1. **What are the primary elements used for flow measurement?**
   Orifice plate, venturi tube, flow nozzle, pitot tube and anubar.

2. **what are the different types of orifice plates and its uses?**

Concentric – liquid, steam and gas service
Eccentric - viscous and slurry flow
Segmental - slurry and colloidal flow
Quadrant - used for viscous flows

3. **how do you identify an orifice in the pipe line and the inlet of HP?**

Indication of an orifice plate in a line is identified by the tab which extends out of the line. HP high pressure side identified by indent on tab.

4. **why do you have a small hole sometimes, above as below the orifice hole?**

A small hole at bottom as top of the orifice hole called weep hole. Dia: 2.5mm
Liquid service: weep hole will be in top of the orifice hole to pass out any gas or vapor present in liquids.
Gas service: weep hole will be in bottom of the orifice hole to pass out any condensation or liquid present in the gas

5. **Advantages and disadvantages of orifice plates, venturi flow nozzle, and Pitot tube?**

Orifice plate: the orifice plate is quite simple and inexpensive. It is easiest to install, and to replace. The orifice plate is not so accurate as either the venturi or flow nozzle. It cannot be used with high beta ratios. It is the most widely used of the primary flow elements.
Venturi tube: it is the most expensive and most accurate high beta ratios (above .75) can be used with good results. The pressure recovery of the venturi tube in excellent, which means that there in little pressure drop through it. The venturi tube can be used to handle any fluid an orifice plate can handle, plus liquids that contain same solids, slurries and dirty liquids, its difficult to install and used above 2 inches to 30 inches pipe dia.

A. **Flow nozzle:**

Higher maintenance
Used in gas service
Used for high liquid velocities
Higher cast than orifice plats
Taps are normally located one diameter upstream and 1 ½ dia downs stream form the inlet paces of the nozzle.

A. **Pitot tube**

Measure the velocity of fluid flow and not the rate of flow
May be used where the flowing fluid is net enclosed in a pipe or duct. Used to measure the flow of river water
Not recommended for dirty or sticky fluids.

B. Anubar tubes

The anubar rube has two elements one facing upstream measures average velocity, one facing down steam measures static pressure. Available for pipe sizes from ½ to 150inches. It can be installed, and placed in service while the line is pressure.

Types of orifice tap connections:

Flange taps: most commonly used on pipe sizes of 2 inches and larger dia. located an the orifice flange 1inch upstream and 1 inch downs stream from the face of the orifice plate.

Corner tapes: corner taps are located directly at the face of the orifice plate. They are particularly useful for pipe sizes less than 2 inches.

Vena contracta taps: vena contracta taps are located to take advantage of the maximum pressure differential developed by the orifice. The upstream tap is located one pipe diameter from the pace of the orifice plate while the downstream tap is located at the vena contracta. The point of minimum pressure caused by the restriction.

Radius taps: located 1pipe dia upstream and ½ pipe dia downstream.

Pipe taps: pipe taps are installed to measure the permanent pressure loss across the orifice. The taps are located 2 ½ pipe diameter upstream and eight pipe diameters downstream.

6. Where is integral orifice used?

Integral orifice is used to measure small flow rates. Mounts directly in the line, with the transmitter, orifices installed in the sizes under 1 ½ inches.

7. Why flow measured in square root?

Flow varies directly as the square root of DP since this flow varies directly the pen does not indicate flow directly. This flow can be determined only by taking the square root of the pen.

F α μ squire root of DP.

8. What is a Reynolds numbe?

In flow metering the nature of flow can be determined by a number. The Reynolds number which is the average velocity X density X internal diameter of pipe α ÷ viscosity.

Where R= VDP ÷ μ

V= velocity, D= internal diameter of pipe.

P= fluid density, μ= viscosity.

Form the Reynolds number, it can be determined, whether the flow is laminar or turbulent. If the Reynolds is less than 2000 the flow is laminar. If greater than 4000 the flow is turbulent. Between these two values the nature of the flow the is in predictable. In most industrial applications the flow is turbulent.

9. An operator tells you that flow indication is more. How would you start checking it? [Not filled type]

First flush the transmitter (both impulse lines) check zero and if error, adjust the same. If still the indication is more then check LP side for choke. Check LP side for leakage. Calibrate the transmitter and inspect the LP side diaphragm.

