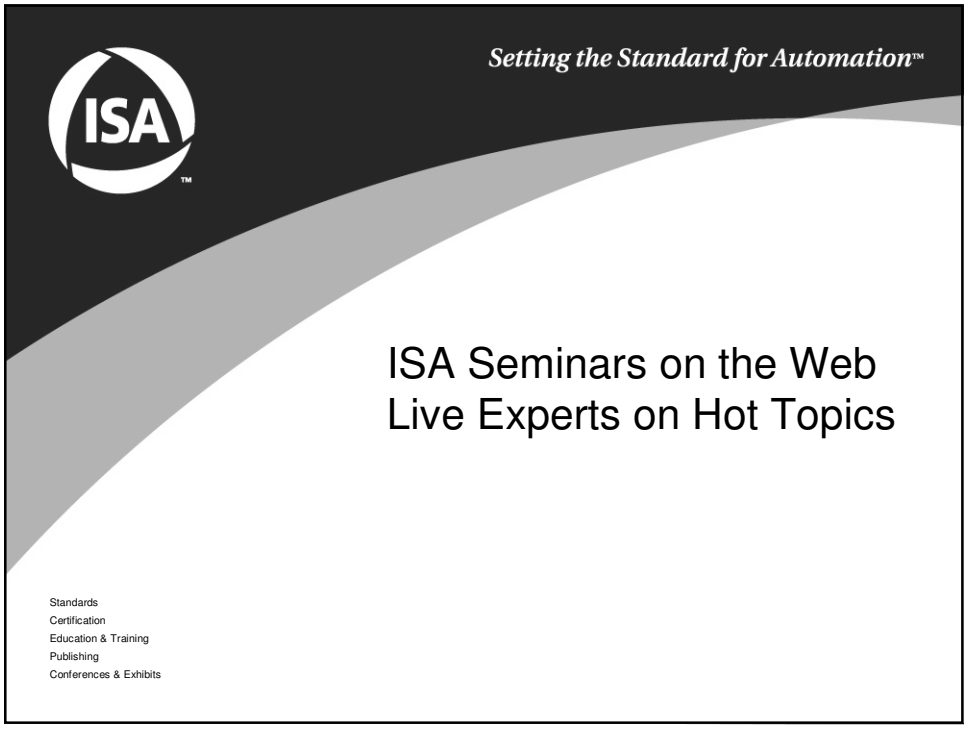
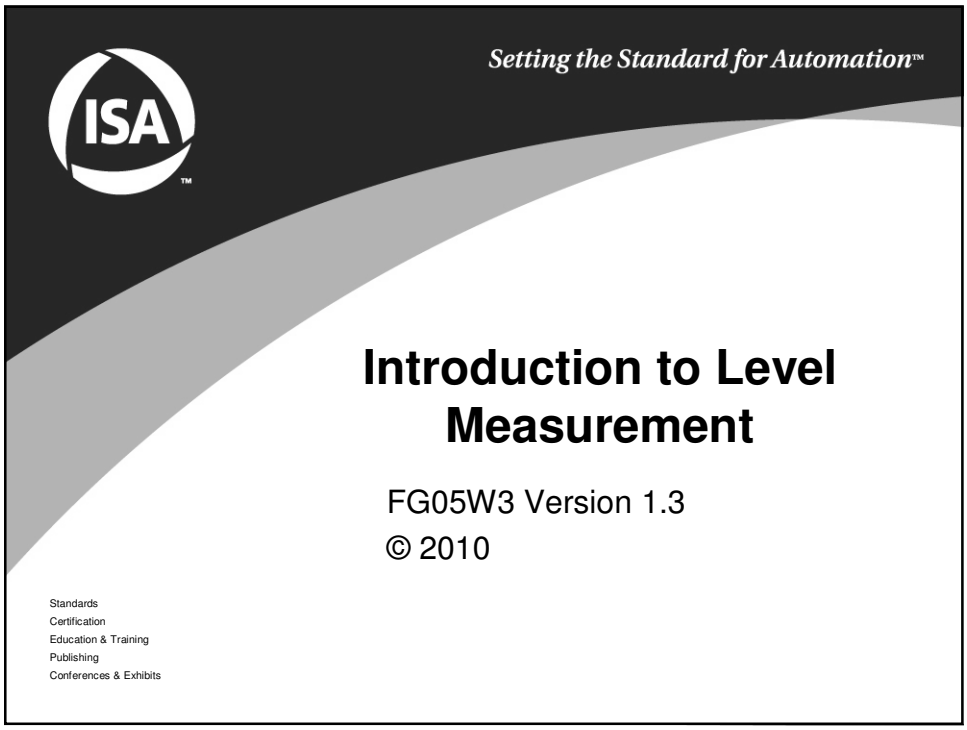

