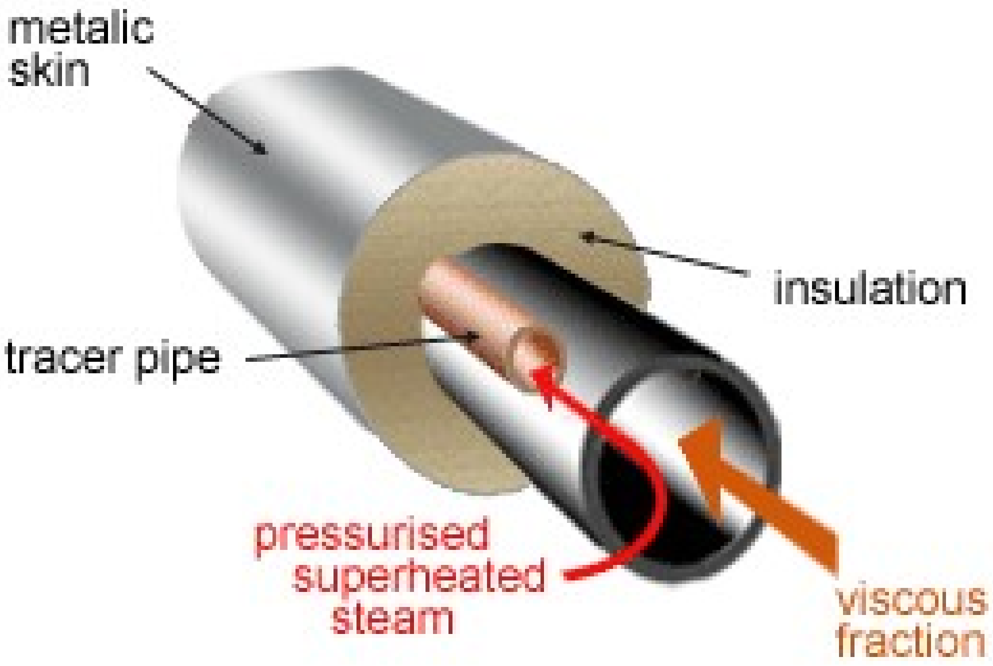
V- External Painted

Painted Pipe

PIPE COATING DESIGNATOR - T

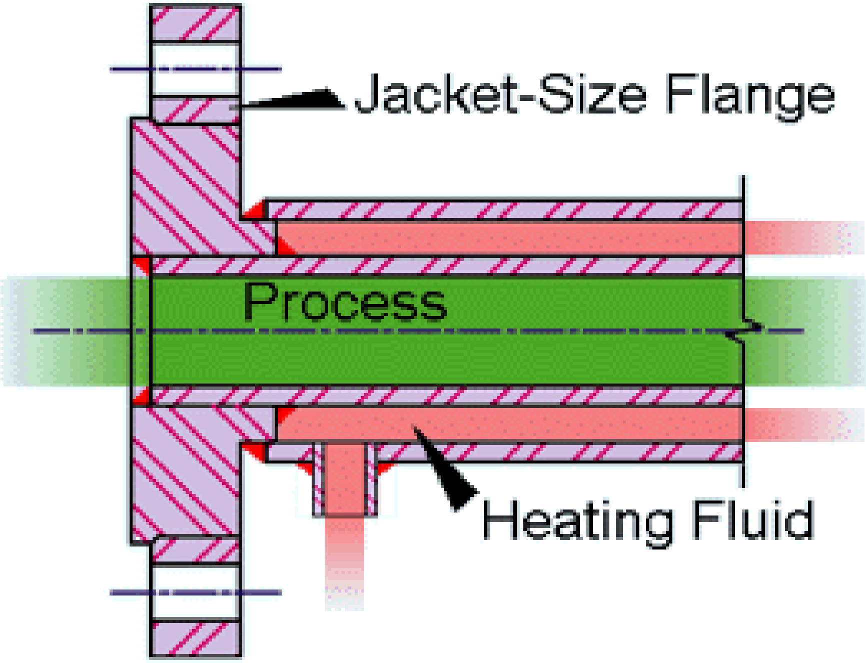
T- Steam Traced

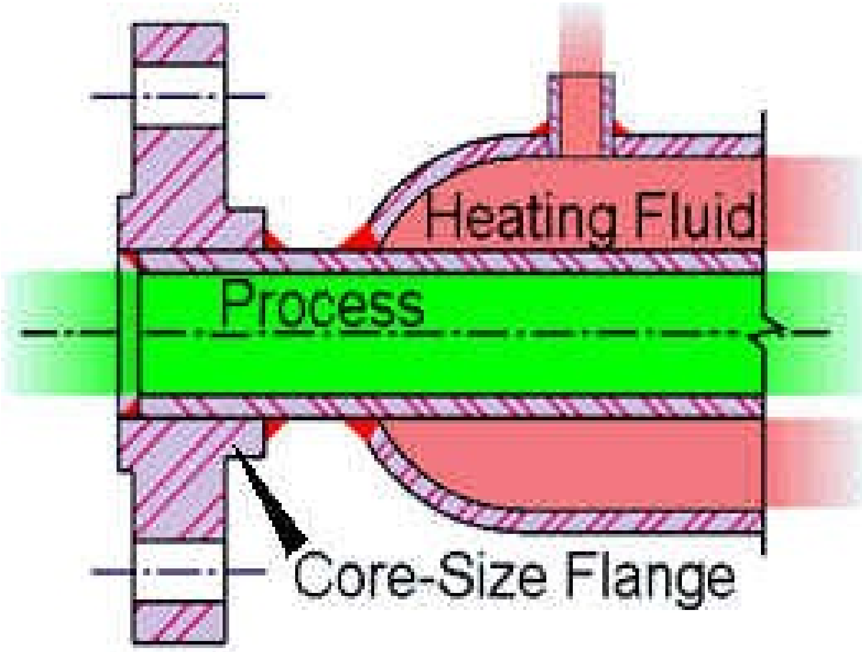


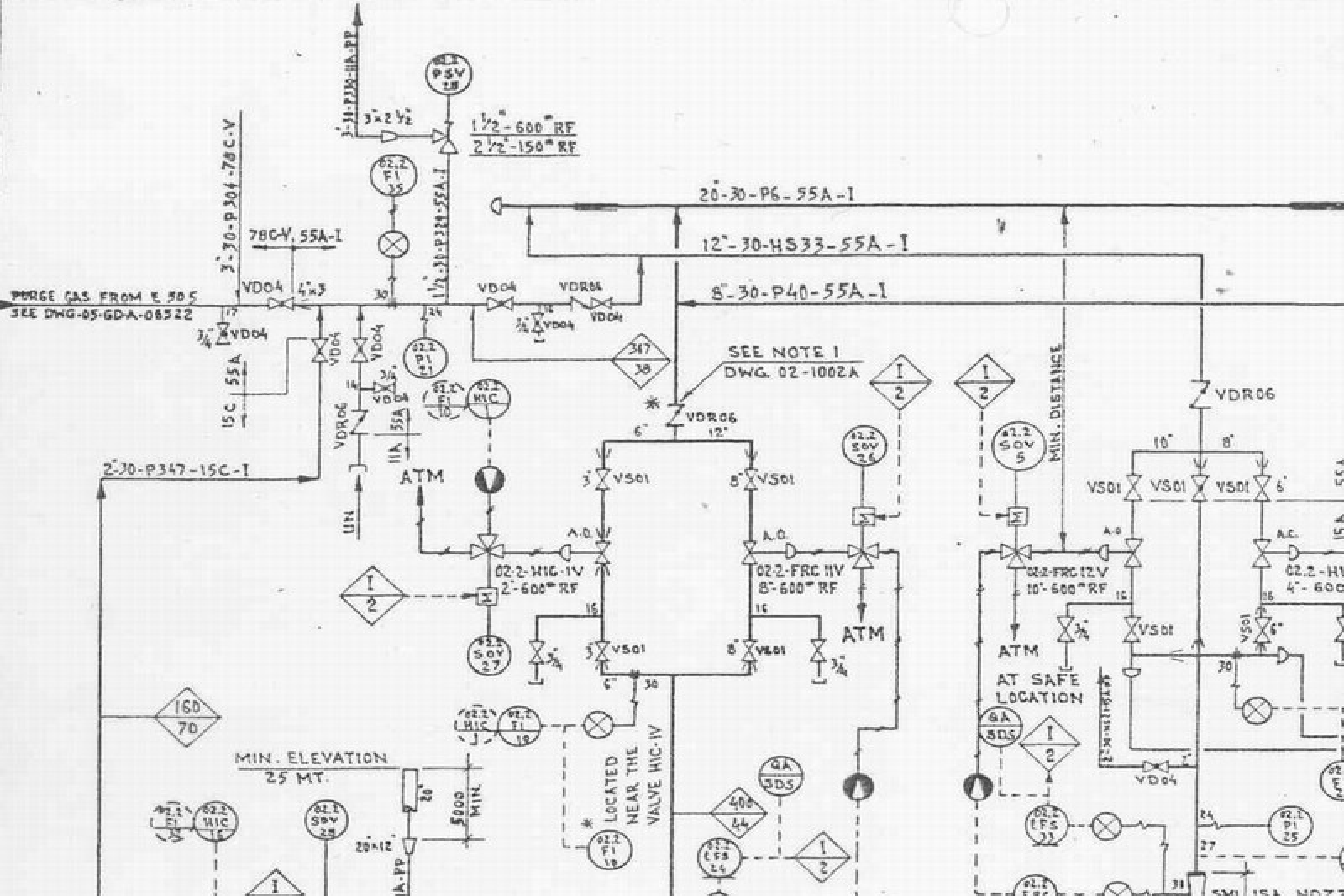


PIPE COATING DESIGNATOR - W

W- Jacketed

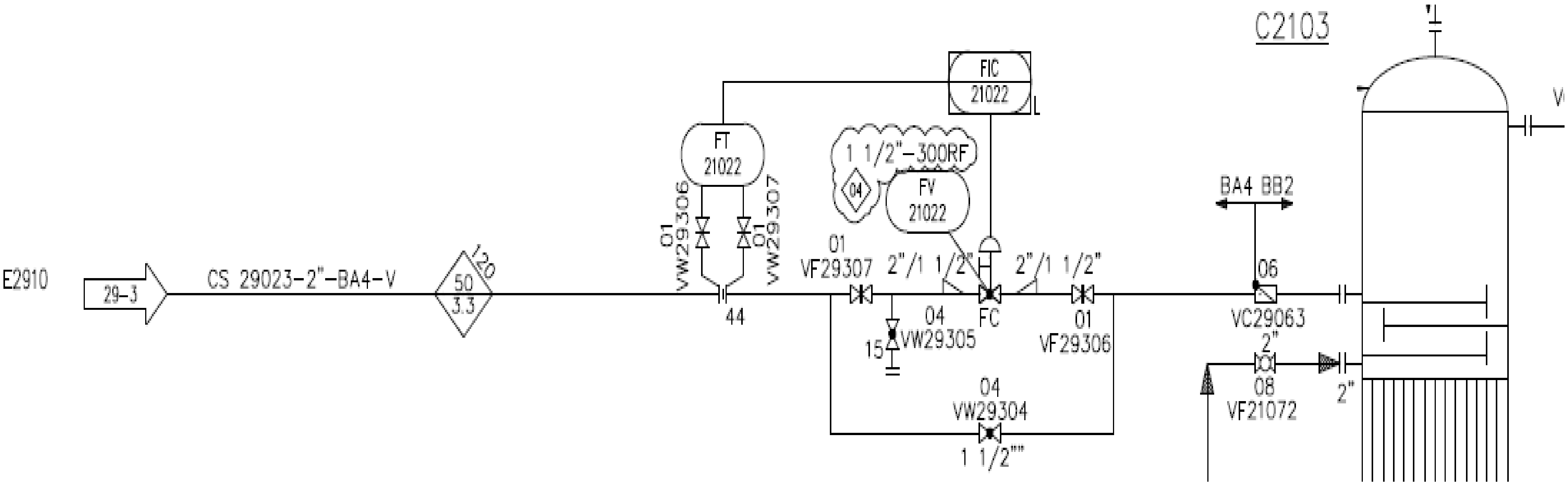






PURGE GAS FROM E 505
SEE DWG-05-GD-A-08522
3"-30-P304-78C-V
78C-V, 55A-I
4"x3
VD04
VDR06
1½"-600# RF
2½"-150# RF
3"x2½"
PSV
1½"-30-P329-55A-I
20"-30-P6-55A-I
12"-30-HS33-55A-I
8"-30-P40-55A-I
SEE NOTE 1
DWG. 02-1002A
2"-30-P347-15C-I
ATM
