



Theory of Basic Instruments

By
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INTRODUCTION:

It is the branch of engineering which deals with the measurement, monitoring, display etc. of the several of energy exchanges which take place during process operations. "In short Instrumentation is the study of Instrument."

INSTRUMENT:

Instrument is a device which is used to measure, monitor, display etc. of a process variable.

1. What are the processes Variables?

The process Variables are:

- Flow.
- Pressure.
- Temperature.
- Level.
- Quality i.e. % O₂, CO₂, pH etc.

2. Define all the process Variable and state their unit of measurement.

Flow: Any fluids or liquids flowing from one place to another place is called flow and it is defined as volume per unit of time at specified temperature and pressure Conditions, is generally measured by positive-displacement or rate meters.

Units: kg / hr, litter / min, gallon / min, m³ / hr, Nm³ / hr. (Gases)

Pressure: It is defined as Force per unit Area. $P = F/A$

Units : bar, Pascal, kg / cm², lb / in².

Level: The height of the water column, liquid and powder etc., at the desired measurement of height between minimum level points to maximum level point is called level. The measurement principle is, head pressure method.

Units: Meters, mm, cm, percentage.

Temperature: It is the degree of hotness or coldness of a body is called temperature.

Units : Degree Centigrade, Degree Fahrenheit, Degree Kelvin, Degree Rankin.

Quality: It deals with analysis.(pH, % CO₂, % O₂, Conductivity, Viscosity)

3. What are the primary elements used for flow measurement?

The primary elements used for flow measurement are:

- Orifice Plate.
- Venturi tube.
- Pitot tube.
- Annubars.
- Flow Nozzle.
- Weir & Flumes.

4. What are the different types of orifice plates and state their uses?

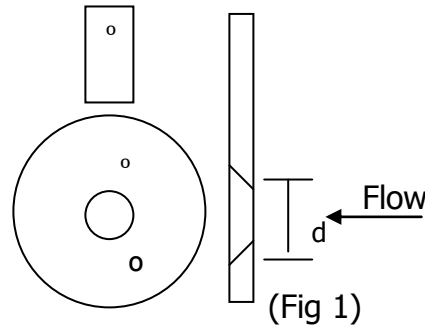
The different types of orifice plates are:

1) Concentric, 2) Segmental. 3) Eccentric. 4) Quadrant Edge.

Concentric:

The concentric orifice plate is used for ideal liquid as well as gases and steam service. This orifice plate beta ratio fall between of 0.15 to 0.75 for liquids and 0.20 to 0.70 for gases, and steam. Best results occur between value of 0.4 and 0.6. Beta ratio means ratio of the orifice bore to the internal pipe diameters.

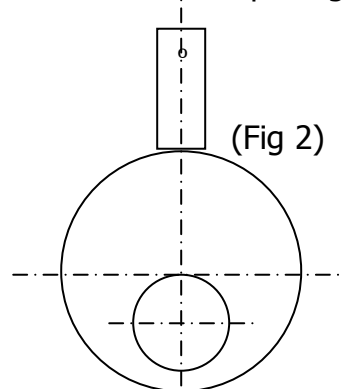
(45° beveled edges are often used to minimize Friction resistance to flowing fluid)



Eccentric:

The eccentric orifice plate has a hole eccentric. Use full for measuring containing solids, oil containing water and wet steam. Eccentric plates can be used either flange or venacontracta taps, but the tap must be at 180° or 90° to the eccentric opening.

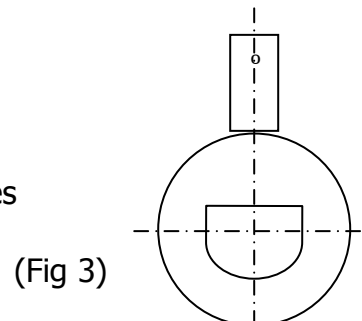
Eccentric orifices have the bore offset from center to Minimize problems in services of solids-containing Materials.



Segmental:

The segmental orifice place has the hole in the form segment of a circle. This is used for colloidal and slurry flow measurement. For best accuracy, the tap location should be 180° from the center of tangency.

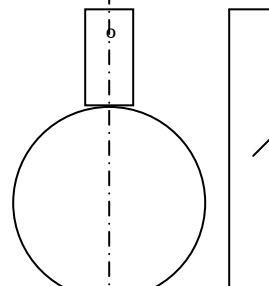
Segmental orifices provide another version of plates Useful for solids containing materials.



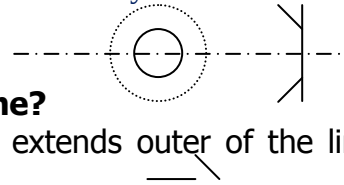
Quadrant Edge:

It common use in Europe and are particularly useful for pipe sizes less than 2 inches.

Quadrant edge orifices produce a relatively constant Coefficient of discharge for services with low



Reynolds numbers in the range from 100,000 down to 5,000. (fig. 4)



5. How do you identify an orifice in the pipe line?

An orifice tab is welded on the orifice plate which extends outer of the line giving an indication of the orifice plate.

6. Why is the orifice tab provided?

The orifice tab is provided due to the following reasons.

- Indication of an orifice plate in a line.
- The orifice diameter is marked on it.
- The material of the orifice plate.
- The tag no. of the orifice plate.
- The mark the inlet of an orifice.

Advantages and Disadvantages of Orifice Plates

Advantages of orifice plates include:

- High differential pressure generated
- Exhaustive data available
- Low purchase price and installation cost
- Easy replacement

7. What is Bernoulli's theorem and where it is applicable?

Bernoulli's theorem states the "total energy of a liquid flowing from one point to another remains constant." It is applicable for non compressible liquids.

8. How do you identify the H. P. side or inlet of an orifice plate in line?

The marking is always done H. P. side of the orifice tab which gives an indication of the H. P. side.

9. How do you calibrate a D. P. transmitter?

The following steps are to be taken which calibrating:

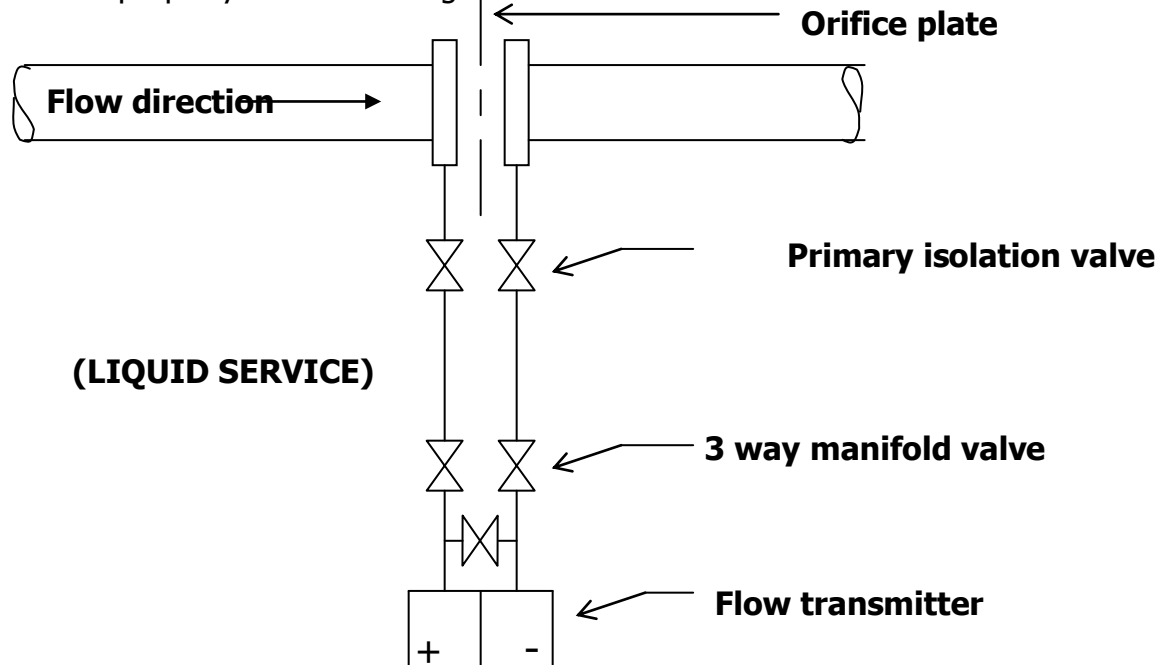
1. Adjust zero of the Tx'r.
2. Static pressure test : Give equal pressure on both sides of the transmitter. Zero should not shift. If it is shifting carry out static alignment.
3. Vacuum test: Apply equal vacuum to both the sides. The zero should not shift.
4. Calibration Procedure:
 - Give 20 psi air or 24V DC supply to the transmitter.
 - Vent the L.P. side to atmosphere.
 - Connect output of the Instrument to a standard test gauge or Multimeter and adjust zero.
5. Apply required pressure to high pressure side of the transmitter and adjust the span.
6. Adjust zero again if necessary.

10. What is the seal liquid using for filling impulse lines on crude and viscous liquid services?

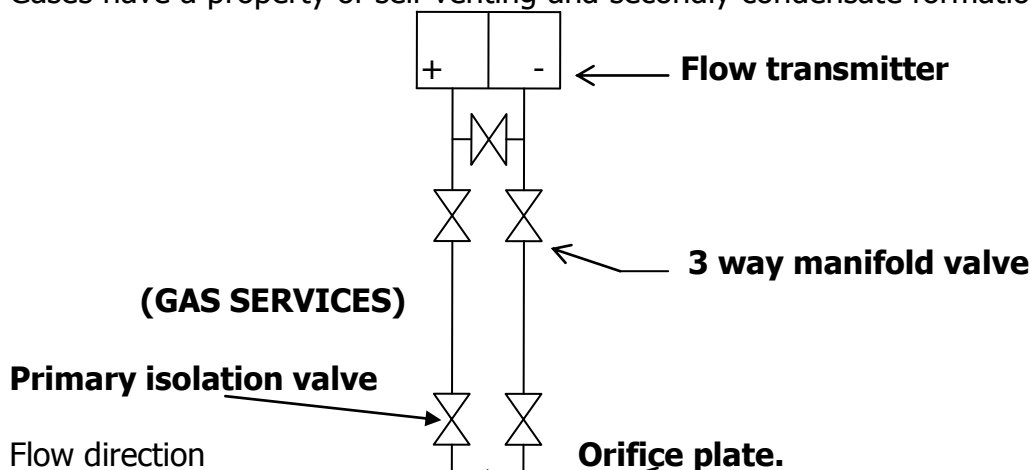
Glycol.

11. How do you carry out piping for a Different pressure flow transmitter on liquids, Gas and steam services Why ?

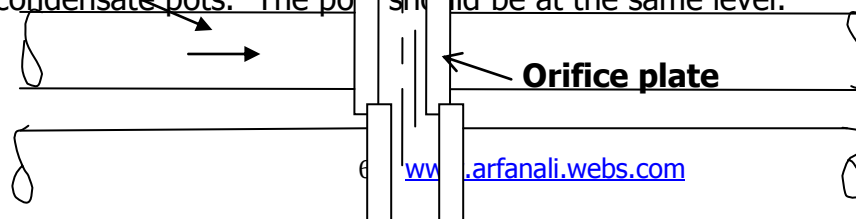
Liquid lines: On liquid lines the transmitter is mounted below the orifice plate because liquids have a property of self draining.

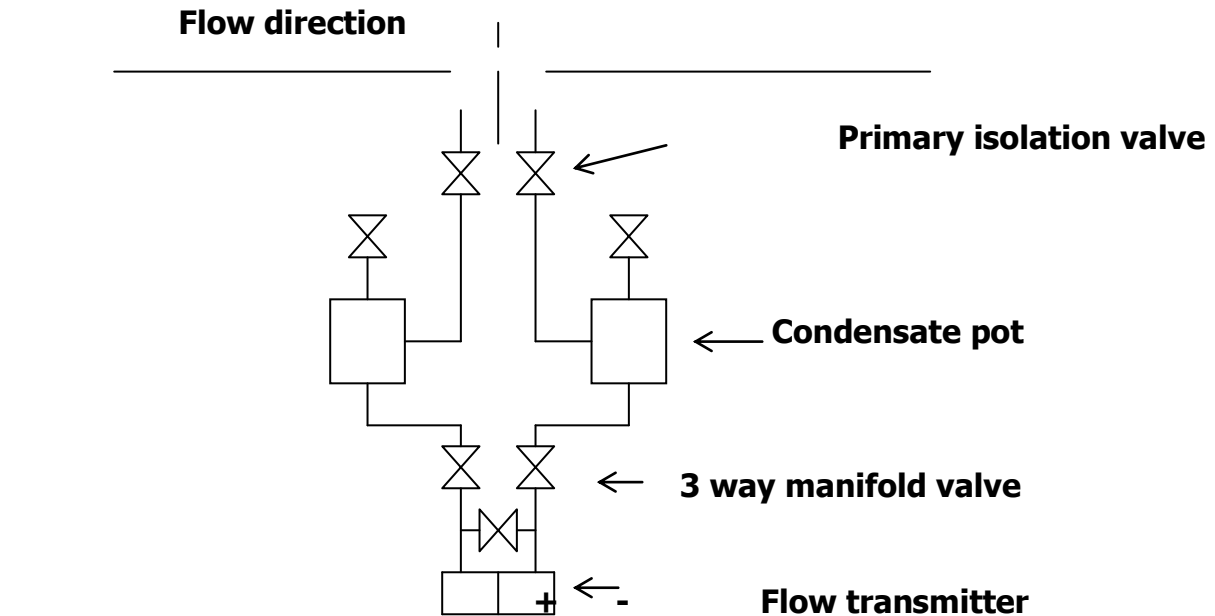


Gas Service: On gas service the transmitter is mounted above the orifice plate because Gases have a property of self venting and secondly condensate formation.

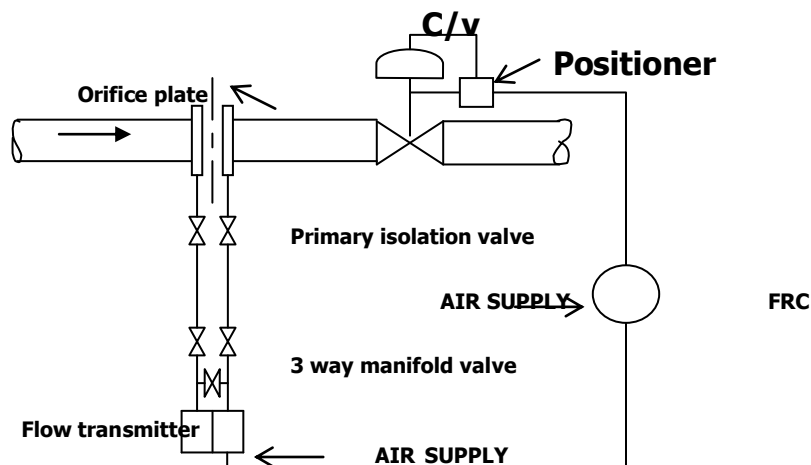


Steam Service: On steam service the transmitter is mounted below the orifice plate with condensate pots. The pots should be at the same level.





12. Draw and explain any flow control loop?



13. An operator tells you that flow indication is more, How would you start checking?

- First flushing the transmitter. Flush both the impulse lines. Adjust the zero by equalizing if necessary. If still the indication is more then.
- Check L.P. side for choke. If that is clean then.
- Check the leaks on L.P. side. If not.
- Calibrate the transmitter.

14. How do you do a zero checks on a D. P. transmitter?

Close one of the valve either H. P. or L.P. open the equalizing valve. The O/P should read zero.

15. How would you do Glycol filling or fill seal liquids in seal pots 7 Draw and explain.

- The procedure for glycol filling is :
- Close the primary isolation valves.
- Open the vent on the seal pots.
- Drain the used glycol if present.
- Connect a hand pump on L.P. side while filling the H. P. side with glycol.
- Keep the equalizer valve open.
- Keep the L.P. side valve closed.
- Start pumping and fill glycol.
- Same repeat for L.P. side by connecting pump to H. P. side, keeping equalizer open and H.P. side isolation valve closed.
- Close the seal pot vent valves.
- Close equalizer valve.
- Open both the primary isolation valves.

16. How do you calculate new factor from new range using old factor and old range?___

$$\frac{Q_1}{Q_2} = \frac{\sqrt{\Delta P_1}}{\sqrt{\Delta P_2}}$$

Q_1 = Old flow
 Q_2 = New flow
 $\sqrt{\Delta P_1}$ = Old DP
 $\sqrt{\Delta P_2}$ = **New DP**

$$Q_2 \times \sqrt{\Delta P_1} = Q_1 \times \sqrt{\Delta P_2}$$

$$Q_2 = \frac{Q_1 \times \sqrt{\Delta P_2}}{\sqrt{\Delta P_1}}$$

$\text{New flow} = \frac{\text{Old flow} \times \sqrt{\text{new DP}}}{\sqrt{\text{Old DP}}}$
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$$F = \frac{\sqrt{\Delta P}}{\sqrt{\Delta P_{\text{full}}}} \times 10 \quad (\text{or}) \quad \text{O/P \%} = \frac{\sqrt{\text{I/P \%}}}{\sqrt{\Delta P_{\text{full}}}} \times 10$$

O/P % = Flow, I/P % = ΔP

17. How will you vent air in the D. P. cell? What if seal pots are used?

- Air is vented by opening the vent plugs on a liquid service transmitter.
- On services where seal pots are used isolate the primary isolation valves and open the vent valves. Fill the line from the transmitter drain plug with a pump.

18. Why flow is measured in square root?

Flow varies directly as the square root of differential pressure $F = K \sqrt{D/P}$. Since this flow varies as the square root of differential pressure the pen does not directly indicate flow. The flow can be determined by taking the square root of the pen. Say the pen reads 50% of chart.

19. What is absolute pressure?

Absolute pressure is the total pressure present in the system

Abs. pressure = Gauge pressure + Atm. pressure.

20. What is absolute zero pressure?

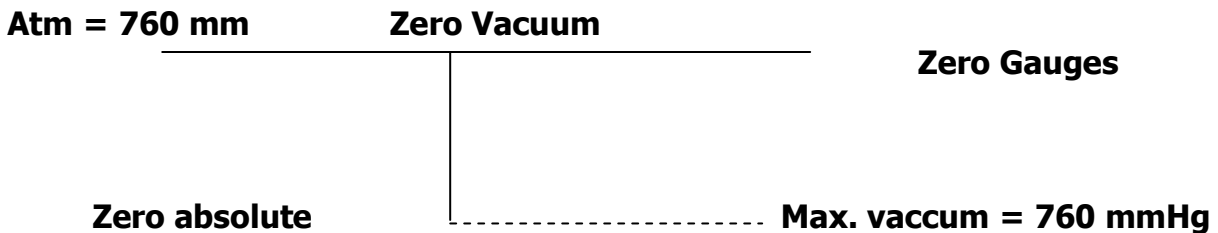
Absolute zero = 760 mm Hg Vacuum.

21. What is the maximum Vacuum?

The maximum Vacuum = 760 mm Hg.

22. What is Vacuum?

Any pressure below atmospheric pressure is vacuum.



23. What are the primary elements for measuring pressure?

The primary elements used for measuring pressure are:

- Bourdon tube.
- Diaphragm.
- Capsule.
- Bellows.
- Pressure Springs.

The above are known as elastic deformation pressure elements.

Type of Bourdon tubes.

- 'C' type.
- Spiral.
- Helix.

Diaphragm: The diaphragm is best suited for low pressure measurement.

Capsules : Two circular diaphragms are welded together to form a pressure capsule.

Material Used: phosphor bronze, Ni-spand stainless steel.