10. How will you check zero of DP flow transmitter while in the line? [Static Zero]

Close the LP value in manifold

Open equalizing value in manifold. The o/p should be 4 m.a. DC. If it is not then zero adjustment to obtain required output.

Close equilising valve and open LP valve..

11. How do you carry out piping for DP TXR on liquids, gas and steam service?

LIQUID SERVICE :

When the transmitter is used for flow measurement of liquids, it should be located below the Point of Measurement in the process pipe. This will make it easier to completely fill the connecting lines with liquids and will minimize the possibility of gas pockets developing during operation.

GAS SERVICE :

When the transmitter is used for gas flow measurement, it should be located above the point of measurement in the process pipe. This will minimize the possibility of condensate collecting in the connecting lines.

STEAM SERVICE :

When the transmitter is used for steam flow measurement it should be located below the point of measurement in the process pipe. This location is necessary because the connecting lines and the transmitter primary must be full of water during operation.

12. What in the seal liquid used for filling impulse lines on crude, viscous liquids?

Glycol. Sp. Gravity –1.12

13. why square root extractors?

Square root extractors are used to linearize flow signals available form differential flow transmitters.

14. Write five parameters most necessary to determine the sizes of an orifice?

- Process pipe I.D (SIZE)
- Pressure
- DP required
- Density
- Viscosity

15. **$Q_1 = 200M^3/hr$, $\Delta p_1 = 2500MMWC$**
$Q_2 = 60M^3/hr$, $\Delta p_2 =$?

$Q_1 / Q_2 = \sqrt{\Delta p_1 / \Delta p_2}$
$= 200 / 60 = \sqrt{2500 / \Delta p_2}$
=Squaring both sides
$=(200)^2 / (60)^2 = 2500 / \Delta p_2$
$=40000/3600=2500/\Delta p_2$
$\Delta p_2 = 2500X3600/40000=225MMWC$

16. $Q_1 = 10\ M^3/hr$, $\Delta p_1 = 100$, $\Delta p_2 = 200$, $Q_2 = ?$

$Q_1 / Q_2 = \sqrt{\Delta p_1 / \Delta p_2}$
$10 / Q_2 = \sqrt{100} / \sqrt{200}$,
$Q_2\ X\ \sqrt{100} = 10\ X\ \sqrt{200}$
$Q_2 = 10\ X\ \sqrt{200} / \sqrt{100}$
$= 10\ X\ 14.14/10$
$= 14.14\ M^3/hr$

16. **$Q_1 = 10$, $Q_2 = 14.14$, $\Delta p_1 = 100$, $\Delta p_2 =$?**

$Q_1 / Q_2 = \sqrt{\Delta p_1 / \Delta p_2}$
$10 / 14.14 = \sqrt{100 / \Delta p_2}$
$10\ X\ \sqrt{\Delta p_2} = 14.14\ X\ \sqrt{100}$
$= \sqrt{\Delta p_2} = 14.14\ X\ \sqrt{100} / 10$
squaring both sides
$\Delta p_2 = 14.14\ X\ \cancel{100}\ X\ 14.14 / \cancel{100} = 200$

17. To convert squire root PSI signal into linear Eg: 6 psi

$\sqrt{A-3/12}\ X\ 12 + 3$
$\sqrt{6-3 / 12}\ X\ 12 + 3$
$= \sqrt{3/12}\ X\ 12 + 3$
=
$= \sqrt{1/4}\ X\ 12 + 3$
$=1/2\ X\ 6+ 3$
=9 psi

18.