VS01
A.O.
02.2-HIC-1V
2"-600# RF
02.2-FRC 11V
8"-600# RF
02.2-FRC 12V
10"-600# RF
MIN. DISTANCE
AT SAFE LOCATION
MIN. ELEVATION
25 MT.
5000 MIN.
LOCATED NEAR THE VALVE HIC-1V
SDS

Line Specification



Equipment Summary Table

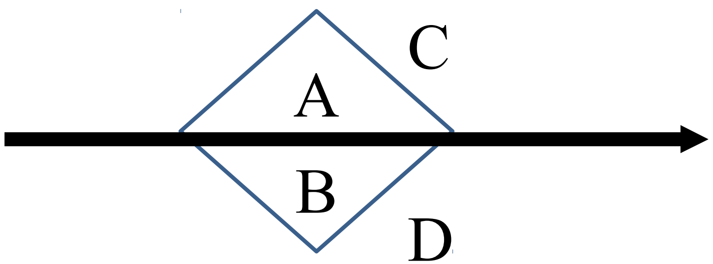
U2909 STRIPPER STEAM CONDENSATE SEPARATOR	X2915 S.M. STEAM SILENCER
D.P. = 2.75 MPa(g) & F.V.	INLET STEAM PRESS. = 0.1 / 0.3 MPa(g)
O.T. = 219°C	INLET STEAM TEMP. = 280/350 °C
D.T. = 234°C	MATERIAL :
I.D. = 2600 mm	– SHELL : C.S.
T.T. = 4900 mm	– INTERNALS : AISI 316 L
INSULATION = YES	
MATERIAL : C.S.	

