-PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

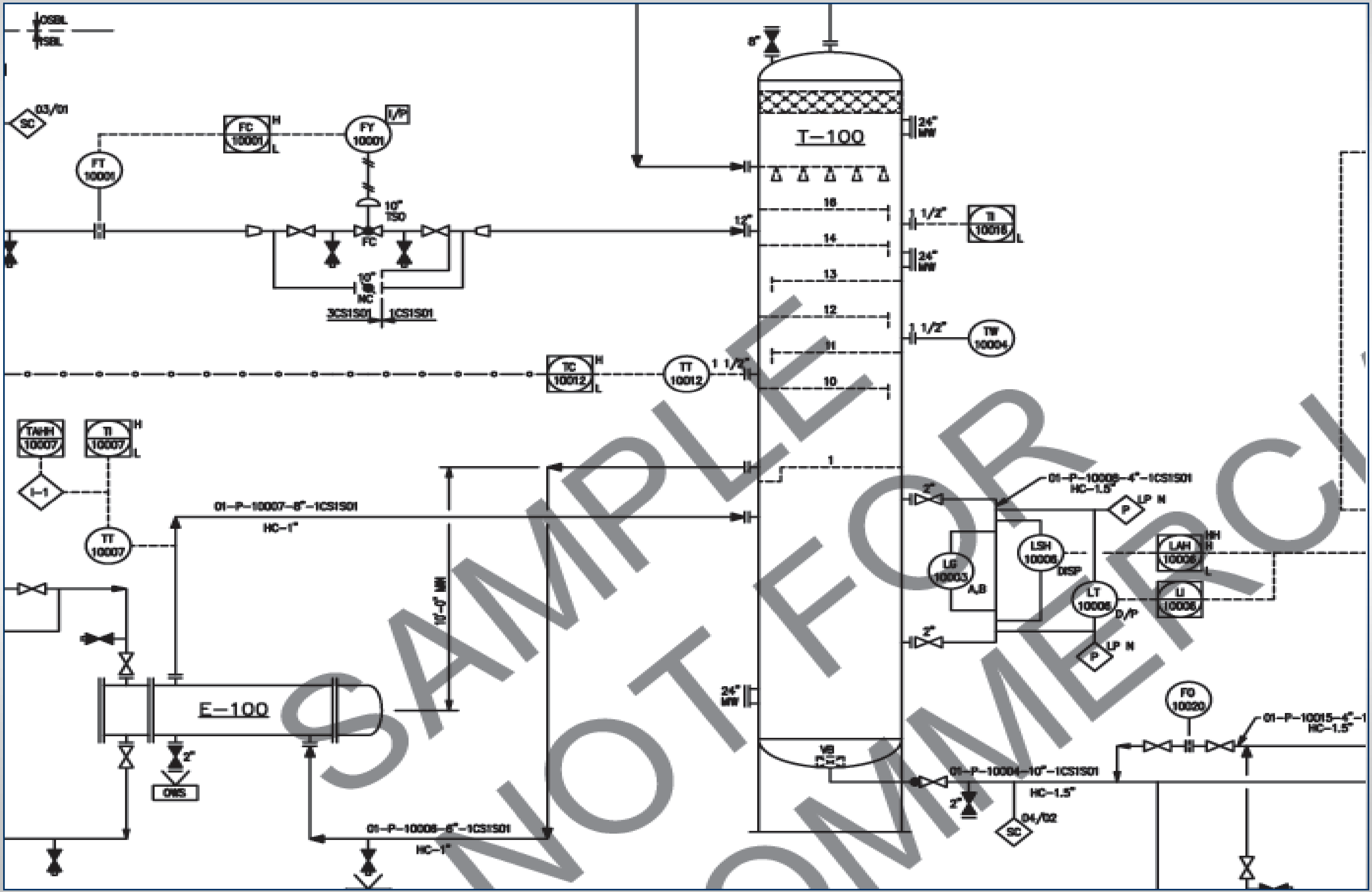
The Piping & Instrumentation Diagram (P&ID)

Sometimes 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).

The Piping & Instrumentation Diagram (P&ID)

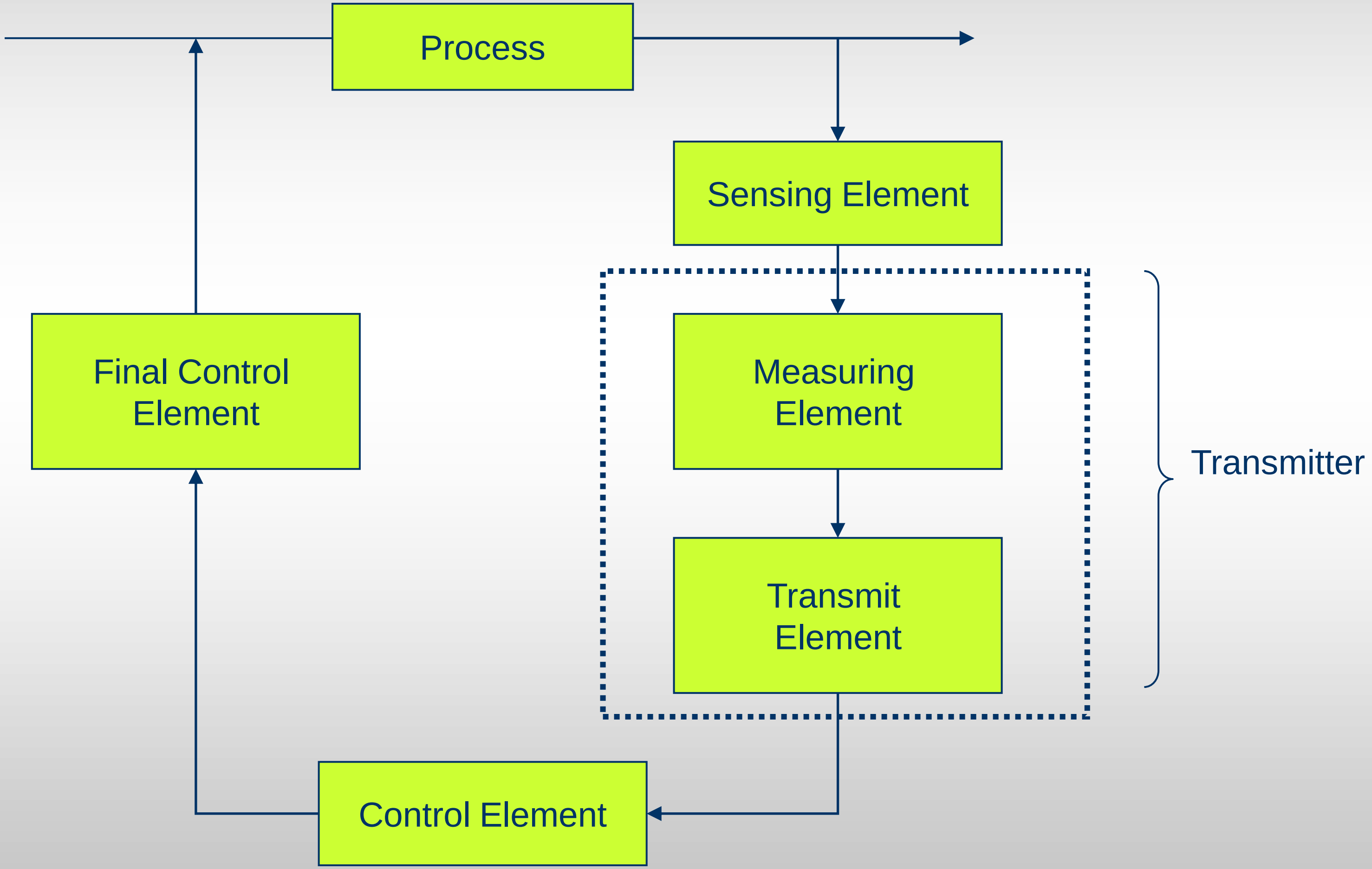
Sometimes also known as Process & Instrumentation Diagram



The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

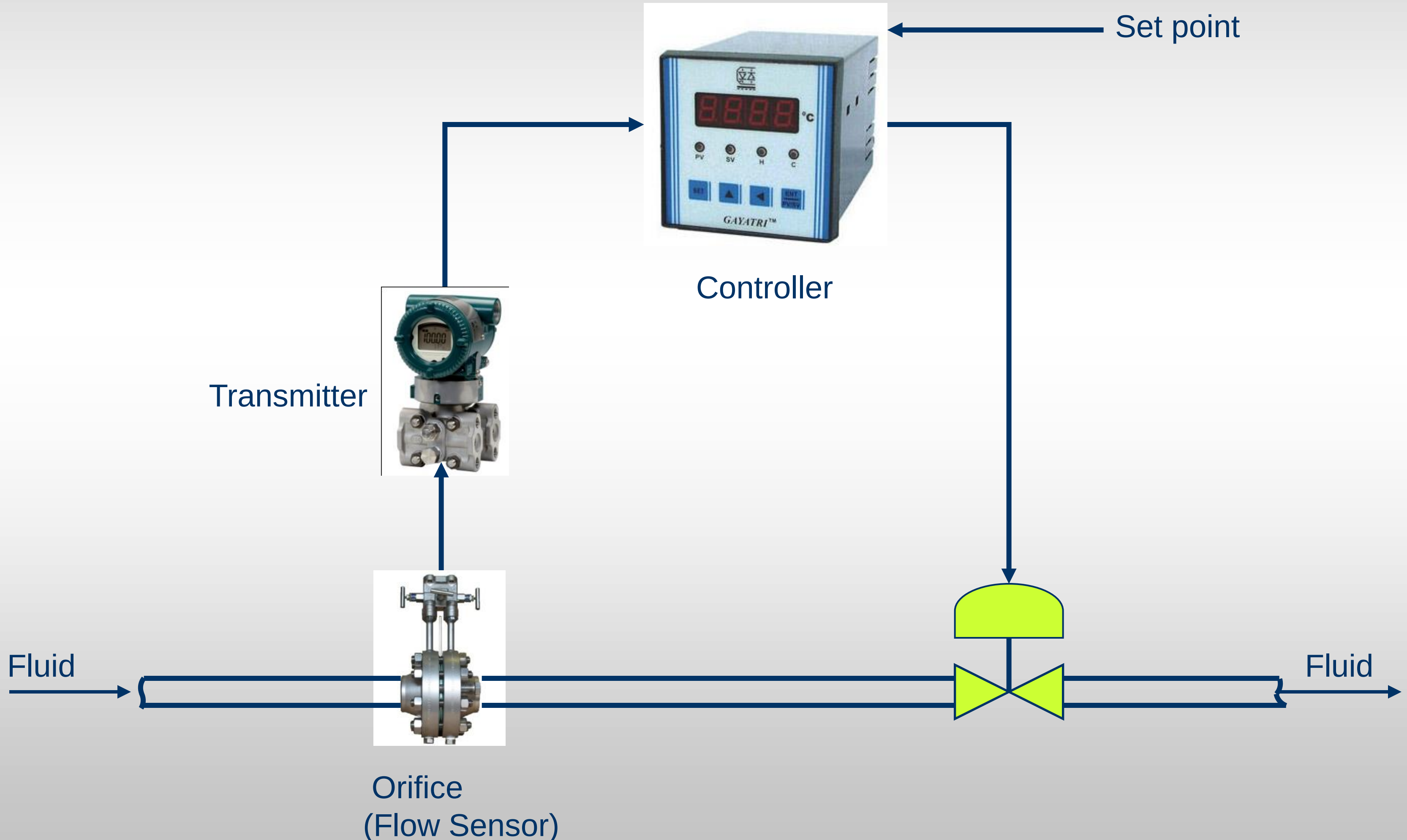
Basic Loop



The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Basic Loop



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.

