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Course Code : AE482
Course Name : Industrial Instrumentation
Total no: of Pages : 17.

Part A

1

a) Resistivity of Metals depends on their temperature. A metallic resistance element changes its ~~res~~ resistance with temperature in a very specific manner. A resistance temperature detector (RTD) can also be called a resistance thermometer. The increasing electrical resistance of conductors with increasing temperature. When the temperature of an object increase or decreases, the resistance also increases or decreases proportionally. A resistive material with leads attached and usually placed into a protective sheath.

Resistance at any particular temperature

$$R = R_0 \left[1 + \alpha_1 T + \alpha_2 T^2 + \cdots \alpha_n T^n\right].$$

$$R_t = R_0 \left[1 + \alpha T\right]$$

Working

An RTD works by using a basic principle, — as the temperature of a metal increases,

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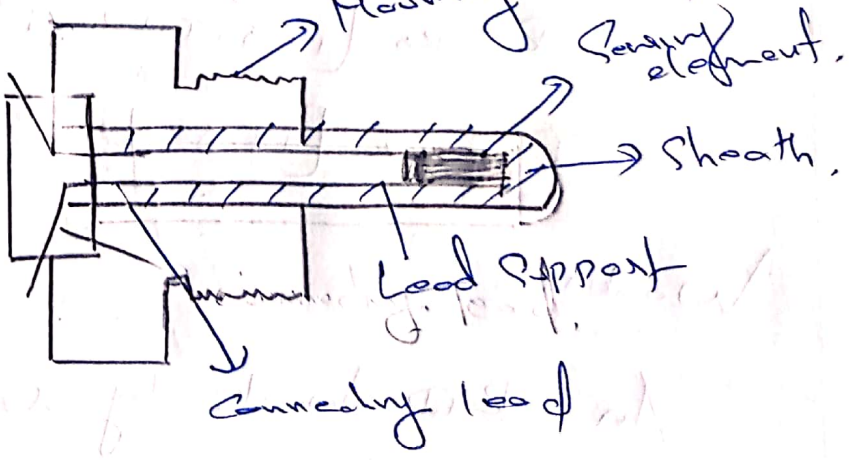
So does the resistance to the flow of electricity. RTD consists of a resistance element and insulated copper wires.

The most common RTDs have 3 or 4 wires. The resistive element is a temperature sensing element of the RTD

An electric current is passed through the sensor, the resistance element is used to measure the resistance of the current being passed through it. As the temperature of the resistance element increases, the electric resistance also increases. The resistance value can be converted into temperature based on the characteristics of the element.



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1.

b) Pneumatic Pyrometers

The Pneumatic Probe was invented in 1893 for use in blast furnace. It is superior to suction in that duct in the combustion. Gases do not plug it as easily and that it can measure very high temperature such as in turbojet engines & rockets. This Pyrometer can detect higher gas temperatures that can be aspirating TC because the thermometer doesn't need to reach the gas temperature. The Pneumatic probe can handled gases heavily loaden with dust because it does not have a radiation shield, which is prone to plug.

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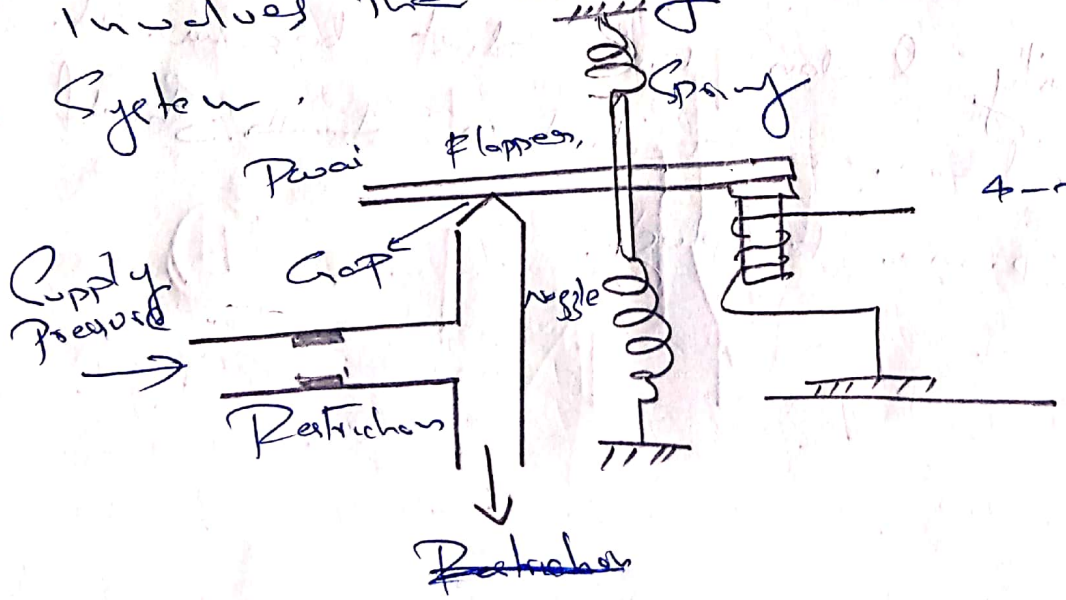
2 a) I/p Converter

