

ERT 422/4

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



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COURSE OUTCOMES

CO

RECOGNIZE all the **pipng** 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.

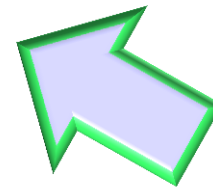
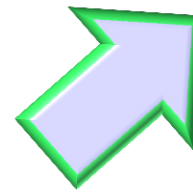


Block Flow
Diagram (BFD)

Process Flow
Diagram (PFD)

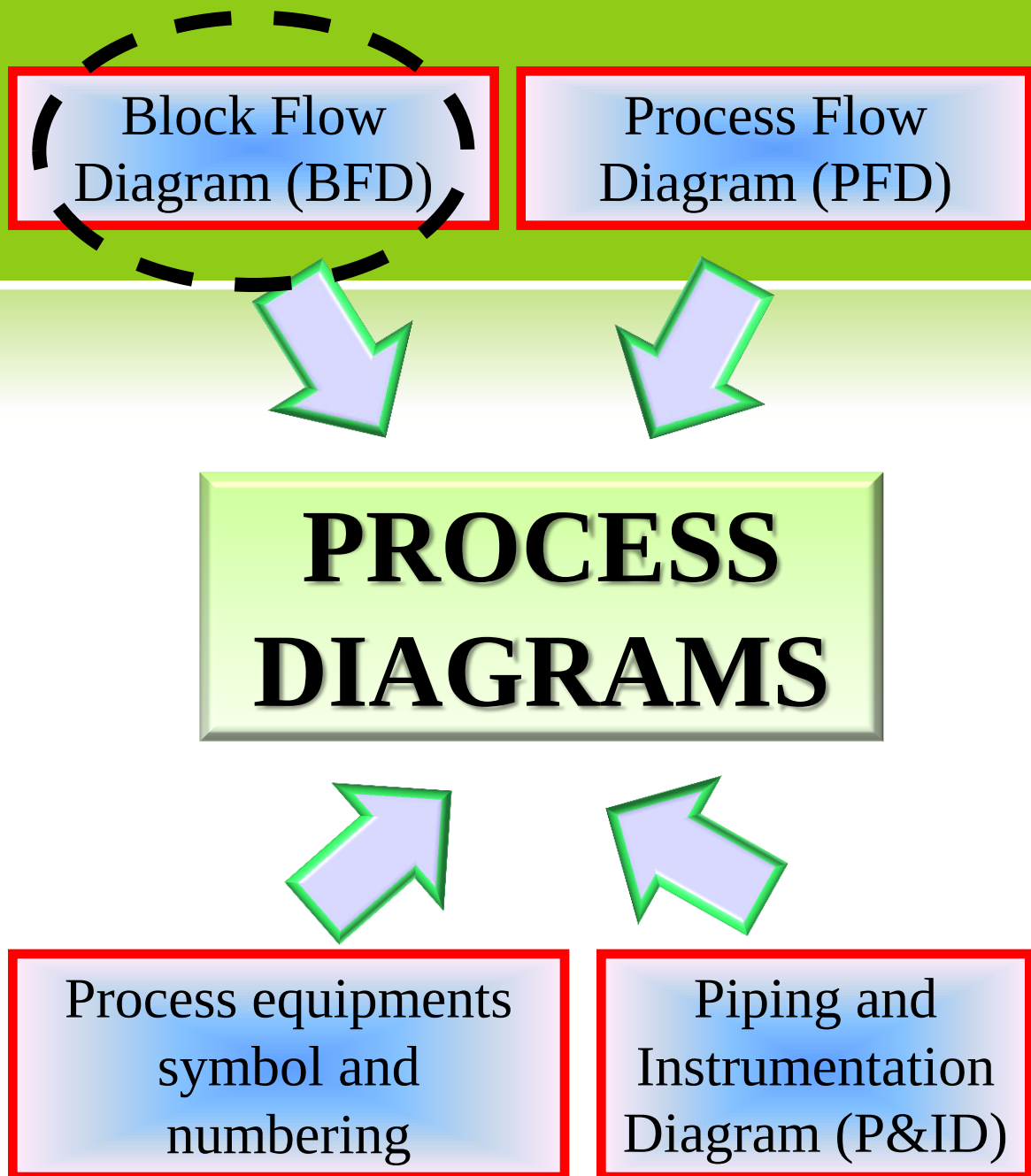


PROCESS DIAGRAMS



Process equipments
symbol and
numbering

Piping and
Instrumentation
Diagram (P&ID)



BLOCK FLOW DIAGRAM (BFD)

- ❑ 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:

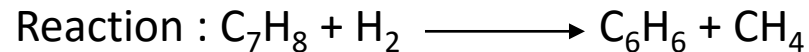
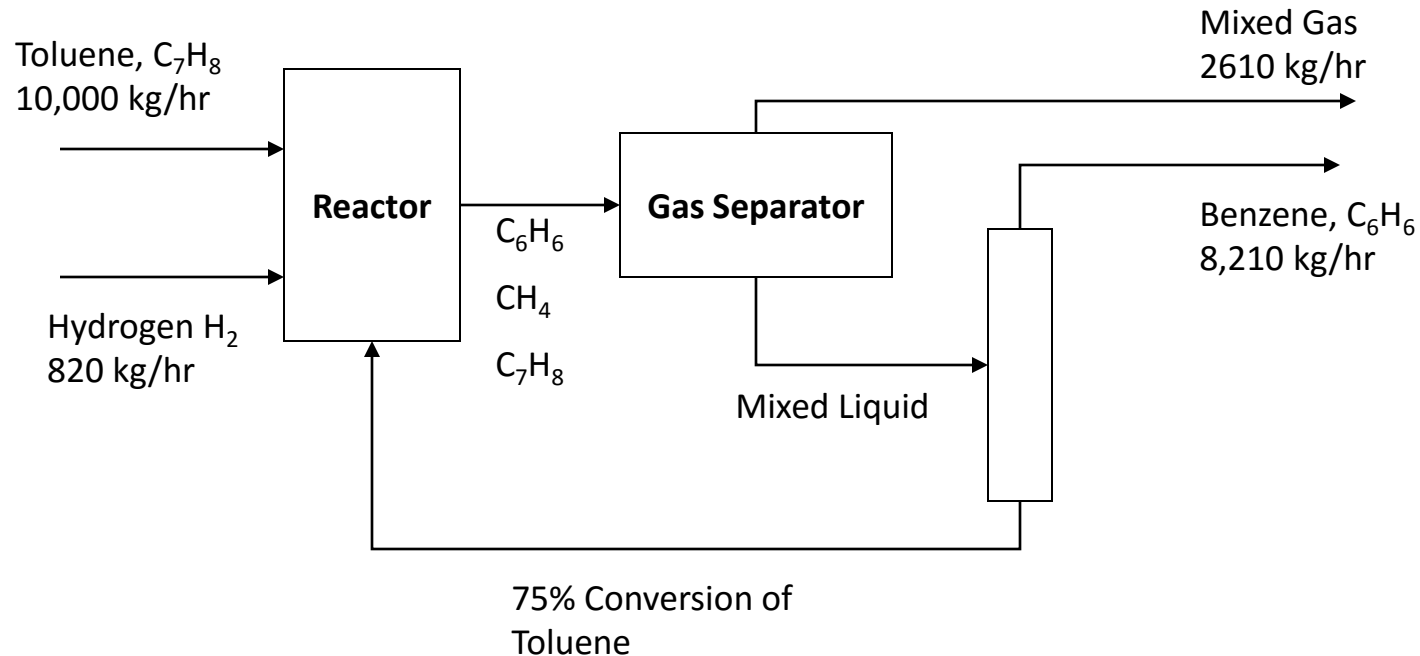
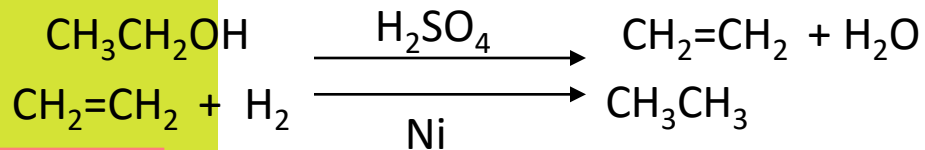


Figure 1: Block Flow Diagram for the Production of Benzene

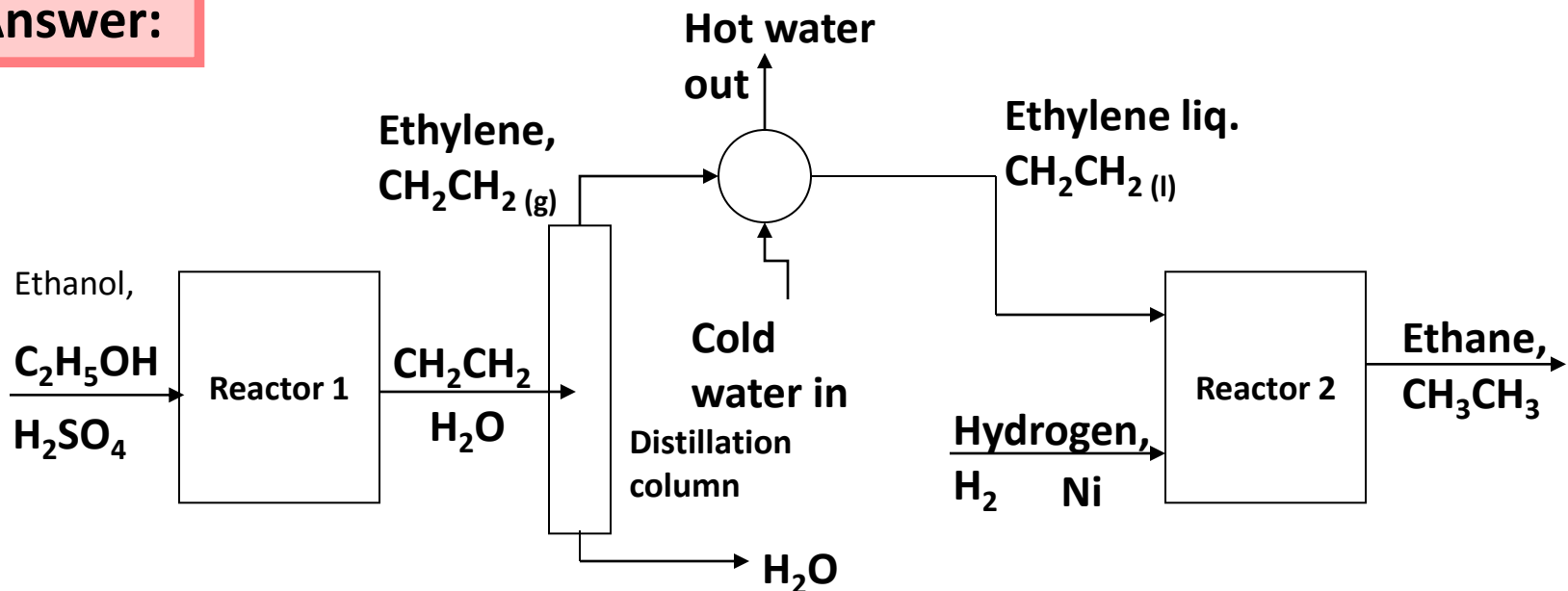
Example 2:

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-H₂O 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.

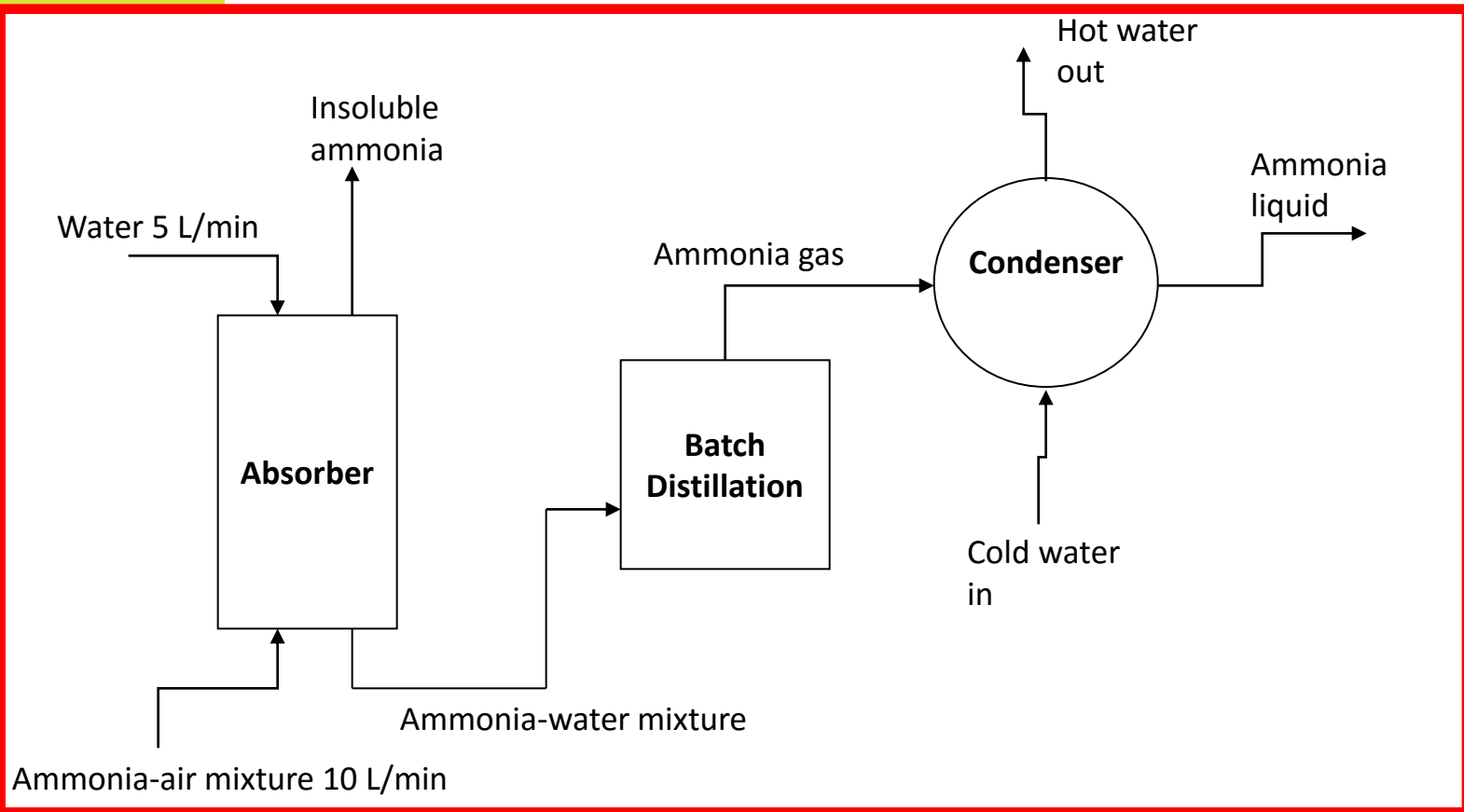


Answer:



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.



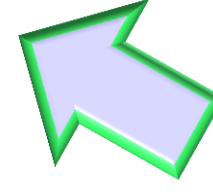
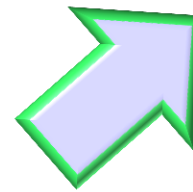


Block Flow
Diagram (BFD)

Process Flow
Diagram (PFD)



PROCESS DIAGRAMS



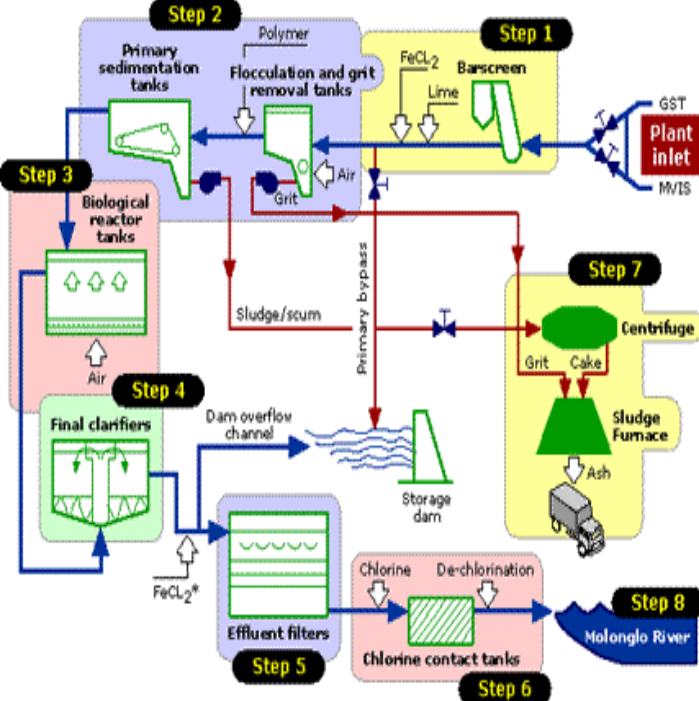
Process equipments
symbol and
numbering

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 steam, 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.**