Bellows : Bellows is a one - piece, collapsible, seamless metallic unit with deep folds Formed from very thin walled tubing.
Material used: Brass, phosphor bronze, stainless steel. Used for high Pressure.

Pre. spring: Pressure springs of helical or spiral shape used for measuring high pressures.

24. How will you calibrate an absolute pressure transmitter using vacuum manometer. Range 0-400B mm abs?

The procedure for calibration is as follows:

- Connect air supply to the transmitter.
- Connect a test gauge of 0-1.4 Kg/cm² to the output.
- Connect Vacuum pump with tee off to the manometer.
- Apply 760 mm Vacuum (or nearest) and adjust zero.
- Apply 360 mm Vacuum adjust span. (760 - 360 = 400 mm abs.)

25. You are given a mercury manometer range 0 -760 mm? A vacuum gauge reads 60 mm vacuum. The test manometer reads 50 vacuums? Which of the two is correct?

The transmitter is correct because $760 - 50 = 710$ mm abs.

26. Why is an inclined manometer used?

It is used to extend the scale of the instrument. Because the manometer is at an angle to the vertical.

27. What is the principle of a pressure gauge?

Pressure works on Hooke's law.

Principle: "Measuring the stress in an elastic medium"

28. Draw and explain a pressure gauge? What is the use of a Hair spring?

The parts of a pressure gauge are:

1. 'C' type Bourdon tube.
2. Connecting link.
3. Sector gear.
4. Pinion gear.
5. Hair Spring.
6. Pointer.
7. Dial.

Uses of Hair Spring: Hair spring serves two purposes namely

- To avoid backlash error (eliminate any play into linkages).
- It serves as a controlling torque.

LEVEL

29. Briefly explain the different methods of level measurement?

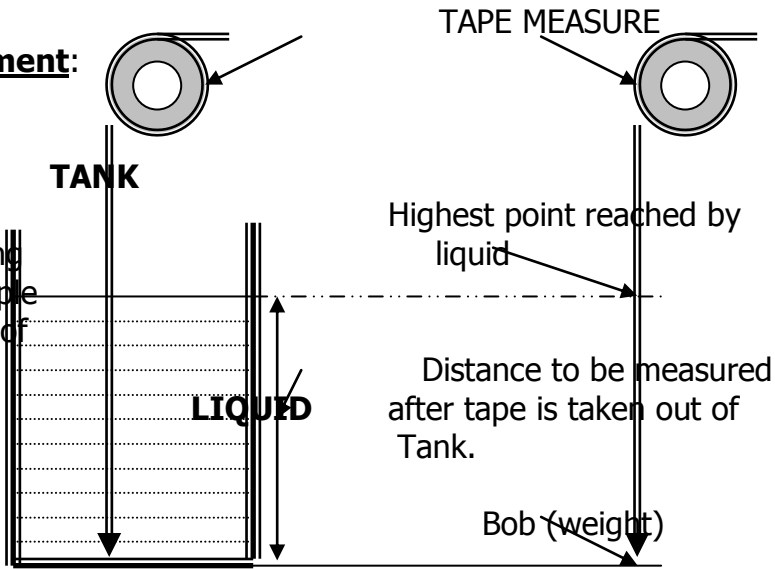
There are two ways of measuring level:

1. Direct
2. Indirect.

1. Direct level measurement:

(a) Bob and tape:

A bob weight and measuring tape provide the most simple and direct method of measuring liquid level.



(b) Sight glass:

This consists of a graduated glass tube mounted on the side of the vessel. As the level of the liquid in the vessel change, so does the level of the liquid in the glass tube.

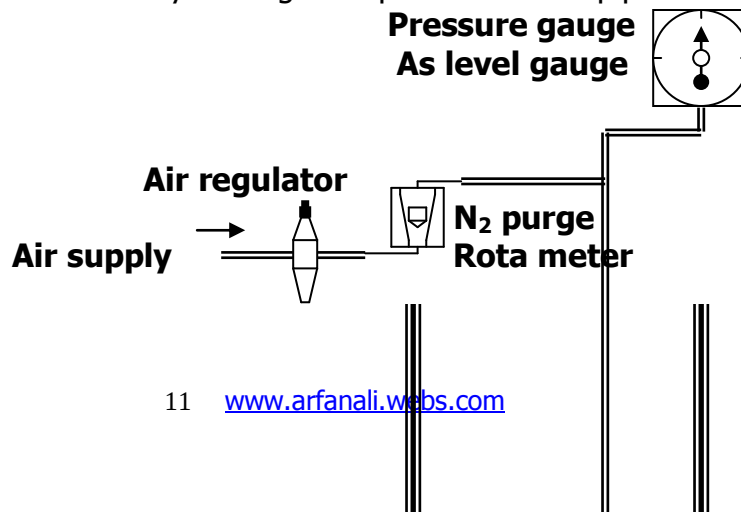
Indirect level measurement:

(A) **Pressure gauge:**

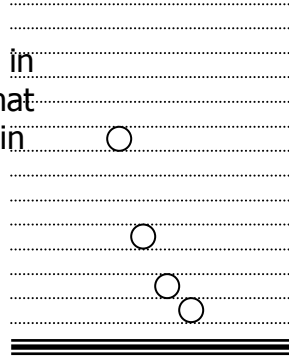
This is the simplest method, for pressure gauge is located at the zero level of the liquid in the vessel. Any rise in level causes an increase of pressure which can be measured by a gauge.

(b) **Purge system:**

In this method a pipe is installed vertically with the open end at zero level. The other end of the pipe is connected to a regulated air supply and to a pressure gauge. To make a level measurement the air supply is adjusted so that pressure is slightly higher than the pressure due to height of the liquid. This is accomplished by regulating the air pressure until bubbles can be seen slowly leaving the open end of the pipe.



The air pressure to the bubbler pipe is minutely in
 Excess of the liquid pressure in the vessel, so that
 Air pressure indicated is a measure of the level in
 The tank.



The method above is suitable for open tank applications. When a liquid is in a pressure vessel, the liquid column pressure can't be used unless the vessel pressure is balanced out. This is done through the use of different pressure meters.

(c) Differential pressure meter:

Connections are made at the vessel top and bottom, and to the two columns of the D.P. meter. The top connection is made to the L.P. column of the transmitter and the bottom to H.P. column of the transmitter. The difference in pressure in the vessel is balanced out, since it is fed to both the column of the meter. The difference in pressure deducted by the meter will be due only to the changing, level of the liquid.

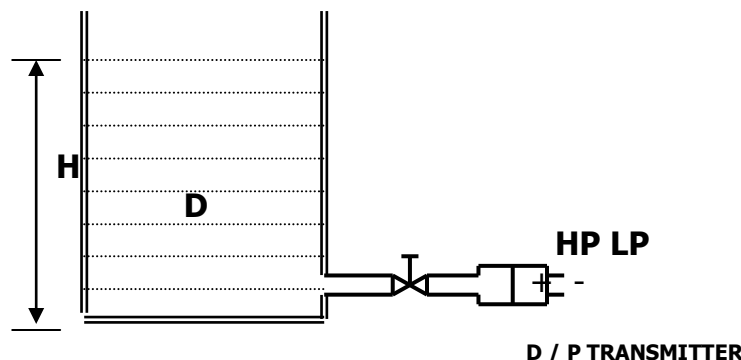
(d) Displacer type level measurement:

The leveltrol is one of the most common instruments used measuring level in closed tanks. This instrument works of Archimedes principle. The displacer is immersed in the liquid due to which there is loss of weight depending on the specified gravity of the liquid. This displacer hangs freely on a knife transmitted to the pneumatic or electronic counterpart at the other end.

30. Explain how you will measure level with a different pressure transmitter.

The bottom connection of the vessel is connected to high pressure side of the transmitter.

Different Pressure = $H \times D$



This difference pressure is applied to H. P. side of the transmitter and calibrated.

31. How is D. P. transmitter applied to a close tank?

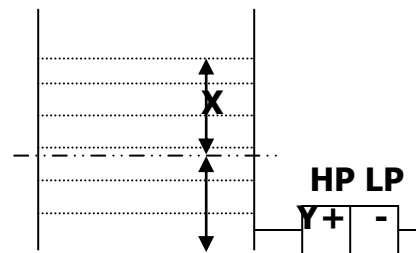
In close tank the bottom of the tank is connected to the high pressure side of the transmitter and top of the tank is connected to L.P. side of the transmitter. In this way the vessel pressure is balanced.

32. How is D.P. transmitter applied to an open tank?

On an open tank level measurement the L.P. side is vented to atmosphere. Whatever pressure acts is on the H.P. side which is a measure of level.

$$\text{SPAN} = (X) (\text{Sp. Graf})$$

$$\text{ZERO SUPPRESSION} = (Y) (\text{Sp.Grav})$$



33. How is D. P transmitter applied to a close tank & open tank with Dry leg?

$$\text{Span} = (X) (G_L)$$

$$H_w \text{ at minimum level} = (Z) (G_S) + (Y) (G_L)$$

$$H_w \text{ at maximum level} = (Z) (G_S) + (X + Y) (G_L)$$

Where:

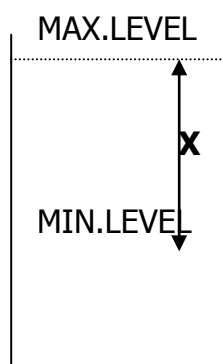
G_L = Specific gravity of tank liquid.

G_S = Specific gravity of seal liquid.

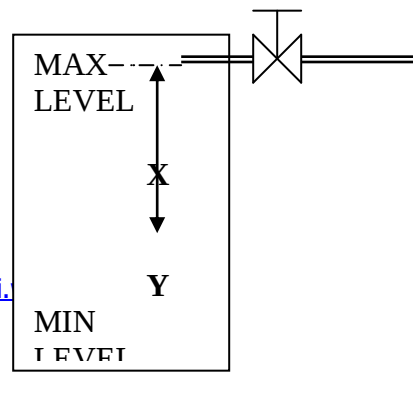
H_w = Equivalent head of water.

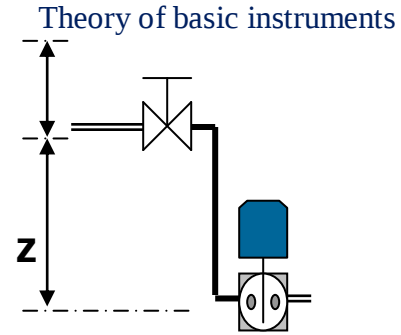
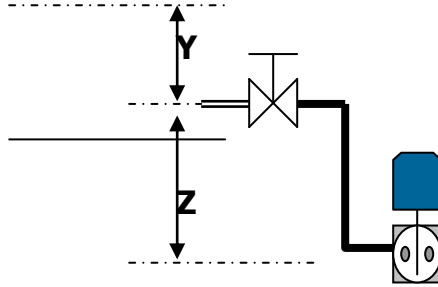
X, Y & Z are shown in fig (1.1)

Open tank



Close tank with dry leg





Example:

Open tank with $X = 300$ inches

$Y = 50$ inches

$Z = 10$ inches

$G_L = 0.8$

$G_S = 0.9$

Span = $(300) (0.8) = 240$ inches

H_w at minimum level = $(10) (0.9) + (50) (0.8) = 49$ inches

H_w at maximum level = $(10) (0.9) + (50 + 300) (0.8) = 289$ inches

Calibrated range = 49 to 289 inches head of water

2.3

DEFINITION OF INSTRUMENT RANGE AND SPAN

Legend:

Range

Defined in IEC 60902 as follows: The region of values between the lower and upper limits of the quantity under consideration.

It is expressed by stating the lower and upper limits (e.g. minus 1 to 10 bars (ga)).

Span

Defined in IEC 60902 as follows: The algebraic difference between the upper and lower limit values of a given range.

It is expressed as a figure and unit of measurement (e.g. 8 bars).

LRL

Lower Range Limit; the lowest quantity that a device is designed to measure.

URL

Upper Range Limit; the highest quantity that a device is designed to measure.

Instrument range

the region in which the instrument is designed to operate. It is a physical capability of the device. The region limits are expressed by stating the LRL and URL.

Instrument minimum span the minimum distance between the URV and LRV for which the instrument is designed. It is a physical limitation of the device.

Instrument maximum span	The maximum distance between the URV and LRV for which the instrument is designed. It is a physical limitation of the device.
LRV	Lower Range Value; the lowest quantity that a device is adjusted to measure.
URV	Upper Range Value; the highest quantity that a device is adjusted to measure.
Adjusted range	The measurement region. It is expressed by stating the LRV and URV.
Adjusted span	The distance between the URV and LRV.

Example: A differential pressure transmitter is used to measure the level in a vessel, using a wet reference leg. 0% level corresponds with a differential pressure of -800 mbar and 100% level with -100 mbar. The catalogue of the selected transmitter lists -1800/+1800 mbar for LRL/URL respectively and span limits of 300 to 1800 mbar, so:

Instrument range	= -1800 to +1800 mbar
Instrument minimum/maximum span	= 300 / 1800 mbar respectively;
LRV / URV	= -800 / -100 mbar respectively;
Adjusted range	= -800 to -100 mbar.
Adjusted span	= 700 mbar.

NOTE: 'Adjusted' range and 'adjusted' span are frequently referred to as 'calibrated' range and 'calibrated' span. This term is however only correct, if a calibration facility is used to set the LRV and URV. For 'intelligent' measuring devices, the supplier is usually calibrating the device at the LRL/URL and the user is setting the required LRV and URV by remote communication.

2.4 SELECTION OF RANGES

The accuracy (2.8) and adjusted range of an instrument should be selected to cover the operating window (2.1), which includes applicable abnormal operation and alternative operating modes. Unless otherwise stated, the normal design value should lie between 50% and 75% of the adjusted range

NOTE: For certain applications it might not be possible to combine all normal and abnormal operating conditions in one measurement at the required accuracy. In such cases, a case-by-case analysis should disclose whether additional instruments are required or the accuracy requirements and/or operating window may be relaxed. It might be acceptable to present measured values during some of the abnormal operating cases at a lower accuracy or it might be justifiable for the measurement not to produce a sensible signal under some of the abnormal process conditions during start-up, commissioning, regeneration, emergency conditions and the like.

IPF transmitters should have the same instrument range, adjusted range and accuracy as corresponding process transmitters in order to facilitate measurement comparison. For details and exceptions, see DEP 32.80.10.10-Gen. Trip settings should lie between 10% and 90% of the adjusted range.

The LRV should be selected so that the displayed result represents the zero or sub-zero value of the process variable (e.g. 0-150 tons/day, 0-100% level, 0-10 bar (ga), -1/+3 bar (ga), 0-500 °C, -50/+50 °C etc.). Elevated zero's (100-300 tons/day, 100-200 °C) should be avoided.

Close tank with wet leg:

$$\text{Span} = (X) (G_L)$$

$$H_W \text{ at minimum level} = (Y) (G_L) - (d) (G_S)$$

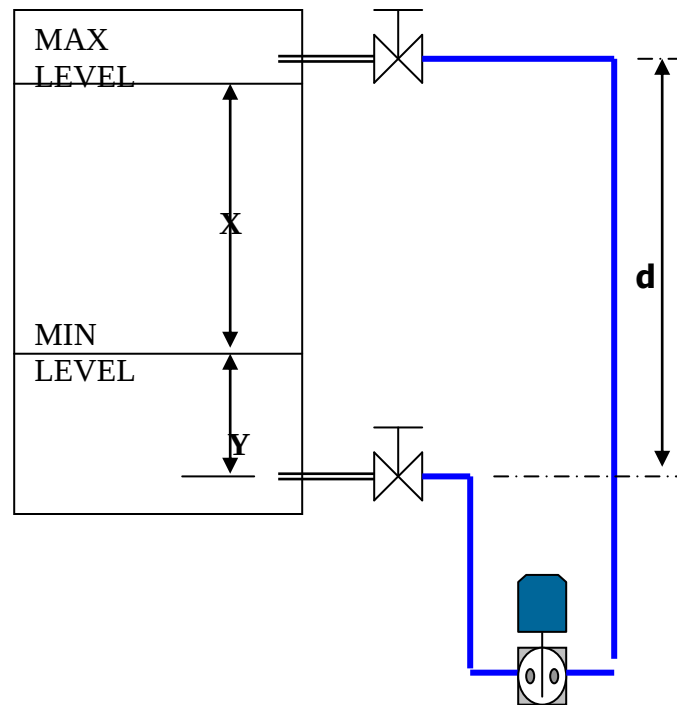
$$H_W \text{ at maximum level} = (X + Y) (G_L) - (d) (G_S)$$

Where: G_L = Specific gravity of tank liquid

G_S = Specific gravity of tank liquid

H_W = Equivalent head of water

X, Y and Z are shown in fig.



Example :

$$X = 300 \text{ inches}$$

$$Y = 50 \text{ inches}$$

$$d = 500 \text{ inches}$$

$$G_L = 0.8$$

$$G_S = 0.9$$

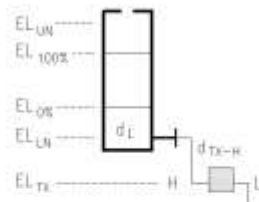
$$\text{Span} = (300) (0.8) = 240 \text{ inches}$$

$$H_W \text{ minimum level} = (50) (0.8) - (500) (0.9) = -410 \text{ inches}$$

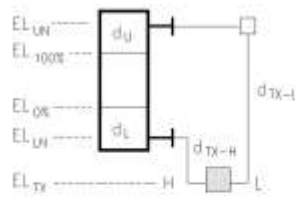
$$H_W \text{ maximum level} = (300 + 50) (0.8) - (500) (0.9) = -170 \text{ inches}$$

Calibrated range = - 410 to -170 inches head of water.

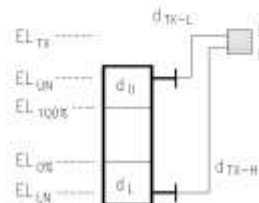
(minus signs indicate that the higher pressure is applied to the low pressure side of the transmitter)



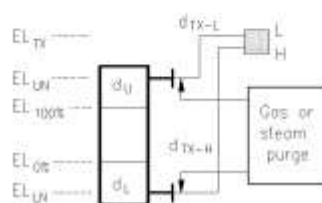
Arrangement-1:
Open equipment;
No reference leg;
Term T-1 = 0;
Term T-4 = 0.



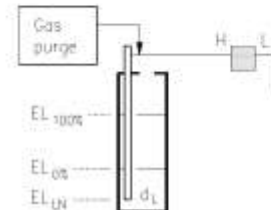
Arrangement-2:
Closed equipment;
Wet reference leg.



Arrangement-3:
Closed equipment;
Dry reference leg;
Self purging.



Arrangement-4:
Closed equipment;
Dry reference leg;
External gas or steam purging
(entry point near equipment
nozzles).



Arrangement-5:
Open equipment;
No reference leg;
External gas purging
(entry point near purge
pipe);
Terms T-1/3/4 = 0.

