

# The basics of DP level measurement

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# Pressure Basics

$$\text{Pressure} = \frac{\text{Force}}{\text{Cross Sectional Area}}$$

$$\text{Force} = \text{Mass} \times \text{Acceleration (g)}$$

$$\text{Mass} = \text{Volume} \times \text{Density } (\rho)$$

$$\begin{aligned} \text{Pressure} &= \frac{\text{Volume} \times \rho \times g}{\text{Cross Sectional Area}} \\ &= \rho \times g \times h \end{aligned}$$

$$\rho = \text{Ratio of Densities (RoD)} \times \rho_{\text{Reference}}$$

$$\text{Pressure} = \text{RoD} \times h$$

## Typical Units

### Metric

Bar, Pa (SI), N/m<sup>2</sup>,  
kg/cm<sup>2</sup> or ATM

### Imperial

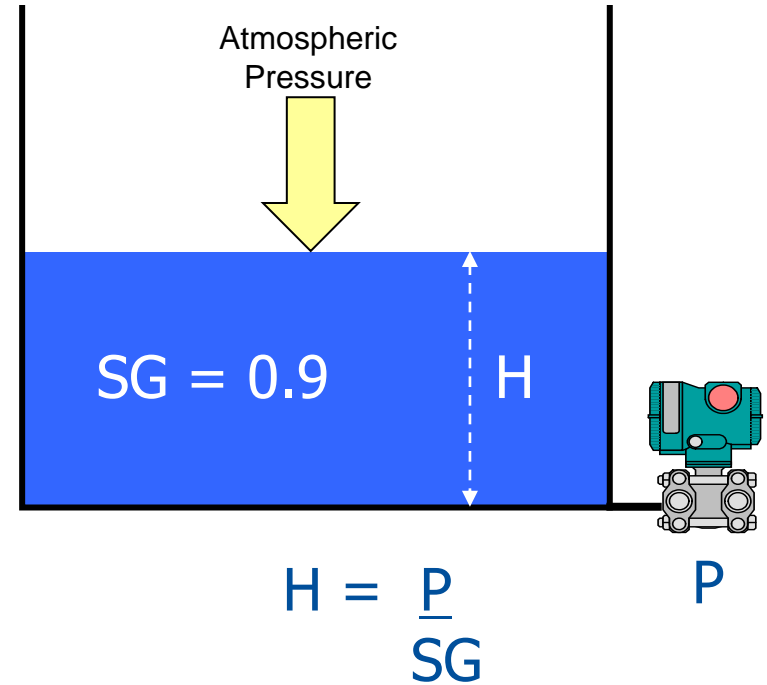
PSI

### Reference

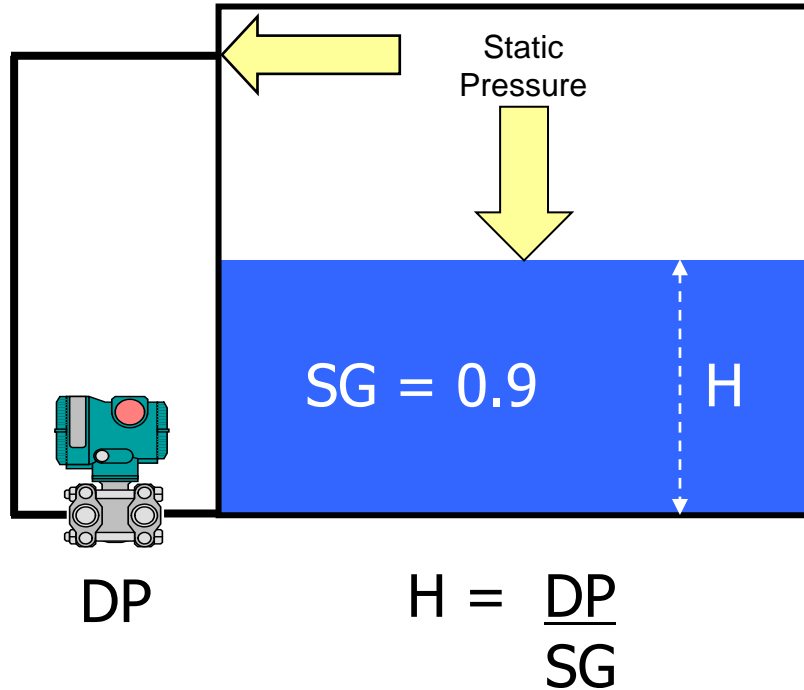
inH<sub>2</sub>O, mmH<sub>2</sub>O,  
mmHg or Torr