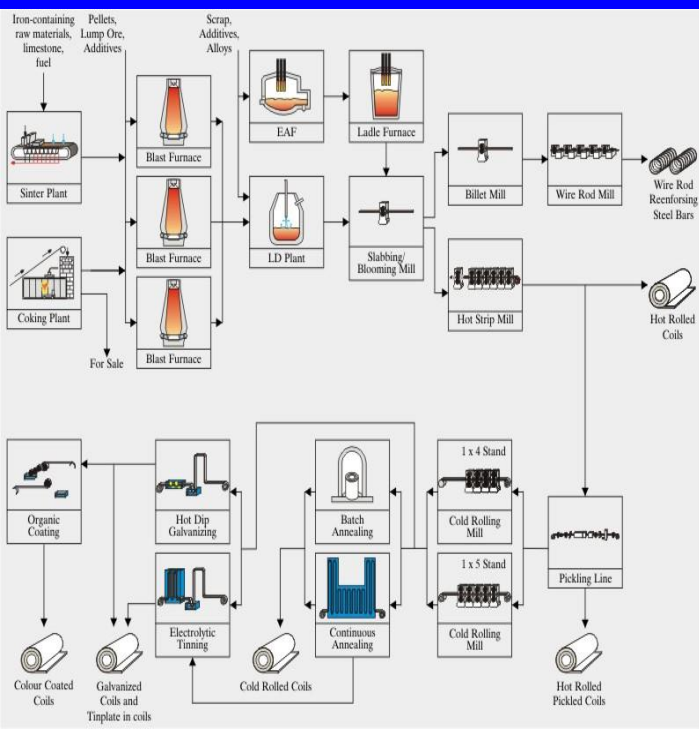
1. Major Pieces Of Equipment

2. Utility Streams

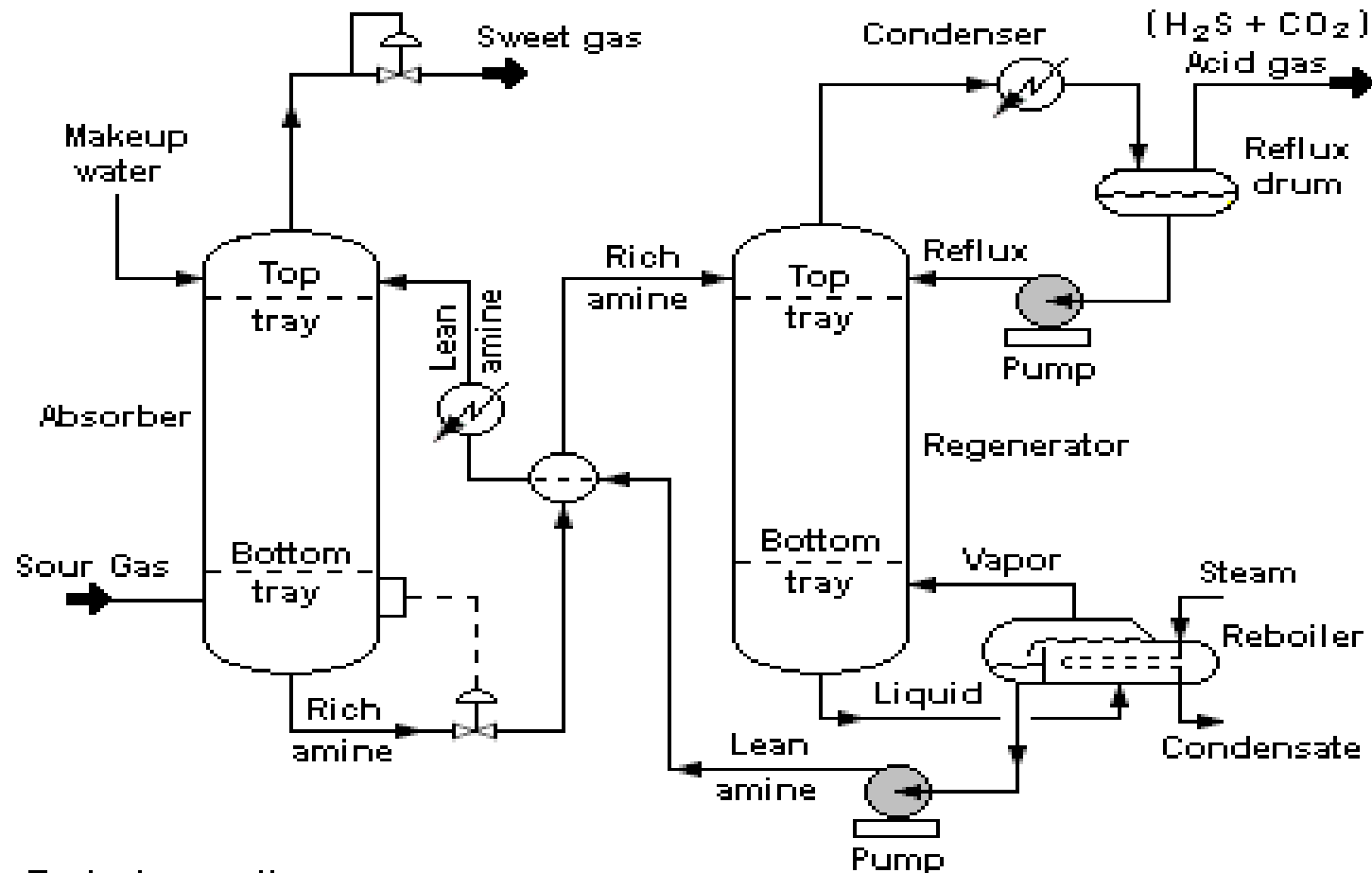
PFD

4. Basic Control Loops

3. Process Flow Streams



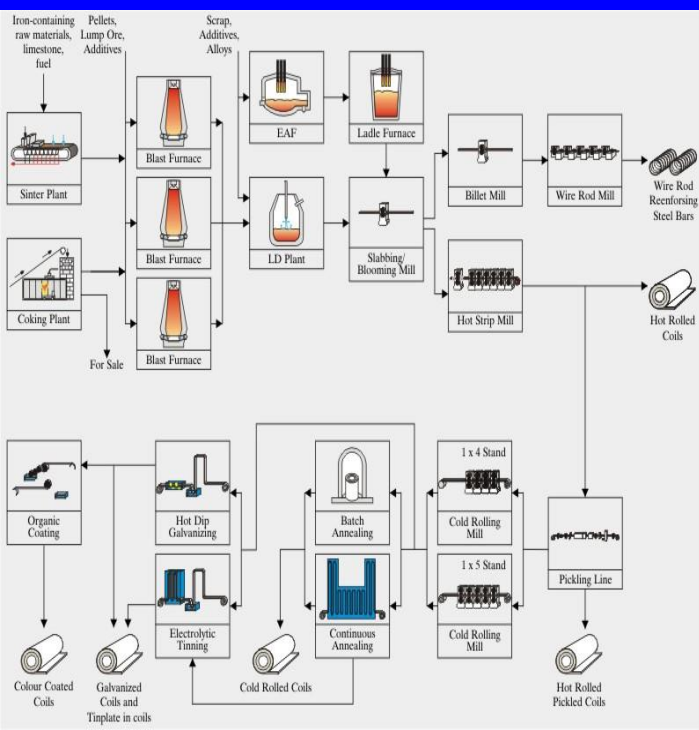
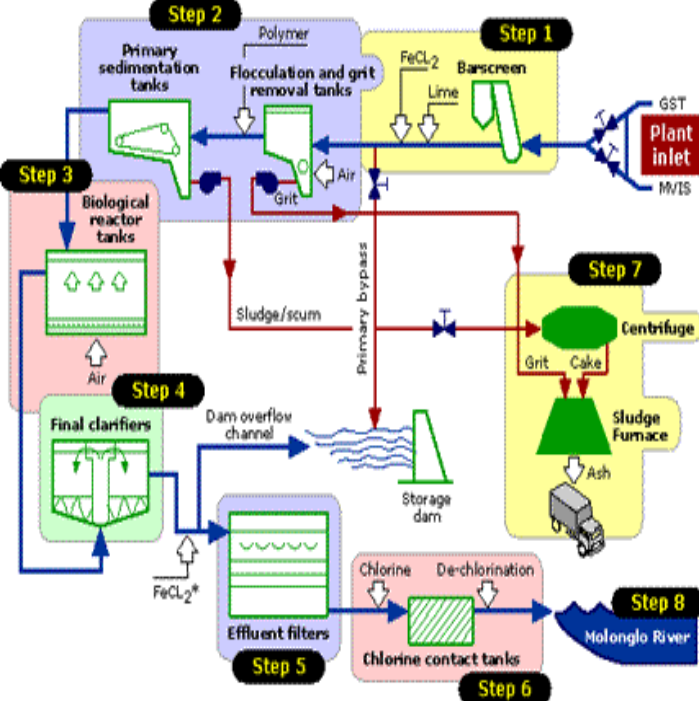
PROCESS FLOW DIAGRAM (PFD)



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)

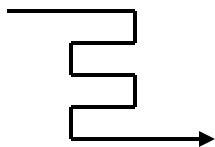
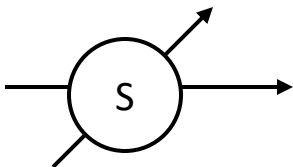
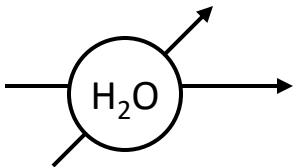
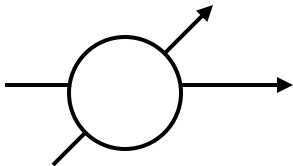
PFD will contains the following information:-

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 Symbolology

Symbol



Description

Heat exchanger

Water cooler

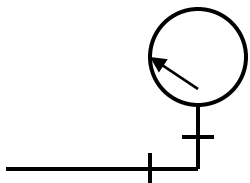
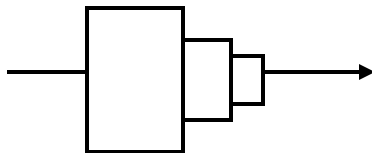
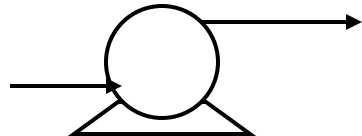
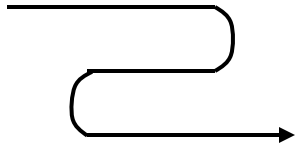
Steam heater

Cooling coil

PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbolology

Symbol



Description

Heater coil

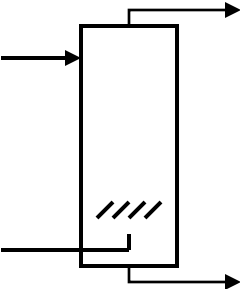
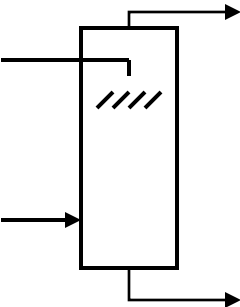
Centrifugal pump

Turbine type compressor

Pressure gauge

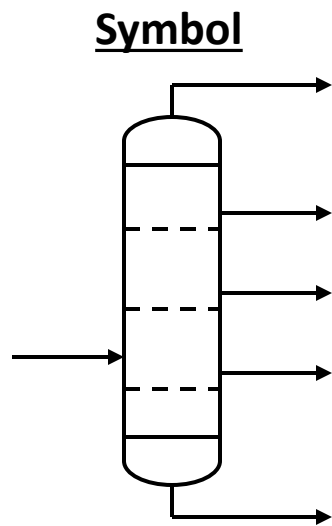
PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbolology

<u>Symbol</u>	<u>Name</u>	<u>Description</u>
	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

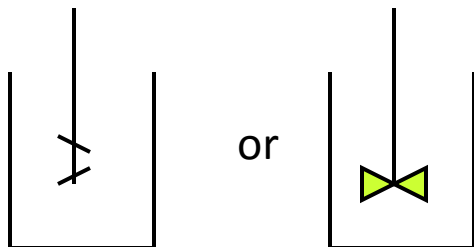


Name

Distillation
column

Description

A separator unit used commonly to crack liquid contains miscellaneous component fractions.



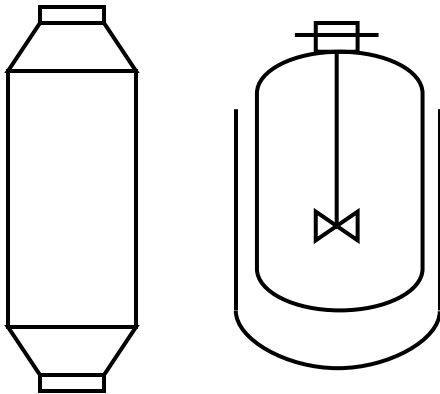
Liquid mixer

A process unit that used to mix several components of liquid.

PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbolology

Symbol



Name

Reaction
chamber

Description

A process unit where chemical
process reaction occurs

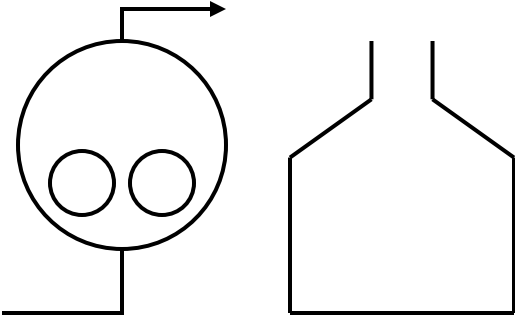
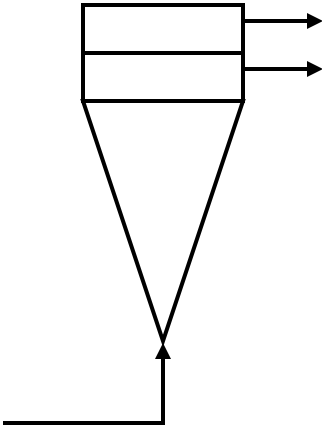


Horizontal tank
or cylinder

A unit to store liquid or gas.

PROCESS FLOW DIAGRAM (PFD)

Process Unit Symbolology

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

PROCESS FLOW DIAGRAM (PFD)

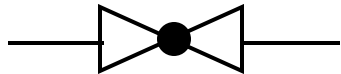
Valve Symbolology

Symbol

Name



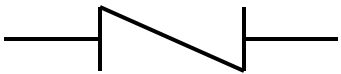
Gate Valve



Globe Valve



Ball Valve



Check Valve



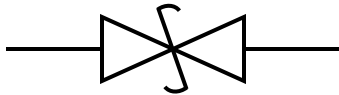
Butterfly Valve

PROCESS FLOW DIAGRAM (PFD)

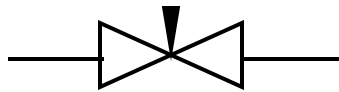
Valve Symbolology

Symbol

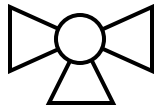
Name



Relief Valve



Needle Valve



3-Way Valve



Angle Valve

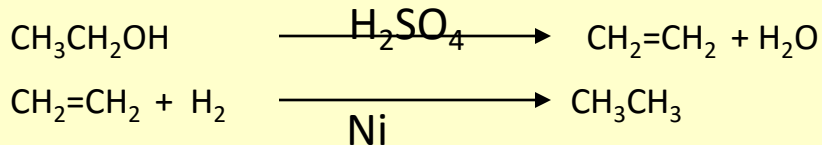


Butterfly Valve

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-H₂O 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.



R-100

Reactor

P-100

Pump

T-100

Distillation Column

E-100

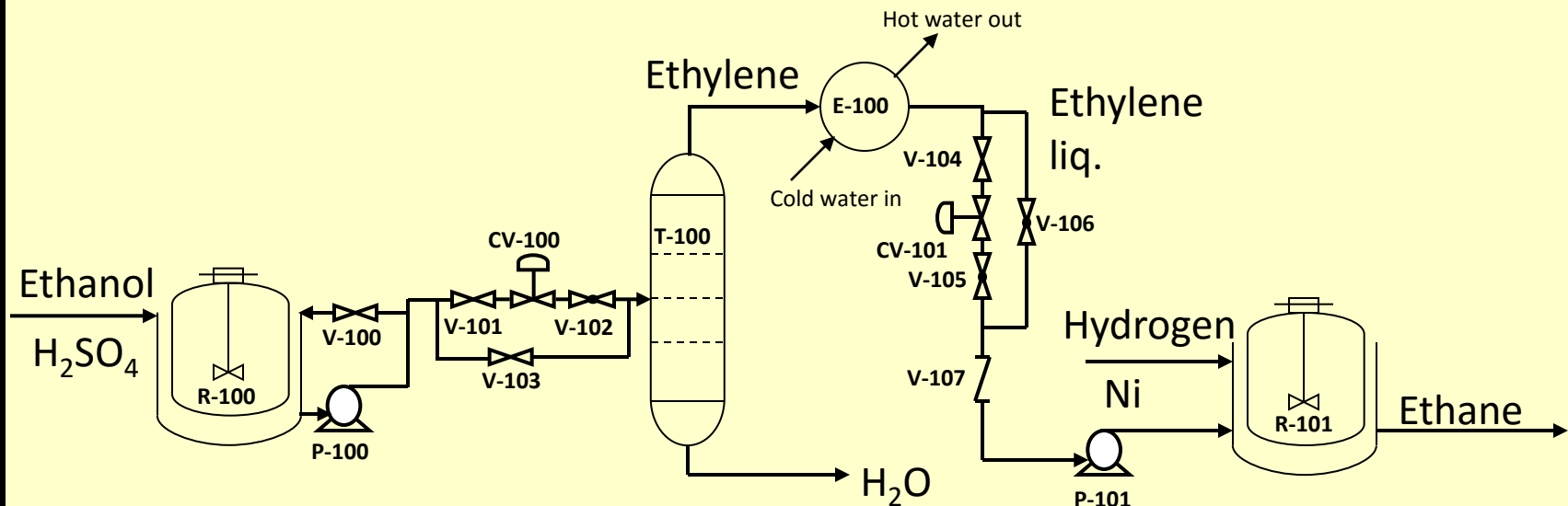
Condenser

P-101

Pump

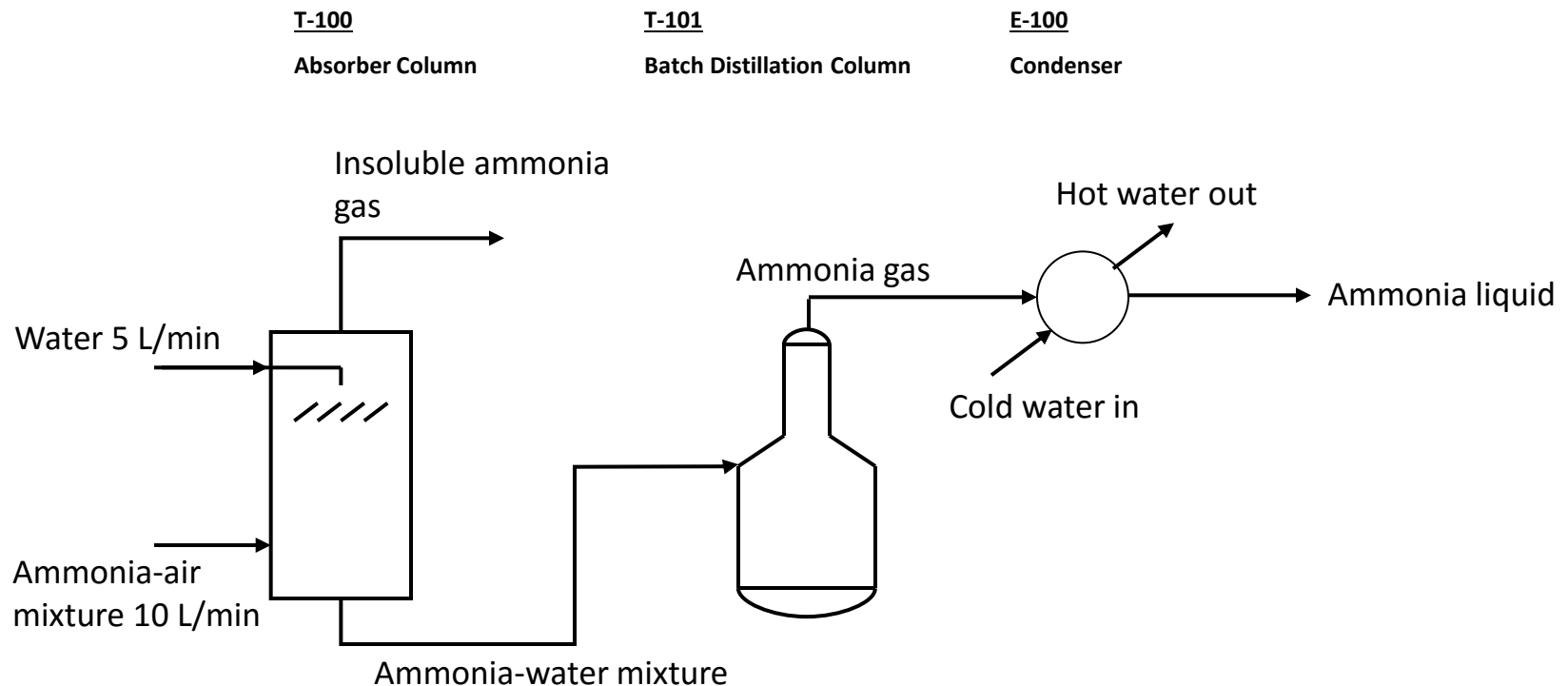
R-101

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

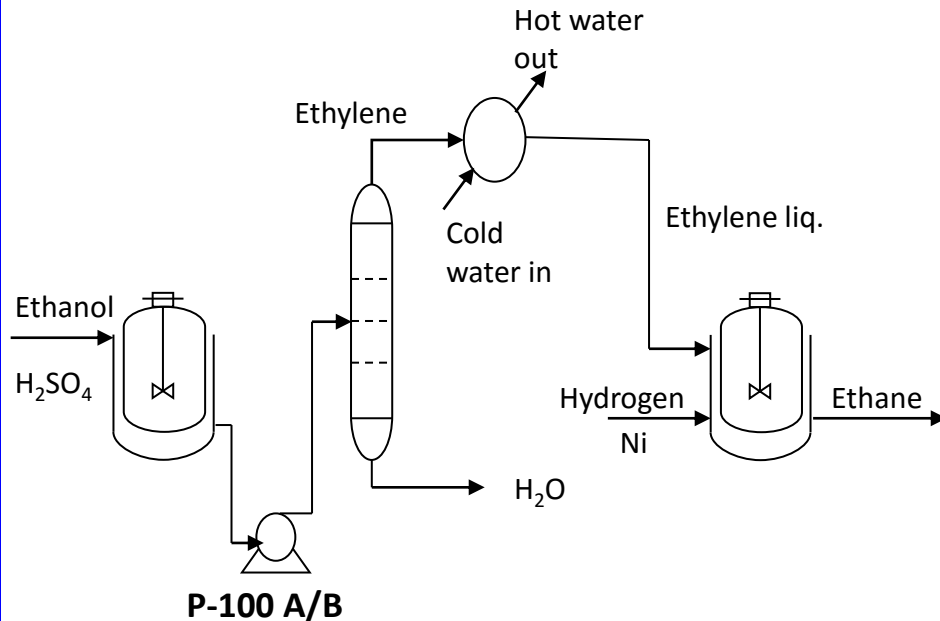
Supplemental Information

Additional description of equipment given on top of PFD

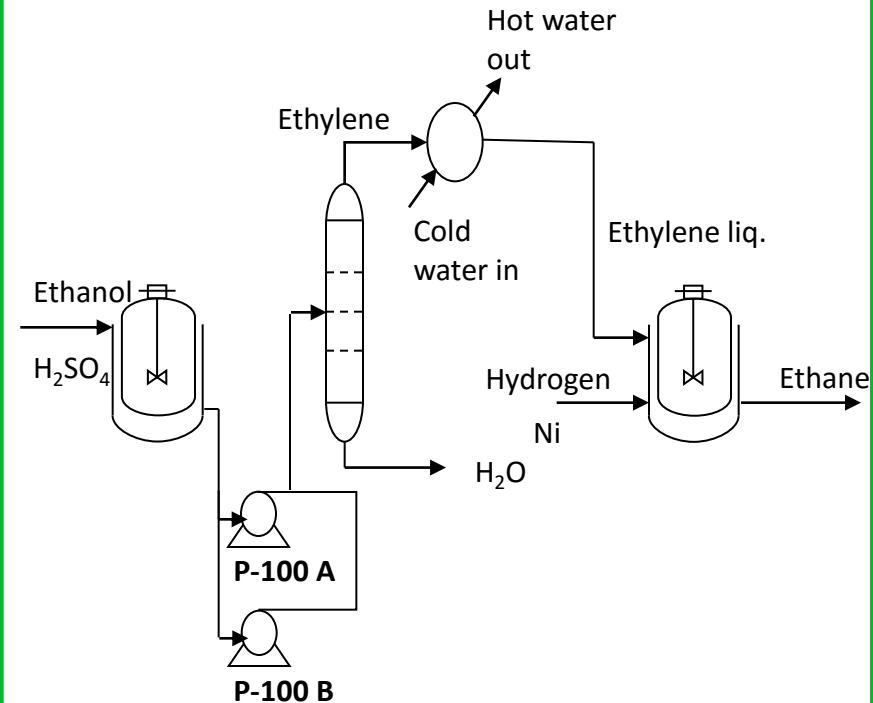
PROCESS FLOW DIAGRAM (PFD)

A/B Letter

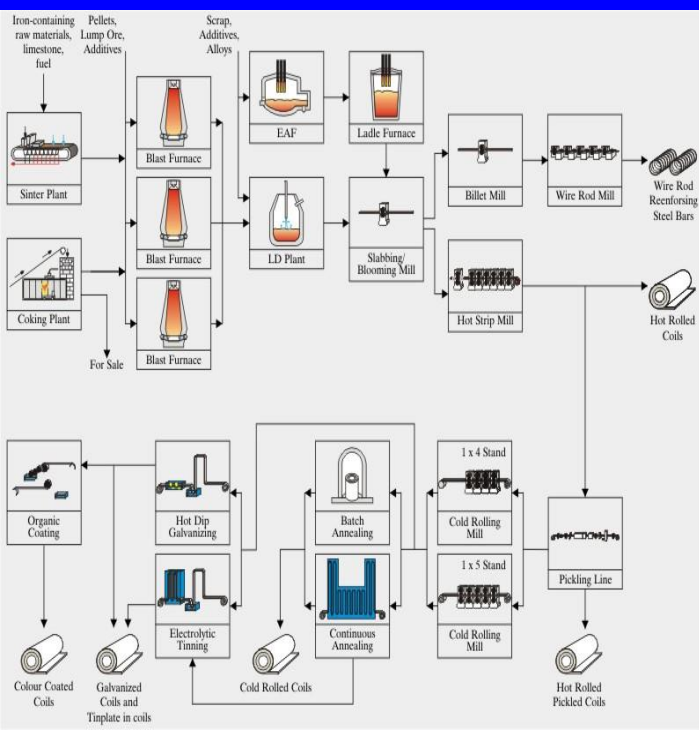
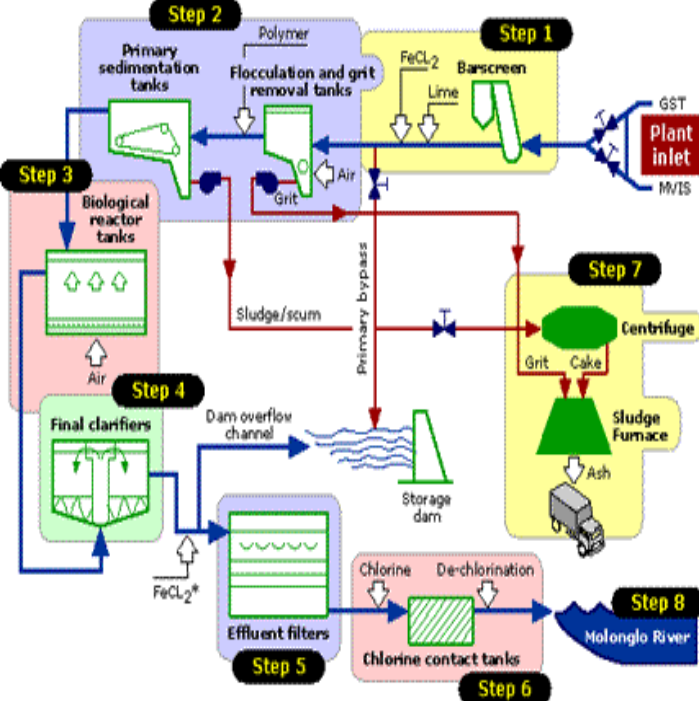
Example



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)

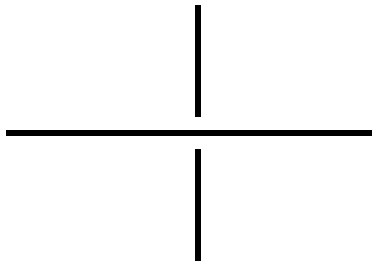
PFD will contains the following information:-

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

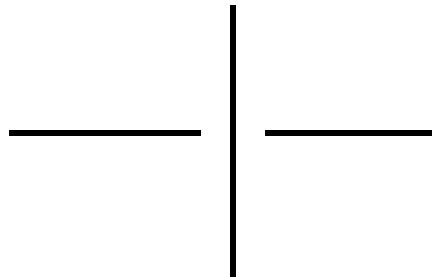
PROCESS FLOW DIAGRAM (PFD)

Stream Numbering and Drawing

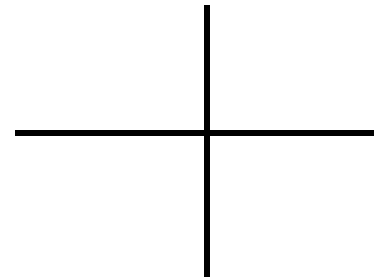
- Number streams from left to right as much as possible.
- Horizontal lines are dominant.