Setting the Standard for Automation™
ISA Seminars on the Web
Live Experts on Hot Topics
Standards
Certification
Education & Training
Publishing
Conferences & Exhibits


Setting the Standard for Automation™
Introduction to Level Measurement
FG05W3 Version 1.3
© 2010
Standards
Certification
Education & Training
Publishing
Conferences & Exhibits

## Seminar Logistics

- Seminar materials
  - Downloadable presentation
  - Question and Answer session (audio and email)
  - Survey
  - Earn 1.5 Professional Development Hours (PDH)
- Seminar length
  - 90 minute total presentation
  - Three approximately 20 minute instructional presentations
  - Three approximately 10 minute question and answer sessions

## Audio Instructions

- Please note the following during the seminar:
- As a participant, you are in a “listen-only” mode.
- You may ask questions via the internet, using your keyboard, at any time during the presentation.
- However, the presenter may decide to wait to answer your question until the next Q&A Session.
- If you have audio difficulties, press *0.

## Audio Instructions for Q & A Sessions

- Questions may be asked via your telephone line.
- Press the *1 key on your telephone key-pad.
- If there are no other callers on the line, the operator will announce your name and affiliation to the audience and then ask for your question.
- If other participants are asking questions, you will be placed into a queue until you are first in line.
- While in the queue, you will be in a listen-only mode until the operator indicates that your phone has been activated. The operator will announce your name and affiliation and then ask for your question.

## Introduction of Presenter

- Instructor
  - Name: William (Tim) Shaw – PhD, CISSP
  - Background/experience: Over 30 years of experience with computer based automation systems including developing three generations of DCS systems and two generations of SCADA systems. Former Adjunct Professor in the Graduate Engineering department of Loyola College in Baltimore. Authored books on Batch Process Control and on SCADA Cyber Security. Currently the Senior Consultant for Cyber SECurity Consulting, an industrial automation cyber security firm. Tim periodically teaches courses for ISA and IEEE.

Email: timshaw4@verizon.net

## Goals of this Session

- Explain the measurement principles, instrument application and specifications to process conditions for level measurement

## Course Objectives

- For successful completion of this course you will:
  - Describe the differences between point and continuous measurement of level
  - List advantages and attributes of direct level measurement devices
  - Define displacement and detail the operation of displacers for level measurement
  - Describe hydrostatic “head” measurement and its uses in level measurement
  - Explain various applications of hydrostatic head measurement in level measurement
  - Define zero elevation and suppression as applied to level measurement

## Course Objectives (cont'd)

- Describe the operation of various electronic level sensors including:
  - Capacitance sensors
  - Conductive sensors
  - Ultrasonic sensors
  - Radar sensors
- Describe the operation of alternate level measurement devices including
  - Radiation sensors
  - Rotating Paddles
  - Thermal Sensing Level Measurement
  - Resistance Tapes
  - Gravimetric

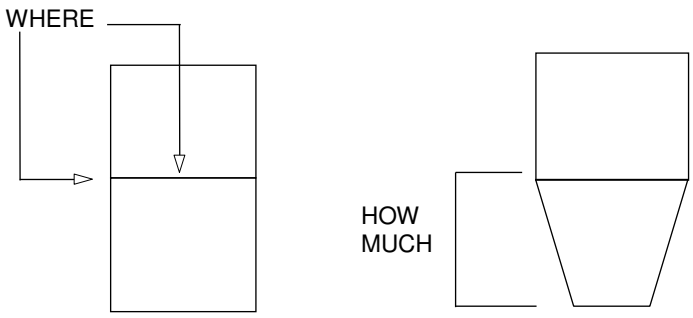
## Section 1: Intro to Level Measurement