* It is also known as Current to Pressure Converter.
* I/P Converter is a very important element in Proces Control.
* I/P Converter gives us a linear way of translating the 4-20mA Current into a 0.2 to 1 kg/cm2 Signal. [3-15 PSI Signal]
* Figure below shows a simple way to Construct I/P Converter
* The basic principle of this design involves the use of a Flapped/Nozzle System.



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A high current produces a high pressure so that the device is direct acting

Adjustment of the springs and perhaps the position relative to the pivot to the position relative to the pivot to which they are attached allows the unit ~~which they are~~ to be calibrated so that 4mA corresponds to 0.2 kg/cm² and 20 mA corresponding to 1 kg/cm²

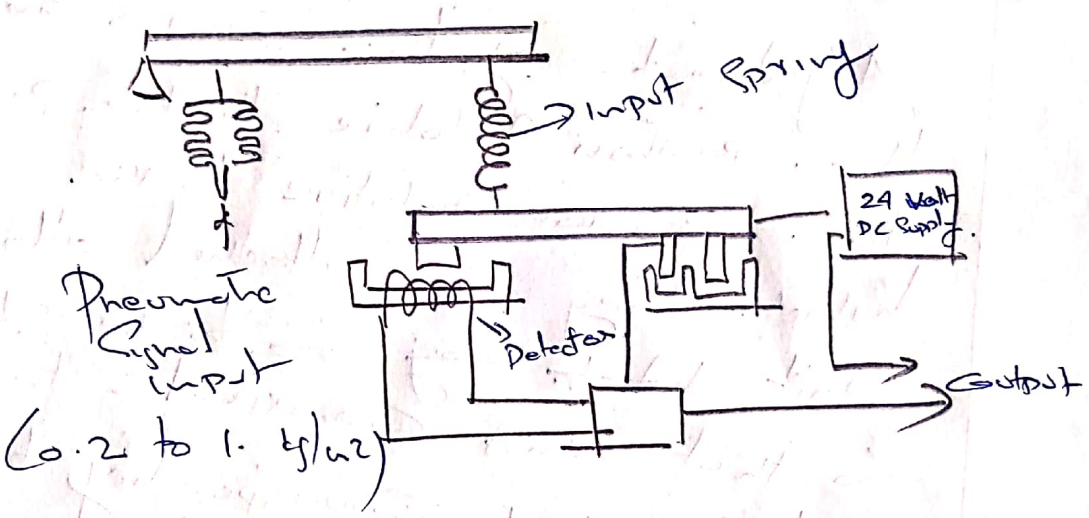
P/I Converter or Pneumatic-Electric Converter

→ This is also known as pressure to current converter.

→ This transducer converts the measurement input which is in the form of 0.2 to 1 kg/cm² (Pneumatic) to electrical output.

