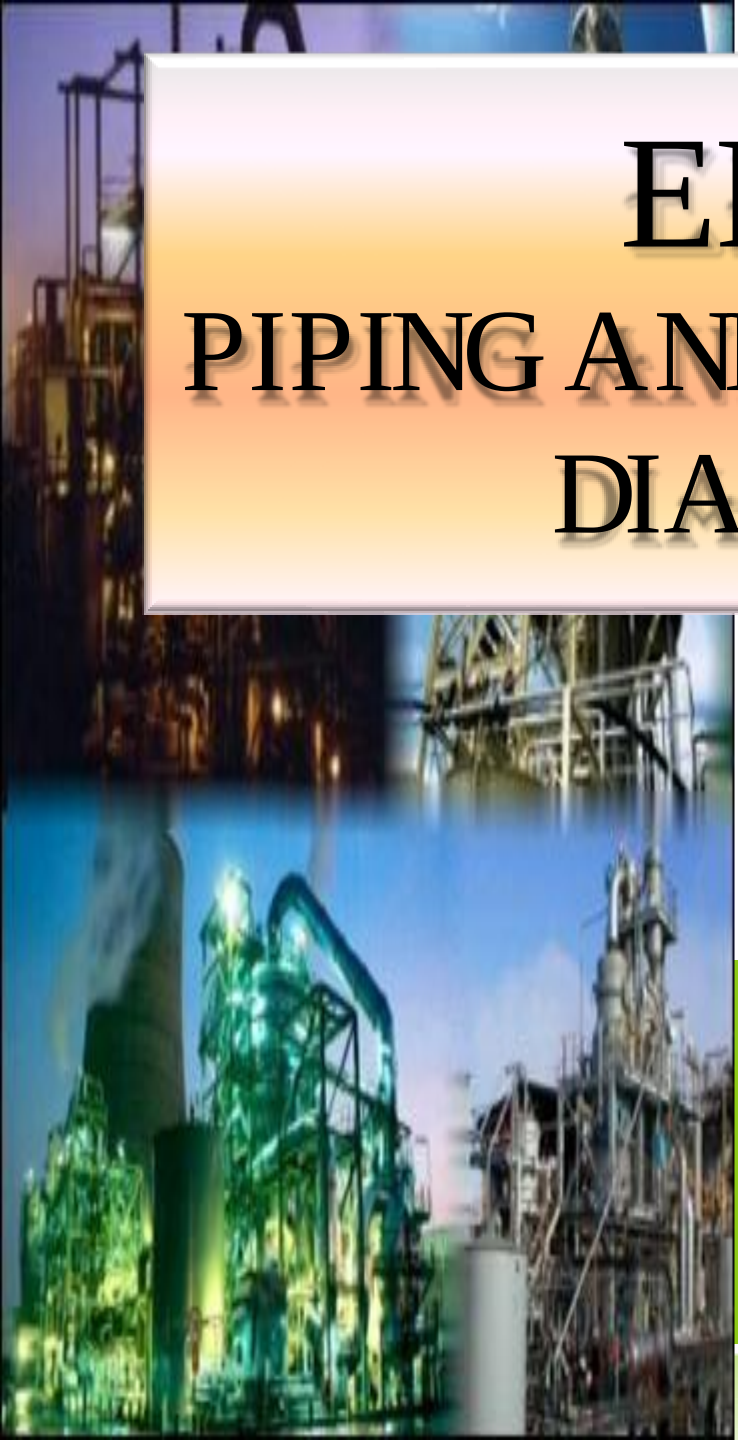
AutomationForum.Co



ERT 422/4
PIPING AND INSTRUMENTATION DIAGRAM(P&ID)

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COURSE OUTCOMES

CO
RECOGNIZE all the **piping and instrumentation symbols**, **CHOOSE** suitable symbols and **DEVELOP** the piping systems and the specification of the process instrumentation, equipment, piping, valves, fittings; and their arrangement in **P&ID** for the **bioprocess plant design**.

OUTLINES

- **TYPES of piping** and instrumentation symbols.
- **How to CHOOSE** the suitable symbols in control system?
- **How to DEVELOP** the piping systems and the specification of the process **instrumentation, equipment, piping, valves, fittings**.
- The **ARRANGEMENT in P&ID** for the **bioprocess plant design**.

Block Flow Diagram (BFD)

Process Flow Diagram (PFD)

PROCESS DIAGRAMS

Process equipments symbol and numbering

Piping and Instrumentation Diagram (P&ID)

Block Flow Diagram (BFD)

Process Flow Diagram (PFD)

PROCESS DIAGRAMS

Process equipments symbol and numbering

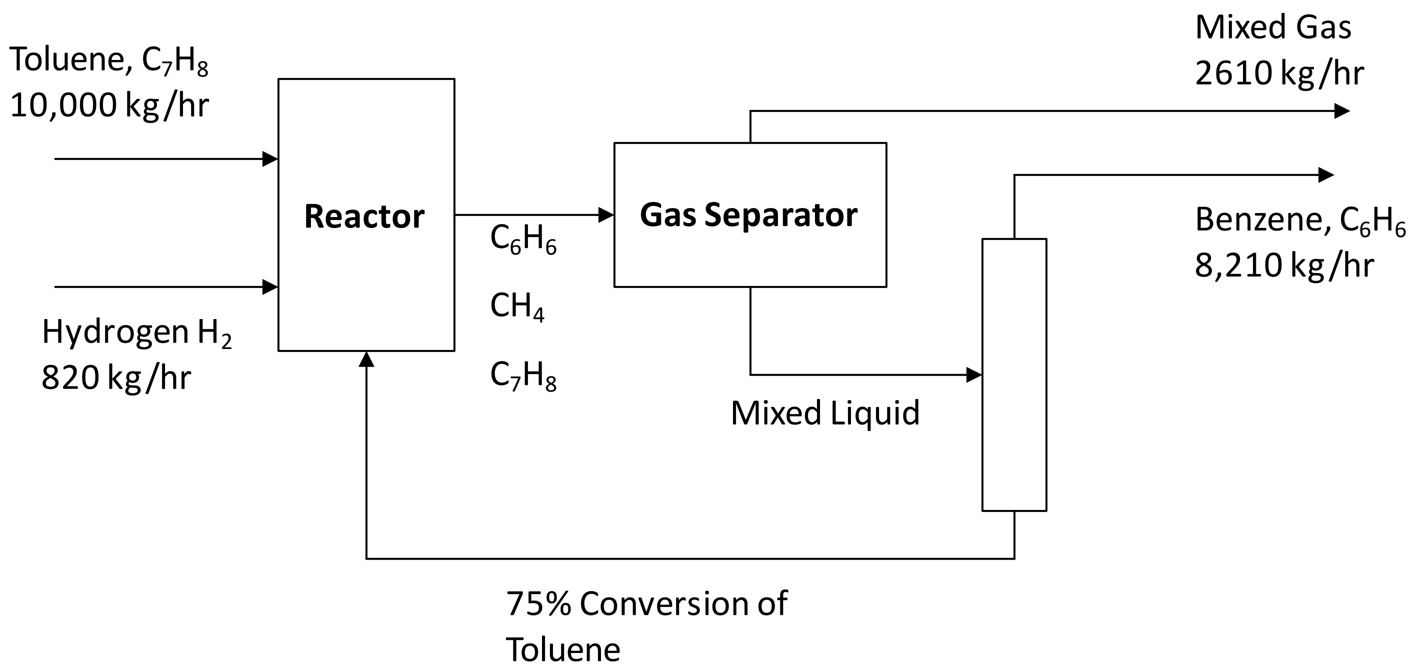
Piping and Instrumentation Diagram (P&ID)

BLOCK FLOW DIAGRAM (BFD)

- Is the **simplest flowsheet**.
- Process engineer **begins** the process design with a block diagram in which **only the feed and product streams are identified**.
- **Input-output diagrams** are not very detailed and are most useful in early stages of process development.
- Flow of **raw materials** and **products** may be included on a BFD.
- The processes described in the BFD, are then broken down into basic functional elements such as reaction and separation sections.
- Also identify the **recycle streams** and **additional unit operations** to achieve the desired operating conditions.

BLOCK FLOW DIAGRAM (BFD)

Example 1:



Reaction : $C_7H_8 + H_2 \longrightarrow C_6H_6 + CH_4$

Figure 1: Block Flow Diagram for the Production of Benzene

Example 2:

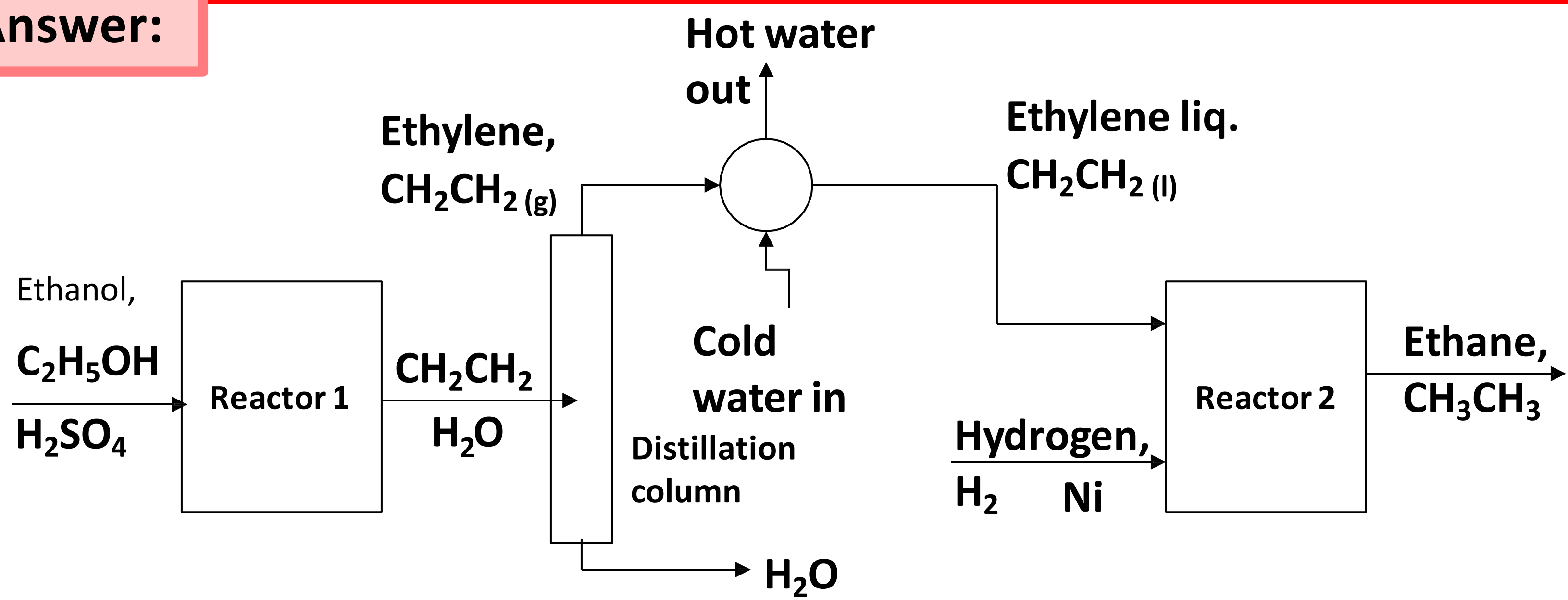
Production of Ethane from Ethanol

Ethanol is feed to **continuous reactor** with presence of **Acid Sulphuric catalyzer** to produce **ethylene. Distillation process** then will be applied to separate ethylene-H_2O mixture. **Ethylene as a top product** is then condensate with **condenser** to perform **liquid ethylene. Hydrogenation of ethylene** applies in another **reactor** with presence of **Nickel catalyzer** to produce **ethane** as a final product. **Develop BFD for these processes.**

$$CH_3CH_2OH \xrightarrow{H_2SO_4} CH_2{=}CH_2 + H_2O$$

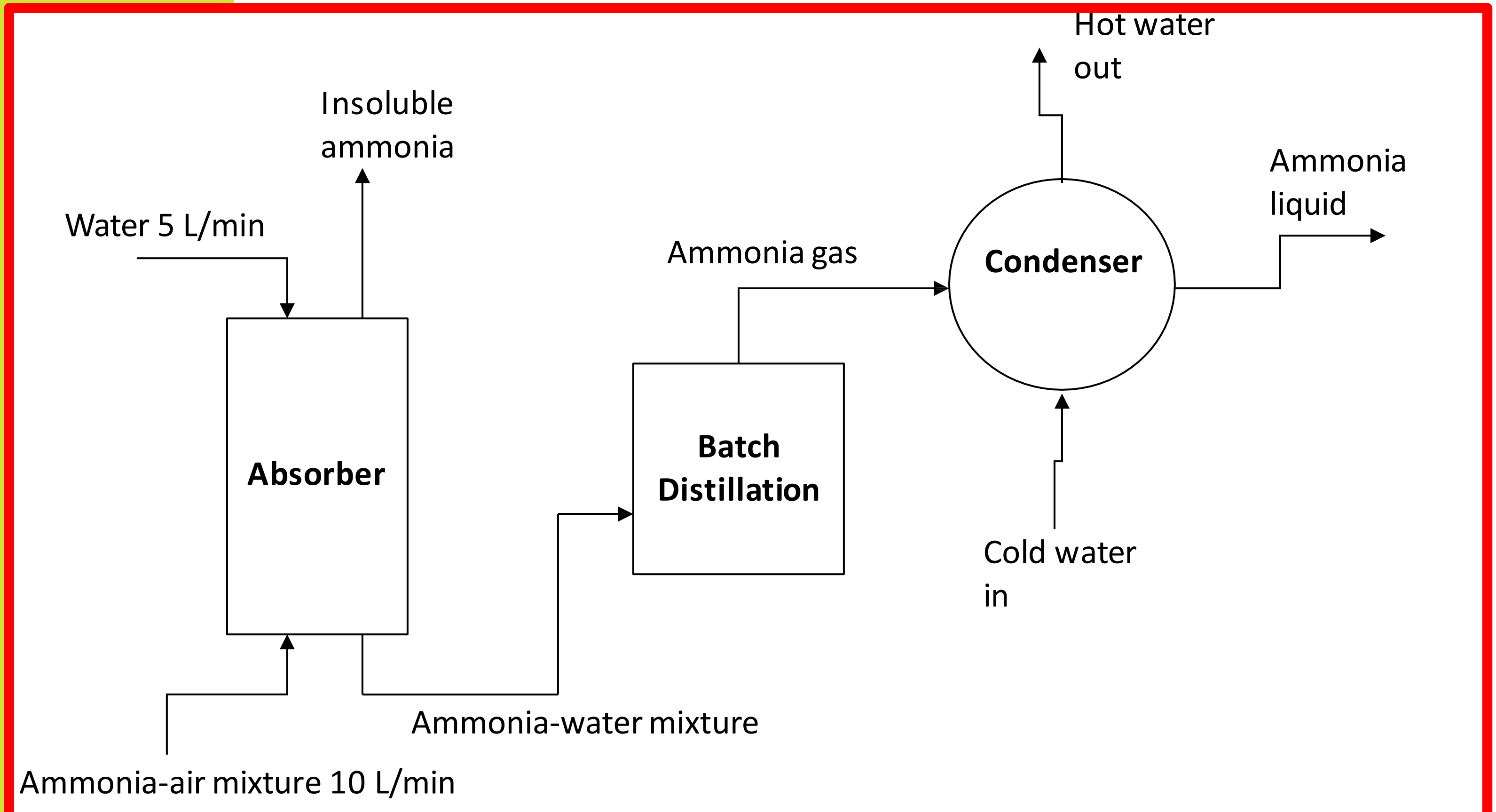
$$CH_2{=}CH_2 + H_2 \xrightarrow[Ni]{} CH_3CH_3$$

Answer:



Example 3:

Ammonia-air mixture is feed to the bottom stream of an absorber with flow rate of 10L/min. Water then feed to the upper stream of the same absorber with desired flow rate of 5L/min. There are two outputs from the absorber where upper stream is insoluble NH_3 and bottom stream is NH_3-Water mixture. This NH_3-water mixture then feed up to a batch distillation column. The column produces ammonia gas as a top product which this product then will be condensate with a condenser to produce liquid ammonia. **Develop Block Flow Diagram (BFD) for this process.**



Block Flow Diagram (BFD)

Process Flow Diagram (PFD)

PROCESS DIAGRAMS

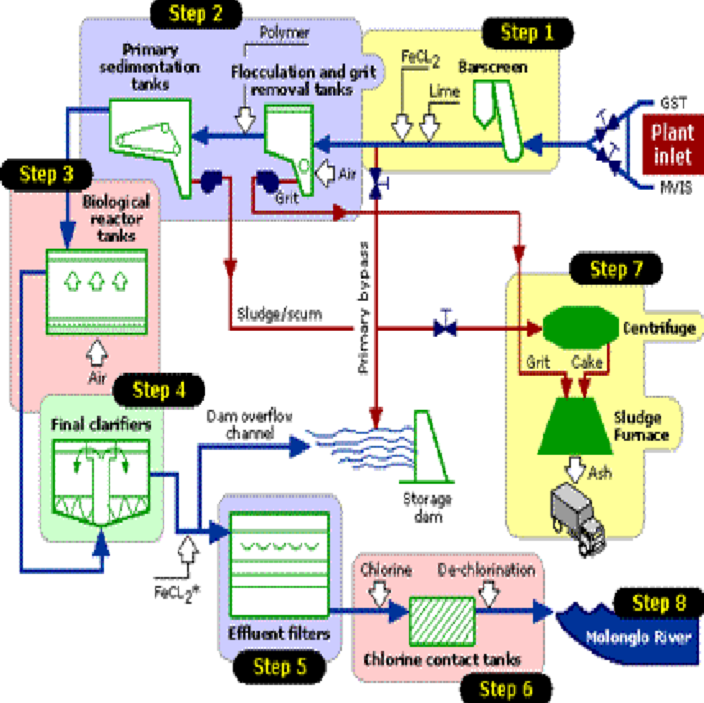
Process equipments symbol and numbering

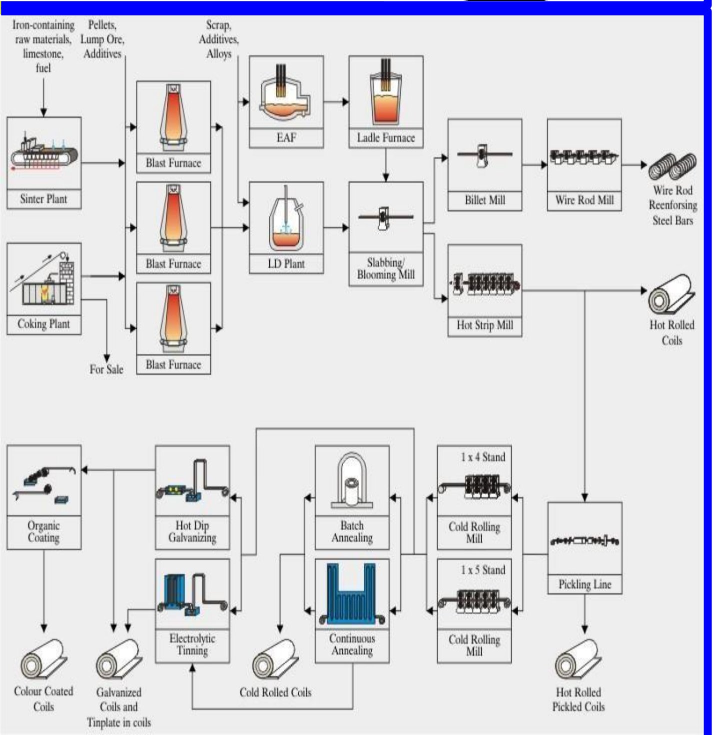
Piping and Instrumentation Diagram (P&ID)

PROCESS FLOW DIAGRAM (PFD)

A Process Flow Diagram generally includes following information;

a) Flow rate of each stream in case of continuous process or quality of each reactant in case of a batch process.
b) Composition streams.
c) Operating conditions of each stream such as pressure , temperature, concentration, etc.
d) Heat added or removed in a particular equipment.
e) Flows of utilities such as stream, cooling water, brine, hot oil, chilled water, thermal fluid, etc.
f) Major equipment symbols, names and identification.
g) Any specific information which is useful in understanding the process. For example, symbolic presentation of a hazard, safety precautions, sequence of flow, etc.





1. Major Pieces Of Equipment

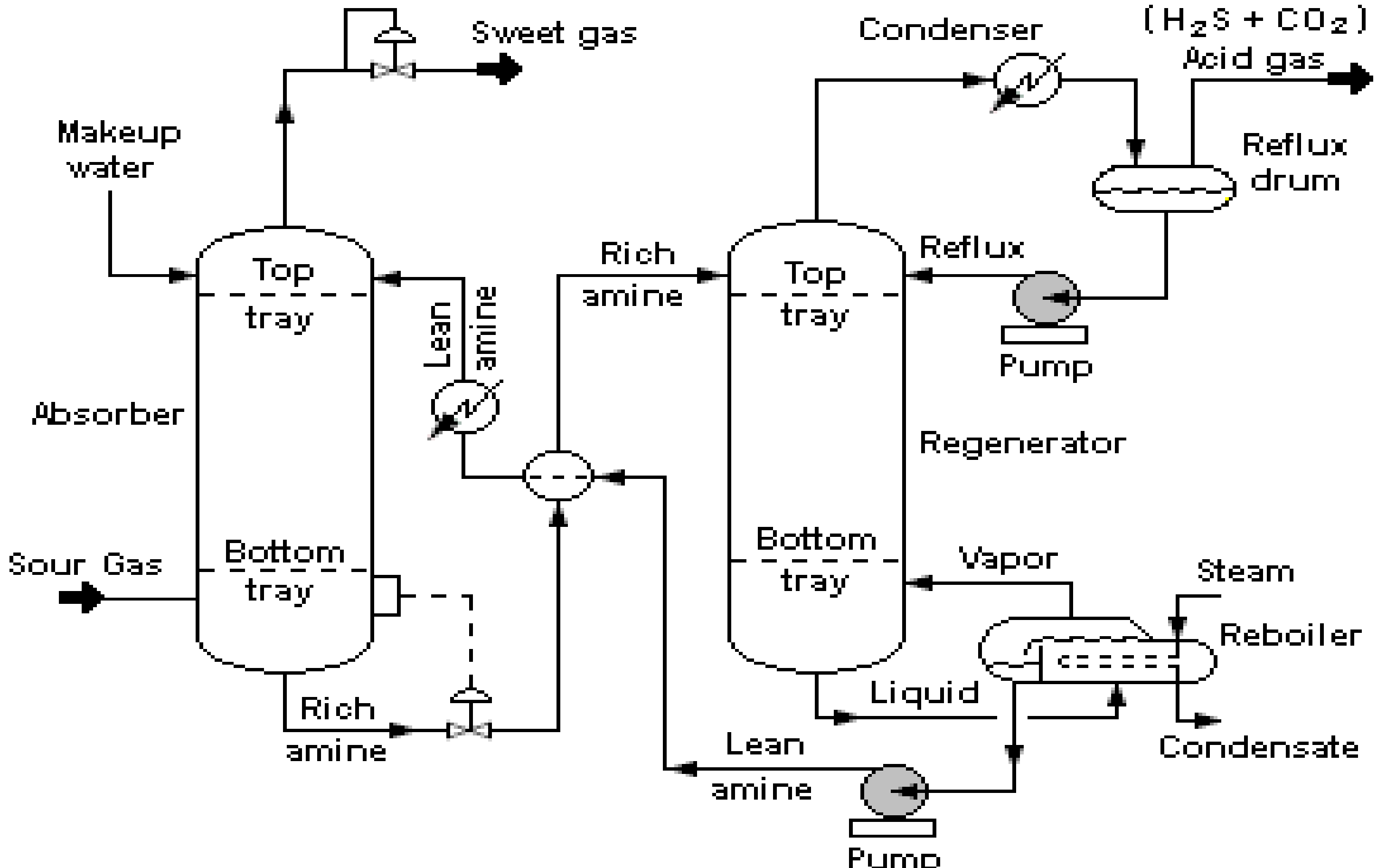
2. Utility Streams

PFD

4. Basic Control Loops

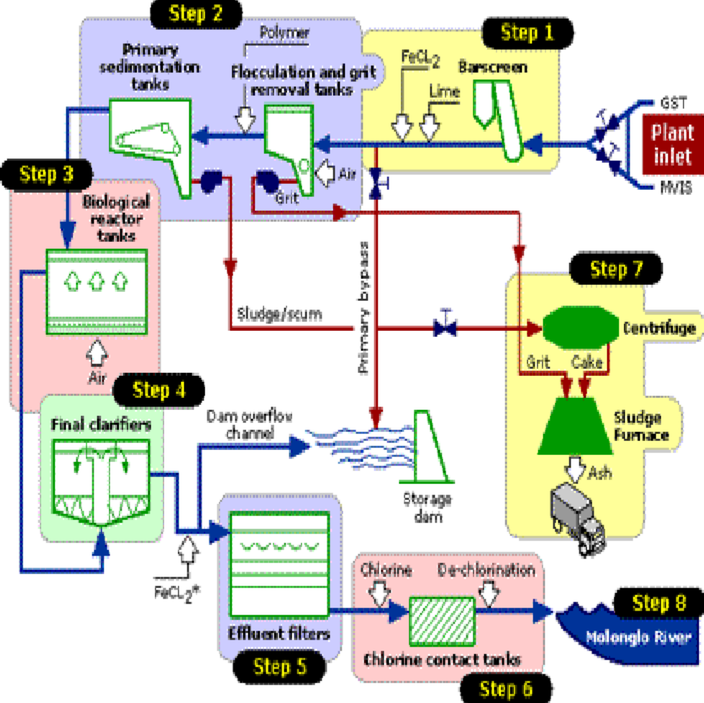
3. Process Flow Streams

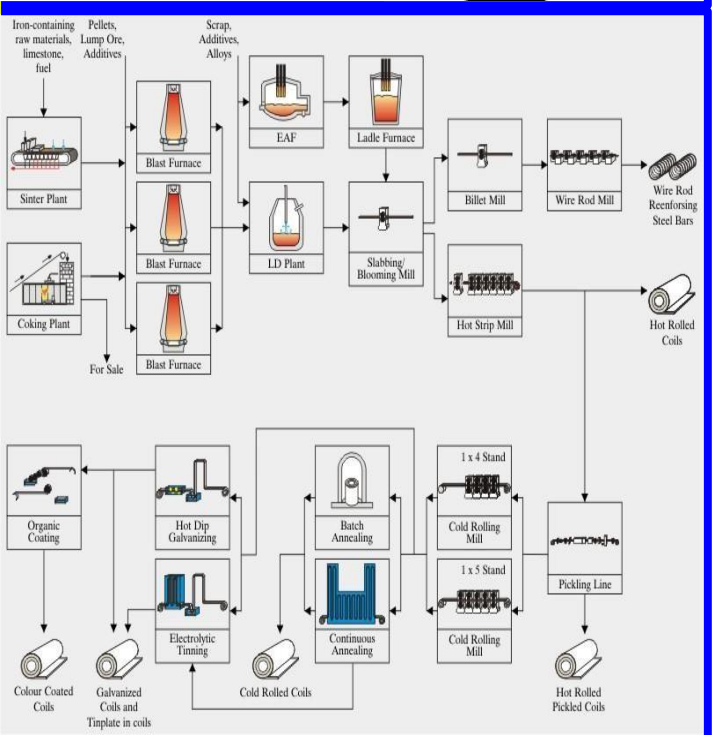
PROCESS FLOW DIAGRAM (PFD)



