Pressure Measurement

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TECH 3821
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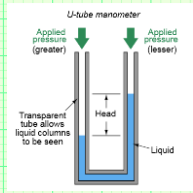
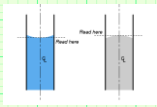
Manometers

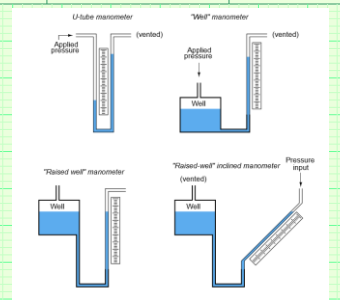
- Manometer: a fluid-filled tube where an applied gas pressure causes the fluid height to shift proportionately. This is why pressure is often measured in units of liquid height (e.g. inches of water, inches of mercury).





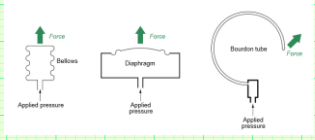
Liquid column height in a manometer should always be interpreted at the centerline of the liquid column, regardless of the shape of the liquid's meniscus (the curved air/liquid interface)

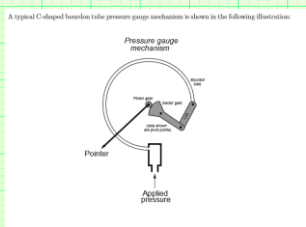
Types of Manometers

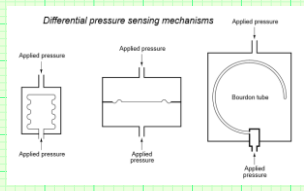


Mechanical Pressure Elements

- converts a fluid pressure into a force



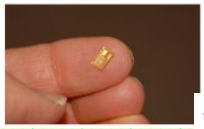


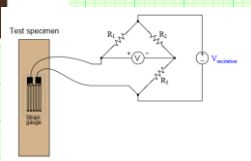


Converting to Electrical Signals

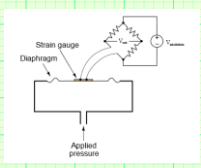
19.3.1 Piezoresistive (strain gauge) sensors

Piezoresistive means "pressure-sensitive resistance," or a resistance that changes value with applied pressure. The *strain gauge* is a classic example of a piezoresistive element, a typical strain gauge element shown here on the tip of my finger:





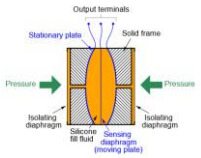
Converting to Electrical Signals



Converting to Electrical Signals

19.3.2 Differential capacitance sensors

Another common electrical pressure sensor design works on the principle of *differential capacitance*. In this design, the sensing element is a taut metal diaphragm located equidistant between two stationary metal surfaces[1], comprising three plates for a complementary pair of capacitors. An electrically insulating fill fluid (usually a liquid silicone compound) transfers motion from the isolating diaphragms to the sensing diaphragm, and also doubles as an effective dielectric for the two capacitors:



Converting to Electrical Signals

19.3.3 Resonant element sensors

As any guitarist, violinist, or other stringed-instrument musician can tell you, the natural frequency of a tensed string increases with tension. This, in fact, is how stringed instruments are tuned: the tension on each string is precisely adjusted to achieve the desired resonant frequency.

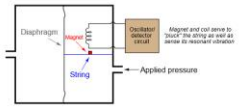
Mathematically, the resonant frequency of a string may be described by the following formula:

$$f = \frac{1}{2L}\sqrt{\frac{Ft}{\mu}}$$

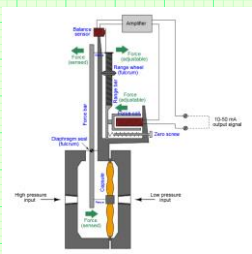
Where,

f = Fundamental resonant frequency of string (Hertz)
L = String length (meters)
Ft = String tension (newtons)
μ = Unit mass of string (kilograms per meter)

It stands to reason, then, that a string may serve as a force sensor. All that is needed to complete the sensor is an oscillator circuit to keep the string vibrating at its resonant frequency, and that frequency becomes an indication of tension (force). If the force originates from pressure applied to some sensing element such as a bellows or diaphragm, the string's resonant frequency will indicate fluid pressure. A proof-of-concept device based on this principle might look like this:



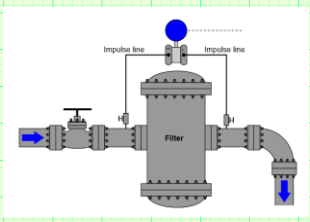
Force Balance



Examples

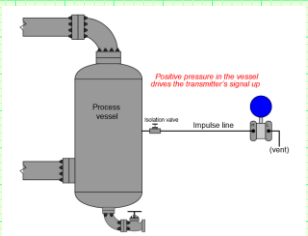
Applications

- Clogged Vessel / Filter



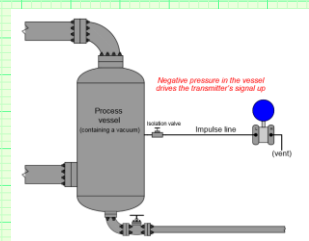
Applications

- Measuring positive gauge pressure



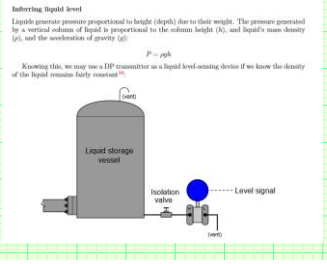
Applications

- Measuring Vacuum



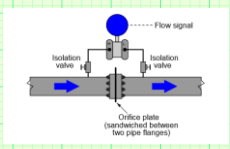
Applications

- Inferring Liquid Level



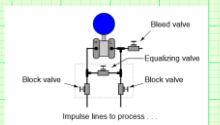
Applications

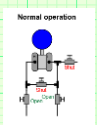
- Inferring gas and liquid flow

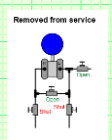


Servicing

- Valve manifolds are used so that pressure sensors can be removed for servicing without disrupting the process:

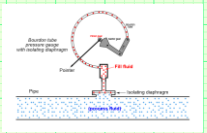


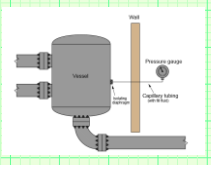




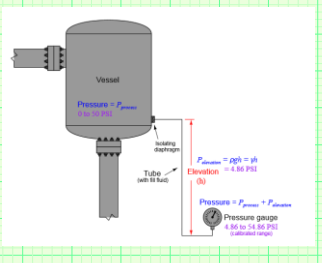
Isolation

- Isolation diaphragms are sometimes used to isolate the pressure sensor or gauge from corrosive chemicals etc





- Problem with remote diaphragms



Purges