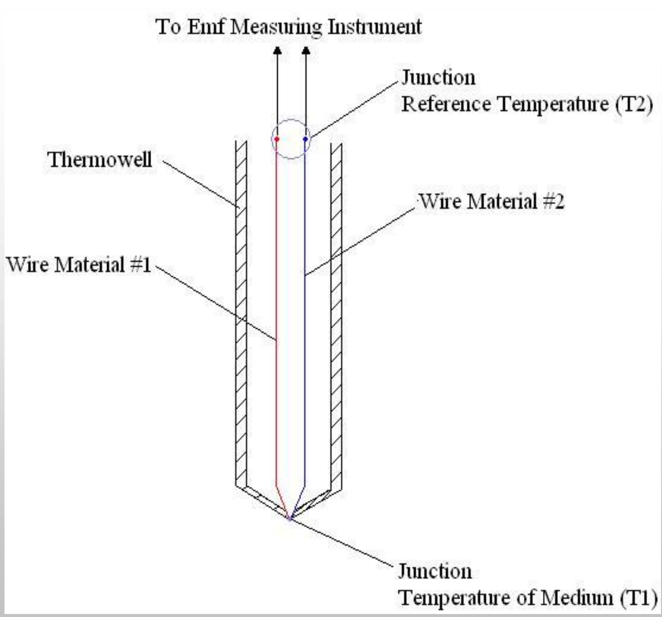
The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Temperature Sensor

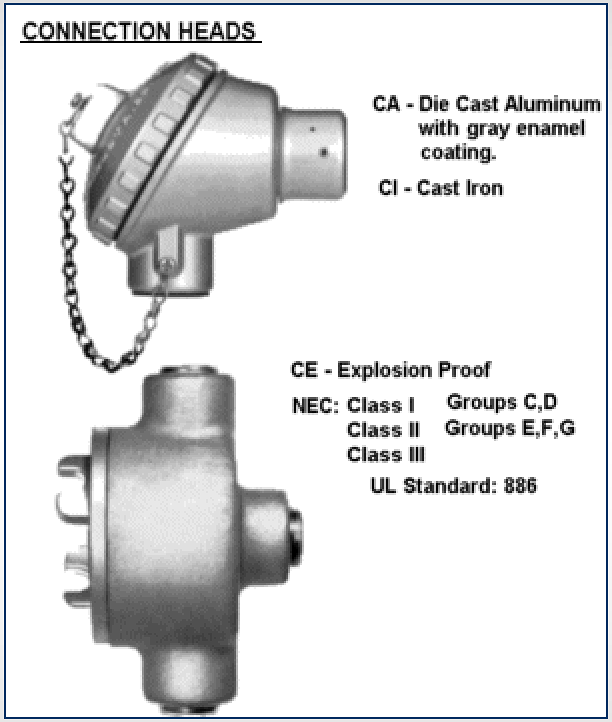
1. Thermocouple

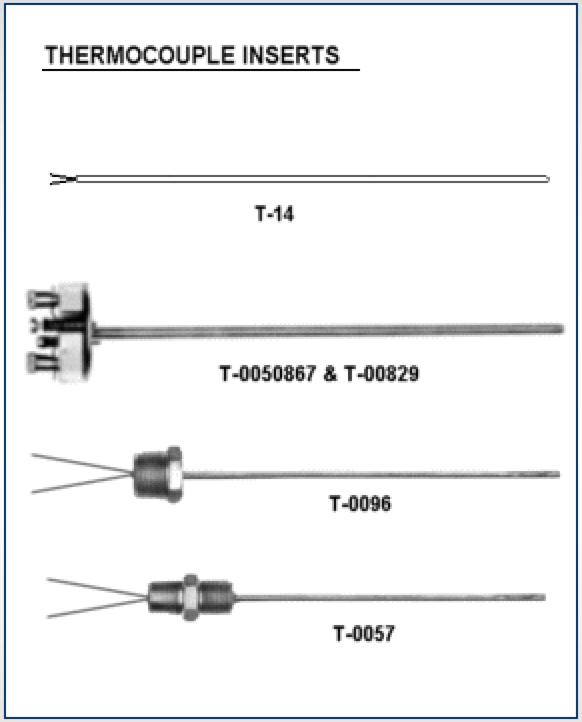
A **thermocouple** is a junction between two different metals that produces a voltage related to a temperature difference. Thermocouples are a widely used type of temperature sensor and can also be used to convert heat into electric power.



The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram





The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Temperature Sensor

2. Resistance Temperature Detector (RTD)

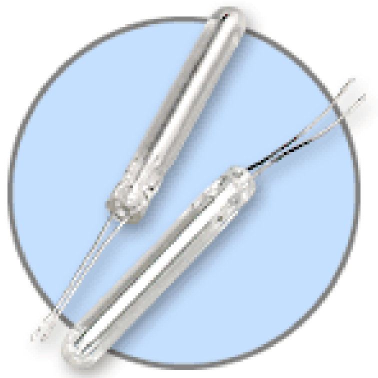
Resistance Temperature Detectors (RTD), as the name implies, are sensors used to measure temperature by correlating the resistance of the RTD element with temperature.

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.

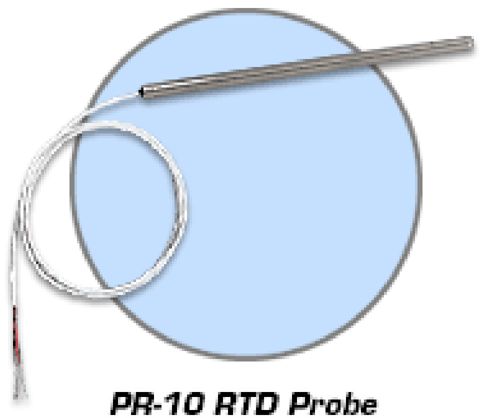
The RTD element is made from a pure material whose resistance at various temperatures has been documented. The material has a predictable change in resistance as the temperature changes; it is this predictable change that is used to determine temperature.

The Piping & Instrumentation Diagram (P&ID)

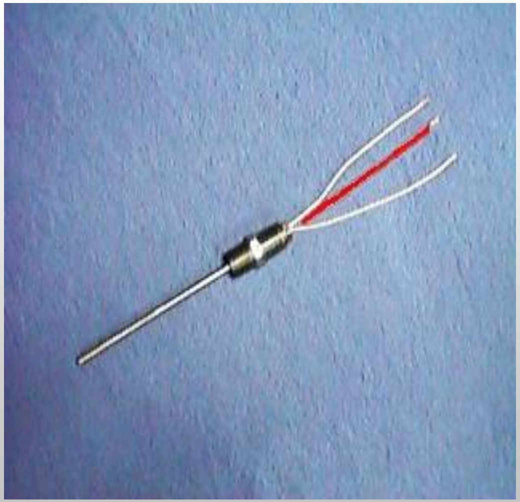
Sometimes also known as Process & Instrumentation Diagram

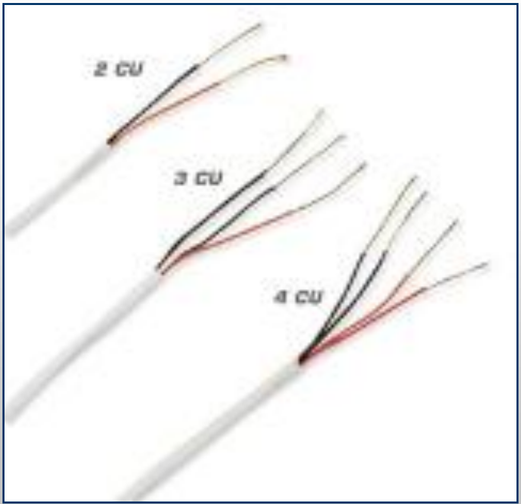


1PT100G RTD Elements



PR-10 RTD Probe



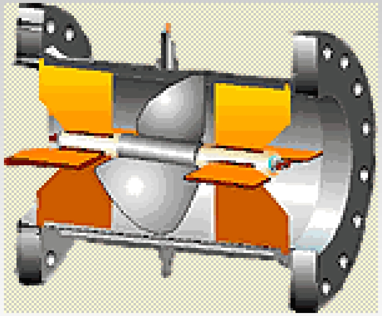


Accuracy for Standard OMEGA RTDs

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

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram



Flow Sensor

1. Turbine Meter

In a turbine, the basic concept is that a meter is manufactured with a known cross sectional area. A rotor is then istalled 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.

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.

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

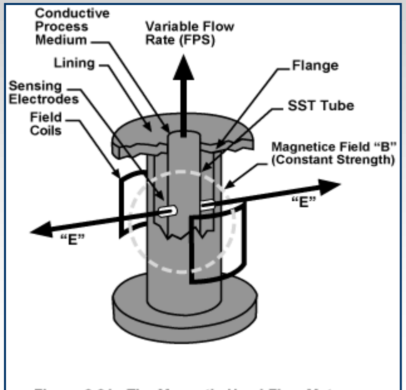
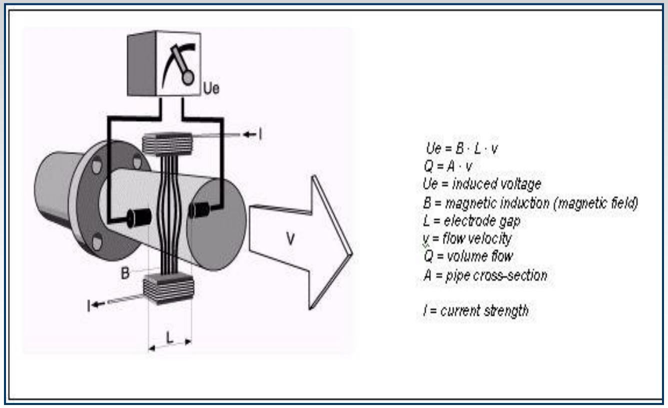


Figure 2.21 - The Magnetic Head Flow Meter



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.

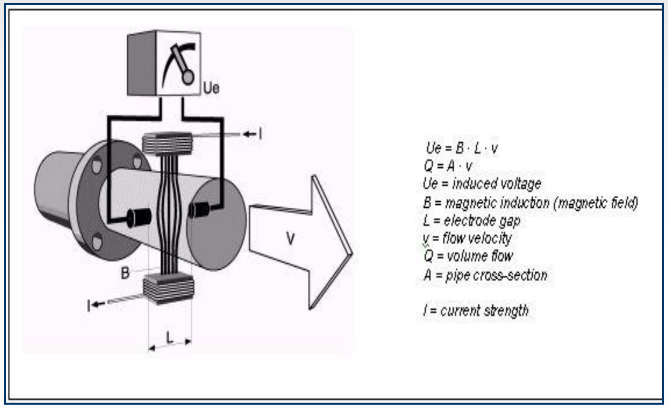
The meters are unaffected by viscosity, density, temperature, pressure and fluid turbulence.

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.

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

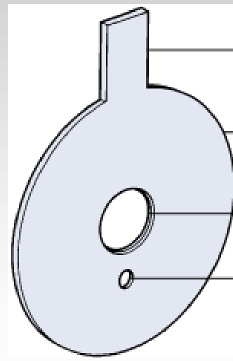


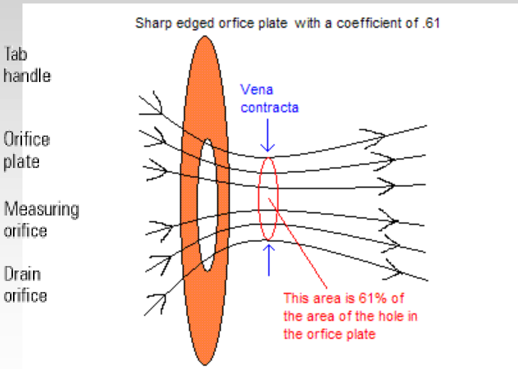
The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

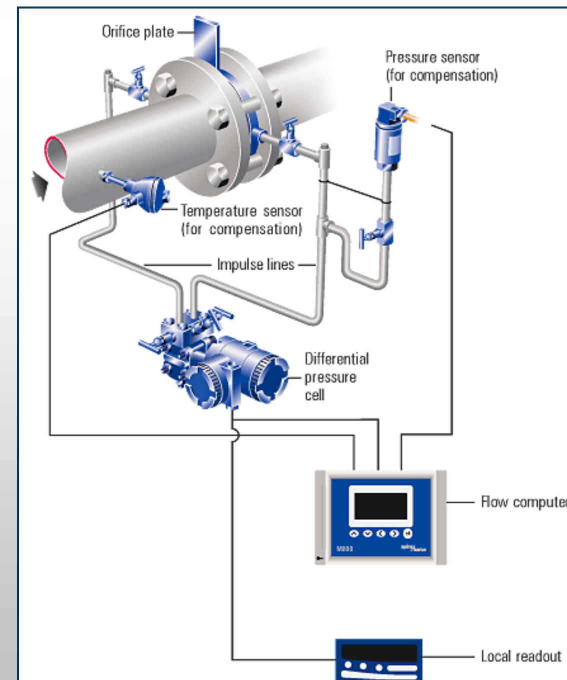
Flow Sensor

3. Orifice Meter



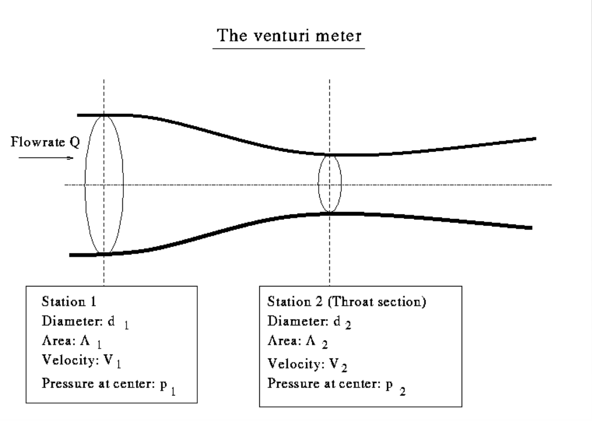


An orifice meter is a conduit and a restriction to create a pressure drop. An hour glass is a form of orifice. A nozzle, venturi or thin sharp edged orifice can be used as the flow restriction. In order to use any of these devices for measurement it is necessary to empirically calibrate them. That is, pass a known volume through the meter and note the reading in order to provide a standard for measuring other quantities. Due to the ease of duplicating and the simple construction, the thin sharp edged orifice has been adopted as a standard and extensive calibration work has been done so that it is widely accepted as a standard means of measuring fluids. Provided the standard mechanics of construction are followed no further calibration is required. An orifice in a pipeline is shown in figure 1 with a manometer for measuring the drop in pressure (differential) as the fluid passes thru the orifice. The minimum cross sectional area of the jet is known as the "vena contracta."



