Continuous Level Measurement

- Level Measurement types
- Level Switches
- Ultrasonic Level Measurement
- Radar Level Measurement
- Hydrostatic Level Measurement
- Capacitive Level Measurement
- Magnetostrictive Level Measurement

Continuous Level Measurement

Level measurement Types

1- Level Switching (Level Point) measurement .

- Float Level Switch .
- Tuning Fork Level Switch.
- Ultrasonic Level Switch .
- Rotary Level Switch .
- Capacitance Level Switch .

2- Continuous Level measurement

- Ultrasonic Level Transmitter
- Radar Level Transmitter
- Hydrostatic Level Transmitter
- Captative Level Transmitter
- Magnetostrictive Level Transmitter

2- Passive Level measurement

- Level Gauge

Continuous Level Measurement

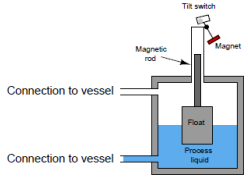
Discrete Level measurements

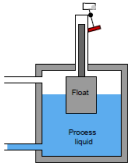
1- Level Switching (Level Point) measurement

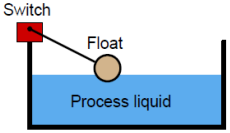
A level switch is one detecting the level of liquid or solid (granules or powder) in a vessel .

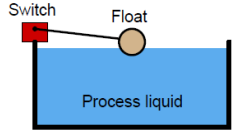
Level switches often use floats as the level-sensing element.

A level switch will be in its “normal” status when it senses minimum level (e.g. an empty vessel).









Continuous Level Measurement

Discrete Level measurements

1- Level Switching (Level Point) – How to select

Process temperature:
Pressure:
Output:
Protection:
Float material
Wire Length
No of floats

Continuous Pressure Measurement

Discrete Level measurements

2- Tuning Fork Level Switch

This level switch uses a metal tuning fork structure to detect the presence of a liquid or solid (powder or granules) in a vessel .

An electronic circuit continuously excites the tuning fork, causing it to mechanically vibrate. When the prongs of the fork contact anything with substantial mass, the resonant frequency of the fork decreases.

The circuit detects this frequency change and indicates the presence of mass contacting the fork.

The forks' vibrating motion tends to shake off any accumulated material, such that this style of level switch tends to be resistant to fouling.

Continuous Level Measurement

Discrete Level measurements

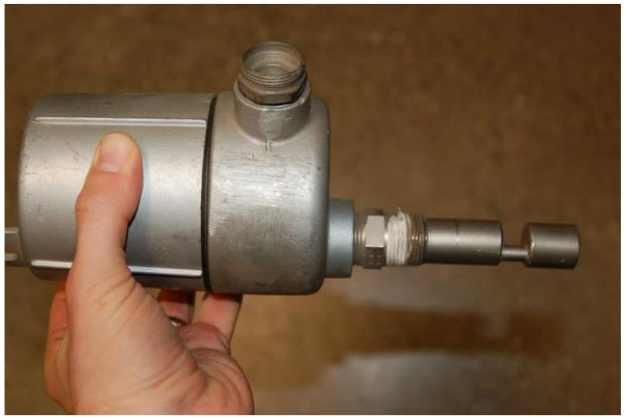
2- Tuning Fork Switch – How to select

Power Supply
Pressure:
Output:
Protection:
Approvals
Process Connection
Process Temperature
Viscocity

Continuous Pressure Measurement

Discrete Level measurements

3- Ultrasonic Level Switch



It uses ultrasonic sound waves to detect the presence of process material (either solid or liquid) at one point:

Sound waves pass back and forth within the gap of the probe, sent and received by piezoelectric transducers.

The presence of any substance other than gas within that gap affects the received audio power, thus signaling to the electronic circuit within the bulkier portion of the device that process level has reached the detection point.

Continuous Level Measurement

Discrete Level measurements

3- Ultrasonic Level Switch – How to select

Power Supply
Pressure:
Output:
Protection:
Approvals
Process Connection
Process Temperature

Continuous Pressure Measurement

Discrete Level measurements

4- Rotary Level Switch

This level switch uses an electric motor to slowly rotate a metal paddle inside the process vessel. If solid material rises to the level of the paddle, the material's bulk will place a mechanical load on the paddle.

A torque-sensitive switch mechanically linked to the motor actuates when enough torsional effort is detected on the part of the motor.

Continuous Level Measurement

Discrete Level measurements

4- Rotary Level Switch – How to select

Power Supply
Pressure:
Output:
Protection:
Approvals
Process Connection
Process Temperature