Typical operating ranges

Absorber : 35 to 50 °C and 5 to 205 atm of absolute pressure
Regenerator : 115 to 126 °C and 1.4 to 1.7 atm of absolute pressure
at tower bottom





1. Major Pieces Of Equipment

2. Utility Streams

PFD

4. Basic Control Loops

3. Process Flow Streams

PROCESS FLOW DIAGRAM (PFD)

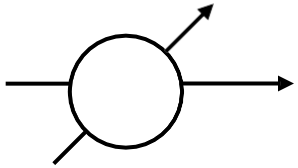
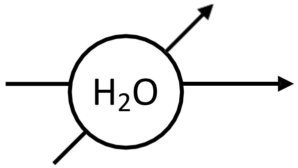
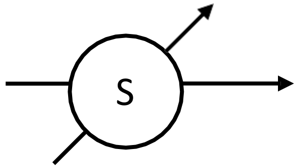
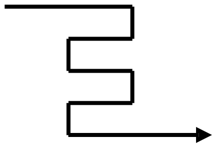
PFD will contains the following information:-

1. All **major pieces of equipment** (descriptive name, unique equipment no.), pumps and valves.

2. All the **utility streams** supplied to major equipments such as steam lines, compressed air lines, electricity, etc.

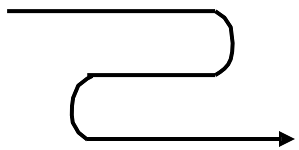
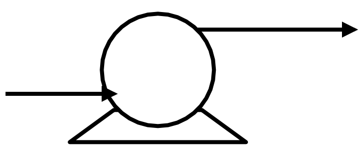
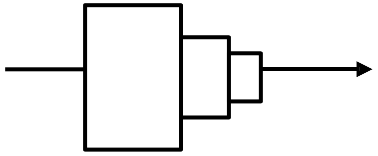
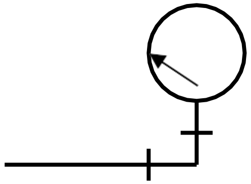
PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbology

Symbol	Description
	Heat exchanger
 	Water cooler
 	Steam heater
	Cooling coil

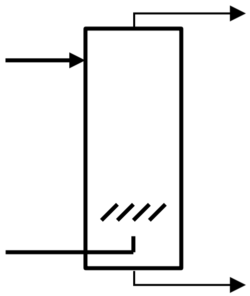
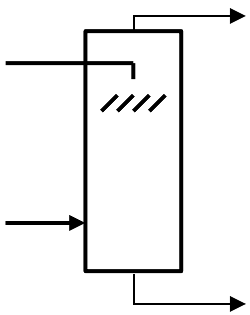
PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbology

Symbol	Description
	Heater coil
	Centrifugal pump
	Turbine type compressor
	Pressure gauge

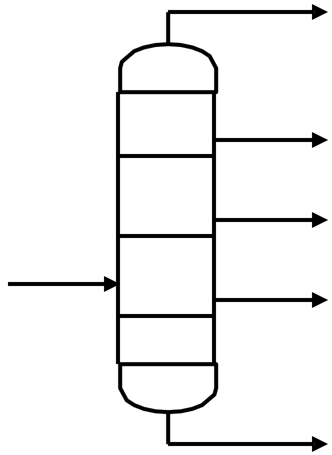
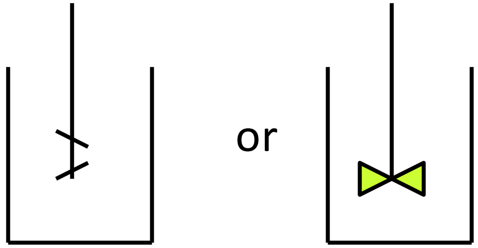
PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbology

Symbol	**Name**	**Description**
	Stripper	A separator unit used commonly to liquid mixture into gas phase.
	Absorber	A separator unit used commonly to extract mixture gas into liquid phase.

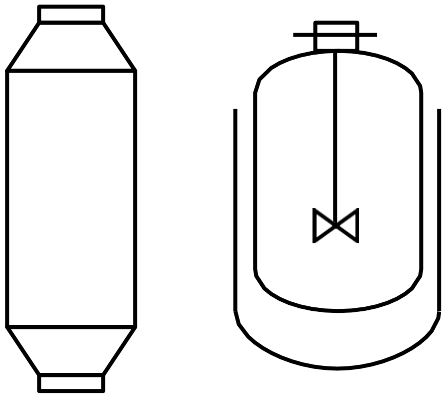
PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbology

Symbol	Name	Description
	Distillation column	A separator unit used commonly to crack liquid contains miscellaneous component fractions.
	Liquid mixer	A process unit that used to mix several components of liquid.

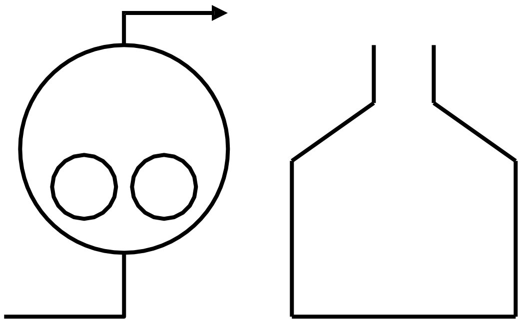
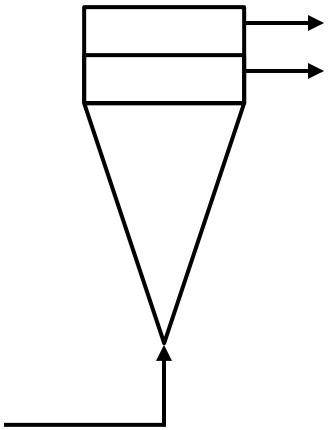
PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbology

Symbol	Name	Description
	Reaction chamber	A process unit where chemical process reaction occurs
	Horizontal tank or cylinder	A unit to store liquid or gas.

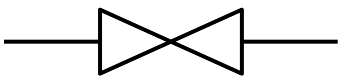
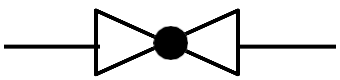
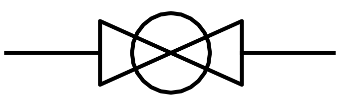
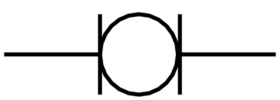
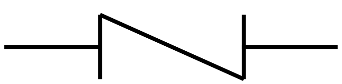
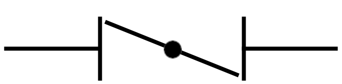
PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbology

Symbol	Name	Description
	Boiler	A unit for heating.
	Centrifuge	A separator unit that to physically separated liquid mixture. (exp: oil-liquid)

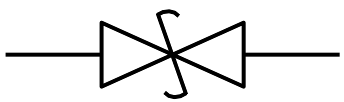
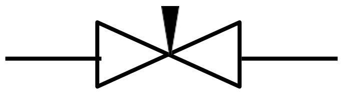
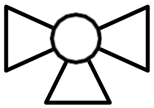
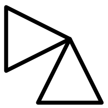
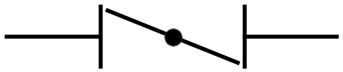
PROCESS FLOW DIAGRAM (PFD)

Valve Symbology

Symbol	**Name**
	Gate Valve
	Globe Valve
 	Ball Valve
	Check Valve
	Butterfly Valve

PROCESS FLOW DIAGRAM (PFD)

Valve Symbology

Symbol	**Name**
	Relief Valve
	Needle Valve
	3-Way Valve
	Angle Valve
	Butterfly Valve

Example 4

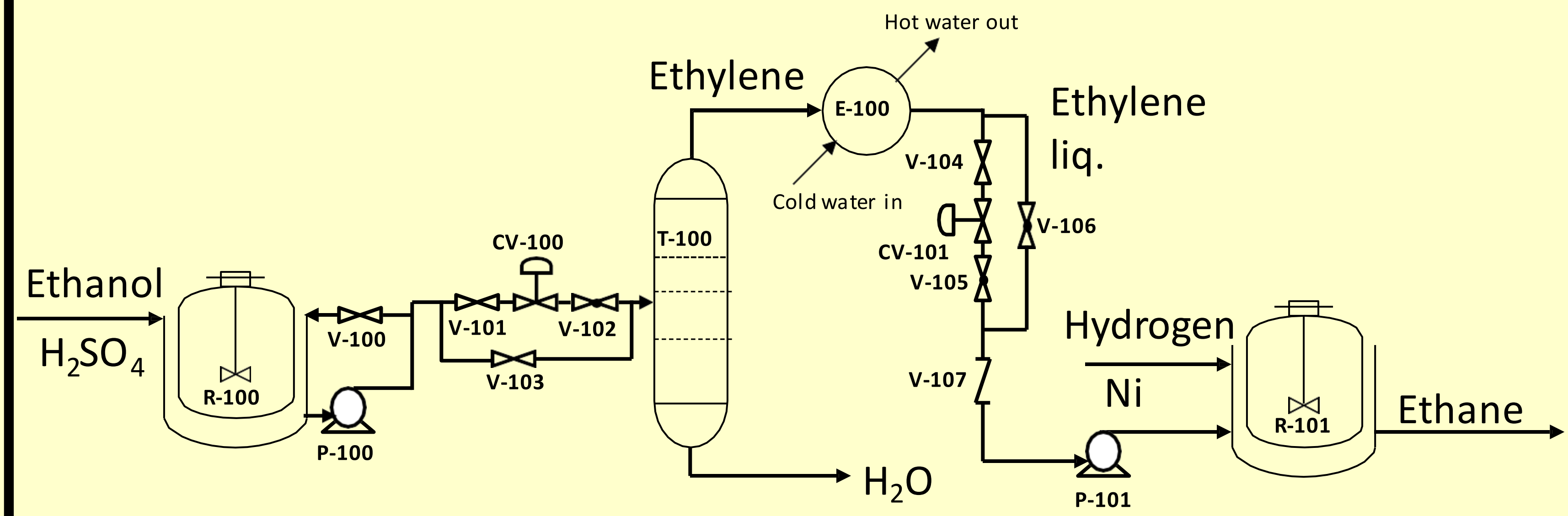
Production of Ethane from Ethanol

Ethanol is feed to continuous reactor with presence of Acid Sulphuric catalyzer to produce ethylene. Distillation process then will be applied to separate ethylene-H_2O mixture. Ethylene as a top product is then condensate with condenser to perform liquid ethylene. Hydrogenation of ethylene applies in another reactor with presence of Nickel catalyzer to produce ethane as a final product. Develop PFD for these processes.

$$CH_3CH_2OH \xrightarrow{H_2SO_4} CH_2{=}CH_2 + H_2O$$

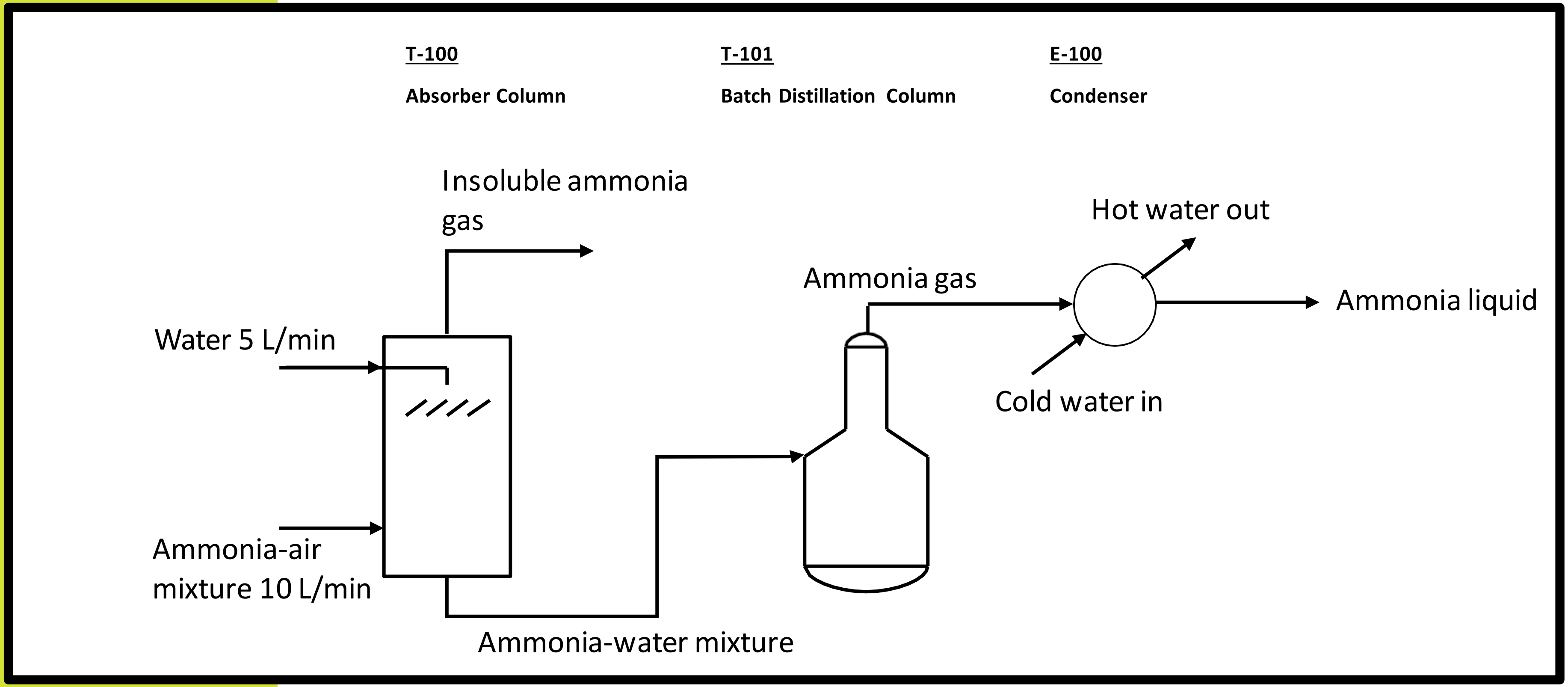
$$CH_2{=}CH_2 + H_2 \xrightarrow[Ni]{} CH_3CH_3$$

R-100	P-100	T-100	E-100	P-101	R-101
Reactor	Pump	Distillation Column	Condenser	Pump	Reactor



Example 5

Ammonia-air mixture is feed to the bottom stream of an absorber with flow rate of 10L/min. Water then feed to the upper stream of the same absorber with desired flow rate of 5L/min. There are two outputs from the absorber where upper stream is insoluble NH_3 and bottom stream is NH_3-Water mixture. This NH_3-water mixture then feed up to a batch distillation column. The column produces ammonia gas as a top product which this product then will be condensate with a condenser to produce liquid ammonia. Develop Process Flow Diagram (PFD) for this process.



PROCESS FLOW DIAGRAM (PFD)

Process Unit Tagging and Numbering

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 - are the number designation for each item in an equipment class

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

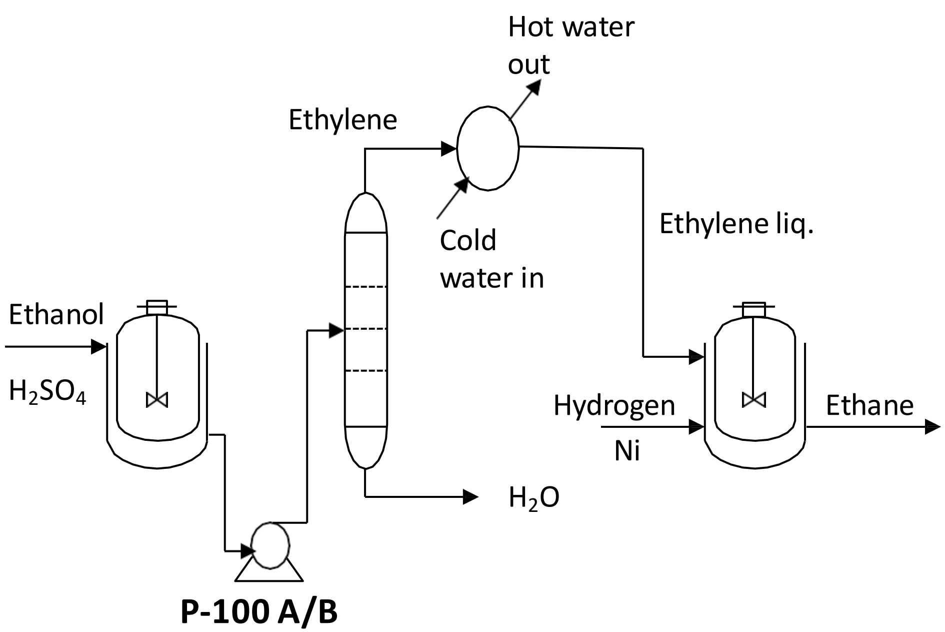
Supplemental Information

Additional description of equipment given on top of PFD

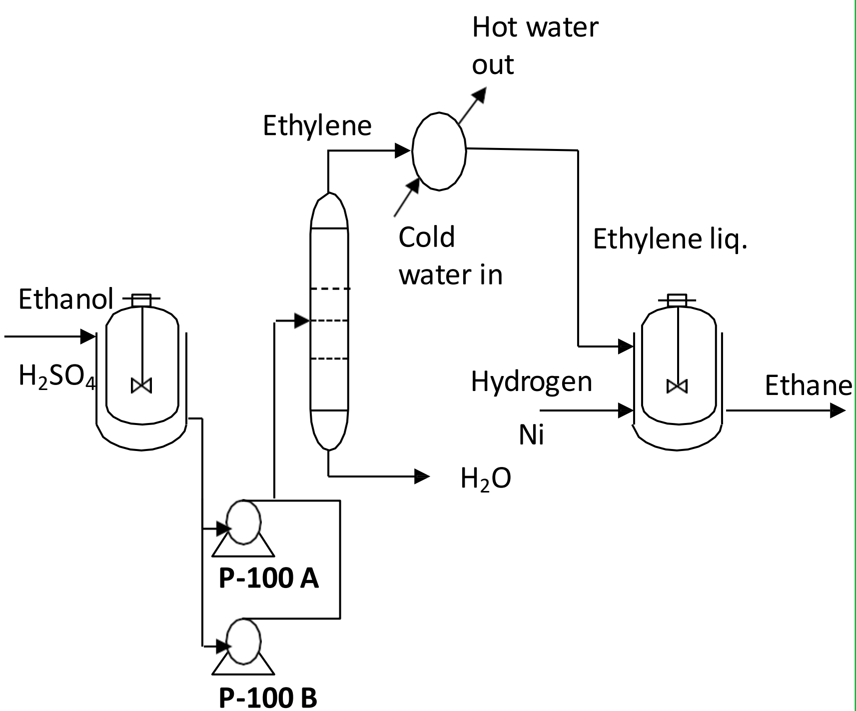
PROCESS FLOW DIAGRAM (PFD)

A/B Letter

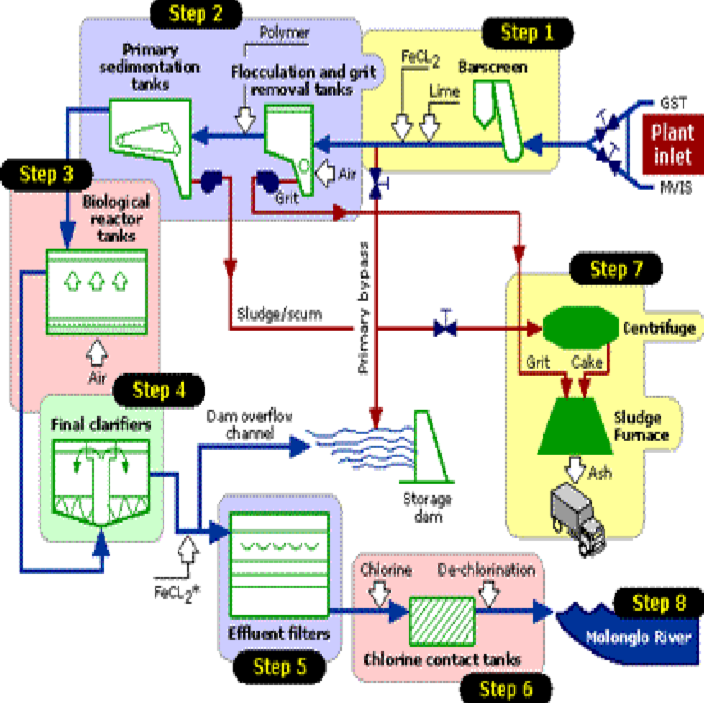
Example

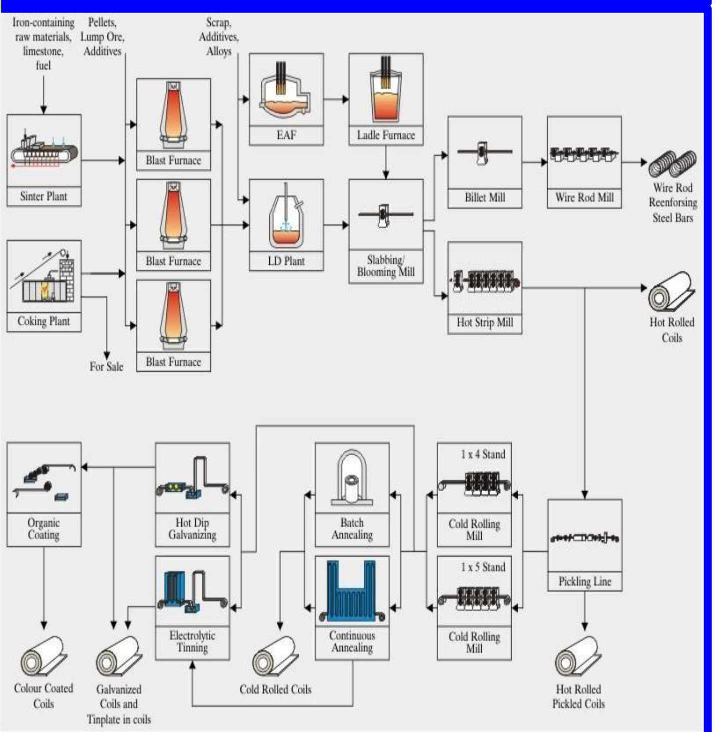


In PFD



In Real Plant





1. Major Pieces Of Equipment

2. Utility Streams

PFD

4. Basic Control Loops

3. Process Flow Streams

PROCESS FLOW DIAGRAM (PFD)

PFD will contains the following information:-

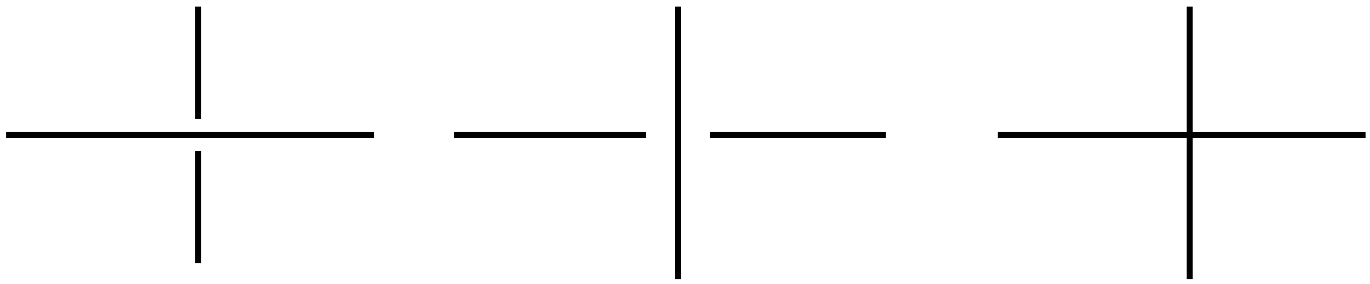
All **process flow streams**: identification by a number, process condition, chemical composition.