The Piping & Instrumentation Diagram (P&ID)

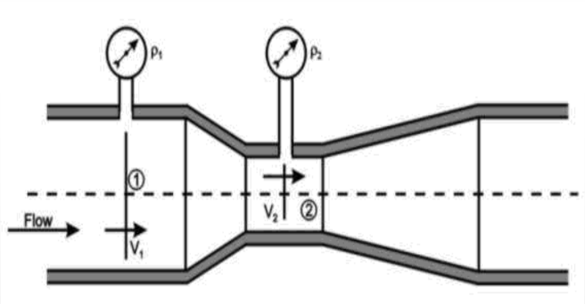
Sometimes also known as Process & Instrumentation Diagram



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 Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.**

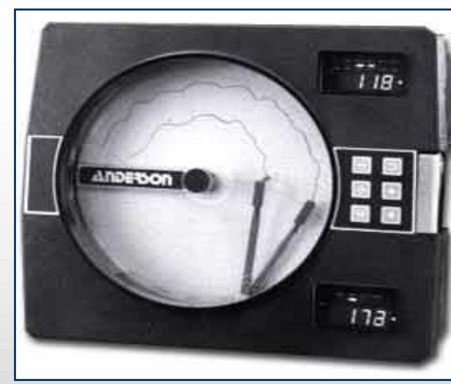
Pressure Level Transmitter

Differential Pressure Transmitter

Pressure Transmitter

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

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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

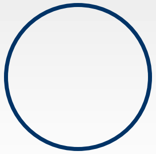
Control Valve

Heater

PART I

-Instrumentation Symbology-

Instrumentation Symbology

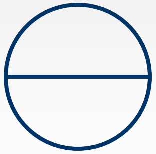


Instruments that are field mounted

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

Field mounted on pipeline

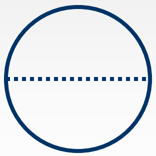
Instrumentation Symbology



Instruments that are board mounted

-Instruments that are mounted on control board.

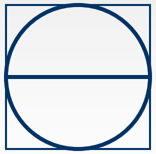
Instrumentation Symbology



Instruments that are board mounted (invisible).

-Instruments that are mounted behind a control panel board.

Instrumentation Symbology



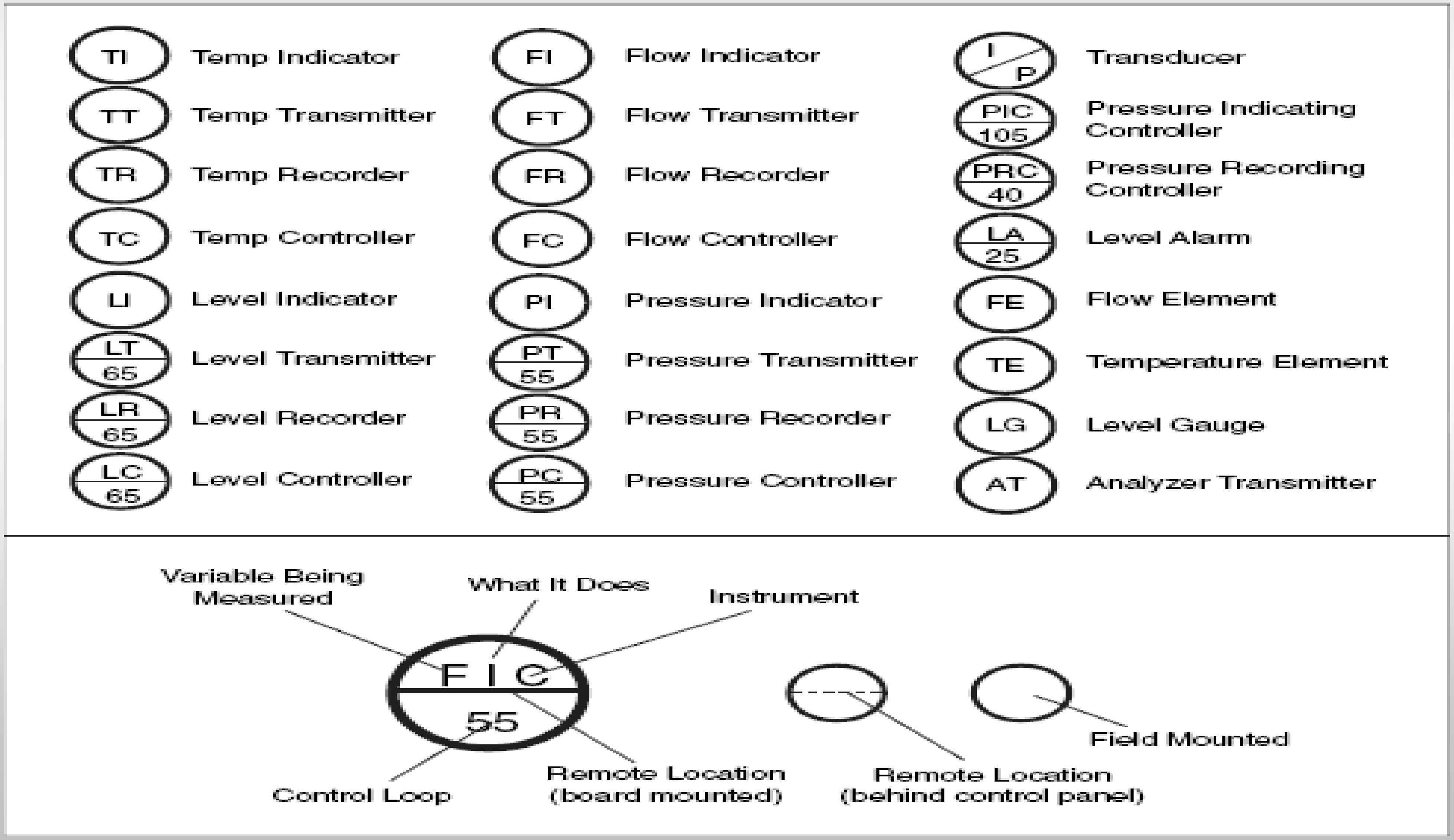
Instruments that are functioned in Distributed Control System (DCS)

- 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.

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Instrumentation Symbology



The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

- FC Flow Controller
- FE Flow Element
- FI Flow Indicator
- FT Flow Transmitter
- FS Flow Switch
- FIC Flow Indicating Controller
- FCV Flow Control Valve
- FRC Flow Recording Controller

- PC Pressure Controller
- PG Pressure Gauge
- PI Pressure Indicator
- PR Pressure Recorder
- PS Pressure Switch
- PIC Pressure Indicating Controller
- PCV Pressure Control Valve
- PRC Pressure Recording Controller
- PDI Pressure Differential Indicator
- PDR Pressure Differential Recorder
- PDS Pressure Differential Switch
- PDT Pressure Differential Transmitter

PT Pressure Transmitter
PTD Pressure Transducer

LC Level Controller
LG Level Gauge
LR Level Recorder
LT Level Transmitter
LS Level Switch
LIC Level Indicating Controller
LCV Level Control Valve
LRC Level Recording Controller

TE Temperature Element
TI Temperature Indicator
TR Temperature Recorder
TS Temperature Switch
TC Temperature Controller
TT Temperature 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	

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Signal Lines Symbology

(1) INSTRUMENT SUPPLY *
OR CONNECTION TO PROCESS

(2) UNDEFINED SIGNAL

(3) PNEUMATIC SIGNAL **

(4) ELECTRIC SIGNAL

(5) HYDRAULIC SIGNAL

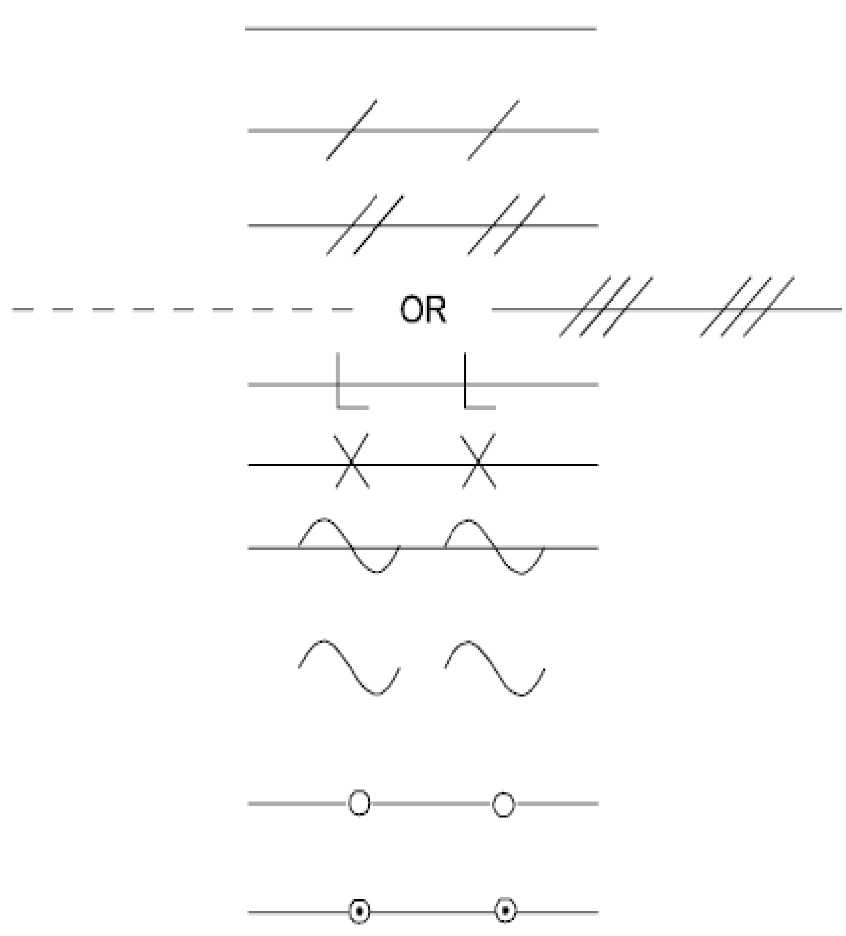
(6) CAPILLARY TUBE

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

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

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

(10) MECHANICAL LINK



PART II

-Principal of P&ID-

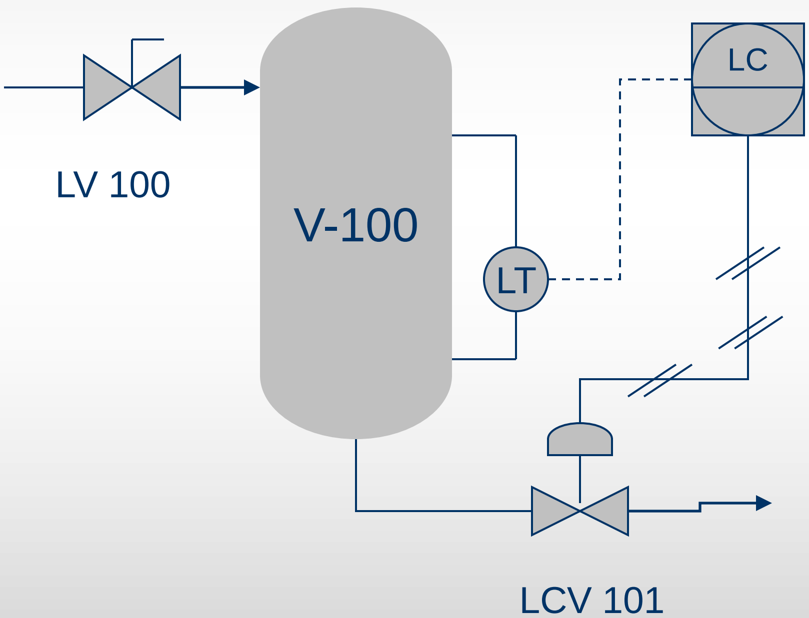
The Piping & Instrumentation Diagram (P&ID)

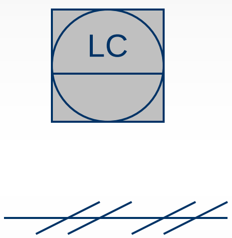
Sometimes also known as Process & Instrumentation Diagram

Principal of P&ID

Example 1

With using these following symbols;



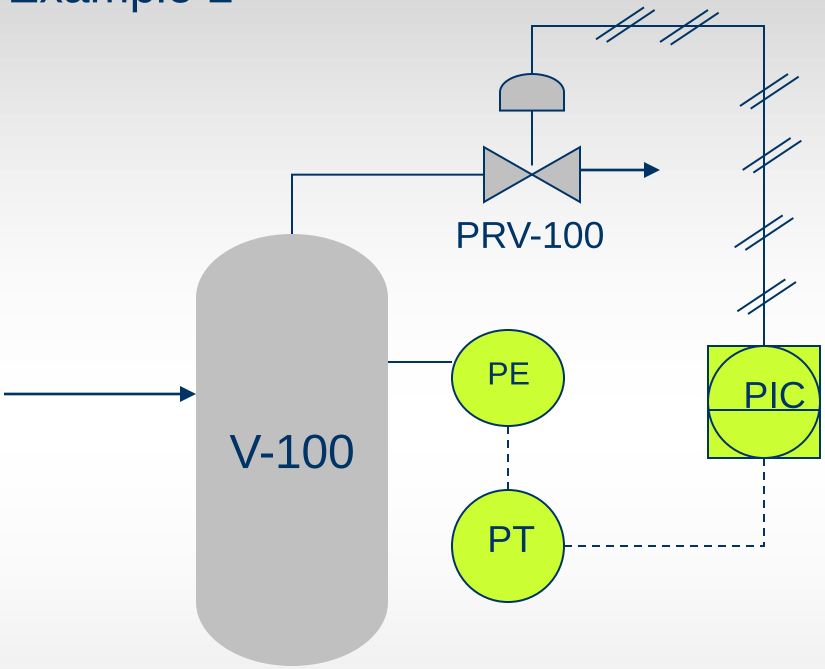


Complete control loop for LCV 101

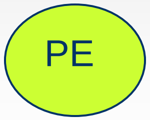
The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

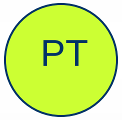
Example 2



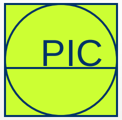
With using these following symbology;