- Introduction to Level
- Concepts of Level Measurement
  - Point Measurement
  - Continuous Measurement
- Selecting Level Measurement Devices
- Visual Level Sensors
  - Dipstick and Steel Tape
  - Sight Glasses
  - Float Actuated Devices
- Variable Displacement Sensors
  - Principles of Buoyancy
  - Devices

## Introduction to Level

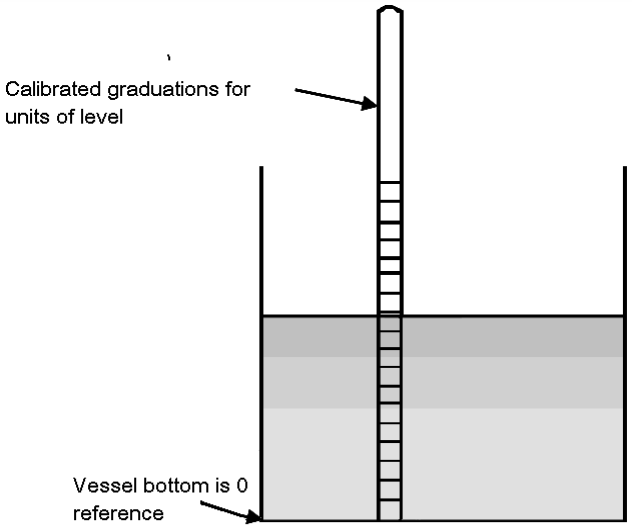
- What is level measurement?
  - Has a process fluid reached (exceeded) this point?
  - Between two fluids, where is the interface?
  - How much (volume) is in this vessel?
  - How fast is level falling (consumption) /rising (inventory)?
  - How deep is the water from the top?
  - At what point in the tank is the process material?
- Levels are taken of process fluids, fluidized solids, and granular solids