18. **To convert sq. root kg/cm^2 signal into linear Eg. 0.4**

$\sqrt{A-0.2/0.8}X0.8+0.2$

= $\sqrt{0.4-0.2/0.8+0.2}$
= $\sqrt{0.2/0.8}$X0.8+0.2
= 0.1/0.4X0.8+0.2
= 0.1/0.2X0.8+0.2
= 0.6

19. To convert Sq. Root current signal into linear. Eg. 8.
$\sqrt{A-4/16}$ X 16 + 4
= $\sqrt{8-4/16}$ X 16 +4
= $\sqrt{1/4}$ X16 +4
= ½ X16 +4
= 12 mA

20. To convert current into %. Eg. 8 mA.
8-4/16 X 100
=1/4 X 100
= 25%
From % to sq root units take sq root.
Eg 25% = 5 units

6 unit in squere root scale convert it in current rang ?
6 units = 36%
36/100X16+4
=144/25+4
=5.76+4
=9.76mA

$(6/10)^2$X16+4
=9.76mA

21. convert from current to square root scale
eg: 9.76 mA
=$\sqrt{9.76 – 4 / 16}$X 100
=$\sqrt{5.76/16}$X 100
=36% 60%

anther method
$\sqrt{5.76/16}$X10
6 units

square root unit =6 units

22. range = 200 M^3/hr, alarm to set at =60 M^3/hr receives switch to be calibrated at what kg/cm^2 pressure?

=$(60/200)^2$ X .8+.2
=3600/40000 X .8 + .2
=0.09 X .8 + .2
=.072 + .2
=0.272 kg/cm^2
22. **range =8 kg/cm^2, alarm to be set at 2 kg/cm^2 at want pressure receiver switch to be calibrated?**

$=(2/8) X .8 + .2$
$= \frac{1}{4} x .8 +.2$
$= .2+.2$
$= .4 KG/CM^2$

23.

24.

25.

26.

27. Different types of flow measurement

Rate of Flow : which is the amount of fluid that flows fast a given point at any given instant.
Total Flow : which is the amount of fluid that flows fast a given point in a definite period of time.

28. What is flow ?

Flow is fluid in motion. Fluids include liquids, air, gases and steam.

29. Compare Differential Pressure Meter (orifice) and Rotameter

In the differential pressure meter, the area is restricted to a fixed size while the differential pressure varies with the rate of flow. In the rotameter, the size of the area is adjusted by the amount necessary to keep the pressure differential constant when the rate f flow changes.

30. **The pressure drop through an orifice plate in a pipe line is 100” wc for given flow. If the flow is doubled, what will be the new pressure drop?**

$\Delta P1 = 100”$, Let us assume given flow as Q1 =1
Q2 = 2, $\Delta P2 = ?$

$Q1/Q2 = \sqrt{\Delta P1/\Delta P2}$

$= ½ \sqrt{100}/\sqrt{\Delta P2}$
$= ½ = 10/\sqrt{\Delta P2}$
$= \sqrt{\Delta P2} = 20$
SQUARING BOTH SIDES,

$\Delta P2 = 400”$ WC

31. **what will be the reading on a flow receiver indicator (0-10 units) if the differential pressure is 50% of the range of dp cell ?**

FROM % TO FLOW UNITS → TAKE SQUARE ROOT
50% = 7.07 UNITS

32. **What is the expected output from a dp cell ()-100”) if the receiver flow recorder is reading 5.0 on a 0-10 scale?**

5 units = 25%
= 25/100 X 16 +4
= 8 mA
= 25/100 X 12 +3
= 6 psi

$(5/10)^2$ X 12 +3
= 6psi

33. **What should be the setting of a Pressure switch if it is required to trip a pump at 30% of the full scale flow? Switch is connected to output of (3-15 psi dp cell)**

- o/p , we know, for finding flow percentage, take square root √
- flow percentage we know, for finding o/p → square

Hence, $(30/100)^2$ X 12 +3
= 0.09 X 12 +3
= 4.08 psi

34. What will be output of a square root extractor if its input is 8 mA in a standard 2 – wire transmitter system?

√ 8-4/16 X 12 + 4
= .5 X 16 + 4
= 12 mA

35.

36.

37. VARIABLE AREA METERS :

Rotameter : - The Rotameter is used as an indicating device. The rotameter is subject to error due to changes in the density of the viscocity of the flowing fluid.

- The rotameter is a variable area type flowmeter consisting of a vertical tapered tube with a floak which is free to move up and down within the tube. The measured fluid enters the tube from the bottom and passes upward around the float and out at the top. As the flow caries the float varies of falls, varying the area of the annuals passage between the float and tube. The tube is tapered so that there is a linear relationship between the flow rte and the position of the float with in the tube. A calibration scale printed on the tube provides a direct indication of flow rate.