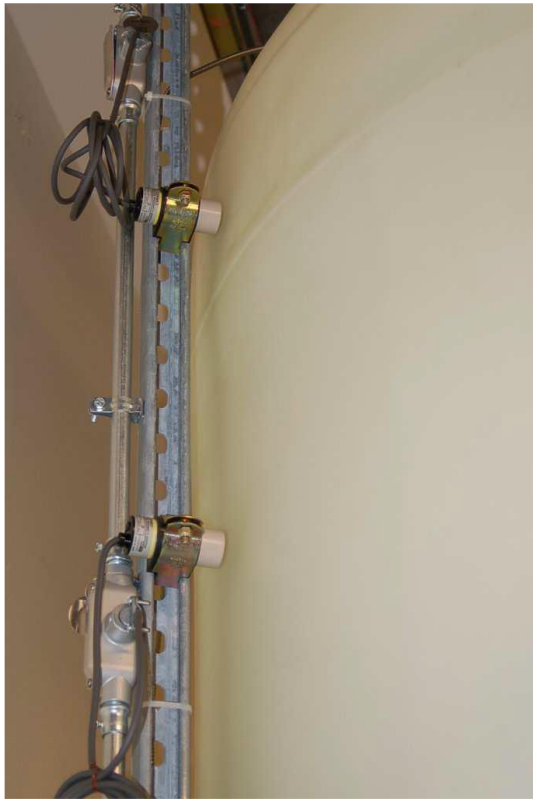
Continuous Pressure Measurement

Discrete Level measurements

5- Capacitance Level Switch

- Sensing level by changes in electrical capacitance between the switch and the liquid.

- Capacitance decreases as long as the distance between liquid and switch decreasing .



Continuous Level Measurement

Discrete Level measurements

5- Capacitance Level Switch – How to select

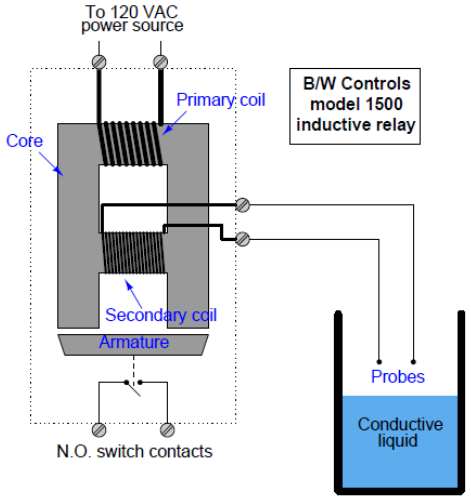
Power Supply
Pressure:
Output:
Protection:
Approvals
Process Connection
Process Temperature

Continuous Pressure Measurement

Discrete Level measurements

6- Conductive Level Switch ---- Add animation & real images

- A pair of metal electrodes contacts the process material to form a complete electrical circuit , actuating a relay.



This type of switch, of course, only works with granular solids and liquids that are electrically conductive (e.g. potable or dirty water, acids, caustics, food liquids, coal, metal powders)

And not with nonconducting materials (e.g. ultra-pure water, oils, ceramic powders).

Continuous Level Measurement

Discrete Level measurements

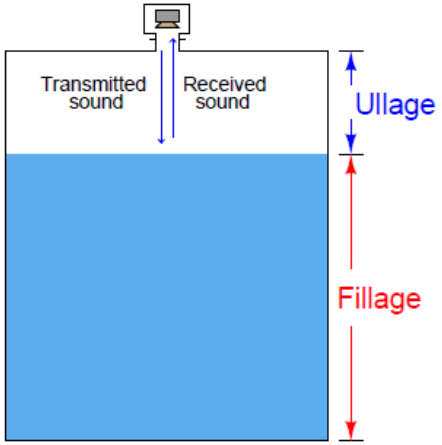
6- Conductive Level Switch – How to select

Power Supply
Pressure:
Output:
Protection:
No of Probes
Process Connection
Process Temperature
Min. Conductivity

Continuous Pressure Measurement

Continuous Level measurements

1- Ultrasonic Level Transmitter



Ultrasonic level instruments measure the distance from the transmitter (located at some high point) to the surface of a process material located farther below using reflected sound waves.

The time-of-flight for a sound pulse indicates this distance, and is interpreted by the transmitter electronics as process level.

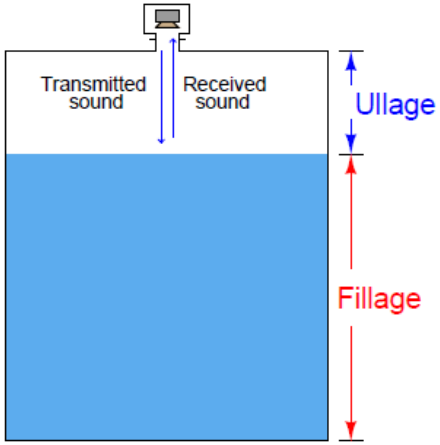
These transmitters may output a signal corresponding either to the fullness of the vessel (fillage) or the amount of empty space remaining at the top of a vessel (ullage).

Ullage is the “natural” mode of measurement for this sort of level instrument, because the sound wave’s time-of-flight is a direct function of how much empty space exists between the liquid surface and the top of the vessel.

Continuous Pressure Measurement

Continuous Level measurements

1- Ultrasonic Level Transmitter



If a sound wave encounters a sudden change in the material's speed of sound, some of that wave's energy will be reflected in the form of another wave in the opposite direction. In other words, the sound wave will "echo" when it encounters a material having a different sonic velocity.

This is the basis of all ultrasonic ranging devices. Thus, in order for an ultrasonic level transmitter to function reliably, the difference in sonic velocities at the interface between liquid and gas must be large.

Liquids with a heavy layer of foam floating on top are more difficult, since the foam is less dense than the liquid, but considerably denser than the gas above.