The universal formulae for calculating the lower and upper range values of any differential pressure type level measurement are:

Lower range value in mbar:

$$9.81 \times 10^{-5} \times \left\{ \underbrace{(EL_{UN} - EL_{0\%}) \cdot d_U}_{\text{Term T-1}} + \underbrace{(EL_{0\%} - EL_{LN}) \cdot d_L}_{\text{Term T-2}} + \underbrace{(EL_{LN} - EL_{TX}) \cdot d_{TX-H}}_{\text{Term T-3}} - \underbrace{(EL_{UN} - EL_{TX}) \cdot d_{TX-L}}_{\text{Term T-4}} \right\}$$

Upper range value in mbar:

$$9.81 \times 10^{-5} \times \left\{ \underbrace{(EL_{UN} - EL_{100\%}) \cdot d_U}_{\text{Term T-1}} + \underbrace{(EL_{100\%} - EL_{LN}) \cdot d_L}_{\text{Term T-2}} + \underbrace{(EL_{LN} - EL_{TX}) \cdot d_{TX-H}}_{\text{Term T-3}} - \underbrace{(EL_{UN} - EL_{TX}) \cdot d_{TX-L}}_{\text{Term T-4}} \right\}$$

34. What is purge level system?

This method is also known as bubbler method of level measurement. A pipe is installed vertically with its open end at the zero level. The other end of the pipe is connected to a regulated air supply and to a pressure gauge or to ΔP transmitter. To make a level measurement the air supply is adjusted so that pressure is slightly higher than the

pressure due to the height of the liquid. This is accomplished by regulating the air pressure until bubbles can be seen slowly leaving the open end of the pipe. The gage then measures the air pressure needed to overcome the pressure of the liquid.

$$\Delta P = H \times D$$

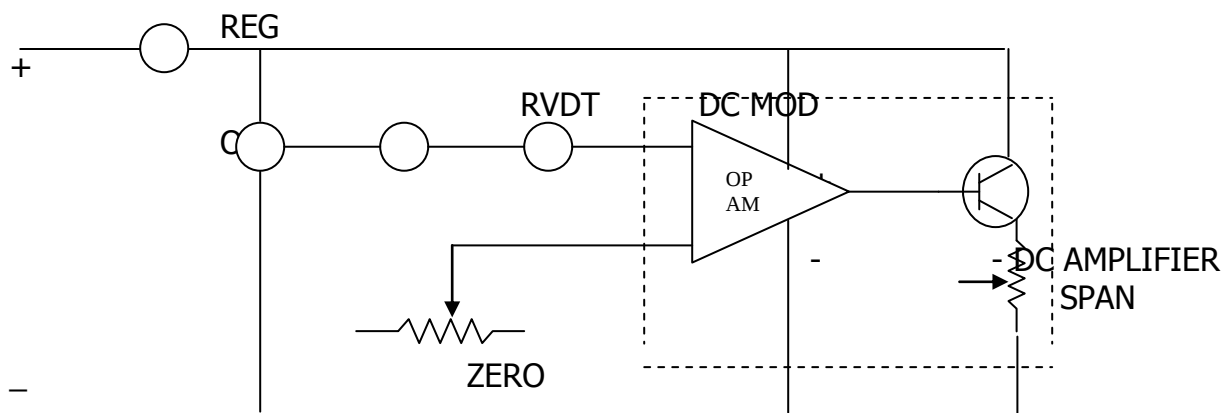
USE: On for corrosive liquids where the transmitter cannot be directly connected to process eg... Acids, Some organic liquids.

35. Explain the working of a leveltrol.

The leveltrol is used for measuring level of liquids in a closed vessel.

1. **PRINCIPLE.** : It works on Archimedes principle "The loss in weight of a body immersed in a liquid is equal to amount of liquid displaced by the body". The leveltrol basically consists of the following :
2. **DISPLACER:** It consists of a cylindrical shape pipe sealed and filled inside with sand or some weight. The purpose of this is to convert change in level to primary motion. The variation in buoyancy resulting from a change in liquid level varies the net weight of the displacer increasing or decreasing the load on the torque arm. This change is directly proportional to change in level and specific gravity of the liquid.
3. **RELAY:** Amplifies pressure variations at the nozzles.
4. **REVERSING ARC:** It is used for the following purposes.
 - Motions take off from Torque tube.
 - Means of reverse control action.
 - Adjustment for specific gravity.
5. **PROPORTIONAL UNIT.** : Converts primary motion to a proportional output air pressure.
6. **CONTROL SETTING UNIT:** Provides motions of varying the set point.

36. Explain the working an electronic leveltrol.



The variation in buoyancy resulting from a change in liquid level, varies the net weight of the displacer increasing or decreasing the load on the torque arm. This change is directly proportional to the change in level and specific gravity of the liquid. The resulting torque tube movement varies the angular motion of the rotor in the RVDT (Rotary Variable

Differential. Transformer) providing a voltage change proportional to the rotor displacement, which is converted and amplified to a D.C. current.

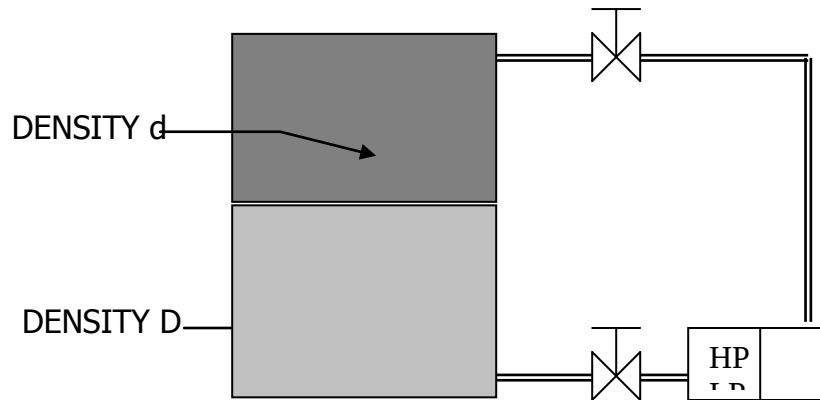
37. How will you reverse an action of the leveltrol?

The reversing arm serves as motion take off arm from the torque tube. It is provided with a slot on each side of the center so that link can be connected either for reverse or direct action.

38. What is interface level? How do you calculate it?

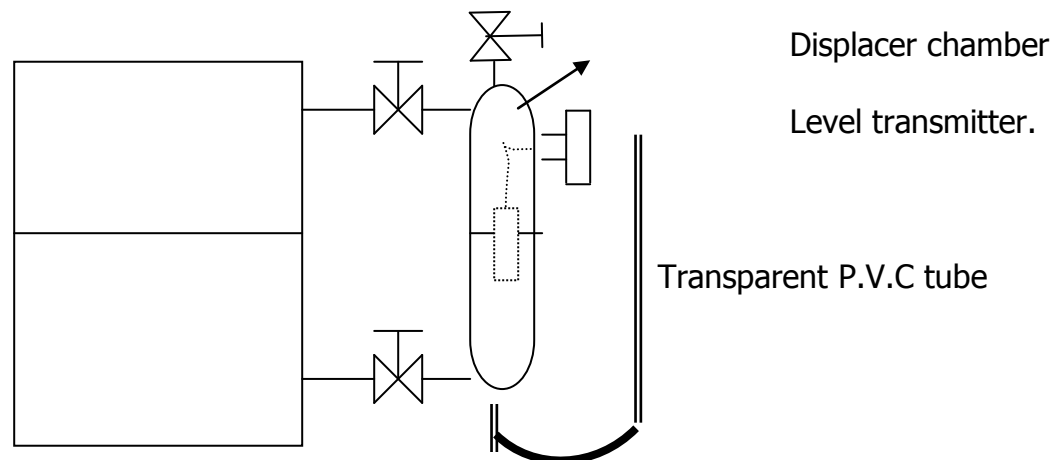
When a vessel is filled with two liquids of two different specific gravities the level measurement refers to as interface level.

$$DP = H (D - d)$$



On a level set the difference of two specific gravities.

39. How will you calibrate a leveltrol in the field?



Calculation # 1 If the calibrating liquid is water: Process Liquid Density / 1* Displacer height = mm of H₂O.

Calculation # 2 If the calibrating liquid is other liquid: Process Liquid Density / Calibrating liquid density * Displacer height = mm of H₂O. (Calibrating liquid height in mm).

1. First close both the primary isolation valves and drain the liquid inside the chamber.
2. Adjust the zero to get 0% output.
3. Connect a transparent PVC tube to the drain point as shown in hook up.
4. Fill it to the center of the top flange.
5. Adjust the specific gravity or span adjustment (Electronic Level).
6. Fill it up to 50 %, check linearity.

40. How will you calibrate on interface level control. ?

On an interface leveltrol there are two liquid of two different specific gravities.

1. The level will be zero when it is full of lighter liquid.

Zero % level = $H \times d$.

H = Displacer length

d = Specific gravity of lighter liquid.

- 2 The level will be 100 % when it is full of heavier liquid.

100 % level = $H \times D$.

D = Specific gravity of heavier liquid.

Calibration with water:

1. Fill H X d level with water adjust zero.
2. Fill H X D level with water adjust Sp. gravity or span.
3. Check linearity.

Displacer length: L in mm

Density Low : dl in Kg / 1

Density High : DH in Kg / 1

Alarm / Trip point %: X

HH Trip Point: Y in mm

$$Y = L * \left(\frac{DH \times X}{100} + \left(1 - \frac{X}{100} \right) * dl \right)$$

41. How will you apply wt. lest calibration to a leveltrol.

Wt. test calibration method:

1. Remove the displacer from the torque arm.
2. Apply equivalent weight on the torque arm that is equal to the wt. of the displacer. Adjust zero % output.
3. For Span : $V = \pi r^2 h$
 Loss in weight = Wt. of float - wt. of the float immersed in liquid
 Loss in weight = [wt. of float - Vol. x d]
 Span wt. = (wt. of float - Loss in wt.)
 r = radius of the displacer.
 h = ht. of displacer.
4. Apply equivalent wt. equal to the (Wt. of float - Loss in weight). Adjust Span to get 100 % out put.

5. To check linearity apply average of the two weights.

42. What will happen if the displacer has fallen down while in line ?

The output will be maximum.

43. What will happen if the displacer has a hole in it while in line?

The output will be minimum.

44. What is the used of Suppression and elevation?

Suppression and elevation are used on Level applications where (1) transmitters are not mounted on some level (2) Wet leg. I.e. condensable vapors are present.

45. What are the limitations of leveltrol?

The limitations of a level control that it cannot be used for lengths more than 72 inches.

46. How will you commission D.P. transmitter in field in pressurized vessel.

1. Close both the isolation valves, Vent the H.P. side.
2. Fill it with the sealing liquid.
3. Open the L.P. side vent valve.
4. Adjust zero with suppression spring.
5. Close the L.P. side vent valve.
6. Open both the isolation valves.

47. How will you check zero of a level D.P. transmitter while is line?

1. Close both the isolation valves.
2. Open the vent valve on L.P. leg and H.P. leg drain.
3. Check and adjust zero if necessary.

48. Explain the working of an Enraf level gauge?

The Enraf precise level gauge are based on servo powered null-balance technique. A displacer serves as a continuous level sensing element.

Principle:

A displacer with a relative density higher than that of the product to be measured, is suspended from a stainless steel wire B, that is attached to a measuring drum. A two phase servo meter controlled by a capacitive balance system winds or unwinds the measuring wire until the tension in the weighing springs is in balance with the weight of the displacer partly immersed in the liquid. The sensing system in principle measures the two capacitance formed by the moving center sensing rod E provided with two capacitor plates and the side plates. In balance position the capacitances are of equal value. Level variations will a difference in buoyancy of the displacer. The center sensing rod will move in the direction of one of the side capacitor plates. This causes a difference in value of these capacitances. By an electronic circuit this change is detected and integrated. During the rotation of the servo motor the cam driven transmitter continuously change

the voltage pattern to a remote indicator of which the receiver motor drives a counter indicating level variation.

TEMPERATURE

49. What are the different methods of temperature measurement? Explain.

The different methods of temperature measurement are:

1. Mechanical
2. Electrical.

Mechanical methods:

1. Mercury in glass thermometers: This consists of a glass tube of very fine bore joined to a reservoir at the bottom and sealed at the top. A measured quantity of mercury is enclosed. When the thermometer is heated the mercury expands much more than the glass and is therefore forced to rise up in the tubing. A scale is fixed at the side.

2. Bimetallic Thermometer: Two metals whose coefficient of linear expansion is different are welded and rolled together to the desired thickness. The actual movement of a bimetal is its flexibility with one end fixed, a straight bimetal strip **deflects in** proportion to its temperature, to the square of its length and inversely with its thickness.

3. Pressure Spring Thermometers: There are four classes of pressure spring thermometers.

1. Liquid filled = class 1
2. Vapor pressure = class 2
3. Gas filled = class 3
4. Mercury filled = class 4

Liquid filled & Mercury filled:

Both types operate on the principle of thermal expansion. Where the bulb is immersed in a heated substance. The liquid expands causing the pressure spring to unwind. The indicating, recording or controlling mechanisms are attached to the pressure spring.

Compensated Thermometer System:

Compensations are provided in order to nullify the effect of changes in ambient temperature. The compensation in liquid filled expansion thermal system consists of the second tubing and helical element, both liquid filled. The two elements are so constructed that the measuring helical floats on a movable base the position of which is governed by the compensating helical. The two tubing and helical are matched in volume so that variation in temperature at the instrument case and along the capillary tubing produces equal motion from both helical. Such motion nullifies each other so that only motion produced by varying the bulb temperature actuates the recorder pen.

Gas filled Thermometers:

This type depends upon the increase in pressure of a confined gas (constant volume) due to temperature increase. The relation between temperature and pressure in this kind of system follows Charles' law and may be expressed.

$$\frac{P_1}{P_2} = \frac{T_1}{T_2}$$

The system is filled under high pressure. The increase in pressure for each degree of temperature rise is therefore greater than if the filling pressure were low. Nitrogen the

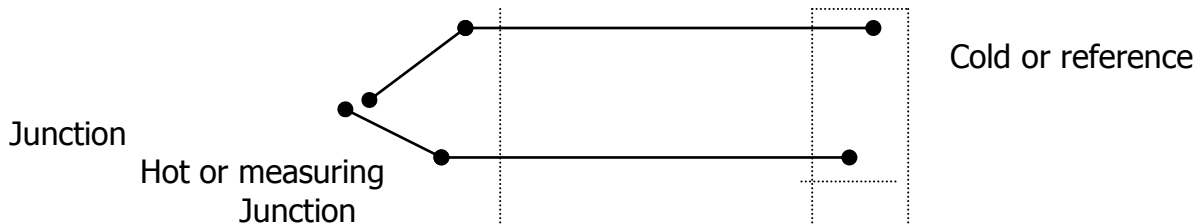
gas most after used for such systems, because it chemically inert and possesses a favorable coefficient thermal expansion.

Vapor - Pressure Thermometers:

Vapor pressure thermometers depend upon vapor pressure of liquid which only partially fills the system. At low temperatures the vapor pressure increase for each unit temperature change is small; at higher temperature the vapor pressure change is much greater.

Electrical method of temperature measurement:

1. Thermocouples: It is temperature measurement device .its works on principle of SEE BACK EFFECT. According this when two dissimilar metal wires joined at their ends. Between the two junctions the electromotive force is produced.



Thermocouples Types and Range:

Type T/C	Positive wire & color	Negative wire & color	Range °F
(J)	Iron & White	Constantan & Red	-300 to 1400
(K)	Chromel & Yellow	Alumel & Red	-300 to 2300
(E)	Chromel & Purple	Constantan & Red	-300 to 1600
(T)	Copper & Blue	Constantan & Red	-300 to 650
(R)	Platinum and 10% Rhodium & Black	Platinum & Red	32 to 2700
(S)	Platinum and 13% Rhodium & Black	Platinum & Red	32 to 2700

Resistance – Temperature Detectors (RTD):

RTD's are generally used for precise temperature measurement. It consists of a fine wire wrapped around an insulator and enclosed in a metal sheath. The most sheath of a resistance thermometer resembles that of a bimetallic thermometer bulb.

PRINCIPLE: "Resistance increases as temperature increases"

$$R_t = R_o (1 + \alpha t)$$

R_t = Resistance of Temperature to measured.

R_o = Resistance of zero temperature.

α = Co. of thermal expansion.

t = Temperature to be measured.

These metals have a positive temperature co-efficient of expansion. Therefore resistance increases as the temperature increases.

Types of material used: (1) Platinum (2) Nickel

These metals have a positive temperature co-efficient of expansion. Therefore resistance increases as the temp. increases.

Calculation of Resistance or Pt100.

$$R_0 = 100$$

$$\alpha \text{ for platinum} = 0.00385 / ^\circ\text{C}$$

To calculate Resistance at 100°C .

$$R_{100} = 100 [1 + (38.5 \times 10^{-4} \times 100)]$$

$$= 100 + (100 \times 0.385)$$

$$R_{100} = 138.5$$

Resistance at $100^\circ\text{C} = 138.5$

50. What is Pt 100 mean?

Pt100 means 100 OHMS at 0°C for a platinum resistance bulb.

51. What is two wire and three wire R.T.D. system?

Two wire R.T.D. system:

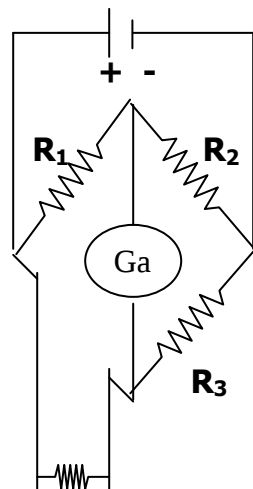
Two wire RTD system use for short distance like a compressor field local panel.

Three wire System:

Three wire systems use for long distance like a field to control Run.

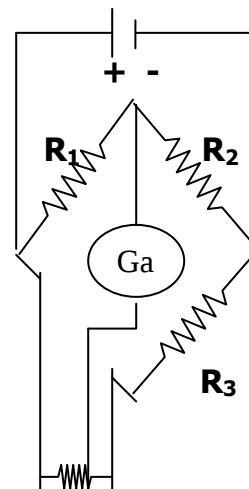
The third wire is used for compensation of lead wire resistance.