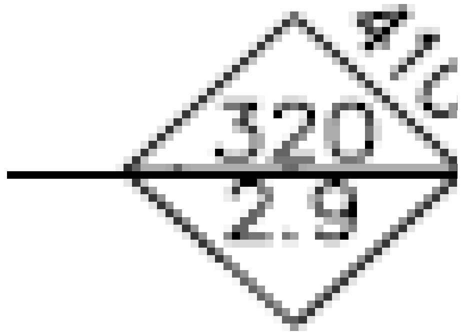
Equipment Summary Table

P2913 A/B STEAM CONDENSATE PUMPS
HEAD AT RATED CAP = 65 m
O.T. = 120 °C
SUCTION PRESS. = 0.16 MPa(g)
RATED CAPACITY = 125 m^3/h
DENSITY AT O.T. = 943 kg/m^3
ABSORBED POWER = 42 kW
MATERIAL : C.S.

E2923 STEAM CONDENSATE COOLER		
	SHELL	TUBE
D.P. = MPa(g)	1.43	0.9
O.T. = °C	114/50	40/47.2
D.T. = °C	160	82
SURFACE AREA = 268 m2		
INSULATION = YES		
MATERIAL :		
– SHELL AND TUBES : AISI 316L		
– CHANNEL : C.S.		