Continuous Pressure Measurement

Continuous Level measurements

1- Ultrasonic Level Transmitter

Foaming Issue :

Liquids with a heavy layer of foam floating on top are more difficult, since the foam is less dense than the liquid, but considerably denser than the gas above.

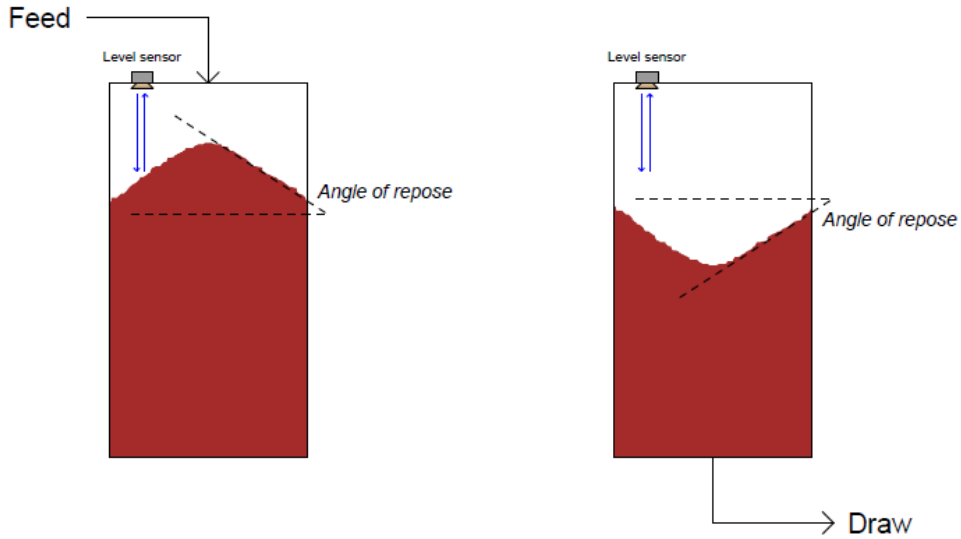
Weak echo will be generated at the interface of foam and gas, and another generated at the interface of liquid and foam, with the foam acting to scatter and dissipate much of the second echo's energy.

Continuous Pressure Measurement

Continuous Level measurements

1- Ultrasonic Level Transmitter

Angle of repose Issue (Not Applicable)



Continuous Pressure Measurement

Continuous Level measurements

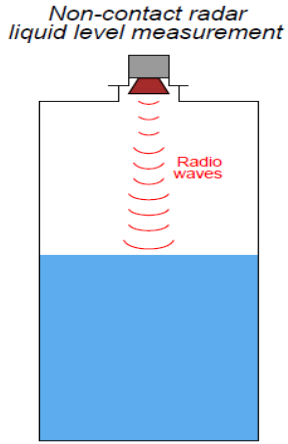
1- Ultrasonic Level Transmitter---- How to Select

Power Supply
Pressure:
Output / Relay Output:
Protection:
Measuring Range / Accuracy
Beam Angle
Type
Cable Length

Continuous Pressure Measurement

Continuous Level measurements

2- Radar Level Transmitter



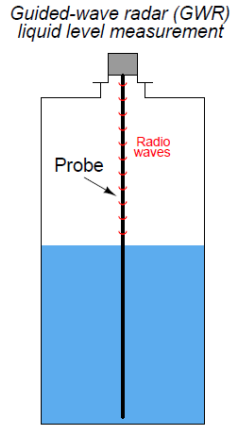
Radar level instruments measure the distance from the transmitter (located at some high point) to the surface of a process material located farther below in much the same way as ultrasonic transmitters – by measuring the time-of-flight of a traveling wave.

The fundamental difference between a radar instrument and an ultrasonic instrument is the type of wave used: radio waves instead of sound waves.

Continuous Pressure Measurement

Continuous Level measurements

2- Radar Level Transmitter



- Radio waves are electromagnetic in nature and very high frequency .
- Sound waves are mechanical vibrations and of much lower frequency .

Both waves will reflect off of an interface of two different substances if those two substances possess different wave-propagation velocities.

-Some radar level instruments use waveguide “probes” to guide the electromagnetic

Continuous Pressure Measurement

Continuous Level measurements

2- Radar Level Transmitter

Continuous Pressure Measurement

Continuous Level measurements

2- Radar Level Transmitter

Non-contact radar devices suffer much more signal loss than guided-wave radar devices, due to the natural tendency of electromagnetic radiation to disperse over space.

Waveguides Radar combat this signal loss by channeling the radio energy along a straight-line path.

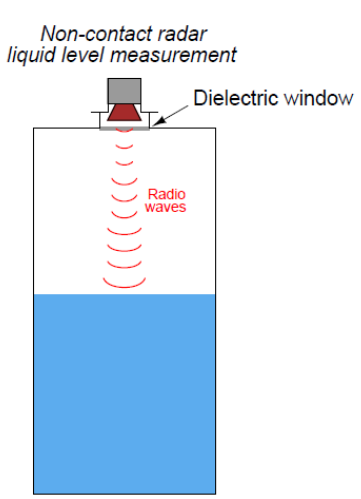
Single-rod probes are much more tolerant of process fouling than two-rod or (especially) coaxial probes, where sticky masses of viscous liquid and/or solid matter cling to the probe.

Such fouling deposits, if severe enough, will cause electromagnetic wave reflections that “look” to the transmitter like the reflection from an actual liquid level or interface.