Two-wire R.T.D



R.T.D

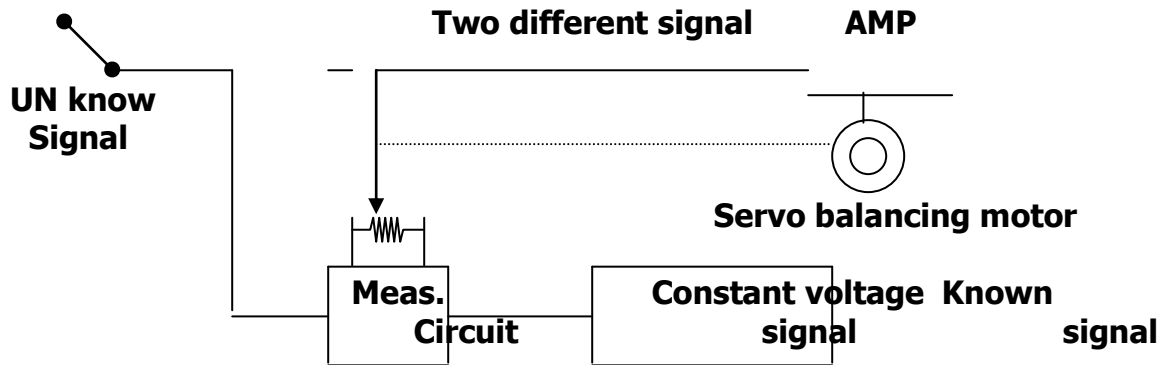
Three-wire R.T.D



R.T.D

52. Draw a potentiometer temp. Measuring circuits and explain its?

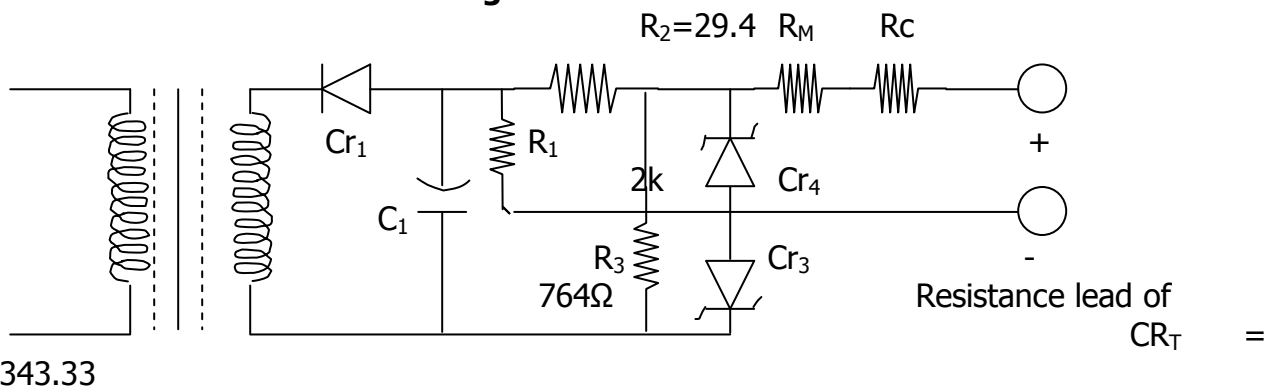




OPERATION:

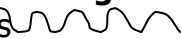
The input to the instrument is a measurement of some in the processes using a sensing element (such as thermocouple) or a device to produce direct voltage, which is the voltage (signal). This voltage is subtracted from a voltage developed by a known constant voltage in a potentiometer measuring circuit. The subtraction occurs by connecting two voltages in series with the opposing polarity, difference between these two voltages produces signal, the voltage going to the amplifier. The error will positive or negative depending on which of the two voltages greater. When amplified, the error signal will drive servo balancing motor in appropriate direction to adjust circuit (actually drive the slide wire) until the difference between the feedback voltage and the input voltage is balance out. An error signal equal to zero results (null point) the balancing (servo motor is be longer driven)

53. What is the constant voltage unit?

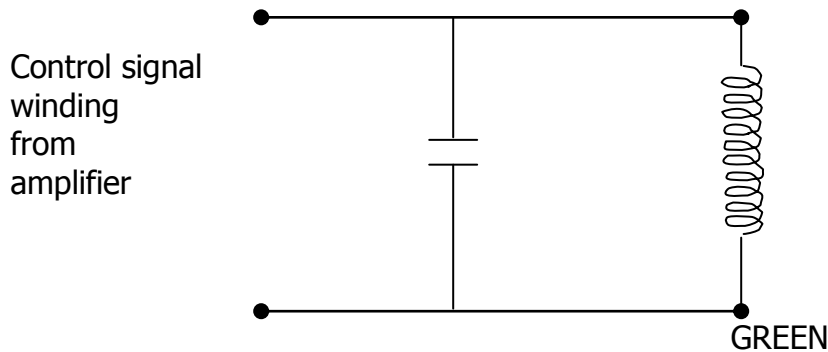


The constant voltage circuit consists of a rectifier, CR, a filter capacitor C1, followed by two stages of zener regulation. Abridge configuration is provided to 1amp line voltage regulation zener CR3, R1 and R2 combine provide relatively constant current to zener CR4, Thus variations. Resistors R2 and R3 form a bridge that any remoment line voltage effects.

54. Explain the working of a balancing motor.

Signal in control winding appears as  due tank circuit formed by winding and capacitor of amp. board.

RED



+ve signal : It lags 90° from line phase capacitor amp. board.

-ve signal : Leads 90° from line due to line phase capacitor of amp. board.

The servo (balancing) motor is an induction motor that functions by creating a rotating magnetic field in the stator.

The rotor (armature) turns by following this field. The field is developed by the use of two windings in the stator.

It has got two windings, one of which is continuously energized by the line voltage. The other winding is energized by the power amplifier, with a current whose phase with respect to line current determines the direction of rotation of motor.

55. What is burnout feature ? Explain.

Burnout provides the warning feature of driving indicator the end of scale if the input circuit should open.

A burnout resistor is provided which develops a voltage drop between the measuring circuit and the amplifier. The polarity of the signal determines the direction of the servo drive upon an open circuit in the input.

Upscale burnout : R value 10 M

Downscale burnout : R value 2.2 M

56. Explain the block diagram of an amplifier in a temp. recorder.

57. Why is a converter used in a temp. recorder ?

The converter is designed to convert D. C. input voltage into an A. C. input voltage proportional in amplitude to the input.

58. Why are Thermowells used ?

In numerous application it is neither desirable nor practical to expose a temperature sensor directly to a process material. Wells are therefore used to protect against damage corrosion, erosion, abrasion and high pressure processes. A thermowell is also useful in protecting a sensor from physical damage during handling and normal operation.

Selecting a Thermowell :

The significant properties considered in selecting a material for the well are as follows :

1. Resistance to corrosion and oxidation.

2. Resistance to mechanical and thermal shock.
3. Low permeability (Resistance to gas leakage).
4. Mechanical strength.
5. Thermal conductivity.

Material for Wells:

1. Stainless steel.
2. Inconel.
3. Monel.
4. Alloy steel.
5. Hastelloy 'C'.

59. How will you calibrate a temp. recorder using a potentiometer ?

Connect the potentiometer output to the input of temp. Recorder.

1. Connect the (+ve) to the (+ve) and (-ve) to the (-ve).
2. If ambient compensation is provided in potentiometer set it to the correct ambient temp.
3. If no ambient compensation is provided take a thermometer and measure the correct ambient temp.. Find out the corresponding mV s for that temp. for the given input type of thermocouple.
4. While feeding subtract the ambient temp. m v s from the corresponding temp. every time.
5. Adjust the necessary adjustments.

Measuring Temperature with a Potentiometer:

1. Connect the input of the potentiometer to the thermocouple.
2. If no ambient compensation is provided find out the corresponding millivolts for that ambient temp. for the type of thermocouple used.
3. Add the ambient temp. millivolts to the corr. input millivolts measured. Find out from the chart for the corresponding temperature.

60. What type of sensing element would you use to measure very low temperature?

The sensing element used for measuring very low temperature is R. T. D.
(Resistance Temperature Detector)

61. What are skin temperature thermocouples?

Skin thermocouples are those which are directly connected to the process without any thermowell. Used for measuring the skin temperature of heaters furnaces, flue gas etc.

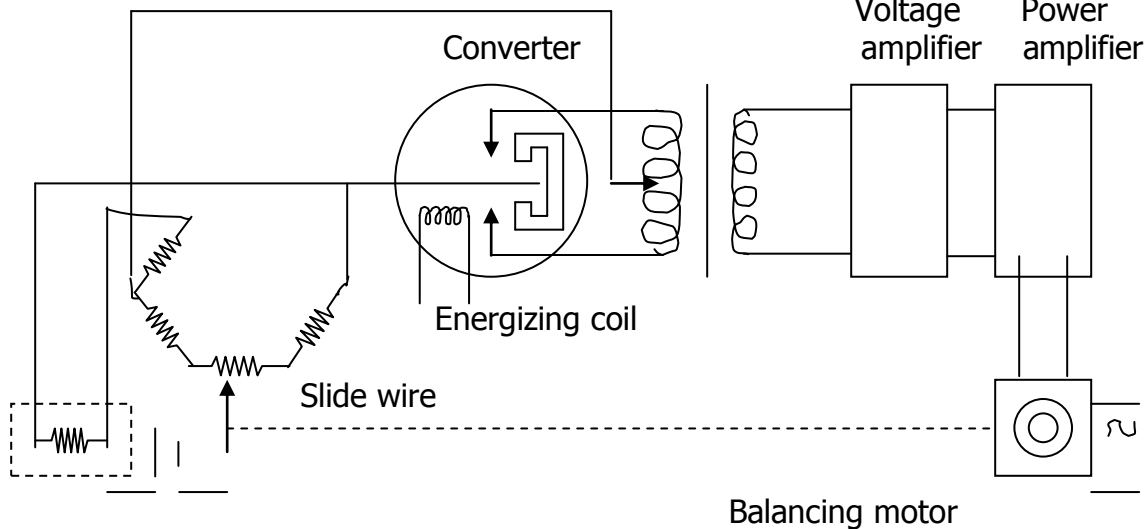
62. What is the specialty of thermocouples lead wires ?

They should be of the same material as the thermocouple.

63. What is the difference the a wheatstone bridge and a potentiometer ?

The difference between a potentiometer and a wheatstone bridge measuring instrument is that potentiometer is a voltage measuring instrument and wheatstone bridge is a current measuring instrument.

64. Explain the continuous balance potentiometer system using R.T.D.'s.



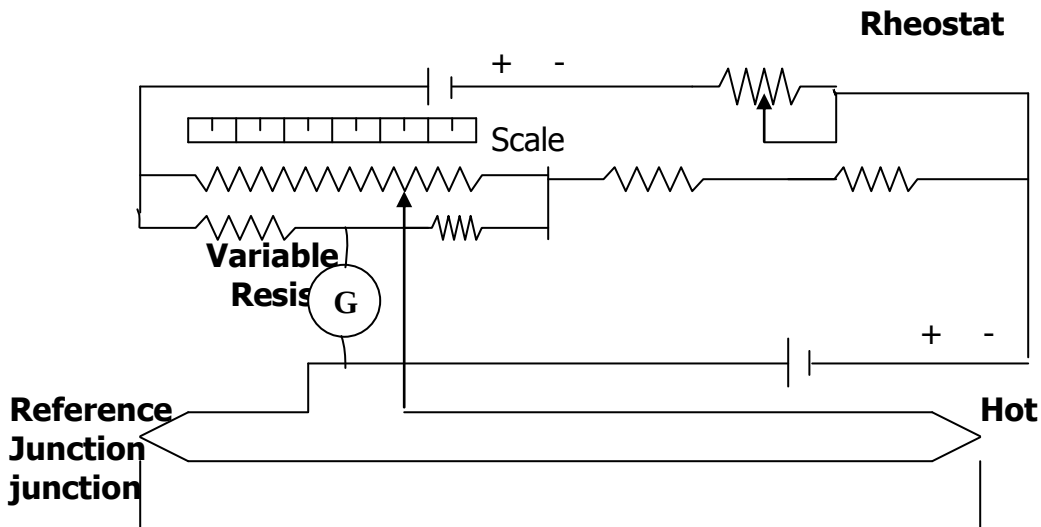
R.T.D

In a balance wheatstone bridge resistance thermometer a resistance bulb is connected into one branch of a d.c. bridge circuit; in another branch is a variable resistance in the form of a calibrated slidewire. Variations in temp. of the measured medium cause a change in resistance of the bulb and a consequent unbalance of the bridge circuit. A self balancing wheatstone bridge recognizes the condition of unbalance, determines its direction and magnitude and position the slidewire contractor to rebalance the bridge and indicate the temp. on the scale.

The D. C. potential appearing at AA is converted by the converting stage to an A. C. voltage appearing at BB and is multiplied by the voltage amplifier to a large value at CC. It is then used to control the power amplifier output DD which drives the balancing motor in the proper direction to balance the bridge.

The polarity of the signal at AA determines the phase of the alternating voltage at BB which in turn determines the direction of rotation of the balancing motor.

65. How is automatic Reference junction compensation carried out in temp? Recorders?



For automatic reference junction compensation a variable nickel resistor is used. As the temperature changes, so does its resistance. This reference junction compensatory is located, so that it will be at the temperature of the reference junction. The reference junction is at the position where the dissimilar wire of the thermocouple is rejoined, which invariably is at the terminal strip of the instrument.

CONTROL SYSTEMS

66. Explain the application of proportional integral and derivative action?

Proportional control only :

Proportional control only attempts to return a measurement to the set point after a load upset has occurred. However it is impossible for a proportional controller to return the measurement exactly to the set point.

Use: It is normally used for level controls. It reduces the effect of a load change but it can not eliminate it.

Proportional plus reset control:

Reset action is introduced to eliminate offset. It will integrate any difference between measurement and set point and cause the controller's output to change until the difference between the measurement and set point is zero. Reset will act as long as the error exists.

Use: Proportional + Reset controllers are by far the common types used in industrial process control and where predominate dead times occur.

Proportional plus reset plus derivative:

Derivative or rate action helps the controller overcome system inertia and result in faster, more precise control. Derivative action occurs whenever the measurement signal changes. Under study conditions the rate action does not act. Derivative allows the controller to inject more corrective action.

Use: On temperature controls.

67. What is difference gap control?

Differential gap control is similar to on off control except that a band or gap exists around the control point.

Use: In industry differential gap control is often found in non critical level control applications where it is desirable only to prevent a tank from flooding or drying. **When a** measured variable exceeds the upper gap the control valve will open fully or be closed fully. Similarly when it exceeds the lower gap it will open or close fully.

68. Where is on off control used?

On off control is used when

1. Precise control is not needed.
2. Processes that have sufficient capacity to allow the final operator to keep up with the measurement cycle.

3. It is mainly used in refrigeration and air conditioning systems.

69. What is reset-wind up?

When reset action is applied in controllers where the measurement is away from the set point for long periods the reset may drive the output to its maximum resulting in reset wind up. When the process starts again the output will not come off its maximum until the measurement crosses the set point causing large overshoots. This problem can be avoided by including anti-reset wind up circuit which eliminates the problem of output saturation.

70. Why is reset called integral and Rate derivative?

Reset is called integral because of the mathematical relationship to the output.

Rate is called derivative because

$$O_i = f \int_{t=0}^{t=i} e (dt) + O_0$$

$$O_i = r (de / dt) + O_0$$

r = is the rate time

O_i = is the Output at any given time

O_0 = is the output at time zero or zero error.

e = is the error signal

t = is time.

f = is the reset rate in respects per minute.

71. Explain tuning of controllers.

Tuning basically involves adjustment of proportional, integral and derivative parameters to achieve good control. The gain, time constants, and dead times around the loop will dictate the settings of various parameters of the controller.

Tuning methods are broadly classified into two :

1. Closed Loop Method : e.g. Ultimate Gain Method.
2. Open Loop Method : e.g. process Reaction curve.

Ultimate gain method:

The term ultimate gain was attached to this method because its use requires the determination of the ultimate gain (sensitivity) and ultimate period. The ultimate sensitivity K_u is the maximum allowable value of gain (for a controller with only Proportional mode) for which the system is stable. The ultimate period is the period of the response with the gain set at its ultimate value.

Process reaction curve :

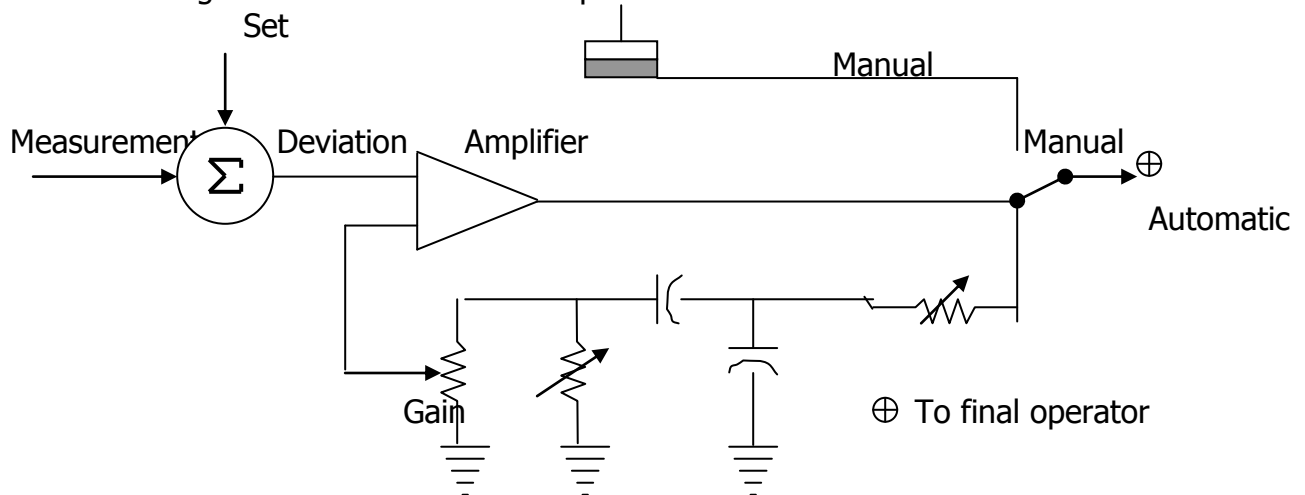
To determine the process reaction curve, the following steps are recommended. :

1. Let the system come to steady state at the normal load level.
2. Place the controller on manual.
3. Manually set the output of the controller at the value at which it was operating in the automatic mode.
4. Allow the system to reach the steady state.
5. With controller on manual, impose a step change in the output of controller, which is an input to the process.

6. Record the response of controlled variable.
7. Return the controller output to its previous value and return the controller to auto operation.

72. Explain the working of an electronic P.I.D. controller.

Input from the measurement transmitter is compared with the set point voltage to produce a deviation signal. The deviation signal is combined with a characterized feed back signal to provide the input for the function generator amplifier. This amplifiers output is delivered to the feed back network, and to the final output which is a 10-50m.a. dc signal for actuation of final operators.



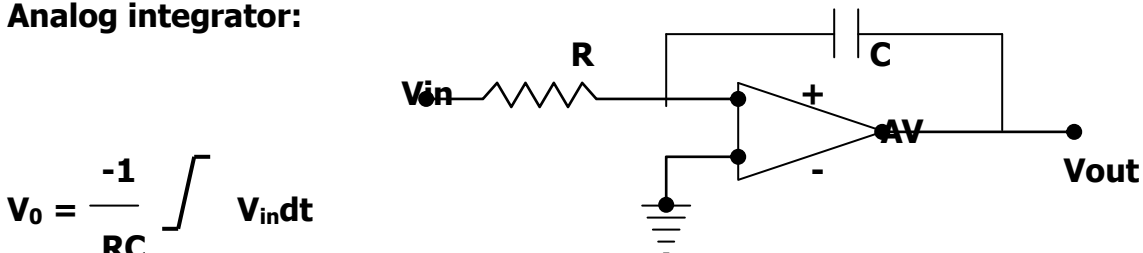
Proportional action: It is obtained by adjusting the magnitude of feed back signal. An increase in negative feed back means less effective gain and thus a broader proportional band.

Reset actions: It is obtained by charging the reset capacitor at a rate determined by the value of reset resistor. The reset resistor is variable, and constitutes reset adjustment.

Derivative action: The connection of a derivative capacitor across the feedback circuit delays feedback until the capacitor is charged to a value approaching amplifier output. This delay is controlled by value of derivative resistor. This resistor is variable and constitutes derivative adjustment.

73. What is an analogue integrator and an analogue differentiator ?

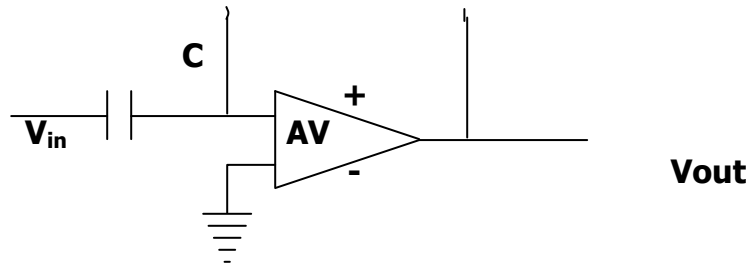
Analog integrator:



Analog differentiator:



$$V_0 = -RC \frac{d}{dt} V_{in}$$



74. What is an anti reset wind up ?

If the limit acts in the feed back section of the control amplifiers integral circuit, the controller output will immediately begin to drive in the opposite direction as soon as the process signal crosses the set point. This approach is referred to as antireset wind up.

