Lecture 9
Chapter 9 Level

D/P method
other methods
+ transmitter

Level

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Level

- **Basic theory:**
  - Level is always relative to some datum (reference) that applies to that particular situation: bottom of the tank, bottom of the gauge glass, ground level
  - Depth: when assessing the quantity of liquid in a tank, level is often measured from the bottom
  - SI Units: m, mm
  - Methods: direct and indirect, most common – differential pressure
    - Differential pressure method
    - Resistance method
    - Capacitance method
    - Radiation method
    - Ultrasonic method

Chapter 9 Level

- Open tank level measurement

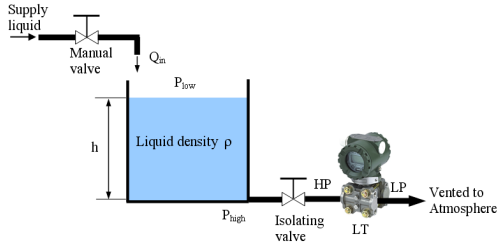

Figure 1 Open tank level measurement with the D/P method

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- **Example 1**
  - A level transmitter has output range of 4 mA to 20 mA. It is applied to an open tank level measurement. When the output reading is 12 mA, the tank is 50% level (5 m). Find the range of level the transmitter can measure and the differential pressure the transmitter actually measures (g = 9.81 m/s^2, and the liquid density = 1000 kg/m^3).

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- Closed Tank Level Measurement

$$\Delta P = P_{high} - P_{low} = \rho gh - \rho_g gh = (\rho - \rho_g)gh \qquad (2)$$

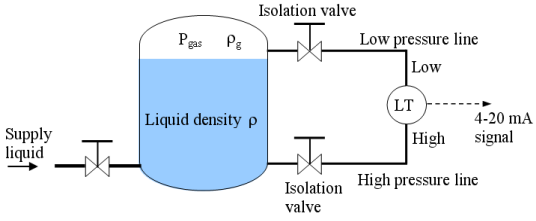

Figure 2 Closed tank level measurement system

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- Dry reference leg installation

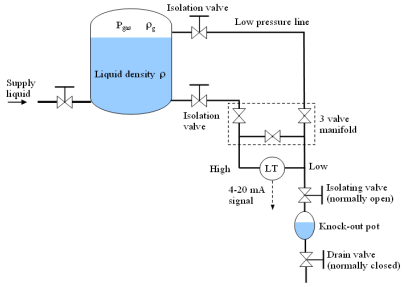

Figure 3 Dry reference leg installation with three-valve manifold

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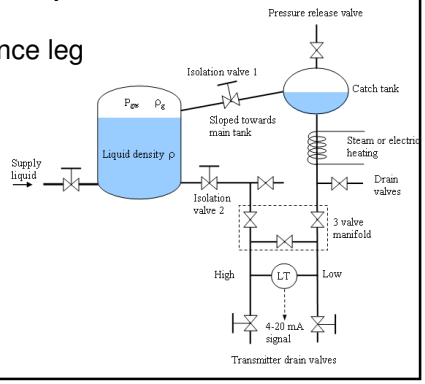
- Wet reference leg



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- A three –valve manifold

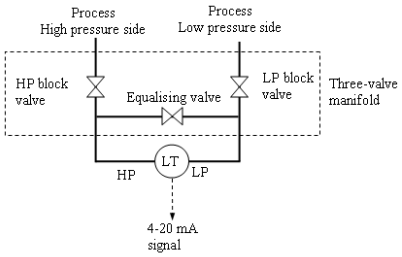

Figure 5a A three valve manifold

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- Bubble level measurement system

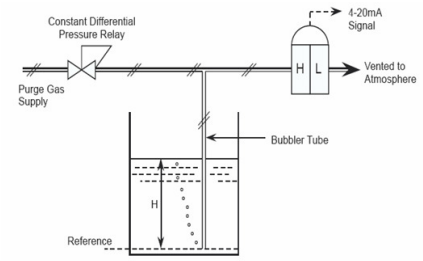

Figure 5b Bubble level measurement system in open tank

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- **Example 2**
  - A bubbler type level transmitter is being used to measure the depth in a tank containing diesel oil. If the level is being indicated at 9 m, what is the actual pressure being indicated by the transmitter at this time. [Density of diesel oil = 850kg/m^3]

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- Float and Resistance Level Transmitters

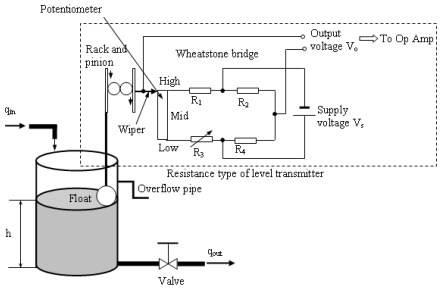

Figure 6 Arrangement of a resistance type level transmitter

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- Capacitance $C = K\frac{A}{D}$