Continuous Pressure Measurement

Continuous Level measurements

2- Radar Level Transmitter – Dielectric Window Usage



Non-contact radar instruments rely on antennas to direct microwave energy into the vessel, and to receive the echo (return) energy. These antennas must be kept clean and dry, which may be a problem if the liquid being measured emits condensable vapors.

For this reason, non-contact radar instruments are often separated from the vessel interior by means of a dielectric window .

Continuous Pressure Measurement

Continuous Level measurements

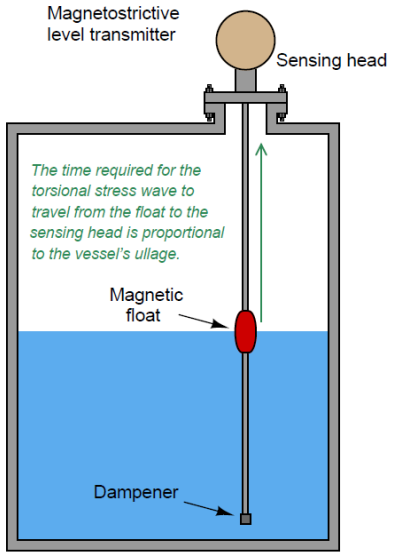
1- Radar Level Transmitter---- How to Select

Power Supply
Pressure:
Output / Relay output:
Protection:
Measuring Range / Accuracy
Beam Angle
Type (Guided Wave)
Cable Length

Continuous Pressure Measurement

Continuous Level measurements

3- Magnetostrictive Level Transmitter



A variation on the theme of echo-based level instruments, where the level of some process material in a vessel is measured by timing the travel of a wave between the instrument and the material interface through float-type instruments

In a magnetostrictive level instrument, liquid level is sensed by a lightweight float containing a magnet.

This float is centered around a long metal rod called a waveguide, hung vertically in the process vessel so that the float may rise and fall with process liquid level.

The magnetic field from the float's magnet at that point, combined with the magnetic field produced by an electric current pulse periodically sent through the rod, generates a torsional stress pulse at the precise location of the float. This torsional (twisting) stress travels at the speed of sound through the rod toward either end. At the bottom end is a dampener device designed to absorb the mechanical wave.

Continuous Pressure Measurement

Continuous Level measurements

3- Magnetostrictive Level Transmitter

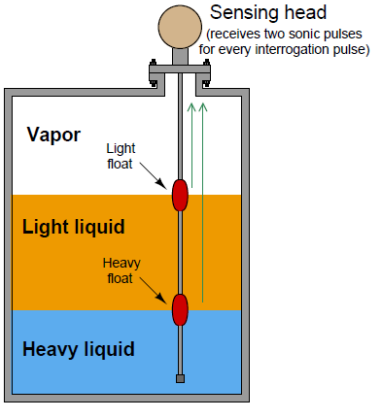
A mechanical wave (pulse) is generated at the location of a magnetic float in response to an electrical pulse.

At the top end of the rod (above the process liquid level) is a sensor and electronics package designed to detect the arrival of the mechanical wave.

A precision electronic timing circuit measures the time elapsed between the electric current pulse and the received mechanical pulse.

Continuous Pressure Measurement

Continuous Level measurements



3- Magnetostrictive Level Transmitter (Interface Level)

It is even possible to measure liquid-liquid interfaces with magnetostrictive instruments.

If the waveguide is equipped with a float of such density that it floats on the interface between the two liquids , the sonic pulse generated in the waveguide by that float's position will represent interface level.

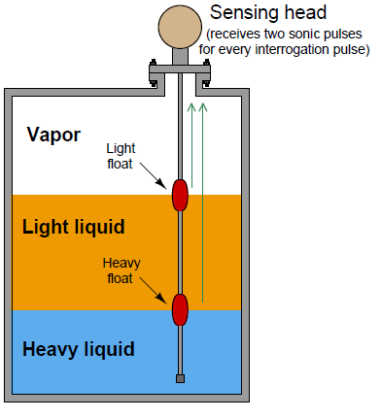
Magnetostrictive instruments may even be equipped with two floats:

one to sense a liquid-liquid interface,
and the other to sense the liquid-vapor interface, so that it may measure both the interface and total levels simultaneously just like a guided-wave radar transmitter .

Continuous Pressure Measurement

Continuous Level measurements

3- Magnetostrictive Level Transmitter (Mechanical interface issue)



In order for the magnetostrictive effect to be strong, the magnet inside the float must be in close proximity to the rod.

This means the inside diameter of the donut-shaped float must fit closely to the outside diameter of the waveguide. Any fouling of the waveguide's or float's surfaces by suspended solids, sludge, or other semi-solid materials may cause the float to bindand therefore not respond to changes in liquid level.