75. What are De-saturators ?

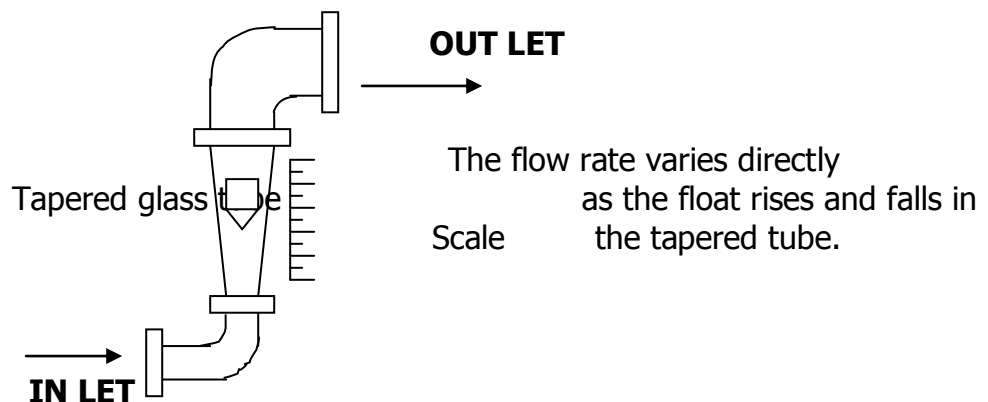
When, in some processes, e.g. batch process, long transient responses are expected during which a sustained deviation is present the controller integral action continuously drives the output to a minimum or maximum value. This phenomenon is called "integral saturation of the control unit". When this condition.

76. What is the effect of weep hole on calculation of orifice bore?

$$d = dm \left\{ 1 + 0.55 \frac{(dm)^2}{dh} \right\} \quad \text{where: } dm = \text{Measured diameter of orifice.}$$

$dh = \text{Drain hole diameter.}$
 $d = \text{Corrected diameter orifice size.}$

77. Explain the working of Rotameter?



Variable area meters are special form of head meters. Where in the area of flow restrictor is varied. So as to hold the differential pressure constant. The rotameters consists of a vertical tapered tube through which the metered fluid flows in upward direction. A "float" either spherical or cone shaped, actually more dense than the fluid being measured, creates an annular passage between its maximum circumference and

the weight of the tapered tube. As the flow varies the "float" rises or falls to vary the area of the passage so that the differential across it just balances the gravitational force on the "float" i.e. the differential pressure is maintained constant. The position of the "float" is the measured of the rate of flow.

78. Explain the working of a magnetic meter.

An electric potential is developed when a conductor is moved across the magnetic field. In most electrical machinery the conductor is a "wire"; the principle is equally applicable to a moving, electrically conductive liquid. The primary device of commercial magnetic meters consists of a straight cylindrical electrically insulated tube with a pair of electrodes nearly flush with the tube wall and located at opposite ends of a tube diameter. A uniform a.c. magnetic field is provided at right angles to electrode diameter and to the axis of the tube. The a.c. voltage developed at the electrodes is proportional to the volume flow rate of fluid, and to a magnetic field strength. This device is limited to electrically conducting liquids. The magnetic meter is particularly suited to measurement of slurries and dirty fluids, since there are no location for solids to collect except the walls of the tube itself.

79. Explain the working of a turbine meter.

Turbine meters consist of a straight flow tube within which a turbine or fan is free to rotate, about its axis which is fixed along the center line of the tube. Straightening vanes upstream of the turbine minimizes possible rotational components of fluid flow. In most units a magnetic pick-up system senses the rotation of the rotor through the tube wall. The turbine meter is a flow rate device, since the rotor speed is directly proportional to flow rate. The output is usually in the form of electrical pulses from the magnetic pick-up with a frequency proportional to flow rate. Turbine meter are primarily applied to measurement of clean and non-corrosive hydrocarbons.

80. Explain the working of a Pitot tube.

The pitot tube measures the velocity at point in the conduct. If quantity rate measurement is desired, it must be calculated from the ratio of average velocity to the velocity at the point of measurement.

Principle : If a tube is placed with its open end facing into a stream of fluid, then the fluid impinging on the open end will be brought to rest, and the kinetic energy converted to pressure energy. This the pressure built up in the tube will be greater than that in the free stream by the impact pressure or pressure produced by loss of kinetic energy. The increase in pressure will depend upon the square of the velocity of the stream. The difference is measured between the pressure in the tube and static pressure of the stream. The static pressure is measured by a tapping in the wall of the main or by a tapping incorporated in the pitot static tube itself. The difference between the pressure in the tube and static pressure will be a measure of the impact pressure and therefore of the velocity of the stream oil.

81. Where is the integral orifice used ?

Integral orifice is used to measure small flow rates. It is mounted directly on the secondary device. The integral orifice diameter varies between 0.020 inch and 0.250 inch diameter. The integral orifice finds considerable use in laboratory and pilot plants.

Calculation of flow rate:

$$Q_n / F_c = K_s \times C_{wi} \times F_a \times F_m \sqrt{G_p / G_e}, \quad h_w$$

82. Explain the working of a target meter.

The target meter combines in a single unit both a primary element and a force balance flow rate transmitter. A circular disc (or target) supported concentrically in the pipe carrying the flowing fluid results in an annular orifice configuration. Pressure difference developed by the fluid flow through this annular orifice produces a force on target proportional to the square of the flow rate. This force is carried out of the pipe through a rod passing through a diaphragm seal, and is measured by a pneumatic or electronic force balance system identical with the mechanism of the force balance D.P. cell. The advantages of the target meter lies primarily in its single unit construction the primary device and responsive mechanism in a single structure. This eliminates the diff. pressure fluid connections in most heads meters. This is particularly used for sticky and dirty material which may plug up differential connections and for liquids which require elevated temperatures to avoid solidification, this elimination of liquid connection is useful.

$$\left(F = \frac{W_m}{C_{st} F_a \sqrt{F_m F_c}} \right)^2 r_f$$

83. Where is a quadrant orifice used ?

If the fluid is viscous and the operating Reynolds number is low quadrant orifice is preferred

84. What are types of taps used for orifices ?

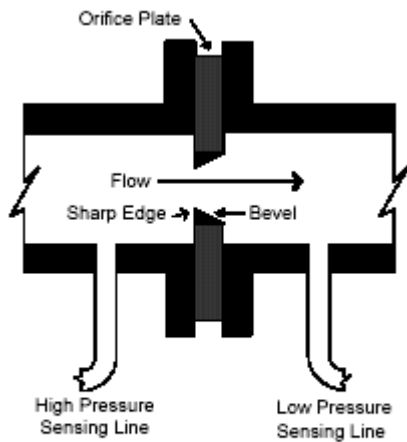


Figure 1
A Typical Orifice Plate

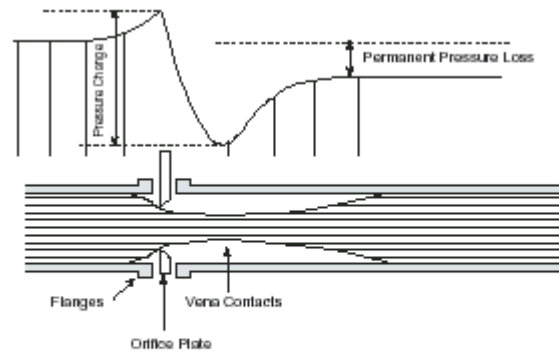


Figure 2
Orifice Plate Installation with Pressure Profile

1. Flange taps:

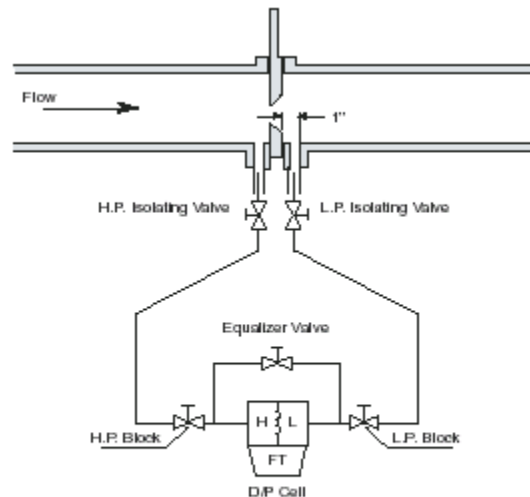


Figure 3
Orifice Plate with Flange Taps and Three Valve Manifold

This are most commonly used on pipe sizes of 2 inches or larger. They are located in the orifice flange 2 inch from upstream and 1 inch downstream from the faces 0 orifice plate.

2. Corner taps:

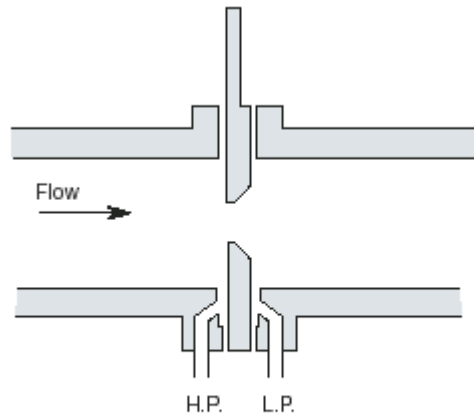


Figure 4
Orifice Plate with Corner Taps

On pipe sizes less than 2 inches corner taps located directly at the face of the orifice plate.

3. Vena contracta and radius taps:

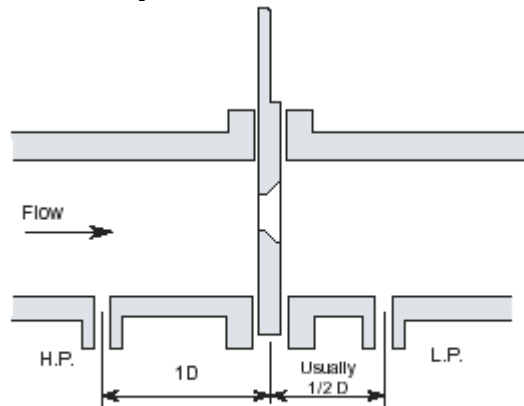


Figure 5
Orifice Plate with Vena Contracta Taps

Vena contracta taps located at 1 pipe diameter upstream and at point of minimum pressure downstream. There are mostly widely used for measurement of steam.

Radius taps are located 1 pipe diameter upstream and $\frac{1}{2}$ pipe diameter downstream for the inlet face of the orifice are a close approximation to vena contracta taps upto $0.72 d / D$.

4. Full flow taps:

Face flow taps are located at $2\frac{1}{2}$ pipe diameter upstream and B pipe diameter downstream. Full flow taps at $2\frac{1}{2}$ and B pipe diameter have the same advantage as vena contracta or radius taps.

Venturi Tubes

For applications where high permanent pressure loss is not tolerable, a venturi tube (Figure 6) can be used. Because of its gradually curved inlet and outlet cones, almost no

permanent pressure drop occurs. This design also minimizes wear and plugging by allowing the flow to sweep suspended solids through without obstruction.

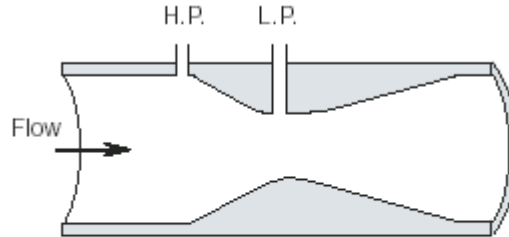


Figure 6
Venturi Tube Installation

However a Venturi tube does have disadvantages:

- Calculated calibration figures are less accurate than for orifice plates. For greater accuracy, each individual Venturi tube has to be flow calibrated by passing known flows through the Venturi and recording the resulting differential pressures.
- The differential pressure generated by a venturi tube is lower than for an orifice plate and, therefore, a high sensitivity flow transmitter is needed.
- It is more bulky and more expensive.

As a side note; one application of the Venturi tube is the measurement of flow in the primary heat transport system. Together with the temperature change across these fuel channels, thermal power of the reactor can be calculated.

85. What is Reynolds number?

Dynamic similarity implies a correspondence of fluid forces in two systems. In general situation there are many classes of forces that influence the behavior of fluids. Some of these are inertial viscous, gravitational, compressibility, pressure and elastic forces. Certain dimensionless ratio is developed based on fluid properties. Velocities and dimension, which are essentially force ratio.

The more important of these are Reynolds number

$$R = \frac{v D \rho}{\mu}$$

V = velocity
D = inside diameter of pipe
ρ = fluid density
μ = viscosity

For most applications in practical flow measurement the Reynolds number is taken to be sufficient criterion of dynamic similarity. The magnitude of Reynolds number not only indicates whether the flow is laminar or turbulent but also furnishes the probable shape of velocity profile. Due to the strong role it plays as an indicator of varying flow characteristics, many of the deviation from the theoretical equations are called Reynaldo number effects.

86. How would you choose differential range ?

The most common diff. range for liquid measurement is 0-100" H₂O. This range is high enough to minimize the errors caused by unequal heads in the seal chambers, differences in temps. of load lines etc. The 100" range permits an increase in capacity up to 400" and a decrease down up to 20" by merely changing range tubes or range adjustments.

87. What is positive Displacement meters?

Principle: The principle of measurement is that as the liquid flows through the meter it moves a measuring element which seals off the measuring chamber into a series of measuring compartments each holding a definite volume. As the measuring element **moves, these** compartments are successively filled and emptied. Thus for each complete of the measuring element a fixed quantity of liquid is permitted to pass from the inlet to the outlet of the meter. The seal between measuring element and the measuring chamber is provided by a film of measured liquid. The number of cycle of the measuring element is indicated by means of a pointer moving over the dial, a digital totalizer or some other form of register, driven from the measuring element through an adjustable gearing.

The most common forms of positive displacement meters are :

1. Reciprocating Piston type.
2. Rotating or Oscillating Piston type.
3. Nutating Disc type.
4. Fluted Spiral Rotor type.
5. Sliding vane type.
6. Rotating vane type.
7. Oval Gear type.

88. Why are two plugs provided on a D.P transmitter?

1. The top plug is a vent plug for venting the air entrapped inside the cell.
2. The bottom plug is a drain plug for draining the liquid accumulated inside the cell.

CONTROL VALVES

89. What is a control valves?

A control valve is the final control element, which directly changes the valve of the manipulated variable by changing the rate of flow of control agent.

A control valve consists of an operator and valve body. The operator provides the power to vary the position of the valve plug inside the body. The plug is connected to the operator by a stem, which slides through a stuffing box. The air signal from the controller is applied above the diaphragm. The increasing air signal from the controller is applied above the diaphragm. An increasing air signal will push the operator stem downwards against the force exerted by the spring on the diaphragm plate. The valve is adjusted in such a way that the plug starts moving when 3 psi is applied to the diaphragm and touches the seat when 15 psi is applied to the diaphragm. Thus an increase in air pressure will close the valve. Hence the home "Air to Close". Another type is "Air to open", such that 3 psi on the diaphragm the value is closed and 15 psi air signal it in fully open.

90. What are the different types of control valves?

The commonly used control valves can be divided as follows.

1. Depending on Action.
2. Depending on the Body.

1. Depending on action:

Depending on action there are two types of control valves, (1) Air to close, (2) Air to open.

2. Depending on body:

1. Globe valves single or double seated.
2. Angle valves.
3. Butterfly valves.
4. Three way valves.

91. What is the use of single seated valve?

The single seated valve is used on smaller sizes, and in valve of larger sizes, where an absolute shut off is required. The use of single seated valve is limited by pressure drop across the valve in the closed or almost closed position.

92. What is the use of double seated valve?

In double seated valves the upward and downward forces on the plug due to reduction of fluid pressure are nearly equalized. It is generally used on bigger size valves and high pressure systems. Actuator forces required are less i.e. a small size actuator.

93. What is Cv of a valve?

Cv is the capacity of a valve and is defined as:

"No of gallons per minute of water which passes through a fully open valve at a pressure drop of 1 psi.

$$C_v = q (\Delta P / G)$$

Where: Cv = Valve co-efficient

q = Volumetric flow rate (gallons minute)

ΔP = Pressure drop across the valve in psi.

G = Specific gravity of flowing fluid.

The valve coefficient Cv is proportional to the area 'A' between the plug and valve seat measured perpendicularly to the direction of flow.

94. What are the different types of actuators?

The different types of actuators are:

1. Diaphragm Operated.
2. Piston Operated.

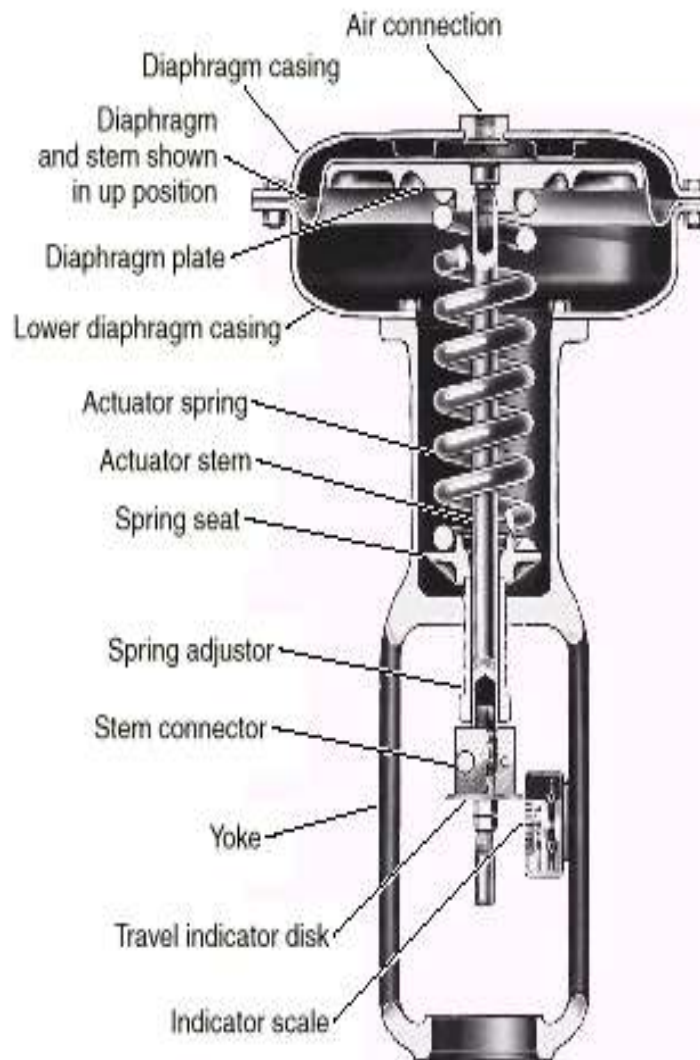


FIG. 8-70 Spring and diaphragm actuator with an "up" fail-safe mode. Spring adjuster allows slight alteration of bench set. (Courtesy Fisher-Rosemount.)

95. What types of bonnets would you use of high temp. and very low temp.?

High temperature: Bonnets are provided with radiation fins to prevent gland packing from getting damaged.

On very low temperature: Extended bonnets are used to prevent gland packing from getting freeze.

96. How will you work on a control valve while it is line?

While the control valve is in line or in service, it has to be by passed and secondly the line to be depressurized and drained.

97. What is the use of a valve positioner?

The valve positioner is used for following reasons:

1. Quick Action control valve.
2. Valve hysteresis.
3. Valves used on viscous liquids.
4. Split Range.
5. Line pressure changes on valve.
6. Valve Bench set not standard.
7. Reversing valve operation.