Where PE is locally mounted on V-100



Where PT is locally mounted



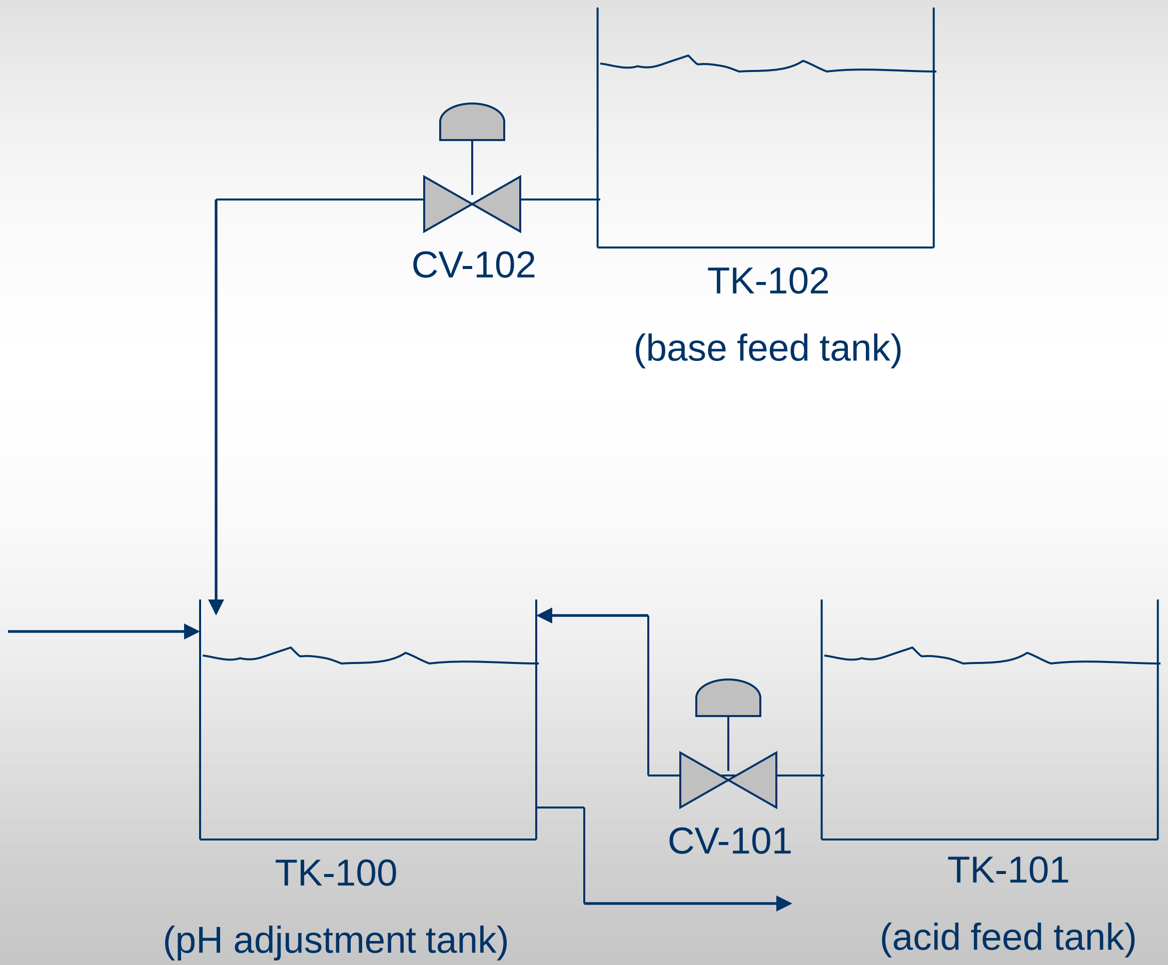
Where PIC is function in DCS

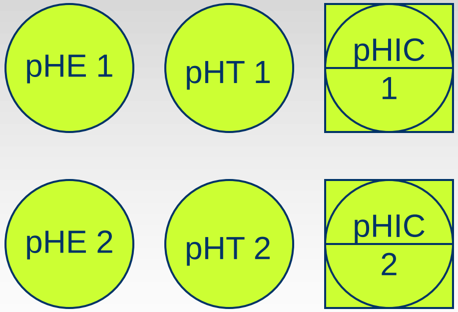
Draw control loop to show that PRV-100 will be activated to relief pressure when the pressure in the V-100 is higher than desired value.

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Exercise 1





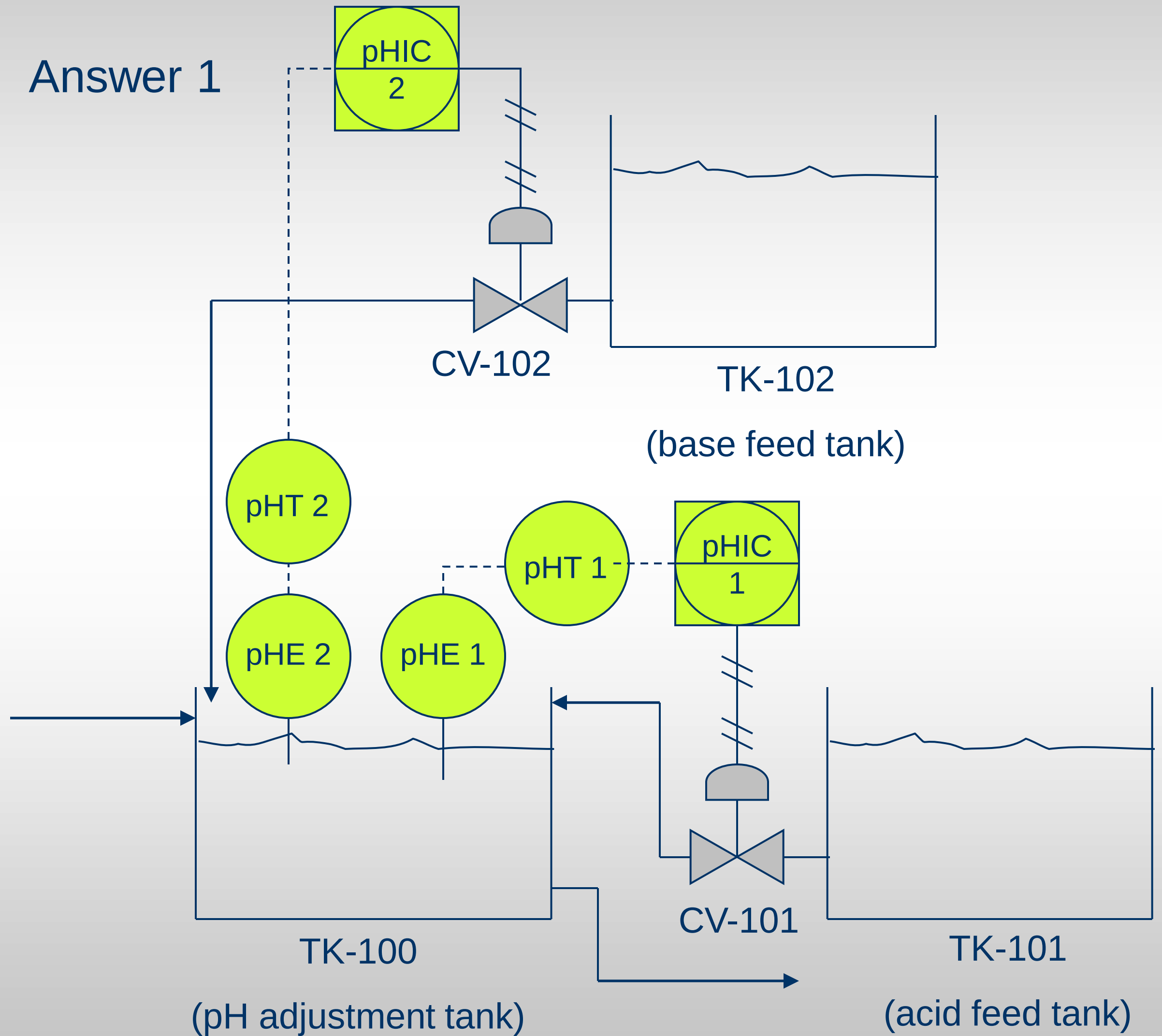
The diagram shows pH adjustment; part of waste water treatment process. With using above symbols, draw control loop where the process need is:

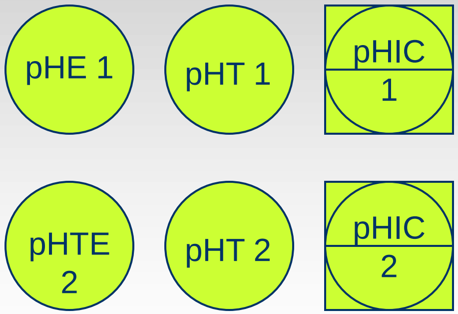
The process shall maintained at pH 6. When the process liquid states below pH 6, CV-102 will be opened to dosing NaOH to the tank TK-100. When the process liquid states above pH 6, CV-101 will be operated to dosing HCl.

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Answer 1





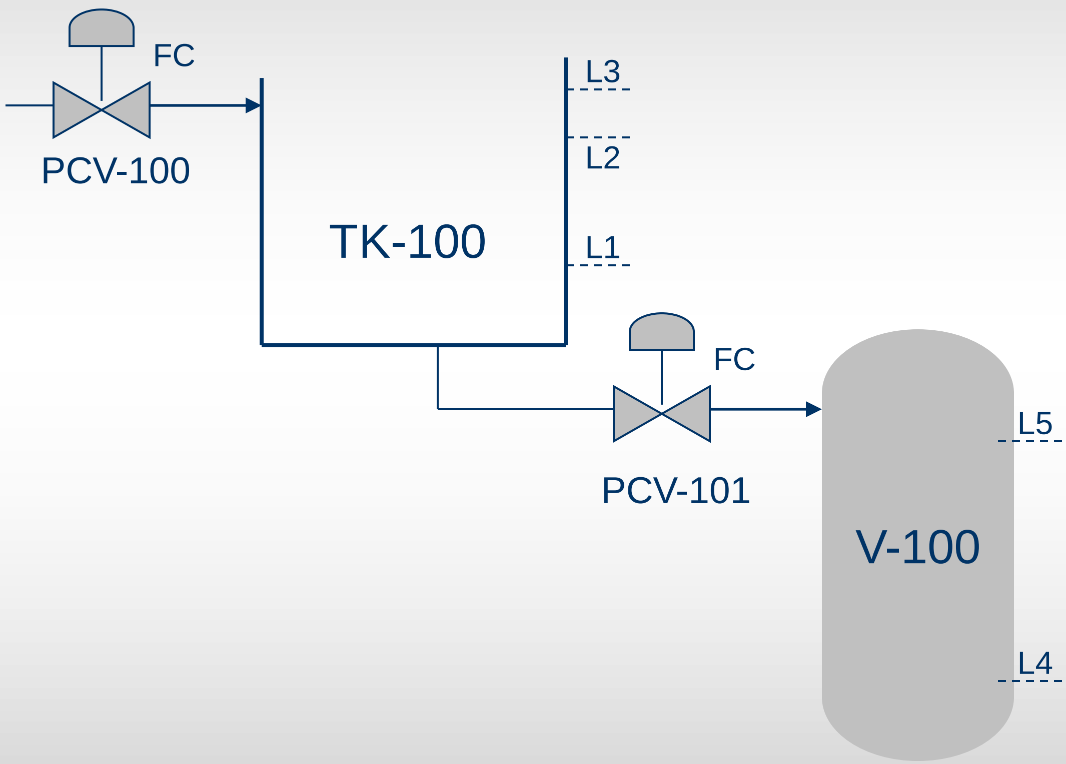
The diagram shows pH adjustment; part of waste water treatment process. With using above symbols, draw control loop where the process need is:

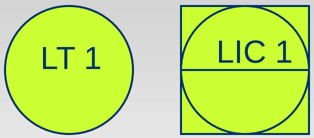
The process shall maintained at pH 6. When the process liquid states below pH 6, CV-102 will be opened to dosing NaOH in the base feed tank. When the process liquid states above pH 6, CV-101 will be operated to dosing HCl in the acid fed tank.