Yes



No



No

EXAMPLE 4- CONT'

R-100

Reactor

P-100

Pump

T-100

Distillation Column

E-100

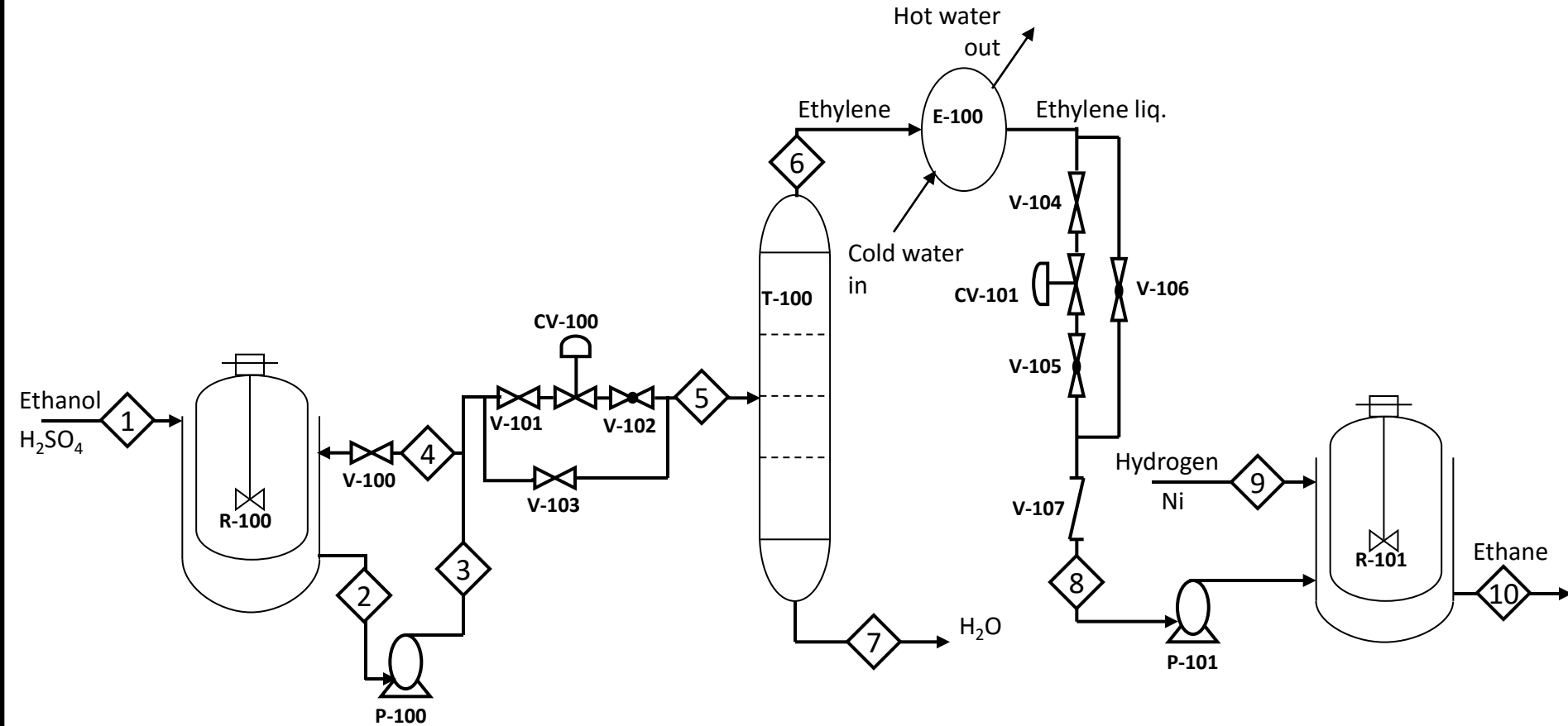
Condenser

P-101

Pump

R-101

Reactor



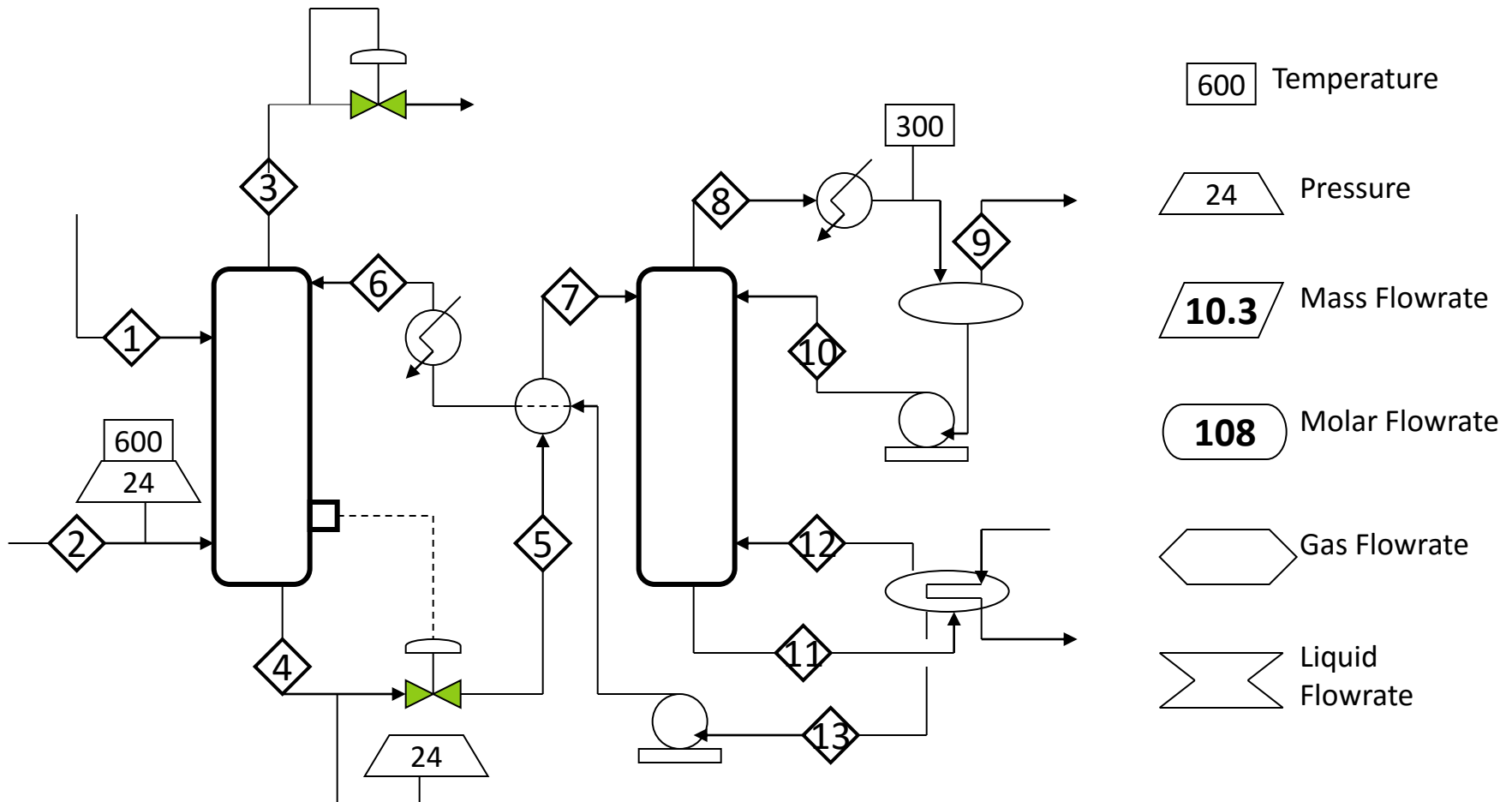
PROCESS FLOW DIAGRAM (PFD)

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'

R-100

Reactor

P-100

Pump

T-100

Distillation Column

E-100

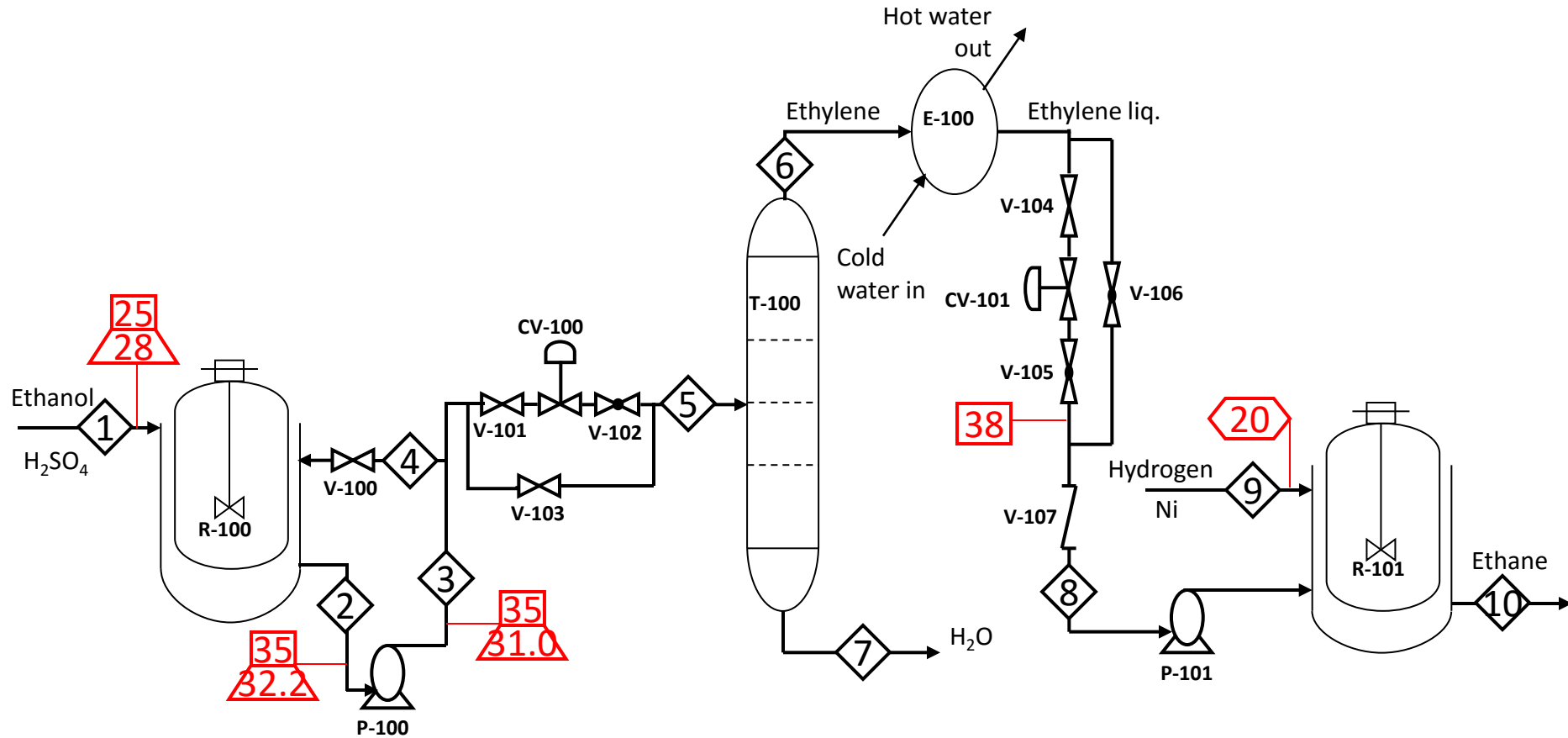
Condenser

P-101

Pump

R-101

Reactor



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'

R-100

Reactor

P-100

Pump

T-100

Distillation Column

E-100

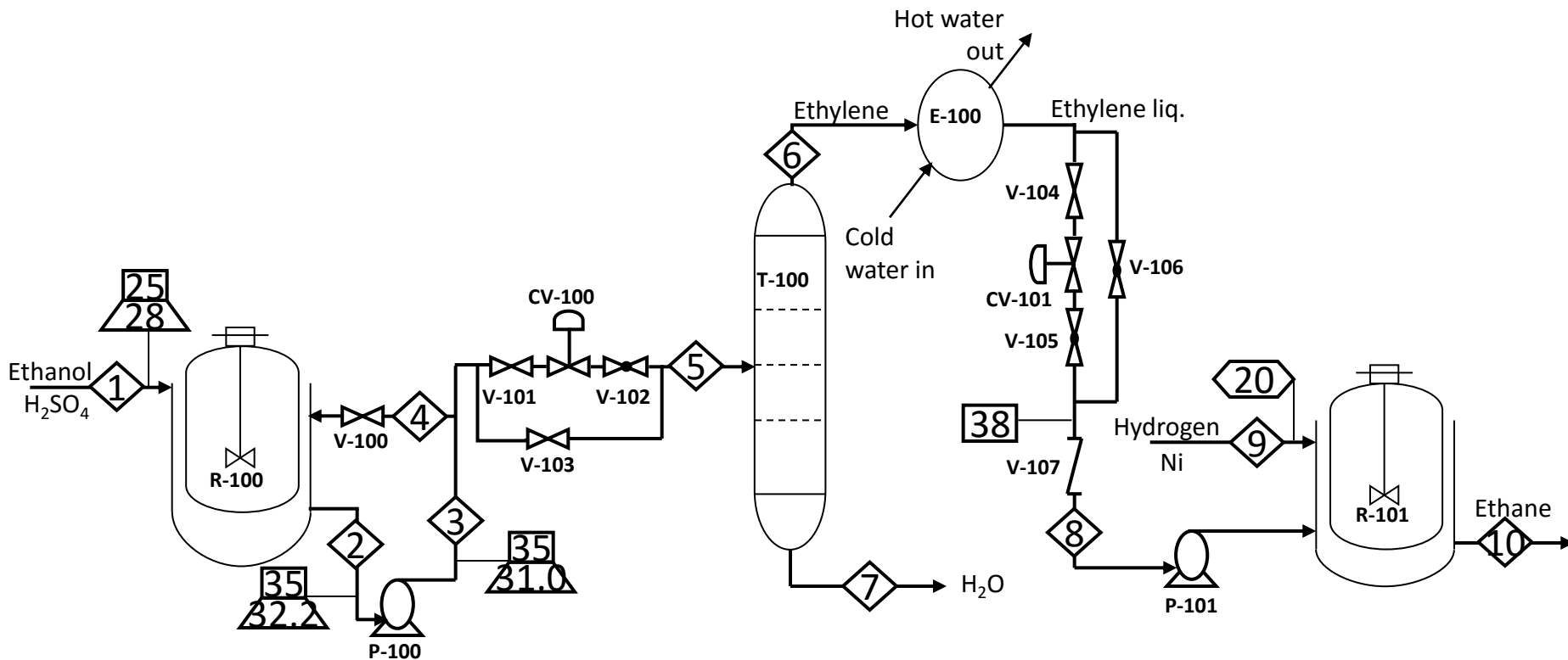
Condenser

P-101

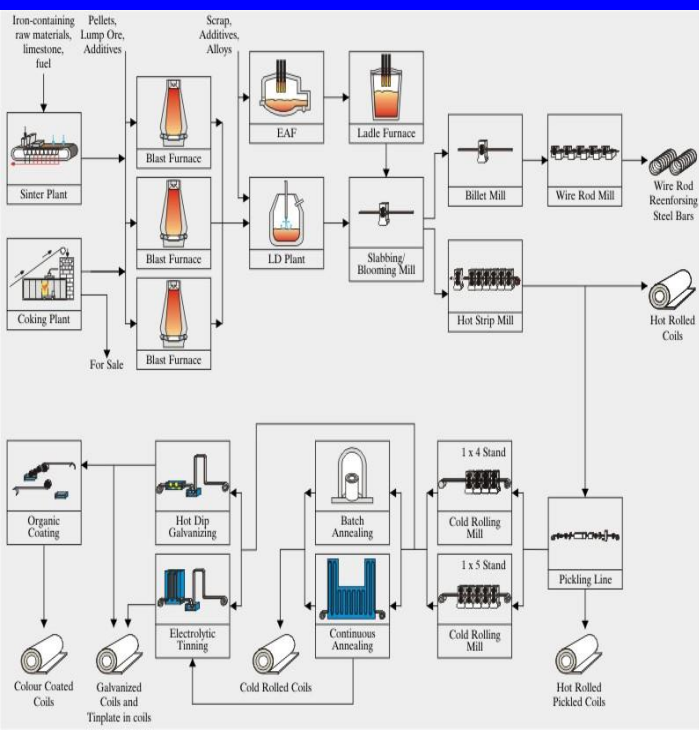
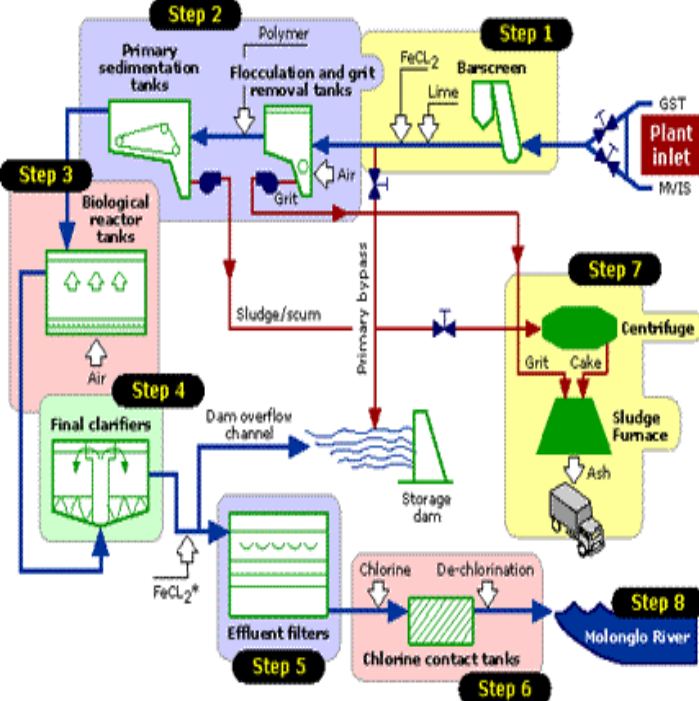
Pump

R-101

Reactor



Stream Number	1	2	3	4	5	6	7	8	9	10
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1. Major Pieces Of Equipment

2. Utility Streams

PFD

4. Basic Control Loops

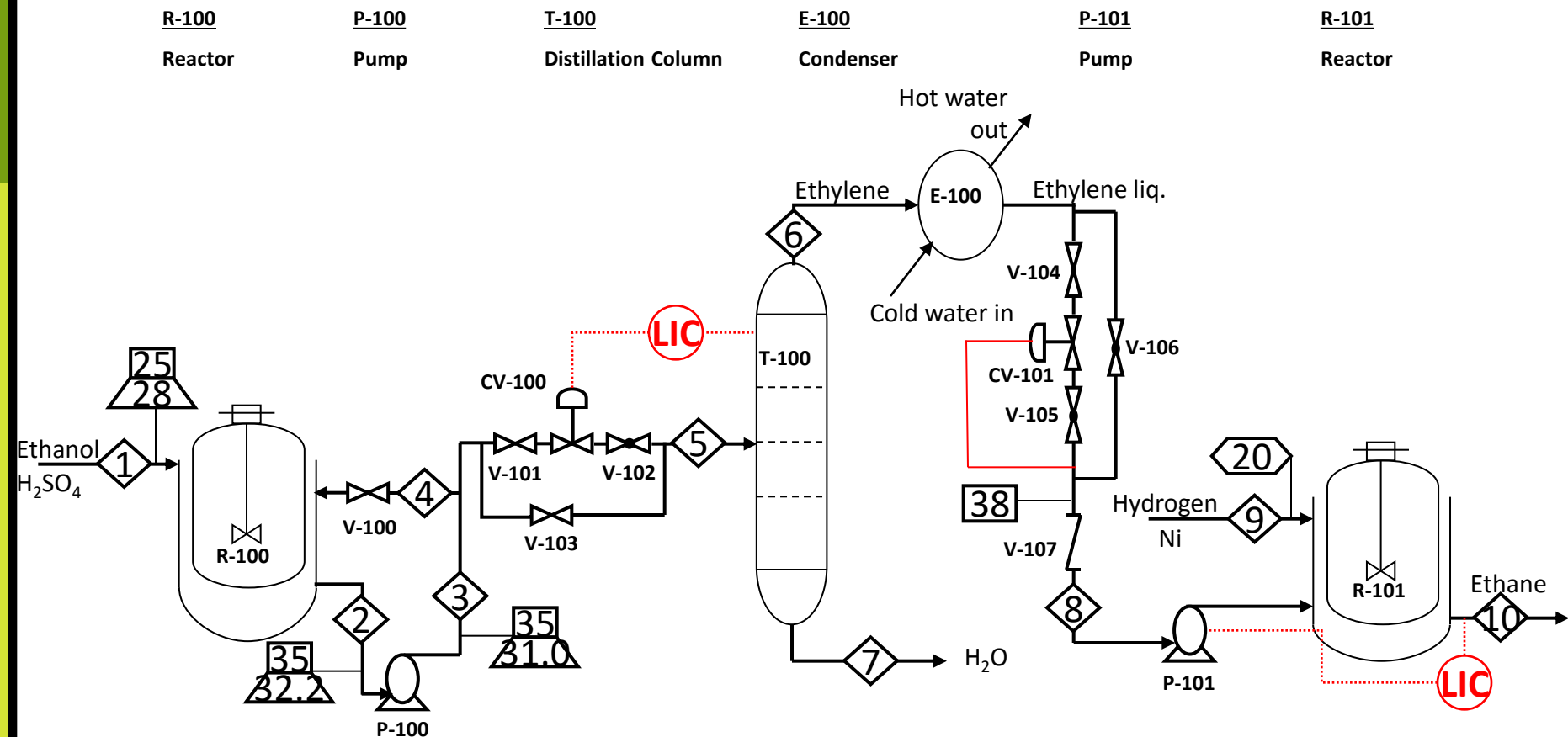
3. Process Flow Streams

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.