98. When can a by pass be not used on a positioner ?

A by pass on a positioner cannot be used when :

1. Split Range operation.
2. Reverse Acting Positioner.
3. Valve bench set not standard.

99. What is the use of butterfly valves?

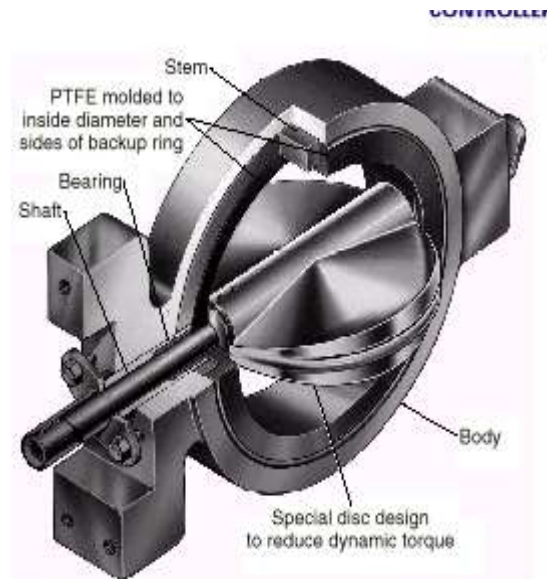


FIG. 8-67 Partial cutaway of wafer-style lined butterfly valve. (Courtesy Fisher-Rosemount.)

Butterfly valves are used only in systems where a small pressure drop across the valve is allowed. The butterfly is fully open when the disc rotates by 90. A **drawback of** this valve is that even a very small angular displacement produces a big change in flow.

100. What is the use of three way valves?

Three way control valves are only used on special systems, where a dividing or mixture of flows according to a controlled ratio is required.

101. What are the different types of plugs?

The different types of plugs are generally used are:

- (1) V. port plug (2) Contoured plug

V-port plug:

Ported plug are generally used on double seated valves. This is because ported plugs have a more constant off balance area.

Contoured plug:

Contoured plugs are generally used on single seated valve with small trim sizes.

102. What is a cage valve?

A cage valve uses a piston with piston ring seal attached to the single seated valve "plug". Here the hydrostatic forces acting on the top or the piston or below the valve plug tend to cancel out. The seat ring is clamped in by a cage. Cage valves are generally used for noise reduction.

103. What are the advantages of Camflex valves?

Camflex valves are intermediates between globe valve and butterfly valve. The plug rotates 60° for full opening.

Advantages:

1. Actuator forces required are very less.
2. Extended bonnet and hence can be used on any service i.e. on high temp. and very low Temperature.
3. Variations in flow.
4. Light weight.

104. What is the use of link connected to the valve positioner?

The link serves as the feed back to the valve. Ant valve movement is sensed by this link. Sometimes due to line pressure changes on H. P. service the valve position may be changed, the link in turn senses this change and the positioner will produce an output which will operate the valve to the original position.

105. What is the use of booster relays?

Booster relays are essentially air load, self contained pressure regulators. They are classified into three broad groups:

- 1. Volume Boosters** : These are used to multiply the available volume of air signal.
- 2. Ratio Relays** : Use to multiply or divide the pressure of an input signal.
- 3. Reversing Relays** : This produces a decreasing output signal for an increasing input signal.

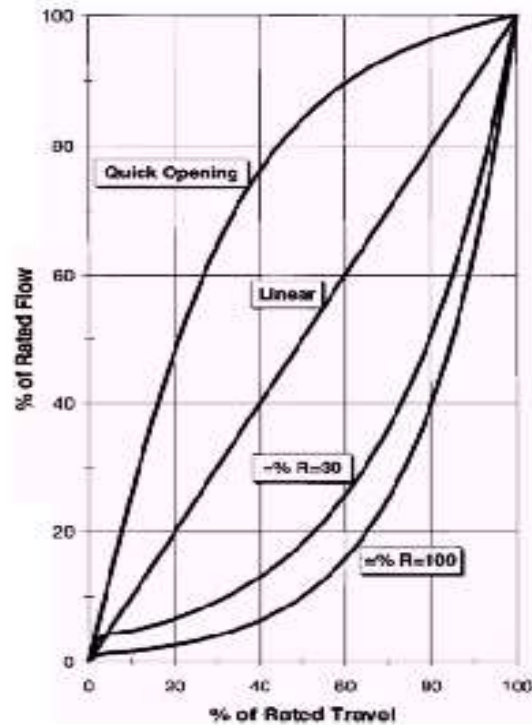
106. What is the use of Angle valves?

Angle valves are used where very high pressure drops are required and under very severe conditions. Where the conventional type of valve would be damaged by erosion.

107. What are the different valve characteristics?

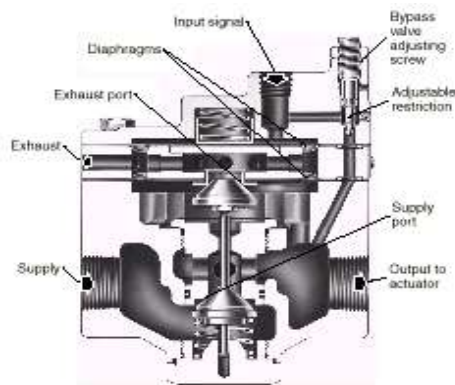
The different types of valve characteristic are:

1. Linear
2. Equal Percentage
3. Quick Opening.



1. **Linear:** The valve opening to flow rate is a linear curve
2. **Equal percentage:** For equal increments of valve opening it will give equal increment in flow rate range. At small opening the flow will also be small.
3. **Quick opening:** At small opening the increments in flow rate is more. At higher opening the flow rate becomes steady.

108. What is a solenoid valve ? Where it is used ?



A solenoid is electrically operated valve. It consists of a solenoid (coil) in which a magnetic plunger moves which is connected to the plug and tends to open or close the valve. There are two types of solenoid valves:

1. Normally open
2. Normally closed

USE: It is used for safety purpose.

109. How will you change the valve characteristics with positioner?

The positioner contains different types of cam in it. Selection of the proper cams in it. By selection of the proper cam the valve opening characteristics can be changed.

110. How will you change the action of a control valve?

1. If the control valve is without bottom cap. The actual needs to be changed.
2. If bottom cap is provided.

- a) Disconnect the stem from the actuator stem.
- b) Separate the body from the bonnet.
- c) Remove the bottom cap and the plug from body.
- d) Detach the plug from the stem by removing the pin.
- e) Fix the stem at the other end of the plug and fix the pin back.
- f) Turn the body upside down. Connect it to the bonnet after inserting the plug and stem.
- g) Connect back the stem to the actuator stem.
- h) Fix back the bottom cap.
- i) Calibrate the valve.

111. How will you select the control valve characteristics?

The graphic display of flow versus lift shows then the Desired or inherent characteristic is changed by variations pressure drop. This occurs as the process changes from condition where most of pressure drop takes place at the control valve is a condition where most of the pressure drop is generally distributed through rest of the system.

% Flow : This variation in where most of the total drop take place is one of the most important aspects is choosing the proper valve characteristics for give process.

Flow control : Normally Equal percentage valve is used.

Pressure Control : Normally linear valve is used to maintain a constant pressure drop.

Temp. Control : Normally equal percentage valve is used.

Liquid Level Control : Normally linear valve is used.

Basically in selecting a valve characteristic two important point have to be taken into account.

- a) There should be a linear relationship between the position of the plug and the flow through the valve in a wide range of change in the pressure drop across the valve.
- b) The pressure drop across a valve should be as low as possible.

Control valve sizing

112. What is the effect of pipe reducers on valve capacity?

When control valves are mounted between pipe reducers, there is a decrease in the actual valve capacity. The reducers create an additional pressure drop in the system by acting as contractions or enlargements in series with the valve.

Metric formula: for inlet and outlet reduces.

$$R = \frac{1}{1 - 1.5 \left(\frac{d_2}{d_1} \right)^4} C_v^2$$

44 www.arfanali.webs.com

$$D_2 \quad 0.04d_2$$

For outlet reducer only or inlet reducer with entrance angle less than 40 inches.

$$R^2 = \left(1 - 1.5 \frac{d_2}{D_2} \right)^2 \frac{Cv^2}{0.04d_2}$$

d = valve size mm. D = line size mm. Cv = required valve co-efficient.

To compensate for reducer losses at sub-critical flow, divide Cv calculated by R.

113. An operator tells you that a control valve is stuck ? How will you start checking ?

1. First of all get the control valve is passed from operation.
2. Check the lingual to the diaphragm of the control valve.
3. Disconnect it possible the actuator stem from the control valve stem.
4. Stroke the actuator and see whether the actuator operates or not. If not then the diaphragm may be punctured.
5. If the actuator operates connect it back to the plug stem stroke the control valve. If it does not operate loosen the gland nuts a bit and see if it operates. If it does not then the control valve has to be removed from the line to w/shop.

114. Where is an Air to close and Air to open control valves used ?

Air to close:

1. Reflux lines.
2. Cooling water lines.
3. Safety Relief services.

Air to open:

1. Feed lines.
2. Steam Service.

115. Why does control valve operate at 15 psi ?

On higher pressure the actuator sizes becomes bigger in area. The actual force produced by the actuator.

Force = Pressure x Area.

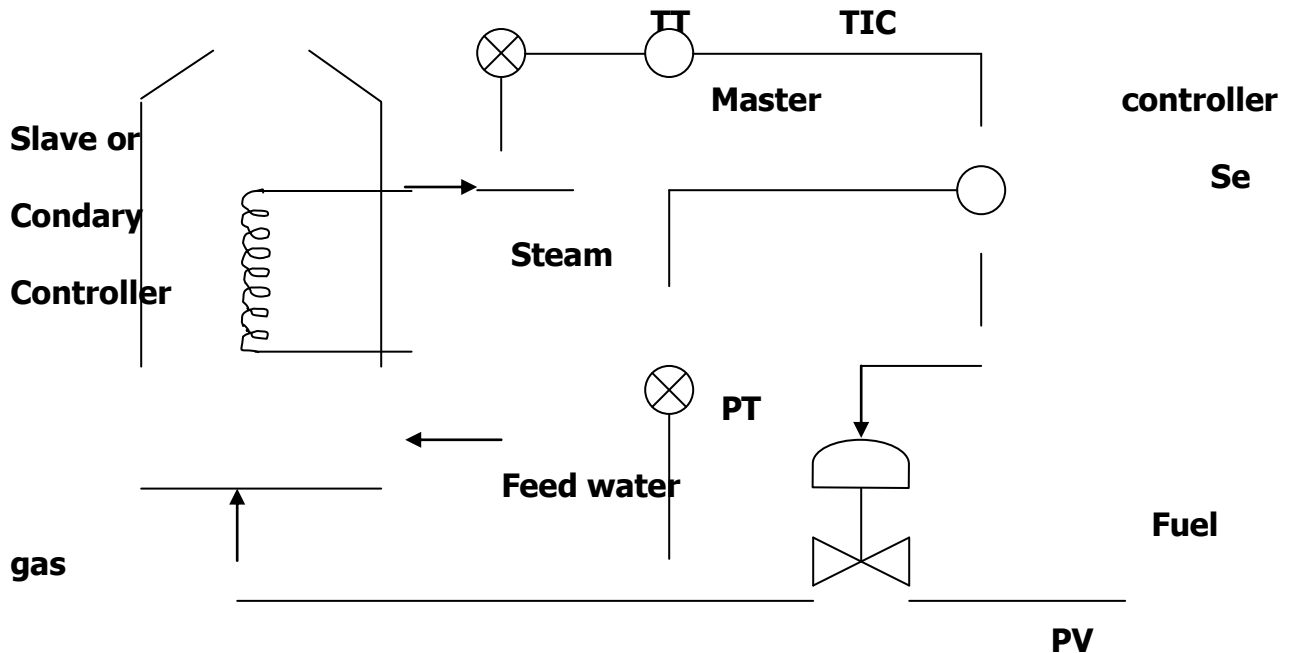
$$= 15 \text{ psi} \times \text{Area, If Area} = 15"$$

Force produced = 15 psi x 25 in² = 375 pounds.

Actual force acting on a control valve = 375 pounds.

GENERAL QUESTIONS

116. Explain Cascade Control system with a diagram. What would happen if a single controller were used ?



Cascade means two controllers in series. One of them is the Master or Primary and the second is the secondary or slave controller. The output of the secondary controller operates the final control element, that is the valve.

Loop explanation:

The output of the temp. transmitter goes as measurement signal to the TIC which is the master controller. Similarly the output of pressure transmitter goes as measurement signal to the PIC which is the secondary controller.

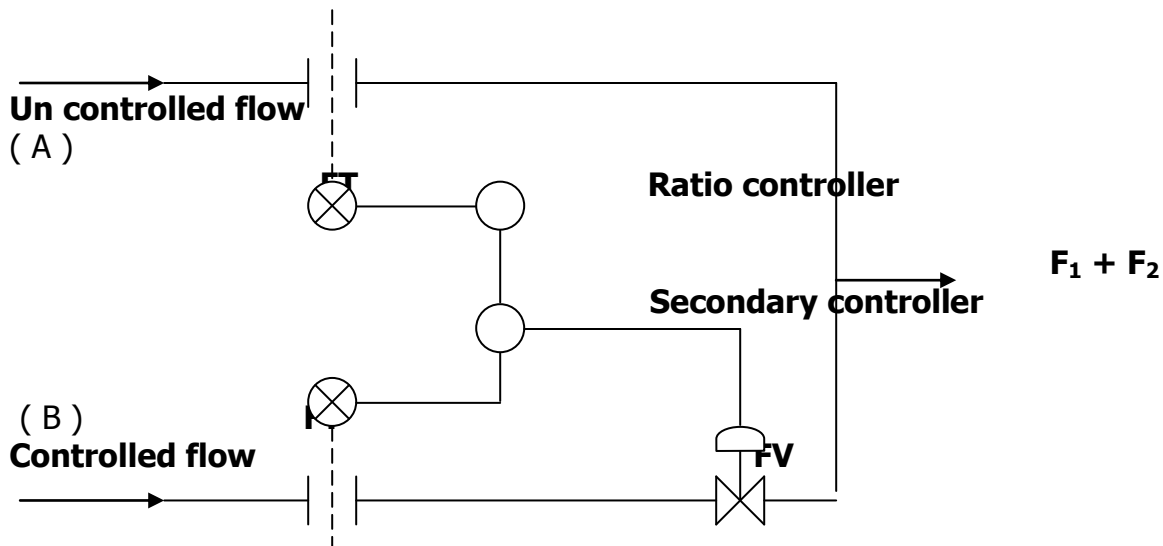
The output of TIC comes at set point to PIC which in turn operates the valve. The reqd. temp. is set on the TIC.

Use of cascade system:

Cascade loops are invariably installed to prevent outside disturbances from entering the process. The conventional single controller as shown in the diagram cannot respond to a change in the fuel gas pressure until its effect is felt by the process temp. sensor. In other words an error in the detected temperature has to develop before corrective action can be taken. The cascade loop in contrast responds immediately correcting for the effect of pressure change, before it could influence the process temperature. The improvement in control quality due to cascading is a function of relative speeds and time lags. A slow primary (Master) variable and a secondary (Slave) variable which responds quickly to disturbances represent a desirable combination for this type of control. If the slave can respond quickly to fast disturbances then these will not be allowed to enter the process and thereby will not upset the control of primary (master) variable. It can be

said that use of cascade control on heat transfer equipment contributes to fast recovery from load changes or other disturbances.

117. Explain ratio control system.



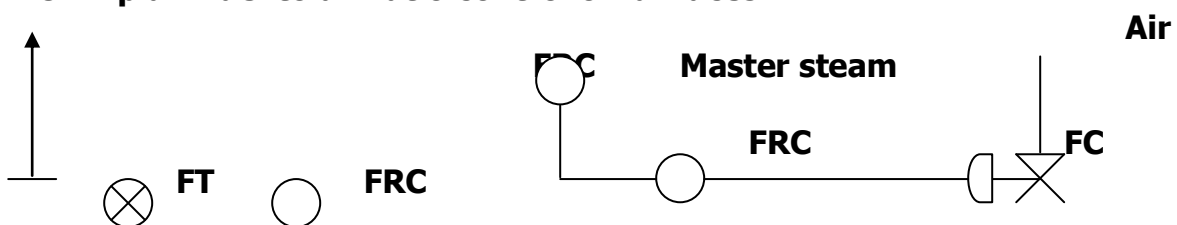
A ratio control system is characterized by the fact that variations in the secondary variable do not reflect back on the primary variable. In the above diagram 0 a ratio control system the secondary flow is hold in some proportion to a primary uncontrollable flow.

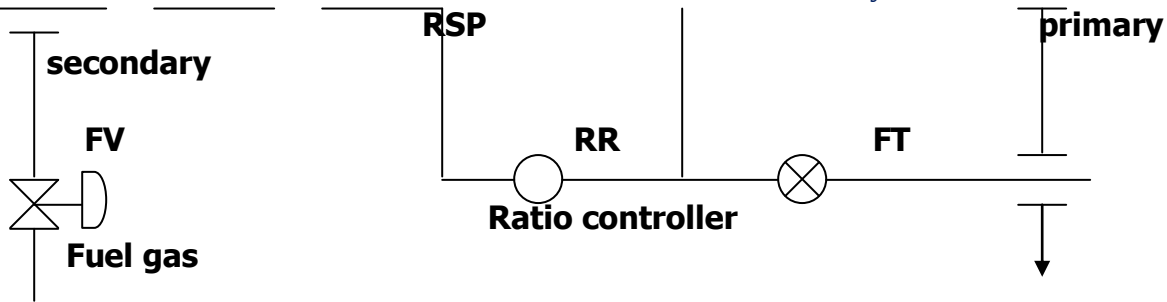
If we assume that the output of primary transmitter is A, and the output of the secondary transmitter is B, And that multiplication factor of the ratio relay is K, then for equilibrium conditions which means set valve is equal to measured valve, we find the following relation :

$$KA - B = 0$$

or $B/A = K$, where 'K' is the ratio setting of the relay.

118. Explain fuel to air ratio control of furnaces.



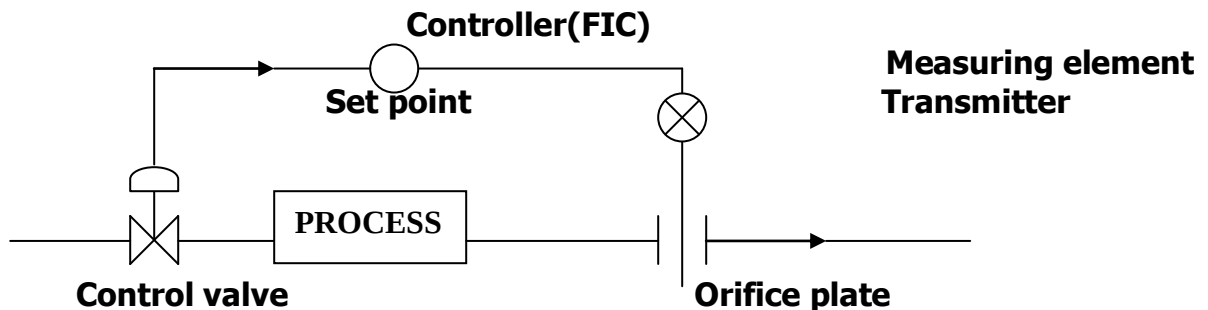


119. What is Furnace Draft control ?

Balanced draft boilers are generally used negative furnace pressure. When both forced draft and induced draft are used together, at some point in the system **the** pressure will be the same as that of atmosphere. Therefore the furnace pressure must be negative to prevent hot gas leakage. Excessive vacuum in the furnace however produces heat losses through air infiltration. The most desirable condition is that the one have is a very slight (about 0.1" H₂O) negative pressure of the top of furnace.