## Level / Inventory Measurement

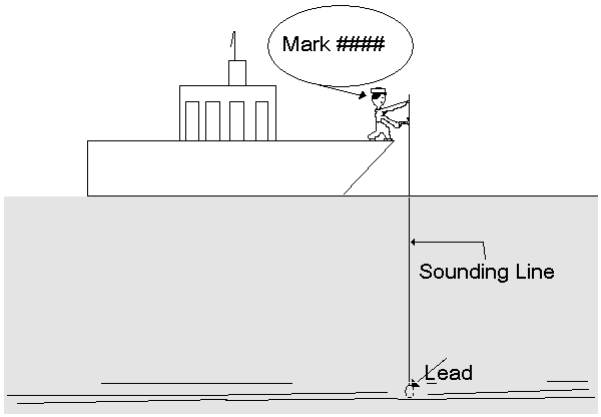



How far from full
How far from empty
How much material

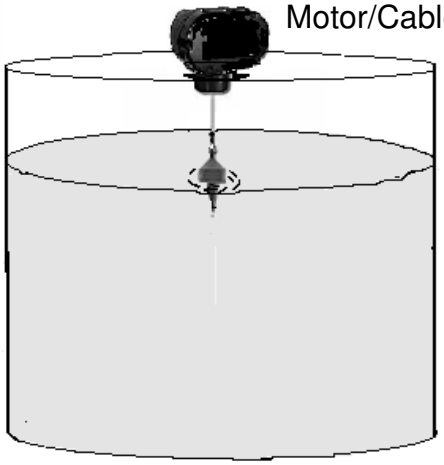
## Dip Stick Level Measurement



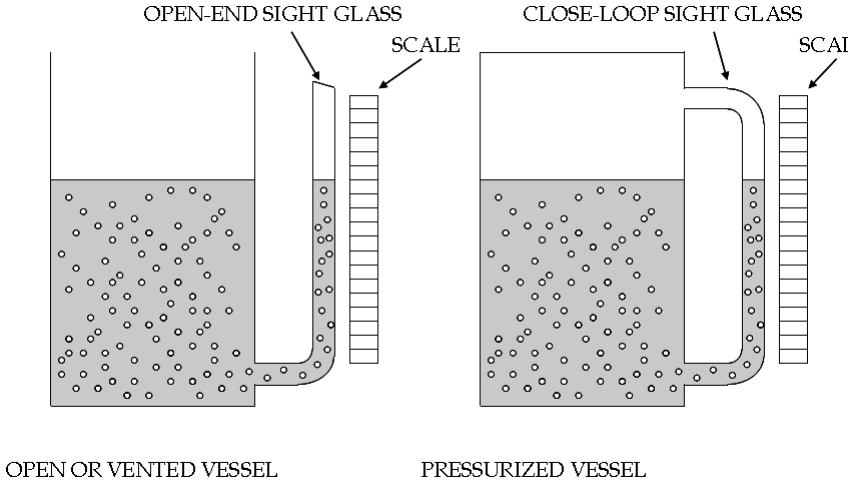

## Sounding Line



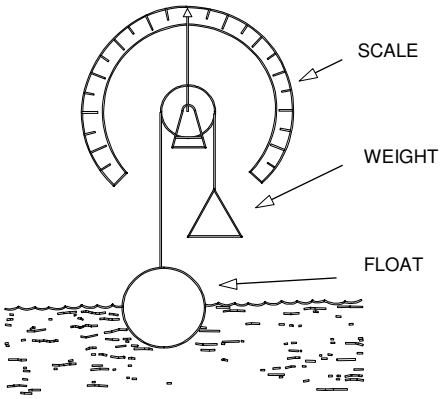
## Sounding Bob



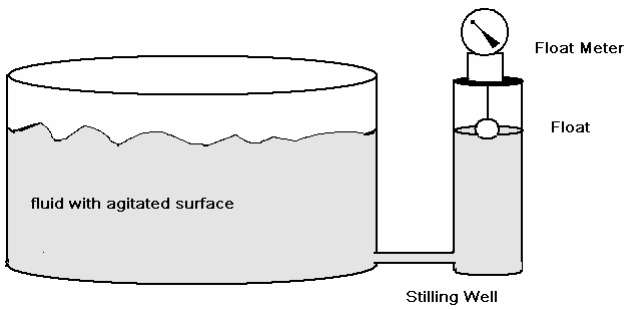

## Basic Sight Glasses



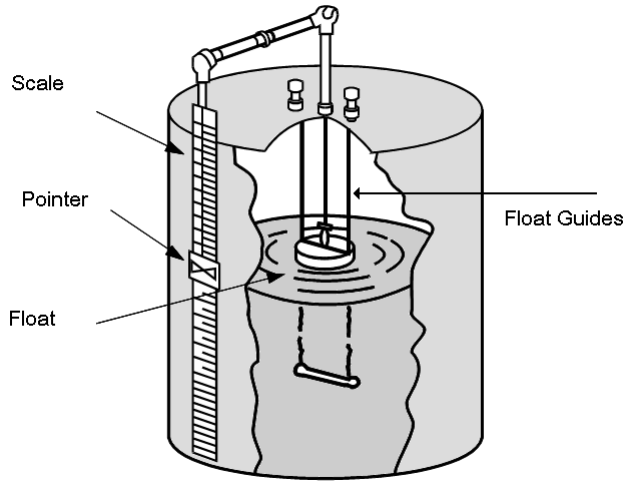
## Float & Cable Arrangements



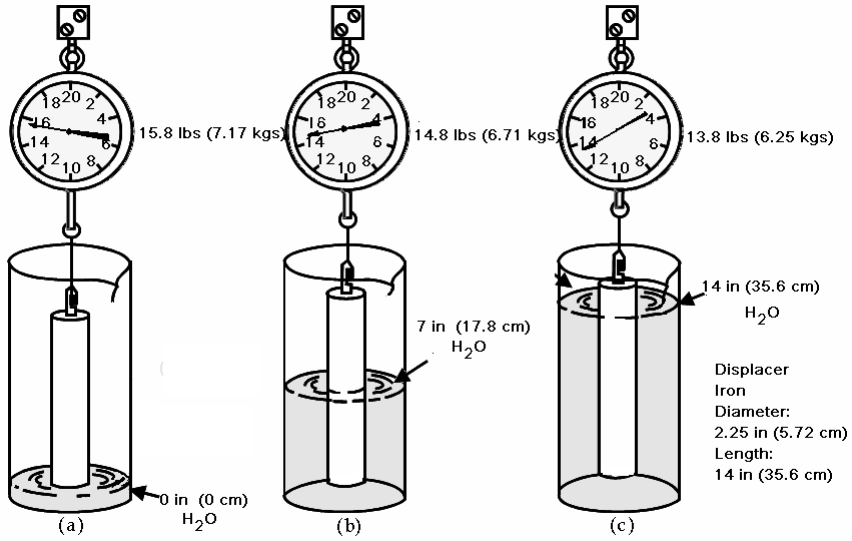

## Stilling Well



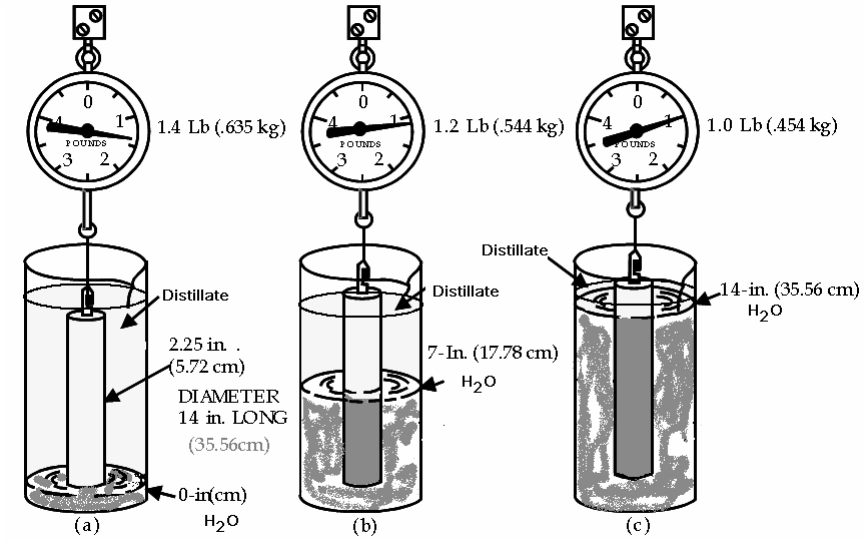
## Tank Level Measurement




## Level Measurement by a Displacer



## Interface Measurement with Displacers




(COURTESY OF MASONEILAN-DRESSER INDUSTRIES)

## Review of Key Points

- Introduction to Level
- Concepts of Level Measurement
  - Point Measurement
  - Continuous Measurement