EXAMPLE 4- CONT'



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										
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Mole flow (kmol/hr)	108	114.2	301.0	1204.0	758.8	1204.4	42.6	1100.8	142.2	244.0

R-100
Reactor

P-100
Pump

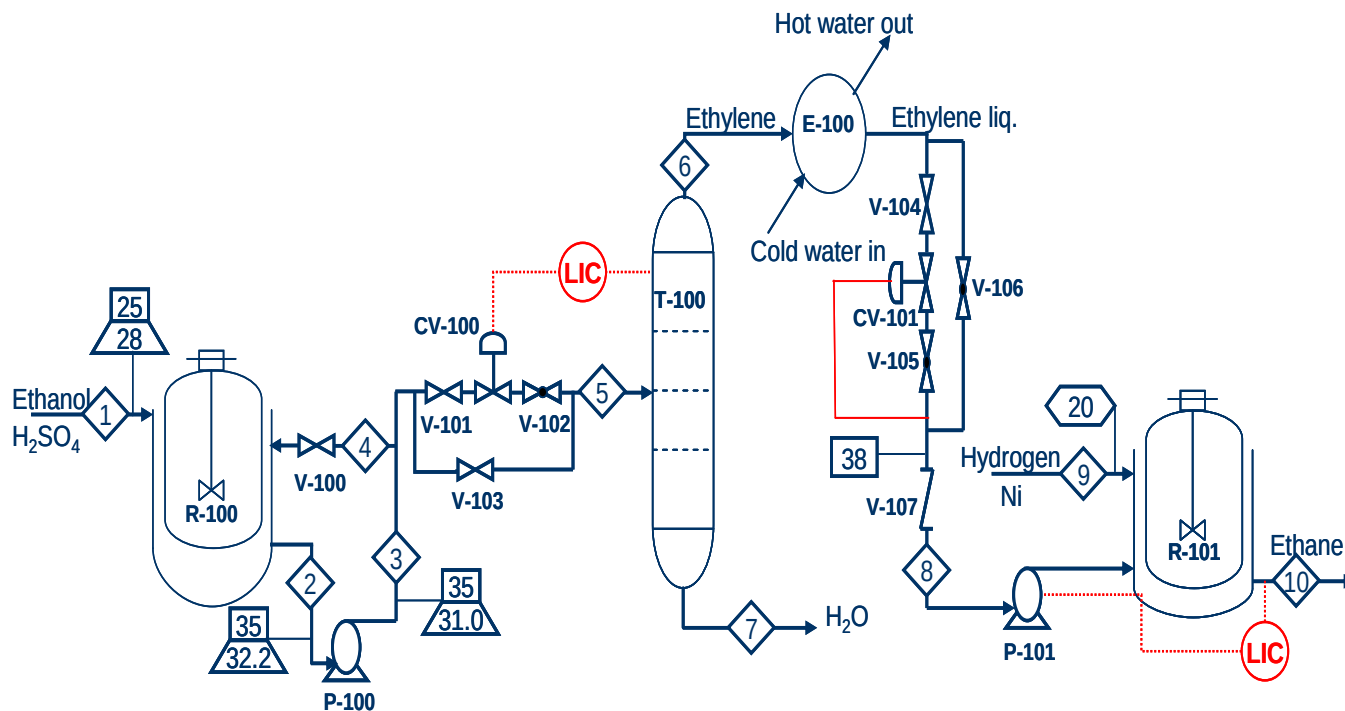
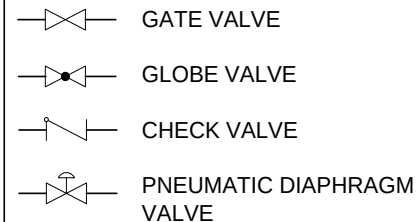
T-100
Distillation Column

E-100
Condenser

P-101
Pump

R-101
Reactor

NOTE:



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
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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

PROCESS FLOW
DIAGRAM

PRODUCTION OF
ETHANE FROM
ETHANOL

DRAWN BY :

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PAGE : 1 OF 1

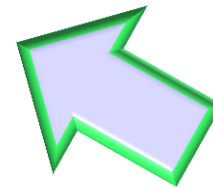
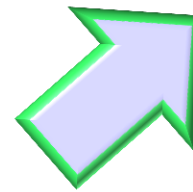


Block Flow
Diagram (BFD)

Process Flow
Diagram (PFD)



PROCESS DIAGRAMS



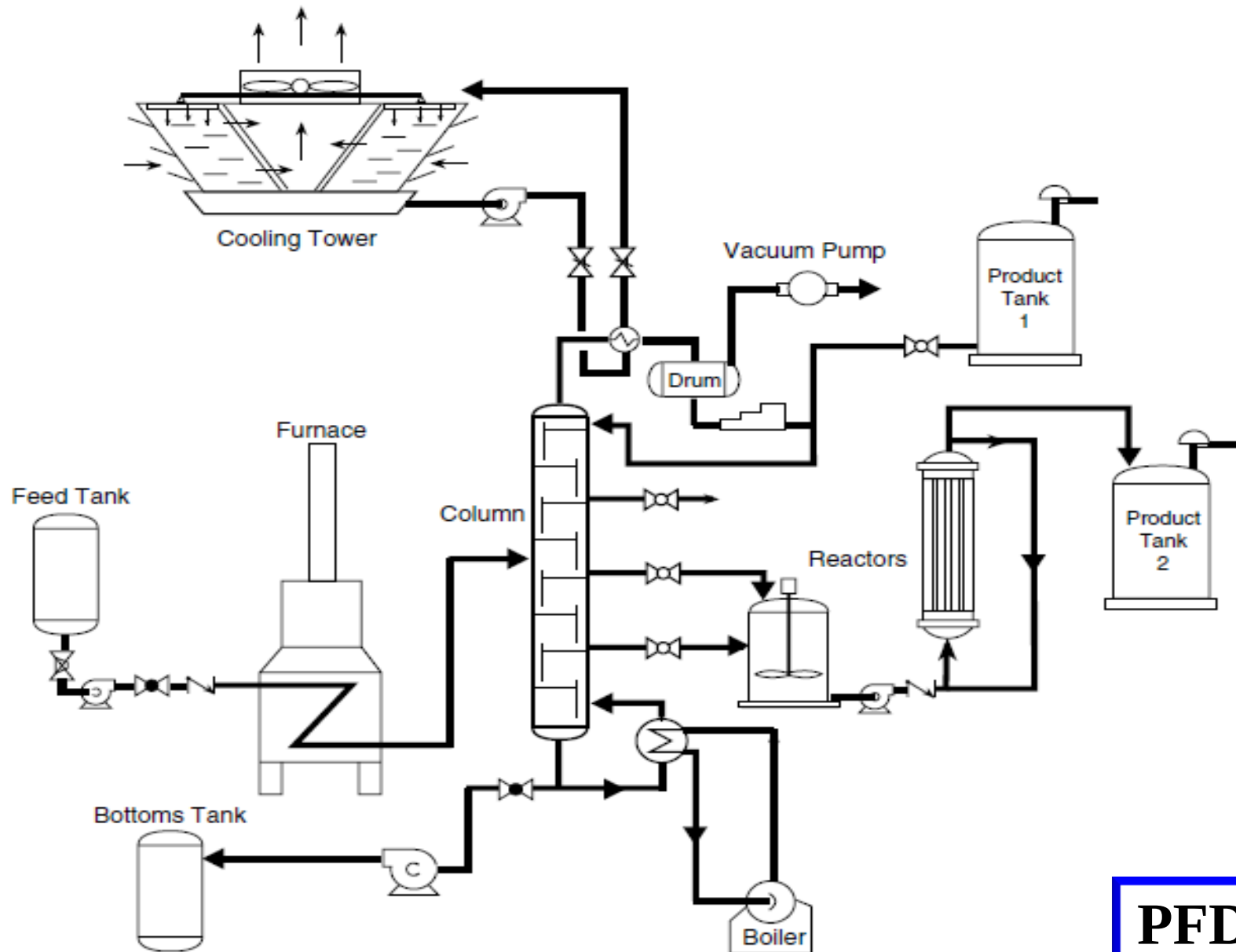
Process equipments
symbol and
numbering

Piping and
Instrumentation
Diagram (P&ID)

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

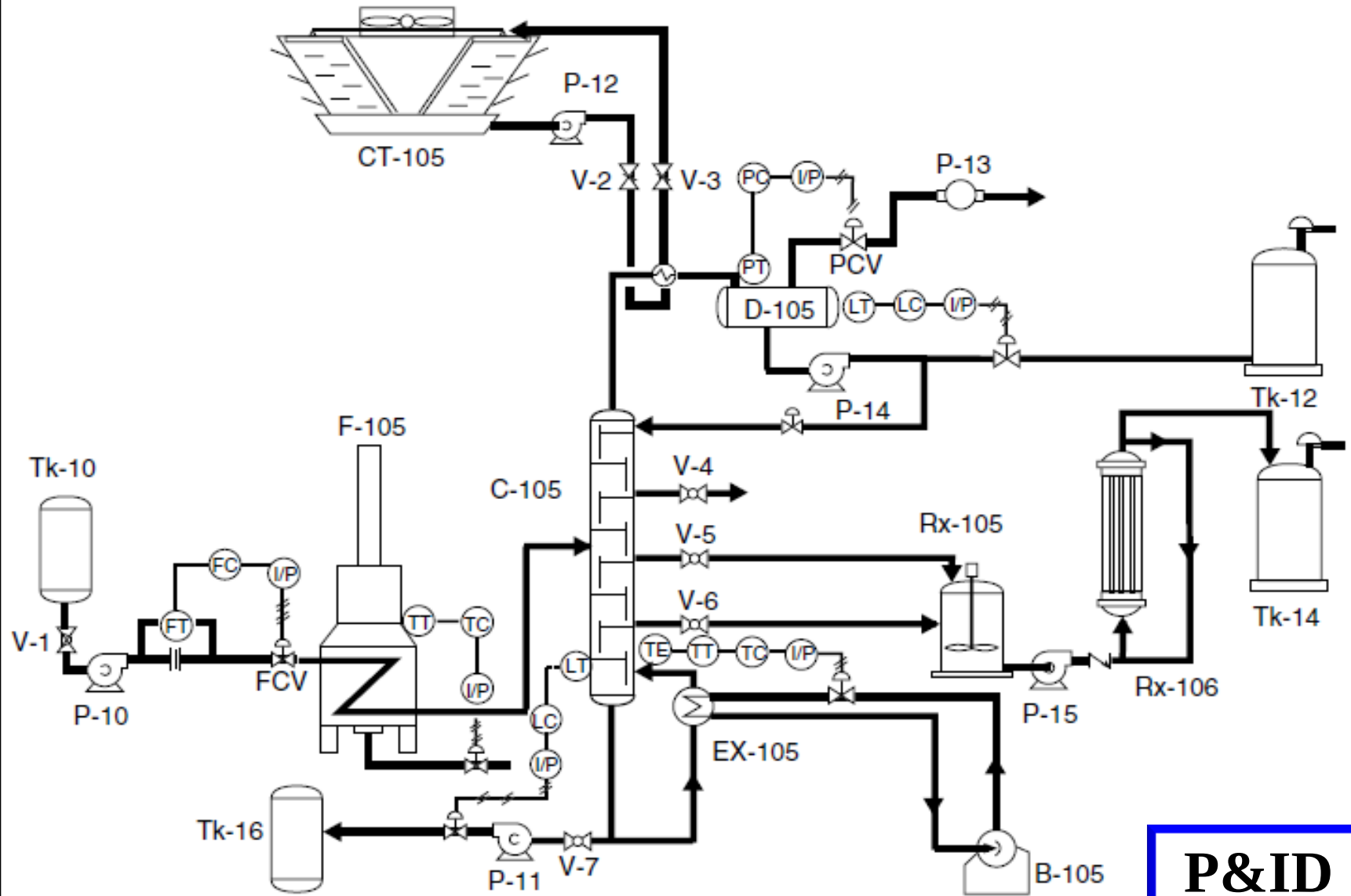
- ❑ Also known as **“PROCESS & INSTRUMENTATION DIAGRAM”**
- ❑ Detailed graphical representation of a process including the hardware and software **(i.e piping, equipment, and instrumentation)** necessary to design, construct and operate the facility.
- ❑ Common synonyms for P&IDs include **Engineering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

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



PFD

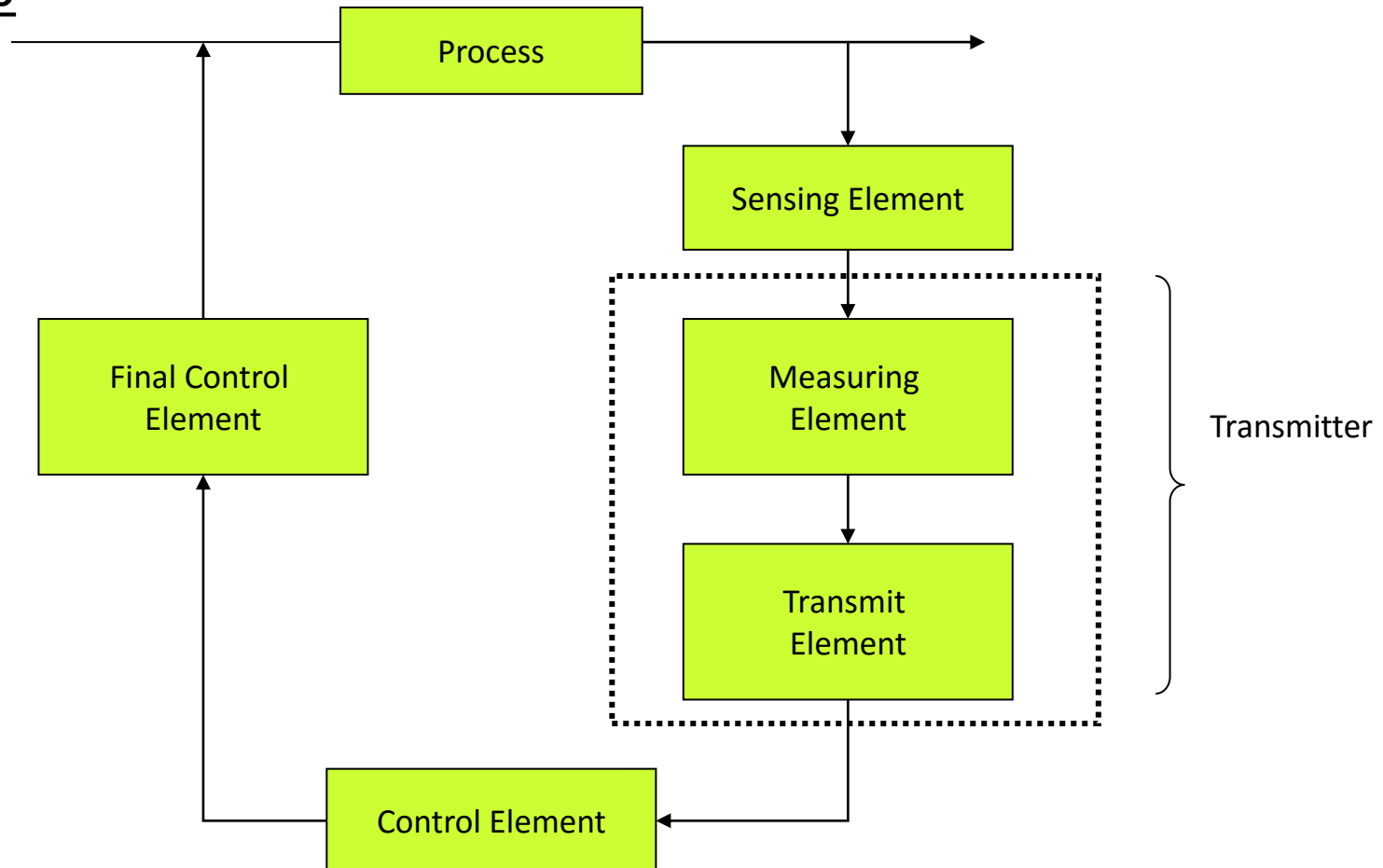
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



P&ID

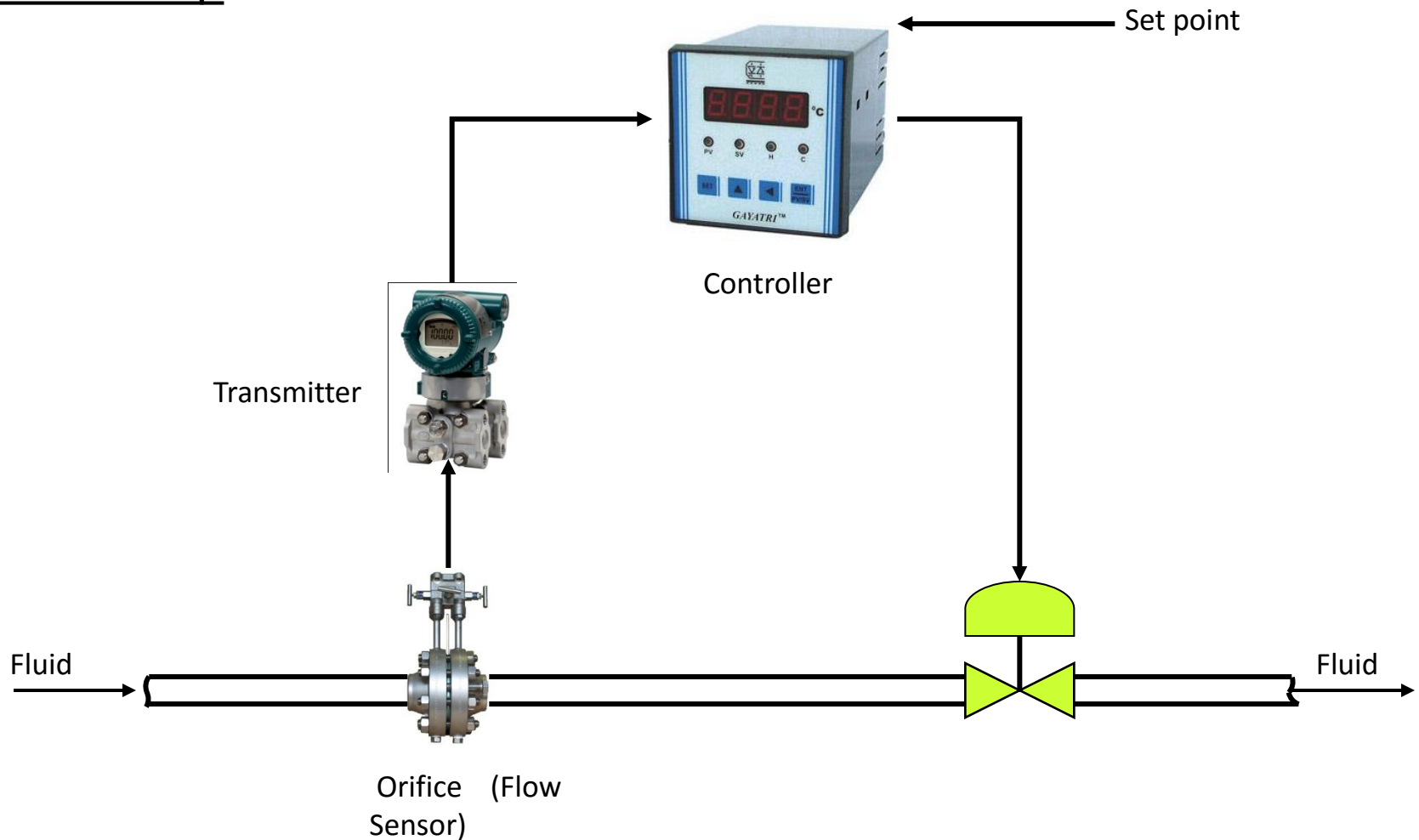
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Basic Loop



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Basic Loop



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

SENSORS (Sensing Element)

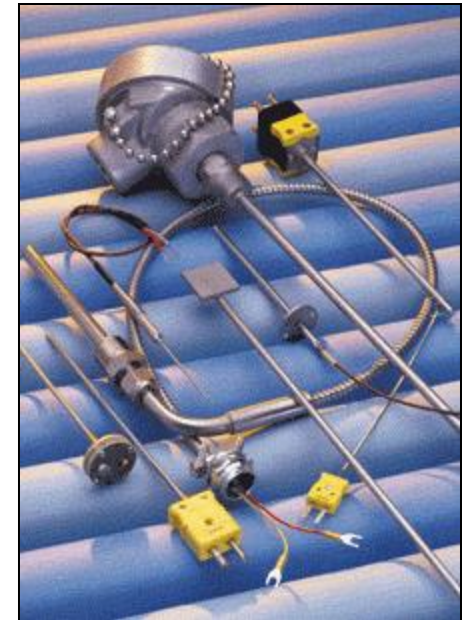
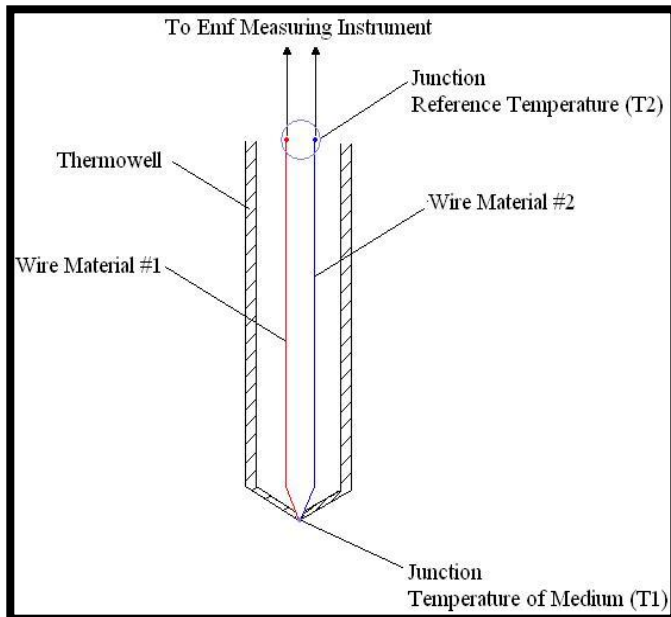
- ✓ A device, such as a **photoelectric cell**, that **receives and responds to a signal or stimulus**.
- ✓ A device, usually **electronic**, which **detects a variable quantity and measures and converts the measurement into a signal to be recorded elsewhere**.
- ✓ A sensor is a device that **measures 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.