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Exercise 2

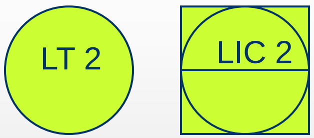




Where LT 1 and LIC 1 to control PCV-100 (failure close);

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);

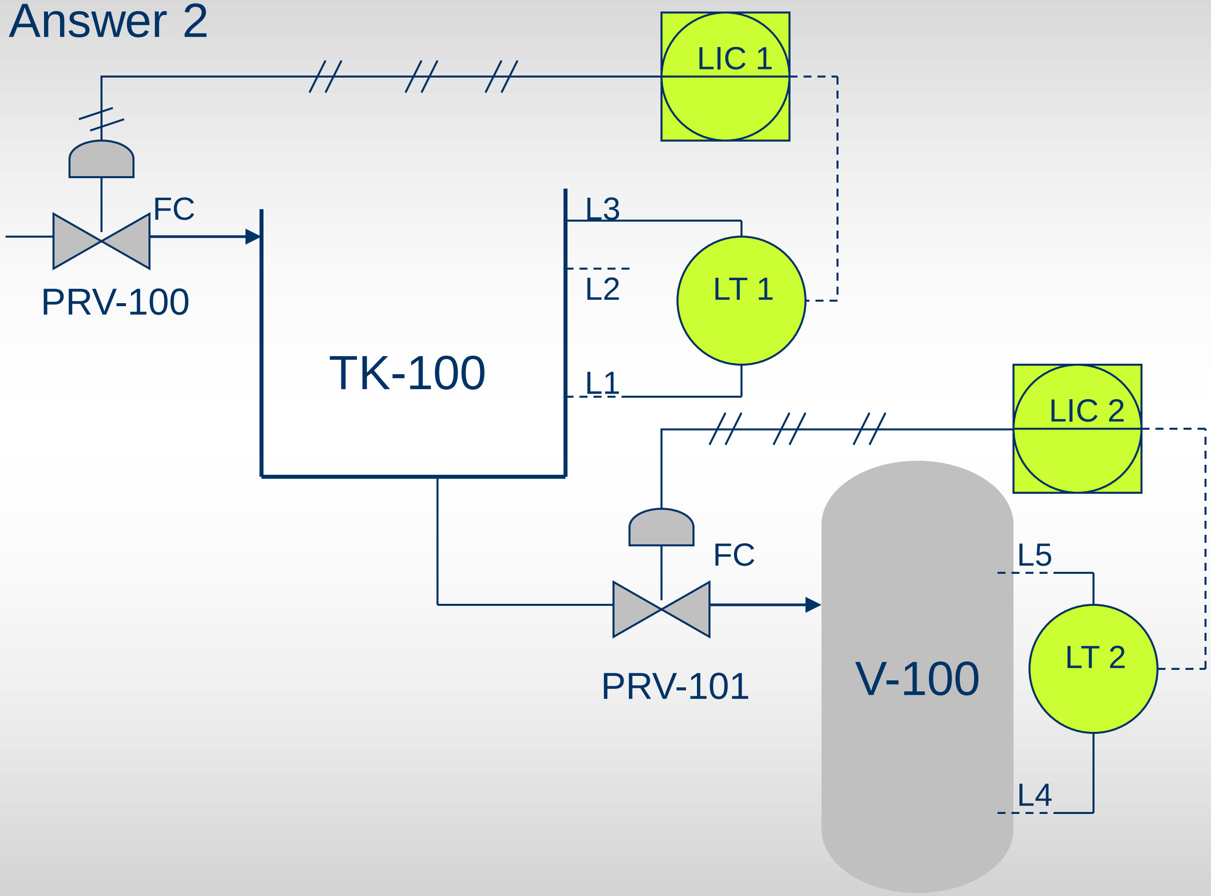
PCV-101 close when level reached L5

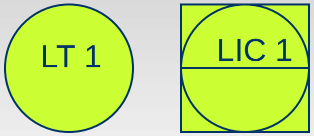
PCV-101 open when level below L5

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Answer 2

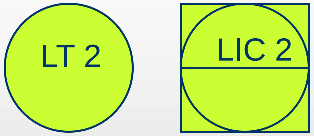




Where LT 1 and LIC 1 to control PRV-100 (failure close);

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

PART II

-Instrumentation Numbering-

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.

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

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

INFORMATION

1) Seminar from industrial Expert- 7 October 2010 (time)

2) Submit assignment 2- 13 October 2010 before 1200 noon.

3) Submit Mini Project- 14 October 2010 before 1700

3) Presentation Mini Project- 19 (1500-1700) and 26 October 2010 (1000-1200) and (1500-1700)

4) Test 2- 21 October 2010 (1500-1600)

PART IV

PIPING & INSTRUMENTATION DIAGRAM

-PROCESS CONTROL VARIETY-

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

SCOPE:

Students will be able to know:-

- Type of Process Control Loop
- Definition and application of various type of Process Control Loop

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Type of Process Control Loop

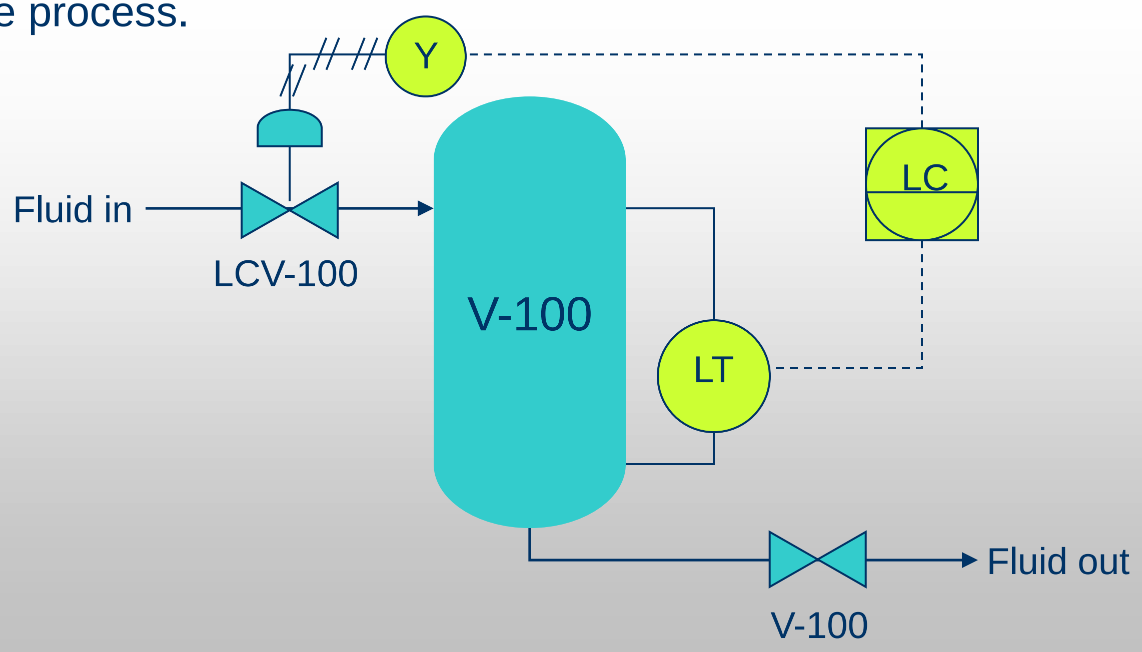
- Feedback Control
- Feedforward Control
- Feedforward-plus-Feedback Control
- Ratio Control
- Split Range Control
- Cascade Control
- Differential Control

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.

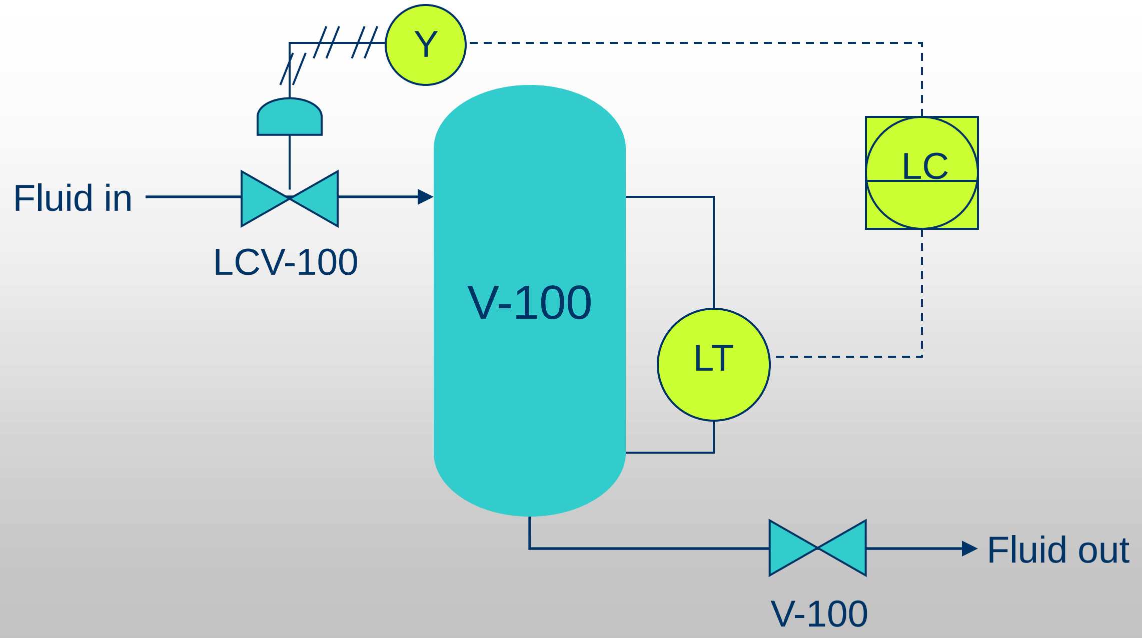


The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.

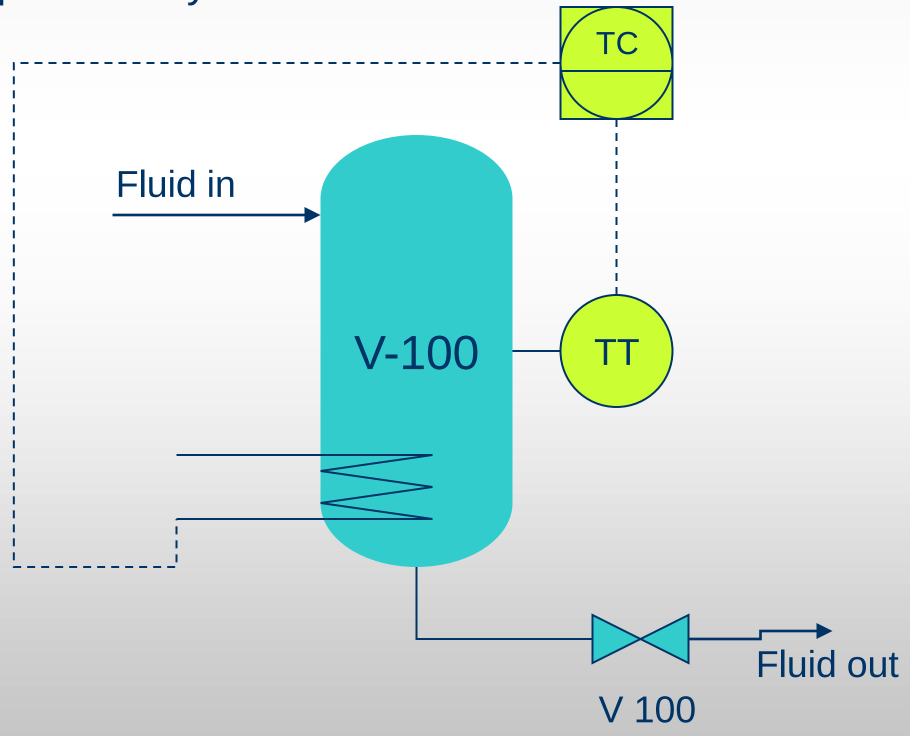


The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Example 1

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

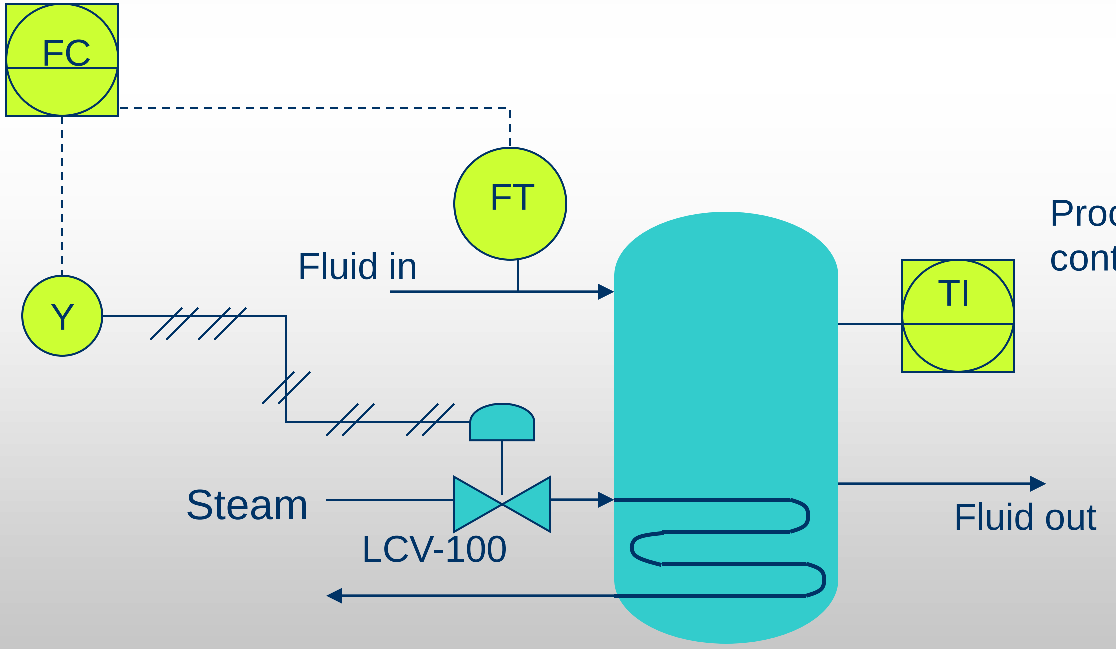


The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.