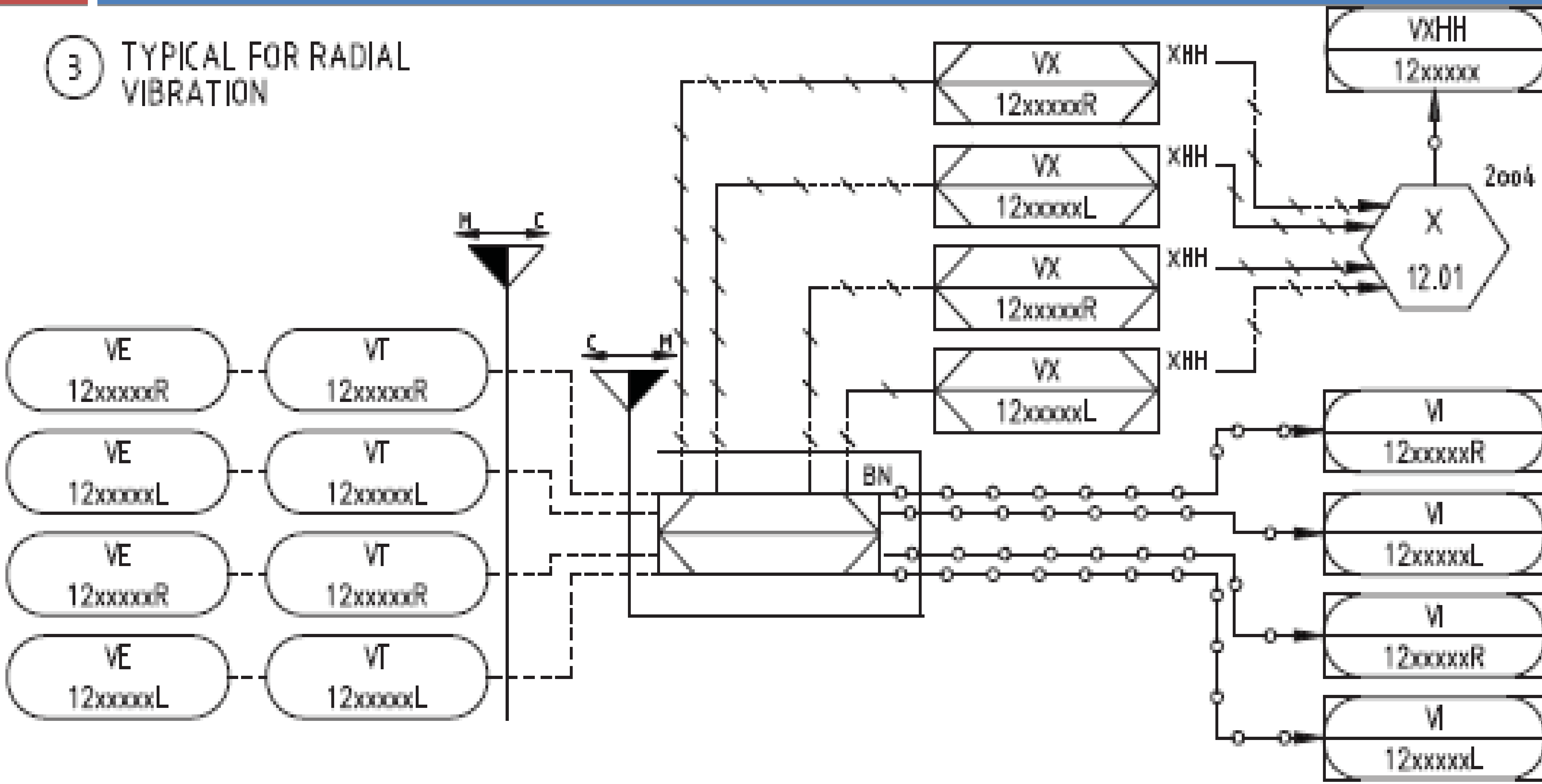
Process Conditions



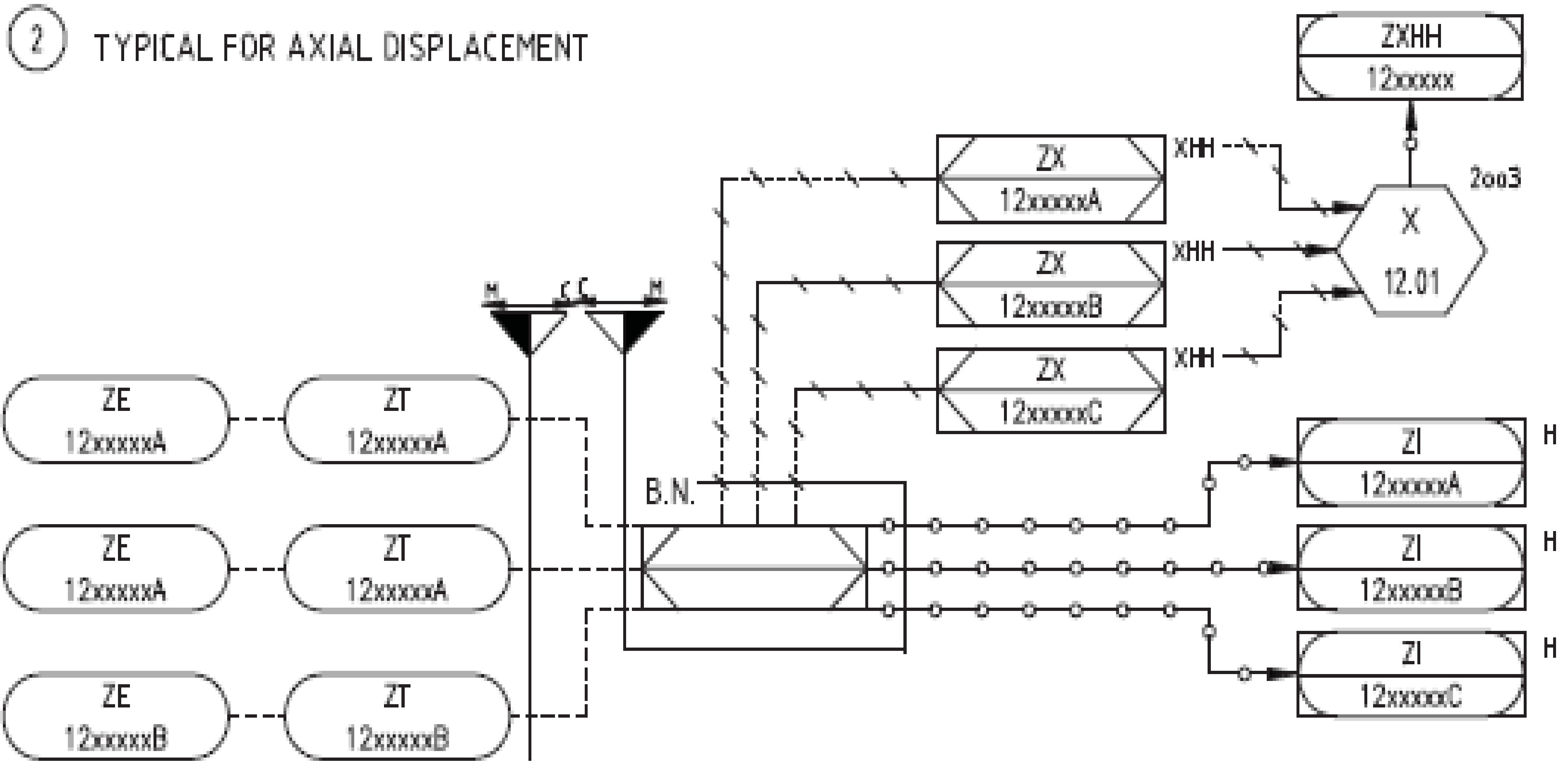


A : Operating Temperature (°C)
B : Design Pressure (Mpag)
C : Design Temperature (°C)
D : Full Vacuum