- Selecting Level Measurement Devices
- Visual Level Sensors
  - Dipstick and Steel Tape
  - Sight Glasses
  - Float Actuated Devices
- Variable Displacement Sensors
  - Principles of Buoyancy
  - Devices

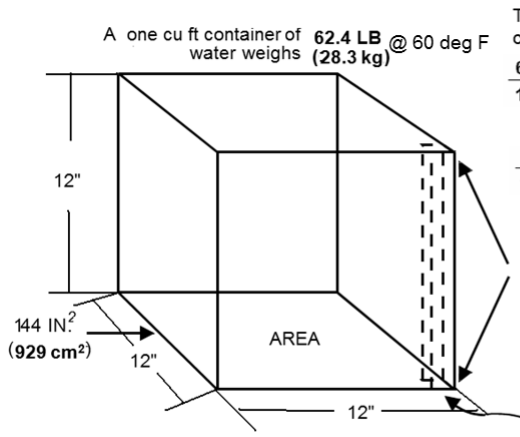
## Live Question and Answer Session

- During Q&A, questions may be asked via your telephone line.
- Press the *1 key on your telephone key-pad.
- If there are no other callers on the line, the operator will announce your name and affiliation to the audience and then ask for your question.
- If other participants are asking questions, you will be placed into a queue until you are first in line.
- While in the queue, you will be in a listen-only mode until the operator indicates that your phone has been activated. The operator will announce your name and affiliation and then ask for your question.