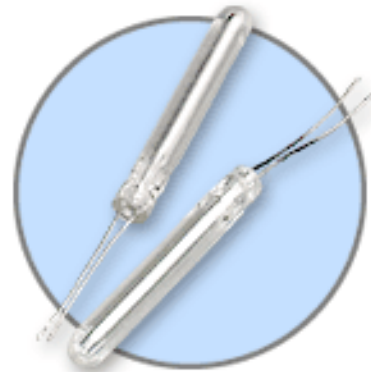
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

TEMPERATURE SENSOR

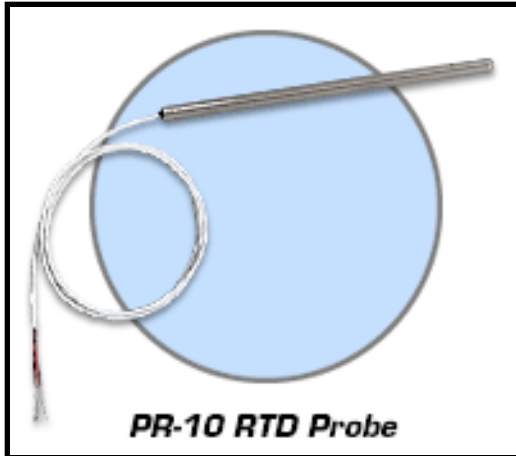
2. Resistance Temperature Detector (RTD)

- ✓ 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.

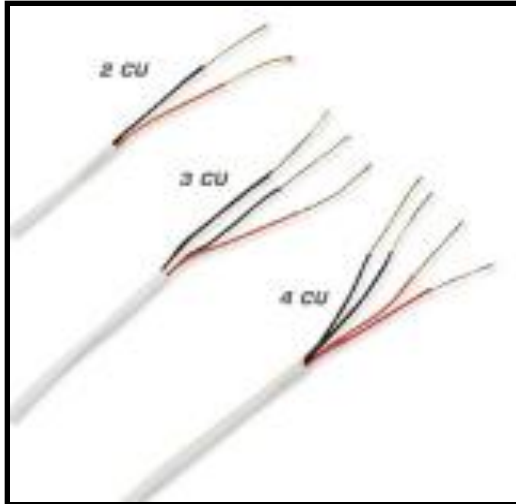
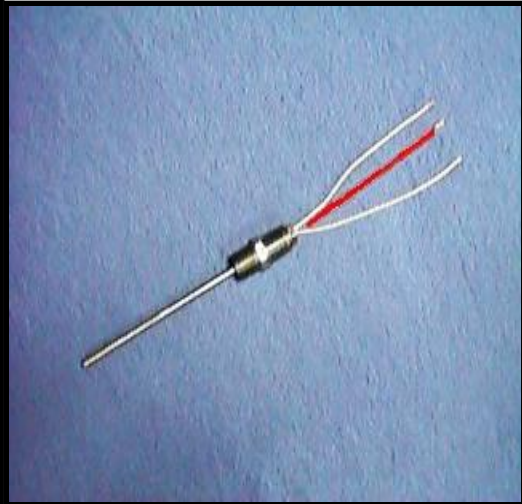
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



1PT100G RTD Elements



PR-10 RTD Probe



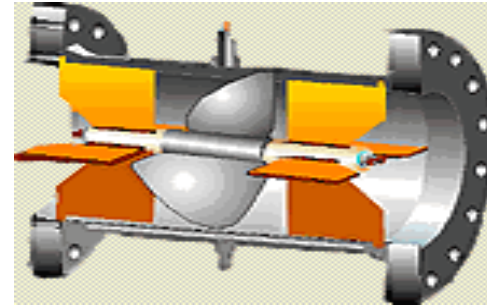
Accuracy for Standard OMEGA RTDs

Temperature °C	Ohms	°C
-200	±0.56	±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



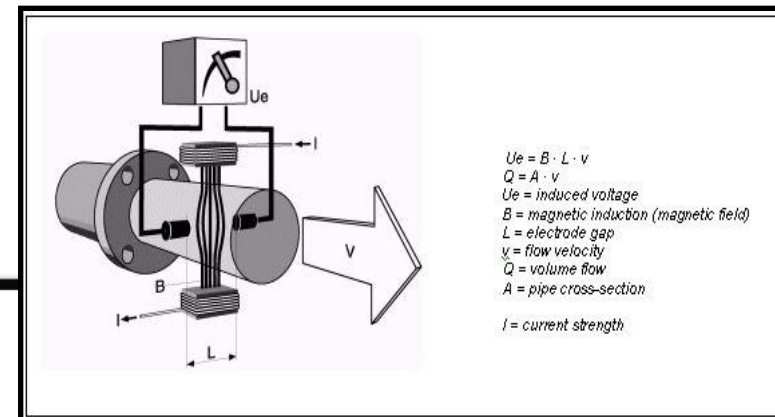
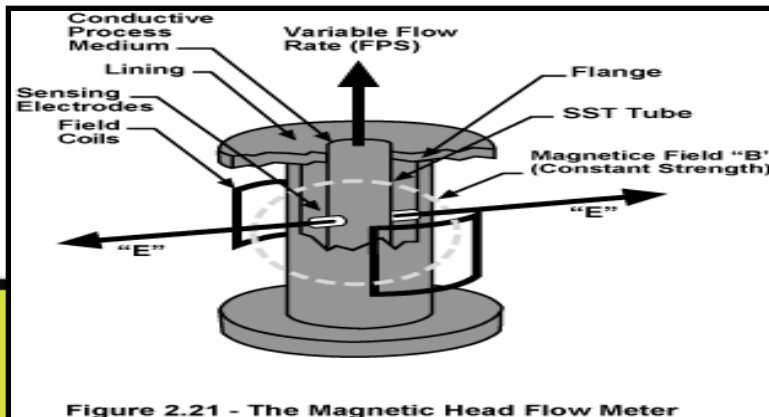
- ☺ Turbine meters are best suited to **large, sustained flows** as they are susceptible to start/stop errors as well as errors caused by unsteady flow states.
- ☺ In a turbine, the **basic concept** is that a meter is manufactured with a known cross sectional area. A rotor is then installed inside the 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

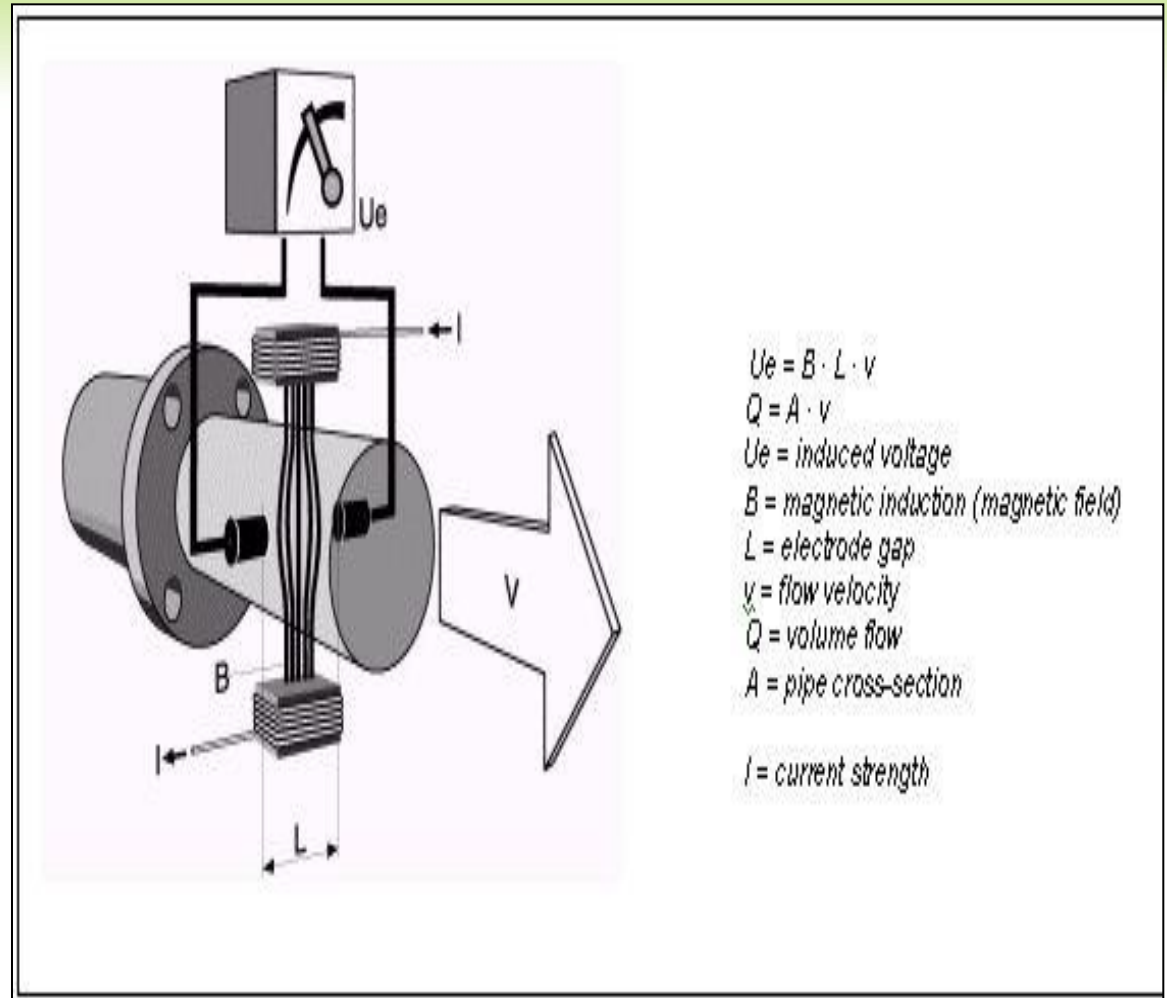
- ☺ Measurement of slurries and of corrosive or abrasive or other difficult fluids is easily made. There is no obstruction to fluid flow and pressure drop is minimal.
- ☺ The meters are unaffected by viscosity, density, temperature, pressure and fluid turbulence.
- ☺ Magnetic flow meters utilize the 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.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)



FLOW SENSOR

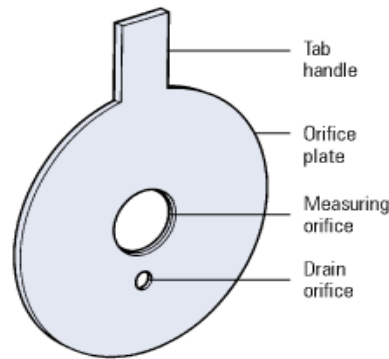


PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

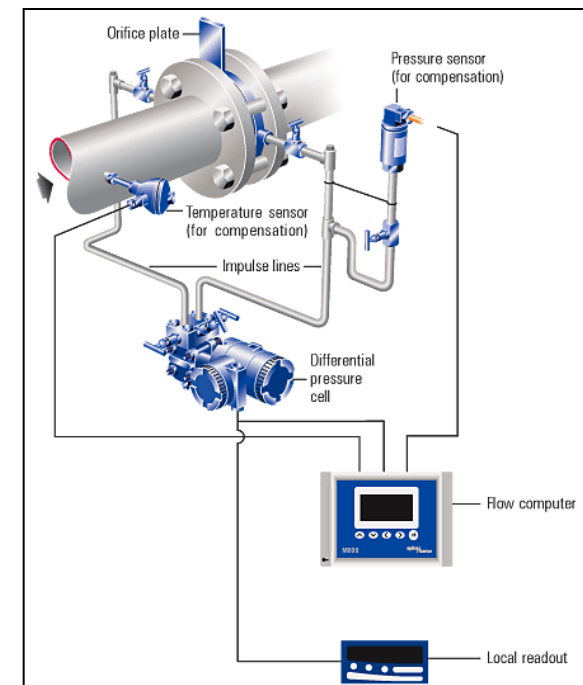
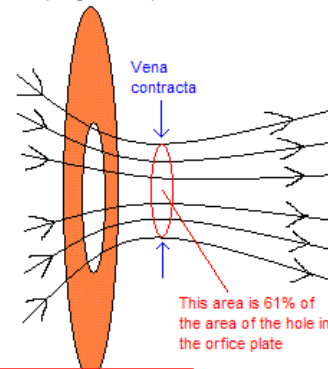
FLOW SENSOR

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.



Sharp edged orifice plate with a coefficient of .61



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

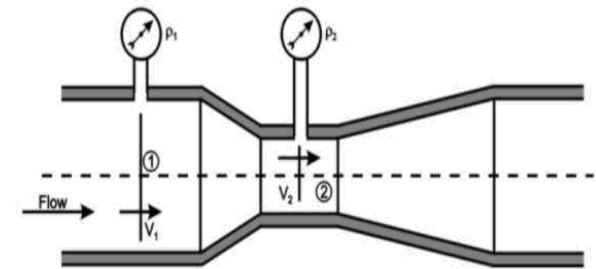
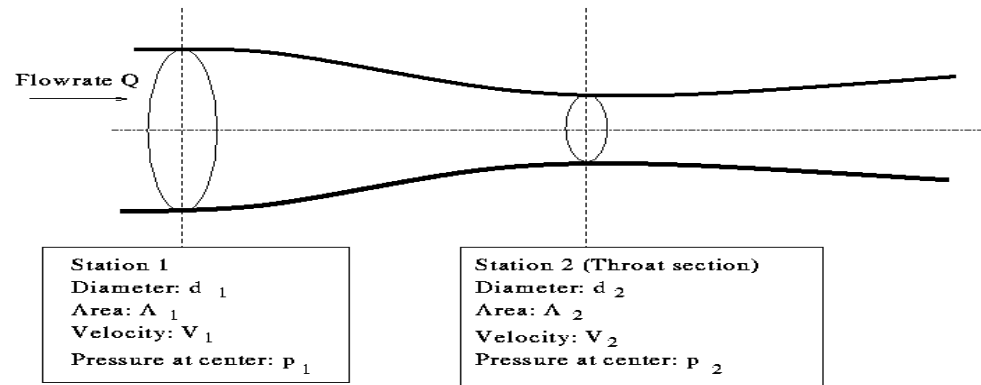
FLOW SENSOR

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 registering devices.

The venturi meter



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 adjusting certain 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

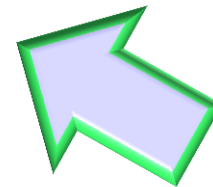
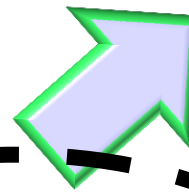


Block Flow
Diagram (BFD)

Process Flow
Diagram (PFD)



PROCESS DIAGRAMS

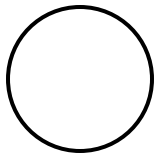


Process equipments
symbol and
numbering

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).

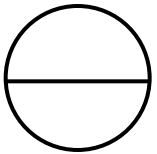


Field
mounted on
pipeline



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbolology



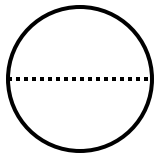
Instruments that are board mounted

-Instruments that are mounted on control board.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbology



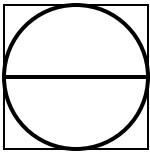
Instruments that are board mounted (invisible).

-Instruments that are mounted behind a control panel board.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Instrumentation Symbolology



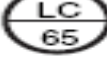
Instruments that are functioned in Distributed Control System (DCS)

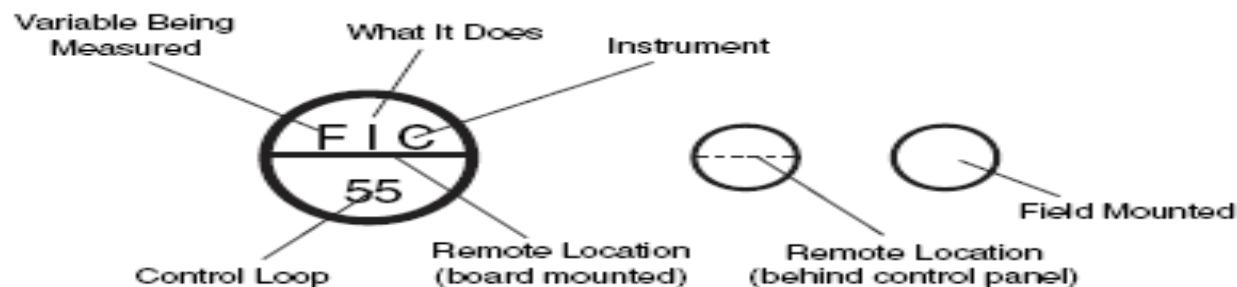
- A **distributed control system** (DCS) refers to a control system usually of a manufacturing system, process or any kind of dynamic system, in which the controller elements are not central in location (like the brain) but are distributed throughout the system with each component sub-system controlled 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 Symbolology

 TI	Temp Indicator	 FI	Flow Indicator		Transducer
 TT	Temp Transmitter	 FT	Flow Transmitter		Pressure Indicating Controller
 TR	Temp Recorder	 FR	Flow Recorder		Pressure Recording Controller
 TC	Temp Controller	 FC	Flow Controller		Level Alarm
 LI	Level Indicator	 PI	Pressure Indicator		Flow Element
 LT 65	Level Transmitter	 PT 55	Pressure Transmitter		Temperature Element
 LR 65	Level Recorder	 PR 55	Pressure Recorder		Level Gauge
 LC 65	Level Controller	 PC 55	Pressure Controller		Analyzer Transmitter



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 Symbolology

(1) INSTRUMENT SUPPLY *
OR CONNECTION TO PROCESS



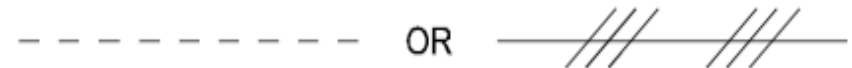
(2) UNDEFINED SIGNAL



(3) PNEUMATIC SIGNAL **



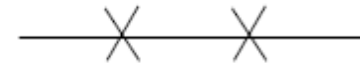
(4) ELECTRIC SIGNAL



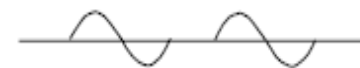
(5) HYDRAULIC SIGNAL



(6) CAPILLARY TUBE



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



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



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



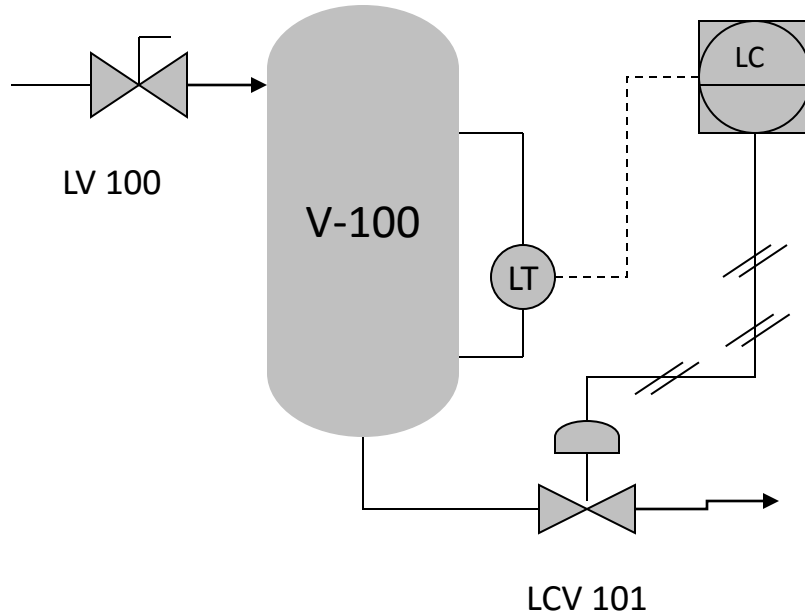
(10) MECHANICAL LINK



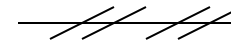
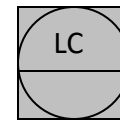
PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Principal of P&ID

Example 1



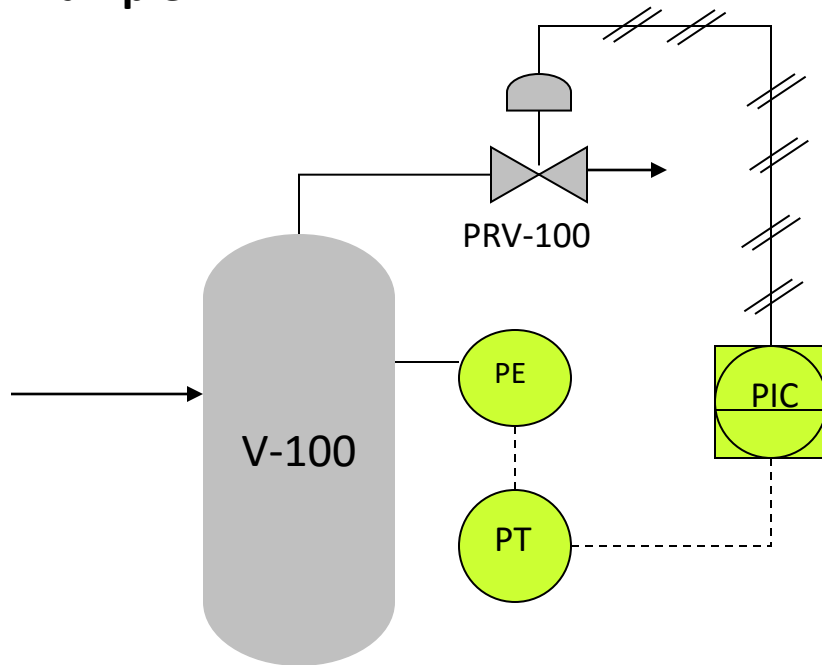
With using these following symbols;