Continuous Pressure Measurement

Continuous Level measurements

3- Magnetostrictive Level Transmitter---- How to Select

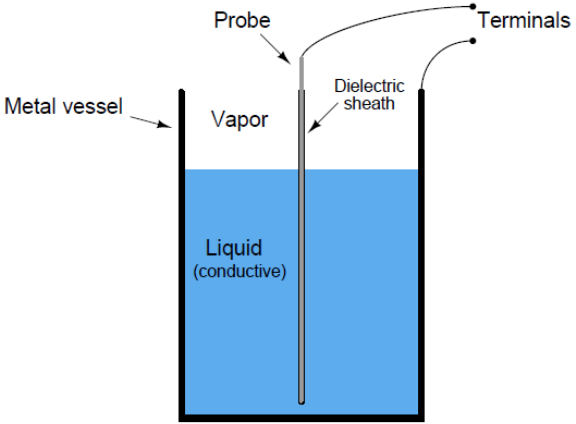
Power Supply
Pressure:
Output / Relay Output:
Protection:
Measuring Range
No of floats
Rod Material
Liquid Densities

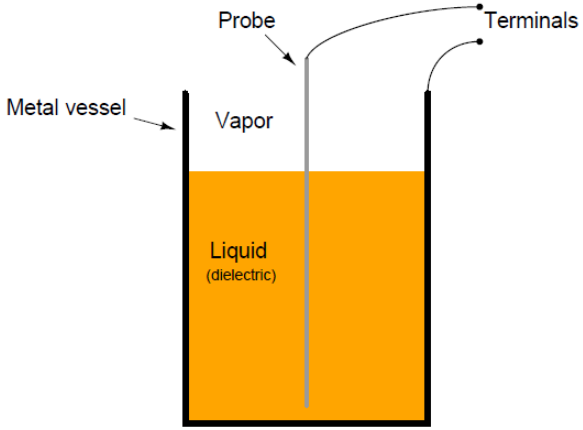
Continuous Pressure Measurement

Continuous Level measurements

4- Capacitive Level Transmitter

The basic principle behind capacitive level instruments is the capacitance equation: $C = \frac{\epsilon A}{d}$





Continuous Pressure Measurement

Continuous Level measurements

4- Capacitive Level Transmitter---- How to Select

Power Supply
Pressure:
Output / Relay Output:
Protection:
Approvals
Process Connection
Process Temperature
Measuring Range

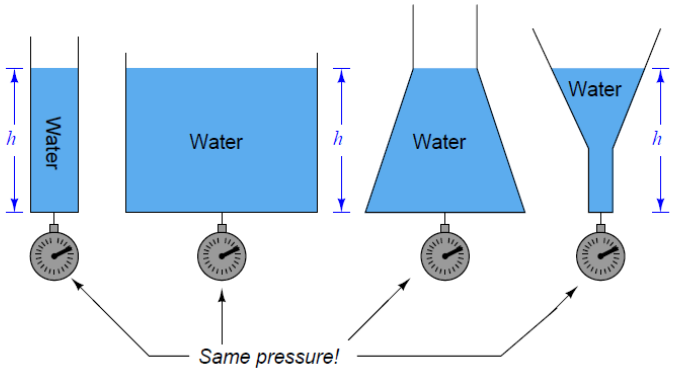
Continuous Pressure Measurement

Continuous Level measurements

5- Hydrostatic Level Transmitter

A vertical column of fluid generates a pressure at the bottom of the column owing to the action of gravity on that fluid.

The greater the vertical height of the fluid, the greater the pressure.



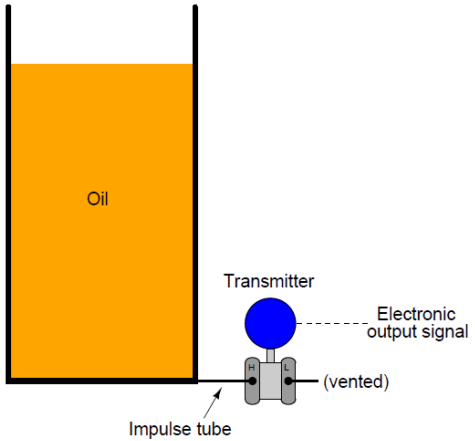
The mathematical relationship between liquid column height and pressure is as follows:

$$P = \rho g h \qquad P = \gamma h$$

Continuous Pressure Measurement

Continuous Level measurements

5- Hydrostatic Level Transmitter



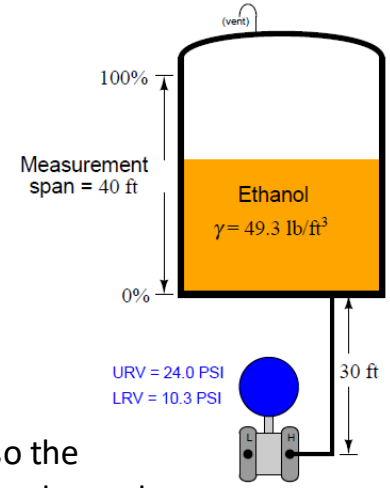
The calibration table for a transmitter close-coupled to the bottom of an oil storage tank would be as follows, assuming a zero to twelve foot measurement range for oil height, an oil density of 40 pounds per cubic foot, and a 4-20 mA transmitter output signal range:

Oil level	Percent of range	Hydrostatic pressure	Transmitter output
0 ft	0 %	0 PSI	4 mA
3 ft	25 %	0.833 PSI	8 mA
6 ft	50 %	1.67 PSI	12 mA
9 ft	75 %	2.50 PSI	16 mA
12 ft	100 %	3.33 PSI	20 mA