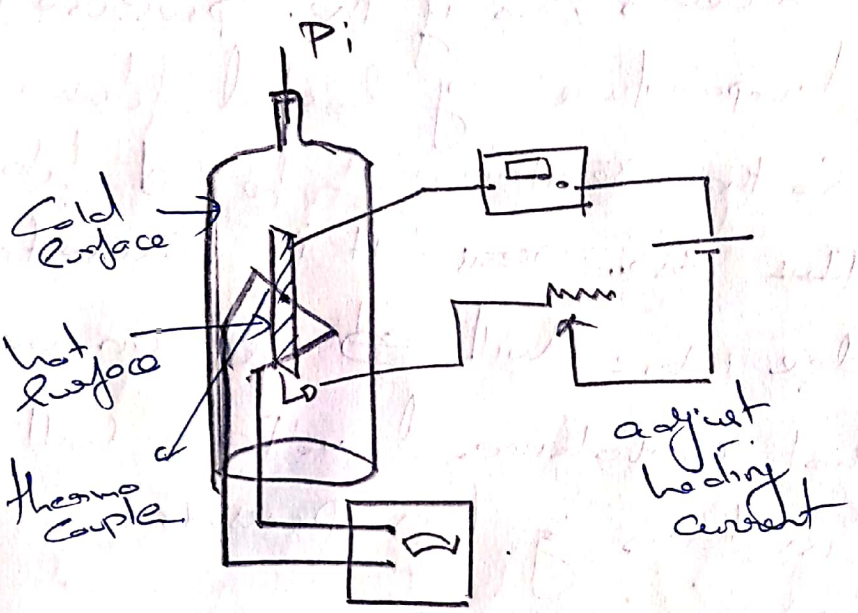
→ Figure shows P/I converter design.

→ Here a change in pneumatic input signal (0.2 to 1 kg/cm²) brings change in air gap of the detector ~~assembly~~ assembly



2 b) Thermocouple Gauge

In thermocouple gauge the response time is quite fast. Its principle is based on the thermal conductivity. Figure shows the schematic of a thermocouple vacuum gauge. The hot surface is a thin metal strip whose temperature may be varied by changing the current passing through it. For a given heating current and gas, the temperature assumed by the hot surface depends on pressure. The cold surface here is the glass tube, which usually is near the room temperature

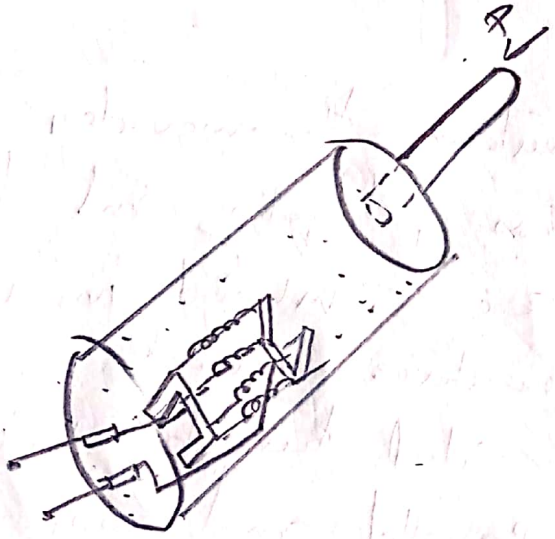


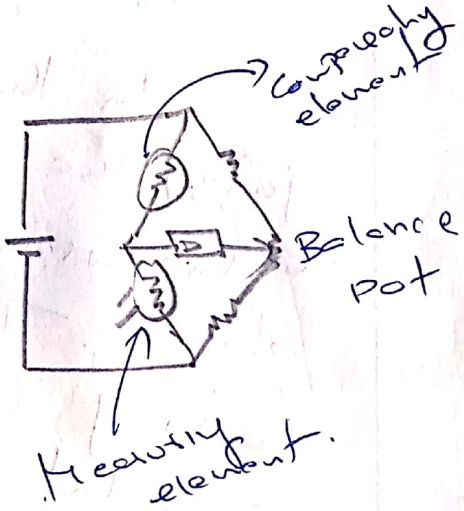
Pirani Gauge

In the resistance thermometer gauge, the function of heating and temperature measurement are combined in a single element. The resistance element is in the form of four coiled tungsten wires connected in parallel and supported inside a glass tube to which the gas is admitted. Again the cold surface is a glass tube.