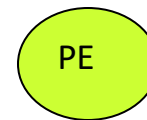
Complete control loop for LCV 101

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Example 2



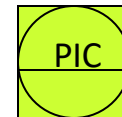
With using these following symbology;



Where PE is locally mounted on V-100



Where PT is locally mounted

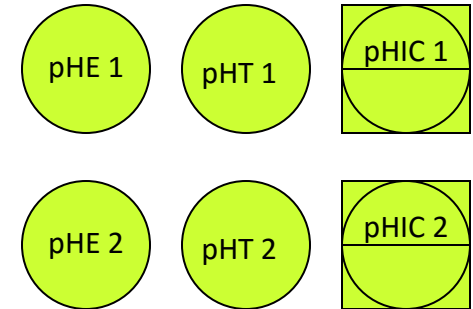
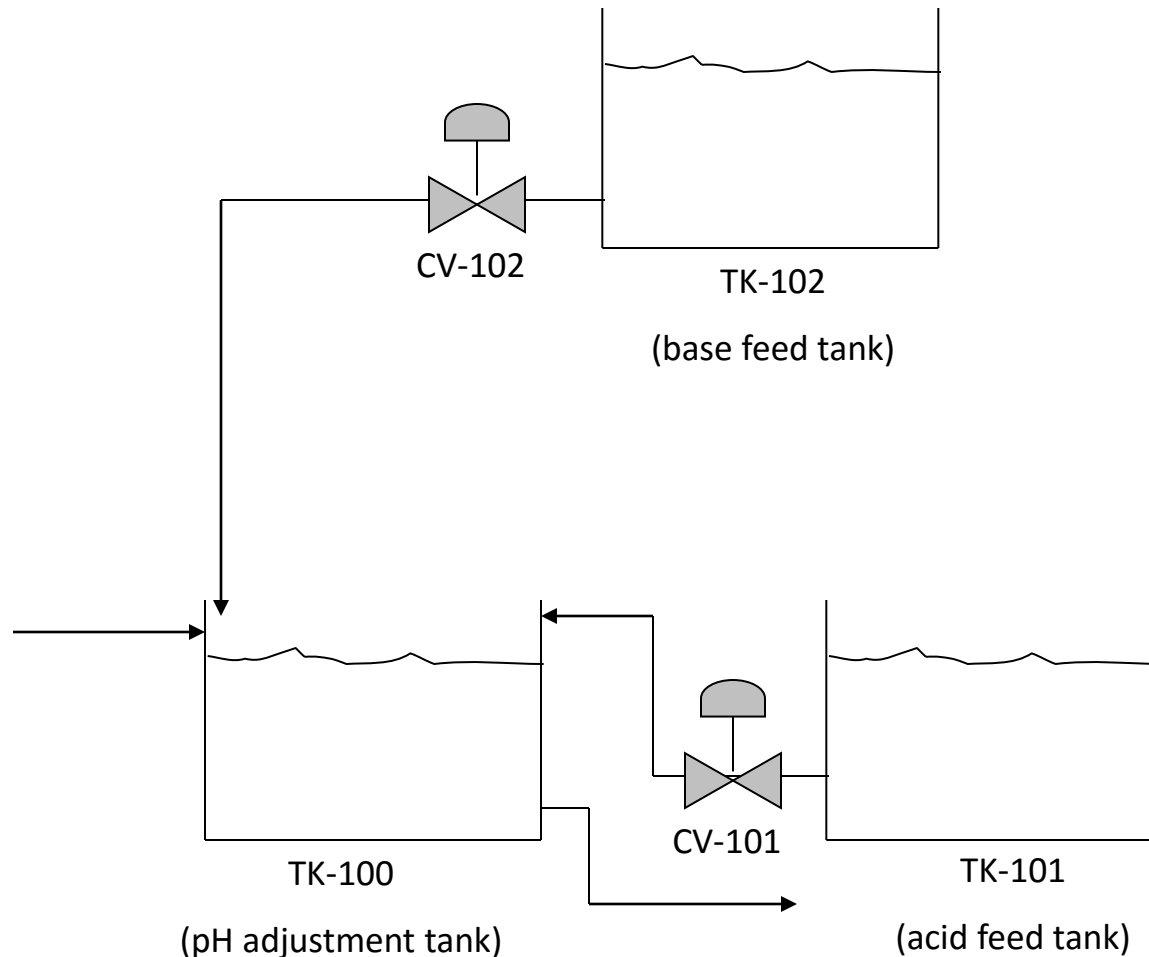


Where PIC is function in DCS

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

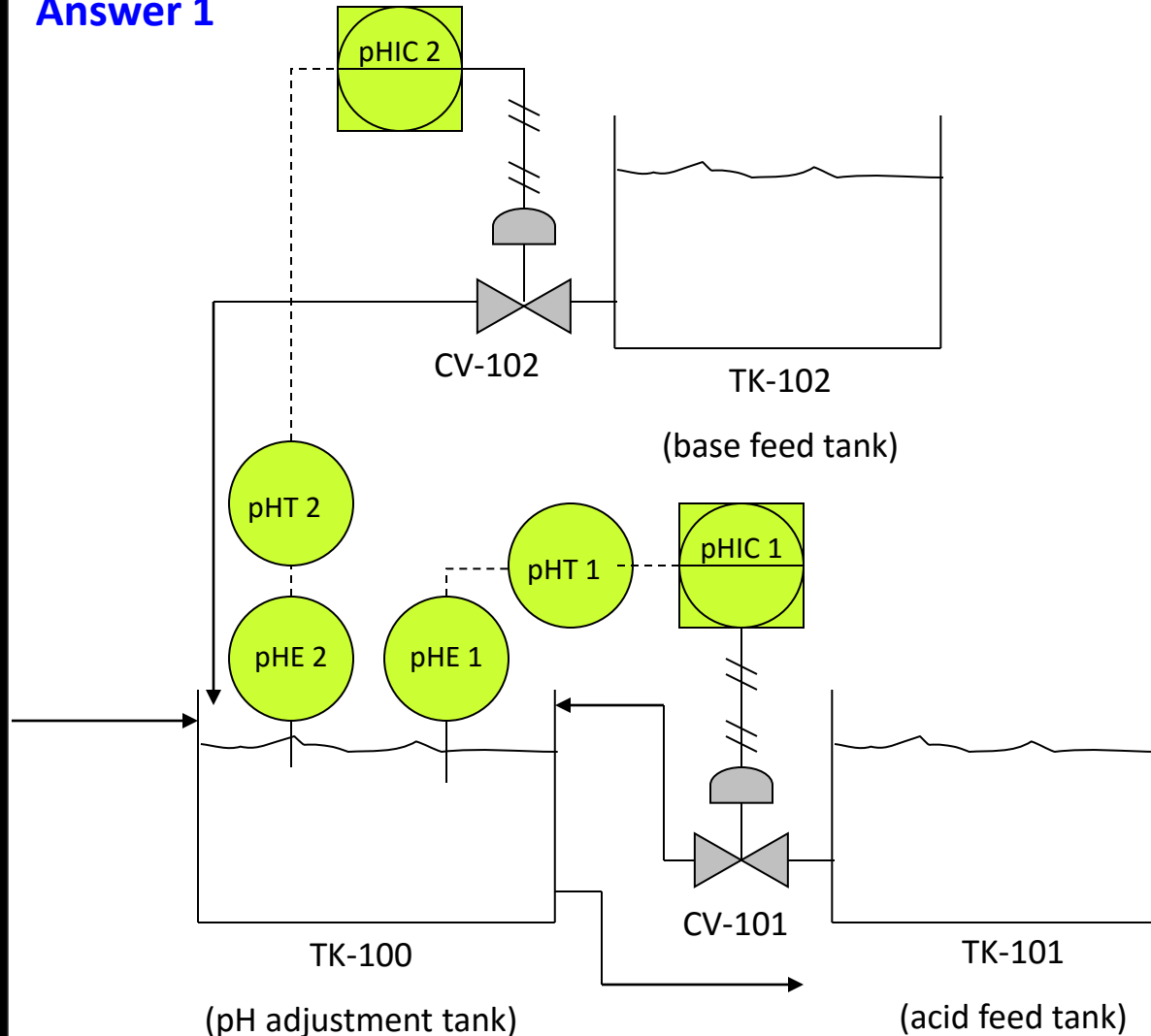


The diagram **shows pH adjustment**; part of waste water treatment process. With using above symbols, draw control loop where the process need is:

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

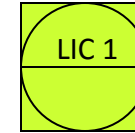
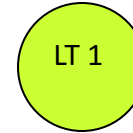
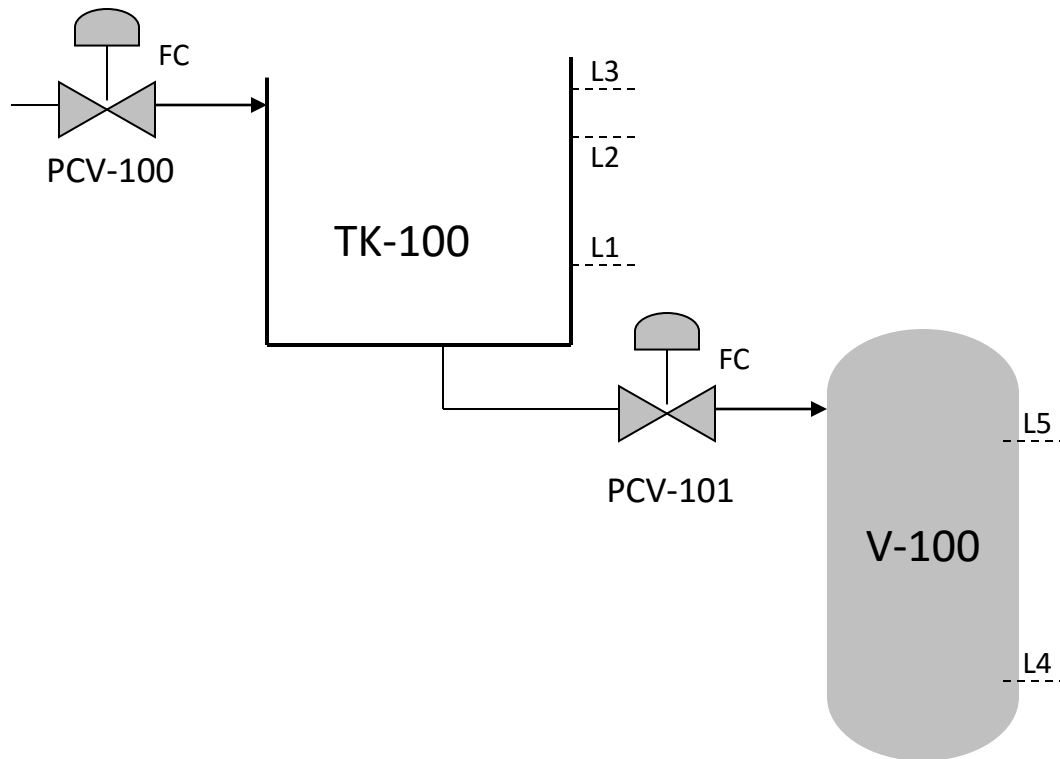


The diagram **shows pH adjustment**; part of waste water treatment process. With using above symbols, draw control loop where the process need is:

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)

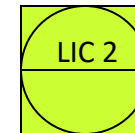
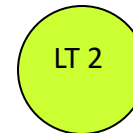
Exercise 2



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



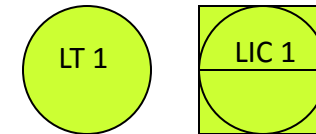
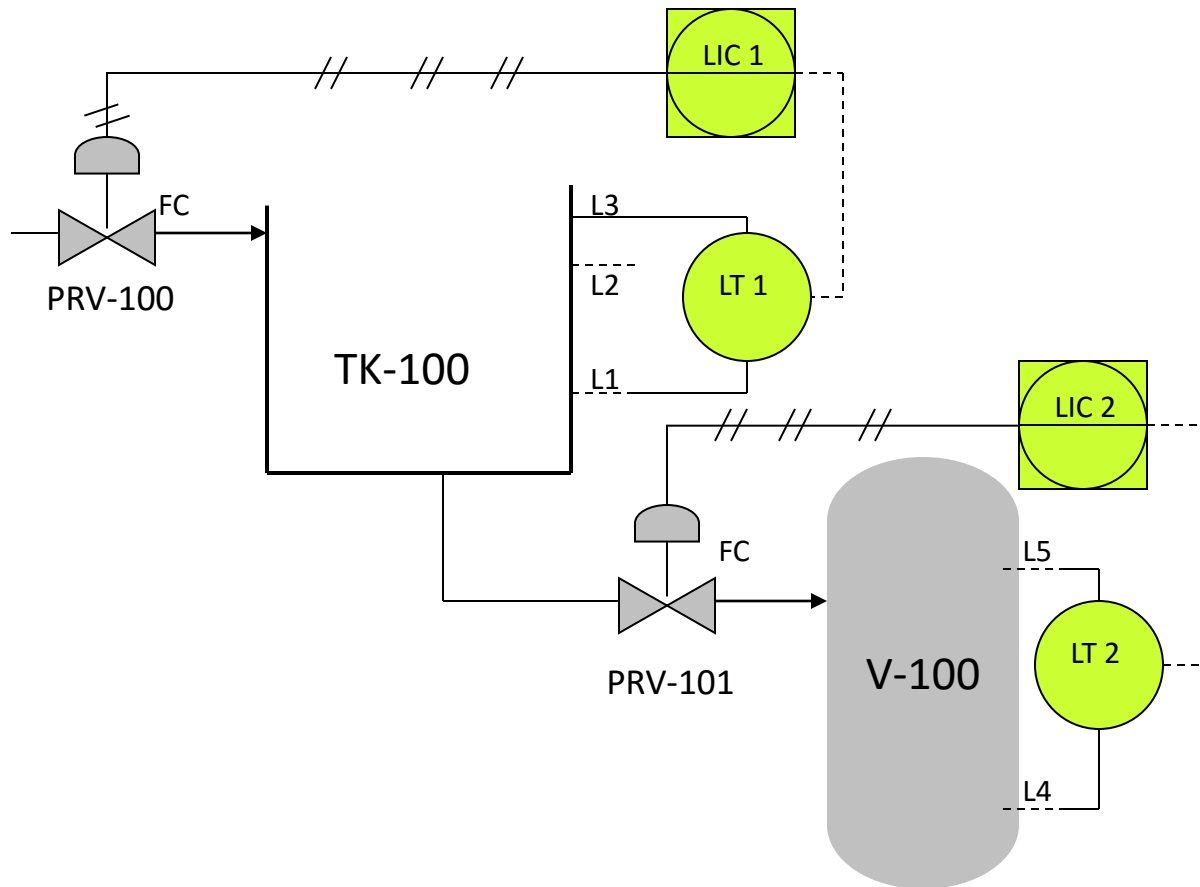
Where LT 2 and LIC 2 to control
PCV-101 (failure close);

PCV-101 close when level reached
L5

PCV-101 open when level below L5

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

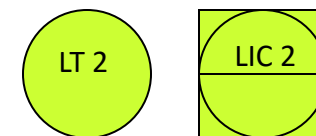
Answer 2



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

PRV-100 close when level reached L3

PRV-100 open when level below L3



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

PRV-101 close when level reached L5

PRV-101 open when level below L5

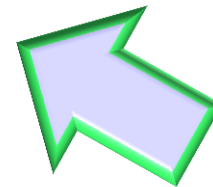
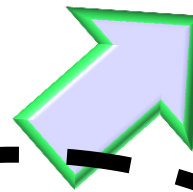


Block Flow
Diagram (BFD)

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

□ **XYX 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

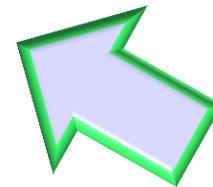
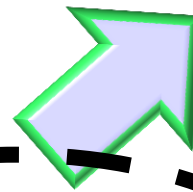


Block Flow
Diagram (BFD)

Process Flow
Diagram (PFD)



PROCESS DIAGRAMS

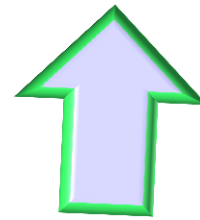


Process equipments
symbol and
numbering

Piping and
Instrumentation
Diagram (P&ID)



P&ID



**PROCESS
CONTROL
VARIETY**

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

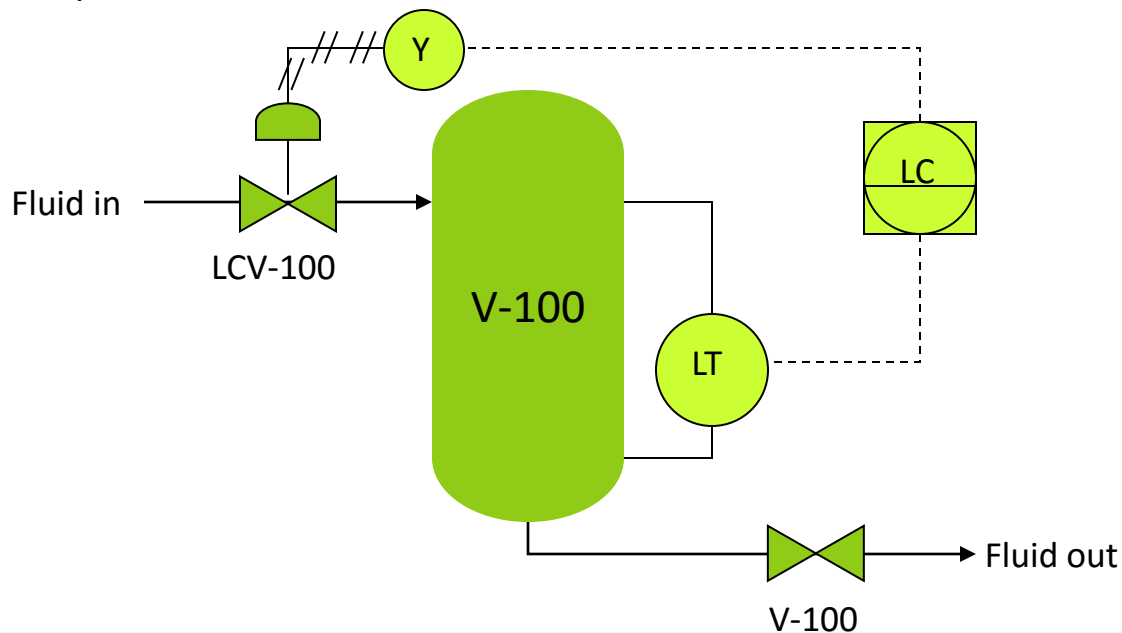
Type of Process Control Loop

- ❖ 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

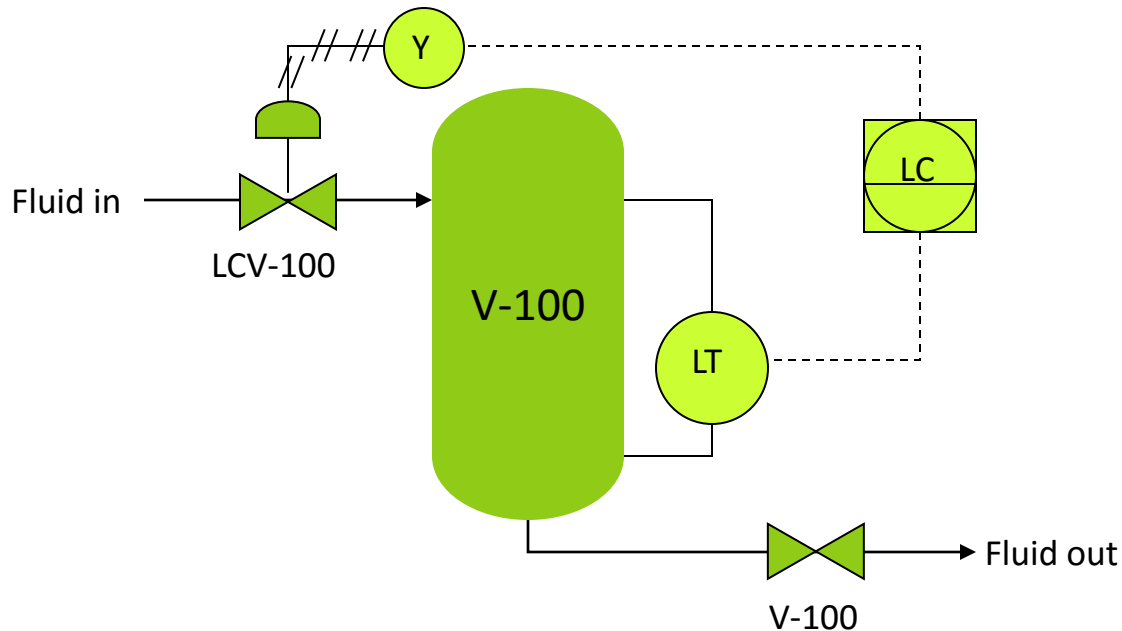
- ❖ One of the simplest process control schemes.
- ❖ A feedback loop measures a process variable and sends the measurement to a controller for comparison to set point. If the process variable is not at set point, control action is taken to return the process variable to set point.
- ❖ The advantage of 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...)