# DP Level (Open Tank)

- Have to assume the liquid density is constant
- Gauge transmitter will eliminate atmospheric pressure variations
- $P$  is directly proportional to liquid height ( $H$ )



# DP Level (Closed Tanks)



## Theory

- ◆ Liquid density is constant
- ◆ DP transmitter will eliminate static pressure
- ◆ DP is directly proportional to liquid height (H)

## Installation

- ◆ Dry or wet leg
- ◆ Diaphragm seals

# Why Use a Diaphragm Seal?

- Process Fluid
  - Is corrosive, toxic, highly viscous, very hot or cold...?
  - Can crystallise or polymerise...?
  - Requires hygienic cleanliness...?
- Increase Fill Fluid Volume
  - Will create additional inaccuracy
  - Will increase response time

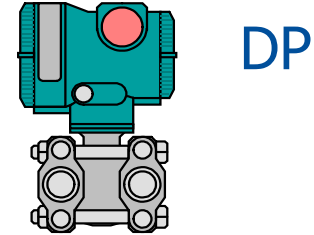


# DP vs Two Static Pressure (SP) Transmitters

## ■ DP Transmitter

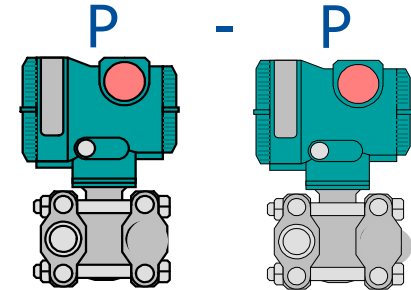
- ◆ DP accuracy +/- 0.04% of span
- ◆ SP accuracy

Accuracy  
Absolute Pressure  
1 MPa or higher:  $\pm 0.2\%$  of span  
Less than 1 MPa:  $\pm 0.2\% \times (1 \text{ MPa}/\text{span})$  of span



## ■ Two SP Transmitters

- ◆ SP accuracy +/- 0.04% of span
- ◆ DP accuracy +/- 0.056% of span\*



# Ambient Temperature – Seal Effects

- Same Variation on High & Low Side
- Countermeasure
  - ◆ Balanced diaphragm seals



# Volume Measurement





# Yokogawa Pressure Solutions

## DP<sub>harp</sub> Transmitters



DP<sub>harp</sub> **EJA**<sup>™</sup>



DP<sub>harp</sub> **EJX**<sup>™</sup>

DP Level (DRS)

DP Flow (MV)