Here also the principle is at low

temperature the effective Conductivity of the ~~Gas~~ Gases decreases, So if the pressure is low the temperature of heated filament will rise, So the resistance of heated filament also rise. ~~This then seen~~. It is connected to a bridge, we will ~~get~~ get an unbalanced voltage. That unbalanced voltage will be Calibrated in terms of low Pressure.





Part C

Hot Wire Anemometer

7 a) Popular for the measurement of Unsteady flow of ~~gas~~ gases.

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The basic s/m consists of an electrically heated wire suitably mounted in the flowing fluid. Due to change in velocity of fluid flow, the heat losed by the hot wire will also change.

* The relation b/w this loss of heat and fluid flow can be derived.
* This heat loss changes the temp and ct. as consequences resistence of the hot wire changes
* This generally changes the current through the hot wire for the constant voltage supply
* There are two basic technique.

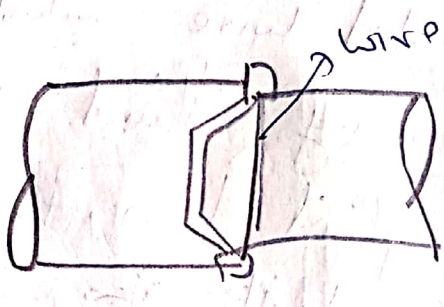
1.) By measuring resistence keeping the current constant

2) By measuring the current keeping the temperature constant.

* The thermo element is generally made of platinum wire having a diameter of 0.0005 to 0.003 cm. and a length of 0.1 to 1 cm depending

of the flow channel diameter.

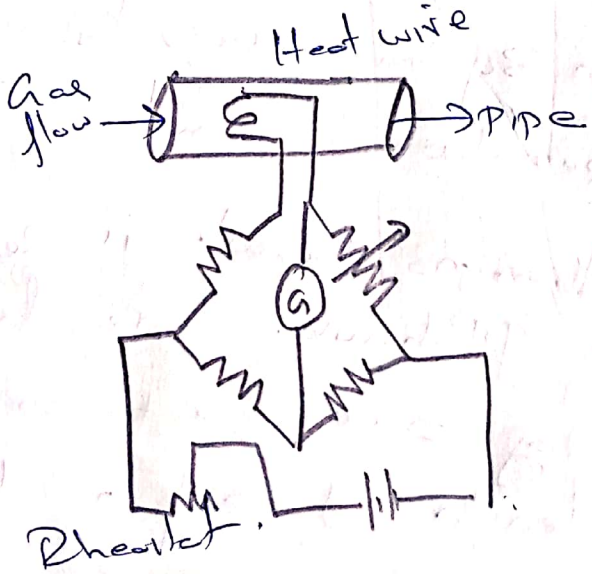
~~the heat transfer~~



Constant Current Method.

In constant current method, the anemometer is placed in the stream of the fluid whose flow rate needs to be measured.

The current of constant magnitude is passed through the wire. The wheatstone bridge is also kept on the constant voltage.



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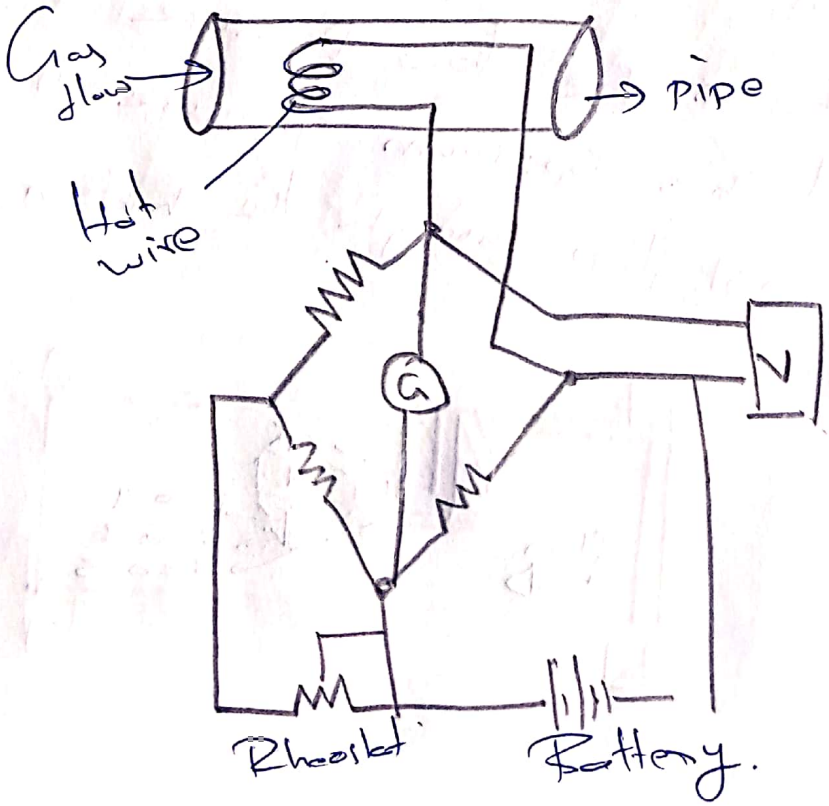
Constant temperature method