PROCESS FLOW DIAGRAM (PFD)

Stream Numbering and Drawing

- Number streams from left to right as much as possible.

- Horizontal lines are dominant.

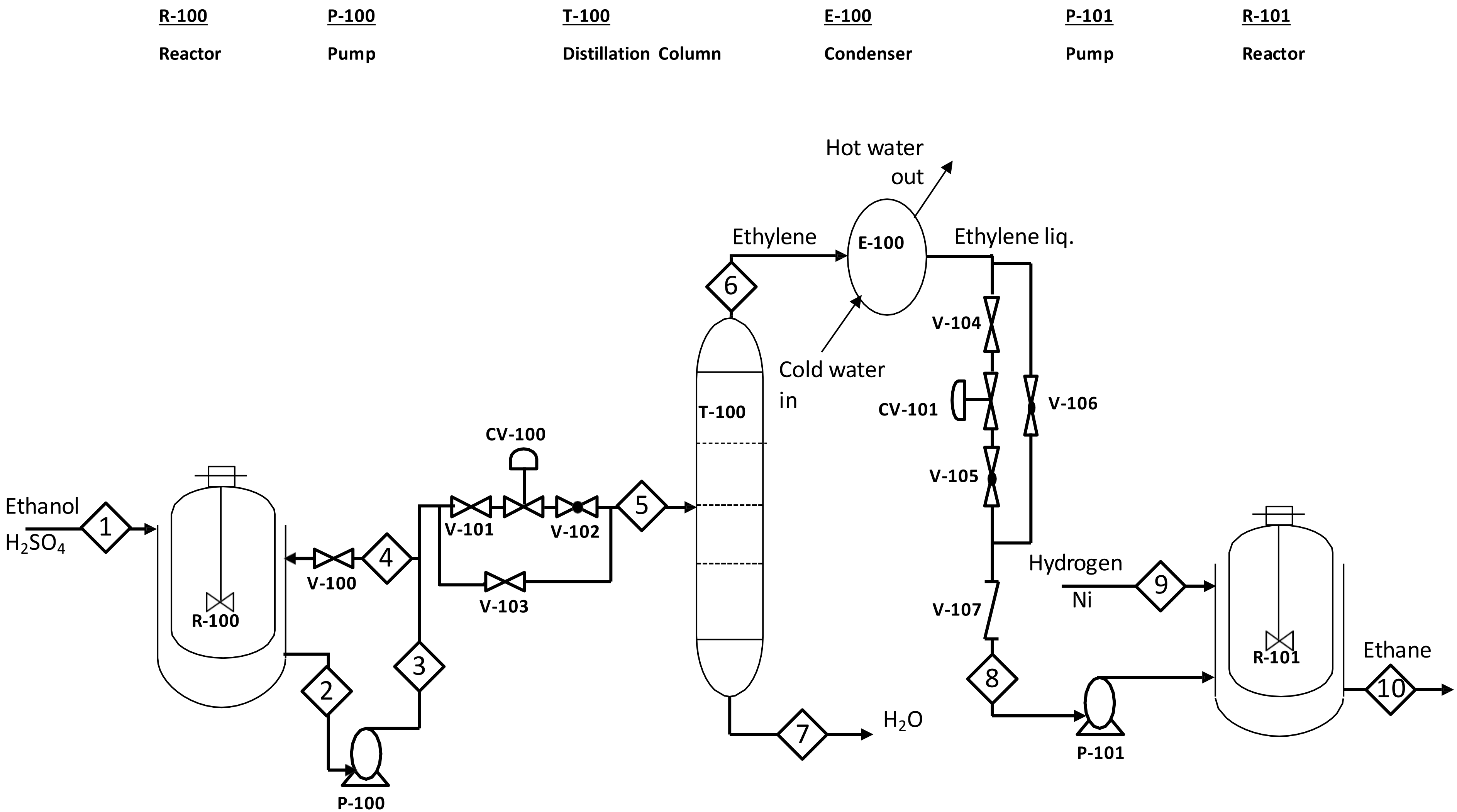


Yes

No

No

EXAMPLE 4- CONT'



PROCESS FLOW DIAGRAM (PFD)

Stream Information

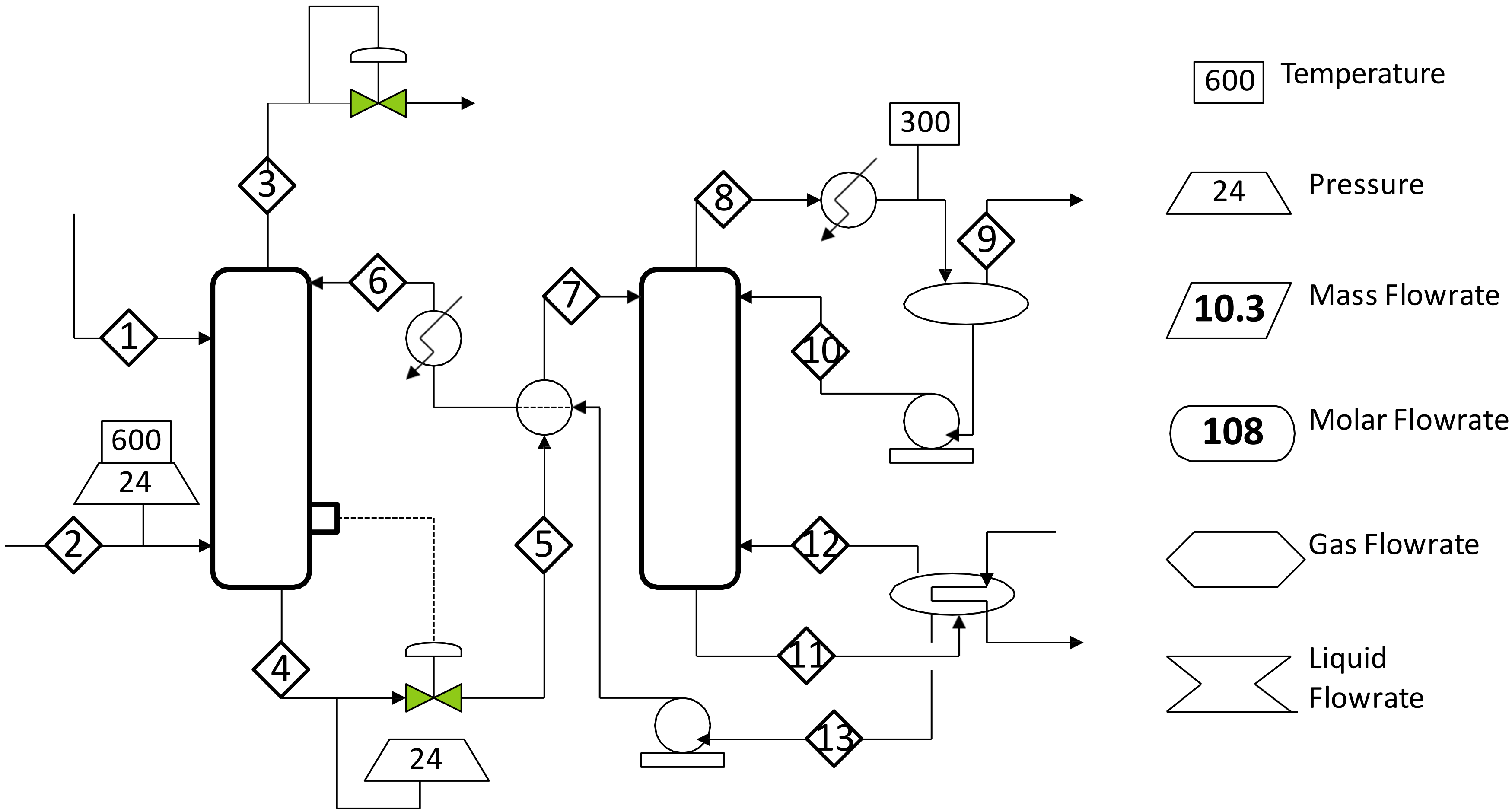
-Since diagrams are small not much stream information can be included.

-Include important data – around reactors and towers, etc.

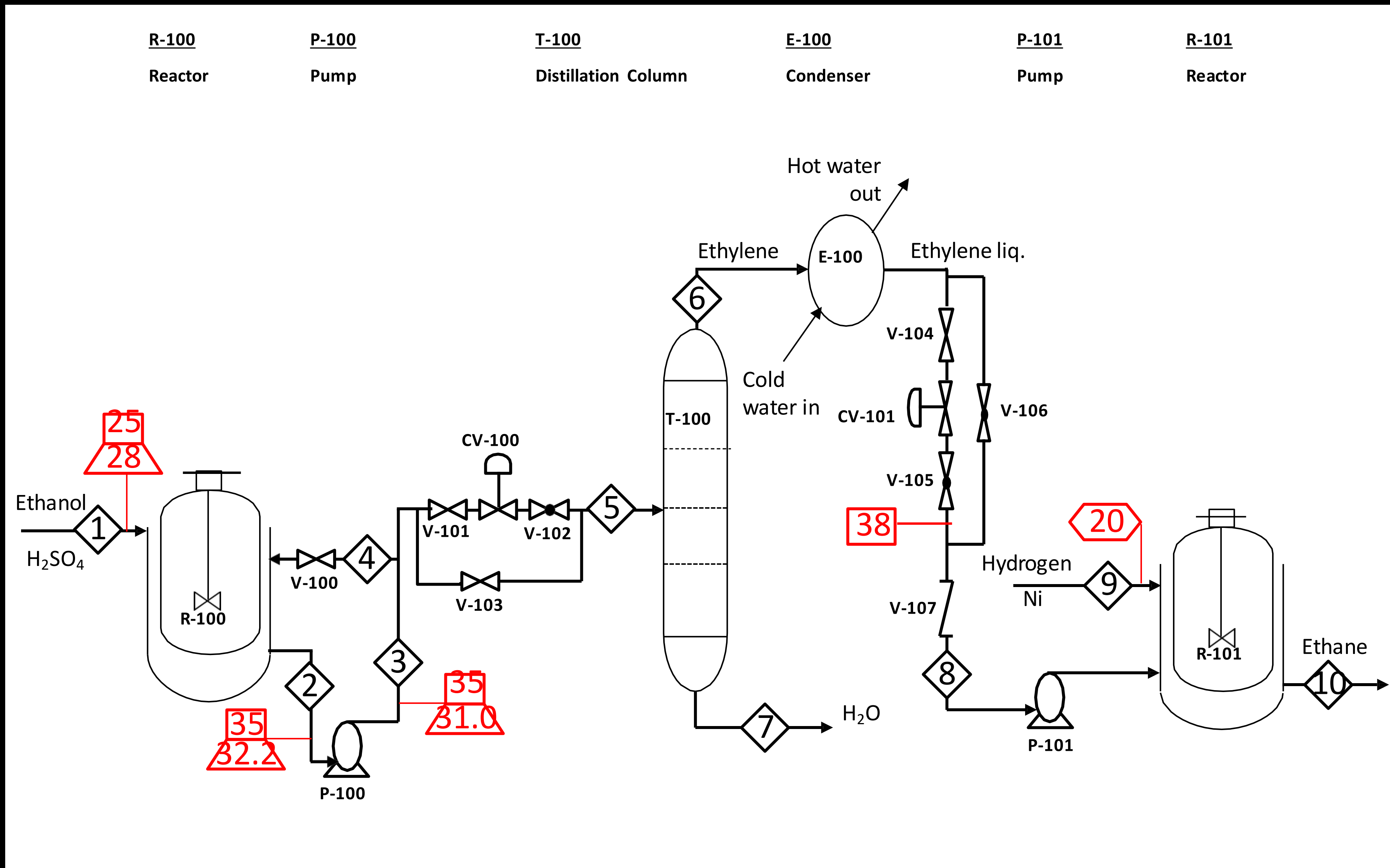
- Flags are used
- Full stream data

PROCESS FLOW DIAGRAM (PFD)

Stream Information - Flag



Example 4- cont'

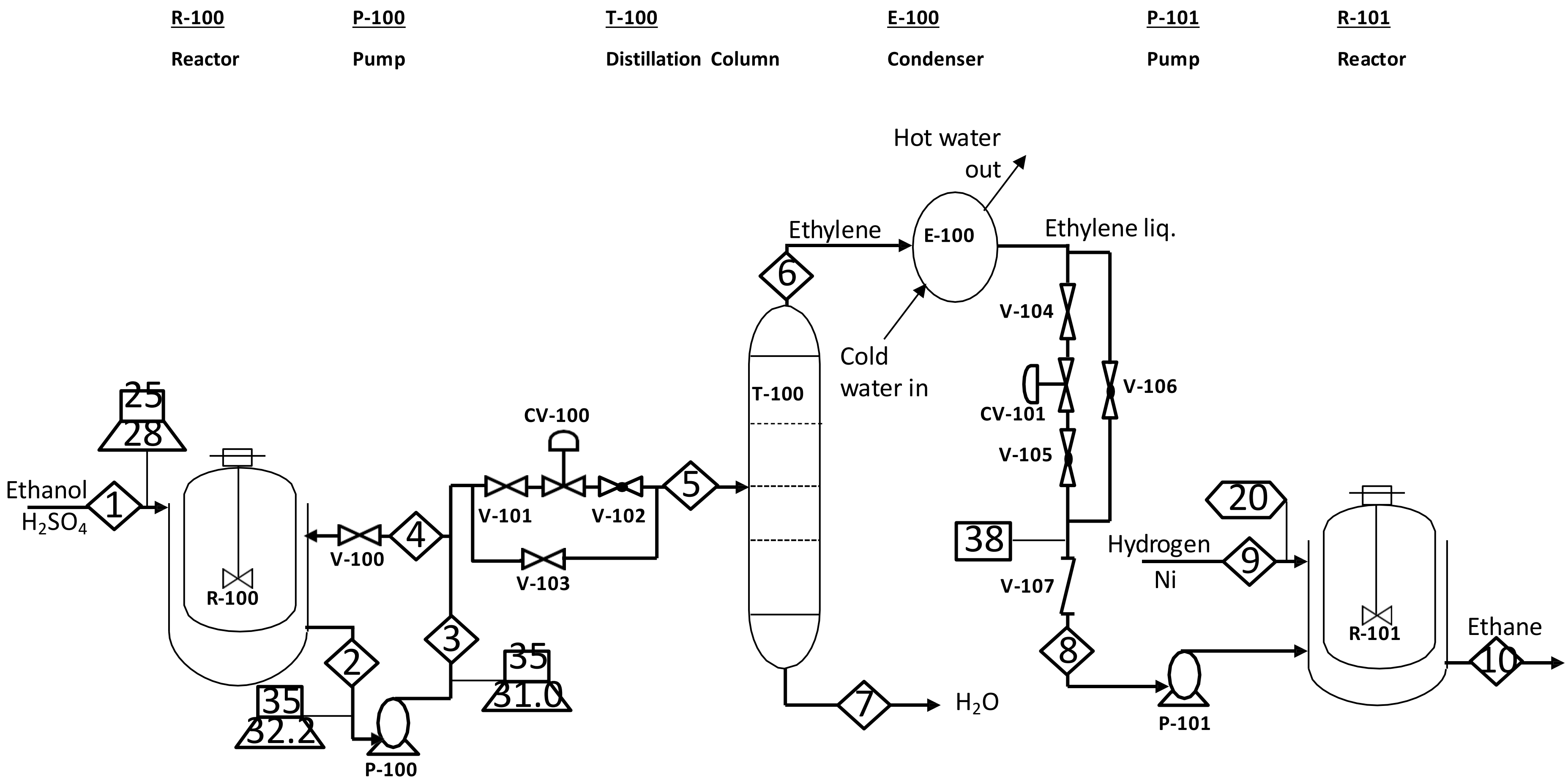


PROCESS FLOW DIAGRAM (PFD)

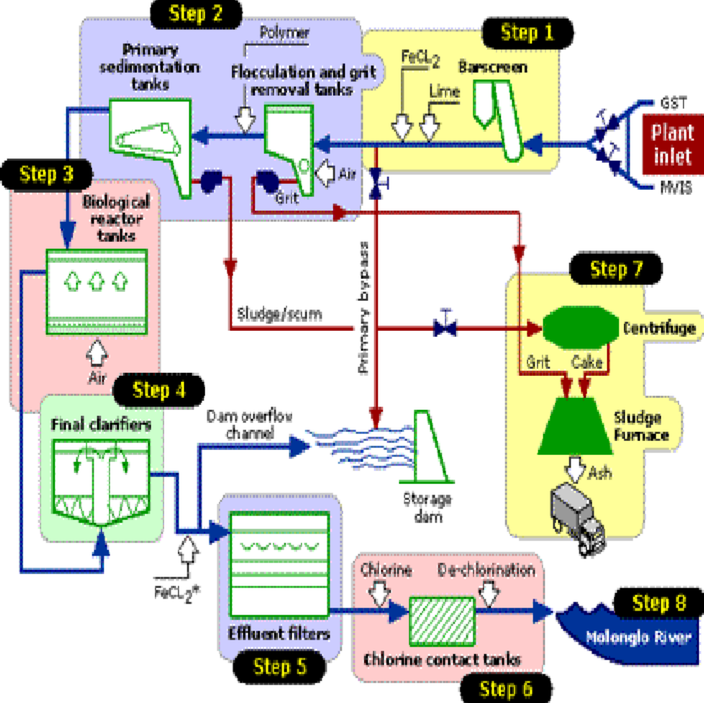
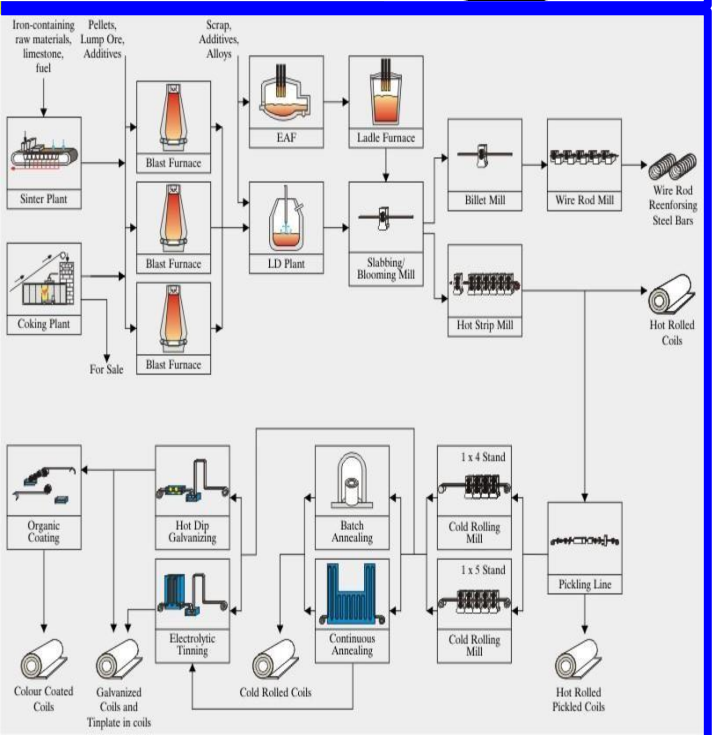
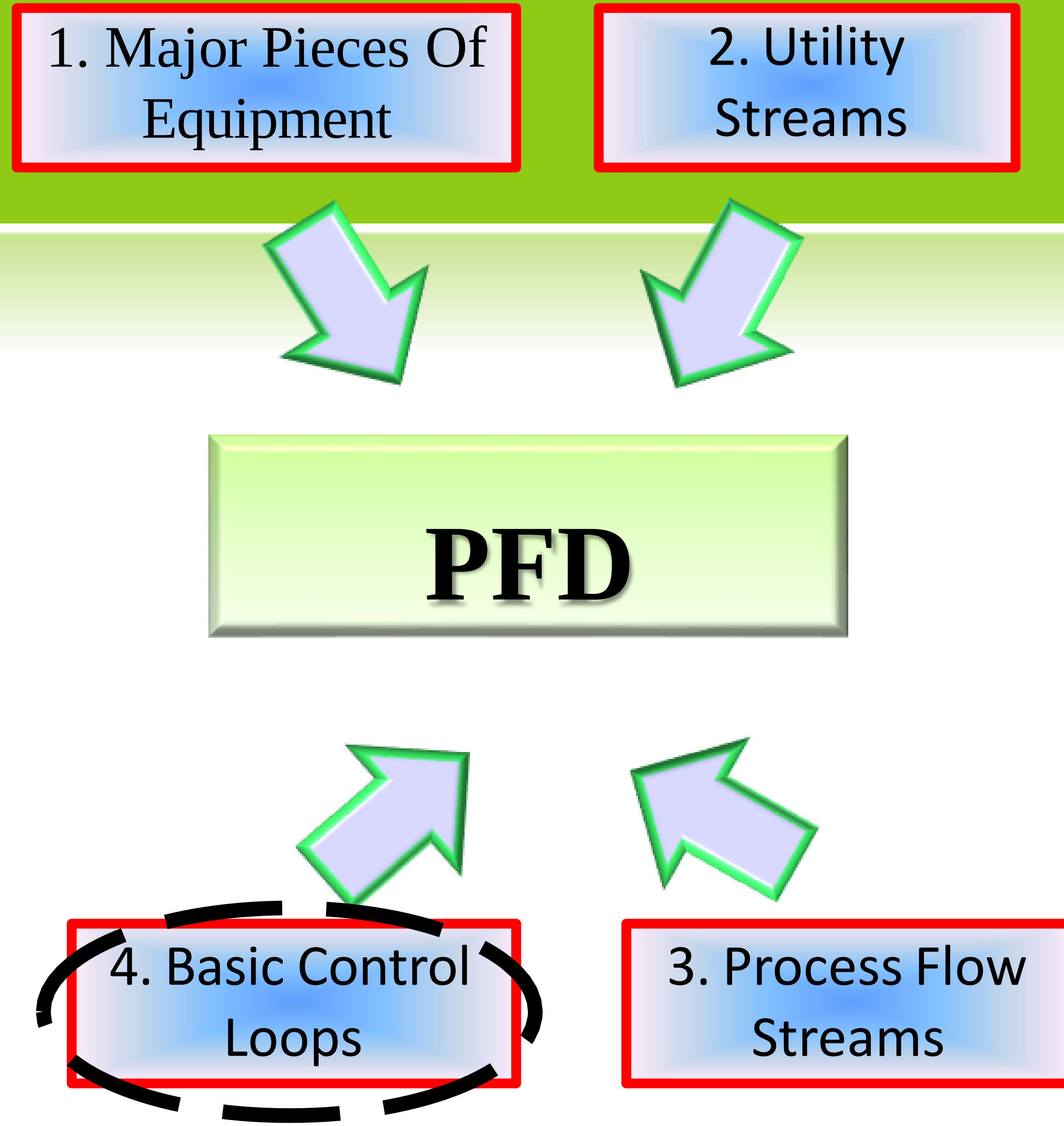
Stream Information - Full stream data:

Stream Number	1	2	3	4	5	6	7	8	9	10
Temperature (oC)	25.0	35.0	35.0	35.0	35.0	60.3	41	38	54.0	45.1
Pressure (psi)	28	32.2	31.0	31.0	30.2	45.1	31.3	24.0	39.0	2.6
Vapor fraction										
Mass flow (tonne/hr)	10.3	13.3	0.82	20.5	6.41	20.5	0.36	9.2	20.9	11.6
Mole flow (kmol/hr)	108	114.2	301.0	1204.0	758.8	1204.4	42.6	1100.8	142.2	244.0

EXAMPLE 4- CONT'



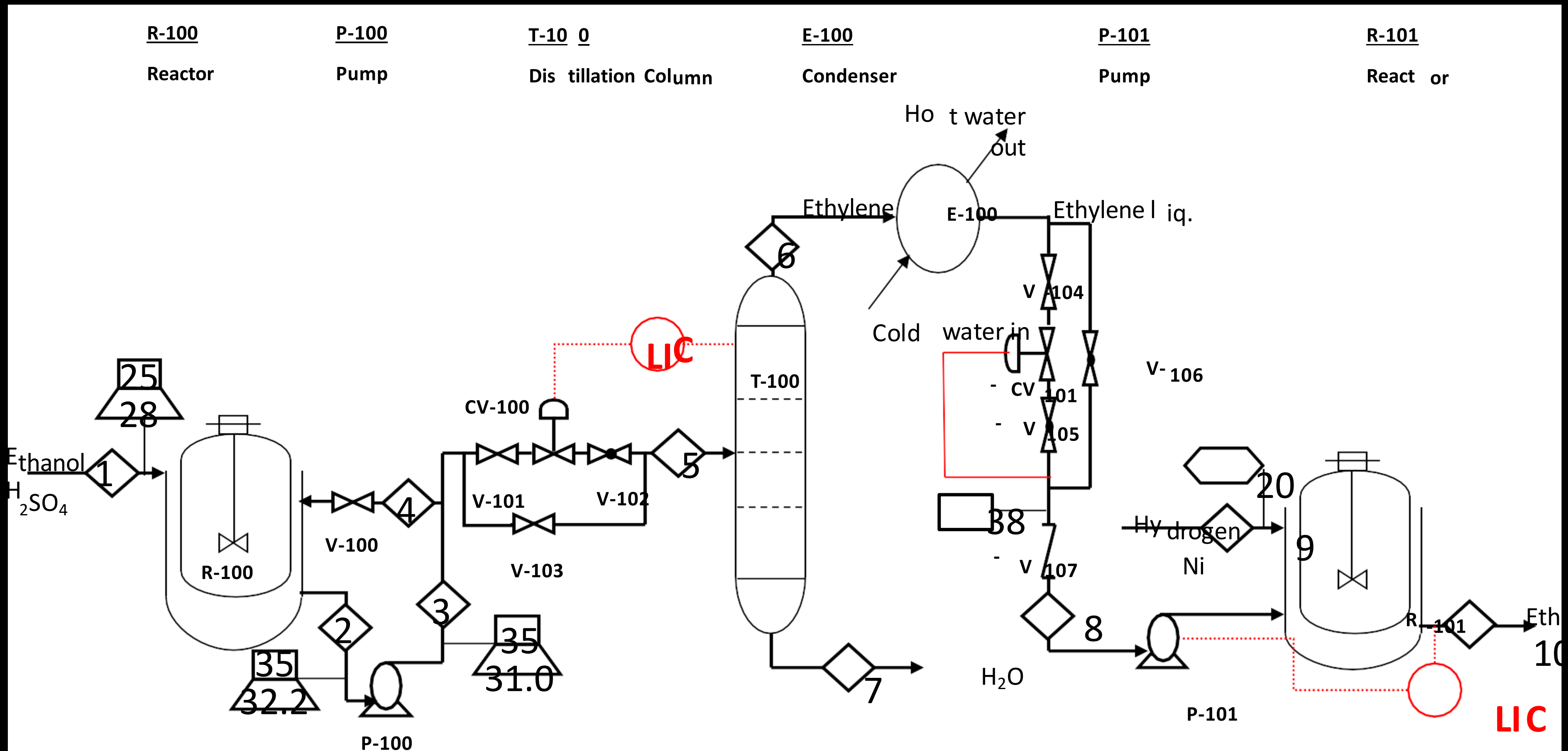
Stream Number	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	25.0	35.0	35.0	35.0	35.0	60.3	41	38	54	45.1
Pressure (psi)	28	32.2	31.0	31.0	30.2	45.1	31.3	24.0	39	2.6
Vapor fraction										
Mass flow (tonne/hr)	10.3	13.3	0.82	20.5	6.41	20.5	0.36	9.2	20.9	11.6
Mole flow (kmol/hr)	108	114.2	301.0	1204.0	758.8	1204.4	42.6	1100.8	142.2	244.0