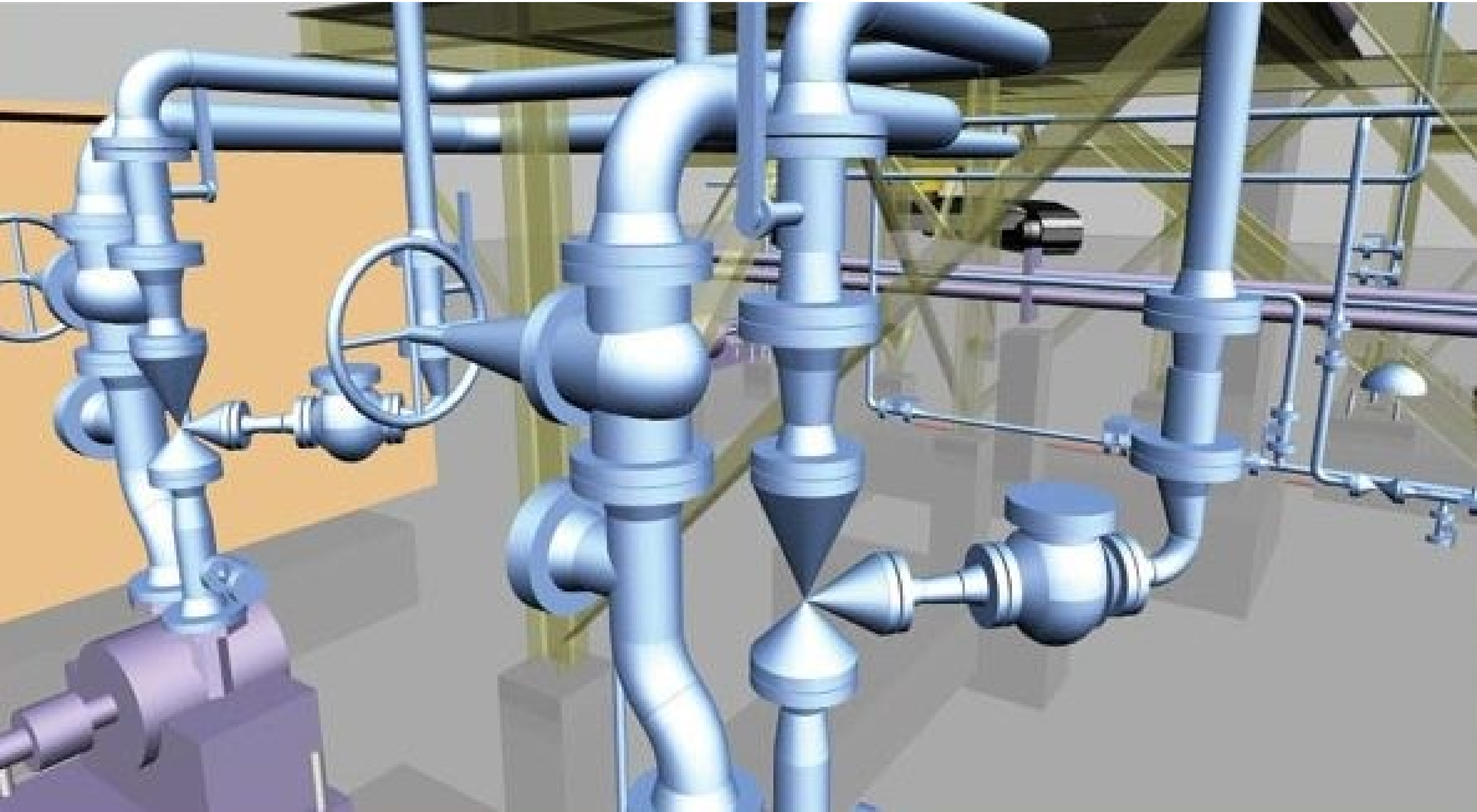
Radial Vibration Interlock system



Axial Vibration Interlock system



Piping Isometrics

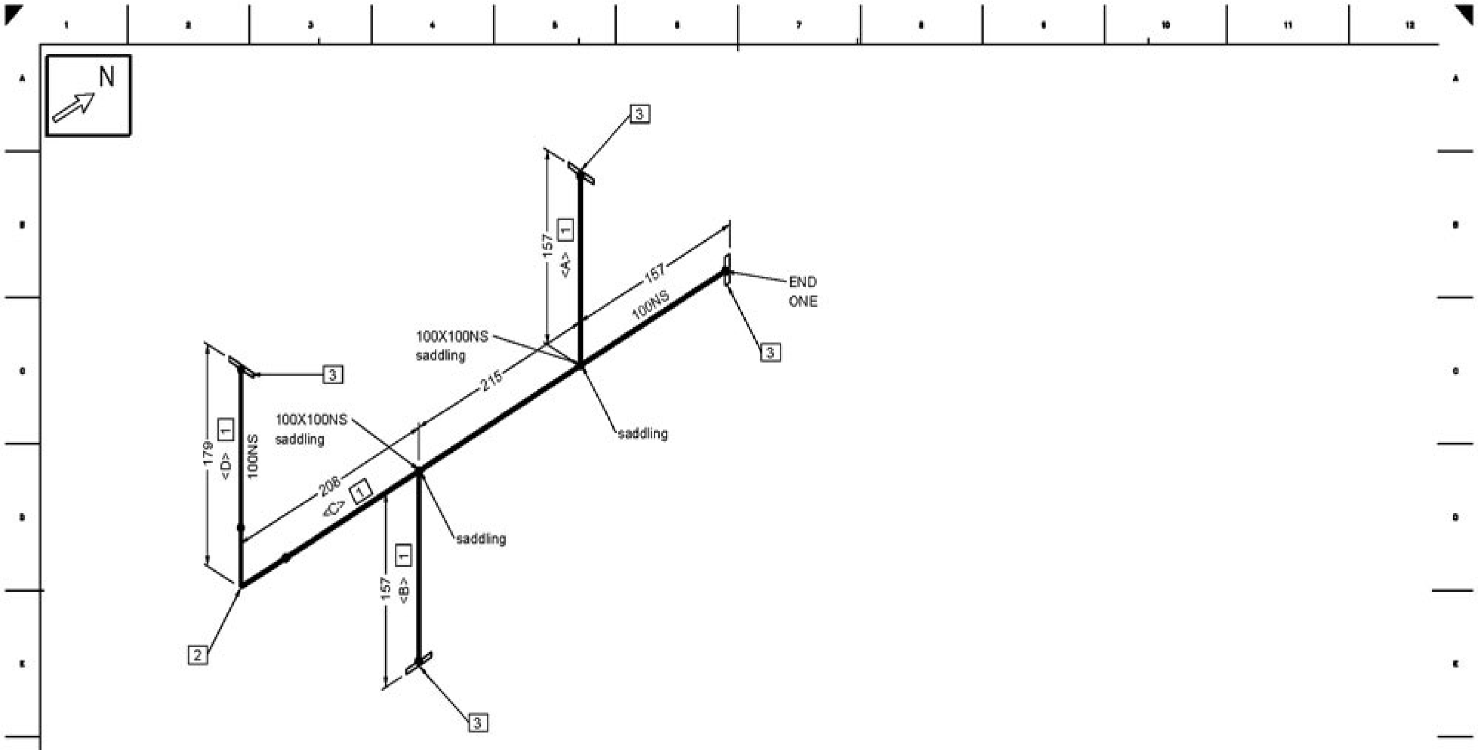


Piping Isometrics

Used for fabrication and then construction of the piping system

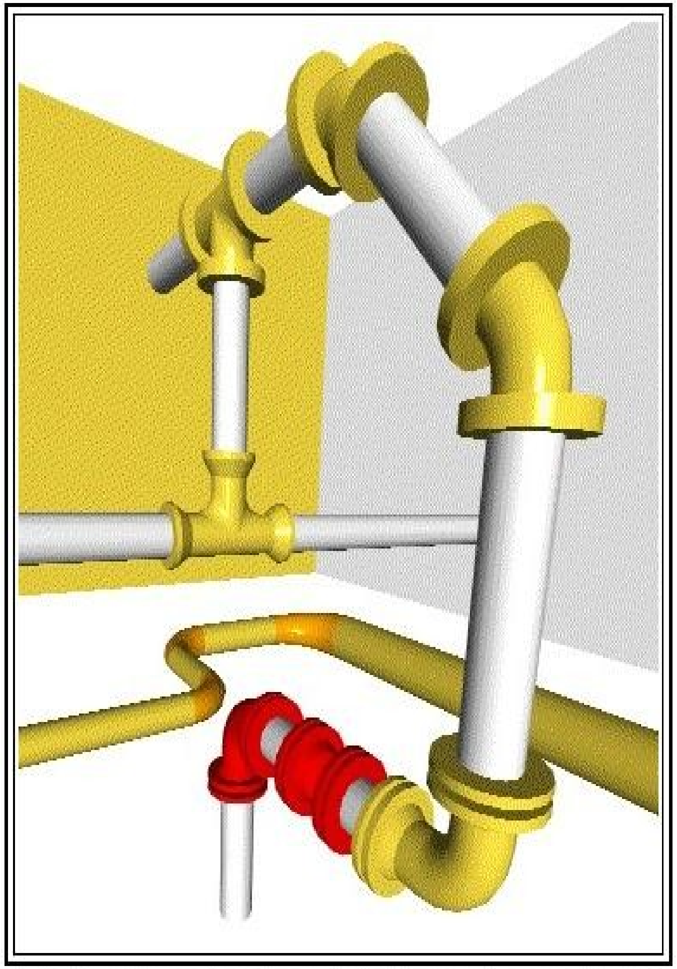
- Represents 3D structure of pipe between two points
- Drawn to scale
- All the fittings including, valves, flanges, elbows etc. are clearly represented
- Detail about bill of material needed for execution of piping layout
- A table gives the number and detailed description of each type of fittings