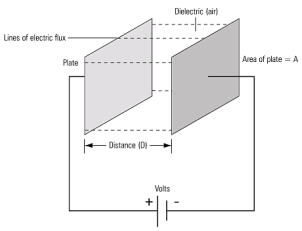

Figure 7 A capacitor

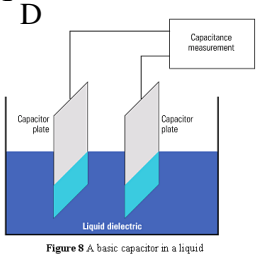

Figure 8 A basic capacitor in a liquid

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- Capacitance

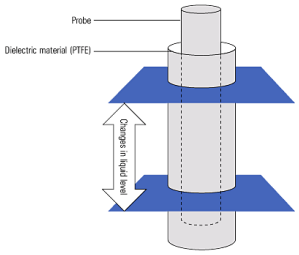

Figure 10 Capacitance in water

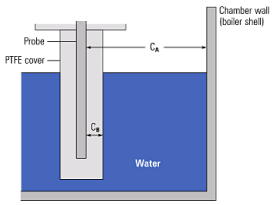

Figure 11 Components of a capacitor signal (not to scale)

Chapter 9

- Capacitance

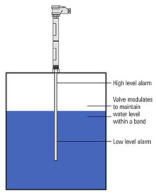

Figure 12 Typical control using a capacitance probe in a feedback (not to scale)

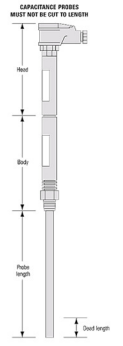

Figure 12 Typical capacitance probe (shown with head)

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- Radiation method

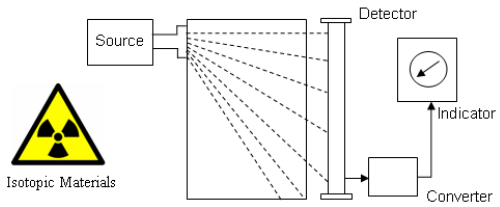

Figure 13 Radiation level measuring method

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- Ultrasonic method

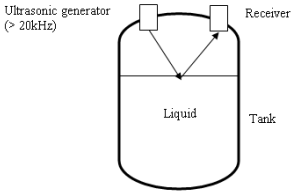

Figure 14 Ultrasonic method

Chapter 9 Level

- Applications of level transmitters
  - Indication
  - Level control

Other methods

- Sight glass (gauge glass) (Dunn, 2005)

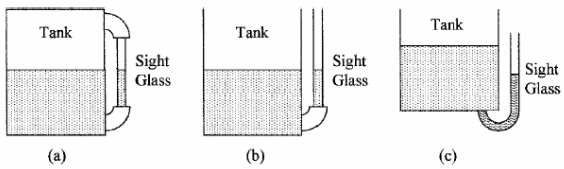

Figure 6.2 Various configurations of a sight glass to observe liquid levels (*a*) pressurized or closed container, (*b*) open container, and (*c*) higher density sight glass liquid.

Other methods: float and cable

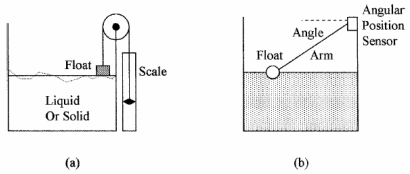

Figure 6.3 Methods of measuring liquid levels using (*a*) a simple float with level indicator on the outside of the tank and (*b*) an angular arm float.

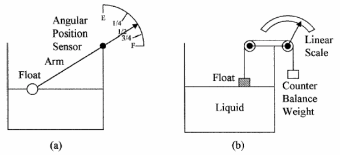

Figure 6.4 Scales used with float level sensors (*a*) nonlinear scale with angular arm float and (*b*) linear scale with a pulley type of float.

Chapter 9 Level

- Summary of Chapter 9
  - Functional uses of level detectors: to store or process materials.
  - Differential pressure method
  - Resistance method
  - Capacitance method
  - Radiation method
  - Ultrasonic method

Level measurement

- Question?

References & further reading

- LVDT Level Transmitter:
  - http://www.macrosensors.com/lvdt_macro_sensors/lvdt_applications/h20_level_measurement.pdf

Linear inductive LVDT sensors

The electromagnetic sensors in the induSENSOR series are based on the inductive measuring principle, the LVDT (Linear Variable Differential Transformer) principle and patented variants of these measuring methods. They are employed both in single and large-scale applications.

- induSENSOR EDS series
- induSENSOR LDR
- induSENSOR gaging series
- induSENSOR Sensors
- induSENSOR LVP
- induSENSOR VIP