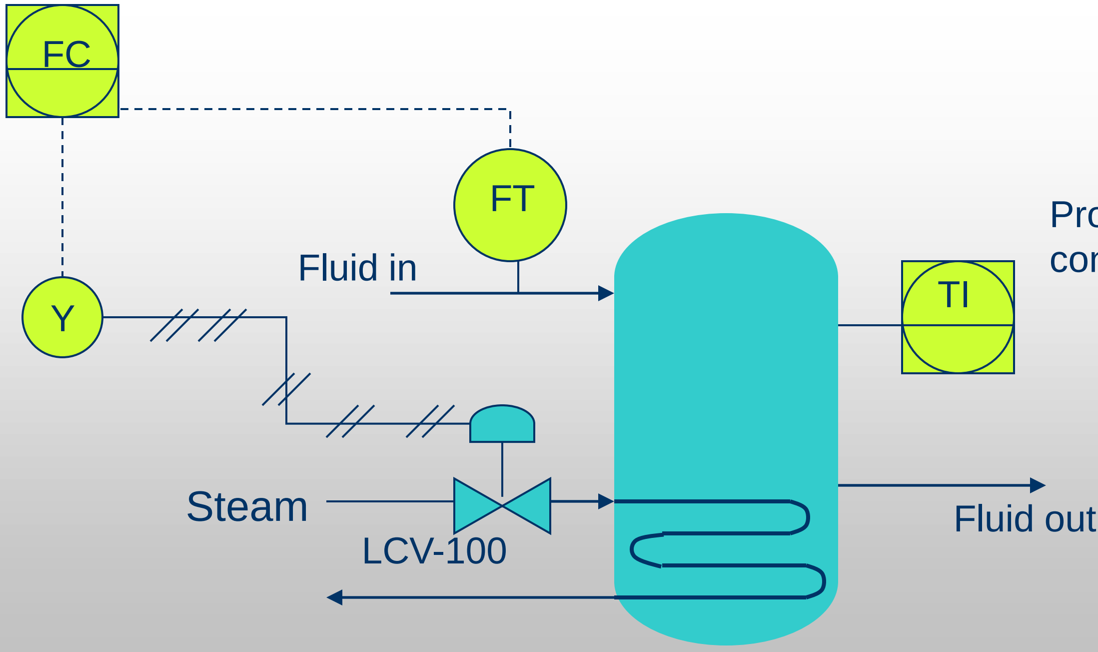
Process variable need to be controlled = Temperature

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.



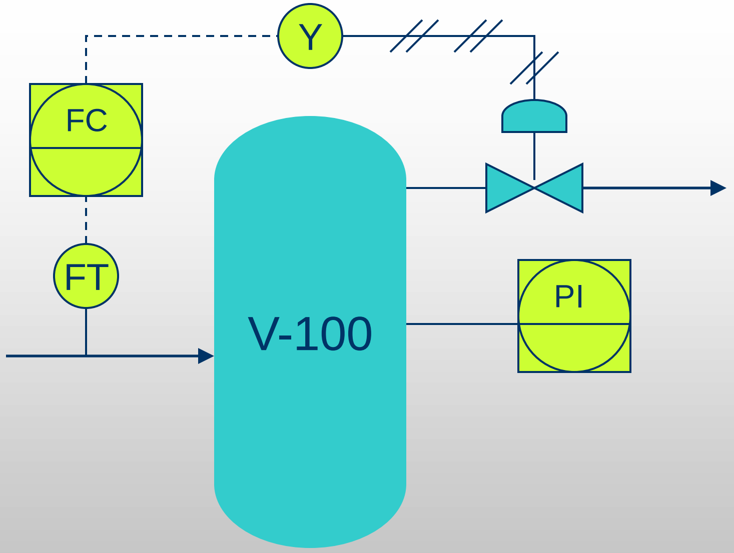
Process variable need to be controlled = Temperature

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.



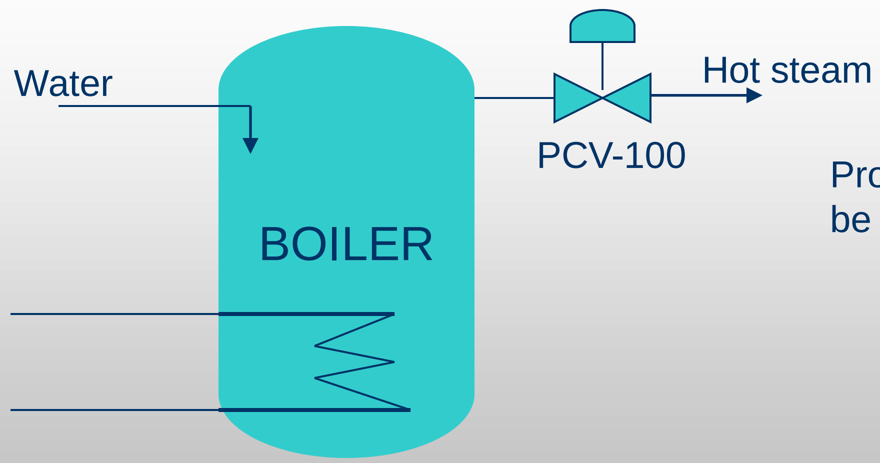
Process variable need to be controlled = Pressure

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Exercise 1

❖ 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 measurement in the boiler, draw a feedforward loop control system.



Process variable need to be controlled = Pressure

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Answer 1

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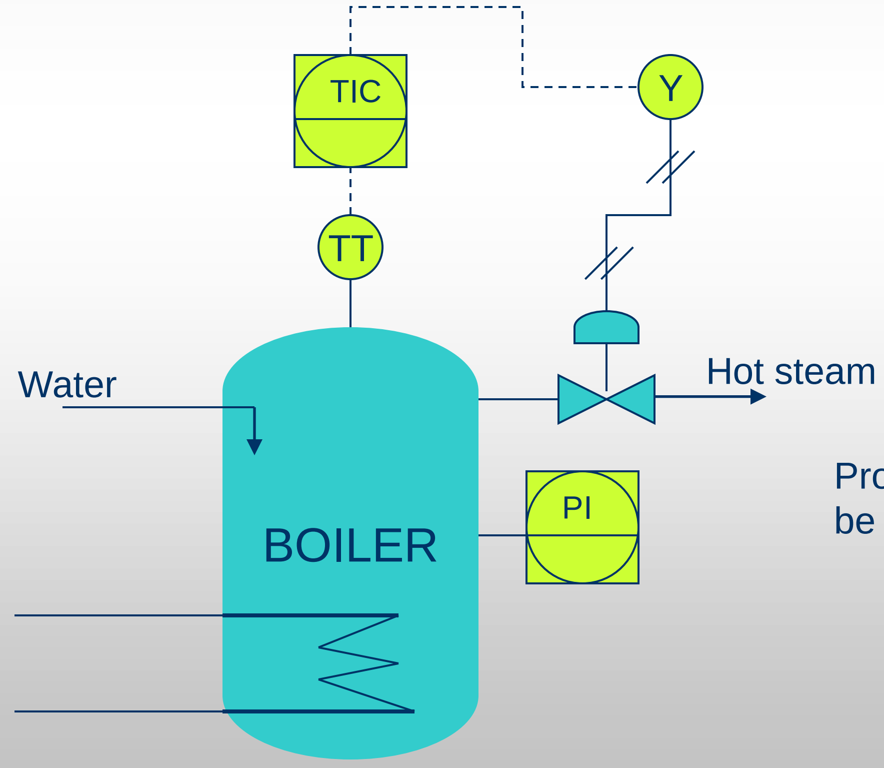


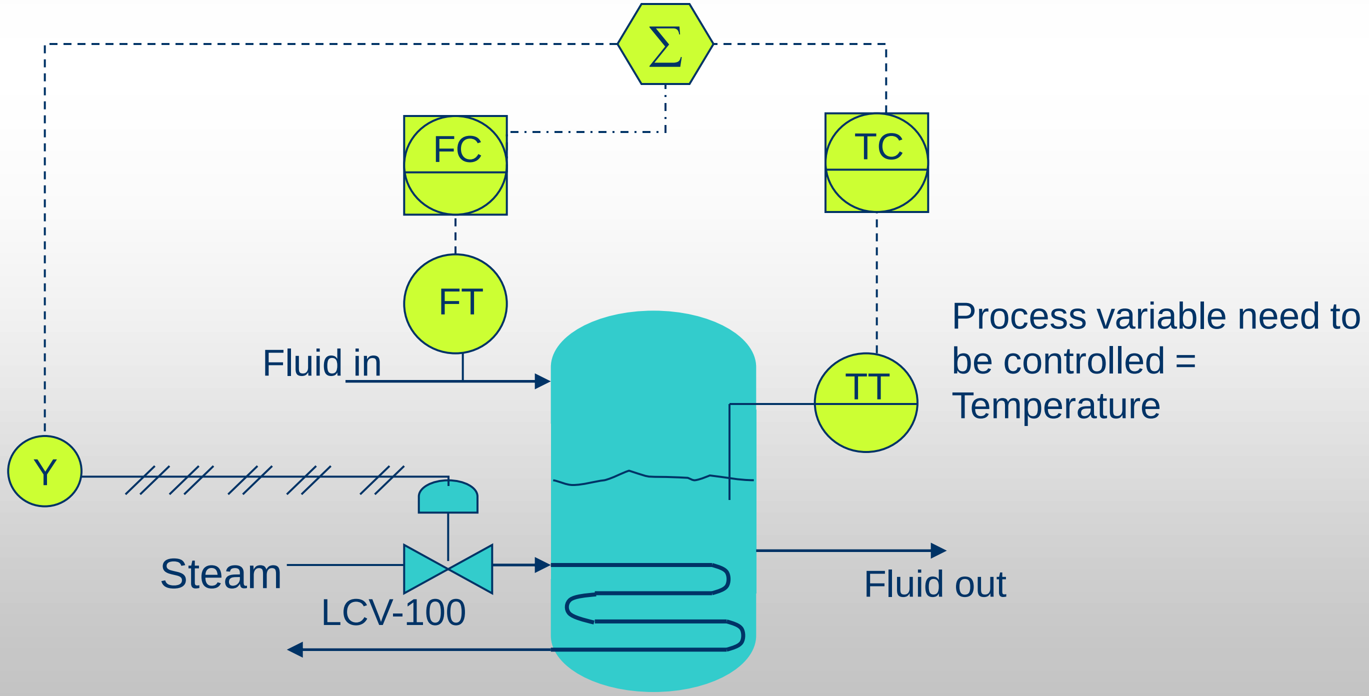
Process variable need to be controlled = Pressure

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.

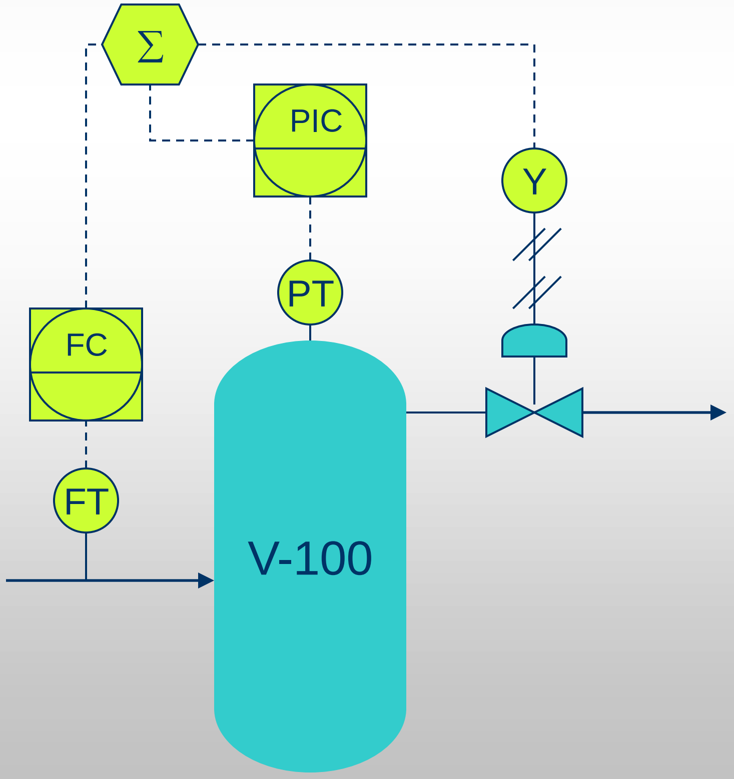


The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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

The Piping & Instrumentation Diagram (P&ID)

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Exercise 2

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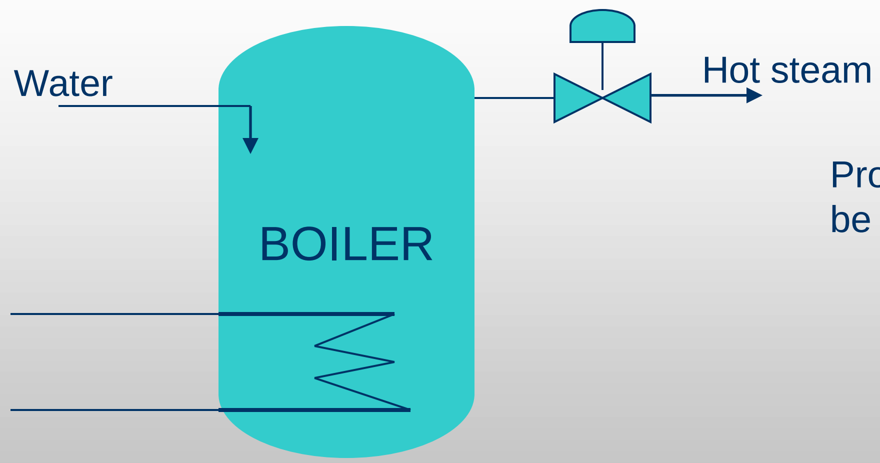