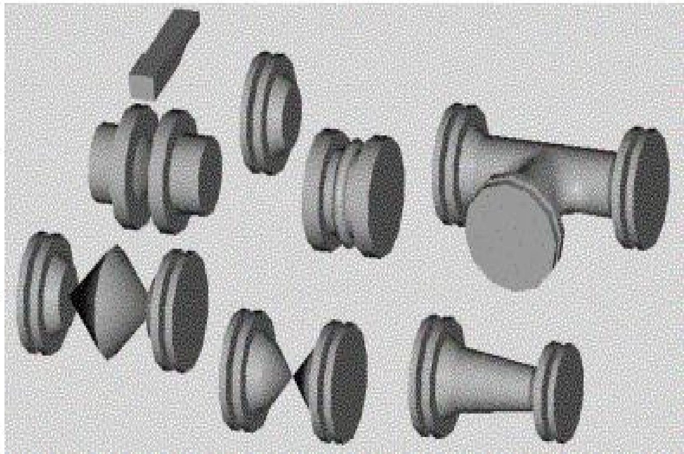
Piping Isometrics



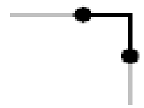
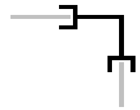
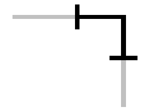
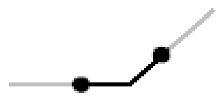
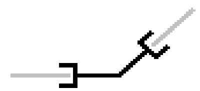
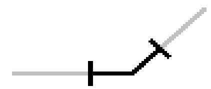
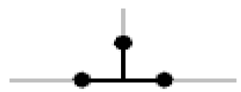
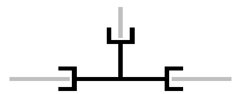
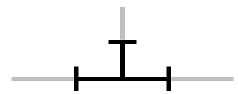
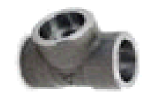
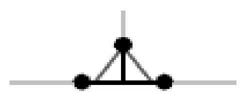
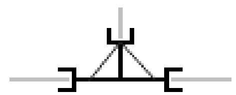
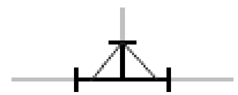
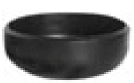
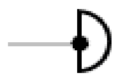
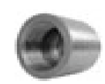
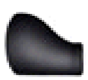
MATERIAL LIST				
PT.NO.	SIZE	ITEM CODE	DESCRIPTION	QTY
1	100	DIN2458-114.	Pipe.DIN2458-114.3x4.5-St37	842 MM
2	100	E.T2.90-114.	Elbow,DIN 2605-2-90-2-114.3X6.3-W-A	1
3	100	D2573-B-100-	Slip on flange-DIN 2573-DN100-PN6-ST44.2	4

WELDS SUMMARY				CUTTING LIST				
WELD NO.	SIZE	TYPE	LOCATION	PIECE NO.	SIZE	LENGTH	END PREP.1	END PREP.2
				A	100	150	SHAPED	SQ.CUT
				B	100	150	SHAPED	SQ.CUT
				C	100	472	SQ.CUT	BEVEL
				D	100	70	BEVEL	SQ.CUT





Piping Isometrics

Image	Fittings	Butt weld Symbol	Socket weld Symbol	Threaded Symbol	Fittings	Image
	Elbow 90°				Elbow 90°	
	Elbow 45°				Elbow 45°	
	Tee equal				Tee equal	
	Tee reducing				Tee reducing	
	Cap				Cap	
	Reducer concentric		...	...	Reducer concentric	...
	Reducer eccentic		...	...	Reducer eccentic	...
Image	Fittings	Butt weld Symbol	Socket weld Symbol	Threaded Symbol	Fittings	Image

