JACOBS Engineering SA

Selection guide

Peering into different instrumentation technologies

JACOBS Engineering SA
INITEC Energia

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Key applications:

Ultrasonic flowmeters are commonly applied to measure the velocity of liquids that allow ultrasonic waves to pass, such as water, molten sulfur, cryogenic liquids, and chemicals.

Typical applications:

- Water distribution flow metering
- Wastewater flow-metering
- Building Services
- Inspection of fixed installation meters
- Power/Energy Management
- Chemical / Pharmaceutical
- Petro-Chemical
- Pump inspection
- Food/Hygienic flow-monitoring
- Steel
- Light Industrial
- Survey work

More at: https://www.rshydro.co.uk/flow-meters/ultrasonic-flow-meters/, https://www.omega.com/prodinfo/ultrasonicflowmeters.html, http://www.flowmeters.com/ultrasonic-technology,

b. Turbine & pistons flow meters:

Definition:

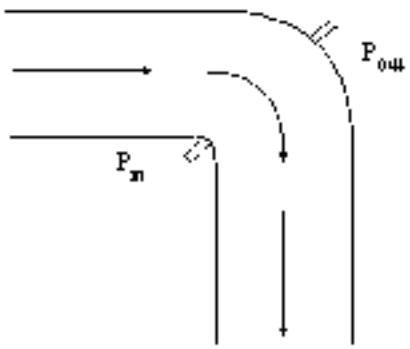
The turbine flowmeters are a technology of flowmeters that are characterized by the use of a turbine to determine the flow of liquid in a pipe.

Working principle:

If a fluid moves through a pipe and acts on the vanes of a turbine, the turbine will start to spin and rotate. The rate of spin is measured to calculate the flow.

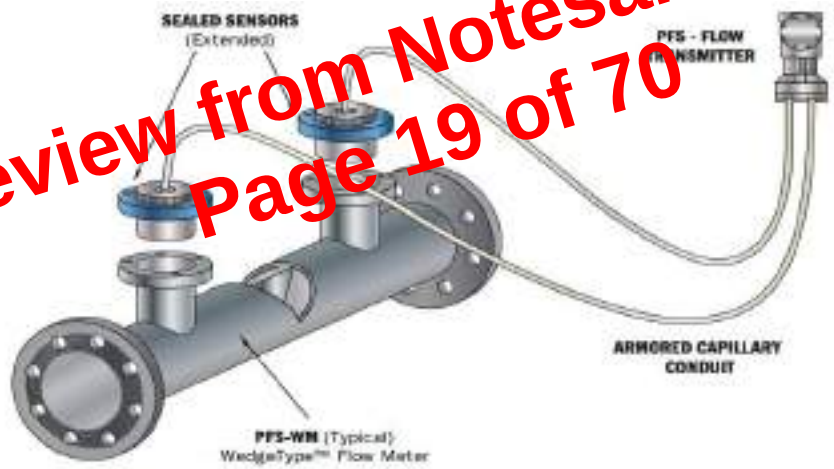
Characteristics (depending on the model, better refer to datasheets):

- Flow range: 1 to 15 gpm (smallest) and 8 to 120 gpm (largest).
- Temperature: max 105°F.
- Pressure: 150 PSIG.
- Accuracy: 0.5 %- 1.5 %

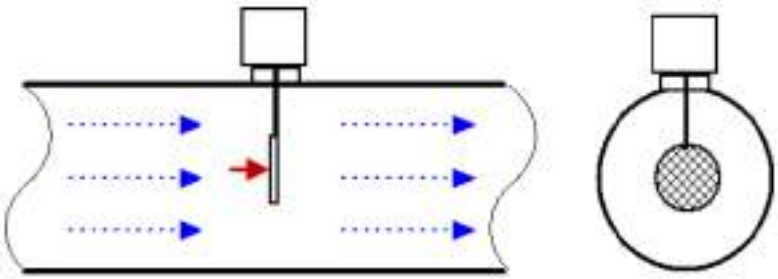


The pressure difference results from the centrifugal force. Since pipe elbows exist in plants, the cost for these meters is very low. However, the accuracy is very poor; there are only applied when reproducibility is sufficient and other flow measurements would be very costly.