Continuous Pressure Measurement

Continuous Level measurements

5- Hydrostatic Level Transmitter - Transmitter suppression and elevation



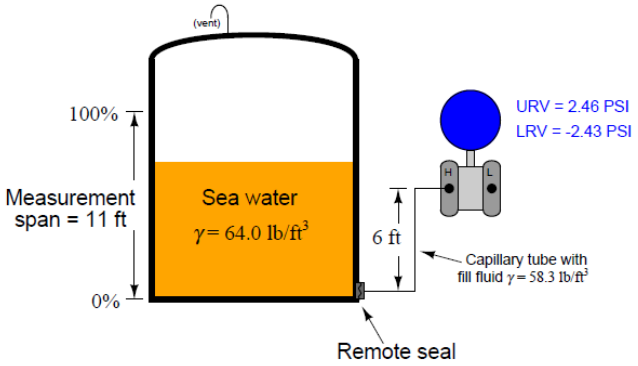
This means the transmitter's impulse line contains a 30-foot elevation head of ethanol, so the transmitter "sees" 30 feet of ethanol when the tank is empty and 70 feet of ethanol when the tank is full. A 3-point calibration table for this instrument would look like this, assuming a 4 to 20 mA DC output signal range:

Ethanol level in tank	Percent of range	Pressure (inches of water)	Pressure (PSI)	Output (mA)
0 ft	0 %	284 "W.C.	10.3 PSI	4 mA
20 ft	50 %	474 "W.C.	17.1 PSI	12 mA
40 ft	100 %	663 "W.C.	24.0 PSI	20 mA

Continuous Pressure Measurement

Continuous Level measurements

5- Hydrostatic Level Transmitter - Transmitter suppression and elevation



If the transmitter is elevated above the process connection point, it will most likely "see" a negative pressure (vacuum) with an empty vessel owing to the pull of liquid in the line leading down from the instrument to the vessel.

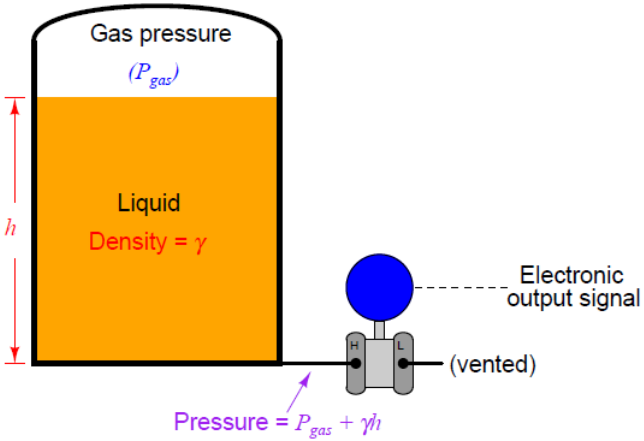
It is vitally important in elevated transmitter installations to use a remote seal rather than an open impulse line, so liquid cannot dribble out of this line and into the vessel .

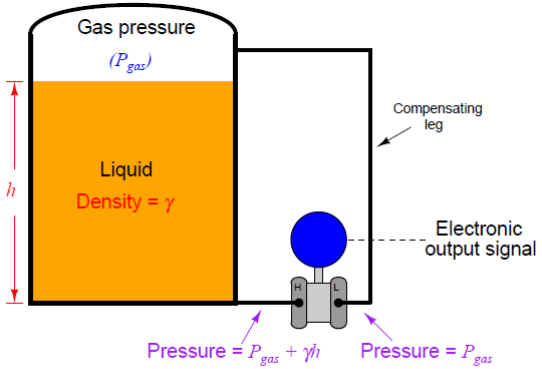
The transmitter elevation is 6 feet, which means it will "see" a vacuum of −2.43 PSI .