Step 1
Step 2
Step 3
Step 4
Step 5
Step 6
Step 7
Step 8
Polymer
Primary sedimentation tanks
Flocculation and grit removal tanks
$FeCl_2$
Barscreen
Lime
GST
Plant inlet
MVIS
Air
Grit
Biological reactor tanks
Sludge/scum
Primary bypass
Centrifuge
Grit
Cake
Sludge Furnace
Ash
Air
Final clarifiers
Dam overflow channel
Storage dam
$FeCl_2$*
Effluent filters
Chlorine
De-chlorination
Chlorine contact tanks
Molonglo River

Iron-containing raw materials, limestone, fuel
Pellets, Lump Ore, Additives
Scrap, Additives, Alloys
Sinter Plant
Coking Plant
For Sale
Blast Furnace
Blast Furnace
Blast Furnace
EAF
Ladle Furnace
LD Plant
Slabbing/ Blooming Mill
Billet Mill
Wire Rod Mill
Wire Rod Reenforsing Steel Bars
Hot Strip Mill
Hot Rolled Coils
Organic Coating
Hot Dip Galvanizing
Batch Annealing
1 x 4 Stand
Cold Rolling Mill
Pickling Line
Electrolytic Tinning
Continuous Annealing
1 x 5 Stand
Cold Rolling Mill
Colour Coated Coils
Galvanized Coils and Tinplate in coils
Cold Rolled Coils
Hot Rolled Pickled Coils

1. Major Pieces Of Equipment
2. Utility Streams
PFD
4. Basic Control Loops
3. Process Flow Streams

PROCESS FLOW DIAGRAM (PFD)

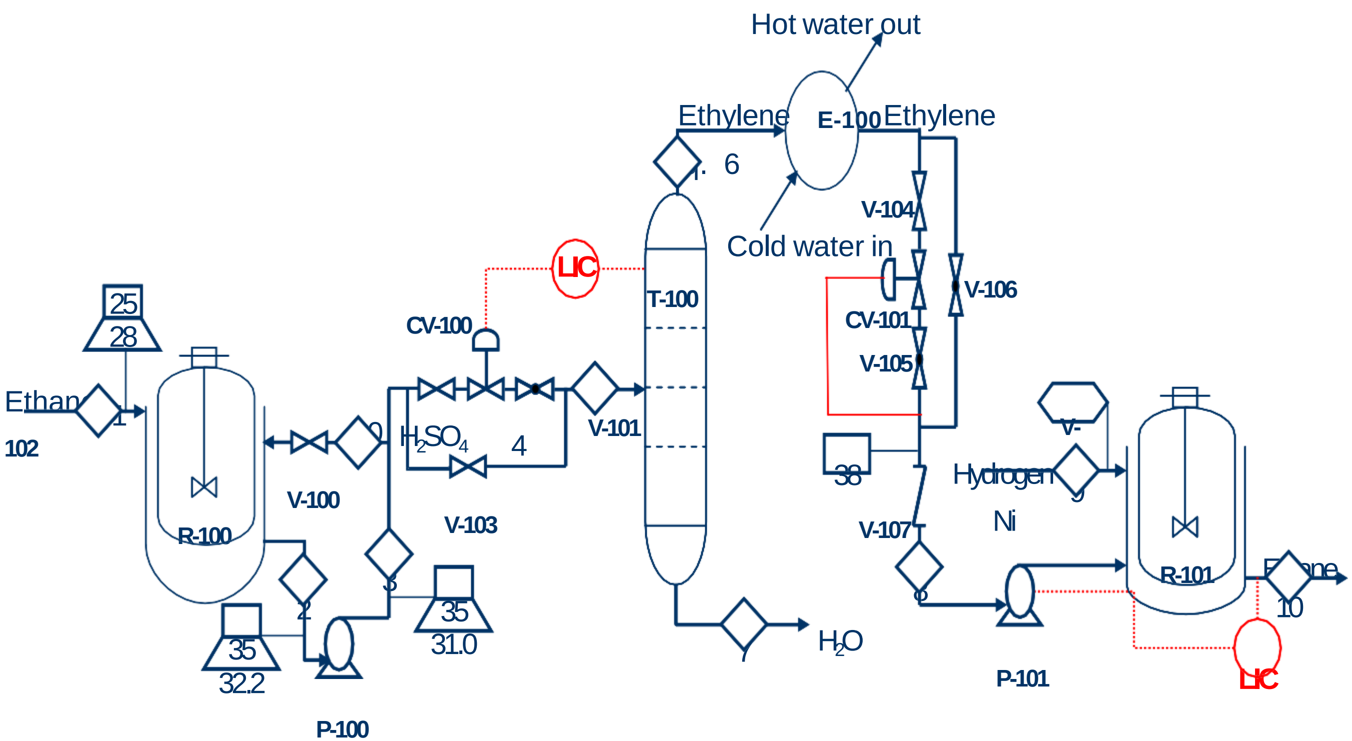
PFD will contains the following information:-

- Basic **control loops**: showing the control strategy used to operate the process under normal operations.



Stream Number	1	2	3	4	5	6	7	8	9	10
Temperature (oC)	25.0	35.0	35.0	35.0	35.0	60.3	41	38	54	45
Pressure (psi)	28	32.2	31.0	31.0	30.2	45.1	31.3	24.0	39	2.
Vapor fraction										
Mass flow (tonne/hr)	10.3	13.3	0.82	20.5	6.41	20.5	0.36	9.2	20.9	11
Mole flow (kmol/hr)	108	114.2	301.0	1204.0	758.8	1204.4	42.6	1100.8	142.2	24

R-100	P-100	T-100	E-100	P-101	R-101
Reactor	Pump	Distillation Column	Condenser	Pump	Reactor



NOTE:

- GATE VALVE
- GLOBE VALVE
- CHECK
- VALVE
- PNEUMATIC DIAPHRAGM VALVE

Stream Number	1	2	3	4	5	6	7	8	9	10
Temperature (oC)	25.0	35.0	35.0	35.0	35.0	60.3	41	38	54	45.1
Pressure (psi)	28	32.2	31.0	31.0	30.2	45.1	31.3	24.0	39	2.6
Vapor fraction										
Mass flow (tonne/hr)	10.3	13.3	0.82	20.5	6.41	20.5	0.36	9.2	20.9	11.6
Mole flow (kmol/hr)	108	114.2	301.0	1204.0	758.8	1204.4	42.6	1100.8	142.2	244.0

FLYSIS CHEMICAL (M) SDN. BHD

fs

PROCESS FLOW DIAGRAM

PRODUCTION OF ETHANE FROM ETHANOL

ISSUED :

DRAWN BY :

PAGE : 1 OF 1

APPROVED BY :

Block Flow Diagram (BFD)

Process Flow Diagram (PFD)

PROCESS DIAGRAMS

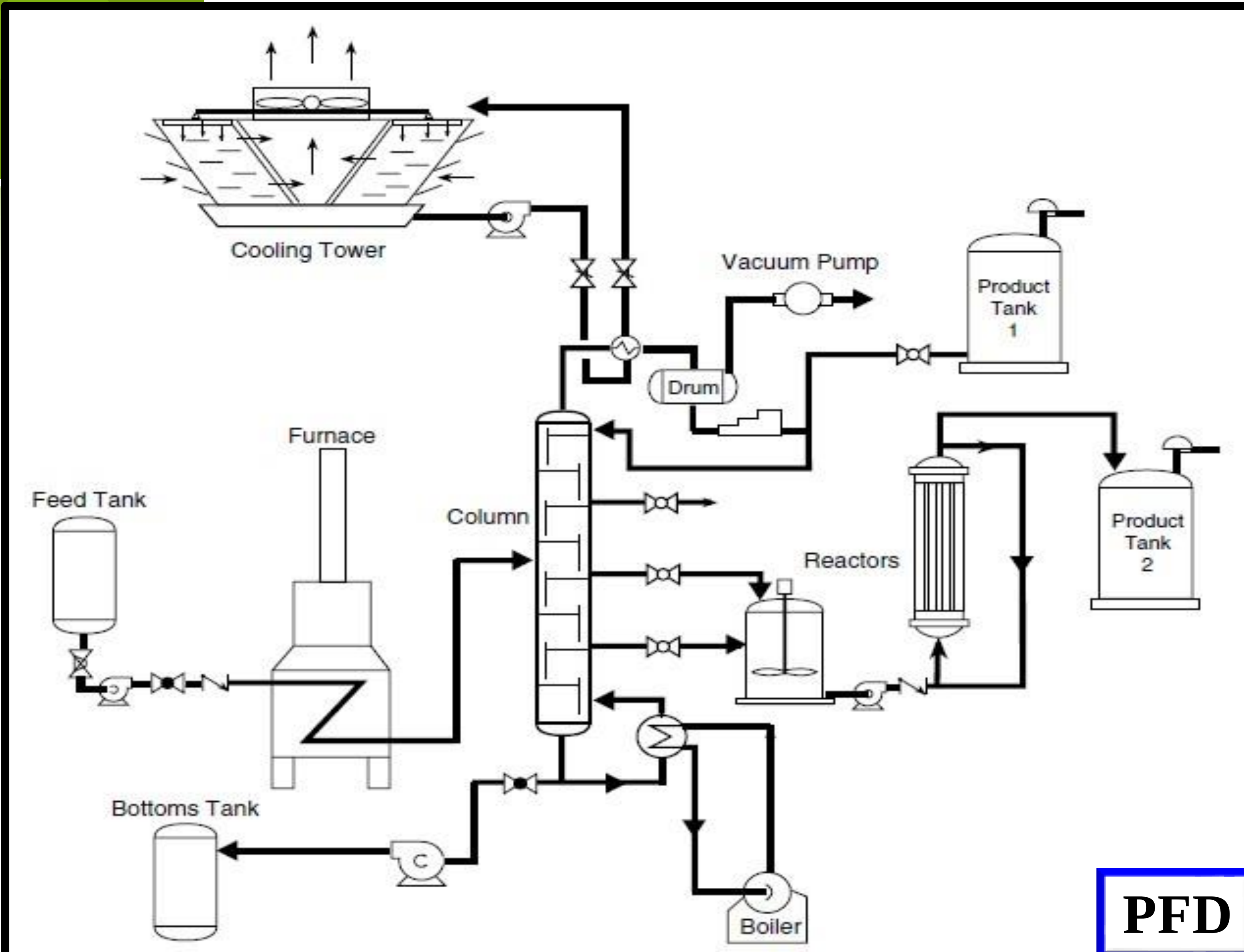
Process equipments symbol and numbering

Piping and Instrumentation Diagram (P&ID)

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

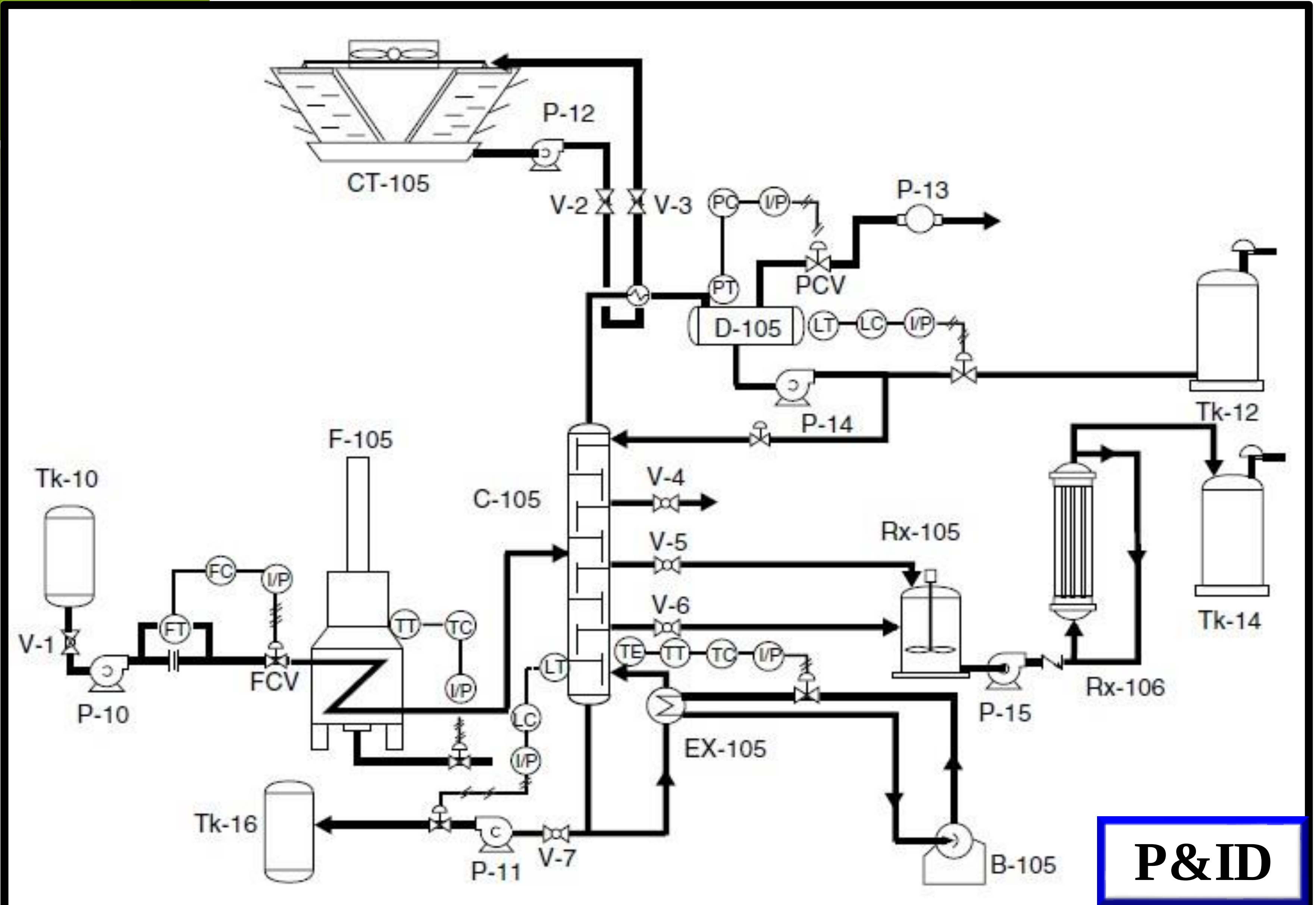
- Also known as **"PROCESS & INSTRUMENTATION DIAGRAM"**
- Detailed graphical representation of a process including the hardware and software **(i.e piping, equipment, and instrumentation)** necessary to design, construct and operate the facility.
- Common synonyms for P&IDs include **Engineering Flow Diagram (EFD), Utility Flow Diagram (UFD) and Mechanical Flow Diagram (MFD).**

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



PFD

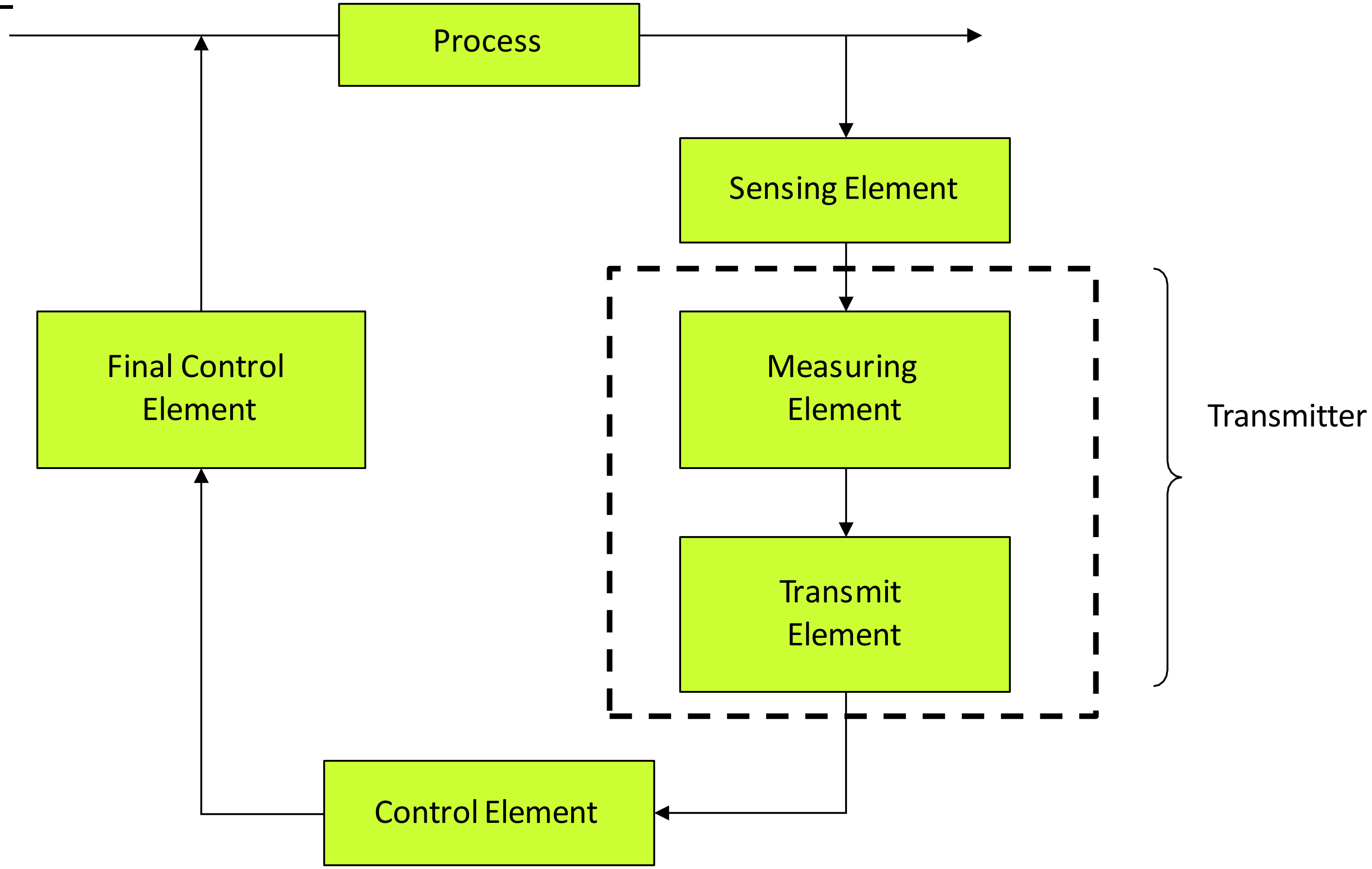
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



P&ID

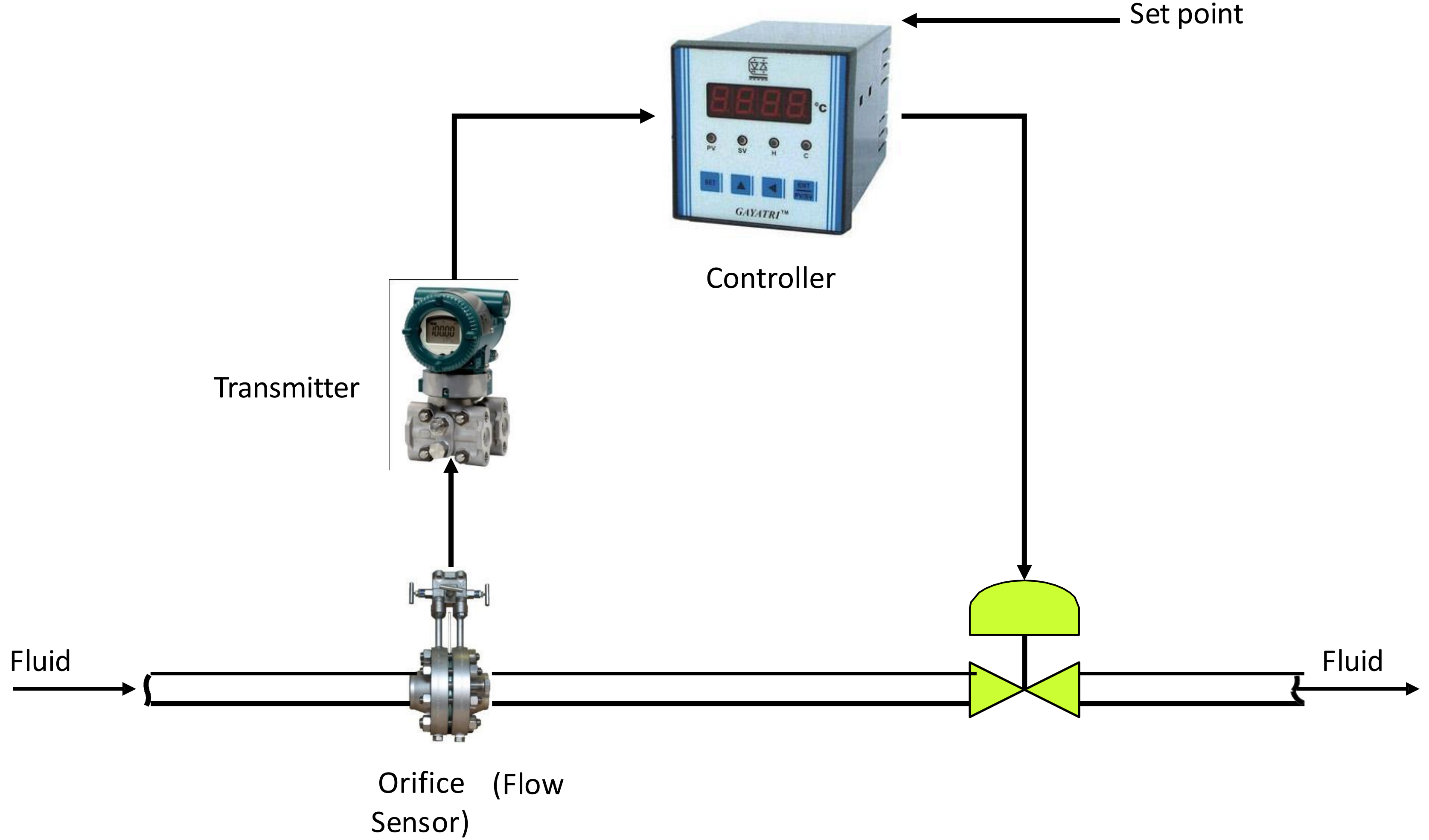
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Basic Loop



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Basic Loop



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

SENSORS (Sensing Element)

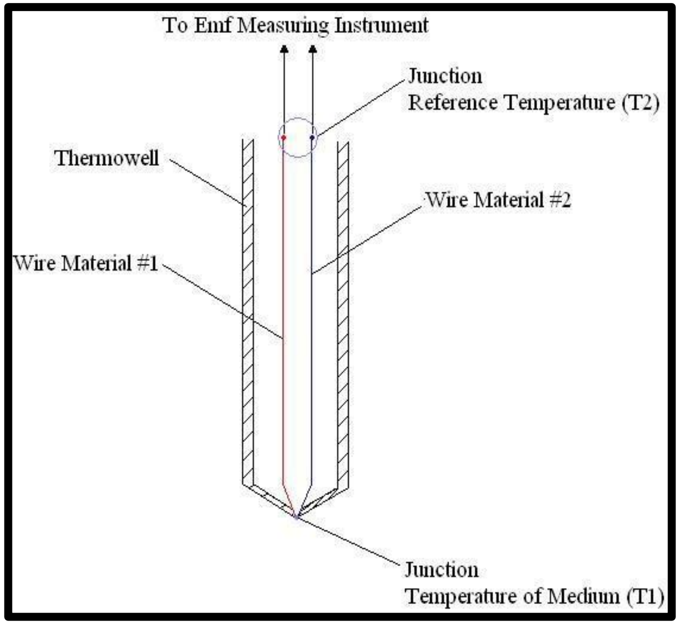
- ✓ A device, such as a photoelectric cell, that receives and responds to a signal or stimulus.
- ✓ A device, usually electronic, which detects a variable quantity and measures and converts the measurement into a signal to be recorded elsewhere.
- ✓ A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.
- ✓ For example, a mercury thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube. A thermocouple converts temperature to an output voltage which can be read by a voltmeter.
- ✓ For accuracy, all sensors need to be calibrated against known standards.