Wireless

Advanced Diagnostics

Best in Class Performance

Safety as Standard

Multi-Sensing

Digital Sensor

DP<sub>harp</sub>  
FOR THE DIGITAL WORLD



excellence of italian engineering

**Technical Partners**  
Manifolds & diaphragm seals



Instrumentatie & Analyse Dagen 2017



Command 3  
Burst Mode

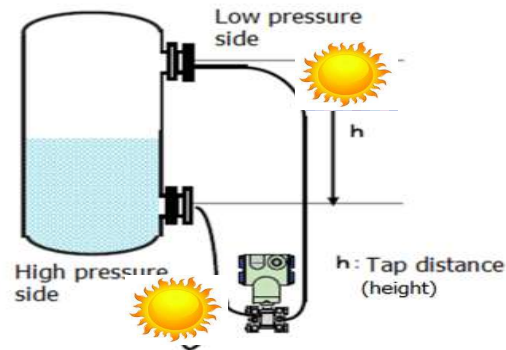


Multiple  
AI Blocks



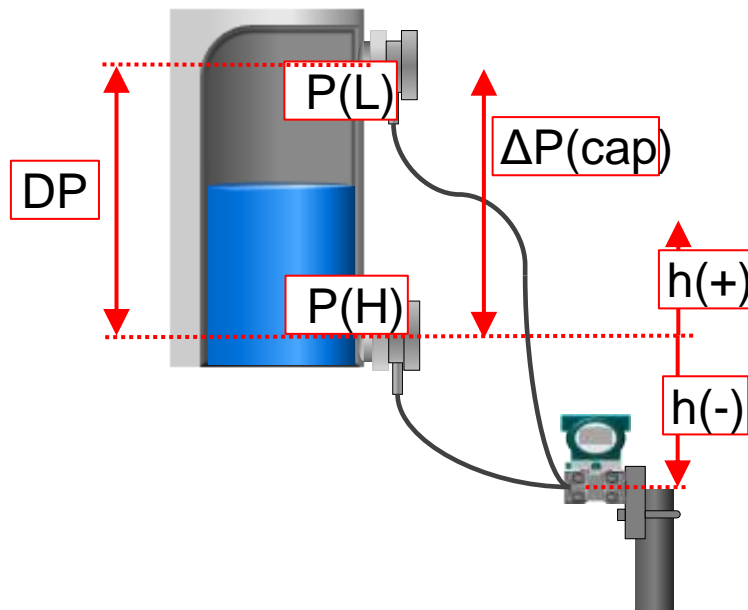
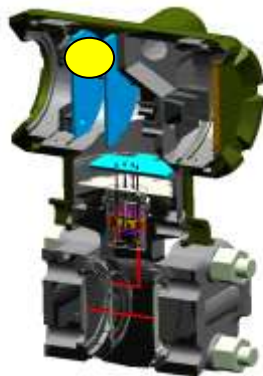
# Ambient Temperature – Head Effects

- Same Variation on High & Low Side
  - ◆ Increase in temperature will raise zero point
  - ◆ Decrease in temperature will lower zero point



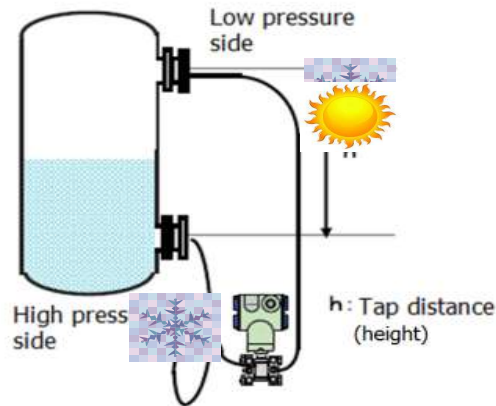
# Capillary Fill Fluid Density Compensation

- Temperature Compensation Mode
  - ◆ Using CPU (ambient) temperature
- Zero Shift Compensation
  - ◆  $DP = P(H) - P(L) + \Delta P(\text{cap})$



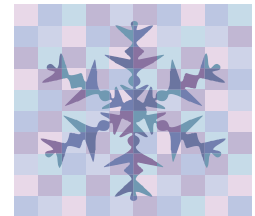
# Ambient Temperature – Seal & Head Effects

- Different Variation on High & Low Side
  - ◆ Solar radiation on one side


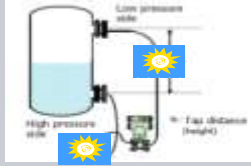
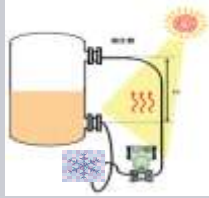



# Digital Remote Sensors (DRS)

- Better Measurement
  - ◆ DP (zero shift minimised)
  - ◆ LP (reduced seal effects)



# Comparison of DP Level Techniques

	Reference Accuracy	Ambient Temperature		Height
				
<b>DP Measurement</b>	<p>★★★★</p> <p>Constant accuracy regardless of SP</p>	<p>★★</p> <p>Capillary fill fluid density compensation</p>	<p>—</p> <p>Zero shift caused by solar radiation</p>	<p>★★</p> <p>Maximum capillary length (10-14 m)</p>
<b>DP Calculation</b>	<p>—</p> <p>Unsuitable for small DP in high pressure tanks</p>	<p>★★</p> <p>No affects using digital data communication</p>		<p>★★★★</p> <p>No limitation for cable length</p>

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**Thank you for your attention!**

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