* In this arrangement the wire is heated by the electric current.
* The hot wire when placed in the fluid stream, the heat transfer from wire to the fluid
* Thus, the temperature of the wire changes. Which also changes their resistance.
* It works on the principle that the temperature of the wire remains constant.



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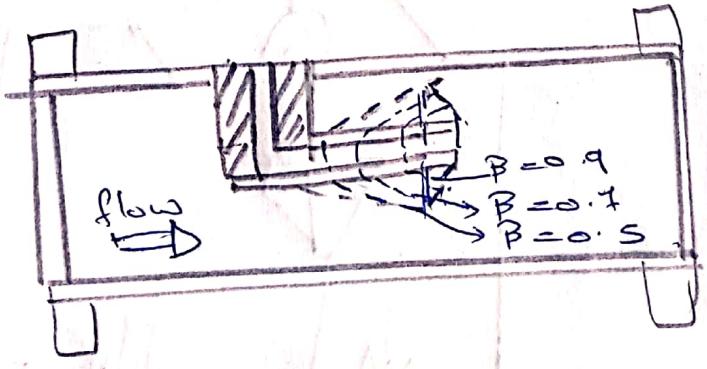
7 b)

V Cone flow meters

* In a Venturi-Cone meter, a cone is positioned in the centre of a metering tube
* This cone reduces the cross sectional area available for the process flow and, much like an orifice restriction generated a low pressure region downstream of the flow element.
* The square root of the difference between the low pressure downstream and the upstream pressure is related to the flow through the meter



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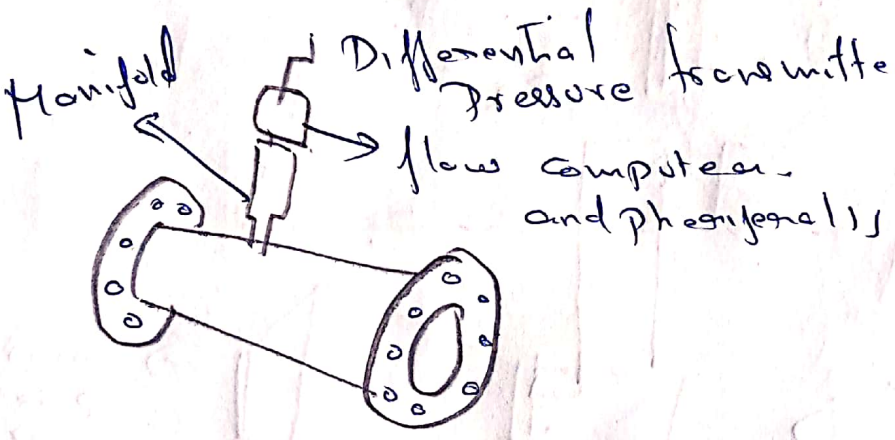

Principle & operation

* The V Cone flow meter is a differential Pressure type flow meter
* The Principle theory is Bernauli's theorem. for a Constant flow, the Pressure in a Pipe is inversely proportional to the Square of the velocity in the Pipe
* The DP created by a V cone FM will increase and decrease exponentially with the flow velocity. As the Contraction takes up more of the pipes Cross Sectional area more diff Press, will be Created at the same flow rate