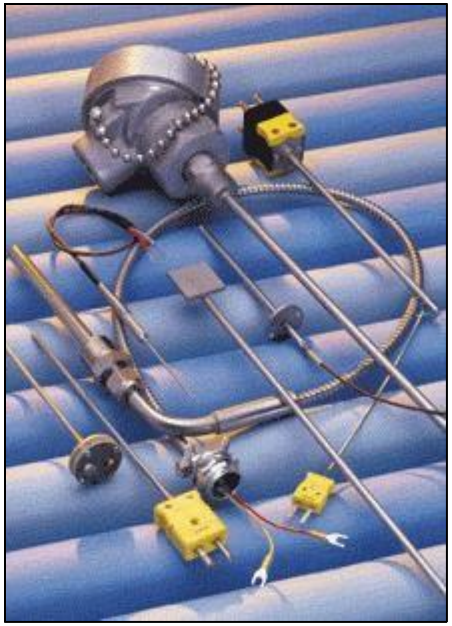
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

TEMPERATURE SENSOR

1. Thermocouple

A **thermocouple** is a junction between two different metals that produces a voltage related to a temperature difference. Thermocouples are a widely used type of temperature sensor and can also be used to convert heat into electric power.





PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

TEMPERATURE SENSOR

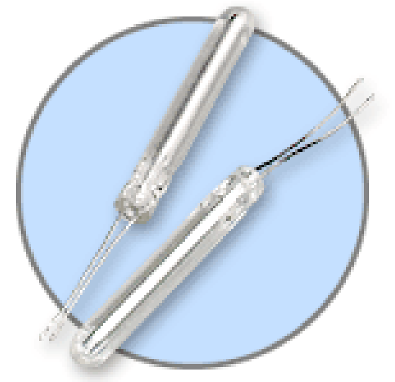
2. Resistance Temperature Detector (RTD)

✓Resistance Temperature Detectors (RTD), as the name implies, are sensors used to measure temperature by correlating the resistance of the RTD element with temperature.

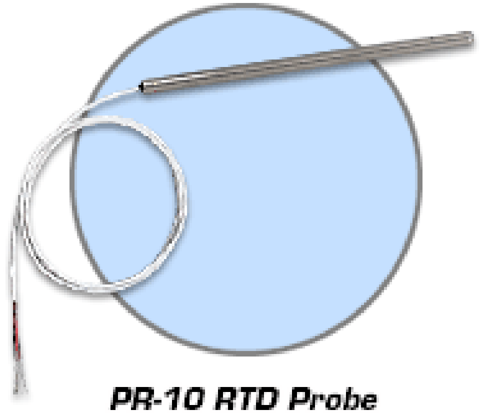
✓Most RTD elements consist of a length of fine coiled wire wrapped around a ceramic or glass core. The element is usually quite fragile, so it is often placed inside a sheathed probe to protect it.

✓The RTD element is made from a pure material whose resistance at various temperatures has been documented. The material has a predictable change in resistance as the temperature changes; it is this predictable change that is used to determine temperature.

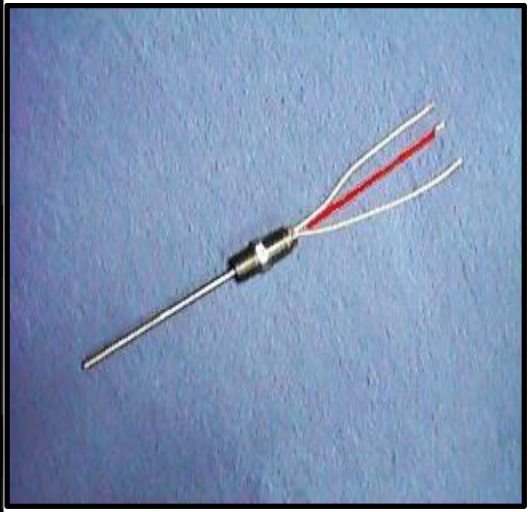
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



1PT100G RTD Elements



PR-10 RTD Probe

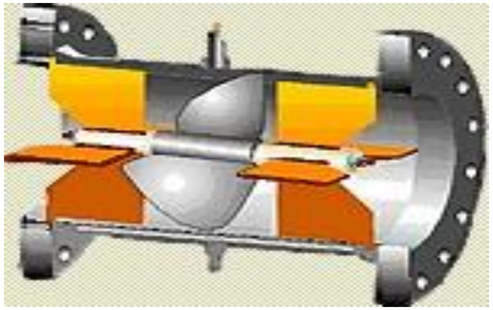


Accuracy for Standard OMEGA RTDs

Temperature °C	Ohms	°C
-200	±056	±1.3
-100	±0.32	±0.8
0	±0.12	±0.3
100	±0.30	±0.8
200	±0.48	±1.3
300	±0.64	±1.8
400	±0.79	±2.3
500	±0.93	±2.8
600	±1.06	±3.3
650	±1.13	±3.6

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

FLOW SENSOR



1. Turbine Meter

- Turbine meters are best suited to large, sustained flows as they are susceptible to start/stop errors as well as errors caused by unsteady flow states.

- In a turbine, the basic concept is that a meter is manufactured with a known cross sectional area. A rotor is then installed inside the meter with its blades axial to the product flow. When the product passes the rotor blades, they impart an angular velocity to the blades and therefore to the rotor. This angular velocity is directly proportional to the total volumetric flow rate.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

FLOW SENSOR

2. Magnetic Flow Meter

- Measurement of slurries and of corrosive or abrasive or other difficult fluids is easily made. There is no obstruction to fluid flow and pressure drop is minimal.
- The meters are unaffected by viscosity, density, temperature, pressure and fluid turbulence.
- Magnetic flow meters utilize the principle of Faraday's Law of Induction; similar principle of an electrical generator.
- When an electrical conductor moves at right angle to a magnetic field, a voltage is induced.

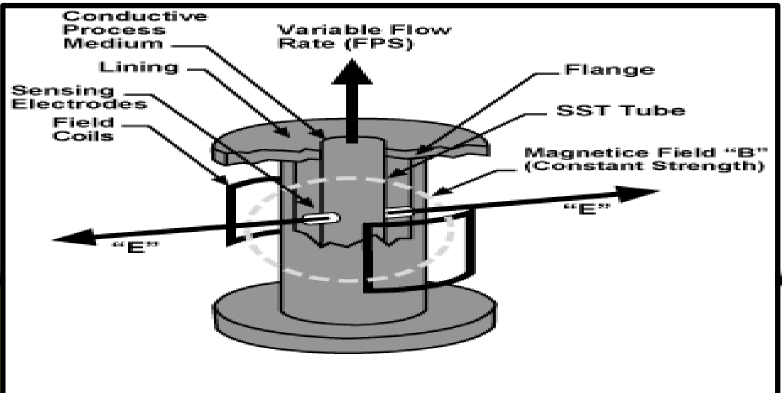
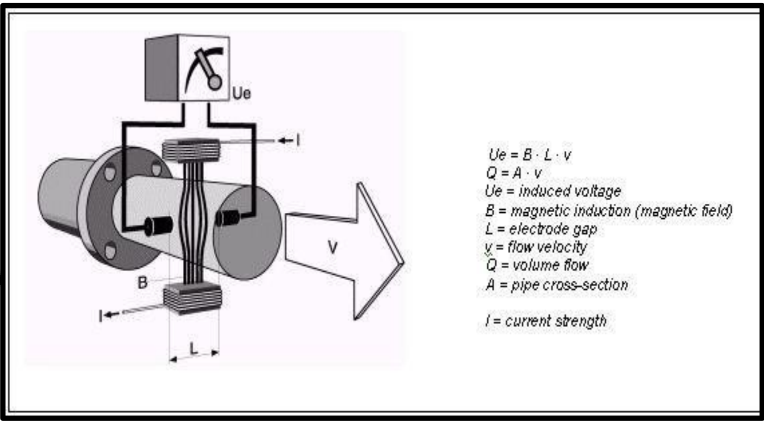
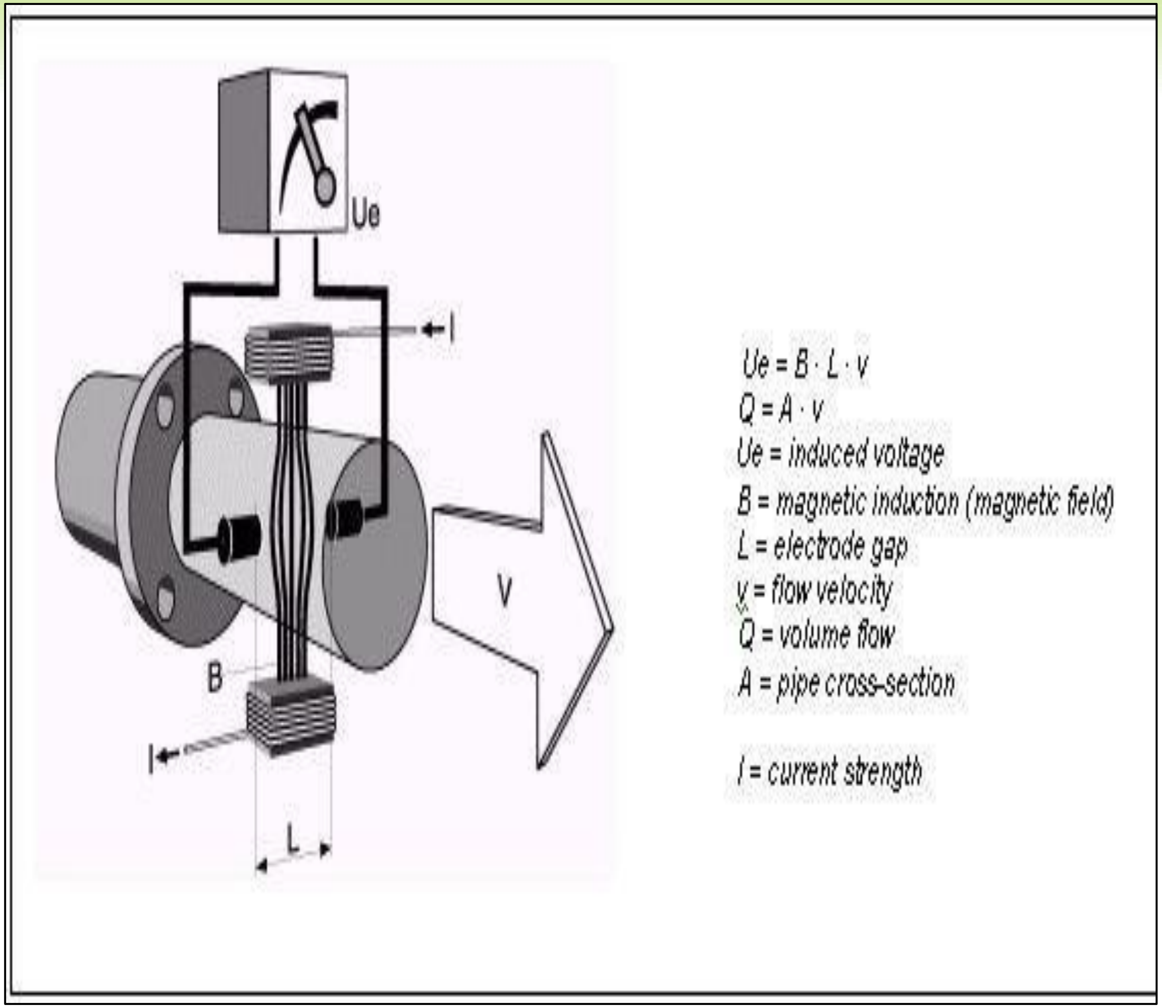


Figure 2.21 - The Magnetic Head Flow Meter



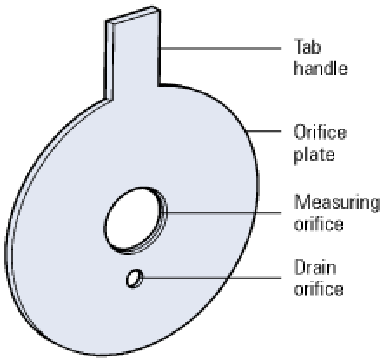
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

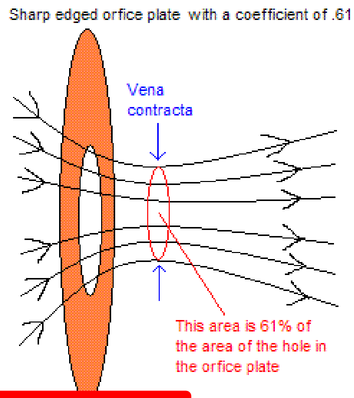
FLOW SENSOR



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

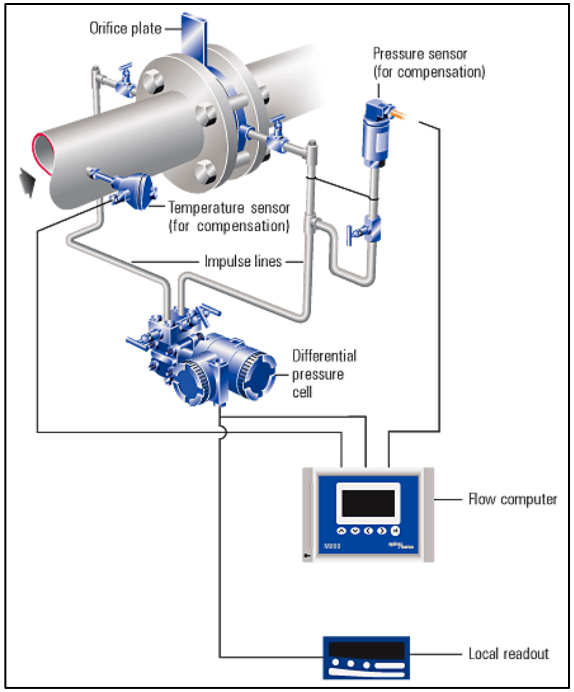
FLOW SENSOR





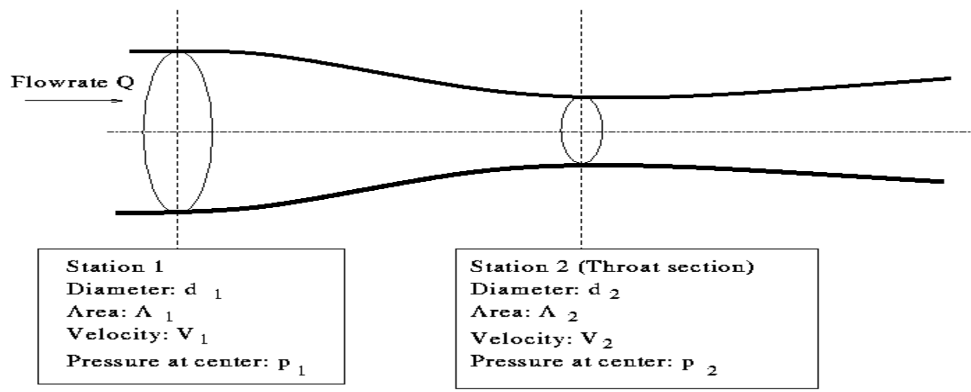
3. Orifice Meter

- An orifice meter is a conduit and restriction to create a pressure drop.
- A nozzle, venture or thin sharp edged orifice can be used as the flow restriction.
- To use this type of device for measurement, it is necessary to empirically calibrate this device.
- An orifice in a pipeline is shown in the figures with a manometer for measuring the drop in pressure (differential) as the fluid passes thru the orifice.



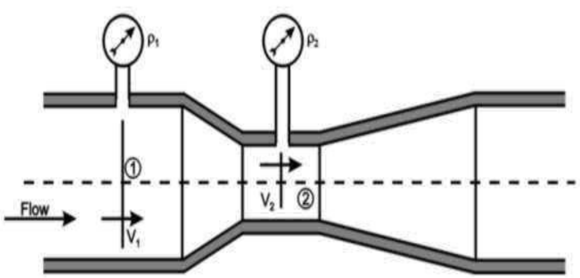
FLOW SENSOR

The venturi meter



4. Venturi Meter

- A device **for measuring flow of a fluid in terms of the drop in pressure** when the fluid flows into the constriction of a Venturi tube.



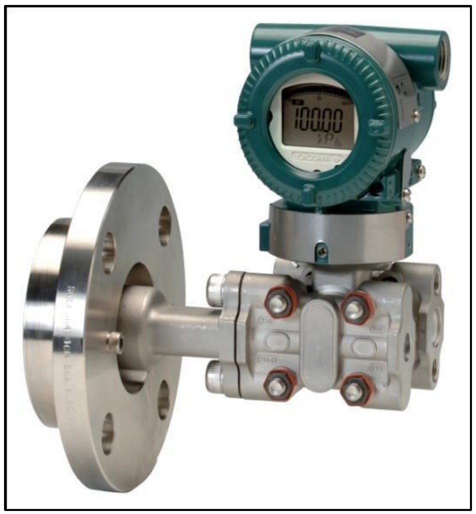
- A meter, developed by Clemens Herschel, **for measuring flow of water or other fluids through closed conduits or pipes**. It consists of a venturi tube and one of several forms of flow registeringdevices.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

TRANSMITTER

- Transmitter is **a transducer* that responds to a measurement variable and converts that input into a standardized transmission signal.**

*Transducer is a device that receives output signal from sensors.



Pressure Level Transmitter

Differential Pressure Transmitter

Pressure Transmitter

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

CONTROLLER

- **Controller** is **a device which monitors and affects the operational conditions of a given dynamical system**.

- The operational conditions are typically referred to as output variables of the system which can be affected by adjustingcertain input variables.

Indicating Controller

Recording Controller

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

FINAL CONTROL ELEMENT

- **Final Control Element** is a device that directly controls the value of manipulated variable of control loop.

- Final control element may be control valves, pumps, heaters, etc.

Pump

Control Valve

Heater

Block Flow Diagram (BFD)

Process Flow Diagram (PFD)

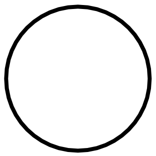
PROCESS DIAGRAMS

Process equipments symbol and numbering

Piping and Instrumentation Diagram (P&ID)

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbology



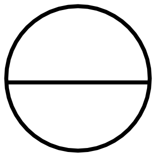
Instruments that are field mounted.

-Instruments that are mounted on process plant (i.e sensor that mounted on pipeline or process equipments.

Field mounted on pipeline

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbology

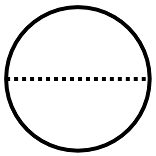


Instruments that are board mounted

-Instruments that are mounted on control board.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbology

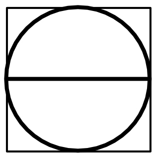


Instruments that are board mounted (invisible).

-Instruments that are mounted behind a control panel board.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbology

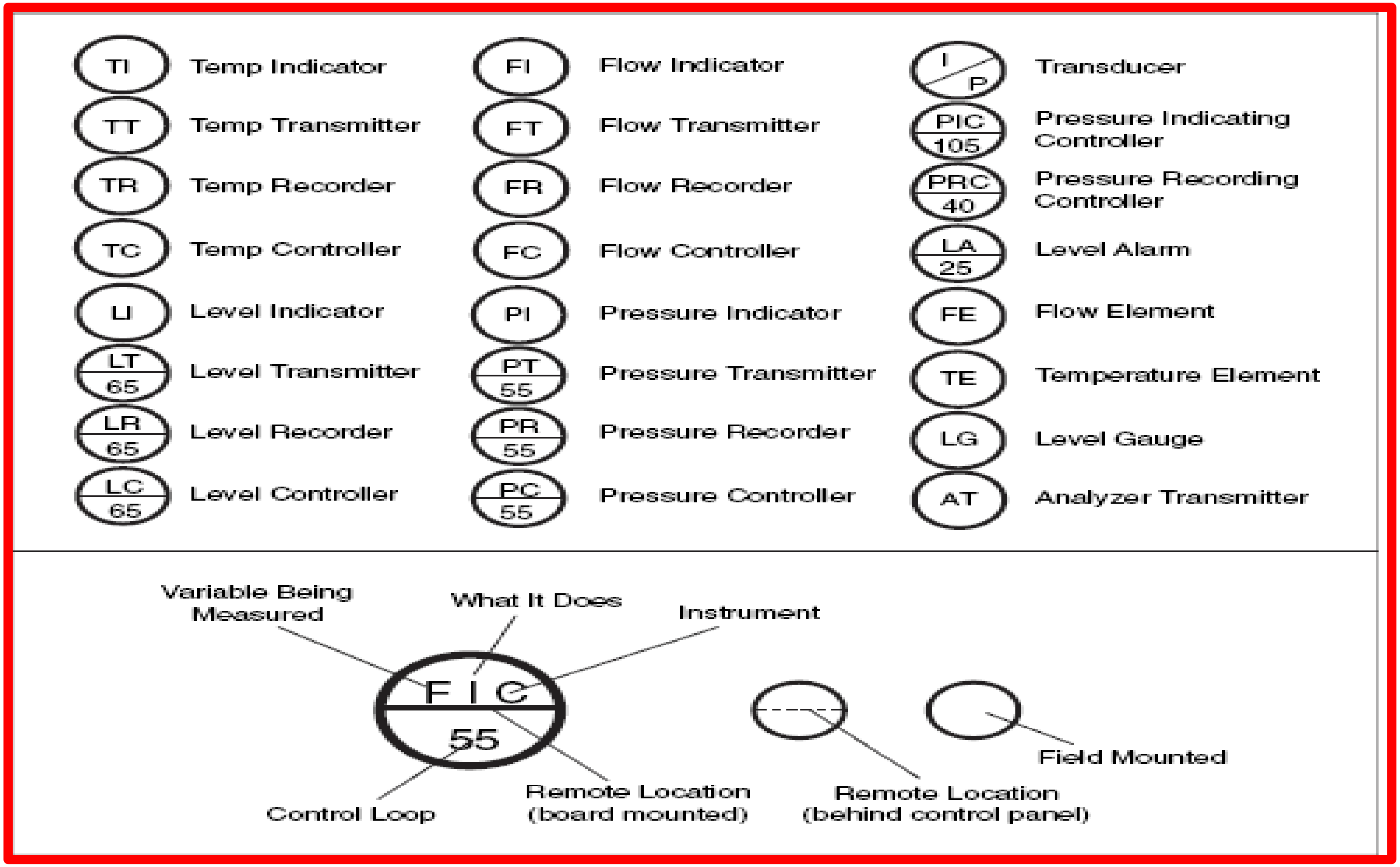


Instruments that are functioned in Distributed Control System (DCS)

- A **distributed control system** (DCS) refers to a control system usually of a manufacturing system, process or any kind of dynamic system, in which the controller elements are not central in location (like the brain) but are distributed throughout the system with each component sub-system controlled by one or more controllers. The entire system of controllers is connected by networks for communication and monitoring.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbology



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

FC	Flow Controller	PT	Pressure Transmitter
FE	Flow Element	PTD	Pressure Transducer
FI	Flow Indicator		
FT	Flow Transmitter	LC	Level Controller
FS	Flow Switch	LG	Level Gauge
FIC	Flow Indicating Controller	LR	Level Recorder
FCV	Flow Control Valve	LT	Level Transmitter
FRC	Flow Recording Controller	LS	Level Switch
		LIC	Level Indicating Controller
PC	Pressure Controller	LCV	Level Control Valve
PG	Pressure Gauge	LRC	Level Recording Controller
PI	Pressure Indicator		
PR	Pressure Recorder	TE	Temperature Element

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

PS	Pressure Switch	TI	Temperature Indicator
PIC	Pressure Indicating Controller	TR	Temperature Recorder
PCV	Pressure Control Valve	TS	Temperature Switch
PRC	Pressure Recording Controller	TC	Temperature Controller
PDI	Pressure Differential Indicator	TT	Temperature Transmitter
PDR	Pressure Differential Recorder		
PDS	Pressure Differential Switch		
PDT	Pressure Differential Transmitter		

	FIRST-LETTER (4)		SUCCEEDING-LETTERS (3)		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	Analysis (5,19)		Alarm		
B	Burner, Combustion		User's Choice (1)	User's Choice (1)	User's Choice (1)
C	User's Choice (1)			Control (13)	
D	User's Choice (1)	Differential (4)			
E	Voltage		Sensor (Primary Element)		
F	Flow Rate	Ratio (Fraction) (4)			
G	User's Choice (1)		Glass, Viewing Device (9)		
H	Hand				High (7, 15, 16)
I	Current (Electrical)		Indicate (10)		
J	Power	Scan (7)			
K	Time, Time Schedule	Time Rate of Change (4, 21)		Control Station (22)	
L	Level		Light (11)		Low (7, 15, 16)
M	User's Choice (1)	Momentary (4)			Middle, Intermediate (7,15)
N	User's Choice (1)		User's Choice (1)	User's Choice (1)	User's Choice (1)
O	User's Choice (1)		Orifice, Restriction		
P	Pressure, Vacuum		Point (Test) Connection		
Q	Quantity	Integrate, Totalize (4)			
R	Radiation		Record (17)		
S	Speed, Frequency	Safety (8)		Switch (13)	
T	Temperature			Transmit (18)	
U	Multivariable (6)		Multifunction (12)	Multifunction (12)	Multifunction (12)
V	Vibration, Mechanical Analysis (19)			Valve, Damper, Louver (13)	
W	Weight, Force		Well		
X	Unclassified (2)	X Axis	Unclassified (2)	Unclassified (2)	Unclassified (2)
Y	Event, State or Presence (20)	Y Axis		Relay, Compute, Convert (13, 14, 18)	
Z	Position, Dimension	Z Axis		Driver, Actuator, Unclassified Final Control Element	