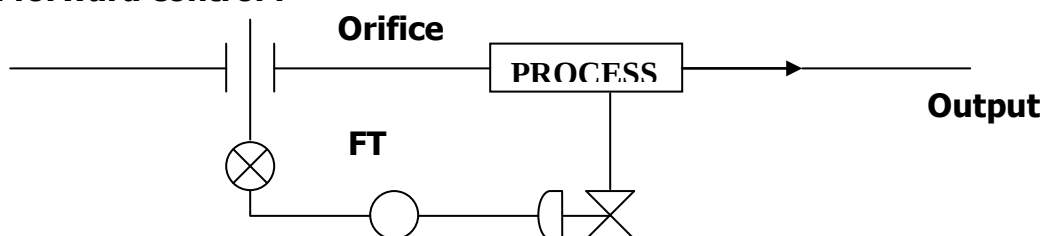
120. What is feed back control ? What is feed forward control ? Discuss its application ?

Feed back control:



Feed back control involves the detection of the controlled variable and counteracting of changes its it's value relative to set point, by adjustment of a manipulated variable. This mode of control necessities that the disturbance variable must affect the controlled variable itself before correction can take place. Hence the term 'feedback' can imply a correction 'back' in terms of time, a correction that should have taken place earlier when the disturbance occurred.

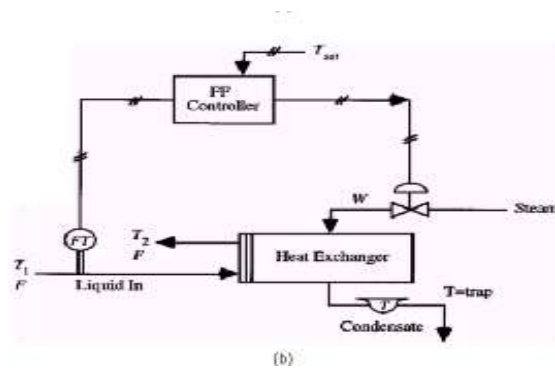
Feed forward control :



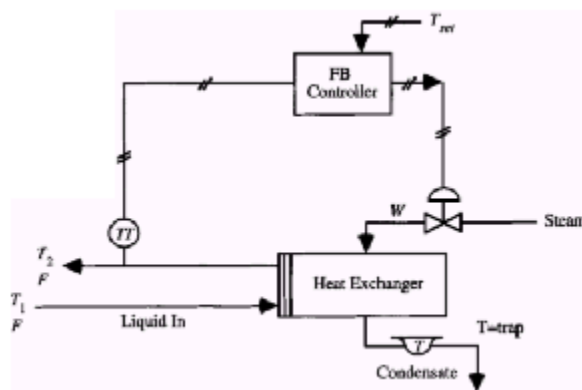


Feed forward control system is a system in which corrective action is based on measurement of disturbances inputs into the process. This mode of control responds to a disturbance such that it instantly compensates for that error which the disturbance would have otherwise caused in the controlled variable later in time.

Feed forward control relies on a prediction. As can be seen from the figure of feed forward control a necessary amount of input goes to the process. This measurement goes to the controller which gives output to the control valve. The control valve regulates the flow.

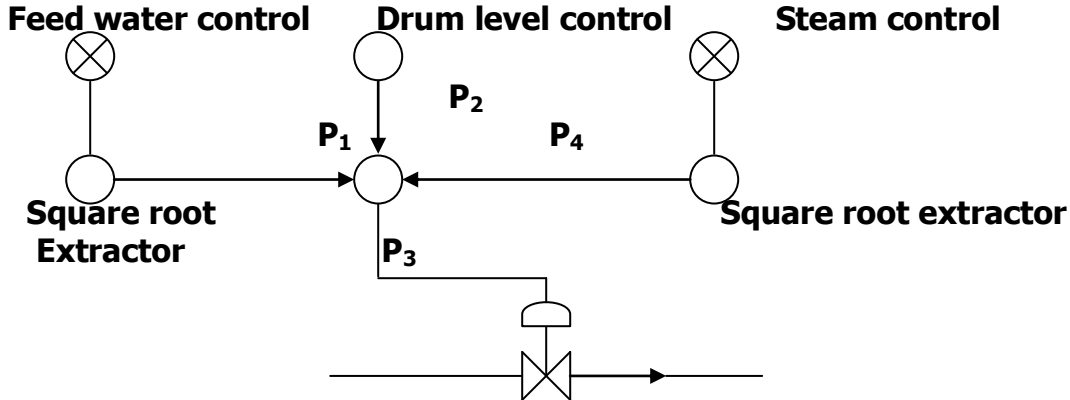


Feed back control :



In feed forward control no difference between the desired result and actual result need exist before corrective action is taken in feed back control a difference must exist. Hence, open loop or feed forward control is capable of perfect control, but feed back is not. Due to economic impartibility of precision, predicting the amount of correction necessary to achieve satisfactory results with feed forward control, feed back control is most often used. In order to properly choose the type of feed back controller for a particular process application, two factors time and gain must be considered.

121. Explain three element feed water control system?



Computing equation:

$$P_3 = R (P_2 - P_1 - K) + P_4 + K_0$$

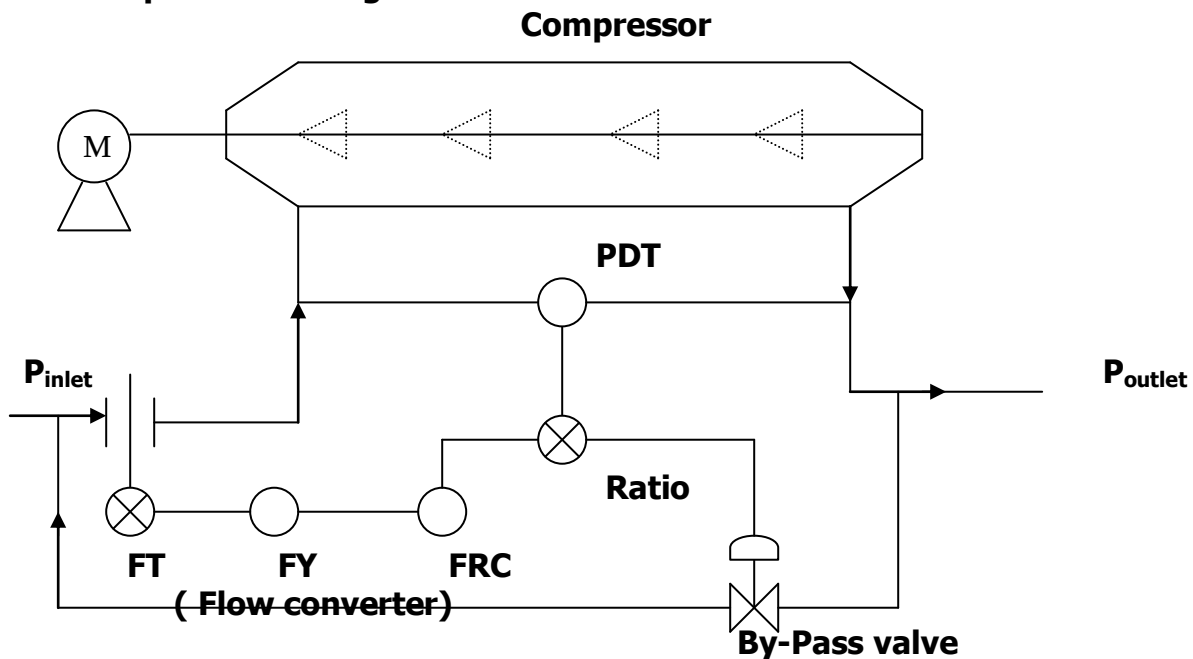
P_3 = Output.

P_1, P_2 & P_4 = Input

K_1 = Adjustable suppression.

K_0 = Adj. Bias.

122. Explain Anti-surge control?



This method of surge control uses the ratio of compressor pressure rise to inlet flow rate to set the flow in by-pass loop. When the suction pressure drops and discharge shoots up, the compressor starts surging. The pdt senses this and gives the signal to the FRC which will open the by-pass valve.

What is Surge?

Surge occurs in a turbo compressor when discharge head cannot be sustained at the available suction flow. Surge occurs at specific combinations of head and flow, as defined by the compressor manufacturer's performance curves. One or more of the following can result from surge:

- Unstable operation
- Partial or total flow reversal through the compressor
- Disrupted process
- Mechanical damage to the compressor

Surge is usually accompanied by the following:

- Increase in discharge temperature
- Reduction in discharge pressure
- Increase in vibration
- Sharp rise in inlet temperature dependent on the volume flow at the suction.

Avoiding Surge

In the gas compressor section (Figure 4), surge can be avoided by recycling a controlled portion of the discharge flow back to the suction through a recycle valve. Recycling raises the suction pressure and lowers the discharge pressure, which increases flow and moves the operation away from surge. Raising speed also moves the compressor away from surge. This is a temporary solution because it also raises P_d and lowers P_s , which tends to drive the machine back towards surge. In the air compressor section (Figure 5), a blowoff valve is used to vent the compressor discharge to atmosphere. This does not affect the suction conditions, but it reduces discharge pressure and increases flow, which moves the operating point away from surge.

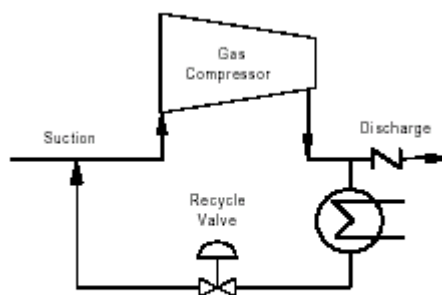


Figure 4
Gas Compressor Anti-Surge Valve

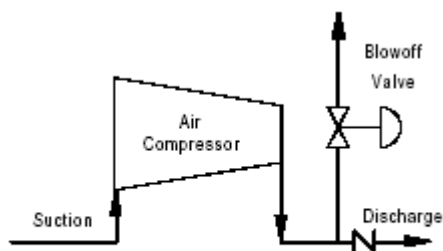


Figure 5
Air Compressor Anti-Surge Valve

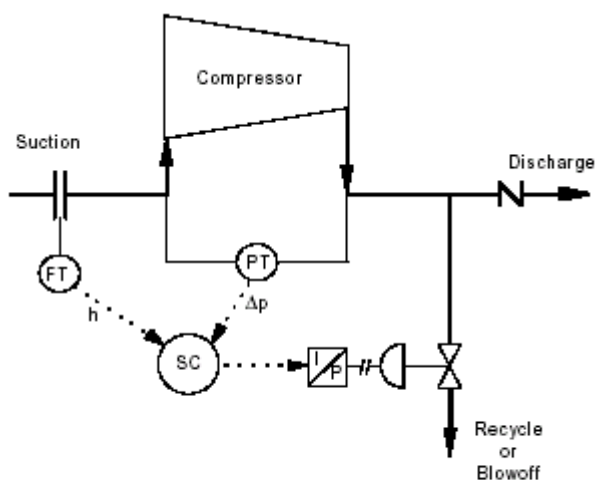


Figure 8
Pressure Rise Method

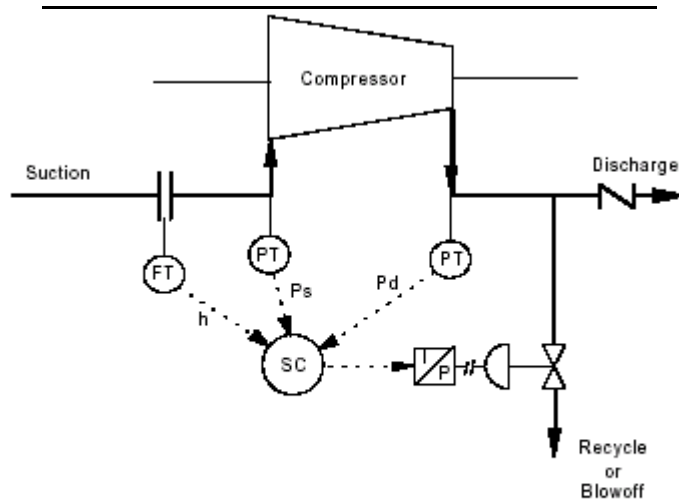


Figure 9
Pressure Ratio Method

GENERAL QUESTION - II

Que. : Draw an electronic two wire system control loop.

Ans. :

Que. : What are Intrinsically safe system ?

Ans. : Intrinsic safety is a technique for designing electrical equipment for safe use in locations made hazardous by the presence of flammable gas or vapors in air.

"Defn. : " Intrinsically safe circuit is one in which any spark or thermal effect produce either normally or under specified fault conditions is incapable of causing ignition of a specified gas or vapor in air mixture at the most easily ignited concentration.

HAZARDOUS AREAS :

The specification of products or systems sold as intrinsically safe must state in what hazardous areas they are intrinsically safe. Universal cooling of hazardous areas has not, unfortunately, been adopted in all countries. However two sets of codes in common use are.

Que. : What does a transmitter output start from 3-15 psi or (0.2 - 1 Kg/Cm²) or 4 - 20 ma. etc. ?

Ans. : The transmitter output starts from what is known as "live zero". This system has specific advantages :

1. The systems automatically alarms when the signal system becomes inoperative.
2. The output range is linear (Ratio of 1 : 5).

DEAD ZERO SIGNAL :

The advantage is that it does not have to be biased to true zero. A "Live zero" gives the computer additional information, so that it can take appropriate alarm action in case of a measurement failure, because it can discriminate between a transmitter operating, but transmitting a zero measurement and a failure, in the signal system.

Que. : What is force balance and motion balance principle ?

Ans. :

FORCE BALANCE PRINCIPLE :

"A controller which generates an output signal by opposing torque's".

The input force is applied on the input bellows which moves the beam. This creates nozzle back pressure. The nozzle back pressure is sensed by the balancing bellows which brings the beam to balance. The baffle movement is very less about 0.002" for full scale output.

MOTION BALANCE PRINCIPLE :

"A controller which generates an output signal by motion of its parts".

The increase in input signal will cause the baffle to move towards the nozzle. The nozzle back pressure will increase. This increase in back pressure acting on the balancing bellows, will expand the bellows, thereby moving the nozzle upward. The nozzle will move until motion (almost) equals the input (baffle) motion.

Advantages of force Balance :

1. Moving parts are fewer.
2. Baffle movement is negligible.
3. Frictional losses are less.

AUTOMATIC CONTROLLER :

It is a device which measures the value of variable quantity or condition and operates to correct or limit its deviation of this measured value from a selected reference.

AUTOMATIC CONTROL SYSTEM :

It is any operable arrangement of one or more automatic controllers in closed loops with one or more processes.

SELF OPERATED CONTROLLER :

It is one in which all the energy needed to operate the final control element is derived from the controlled medium through the primary element.

RELAY OPERATED CONTROLLER :

It is one in which the energy transmitted through the primary element is either supplemented or amplified for operating the final control element by employing energy from another source.

PROCESS :

A process comprises the collective function performed in and by the equipment in which a variable is to be controlled.

SELF REGULATION :

It is an inherent characteristic of the process which aids in limiting the deviation of the controlled variable.

CONTROLLED VARIABLE :

The controlled variable is that quantity and condition which is measured and controlled.

CONTROLLED MEDIUM :

It is that process energy or material in which a variable is controlled. The controlled variable is a condition or characteristic of the controlled medium. For e.g. where temperature of water in a tank is automatically controlled, the controlled variable is temperature and controlled medium is water.

MANIPULATED VARIABLE :

It is that quantity or condition which is varied by the automatic controller so as to affect the value of the controlled variable.

CONTROL AGENT :

It is that process energy or material of which the manipulated variable is a condition or characteristic. The manipulated variable is a condition or characteristic of the control

agent. For e.g. when a final control element changes the fuel gas flow to burner the manipulated variable is flow the control agent is fuel gas.

ACTUATING SIGNAL :

The actuating signal is the difference at anytime between the reference input and a signal related to the controlled variable. This basically known as error signal.

DEVIATION : It is the difference between the actual value of the controlled variable and the value of the controlled variable corresponding with set point.

OFFSET :

It is the steady state difference between the control point and the value of the controlled variable corresponding with setpoint

CORRECTIVE ACTION :

It is the variation of the manipulated variable produced by the controlling means. The controlling means operates the final control element (control value) which in turn varies the manipulated variable.

REFERENCE INPUT :

It is the reference signal in an automatic controller.

POINT :

It is the position to which the control point setting mechanism is set.

CONTROL POINT :

It is the value of the controlled variable which under any fixed set of conditions the automatic controller operates to maintain.

DEFINITION.

ACCURACY :

A number or quantity which defines the limit of error under reference conditions.

ATTENUATION :

A decrease in signal magnitude between two points, or between two frequencies.

DEAD TIME :

The interval of time between initiation of an impact change or stimulus and the start of the resulting response.

DRIFT :

As undesired change in output over a period of time, which change is unrelated to input, operating conditions, or load.

ERROR :

The difference between the indication and the true value of the measured signal.

SPAN ERROR :

It is the difference between the actual span and the specified span and is expressed as the percent of specified span.

ZERO ERROR :

It is the error of device operating under the specified conditions of use when the input is at the lower range value.

STATIC GAIN :

It is the ratio of the output change to an input been change after the steady state has been reached.

HYSTERESIS :

The maximum difference between the upscale and downscale indications of the measured signal during a full range traverse for the same input.

INTERFERENCE :

Interference is any spurious voltage or current arising from external sources and appearing in the circuits of a device.

COMMON MODE INTERFERENCE :

It is the form of interference which appears between the measuring circuit terminals and ground.

NORMAL MODE INTERFERENCE :

It is the form of interference which appears between measuring circuit terminals.

LINEARITY :

The closeness to which a curve approximate a straight line.

RANGE :

The region between the limits within which a quantity is measured received or transmitted, expressed by stating the lower and upper range values.

REPEATABILITY :

The closeness of agreement among a number of consecutive measurements of the output for the same value of the measured signal under the same operating conditions.

REPRODUCIBILITY :

The closeness of agreement among repeated measurements of the output for the same value of the input made under the same operating conditions.

RESPONSE :

It is the general behavior of the output of a device as a function of input both with respect to time.

SIGNAL TO NOISE RATIO :

Ratio of signal amplitude to noise.

TIME CONSTANT :

The time required for the output to complete 63.2 % of the total rise or decay.

SPAN :

The algebraic difference between upper and lower range values.

ZERO SHIFT :

Any parallel shift of the input output curve.

Explanation of Terms used in Computerized Data Acquisition

Alternating Current Abbreviation *ac*. Electric current whose flow alternates in direction. The number of times the current changes direction in one second is called the frequency. The normal waveform of ac is sinusoidal.

Alumel Trade name for an alloy of nickel with up to 5% aluminium, manganese and silicon, used with chromel in K-type thermocouples.

Ampere Abbreviation *A*. SI unit of electric current.

Amplifier A circuit that produces a larger output power, voltage or current than was applied at its input.

Amplitude The size or magnitude of a signal.

Analogue-to-Digital (A/D) Converter Converts an analogue signal (such as a voltage signal from a temperature sensor) into a digital signal suitable for input to a computer.

Anti-Alias Filter An anti-alias (or anti-aliasing) filter allows through the lower frequency components of a signal but stops higher frequencies, in either the signal or noise, from introducing distortion. Anti-alias filters are specified according to the sampling rate of the system and there must be one filter per input signal.

Backbone The major multi-channel link in a network, from which smaller links branch off.

Background Noise Extraneous signals that might be confused with the required measurement.

Baud The rate of data transmission in serial data communications, approximately equal to one bit per second.

Chromel An alloy of nickel with about 10% chromium, used with Alumel in K-type thermocouples.

Constantan An alloy of 40% nickel and 60% copper, with a high volume resistivity and almost negligible temperature coefficient. Used with copper in T-type thermocouples.

Current Current is often used to transmit signals in noisy environments because it is much less affected by environmental noise pick-up. Before A/D conversion the current signals are usually turned into voltage signals by a current-sensing resistor.