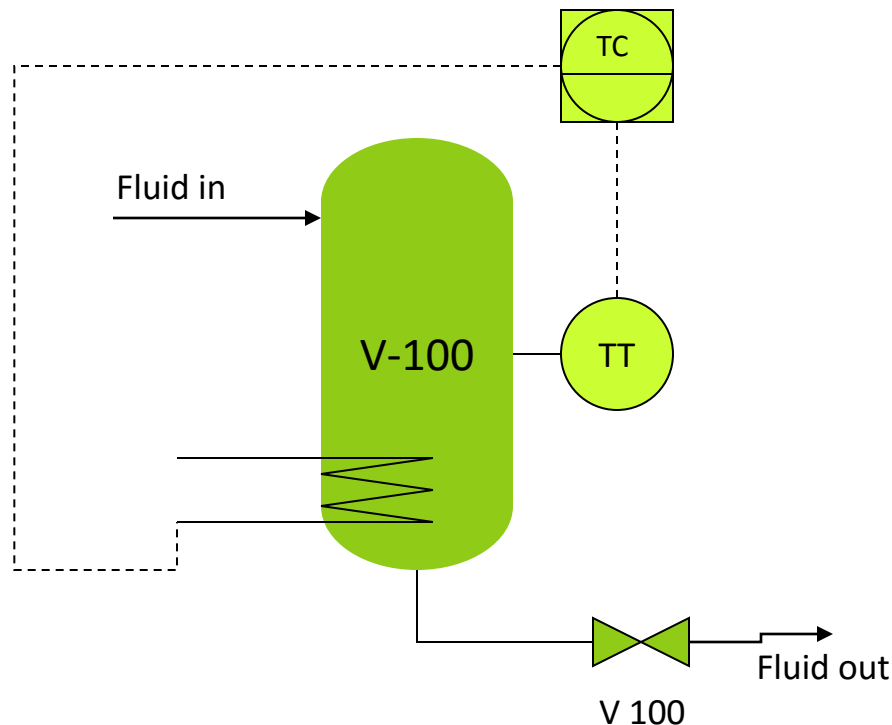
- ❖ Feedback loops are commonly used in the process control industry.
- ❖ The advantage of a feedback loop is that it directly controls the desired process variable.
- ❖ The disadvantage of feedback loops is that the process variable must leave set point for action to be taken.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Example 1

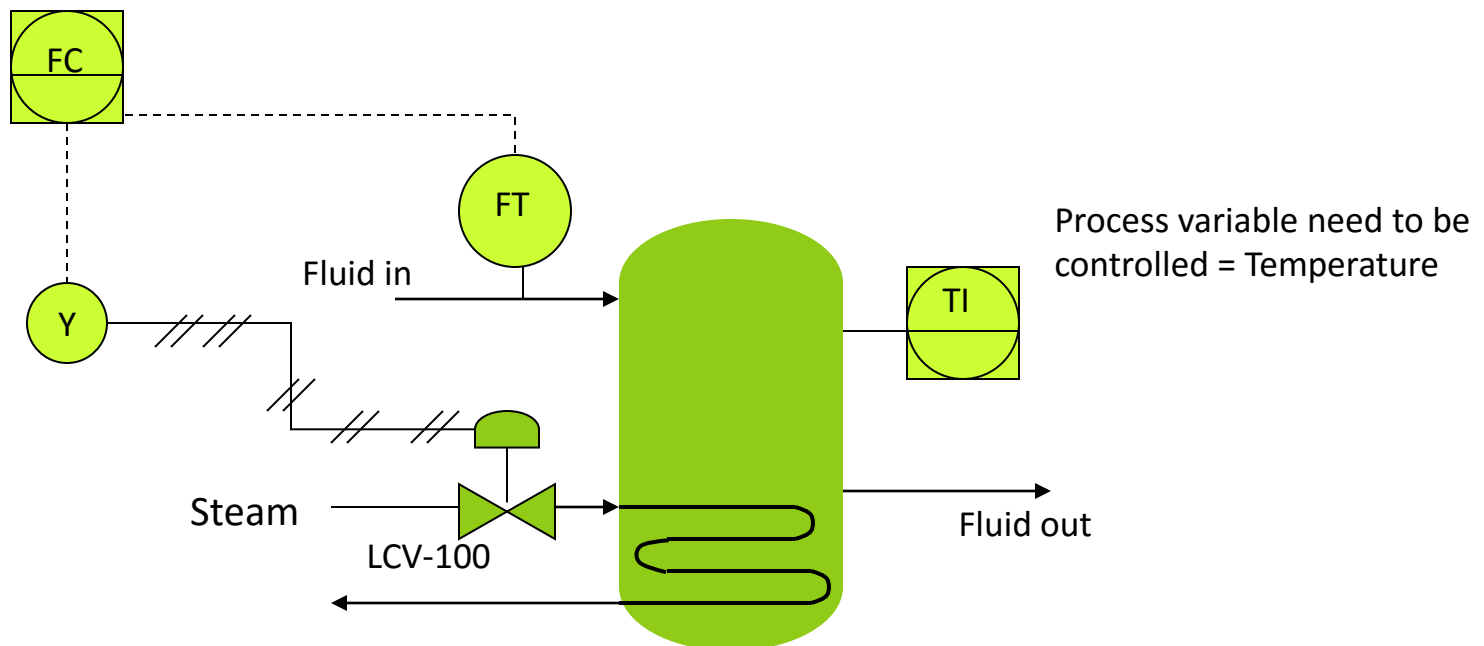
- ❖ Figure below shows the liquid vessel for boiler system. This system has to maintain maximum desired temperature of 120 °C (L2) where the heater will be cut off when the temperature reached desired temperature. Draw feedback control loop for the system.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Feedforward Control

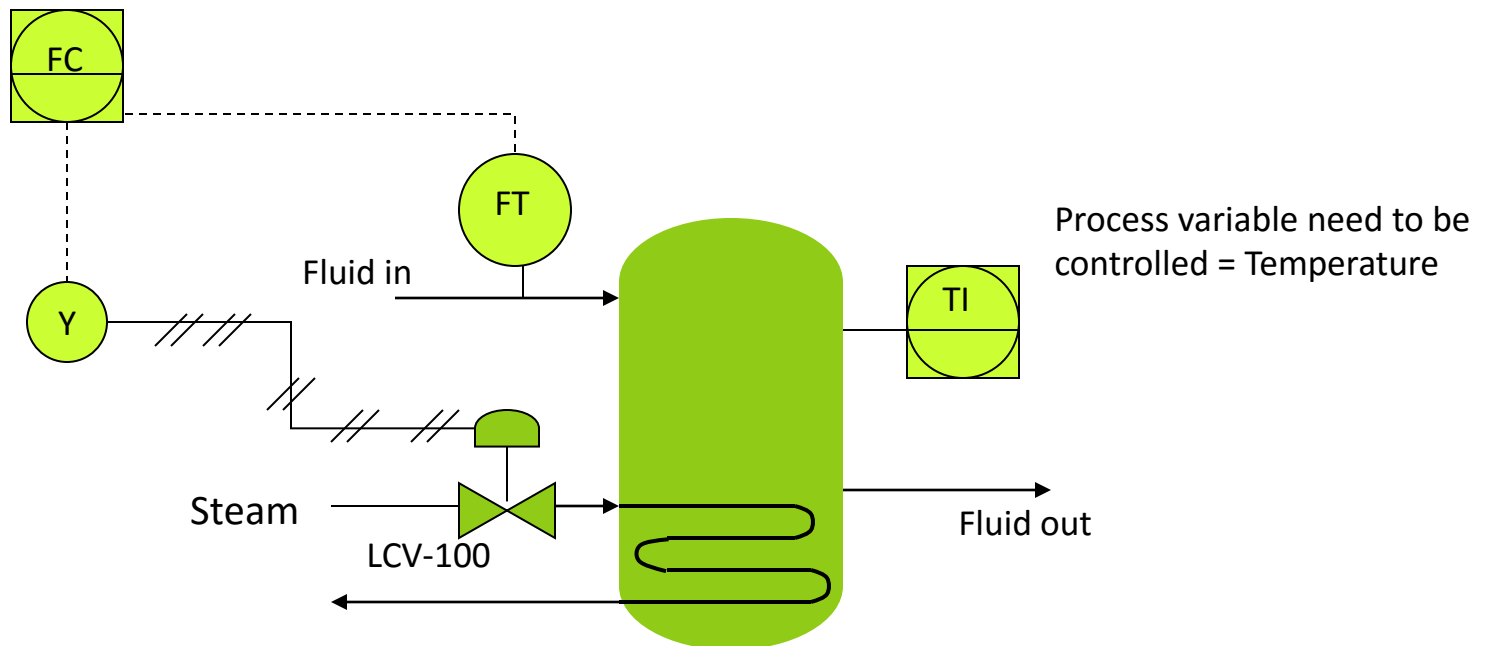
- ❖ Feedforward loop is a control system that anticipates load disturbances and controls them before they can impact the process variable.
- ❖ For feedforward control to work, the user must have a mathematical understanding of how the manipulated variables will impact the process variable.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Feedforward Control (cont...)

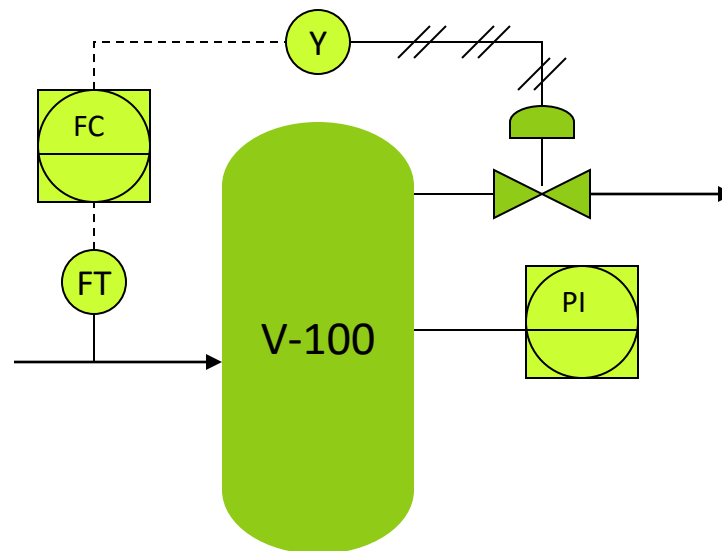
- ❖ An advantage of feedforward control is that error is prevented, rather than corrected.
- ❖ However, it is difficult to account for all possible load disturbances in a system through feedforward control.
- ❖ In general, feedforward system should be used in case where the controlled variable has the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

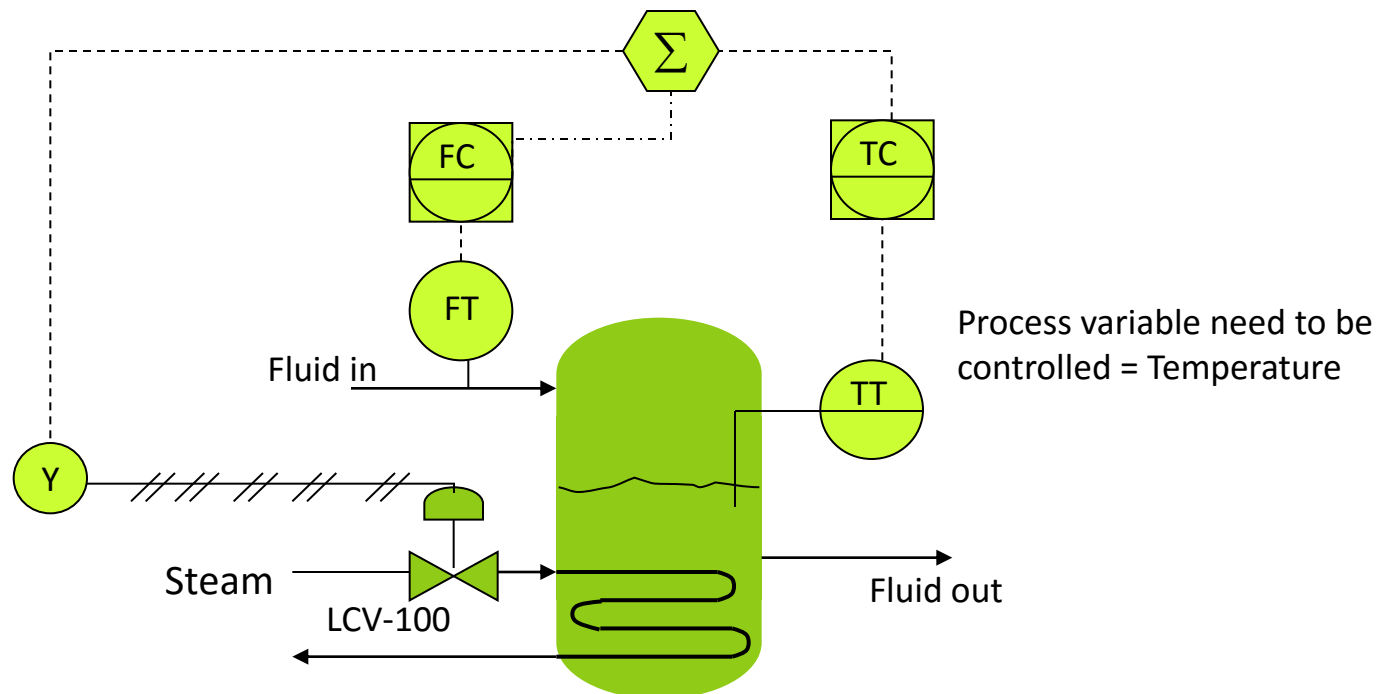


Process variable need to be controlled = Pressure

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Feedforward-plus-Feedback Control

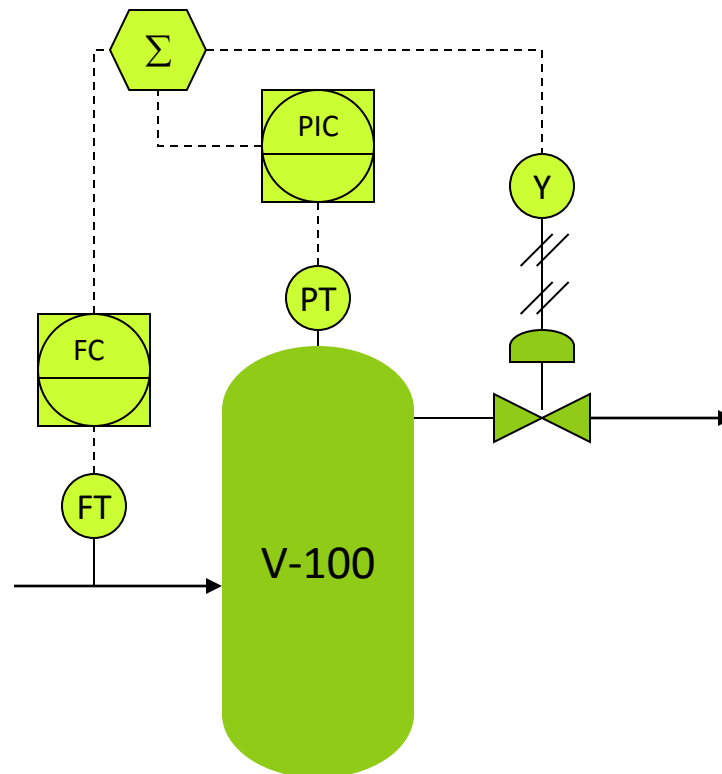
- ❖ Because of the difficulty of accounting for every possible load disturbance in a feedforward system, this system are often combined with feedback systems.
- ❖ Controller with summing functions are used in these combined systems to total the input from both the feedforward loop and the feedback loop,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

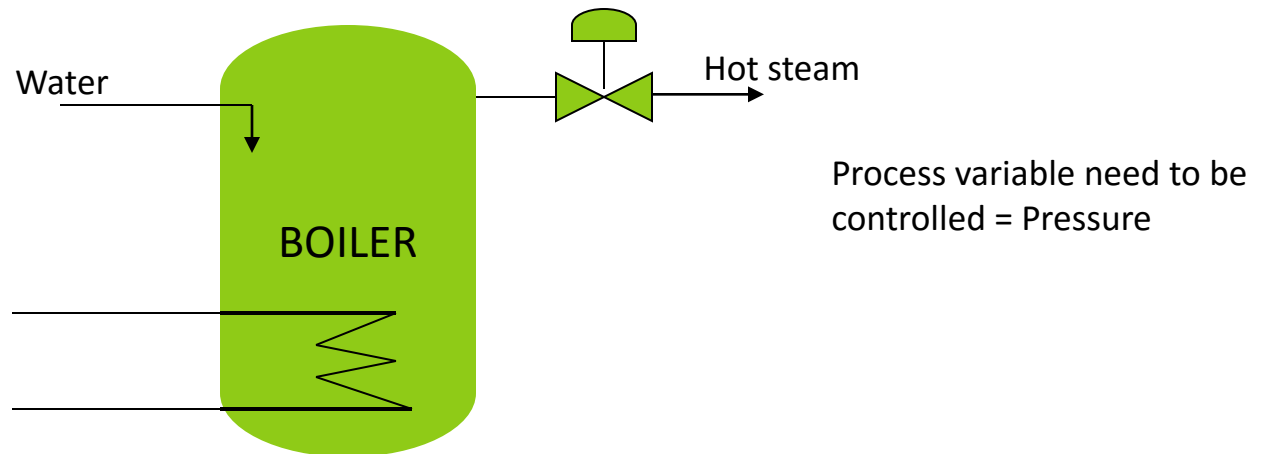


Process variable need to be controlled = Pressure

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Exercise 2

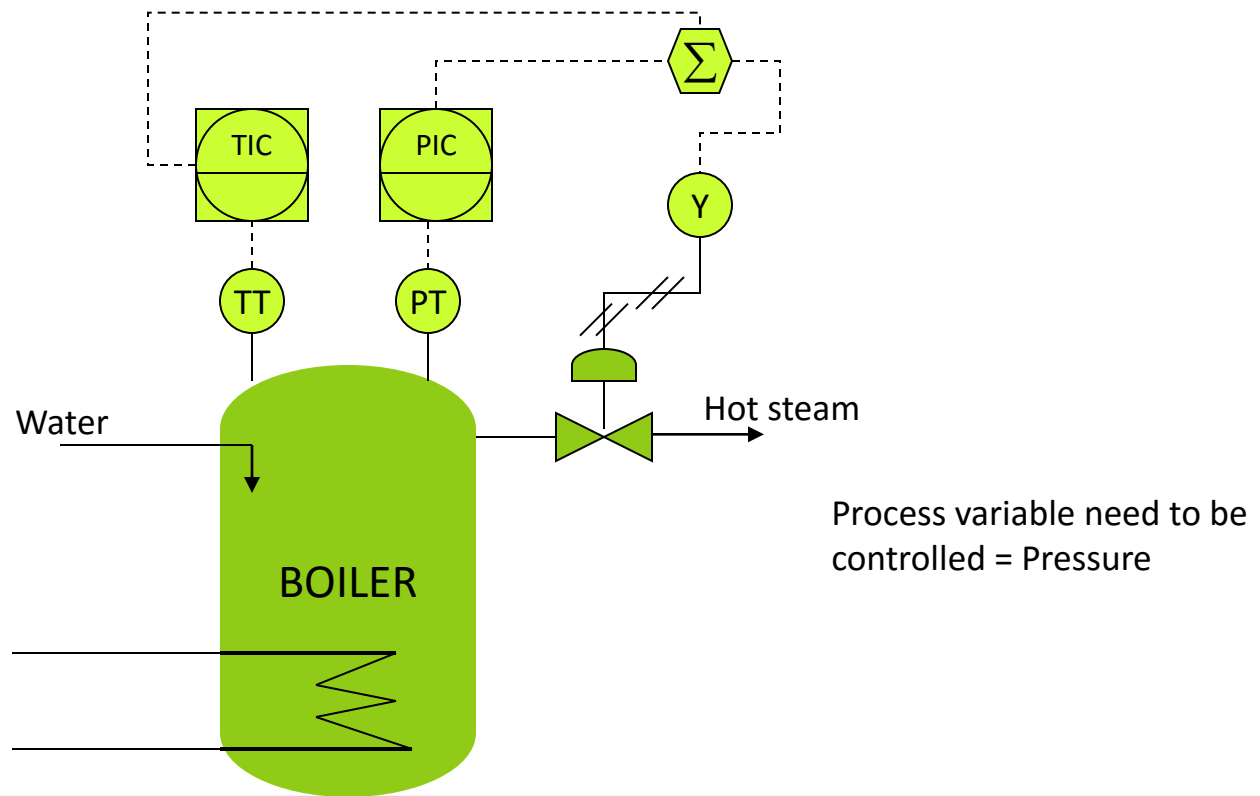
❖ Figure below shows the boiler system that used to supply hot steam to a turbine. This system need to supply 100 psi hot steam to the turbine where the PCV-100 will be opened when the pressure reached that desired pressure. With using pressure control through temperature and pressure measurement in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



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Answer 2

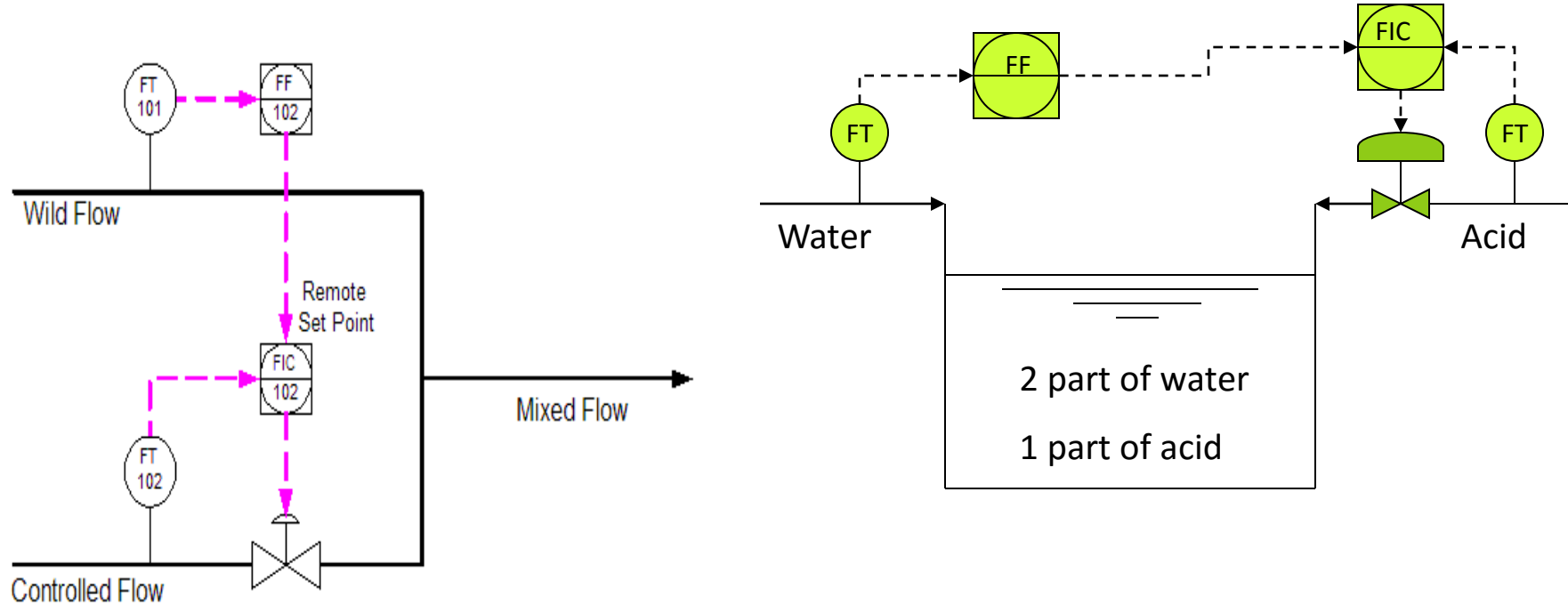
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PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

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.