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Signal Lines Symbology

(1) INSTRUMENT SUPPLY *
OR CONNECTION TO PROCESS

(2) UNDEFINED SIGNAL

(3) PNEUMATIC SIGNAL **

(4) ELECTRIC SIGNAL

(5) HYDRAULIC SIGNAL

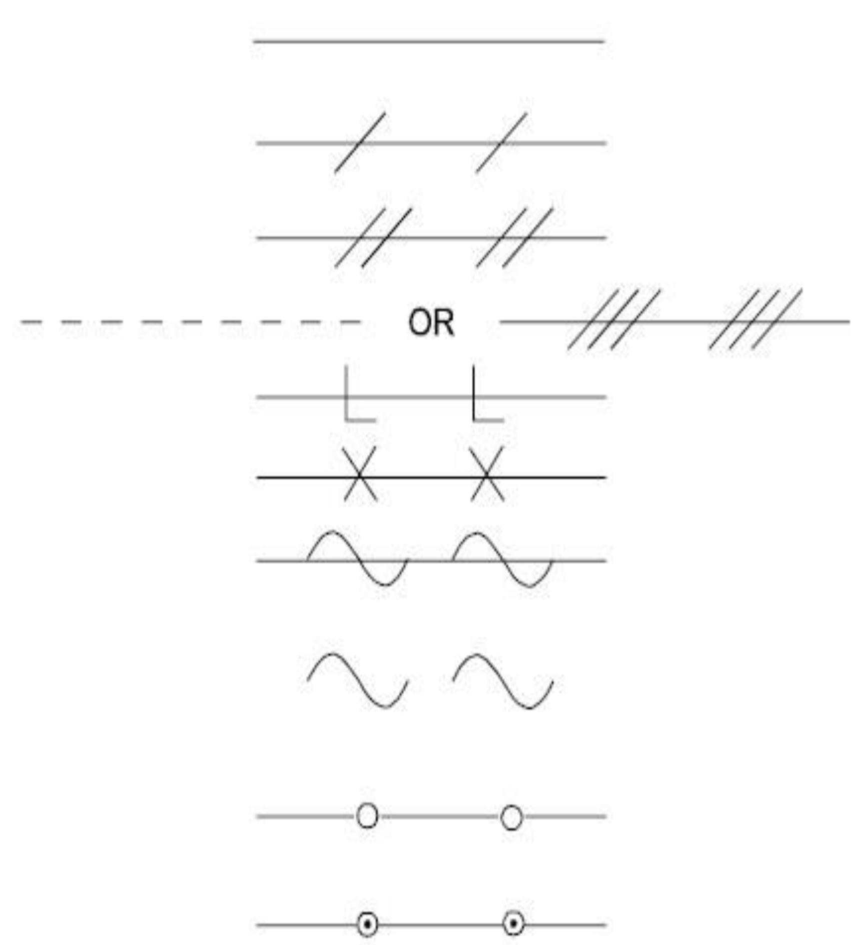
(6) CAPILLARY TUBE

(7) ELECTROMAGNETIC OR SONIC SIGNAL ***
(GUIDED)

(8) ELECTROMAGNETIC OR SONIC SIGNAL ***
(NOT GUIDED)

(9) INTERNAL SYSTEM LINK
(SOFTWARE OR DATA LINK)

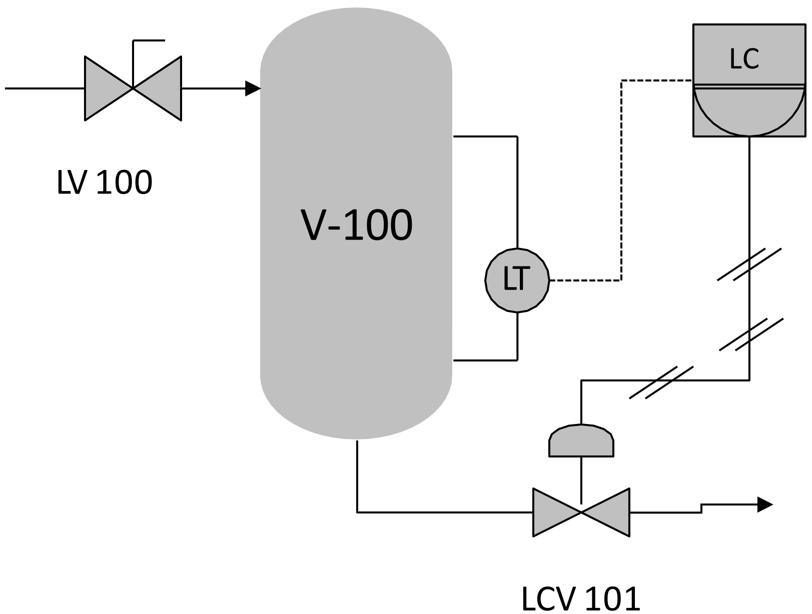
(10) MECHANICAL LINK



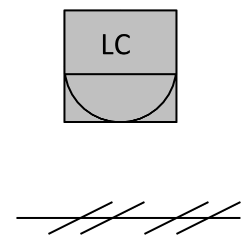
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Principal of P&ID

Example 1



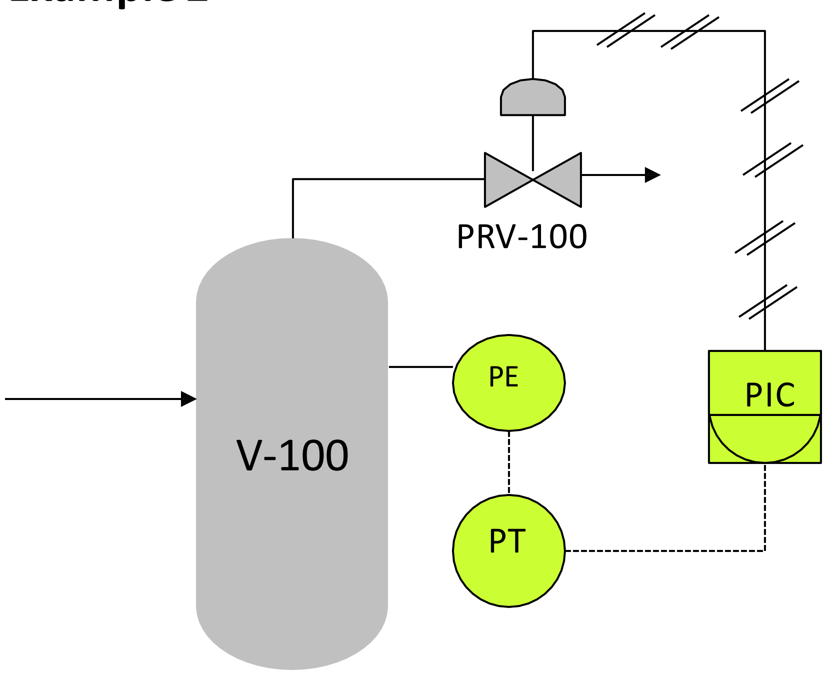
With using these following symbols;



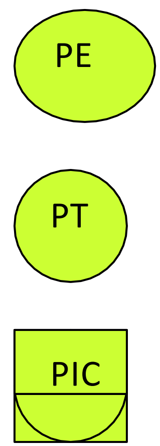
Complete control loop for LCV 101

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Example 2



With using these following symbology;



Where PE is locally mounted on V-100

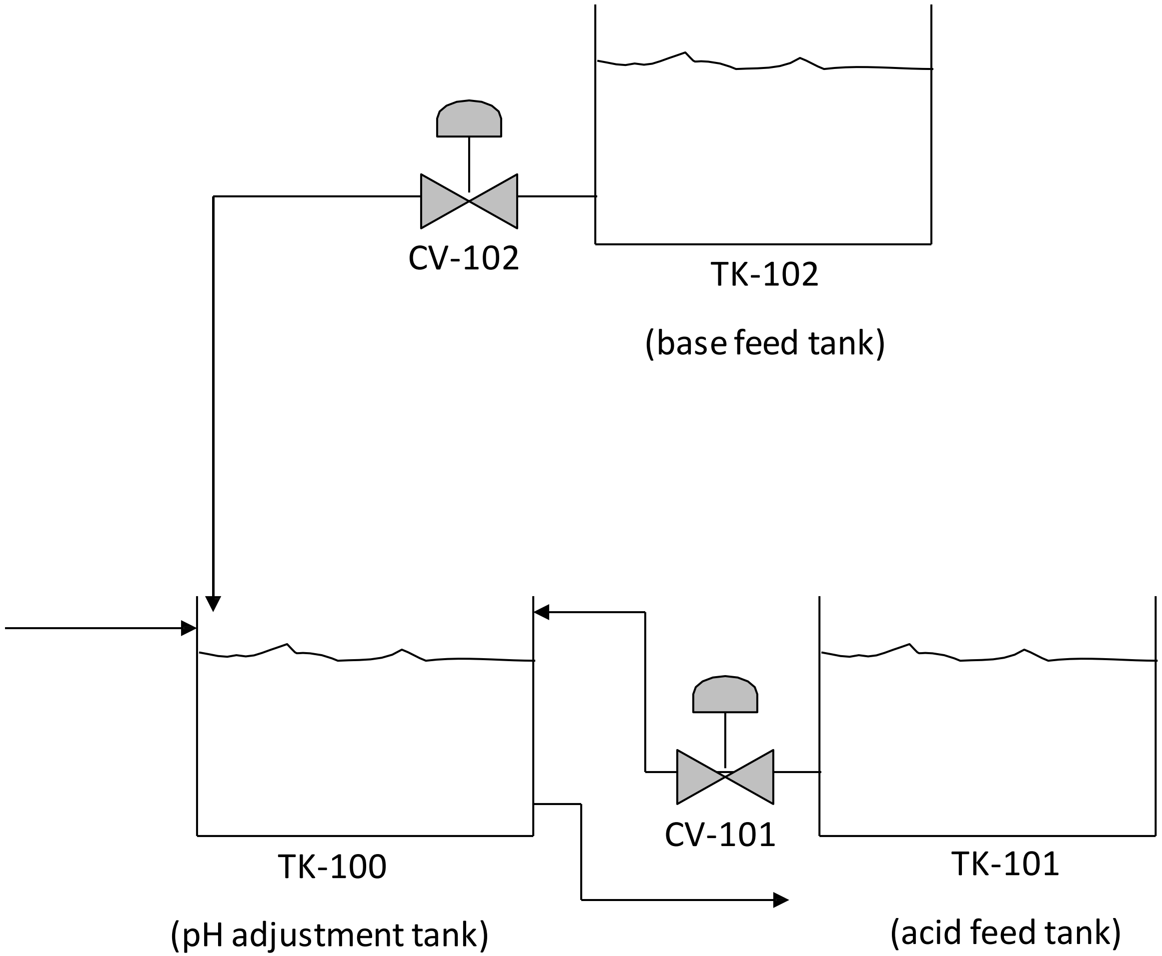
Where PT is locally mounted

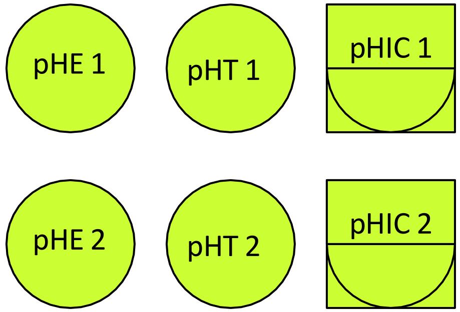
Where PIC is function in DCS

Draw control loop to show that PRV-100 will be activated to relief pressure when the pressure in the V-100 is higher than desired value.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Exercise 1



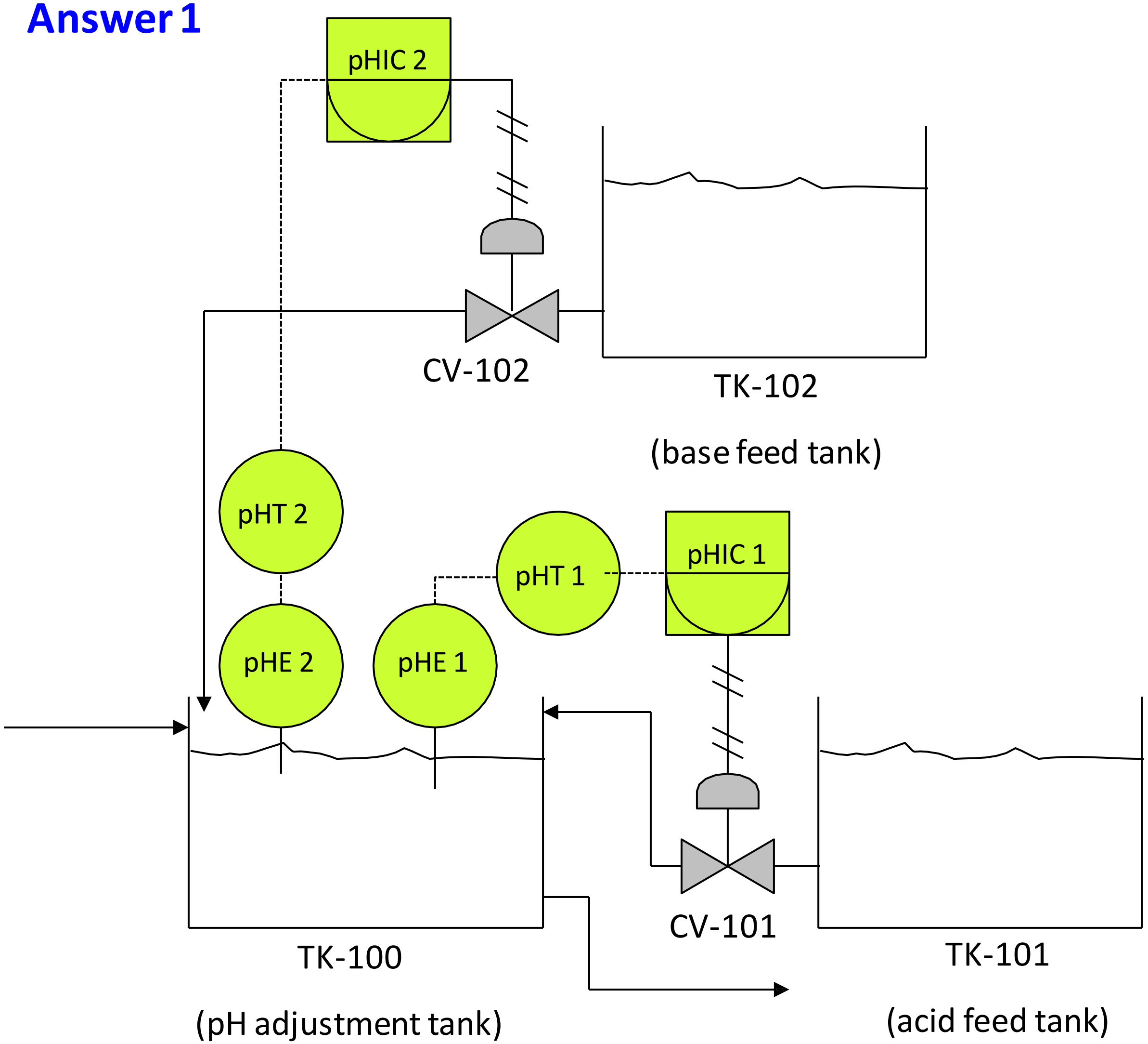


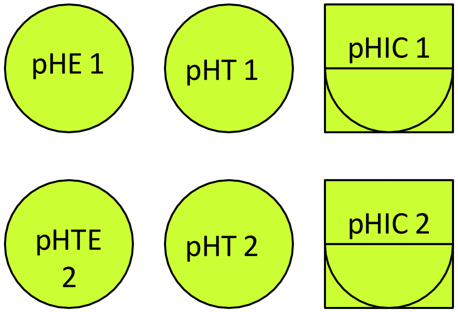
The diagram **shows pH adjustment**; part of waste water treatment process. With using above symbols, draw control loop where the process need is:

The process shall maintained at pH 6. When the process liquid states below pH 6, CV-102 will be opened to dosing NaOH to the tank TK-100. When the process liquid states above pH 6, CV-101 will be operated to dosing HCl.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Answer 1



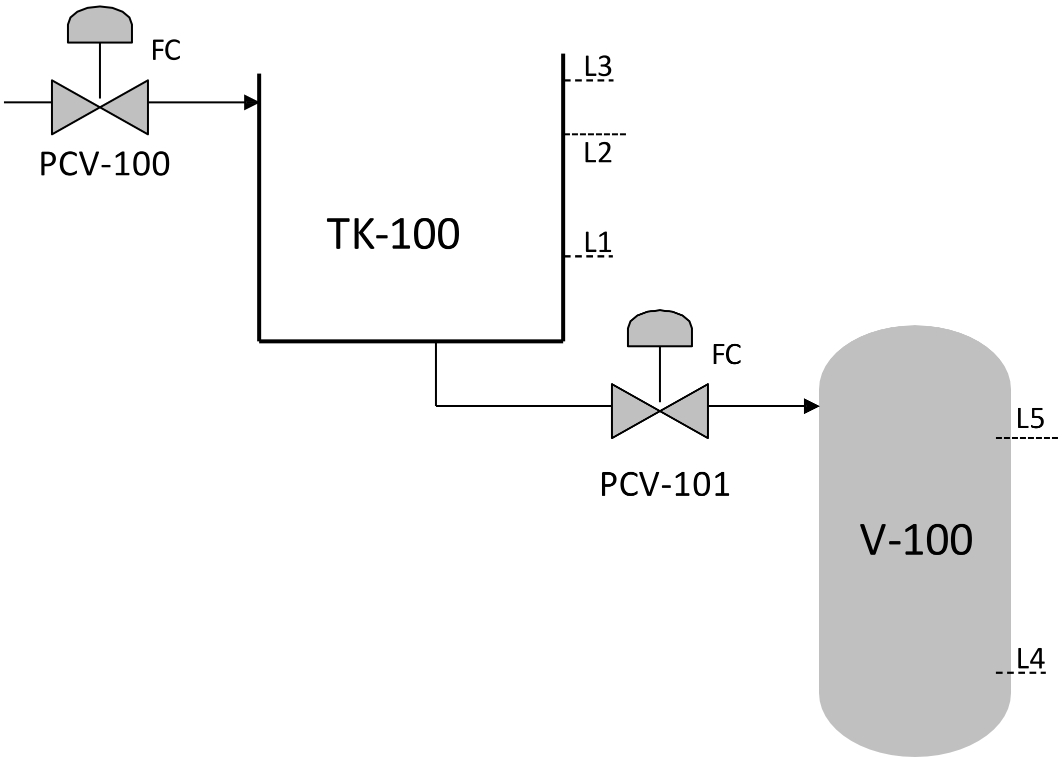


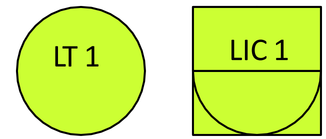
The diagram **shows pH adjustment**; part of waste water treatment process. With using above symbols, draw control loop where the process need is:

The process shall maintained at pH 6. When the process liquid states below pH 6, CV-102 will be opened to dosing NaOH in the base feed tank. When the process liquid states above pH 6, CV-101 will be operated to dosing HCl in the acid fed tank.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Exercise 2

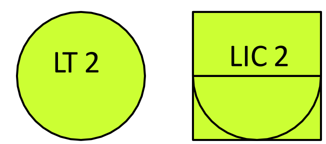




Where LT 1 and LIC 1 to control PCV-100 (failure close);

PCV-100 close when level reached L 3

PCV-100 open when level below L3



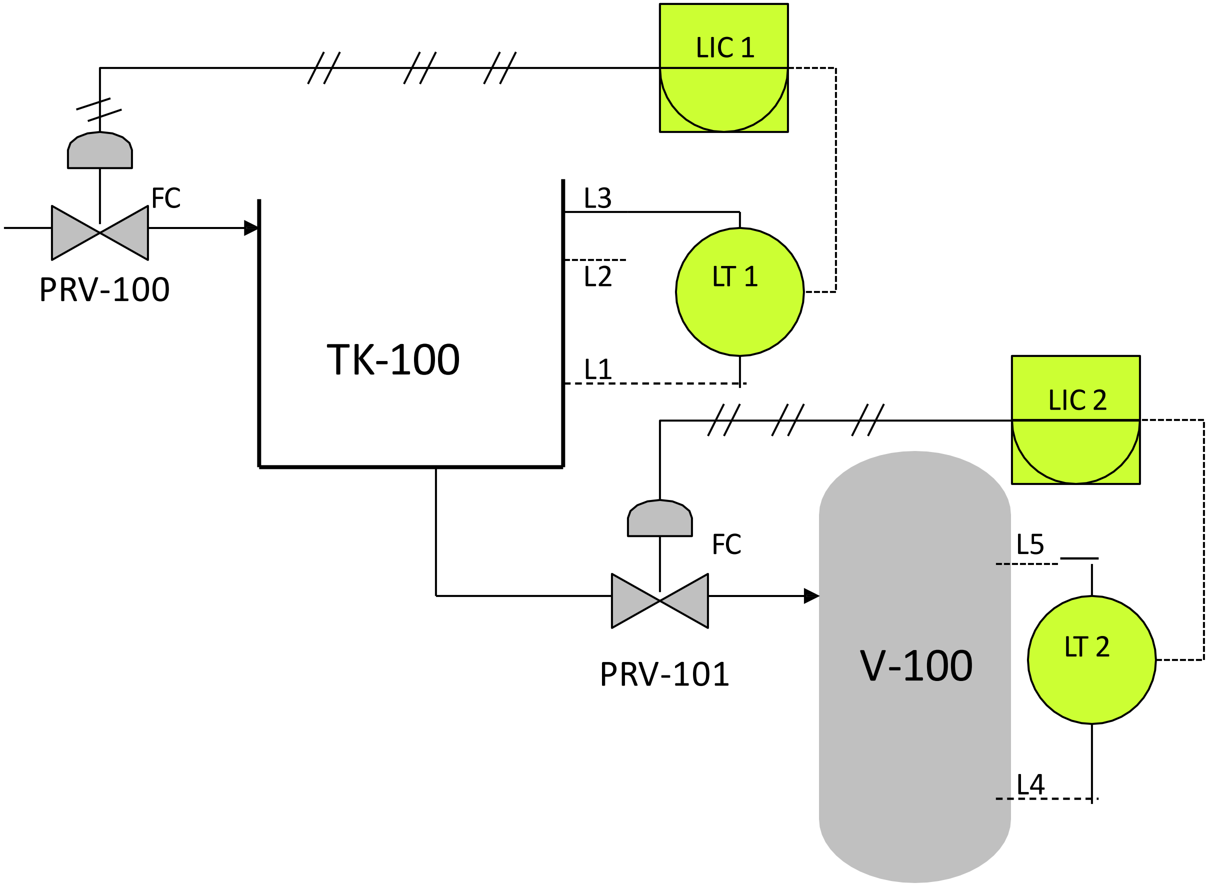
Where LT 2 and LIC 2 to control PCV-101 (failure close);

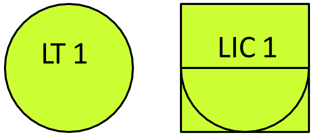
PCV-101 close when level reached L5

PCV-101 open when level below L5

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Answer 2

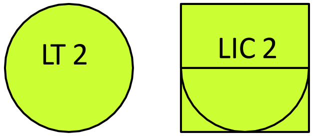




Where LT 1 and LIC 1 to control PRV-100 (failure close);

PRV-100 close when level reached L 3

PRV-100 open when level below L3



Where LT 1 and LIC 1 to control PRV-101 (failure close);

PRV-101 close when level reached L5

PRV-101 open when level below L5

Block Flow Diagram (BFD)

Process Flow Diagram (PFD)

PROCESS DIAGRAMS

Process equipments symbol and numbering

Piping and Instrumentation Diagram (P&ID)

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Numbering

- **XYY CZZLL**

X represents a process variable to be measured. (T=temperature, F=flow, P=pressure, L=level)

YY represents type of instruments.

C designates the instruments area within the plant.

ZZ designates the process unit number.