Differential Inputs Reduce noise picked up by the signal leads. For each input signal there are two signal wires. A third connector allows the signals to be referenced to ground. The measurement is the difference in voltage between the two wires: any voltage common to both wires is removed.

Digital-to-Analogue (D/A) Converter Used to produce analogue output signals. These may be control signals or synthesised waveforms.

Electromotive Force (emf) Difference of potential produced by sources of electrical energy which can be used to drive currents through external circuits. Unit is the volt.

Endurance limit In fatigue testing, the number of cycles which may be withstood without failure at a particular level of stress.

EIA Electronic Industries Association.

Ethernet A local area network to which you can connect data acquisition devices.

E-Type Thermocouple Chromel-constantan thermocouple with a temperature range of 0-800 °C.

FIFO buffer A first in, first out, store. The first value placed in the buffer (queue) is the first value subsequently read.

Filtering Attenuates components of a signal that are undesired: reduces noise errors in a signal.

Frequency Measured in hertz (cycles per second), rate of repetition of changes.

Frequency Counter Counts digital pulses over a defined gate time. A typical gate time is between 0.1 and 10 seconds.

Front panel The front surface of a unit, generally containing switches and indicator lights.

Gain Amplification of a circuit.

GPIB General Purpose Interface Bus. Also known as IEEE-488 bus. The GPIB standard was designed to connect several instruments to computers for data acquisition and control. Data can be transferred over GPIB at 200 000 bytes per second, over distances of 2 meters.

Ground See earth.

Hertz (Hz) Cycles per second unit of frequency.

Human machine interface (hmi) Also known as man machine interface. The communication between the computer system and the people who use it.

IEEE-488 Bus See GPIB

Integration Time An integrating A/D converter measures an input voltage by allowing it to charge a capacitor for a defined period. The integration averages the input signal

over the integration time, which if chosen appropriately will average over a complete mains cycle thereby helping to reduce mains frequency interference.

Isolation Two circuits are isolated when there is no direct electrical connection between them.

Isolation to Earth or System A high transient voltage at one input may damage not only the input circuit, but the rest of the data acquisition hardware, and, by propagating through the signal conditioning and A/D circuits, eventually damage the computer system as well. You can prevent this type of damage by isolating the input from the earth of the data acquisition and computer hardware.

Isolation Between Inputs A transient at an input can also propagate to other equipment connected to that input. This is prevented by providing isolation between inputs.

J-Type Thermocouple Iron-constantan thermocouple with a temperature range of 0 to 750 °C.

K-Type Thermocouple Chromel-Alumel thermocouple with a temperature range of -200 to 1200 °C.

N-Type Thermocouple Nicrosil-Nisil thermocouple with a temperature range of -200 to 1200 °C.

Resolution The resolution of an A/D or D/A converter is the number of steps the range of the converter is divided into. The resolution is usually expressed as bits (n) and the number of steps is 2^n (2 to the power n), so a converter with a 12-bit resolution divides its range into 2^{12} or 4096 steps. In this case a 0-10 volt range will be resolved to 0.25 millivolts.

Rms Root mean square. The square root of the sum of the squares of a set of quantities divided by the total number of quantities. Used when monitoring ac (alternating current) signals. Many power supplies, for example, issue an ac signal. This needs to be converted to a dc (direct current) signal for the PC interface. The solution is a signal conditioning input that produces a dc signal proportional to the rms of the amplitude of the input signal. The rms operation means the reading will always be positive.

Settling Time When an output voltage swings full-scale through the range of the D/A converter, the settling time tells how long it will take for the output to settle to its new value.

Signal Conditioning Makes a signal suitable for input to an analogue-to-digital converter. For example, a signal may be filtered to remove noise, or amplified to meet the range of the A/D converter.

Simultaneous Sampling When all analogue signals are read simultaneously. This is achieved by providing each input with its own A/D converter, and initiating sampling from a single clock. It ensures that there is no reduction in sampling rate when more signals are connected.

Slew Rate The maximum rate of change of an output signal.

Strain Gauge A device which experiences a change in resistance when it is stretched or strained.

Thermistor A temperature sensor. The name comes from *thermal resistor*. It comprises a mixture of certain oxides with finely divided copper, of which the resistance is very sensitive to change of temperature. **Thermocouple** Popular temperature sensor because of its low cost, versatility and ruggedness. Consists of two different metals joined together, making a continuous circuit. When one junction has a different temperature from the other an electromotive force (voltage) occurs. There are several types of thermocouples, constructed from different metals and with differing temperature ranges and accuracies.

Transducer A device which converts a physical quantity into an electrical signal. Examples include thermocouples and photocells.

Transient A short surge of current or voltage, often occurring before steady-state conditions have become established.

T-Type Thermocouple Copper-constantan thermocouple with a temperature range of -200 to 400 °C.

P R E S S U R E.

PRESSURE CONVERSIONS :

1psi =	27.74 "
	H2O
1	14.223 psi
Kg/cm	
2 =	
1 Bar =	14.504 psi
1 Kpa	0.145 psi
=	
1	10.000mm
Kg/cm	of H2O
2 =	
1 Bar =	1.0197
	Kg/cm²
1	0.98 Bar
Kg/cm	
2 =	
1 Torr	1 mm of
=	Hg.

Que. :Explain the working of an Enraf level gauge ?

Ans. : The Enraf level precise level gauges are based on servo powered null balance technique. A displacer serves as continuous level sensing element.

Principle :

A displacer A with a relative density higher than that of a product to be measured, is suspended from a stainless steel wire B that is attached to a measuring drum. A two phase servo motor controlled by a capacitive balance system winds/unwinds the measuring wire until the tension on the weight springs is in balance with the wt. of the displacer part immersed in the liquid. The sensing system in principle measures the two capacitance formed by the moving central sensing rod E provided with two capacitor plates and the fixed plates. In balance positions the capacitance are of equal value. A level variation will cause a difference in buoyancy of the displacer. The center sensing rod will move in the direction of one of the side capacitor plates. This causes a difference in value of this capacitance. By an electrolyte rotation of the servo motors the can driven transmitter continuously changes the voltage pattern to remote indicate of which the receiver motor drives a counter indicating level variation.

PRIMARY FEEDBACK :

It is the signal, which is related to the reference input to obtain the actuating signal. Simply stated primary feedback is the actual measurement of the controlled variable which when compared with the desired measurement of the controlled variable produces the actuating signal.

POSITIONING ACTION :

It is that in which there is a predetermined relation between the value of the controlled variable and the position of the final control element.

PROPORTIONAL ACTION :

It is that in which there is a continuous linear relationship between the value of the actual measurement of the controlled variable and the value position.

FLOATING ACTION :

It is that in which there is a predetermined relation between the deviation and speed of final control element.

DERIVATIVE ACTION :

It is that in which there is a predetermined relation between a time derivative of the controlled variable and position of final control element.

REST ACTION :

It is the value movement at a speed proportional to the magnitude of deviation.

RATE ACTION :

It is that in which there is a continuous linear relation between the rate of change of controlled variable and position of final control element. Rate action produces value motion proportional to the rate of change of actual measurement.

PROPORTIONAL BAND :

It is the range of values of the controlled variable which correspond to the full operating range of the final control element.

RESET RATE :

It is the number of times/minute that the effect of proportional position action upon the final control element is repeated by proportional speed floating action.

There are two ways of expressing reset action:

1. Reset time and 2. Reset Rate

1. Reset Rate : It is commonly expressed as a number of "repeats" per minute. It is determined by dividing.

a) Travel of final control element (Value stroke) in one minute as a result of the effect of proportional speed floating action.

b) The travel as a result of the effect of proportional position action with the same deviation in both cases.

2. Reset Time : It is the time interval by which the rate is commonly expressed in minutes. It is determined by subtracting.

a) The time required for a selected motion of the final control element resulting from combined effect of the proportional position plus rate action.

b) The time required for the same motion as a result of the effect of proportional position action alone with the same rate of change of controlled variable in both cases or

expressed in another way. It is the time lead in terms of air pressure on the control value produced by rate action compared with proportional position action for the same rate of change of actual measurement in both cases.

ELECTRONICS

Que. :What is a diode?

Ans. : A diode consists of two electrodes (1) Anode (2) Cathode. The current flow is only in one direction.

A diode is the most basic solid state (semi conductor) device. The above figure shows a P.N. junction. The P. material has holes and the N. material has electrons.

FORWARD BIAS :

REVERSE BIAS :

(1) Where the applied voltage overcomes the barrier potential (the p side is more positive than the n side) the current produce is large because majority carriers cross the junction in large numbers. This condition is called forward bias.

(2) When the applied voltage aids the barrier potential (n side + ve than p side) the current in small. This state is known as Reverse Bias.

Que. :What is a half wave, full wave and bridge rectifier ?

Ans. :

PEAK INVERSE VOLTAGE : Maximum Reverse voltage across the diode during the cycle.

Que. :What is a filter used for ?

Ans. : The half wave and full wave signals are pulsating D . C. Voltages. The use of such voltages is limited to charging batteries, running D. C. motors, and a few other applications. What we really have is a D.C. voltage that is constant in value, similar to the voltage from a battery. To get a constant voltage from this, we can use a capacitor input filter.

Que. :What is Zener Diode ? What is a voltage Regulator?

Ans. : The breakdown region of a p n diode can be made very sharp and almost vertical. Diodes with almost vertical breakdown region are known as Zener Diodes.

A Zener diodes operating in the breakdown region is equivalent to a battery. Because of this current through Zener diode can change but the voltage remains constant. It is this constant voltage that has made the zener diode an important device in voltage regulation.

VOLTAGE REGULATOR :

The output remains constant despite changes in input voltage due to Zener effect.

Que. :What is transistor ? What are the different types ?

Ans. : A transistor is a three lagged semi conductor device. Basically a transistor means (transfer - resister).

Whether the transistor is pnp or npn it resembles two diodes (back to back). The one of the left is called emitter diodes, and the one on the right is the collector diode. Since two types of charges are involved transistor: are classified as bipolar devices.

Biasing the transistor :

Emitter - Base - Forward Bias.

Collector - Base - Reverse Bias.

Que.: What is CB, CE and CC configuration?

Ans.:

Buffer: A device or a circuit used to isolate two pt'ne circuits or stages. The emitter follows is a example of buffer.

Alpha = I_C / I_E

Beta = I_C / I_B

Que. :How will you test a transistor with a multimeter. ?

Ans. :

1. Emitter +ve of meter and Base -ve output = Low resistance
2. Emitter -ve of meter and base +ve output = High resistance.
3. Collector +ve and Base -ve output = Low.
4. Collector -ve and base +ve output = High.

Emitter : Collector = High Resistance.

PNP : Opposite Results.

Que.: What is a thyristor ? What are its uses?

Ans.: A thyristor is a special kind of semi conductor device that uses internal feedback to produce latching action.

Use : Used for controlling large amounts of load power in motors, heaters, lighting systems etc.

Explanation : Because of the unusual connection we have a +ve feedback also called regeneration. A change in current at any point in the loop is amplified and returned to the starting point with the same phase. For instance if the 02 base current increases, the 02 collector current increases. This force base current through 01. In turn this produces a large 01 collector current which drives the 02 base harder. This build up in currents will continue until both transistors are driven in saturation. In this case the latch acts like a closed switch.

On the other hand , if something causes the 02 base current to decrease, the 02 collector current will decrease. This reduces the 01 base current. In turn, there is less 01 collector current, which reduces the 01 base current even more. This regeneration continues until both transistors are driven into cut off. At this time the latches like a open switch. This latch will always stay in open or close position.

Que.: What are logic gates? Explain with truth table.

Ans. :

GATE: A gate is a logic circuit with one output and one or more inputs . An output signal occurs only for control combination of input signals.

1. OR - GATE :

SYMBOL :

TRUTH TABLE :

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Define : An OR Gate has one output if any or all of its input are 1's.

2. AND GATE :

Define : An AND Gate has output when all inputs are present.

SYMBOL :

TRUTH TABLE :

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

3. NOT GATE :

A not gate is also known as an inverter. This circuit has one input and one out put. All it does is inverting the input signal; if the input is high, the output is low and vice versa.

TRUTH TABLE :

Input	Output
t	t
0	1
1	0

Buffer: This is a non inverting gate, used to drive low impedance loads.

NOR GATE: This is an OR GATE followed by an inverter.

SYMBOL :

TRUTH TABLE :

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Exclusive OR GATE

A	B	Y
0	0	0
0	1	1

1	0	1
1	1	0

NAND GATE : This is an AND GATE followed by an inverter.

TRUTH TABLE :

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Que.: Explain the working of TIL - NAND GATE.

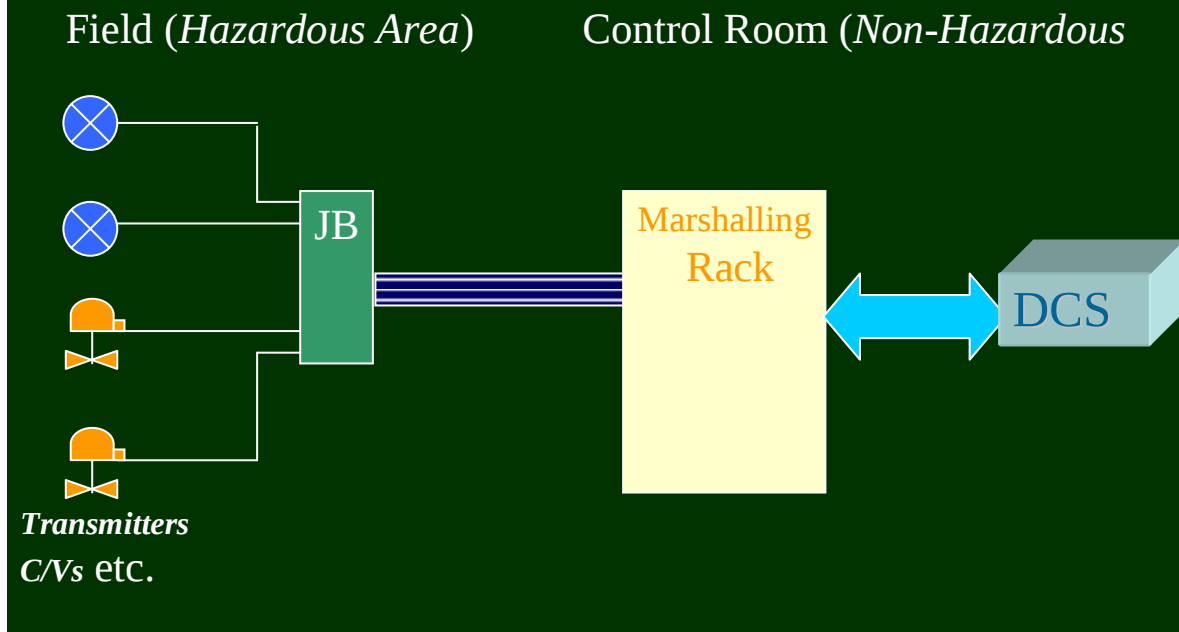
DCS ARCHITECTURE

Evolution of DCS:

- Pneumatic Control System - Single Loop Controllers, More Hardware, Less Accurate, Cumbersome Maintenance.
- SLPC - Electronic Controllers, Single/multi Loop, More Hardware
- DCS - Introduced in the '80s, Microprocessor Based, Graphic User Interface, Interface With Other Devices, Availability of Reports & Diagnostics, User Friendly.

I/O Block Diagram

I/O Block Diagram

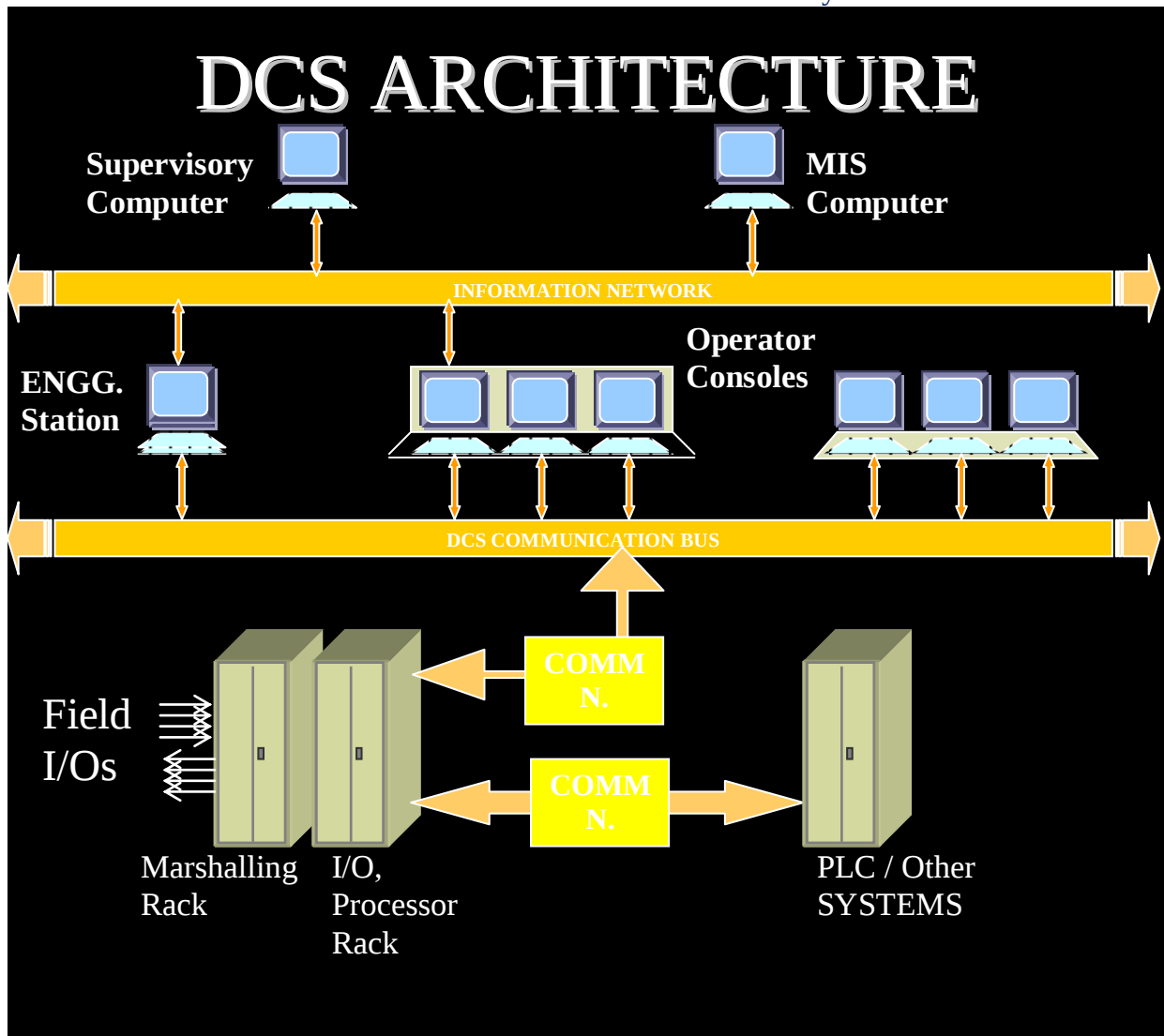


Process Control - Components HARDWARE

- Transmitter, Control Valves etc.
- Cables, Junction Box.
- Barriers, Converters etc.
- Power Supply Modules
- I/O Cards & Processor
- Communication Modules
- System Communication Bus / Network
- Graphic Display Station – CRT
- Operator Interface – Keyboard/ Touchscreen / Mouse etc.

SOFTWARE – DCS

- System Configuration – Database Builder, Control Configuration Etc.
- Graphic Builder
- History Builder & Report Writer
- Diagnostic Tools
- Logic Editor
- Control Language – User Programmable Software



Honeywell DCS