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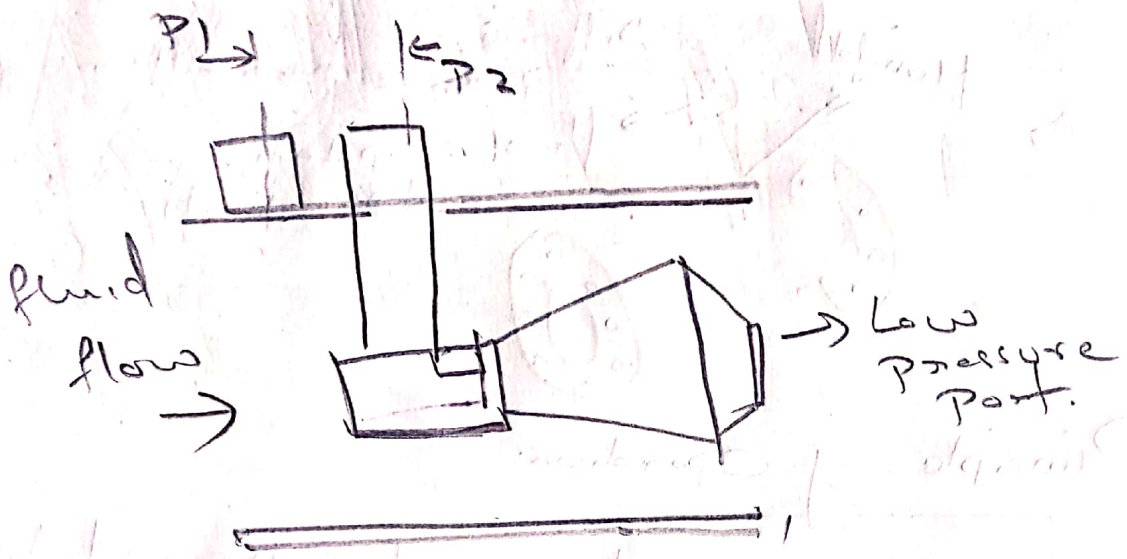

$$Q = 29.808 \times \frac{\beta^2 \times D^3 \times \sqrt{\Delta P}}{\sqrt{1-\beta^4}}$$

$$\Delta P = \frac{Q^2 \times (1-\beta^4)}{888.517 \times \beta^4 \times D^4}$$

Q ⇒ Water flow in GPM.

D ⇒ Inside diameter of the process Pipe in inches.

d ⇒ outside diameter of the cone in inches.

ΔP ⇒ pressure drop at full flow in PSD

β ⇒ Beta ratio defined as $\frac{\sqrt{D^2-d^2}}{D}$.

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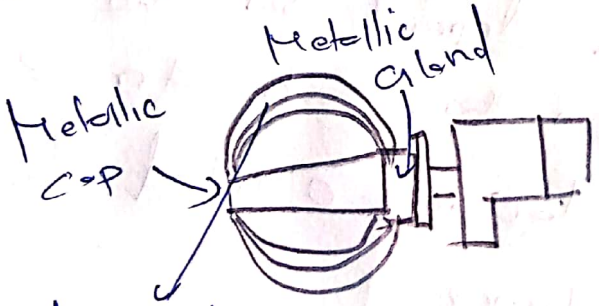
8

a) i) Field effect level Switches

* Field effect Probe Creates a field between a metallic cap cast into a Rylon Probe and the metal in the tank or in the Probe gland and Probe housing
* When a Conductive or nonconductive liquid, slurry, or solid material, breaks the field lines, the high frequency current increases, and the relay trips.

The Probe should be installed horizontally, with a small downward angle, if installed on slurry Services.



ii) Thermal level switches

Thermal level sensors used in on/off sources sense the difference in the thermal conductivity of the process materials

* The simplest of these design is where the sensors is used to detect a low level.

Two types

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b) The principle of capacitive level measurement is based on the capacitive change of a capacitor. The probe and the tank wall form a capacitor whose capacitance is depend on the amount of product in the tank. An empty tank has a lower, a filled tank a higher capacitance

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