Glass Tube Rotameter : - Glass metering tubes are commonly used for relatively low pressure and temperature services of non-hazardous fluids, such as water and air.

- One method used to reduce the hazard of glass tubes is the use of Protective Shields around the tubes.The Shield prevents accidental breakage of the tube and it prevents excessive splashing of dispression of the fluid of breakage or aupti ne does occure.

Metal Tube Rotameter : - Metal metering tubes have been developed so applications where glass is not acceptable. The linear motion of the float is translated into tube. The linear motion of the float is translated into a rotary motion for direct indication or signal transmission. It is not adaptable to dirty or sticky services.

Armoured Rotameter : - The armoured rotameter is adaptable to miot slurry services .

- Most rotameter accessories fall into an area of 2% of full scale. The primary use of rotameters, however in the smaller sizes,They are used in pipe sizes ½ to 2 inches.
- Piping configuration has no effect on relation operation because they must be maintained and fluid flow is upward, many configuration are used. Top and bottom side, screwed connections are used in all the small sizes. Flanged connections are usually available in pipe sizes from ½ inch.

Byoass Rotameters : - Byoass rotameter installations are used occasionally to measure flow rates in large pipe lines by using low-cost orifice plates while still retaining the linear function of the rotameter.

- Valve type area meter : - In the valve type meter, a specially shaped plug and piston moves to a new position to keep the differential pressure constant for each rate of flow. It is most often used to provide remote indication.
- The physical properties of fluids which one important in flow metering are : -

  Pressure, Density, Viscosity, Velocity, Temperature

Pressure: - Pressure is efined as force divided by area.

Density: - Density is defined as weight divided by volume and is usually expressed in pounds per cubic foot.
The density of water at 32˚F and at atmospheric pressure is 62.42 pounds per cubic foot. The densities of gases and vapours are affected greatly by its pressure and temperature.

Viscosity: -The viscosity of a fluid refers to its physical resistance of flow. The most widely used viscosity units centipoises water at 68^0F in a reference point for viscosity measurements. Its

value in 1.0 centipoise the viscosity of kerosene at 68^0F in 2.0 centipoise. The viscosity of liquids decreases as the temperature increases. And gas viscosities increase as temperature increases. The effect of pressure on viscosities of liquids in very small. Its effect on gases in normally significant only at the high pressures other viscosity units – kinematic viscosity expressed in stokes (or) centi stokes and say bolt universal or say bolt final expressed in seconds.

Velocity: - The velocity of a flowing fluid is its speed in the direction of flow. It is an important factor in flow interning. When the average velocity in slow. The flow in said to be laminas. As the velocity increases, the flow becomes turbulent

Velocity = rate of flow (feet per sec)/area of pipe (sq. feet)

Temperature: -Few flow measurements are made that are entirely inspected by temperature variations. The most common method of flow measurement using differential type both temperature and pressure should remain constant.

Laminar flow element are made, however for low flow differential measurement applications.

Measurement methods: -These methods are divided into three broad categories as inferential types. Descrete quantity types and mass measurement types.

Inferential flow measurement :- most flow rates are determined by inferential measurements
(1)d.p type (2) the variable area (or) rotameter type (3)the magnetic meter (4) turbine meter (5) target meter (6) thermal flow meter (7) swril meters (8) sonic flow meters.

Discrete quantity flow measurement:-
(1)positive displacement meter.
(2)positive displacement metering pumps

mass flow measurement :-
(1) the impeller turbine and twin turbine types.

Mass flow devices are rarely found in industrial applications mass flow however through volume flow measurement s such as temp and a density
*100 to 500mv =25ohms

- 1 to 5v = 250ohms
- 0 to 10v = 500 ohms =500mv/20ma = 25 ohms
- crude sp.gravity -.742
- kerosene sp.gravity - .680
- raw naptha sp.gravity - .531
- wild naptha sp.gravity - .653

Differential pressure type: the principal of operation I that a restriction in the line of a of flowing fluid is proportional to the flow rate. The proportionality is in which the flow rate in proportional to the square root of the differential pressure.

- the principal consideration in selecting an orifice plate is the ratio of its opening (d) to the internal diameter of the pipe (D). This is often called the beta ratio. If the d/D ratio is too small. The loss of pressure becomes too great. If the ratio is too great, the loss of pressure becomes too small. Ratios from .2 to .6 generally provide best accuracy.