Piping Isometrics

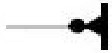
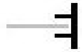
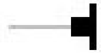
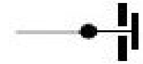
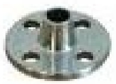
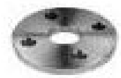
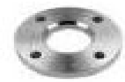
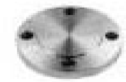
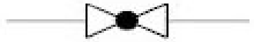
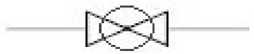
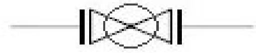
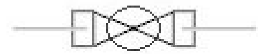
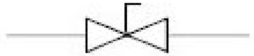
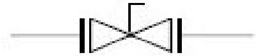
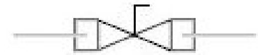
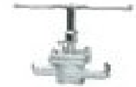
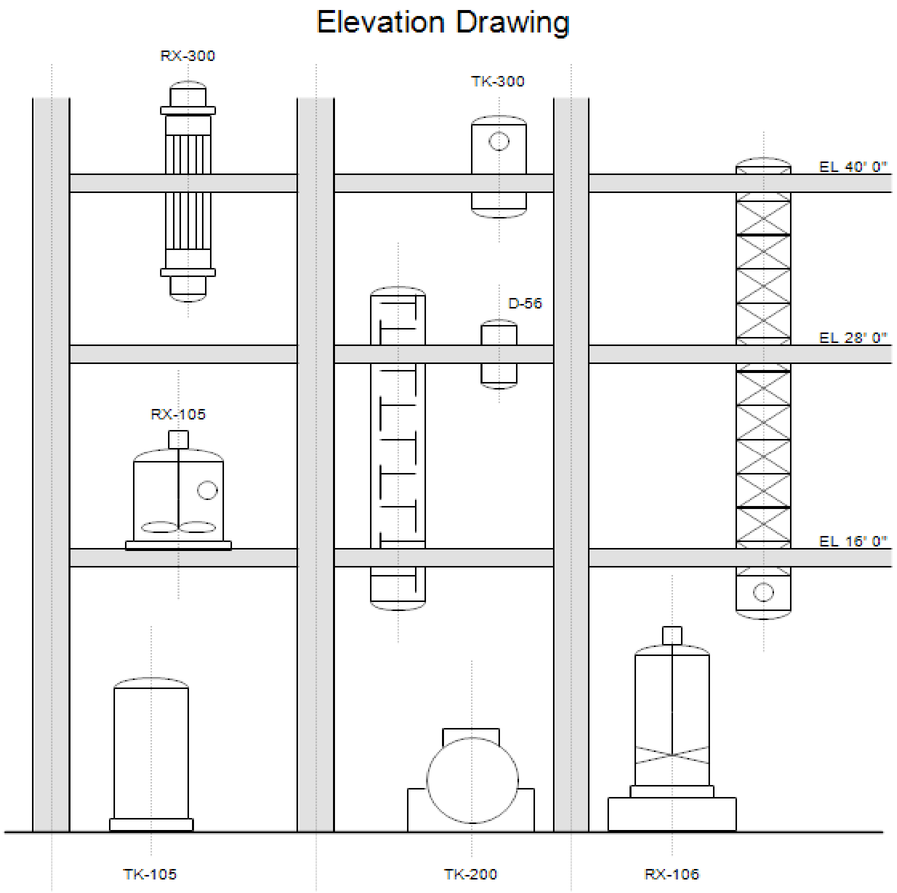
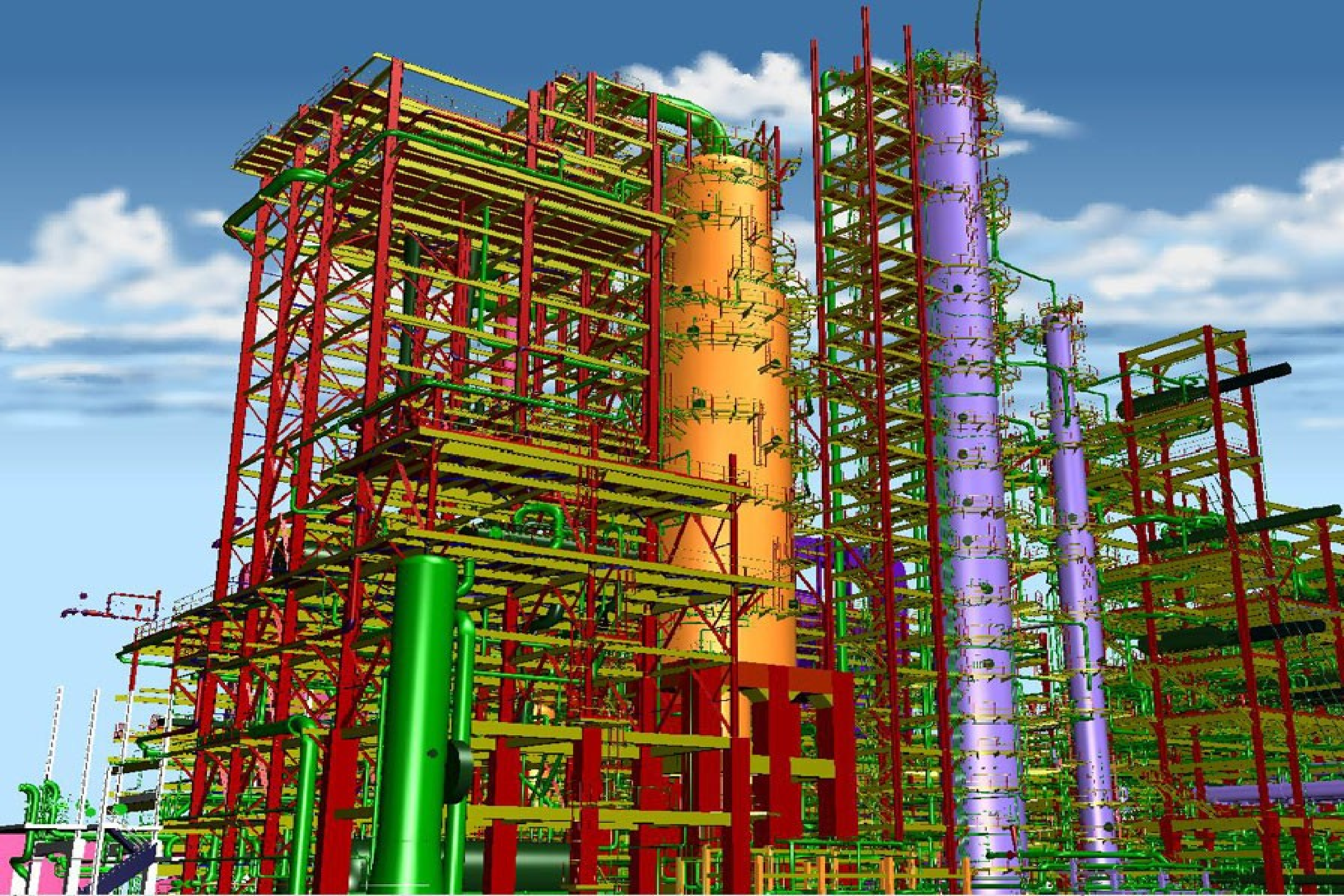
Flanges	Welding Neck	Socket weld	Threaded	Slip-On	Lap-Joint	Blind	Flanges
Symbol							Symbol
Image							Image
Flanges	Welding Neck	Socket weld	Threaded	Slip-On	Lap-Joint	Blind	Flanges

Image	Valves	Butt weld Symbol	Flanged Symbol	Socket or Threaded Symbol	Valves	Image
	Gate				Gate	
	Globe				Globe	
	Ball				Ball	
	Plug				Plug	