Continuous Pressure Measurement

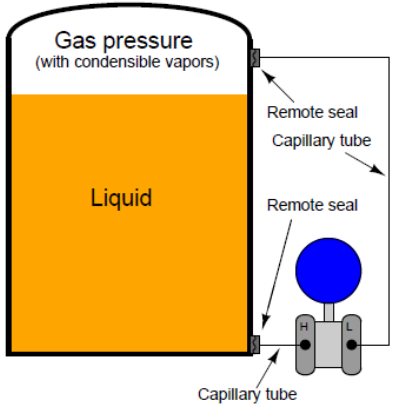
Continuous Level measurements

5- Hydrostatic Level Transmitter – Compensated Leg System





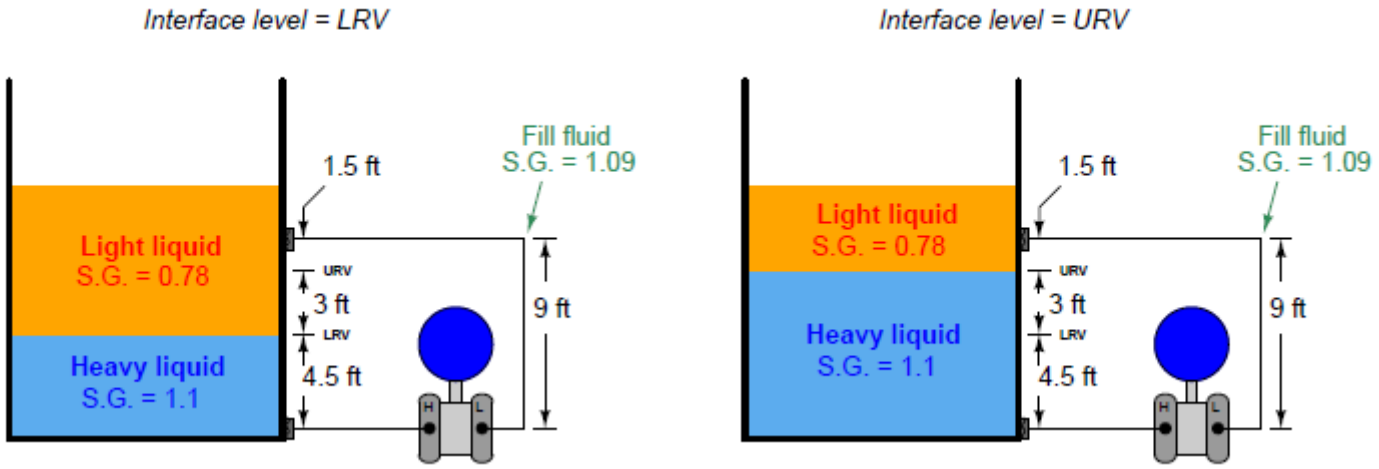
$$(P_{gas} + \gamma h) - P_{gas} = \gamma h$$



Continuous Pressure Measurement

Continuous Level measurements

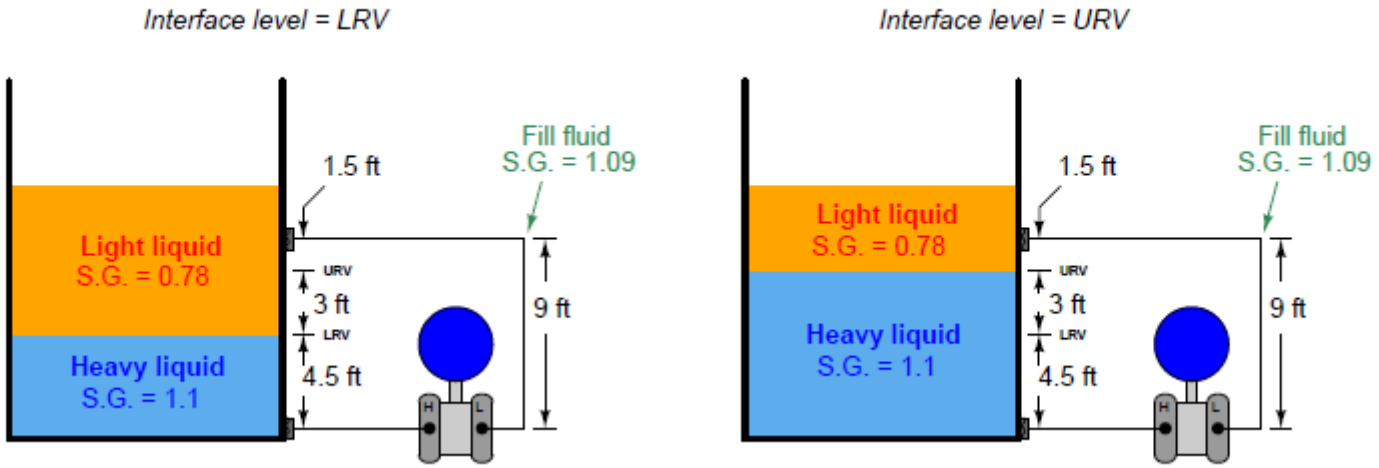
5- Hydrostatic Level Transmitter – Compensated Leg System



Continuous Pressure Measurement

Continuous Level measurements

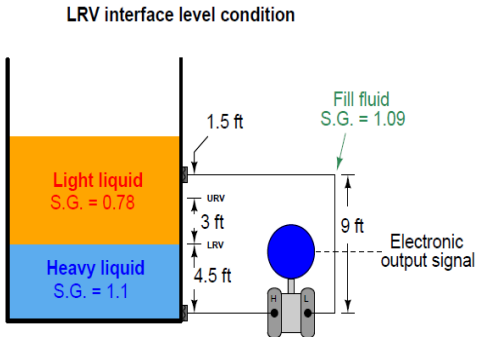
5- Hydrostatic Level Transmitter – Compensated Leg System



Continuous Pressure Measurement

Continuous Level measurements

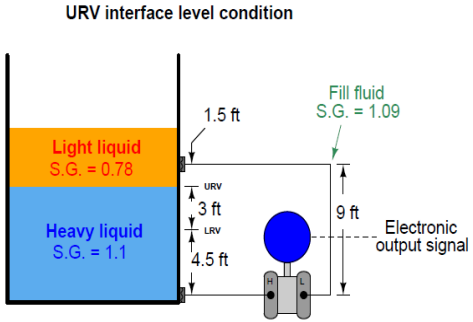
5- Hydrostatic Level Transmitter – Compensated Leg System