Process variable need to be controlled = Pressure

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

Answer 2

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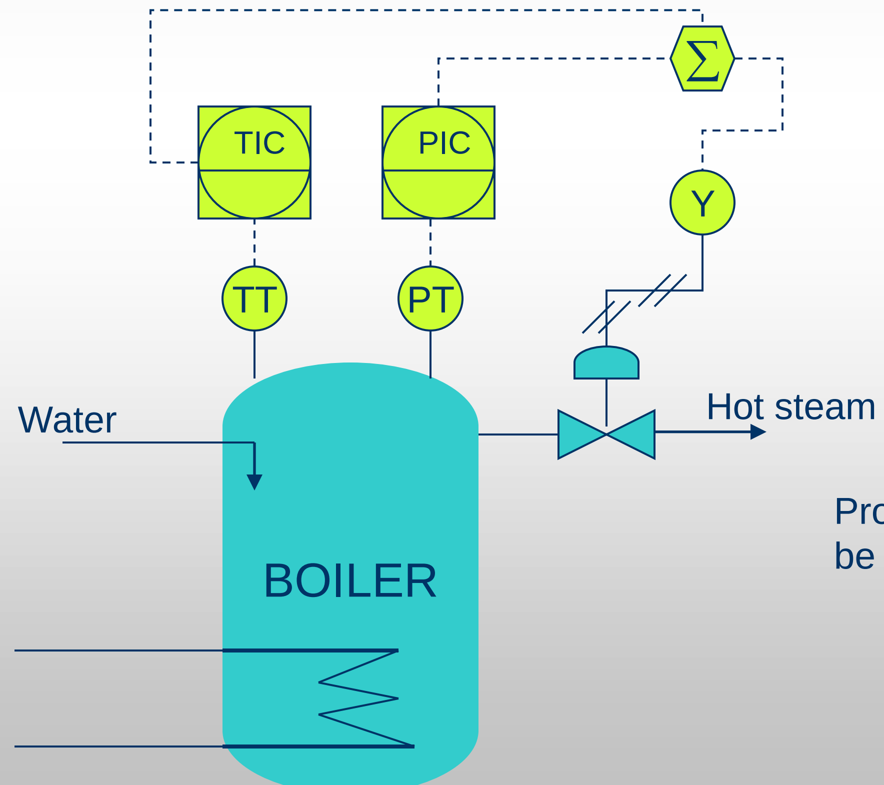


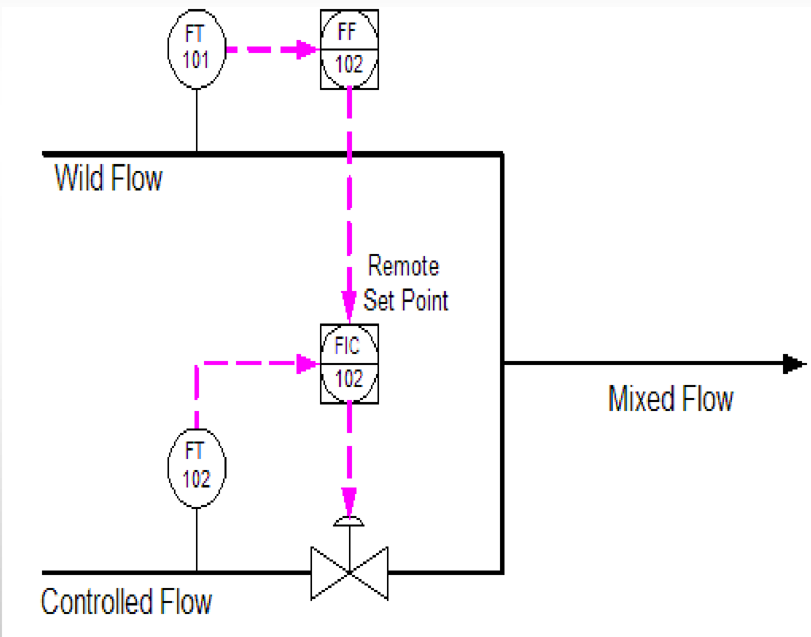
Process variable need to be controlled = Pressure

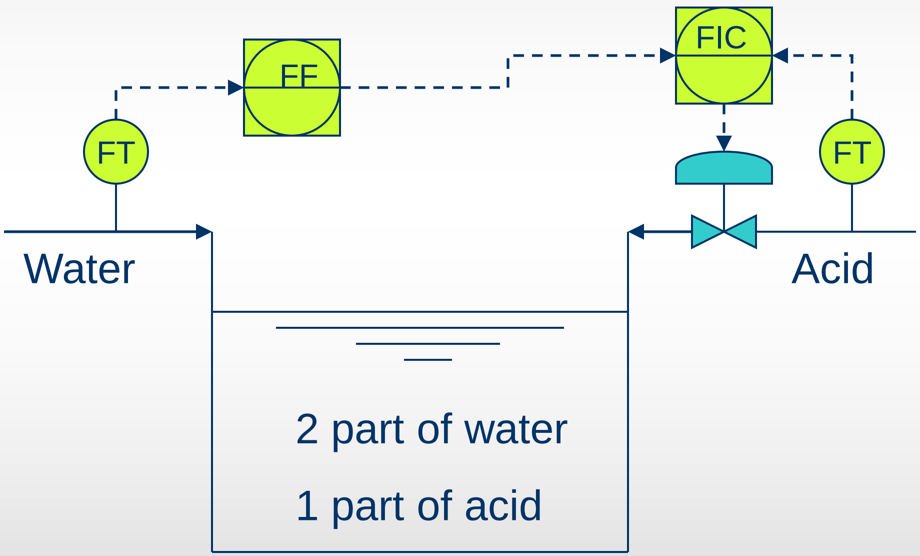
The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.



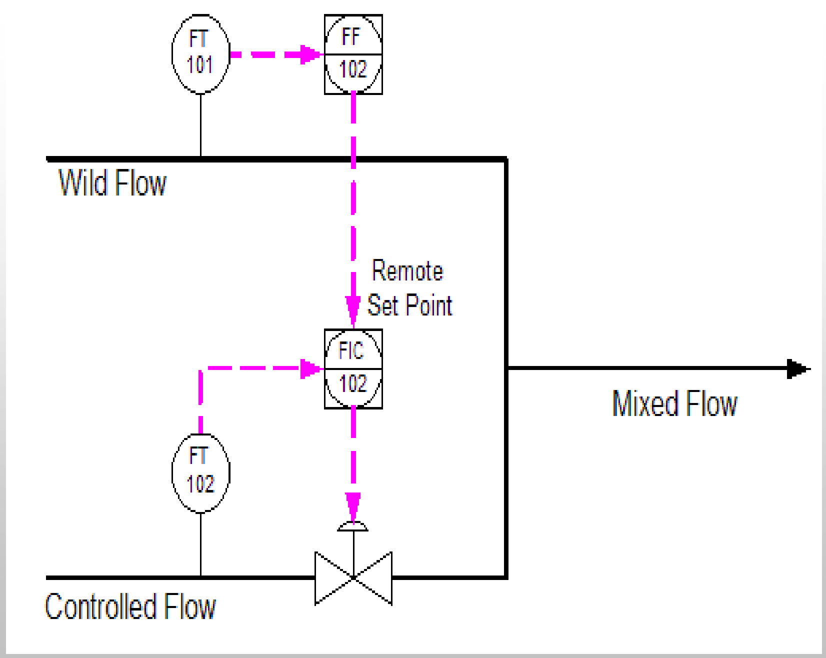


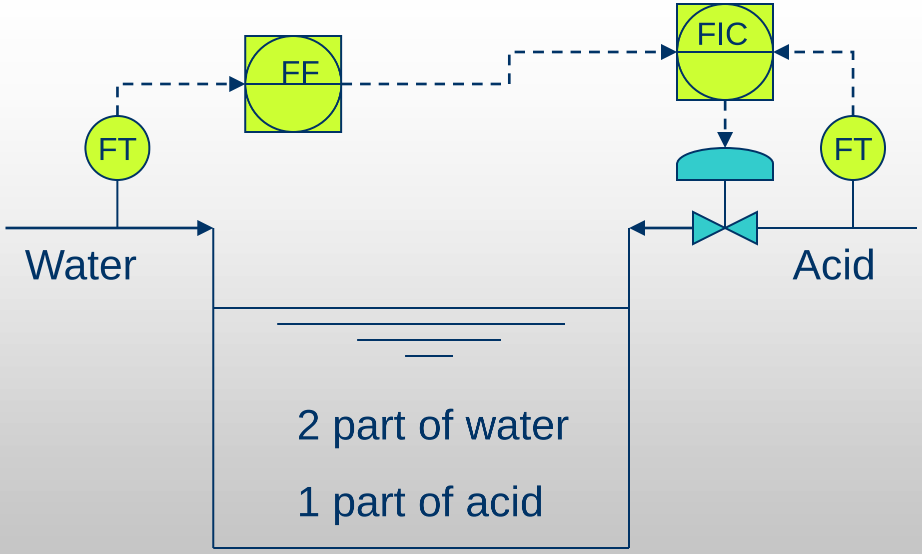
The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.





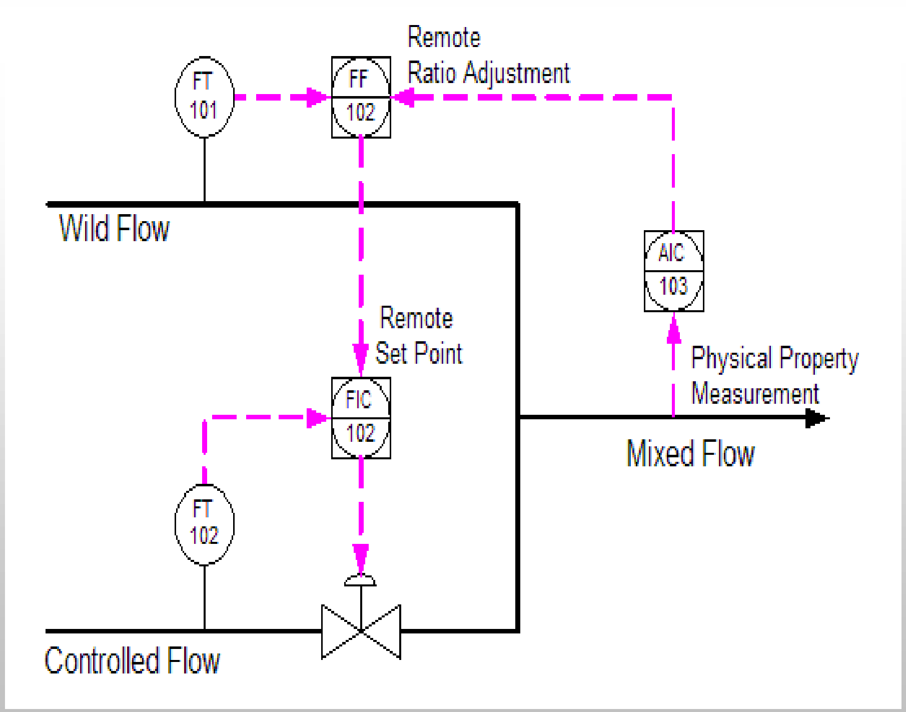
The Piping & Instrumentation Diagram (P&ID)

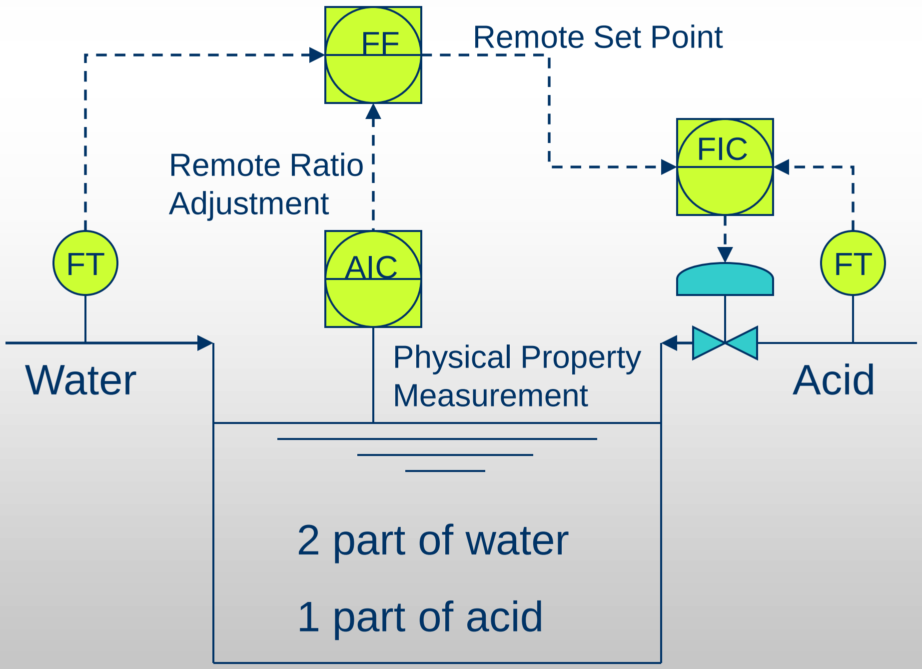
Sometimes also known as Process & Instrumentation Diagram

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.





The Piping & Instrumentation Diagram (P&ID)

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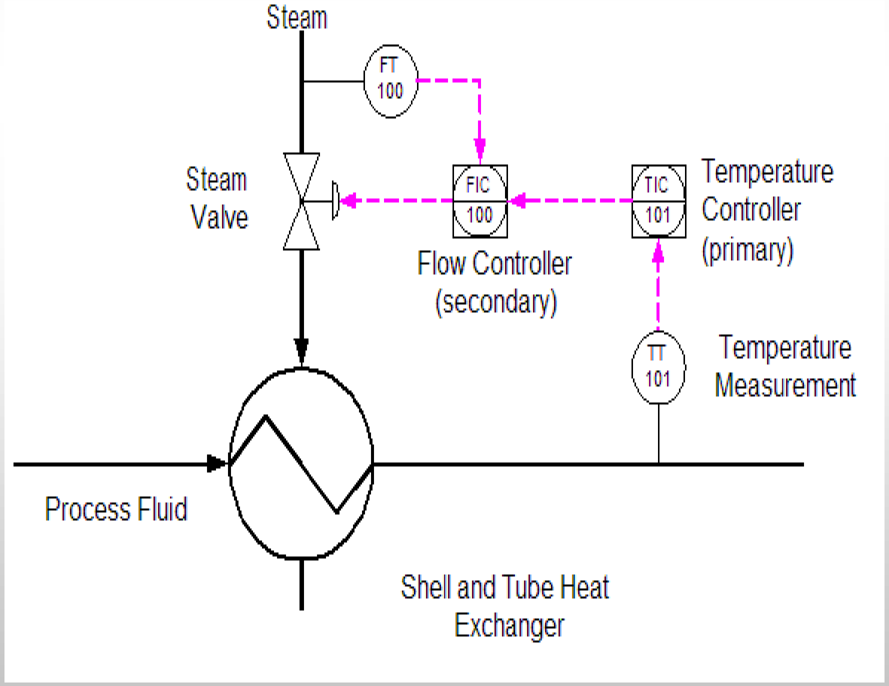
Cascade Control

❖ 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.