In orifice, when insufficient straight pipe is not possible the disturbances can be reduced or eliminated by the installation of straightening vanes consists of a bundle of bundle of tubes the orifice to reduce turbulence and make accurate measurement possible.

When “pipe taps” are used upstream should be increased by 2 pipe diameters and (B) downstream by 8 pipe dia.

The Integral orifice – orifices installed in line sizes under 11/2 inches.

A d/p cell, when equipped with a “zero elevation” kit can be used to measure bi-directional flow.

The measurement of gas flow, to be accurate, demands knowledge of the temperature and pressure, since the volume of gas varies directly with temperature and inversely with pressure..

Magnetic flow meter:

Magnetic flowmeter consists of a magnetic flow meter tube, a flow converter outputs analog dc signal (4ma to 20ma), totalization pulses, by converting and amplifying minute voltages proportional to flow rates from the magnetic flow meter tube.

The magnetic principle of the magnetic flowmeter is based on the law of electromagnetic induction which states that when a conductor moves in a magnetic field. In the direction perpendicular to the magnetic field, an electromotive force is induced perpendicular to the direction of the conductor movement and to the direction of the magnetic field. The value of e.m.f is proportional to the conductor velocity and magnetic flux density.

Some of the desirable feautures of the magnetic flow meter follow.

(I) Pressure drop is minimal.
(II) There are no obstructions to fluid flow.
(III) Measurement of slurries and corrosive or abrasive or other difficult fluids is easily made.
(IV) Piping configurations are not critical since the meter measures average velocity.
(V) Bi-directional flow can be measured by reversing connections.
(VI) Meters are unaffected by viscosity, density, temperature, pressure or fluid turbulence.

The following precautions need to be taken:

- Conductivity must be as high as the minimum required by the particular manufacturer from 0.1 to 20 micrometers.
- The meter must be full at all times because the meter sees velocity as analogous to volume flow rate.
- Contained gas bubbles result an measurement error.

Fouling of the electrodes occurs in some fluids, coating them and either reducing or completely eliminating the generated signal. In such cases, cleaning methods have been introduced,(electrical or mechanical) to keep the electrodes clean and conductive.

Turbine meters:

Turbine meters consists of a straight flow tube within which a turbine of fan is free to rotate about its axis which is fixed along the centerline of the tube. The velocity of the flowing stream imparts a force to the turbine blades or rotor which rotate at a speed proportional to flow rate. In most units a magnetic pickup coil, one pulse of AC voltage is induced. Each pulse representing a definite flow quantity.

The insertion of a turbine in a flow line passes some obvious problems. The entire mechanism is subjected to dirt, corrosive chemicals, solids that may be in the line and erosive action of the fluid.

The rotors are mounted on sleeve bearings, which rely on the lubricating quality of the flowing medium for lubrication sleeve bearings made from non-metallic materials such as rein-forcedd Teflon, reinforced carbon, carbon graphite, and ceramics are often used in non-lubricating and dirty liquid services.

Turbine meters have been widely used for military applications and commercial applications. They are used both liquids and for gas flow measurement. They are particularily useful in blending systems, where clean liquids are mixed or blended in carefully controlled ratios. They are especially suitable for dirty services although ther are same special designs, that handle slurries and suspended solids. Installation of turbine meter – 15 pipe dia in upstream and 6 pipe dia in downstream.

Target meters: (inferred from a force measurement) target meters are especially useful in measuring heavy viscous, dirty, or corrosive fluids. The flow develops a force on the target on disc. Witch is proportional to the square to the flow .

Vortex meter: -two meters are available that may be classified as vortex meter. One is called a processing vortex meter or swirl meter and the other uses the term vortex shedding

When an columnar obstacle (vortex shedder) is installed in a fluid flow inside a pipe line, vortices are generated on the down stream side of the obstacle alternately on both sides. These vertices are known as karman vortices.

$$F=st.v/d.$$

Where f= karman vortex generating area on one side.
St=strounal number.
V=fluid flow velocity.
D=width of vortex shedder across the flow.