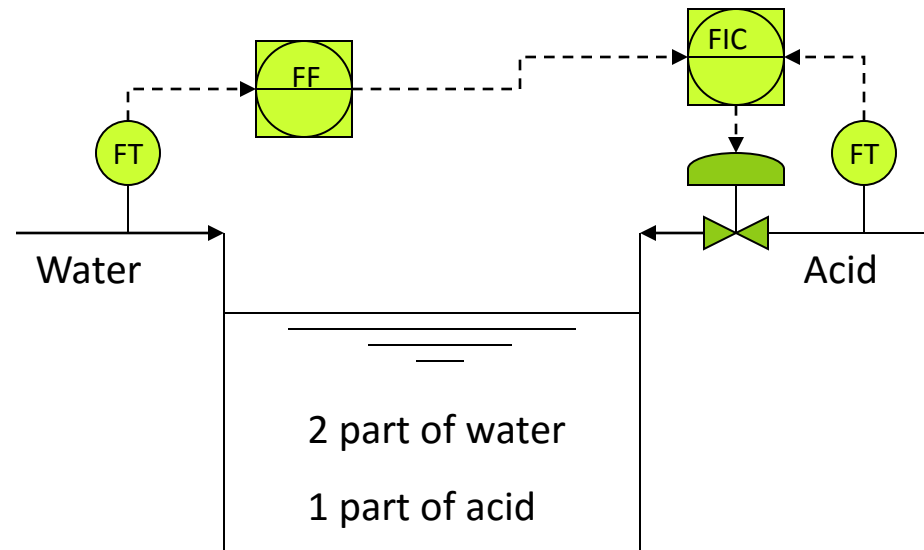
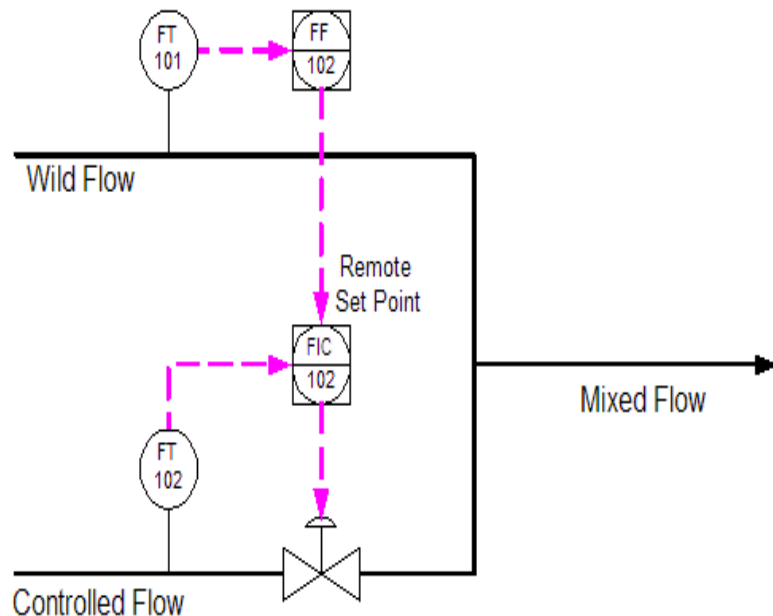


PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Ratio Control (cont...)

Application:

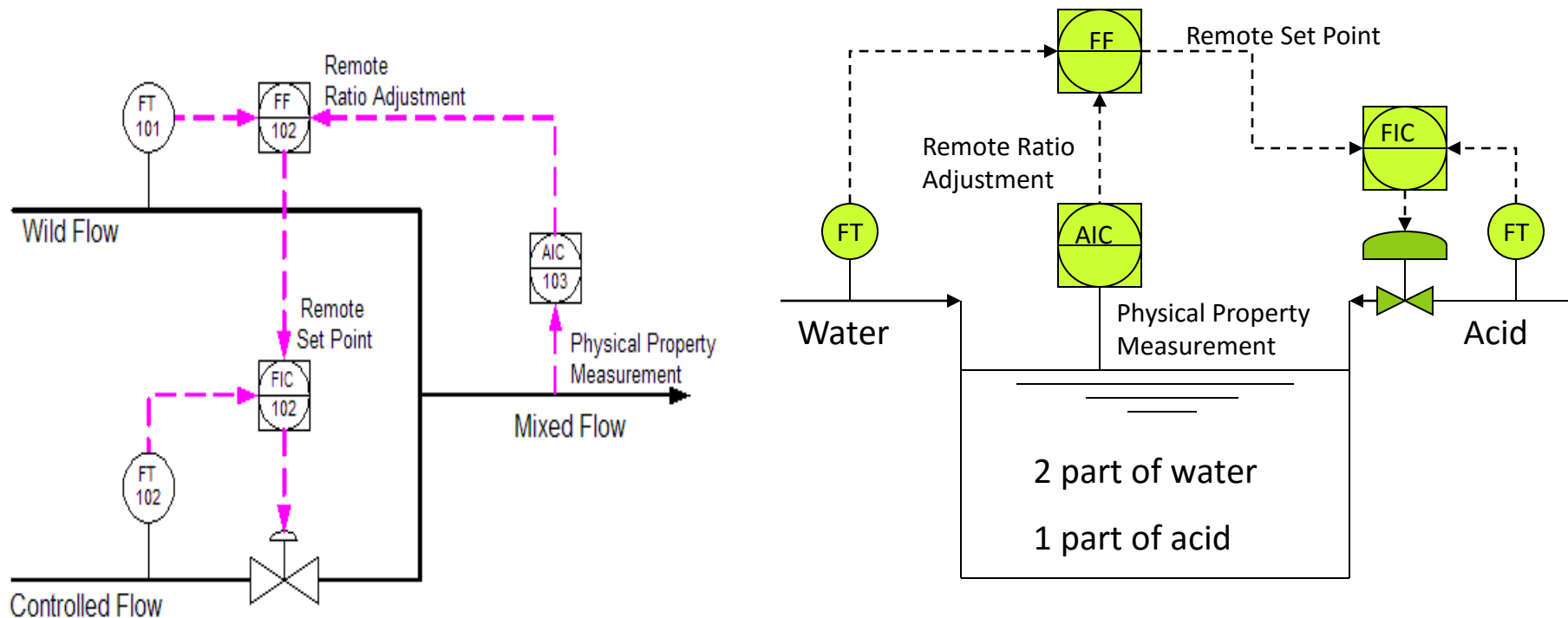
- Blending two or more flows to produce a mixture with specified composition.
- Blending two or more flows to produce a mixture with specified physical properties.
- Maintaining correct air and fuel mixture to combustion.



PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Ratio Control (Auto Adjusted)

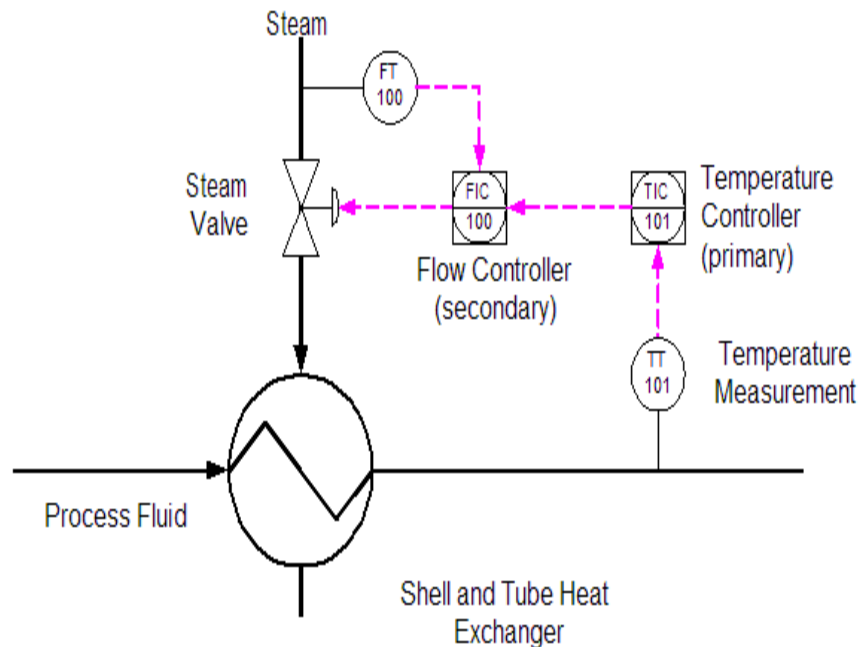
- If the physical characteristic of the mixed flow is measured, a PID controller can be used to manipulate the ratio value.
- For example, a measurement of the density, gasoline octane rating, color, or other characteristic could be used to control that characteristic by manipulating the ratio.



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.

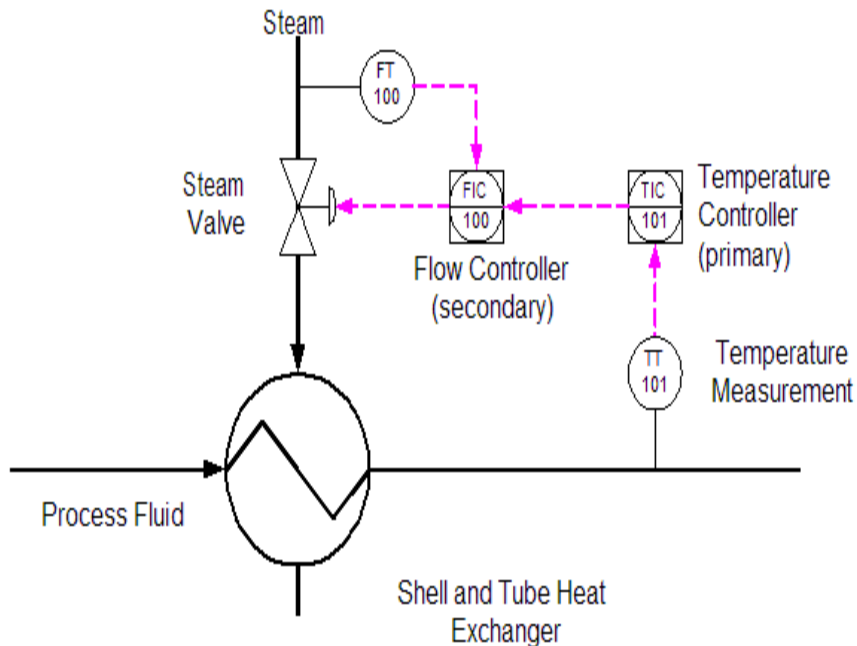


Reasons for cascade control:

- Allow faster secondary controller to handle disturbances in the secondary loop.
- Allow secondary controller to handle non-linear valve 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...)



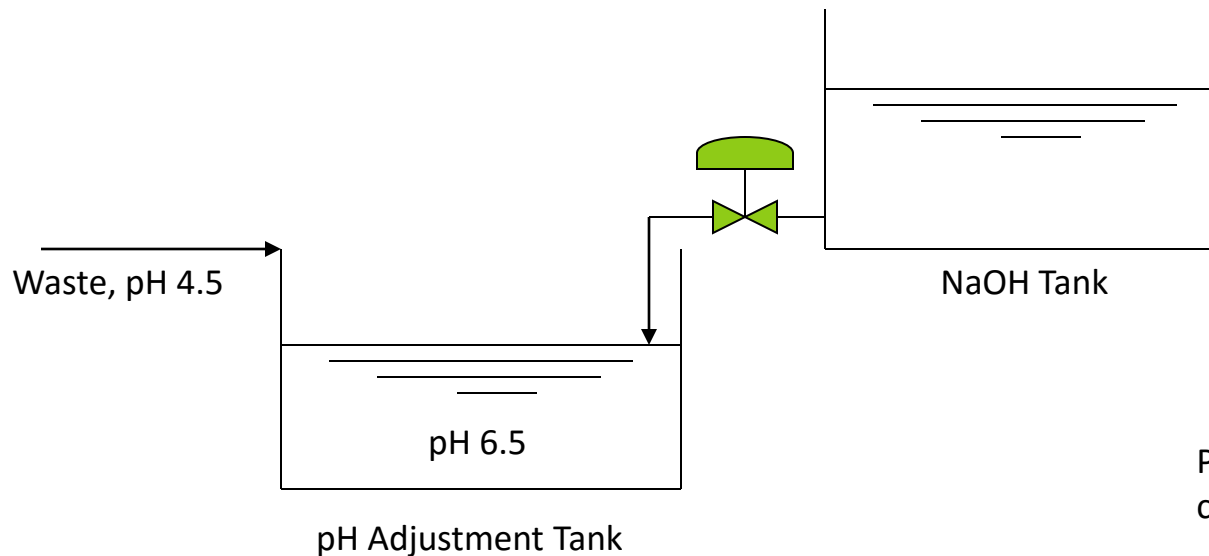
Requirements for cascade control:

- 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 be considered where excess flow of the waste shall make that pH in the tank will decrease. Draw a cascade control loop system.

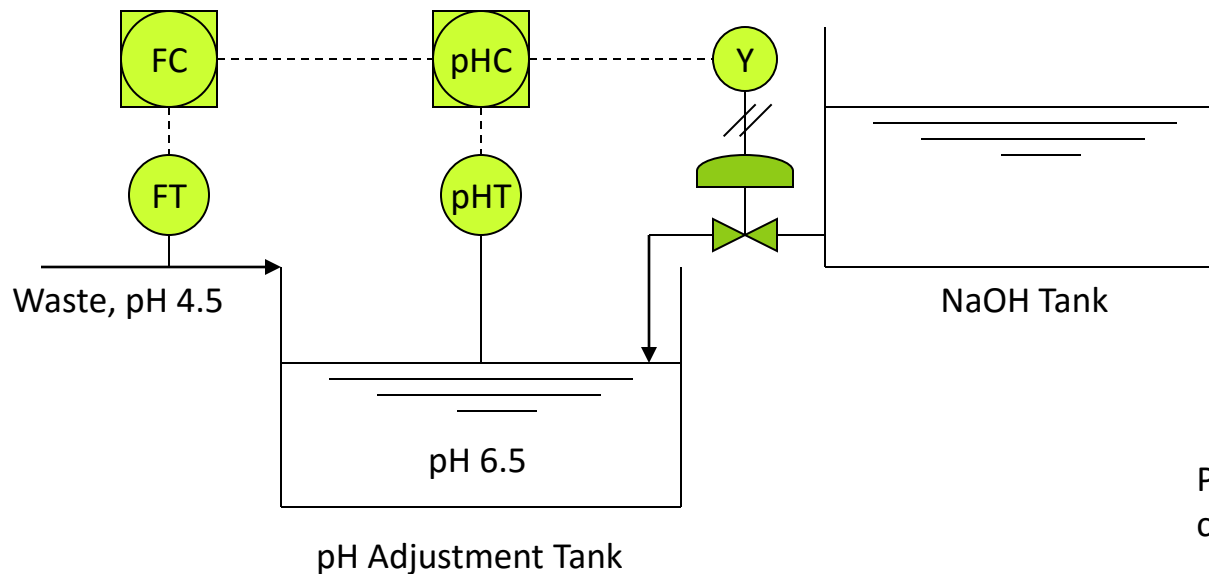


Process variable need to be controlled = pH

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Answer 3

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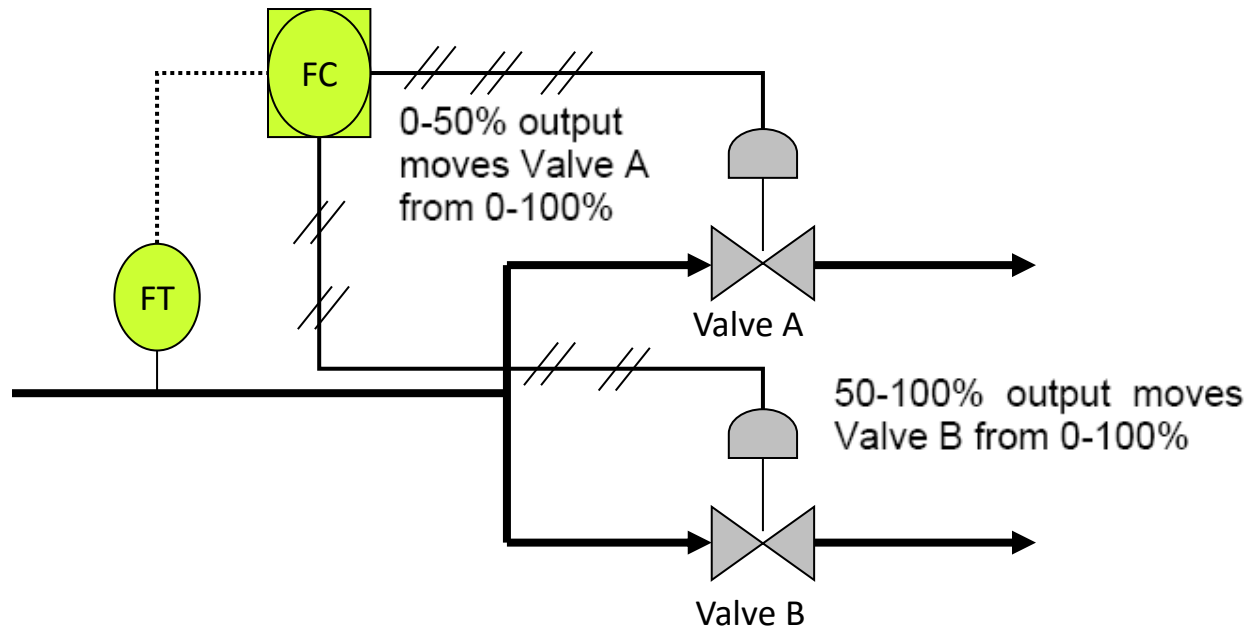
Process variable need to be controlled = pH

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Split Range Control

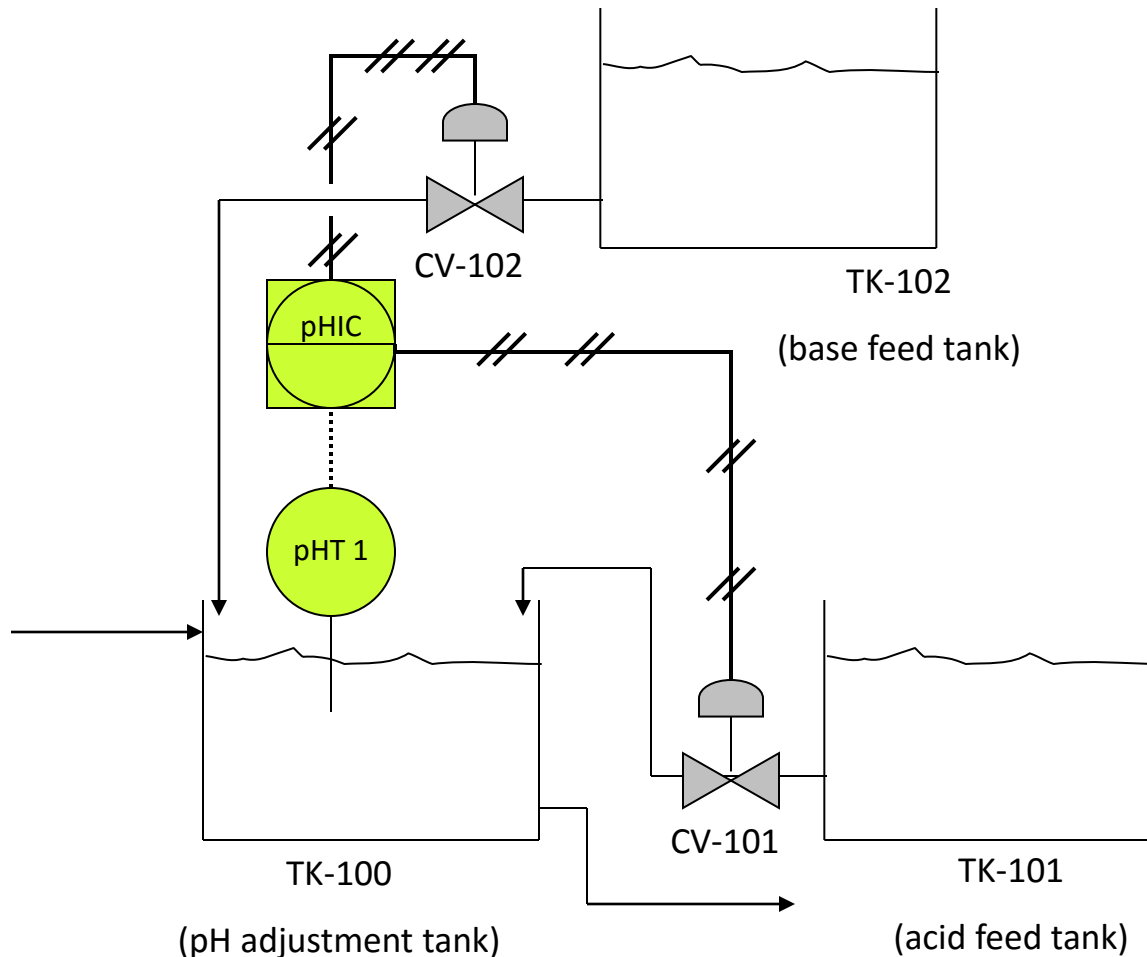
A very common control scheme is split range control in which the output of a controller is split to two or more control valves. For example:

- 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.



THANK YOU

Prepared by,
MISS RAHIMAH OTHMAN