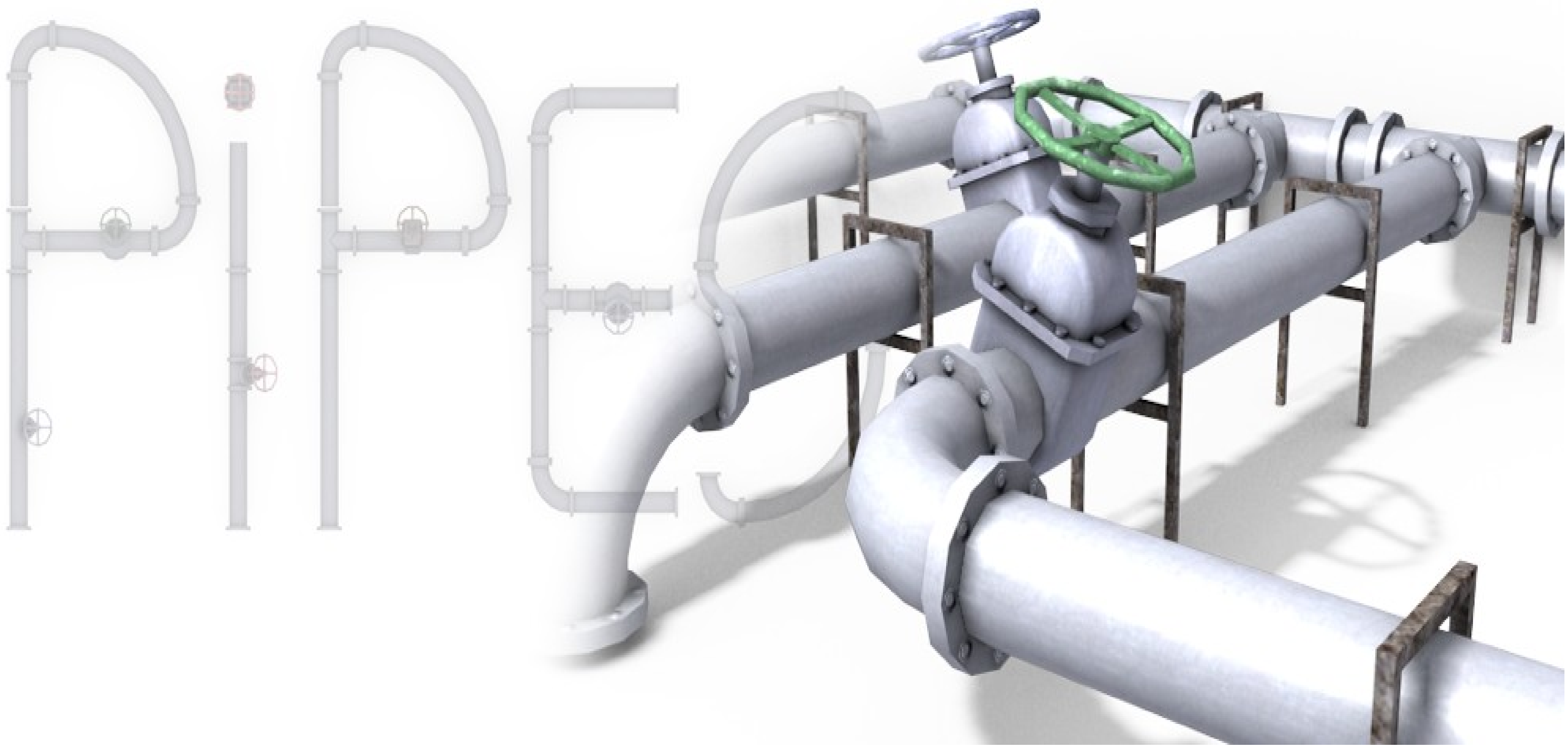
Equipment Elevation Drawing

- Shows the vertical location of process equipment .
- It shows the location of process equipments in relation to existing structures and ground level.
- Useful for performing startups and shutdowns.





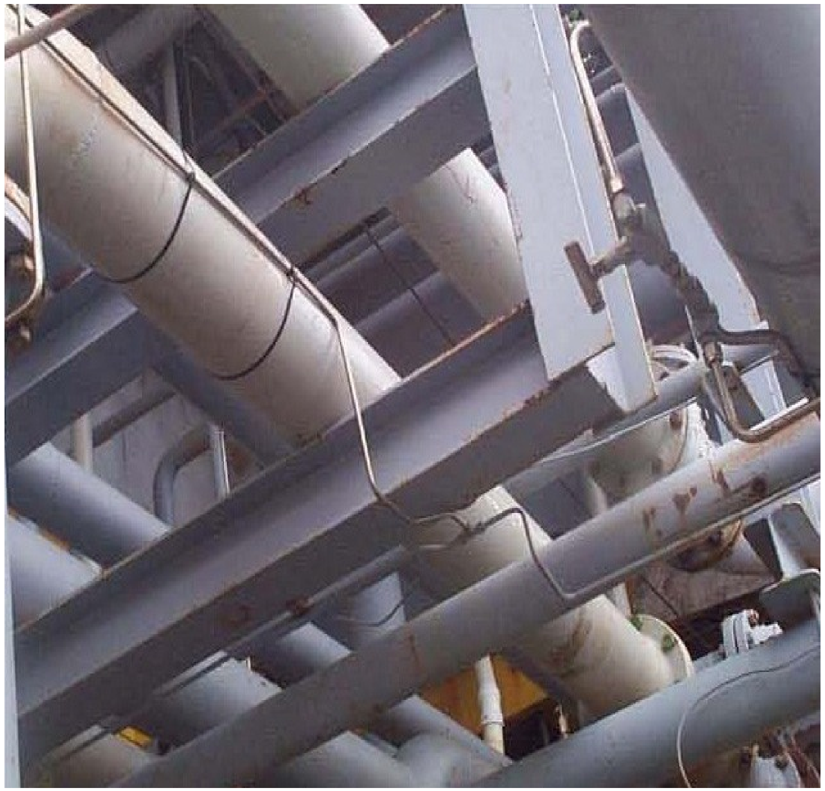
Piping Support Types



Piping Support Types

Base Support

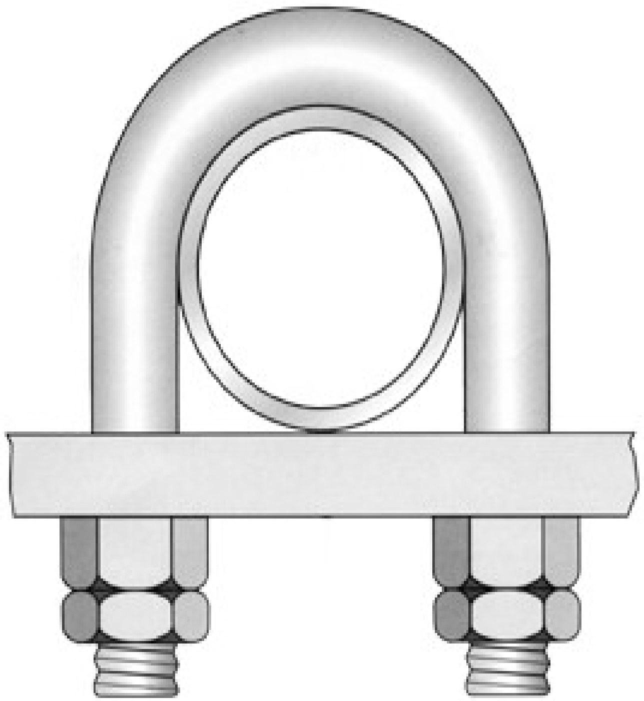
Piping Support Types



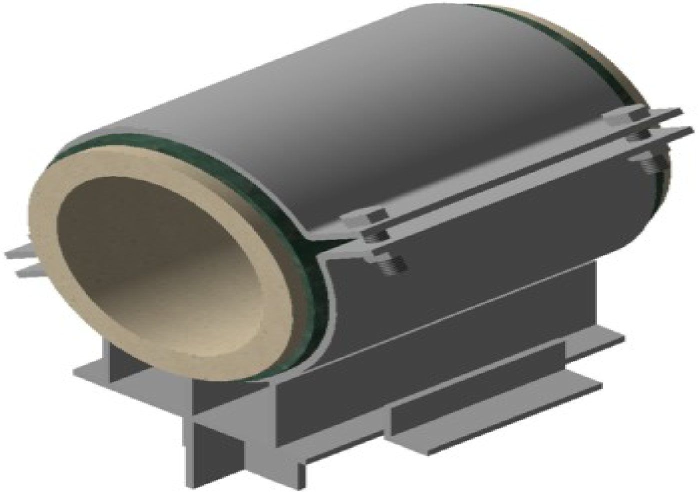
Beam Support

Variable Spring Support

Piping Support Types



U Clamp Support



Anchor Shoes with slide plate

Piping Support Types

Variable Spring Hanger

Constant Load Hanger


thanks