LL designates the loop number.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Numbering

- **LIC 10003**

L	= Level shall be measured.
IC	= Indicating controller.
100	= Process unit no. 100 in the area of no. 1
03	= Loop number 3

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Numbering

- **FRC 82516**

F	= Flow shall be measured.
RC	= Recording controller
825	= Process unit no. 825 in the area of no. 8.
16	= Loop number 16

Block Flow Diagram (BFD)

Process Flow Diagram (PFD)

PROCESS DIAGRAMS

Process equipments symbol and numbering

Piping and Instrumentation Diagram (P&ID)

P&ID

PROCESS
CONTROL
VARIETY

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Type of Process Control Loop

- Feedback Control
- Feedforward Control
- Feedforward-plus-Feedback Control
- Ratio Control
- Split Range Control
- Cascade Control
- Differential Control

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

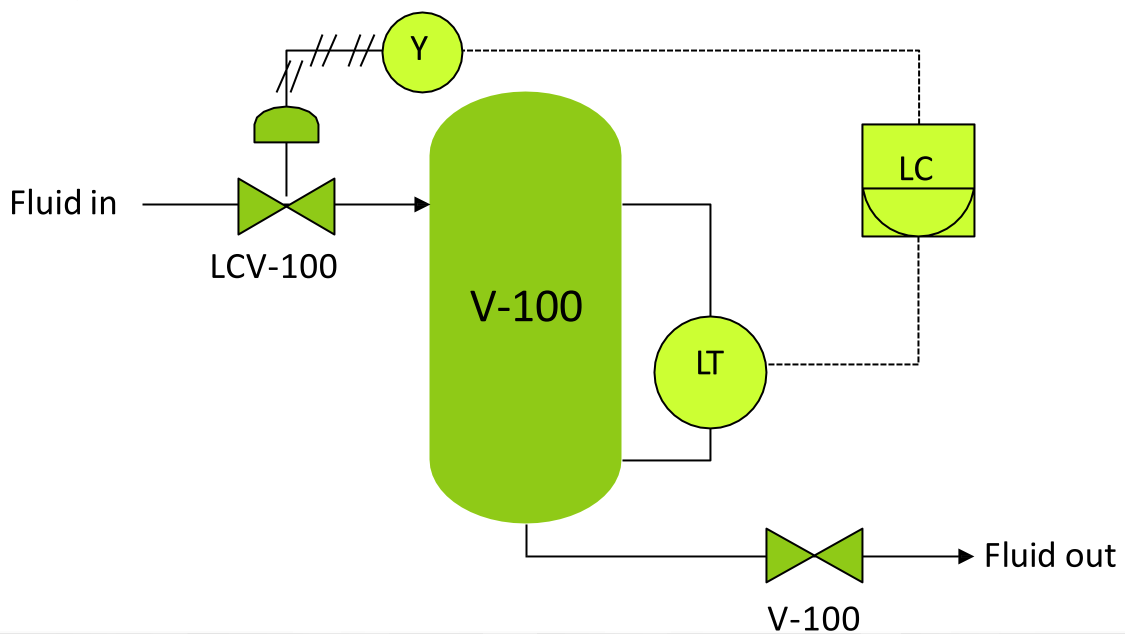
Feedback Control

❖ One of the simplest process control schemes.

❖ A feedback loop measures a process variable and sends the measurement to a controller for comparison to set point. If the process variable is not at set point, control action is taken to return the process variable to set point.

❖ The advantage of this control scheme is that it is simple using single transmitter.

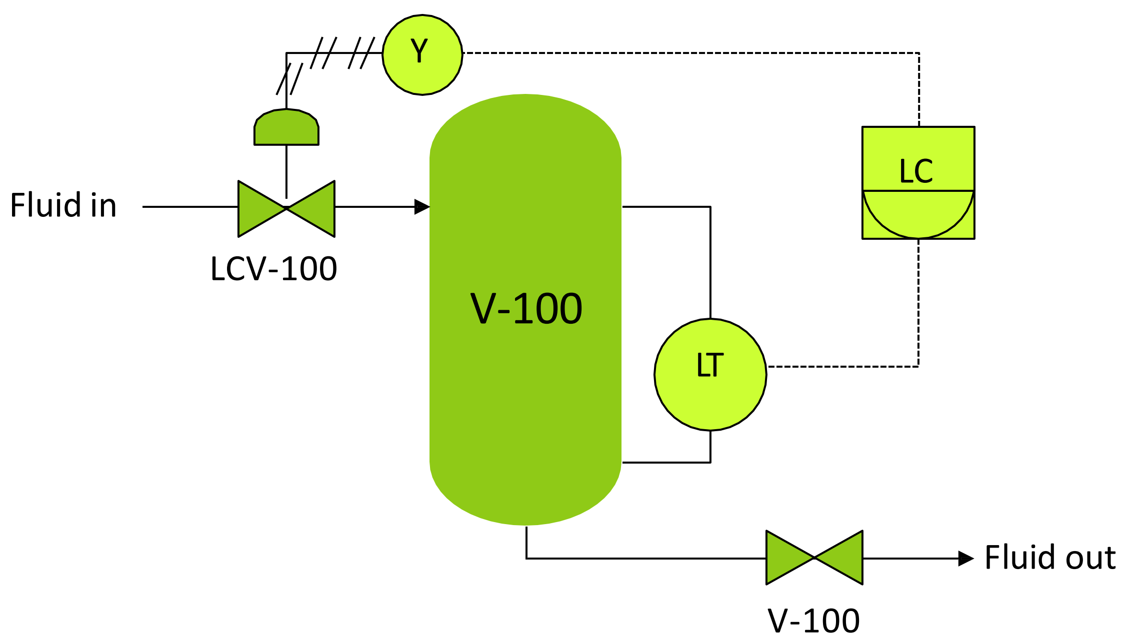
❖ This control scheme does not take into consideration any of the other variables in the process.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Feedback Control (cont…)

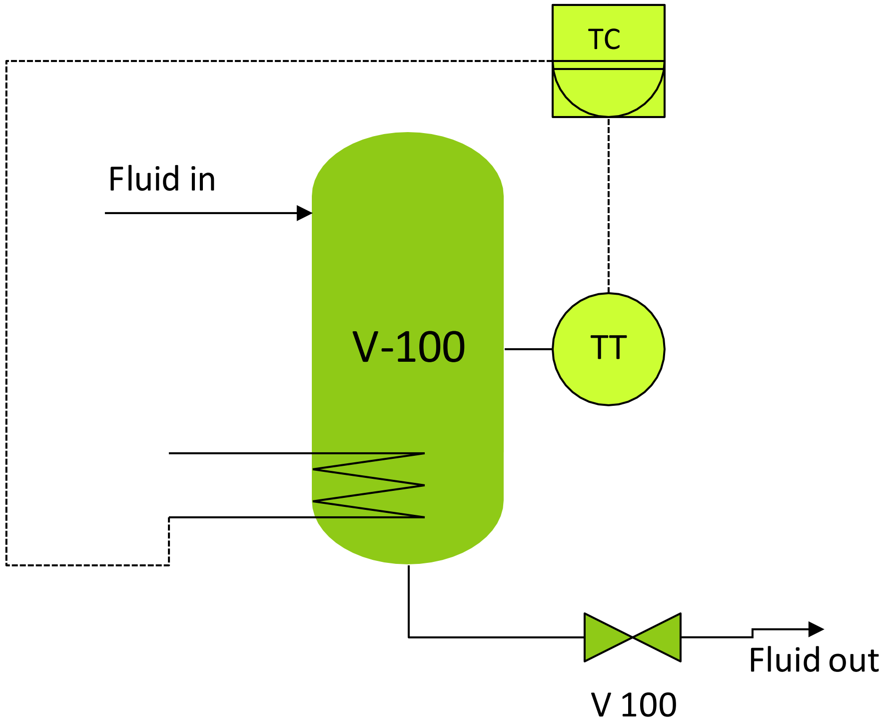
- Feedback loop are commonly used in the process control industry.
- The advantage of a feedback loop is that directly controls the desired process variable.
- The disadvantage of feedback loops is that the process variable must leave set point for action to be taken.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Example 1

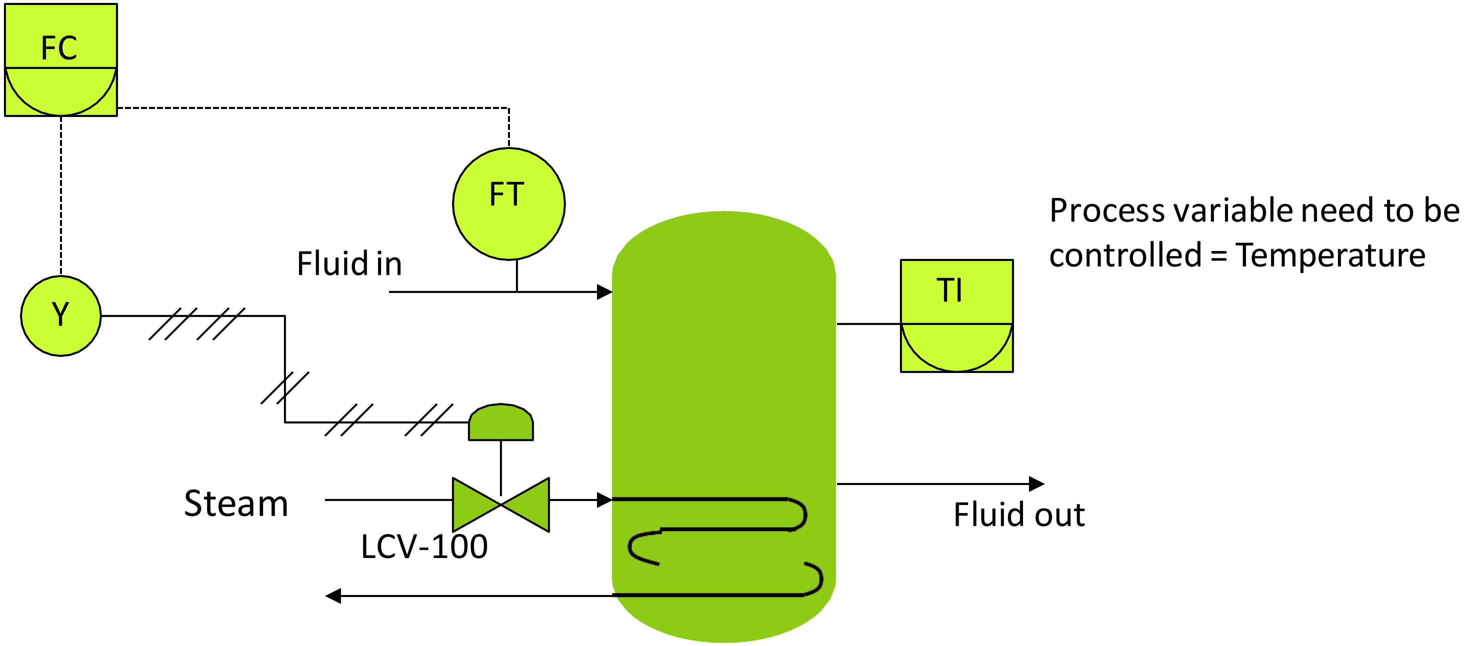
- Figure below shows the liquid vessel for boiler system. This system has to maximum desired temperature of 120 ^{o}C (L2) where the heater will be cut off when the temperature reached desired temperature. Draw feedback control loop for the system.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Feedforward Control

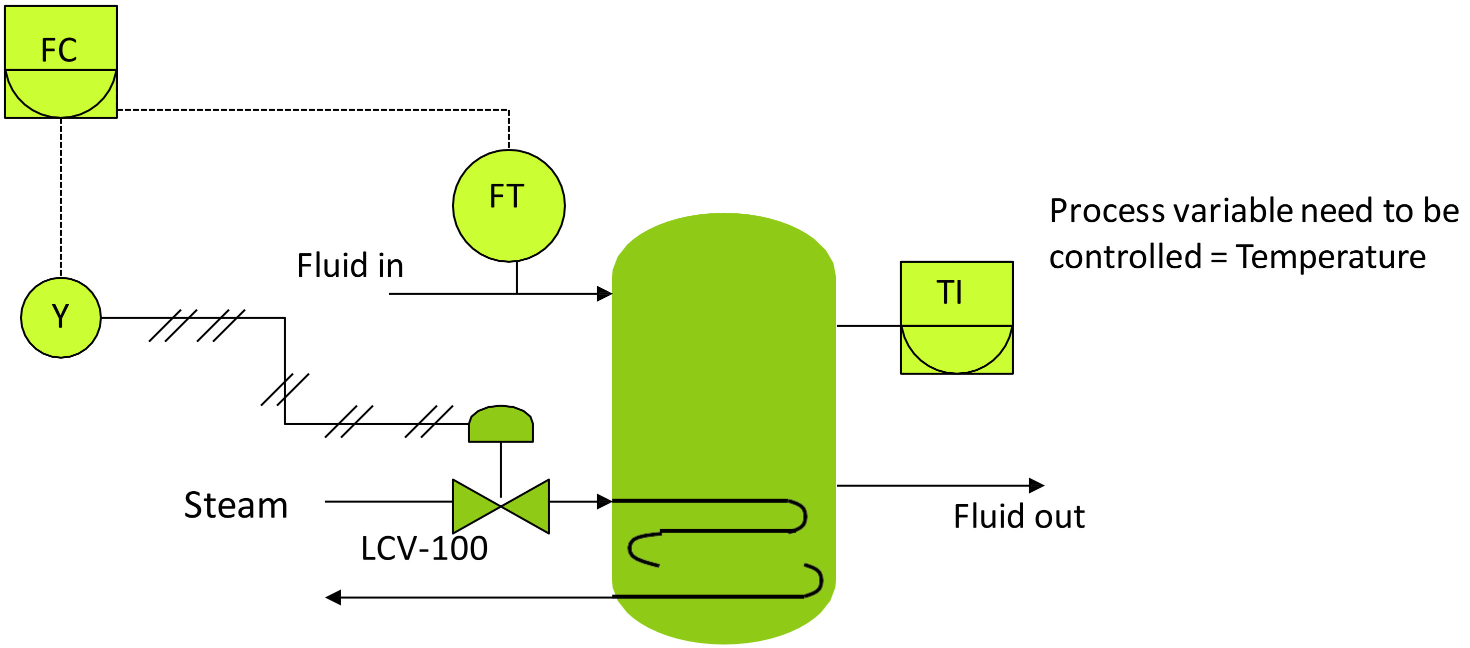
- Feedforward loop is a control system that anticipates load disturbances and controls them before they can impact the process variable.
- For feedforward control to work, the user must have a mathematical understanding of how the manipulated variables will impact the process variable.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Feedforward Control (cont…)

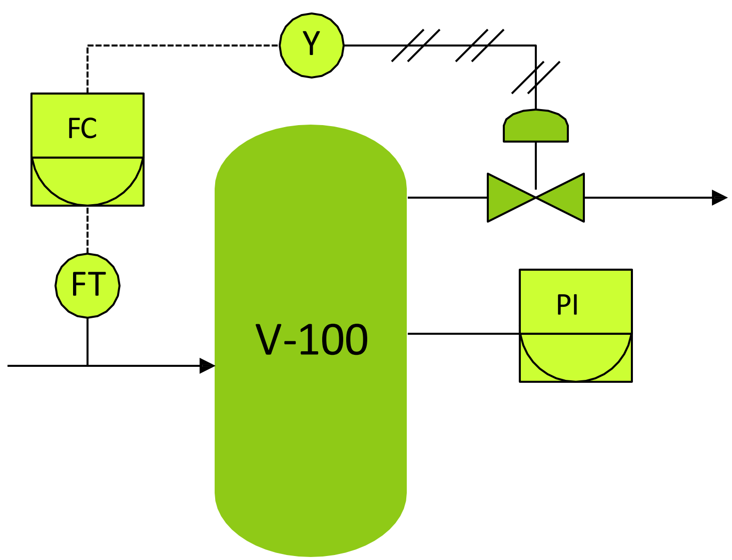
- ❖ An advantage of feedforward control is that error is prevented, rather than corrected.
- ❖ However, it is difficult to account for all possible load disturbances in a system through feedforward control.
- ❖ In general, feedforward system should be used in case where the controlled variable has the potential of being a major load disturbance on the process variable ultimately being controlled.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Example 2

❖ Figure below shows compressed gas vessel. Process variable that need to be controlled is pressure where the vessel should maintain pressure at 60 psi. This pressure controlled through the gas flow measurement into the vessel. By using feedforward control system, draw the loop.

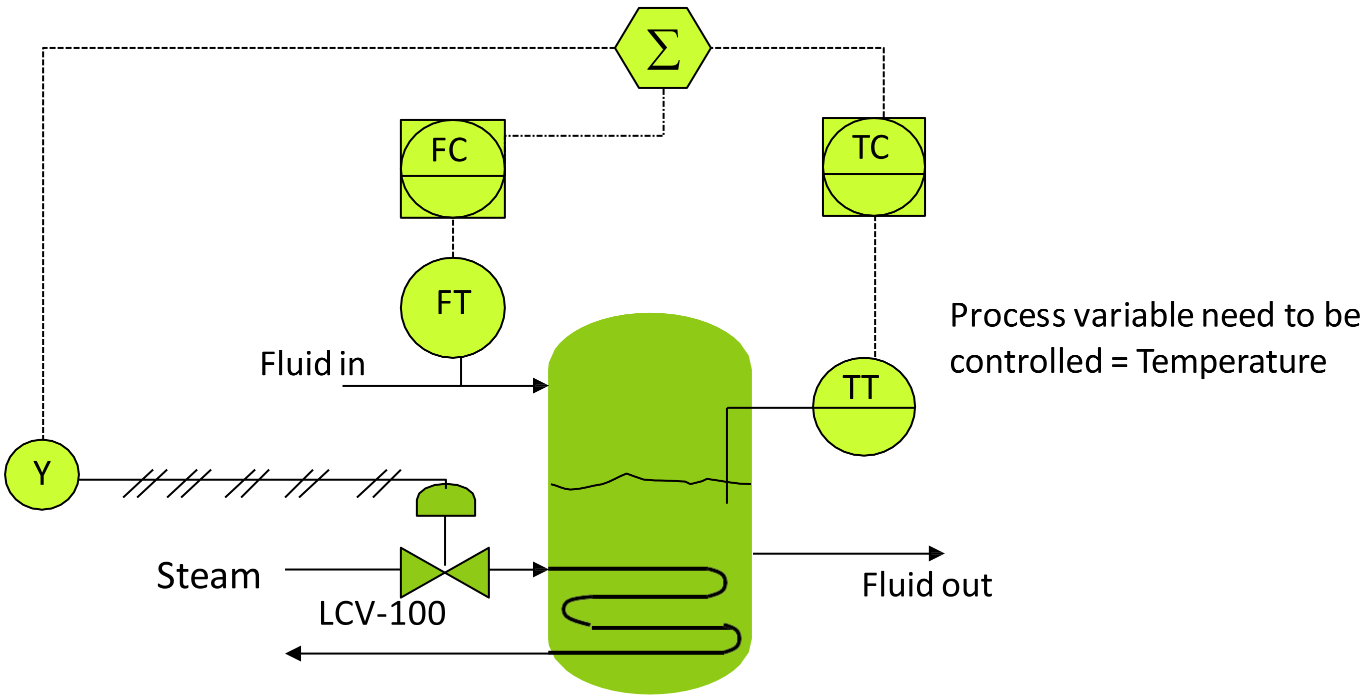


Process variable need to be controlled = Pressure

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Feedforward-plus-Feedback Control

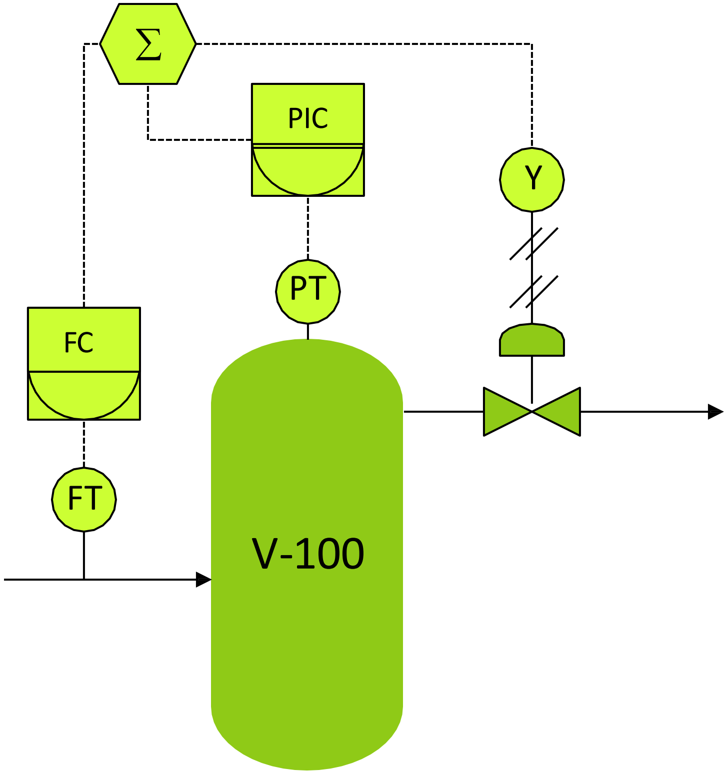
- Because of the difficulty of accounting for every possible load disturbance in a feedforward system, this system are often combined with feedback systems.
- Controller with summing functions are used in these combined systems to total the input from both the feedforward loop and the feedback loop, and send a unified signal to the final control element.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Example 3

❖Figure below shows compressed gas vessel. Process variable that need to be controlled is pressure where the vessel should maintain pressure at 60 psi. By using pressure controlled through both the gas flow measurement into the vessel and vessel pressure itself, draw a feedforward-plus-feedback control loop system.

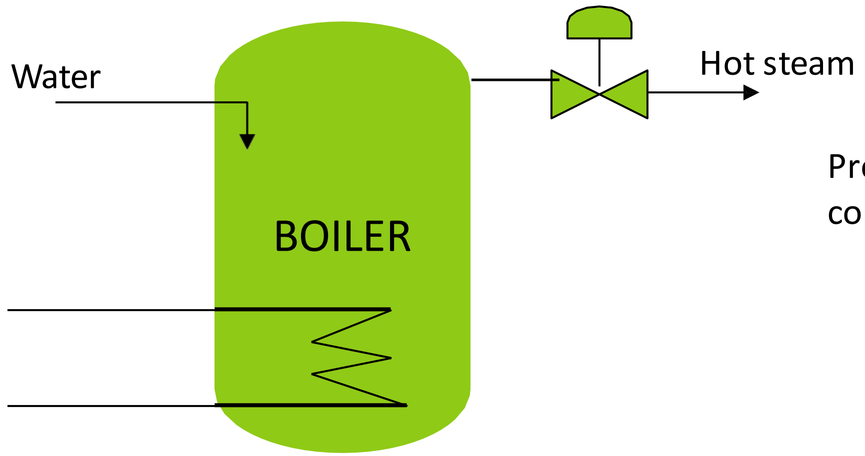


Process variable need to be controlled = Pressure

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Exercise 2

❖Figure below shows the boiler system that used to supply hot steam to a turbine. This system need to supply 100 psi hot steam to the turbine where the PCV-100 will be opened when the pressure reached that desired pressure. With using pressure control through temperature and pressure measurement in the boiler, draw a feedforward-plus-feedback control loop system.

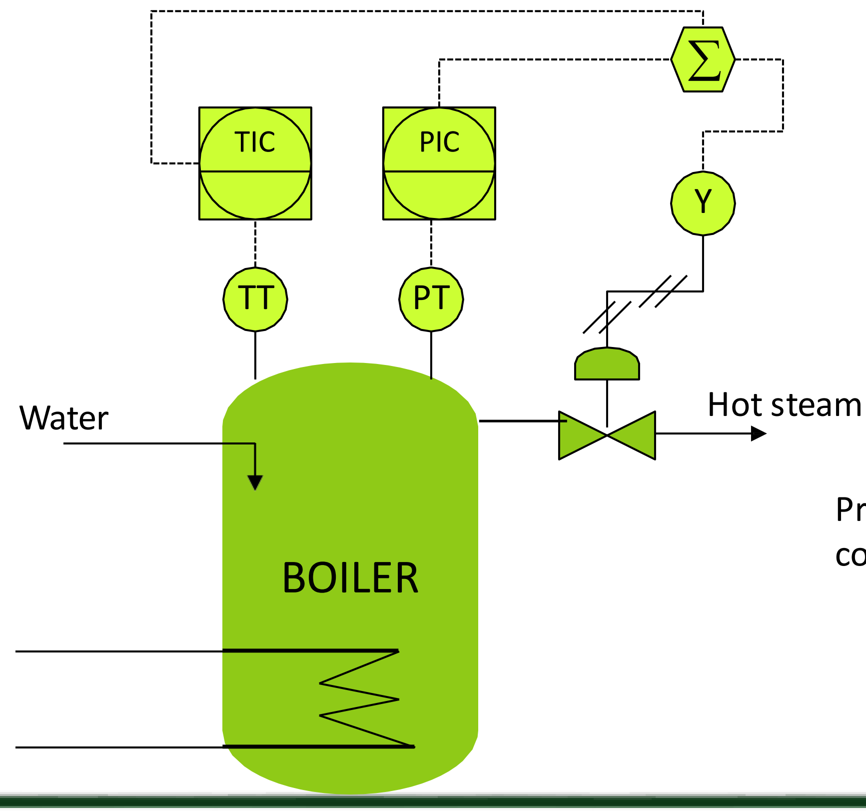


Process variable need to be controlled = Pressure

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Answer 2

❖ Figure below shows the boiler system that used to supply hot steam to a turbine. This system need to supply 100 psi hot steam to the turbine where the PCV-100 will be opened when the pressure reached that desired pressure. With using pressure control through temperature and pressure measurement in the boiler, draw a feedforward-plus-feedback control loop system.