- ✓ *Wedge Flowmeters:* those flow elements utilize V-shaped restrictions to produce a square root relationship between differential pressure and volumetric flow. Elements are designed for either clean or dirty service and are offered in various materials, pipe sizes, and pressure ratings.



- ✓ *Target flow meters:* Target flowmeters measure flow by measuring the amount of force exerted by the flowing fluid on a target suspended in the flow stream.



- They Snag on impurities and are not updated as much as other technologies with new protocols.
- PD meters represent only 8% of global sales for flowmeters.

Key applications:

- Positive displacement flowmeters can be applied to clean, sanitary, and corrosive liquids, such as oil, water and foods, and some gases.
- Some designs can measure gas flow although liquid flow applications are much more prevalent.
- Generally good for smaller line sizes, low flow rates, high viscosity and last a long time especially for oils.
- The positive displacement flowmeter may be used for all relatively nonabrasive fluids such as heating oils, lubrication oils, polymer additives, animal and vegetable fat, printing ink, Dichlorodifluoromethane R-12, and many more.

More at: https://www.smartmeasurement.com/flow-meters/positive-displacement,

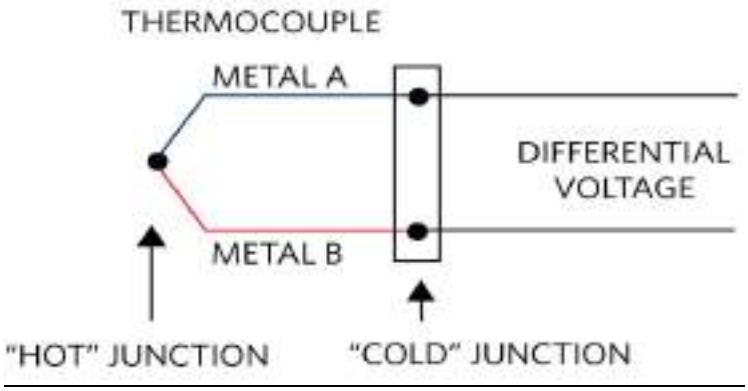
https://www.omega.com/technical-learning/positive-displacement-flow-meter.html,

http://www.flowmeters.com/positive-displacement-technology,

http://www.industrialdynamics.com/blog/types-of-the-flow-meters/,

Working principle:

- There is two wires composed of dissimilar metals are joined at both ends and one of the ends is heated, there is a continuous current which flows in the thermoelectric circuit.



- When the junction of the two metals is heated, or cooled, a voltage is produced that can be correlated back to the temperature.

Types of thermocouples:

- Chromel – gold/iron alloy thermocouple.
- Type P (noble metal alloy).
- Platinum/molybdenum alloy thermocouple.
- Iridium/rhodium alloy thermocouple.
- Pure noble metal thermocouples.

Advantages and drawbacks:

Advantages:

- Thermocouples have the widest temperature range of all the temperature sensors from below -200oC to well over 2300oC.
- They are self-powered, no need for external power supply.
- They have the ability to be brought into direct contact with the material they are measuring.

Downsides:

- Their linearity is very poor, and they need reference.
- They present a medium accuracy.
- *their sensitivity is low.
- They are vulnerable to corrosion, which can sometimes be difficult to detect. Any type of light corrosion can result in a misreading by the thermocouple
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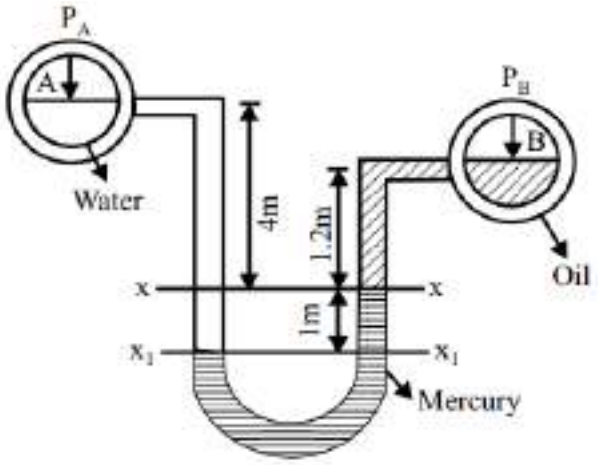
If one end of the tube is in a place with higher air pressure, the pressure will push down the liquid on that side of the tube. By measuring the difference between the heights of liquid, it is possible to calculate the difference in pressure.



Advantages and limitations:

Advantages:

- simple in construction
- Low cost
- Very accurate and sensitive
- It can be used to measure other process variables.

Downsides:

- Fragile in construction.
- Very sensitive to temperature changes.
- Error can happen while measuring the h.

Characteristics:

- Liquid's viscosity should be low.
- Low surface tension is required.
- The liquid should stick on the walls.
- The liquid should not get vaporized.

Key applications:

- It is used for low range pressure measurements.
- Extensively used in laboratories.
- Is used in Orifice meter and Venturi meter for flow measurements.
- It is used for calibration of gauges and other instruments.
- It is used for measuring pressure drop in different joints and valves.

More at: https://sciencing.com/differential-manometer-5964765.html,

- A capillary effect is created due to surface tension of manometric fluid, and
- For better accuracy meniscus has to be measured by accurate means.
- Usually bulky and large in size.

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Morea at: https://sciencestruck.com/manometer-working-principle-types-applications,

https://engineeringinsider.org/manometer-types/,

https://me-mechanicalengineering.com/manometer-types/,

2. Elastic pressure meters:

Elastic pressure elements or mechanical type of transducers are used for measurement of very high pressures up to about 2000N/m^2. They are used extensively to measure pressure in technical applications due to their robustness and ease-of-use. They incorporate measuring elements which deform elastically under the influence of pressure. There are four main types of pressure elements. These are:

- ✓ Bourdon Tube
- ✓ Bellows
- ✓ Diaphragm
- ✓ Dead weight

2.1. Bourdon tube pressure gauge:

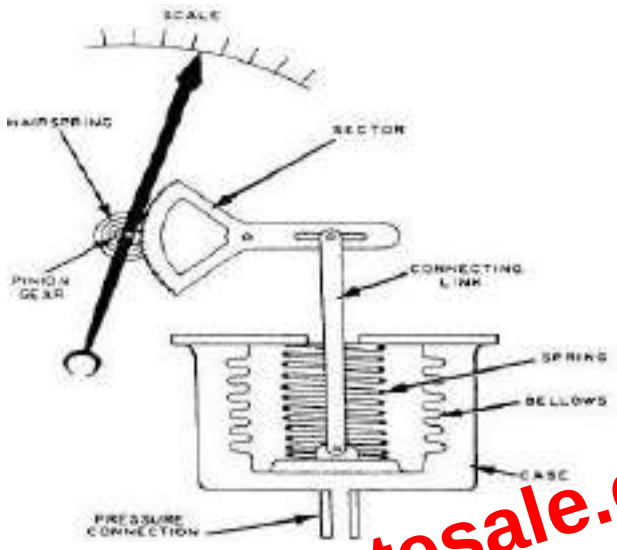
Definition:

Bourdon tube pressure gauges are classified as mechanical pressure measuring instruments, and thus operate without any electrical power.They can be modified to give electrical outputs.

Working principle:

The bellows are made up of an alloy with high strength and ductility. Pressure is applied to one side of the bellows and the resulting deflection is counter balanced by a spring. This arrangement indicates the gauge pressure.

By suitable linkage and calibration of the scale, the pressure difference is indicated by a pointer on the scale.