Continuous Pressure Measurement

Continuous Level measurements

5- Hydrostatic Level Transmitter – Compensated Leg System



Continuous Pressure Measurement

Continuous Level measurements

5- Hydrostatic Level Transmitter---- How to Select

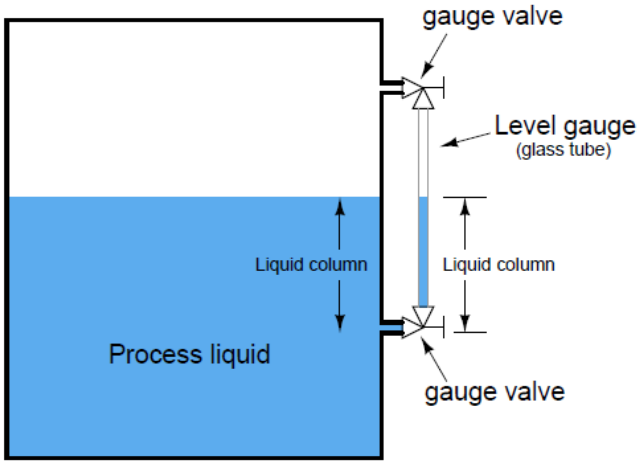
Process temperature:
Pressure:
Output / Relay output:
Protection:
Process Connection
Diaphragm Material
Remote Seal
Type

Continuous Pressure Measurement

Continuous Level measurements – Passive LG

1- Level Gauge

The level gauge, or sight glass is to liquid level measurement as manometers are to pressure measurement. A very simple and effective technology for direct visual indication of process level.



Continuous Pressure Measurement

Continuous Level measurements – Passive LG

1- Level Gauge - Limitation

- Glass Weakness

weakness of glass-tube level gauges is the glass tube itself. The tube must be kept in a clean condition in order for the liquid level to be clearly visible, which may be a problem in a dirty-liquid service. Also, glass tubes may rupture if subjected to thermal or mechanical shock.

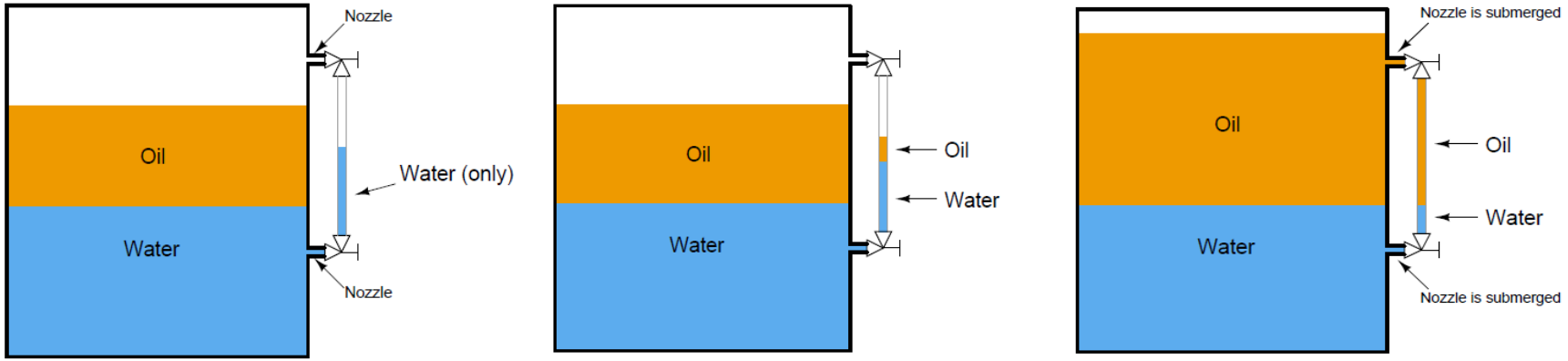
One solution to this problem is to eliminate the glass tube entirely, replacing it with a non-magnetic metal tube (e.g. stainless steel) containing a magnetized float, with magnet-sensing indicator flags outside of this tube to visually indicate level

Continuous Pressure Measurement

Continuous Level measurements – Passive LG

1- Level Gauge - Limitation

- Level Interface

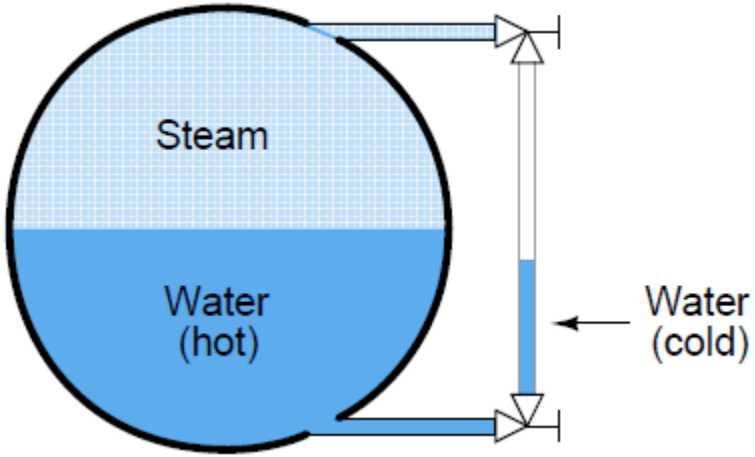


Continuous Pressure Measurement

Continuous Level measurements – Passive LG

1- Level Gauge - Limitation

- Temperature



Continuous Pressure Measurement

Continuous Level measurements

1- Level Gauge---- How to Select

Process temperature:
Pressure:
Output:
Protection:
Process Connection
Accuracy
Magnetic Switches
Application

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