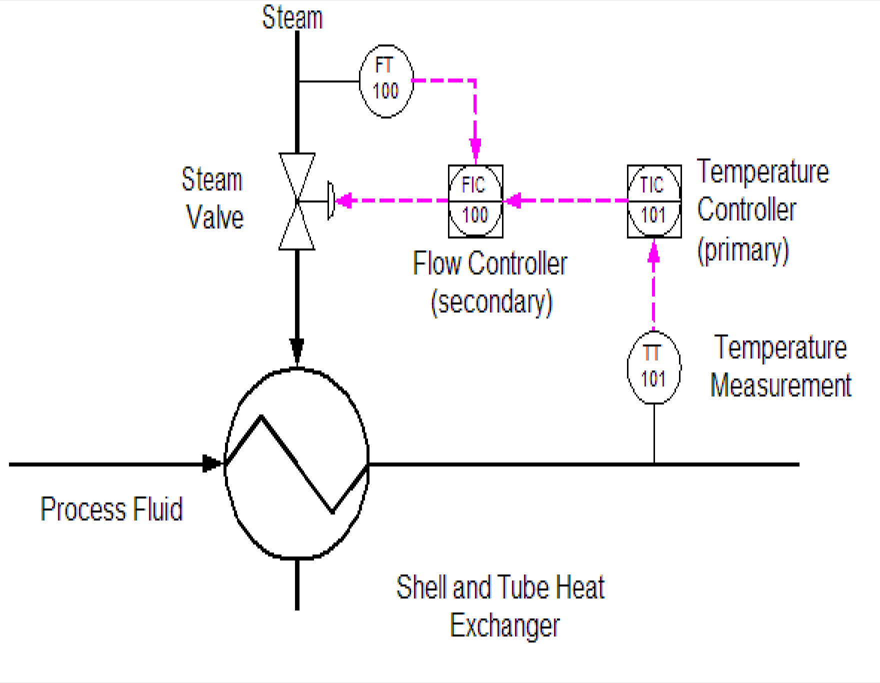
Reasons for cascade control:

- 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).

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.

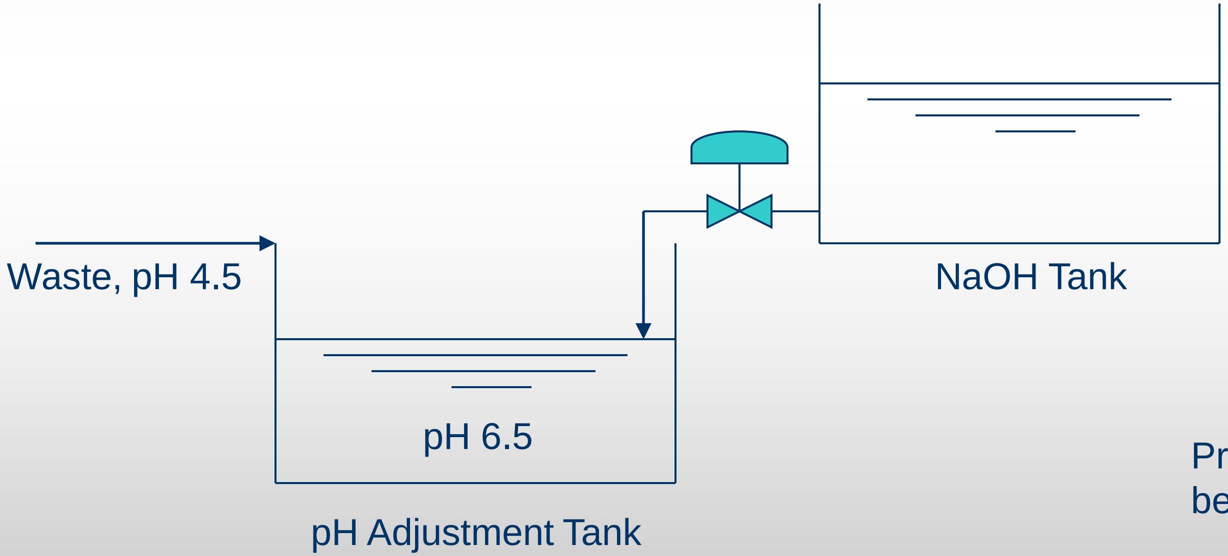
- Secondary loop must be measured and controllable.

The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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

The Piping & Instrumentation Diagram (P&ID)

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Answer 3

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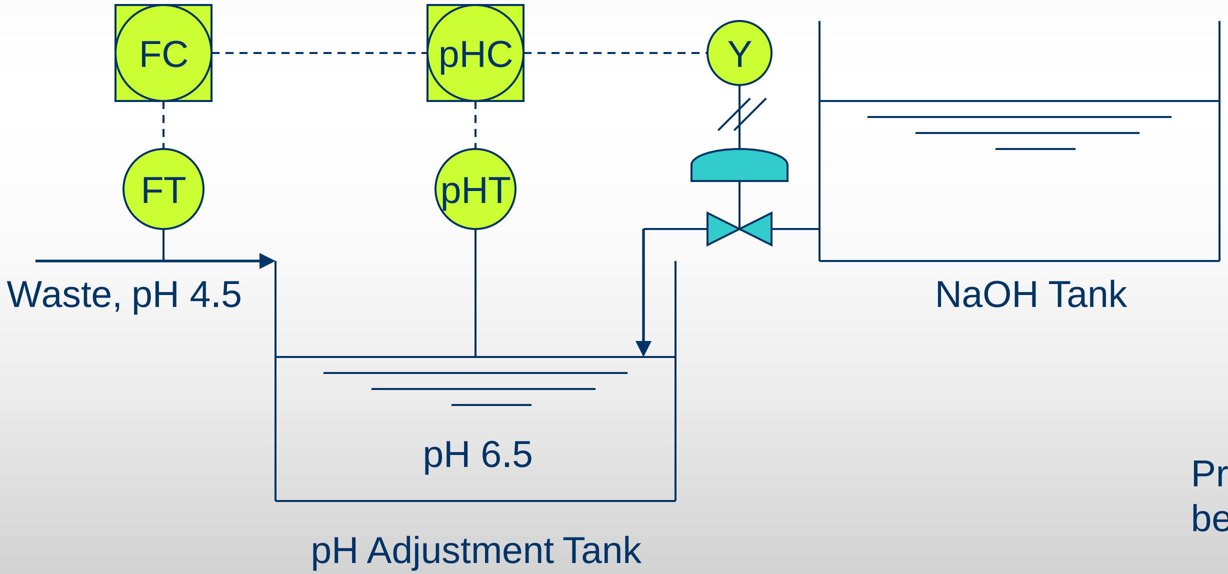


Process variable need to be controlled = pH

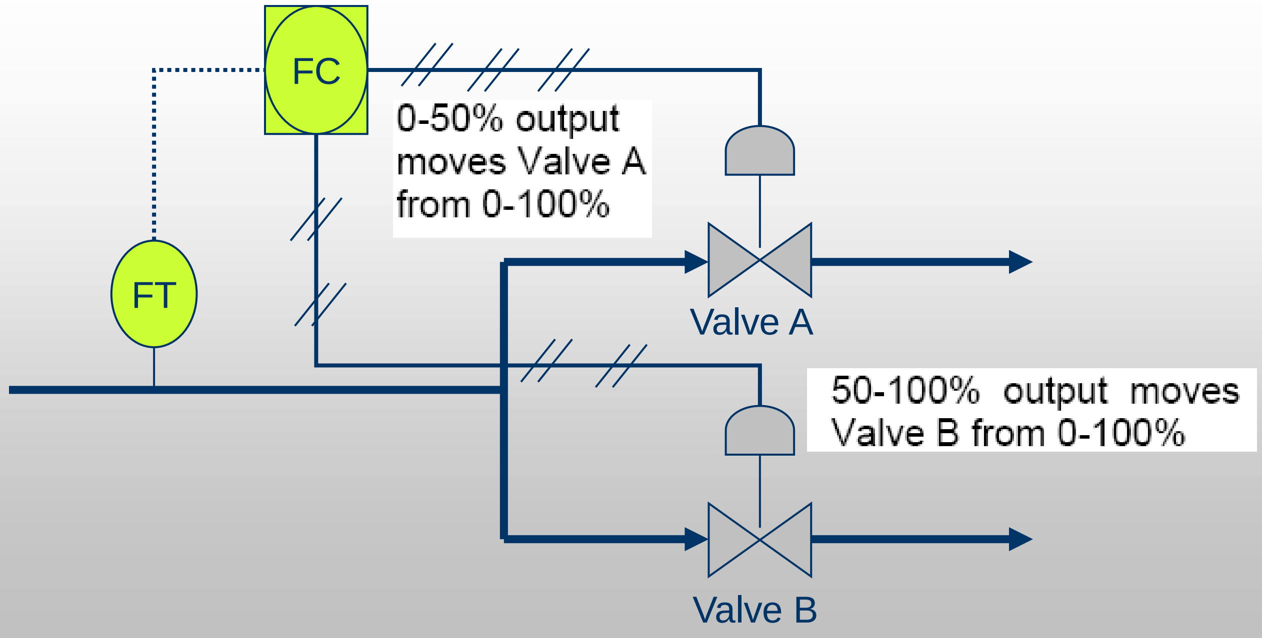
The Piping & Instrumentation Diagram (P&ID)

Sometimes also known as Process & Instrumentation Diagram

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.



The Piping & Instrumentation Diagram (P&ID)

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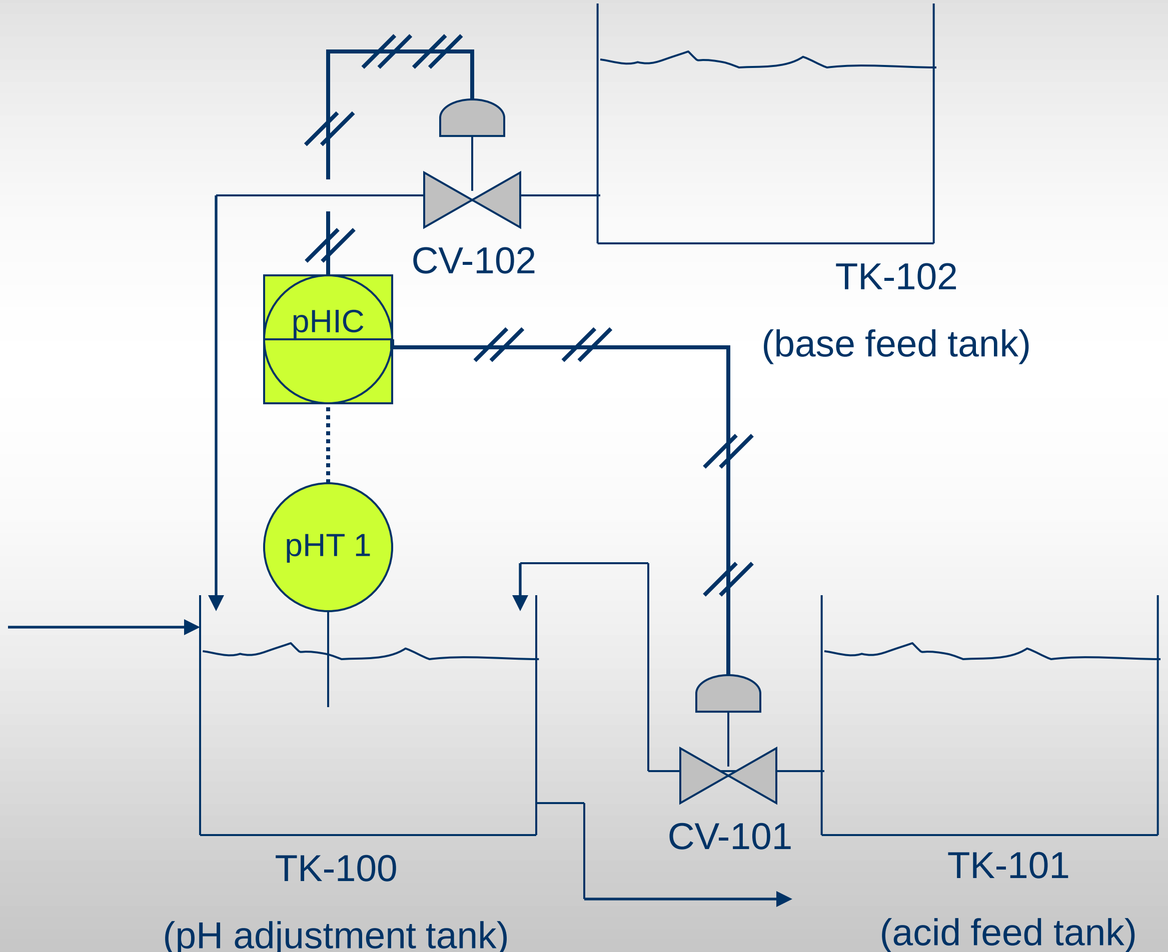
Split Range Control



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.

QUESTION?