Advantages and limitations:

Advantages:

- Its cost is moderate.
- Reliable with low hysteresis and creep.
- It is adaptable for absolute and differential pressures.
- It is good to low-to moderate range.

Limitations:

- It needs ambient temperature compensation.
- Sensitive to vibration and shock.
- It is unsuitable for high pressures.
- The availability of construction metals is limited.

Characteristics:

- Pressure range: Min. 0 à 0.1 bar.
- Accuracy : up to ±0.1%.

Key applications:

1. *Float Level Sensors(magnetic, mechanic and magntoresistive types):*

Definition:

Liquid level floats are spherical or cylindrical objects that are buoyant in water and other liquids. They are used for surface demarcation and level measurement. They may also be incorporated into switch assemblies to control liquid level.

Working principle:

The principle behind magnetic, magnetoresistive or mechanical and other float level sensors often involves the opening or closing of a mechanical switch, either through direct contact with the switch, or magnetic operation of a reed.

- With magnetically actuated float sensors, switching occurs when a permanent magnet sealed inside a float rises or falls to the actuation level.
- With a mechanically actuated float, switching occurs as a result of the movement of a float against a miniature (micro) switch.
- With magnetoresistive type, a permanent magnet pair is sealed inside the float arm pivot. As the float moves up the motion and location are transmitted as the angular position of the magnetic field.

Advantages and limitations:

Advantages:

- The float level sensors continue to be the simplest, most reliable, and cheapest technology for liquid level measurement application.
- Ease of mounting.
- Transmitter/switches can be calibrated/adjusted whilst system still on line.
- Simplified process takeoffs with minimized connections.

Limitations:

- Specifications critical for correct float selection.

- They can be used as single point level sensor or continuous level sensors
- Present a high-accuracy with no contact with the process fluid.
- Can measure level through plastic tanks.
- Detect obstructions in chutes or presses.

Limitations:

- Very sensitive to build-up on sensor surface.
- They are very expensive, price increases with accuracy.

Key applications:

- Storage tanks at refineries and tank terminals
- Power plants
- Chemical & petrochemical industry
- Food and beverage
- Water and sewage treatment
- Hydroelectric power generation and dams

In general, Microwave sensors are ideal for use in moist, vaporous, Liquids Pastes Powders Bulk, solids and dusty environments as well as in applications in which temperatures and pressures vary. Microwaves will penetrate temperature and vapor layers that may cause problems for other techniques, such as ultrasonic detectors.

Characteristics:

- Operating temperature: -35 to 60°C(-31 to 140°F).
- Accuracy: 3 mm (0.125").
- Range: 0.3 to 4.5 m (1 to 15') application dependant

More at: https://www.omega.com/pptst/LVU30.html

https://www.engineersgarage.com/articles/what-is-level-sensor

https://www.instrumentationtoolbox.com/2013/04/operating-principle-of-radar-level.html

https://www.vega.com/en/company/technology/radar-level-measurement

https://www.sensorsmag.com/components/a-dozen-ways-to-measure-fluid-level-and-how-they-work

Characteristics:

- Operating temperature: 40 to 110°C
- Operating pressure: (0 to 17 bar) maximum
- Accuracy(Repeatability): ±1 mm
- Range: 0.3 to 4.5 m (1 to 15') application dependent

Key applications:

- They are commonly used in applications like leak detection and tank level measurement

More at: https://www.elprocus.com/different-types-level-sensors-applications/

https://www.fluidswitch.com/blog/how-do-optical-level-sensors-work/

https://www.engineersgarage.com/articles/what-is-level-sensor

6. Capacitance level sensor:

Definition:

Capacitance level sensors excel in sensing the presence of a wide variety of solids, aqueous and organic liquids, and slurries.

Working principle:

This sensor comprises of two concentric tubes immersed in the fluid whose level is to be measured. As the fluid level changes, the capacitance also changes. This capacitance becomes the function of the fluid level.

Advantages and limitations:

Advantages:

- Solid-state, compact, can be non-invasive, accurate