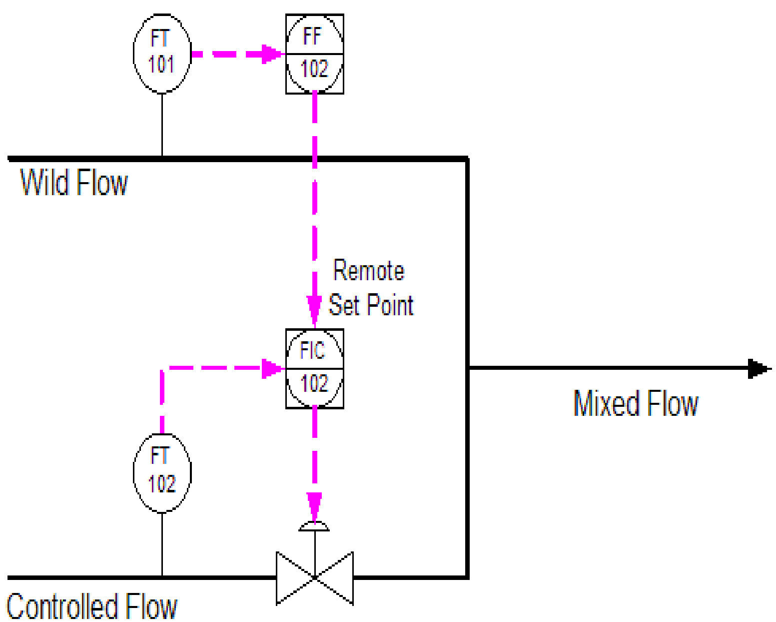


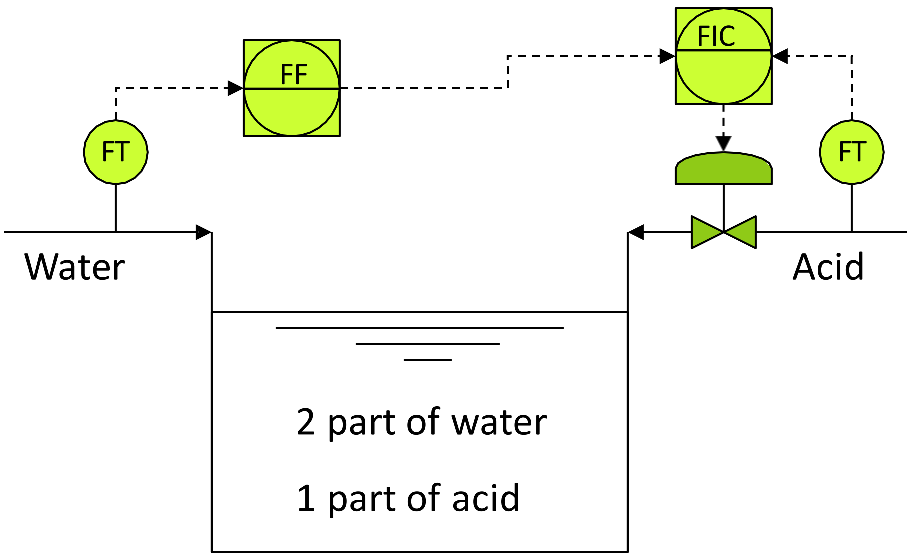
Process variable need to be controlled = Pressure

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Ratio Control

❖ Ratio control is used to ensure that two or more flows are kept at the same ratio even if the flows are changing.



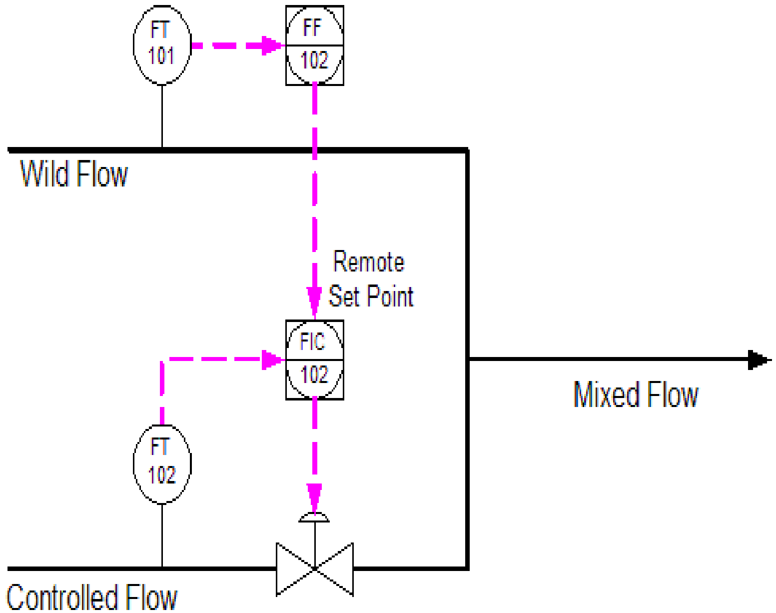


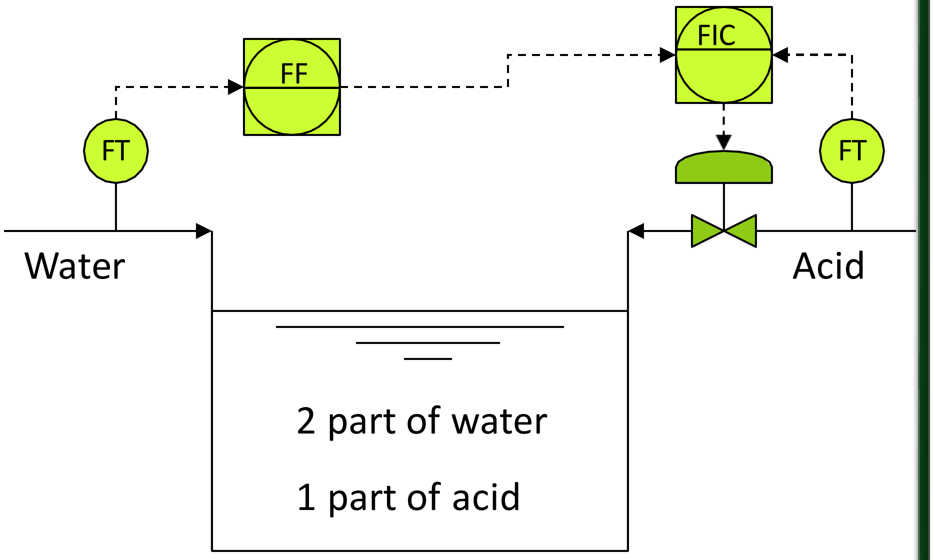
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Ratio Control (cont…)

Application:

- Blending two or more flows to produce a mixture with specified composition.
- Blending two or more flows to produce a mixture with specified physical properties.
- Maintaining correct air and fuel mixture to combustion.



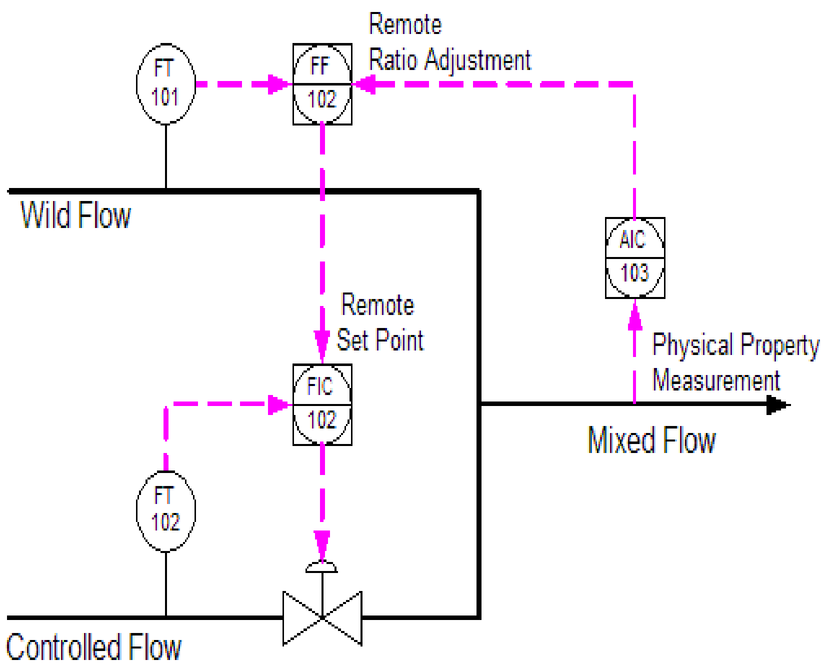


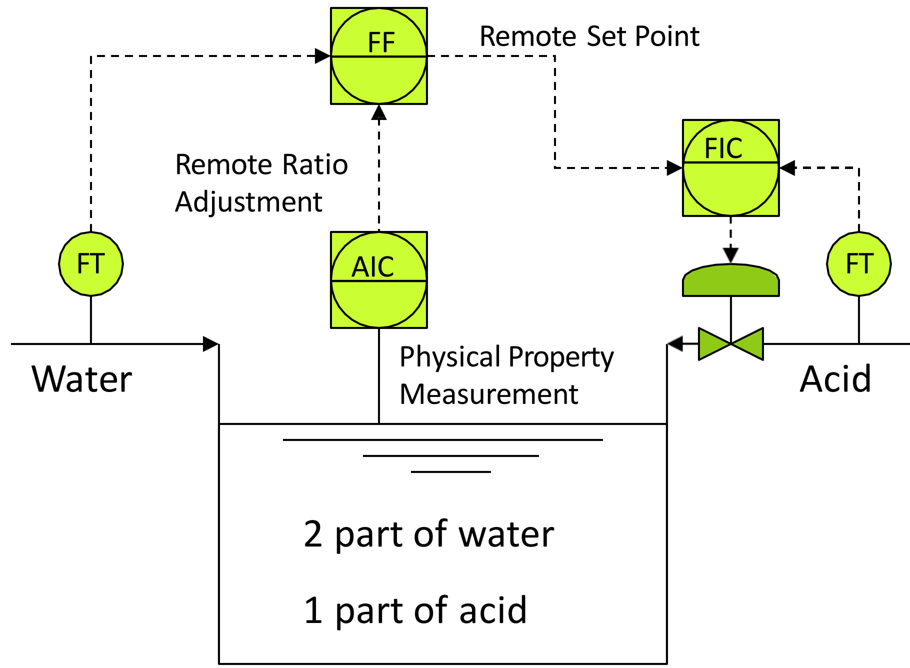
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Ratio Control (Auto Adjusted)

- If the physical characteristic of the mixed flow is measured, a PID controller can be used to manipulate the ratio value.

- For example, a measurement of the density, gasoline octane rating, color, or other characteristic could be used to control that characteristic by manipulating the ratio.

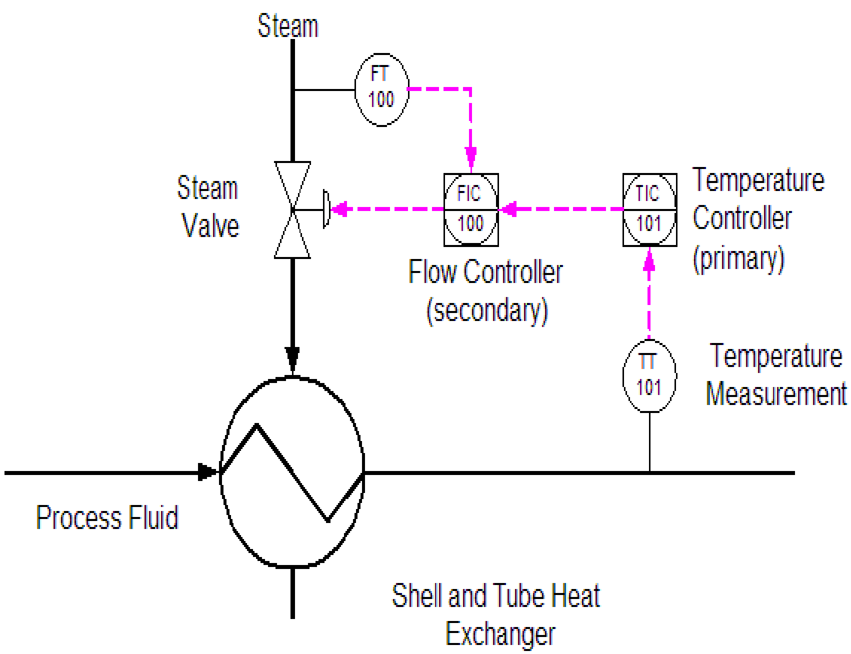




PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Cascade Control

❖ Cascade Control uses the output of the *primary* controller to manipulate the set point of the *secondary* controller as if it were the final control element.

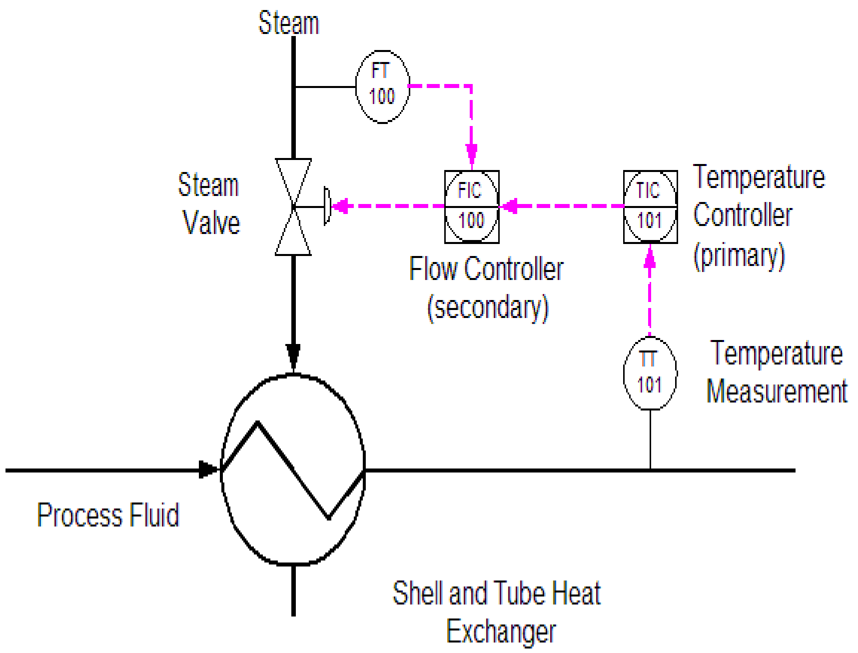


Reasons for cascade control:

- Allow faster secondary controller to handle disturbances in the secondary loop.
- Allow secondary controller to handle non-linearvalve and other final control element problems.
- Allow operator to directly control secondary loop during certain modes of operation (such as startup).

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Cascade Control (cont...)



Requirements for cascade control:

- Secondary loop process dynamics must be at least four times as fast as primary loop process dynamics.

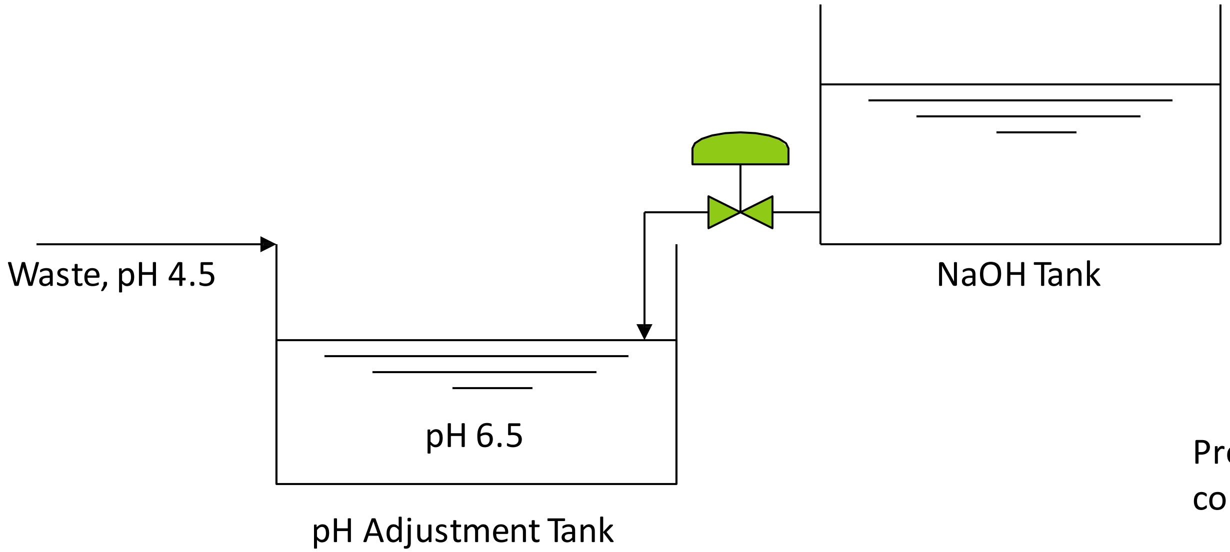
- Secondary loop must have influence over the primary loop.

- Secondary loop must be measured and controllable.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Exercise 3

❖ Figure below shows pH adjustment process where pH 6.5 need to be maintained. pH in the tank is controlled by NaOH dosing to the tank. But somehow, the flow of waste (pH 4.5) also need to considered where excess flow of the waste shall make that pH in the tank will decrease. Draw a cascade control loop system.

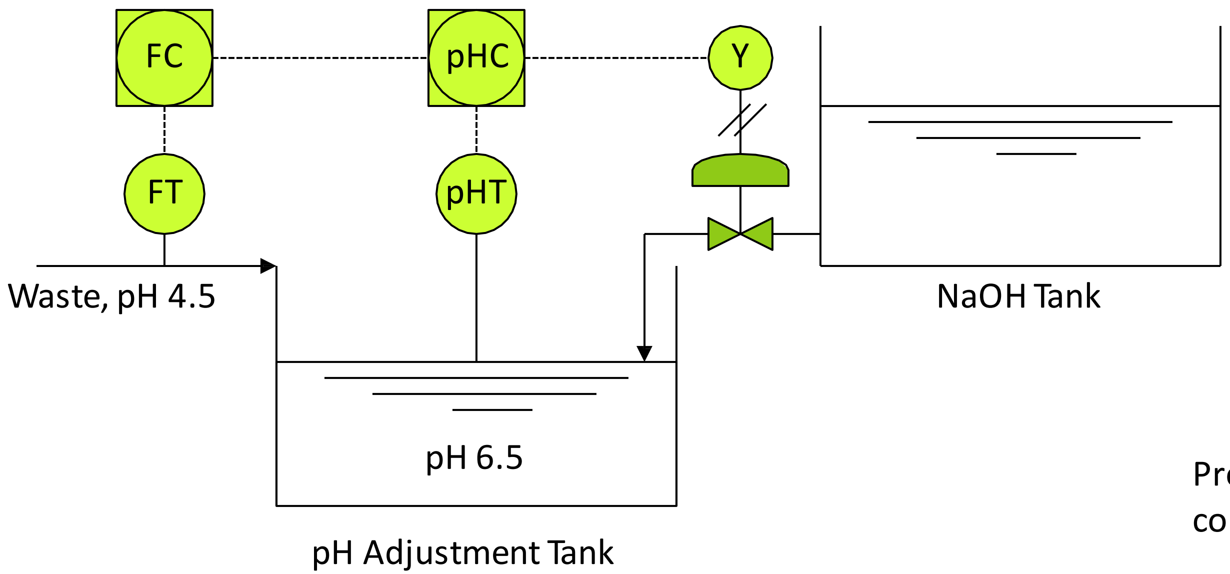


Process variable need to be controlled = pH

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Answer 3

❖Figure below shows pH adjustment process where pH 6.5 need to be maintained. pH in the tank is controlled by NaOH dosing to the tank. But somehow, the flow of waste (pH 4.5) also need to considered where excess flow of the waste shall make that pH in the tank will decrease. Draw a cascade control loop system.



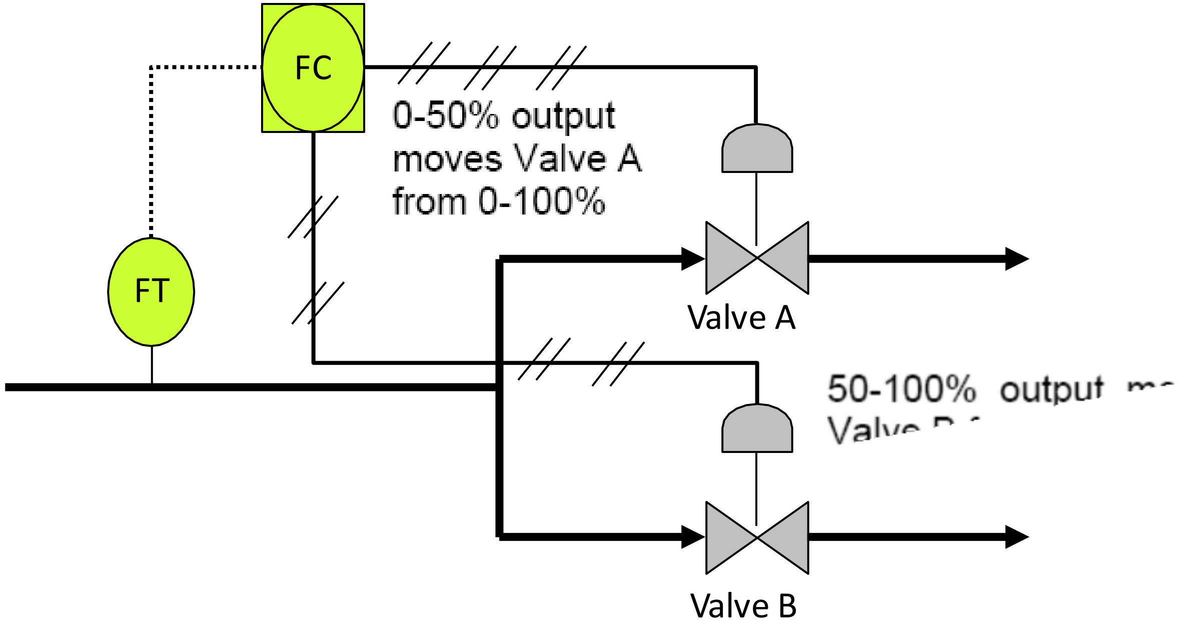
Process variable need to be controlled = pH

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Split Range Control

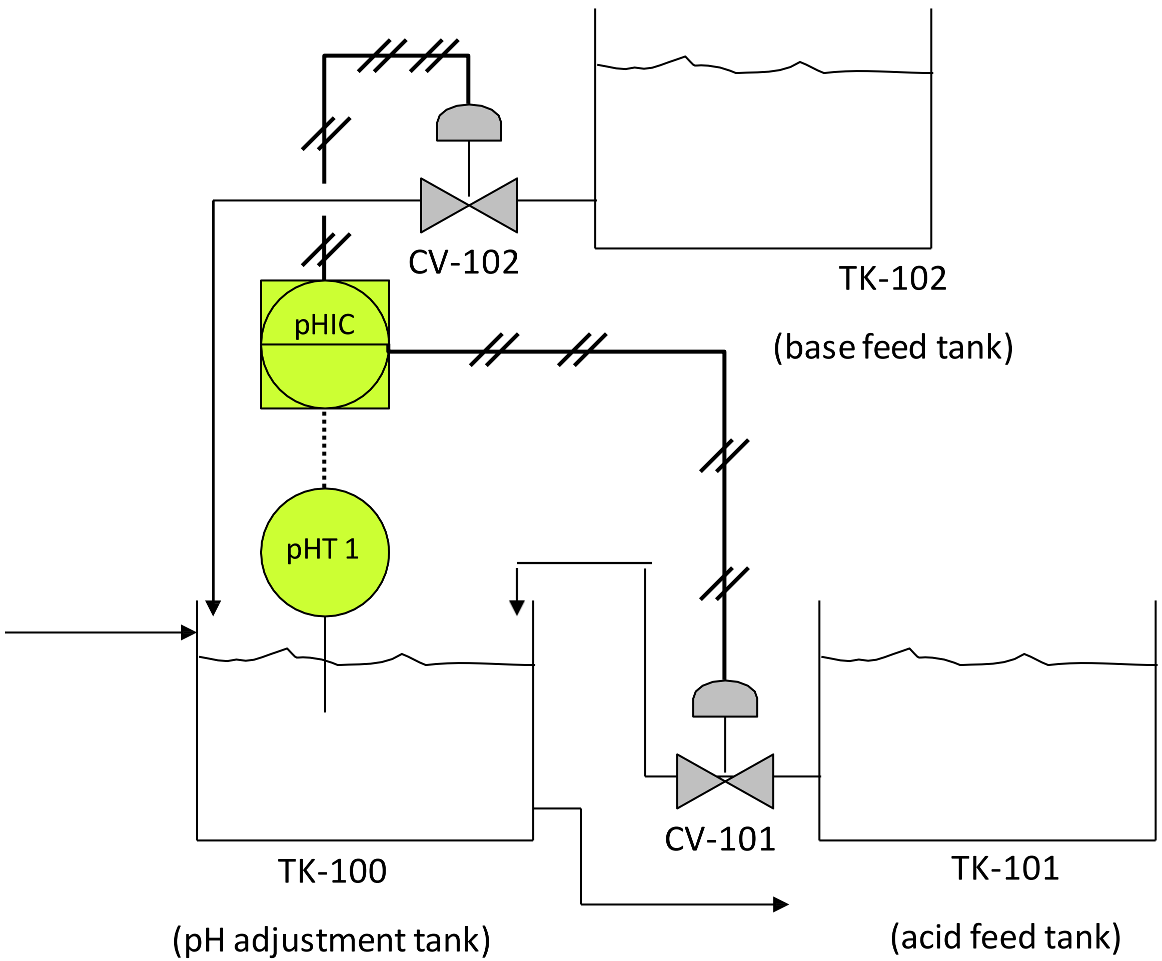
A very common control scheme is split range control in which the output of a controller is split to two or more control valves. For example:

- Controller output 0% — Valve A is fully open and Valve B fully closed.
- Controller output 25% — Valve A is 75% open and Valve B 25% open.
- Controller output 50% — Both valves are 50% open.
- Controller output 75% — Valve A is 25% open and Valve B 75% open.
- Controller output 100% — Valve A is fully closed and Valve B fully open.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Split Range Control



The diagram shows pH adjustment; part of waste water treatment process. The process shall maintained at pH 6. When the process liquid states below pH 6, CV-102 will be opened to dosing NaOH to the tank TK-100. When the process liquid states above pH 6, CV-101 will be operated to dosing HCl.

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