The karman vortex frequency is proportional to the velocity(v). The vortex flowmeter detects the frequency as alternate generated to the vortex shedder with a sensor assembly in which piezo electric elements are incorporated.

Sonic meters:-
The sonic meters uses the Doppler shift technique for high accuracy measurement. Sonic meters can also be used to measure specific gravity. This type of device can be employed to detect the interface between fluids in a pipe line.

Positive displacement meters:-
Positive displacement meters are mainly used for accounting applications or in batch processes. P.d meters may be classified by the movement of the metering element. Included one nutating disc, oscillating piston, rotating types and reciprocating piston types.

Nuttaing disc :- used for residential water service measurement.
Reciprocating piston:-

This meter is very similar in construction to a reciprocating steam engine piston and cylinder. The reciprocating piston meter is not widely used. While it is an accurate meter, it produces a pulsating flow when used for liquid measurement.

Liquid fllow processes are very fast, typically 0.5sec response or less. Gas flow is slightly slower because of the compressibility of the gas.
The orifice element requires 10 to 30 diameters of straight iron pipe upstream and 5 diameters downstream to protect its accuracy.

If a centrifugal pump is the flow energy source, the throttling valve can be placed in the pump discharge line. If a positive displacement pump is used, the valve must be in a bypass line; alternately, pump speed or stroke can be controlled instead of bypass flow.

Flow processes are dominated by noise caused by fluid turbulence and equipment vibration controller gain in invariably low – usually less than 1.0. reset must be used to overcome offset; derivative cannot be used.

Orifice flange unions – threaded union, slip-on union, welding neck union.

Pipe fittings and valves upstream from the primary element generate eddies, swirls and cross currents which if uncorrected by a straightening vane may upset the flow measurement considerably.

250 ohms resistor may be provided to get 100 to 500mv instead of 4 to 20 ma dc.

Types of flow:-there are three types of flow: laminar, transient to turbulent, and turbulent.in laminar flow, the fluid particles travel parallel to the pipe walls and there is very little radial movement.
In transient to turbulent conditions the layers are beginning to break up and layers have started to intermingle. In turbulent flow the layers have disappeared and there is considerable radial motion.

An orifice:- an orifice plate is a disc of metal about 1.5 to 6.0 mm thick usually a circular hole is cut from the center of the disc.

Basic flow law : the actual relationship between flow and differential pressure depends primarily on the ratio of the diameter of the orifice to the inside diameter of the pipe and the physical properties of the fluid. The basic expression in

Q = CA SQUR 2GH

Q is the flowing quantity (flow rate)
C is the co-efficient which takes into accurate the physical properties of the fluid being measured.
2g is due to the force of gravity.
H is the differential pressure.
A is the area of the orifice.

Tappings should come off top of line for steam and gas so that condensate will not block up impulse lines.

For liquid service tappings come off middle of line to avoid gas bubbles which will tend to go at top of line and sediment rust, scale etc. which will tend to go to the bottom of the line.

Dp%	Flow%	ma	psi	Kg/cm2	Flow units
0	0	4	3	.2	0
25	50	8	6	.4	5
50	70.7	12	9	.6	7.07
75	86.60	16	12	.8	8.6
100	100	20	15	1	10

sq.root psi	linear psi	sqroot kg/cm2	linear kg/cm2	sq.ma	lin ma
3	3	.2	.2	4	4
6	9	.4	.6	8	12
9	11.48	.6	.76	12	15.31
12	13.39	.8	.89	16	17.85
15	15	1	1	20	20

Span = 50" at 32" what is the equal % of flow?
Sq root of 32/50 x 100 = 80% of flow
At 12mA transmitter output, Q1= 2500, Δp1= 2000 mmwc. What is the max flow and max DP at 100%

Q2 = √a-4/16*2500 reversing the formula

√16/8*2500 = 3535.33

Δp2 = 16/8 * 2000 = 4000

- if the flow indicates half of the range, the transmitter output will be 25%, i.e 8ma,
- dp also = 25%

√50/100 *16 +4, √50/100 *100

range = 1000 m3/hr, indication showing = 10 m3/hr.
to find out error percentage.

$\sqrt{10/1000} * 100 = 0.01\%$

$\sqrt{10/1000} * 16 + 4 = 4.0016ma$