## Section 2: Hydrostatic Head Devices

- Head Pressure Measurement
- Hydrostatic Pressure Applications
  - Open-tank Pressure Measurement Sensors
  - Closed-Tank Head Pressure Measurement Sensors
- Dip Tube
- Application

## Liquid Pressure




The pressure on the bottom of the container is

$\frac{62.4 \text{ lbs}}{144 \text{ in}^2} = 0.433$ psi

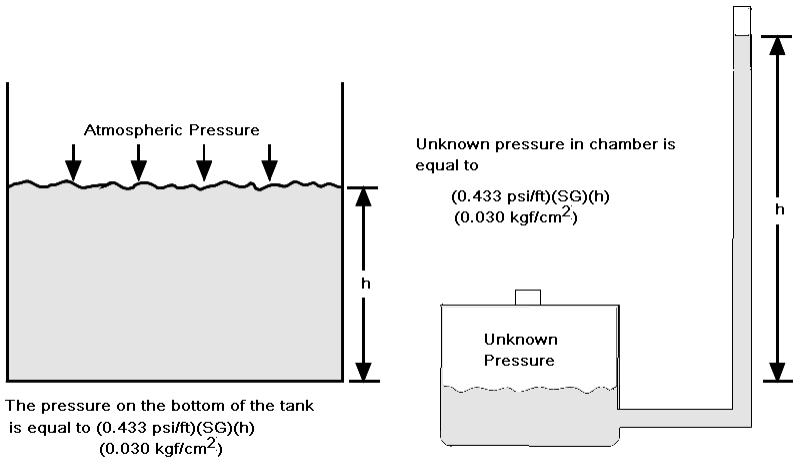
1 psi = 6.895 kPa

1 psi = 27.71" of water

$\frac{28.3 \text{ kg}}{929 \text{ cm}^2} = 0.03 \text{ kg/cm}^2 = 2.94\ (3)$ kPa

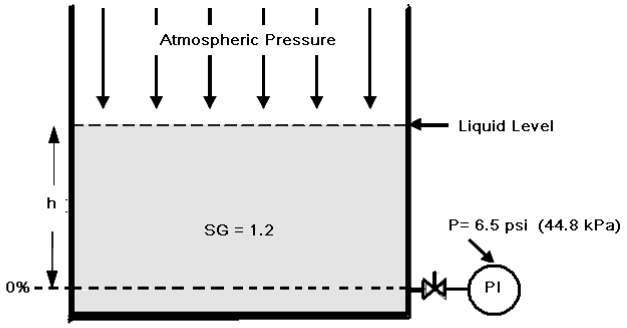
0.433 psi (0.03kg(force)/cm²) for a 12" (30.48) liquid column

## Hydrostatic Pressure




The pressure on the bottom of the tank is equal to (0.433 psi/ft)(SG)(h)
(0.030 kgf/cm$^2$)
'h' in both equations is expressed in feet

## Open Tank Level




To calculate h in feet
h = level in feet
P = gage pressure
SG = Liquid Specific Gravity
C= 2.307 (1 psi=2.307 feet)(0.703 meter)

h = (C * P)/SG

h = (2.307 * 6.5 psi)/1.2

h = 12.5 ft (3.81m)

To calculate h in inches for DP cell calibration

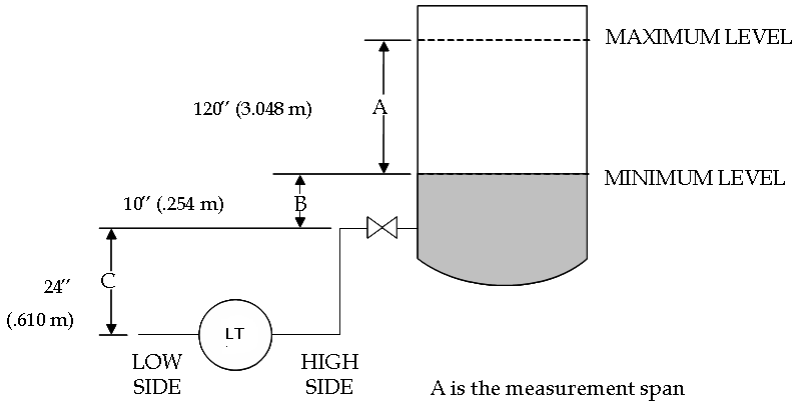
C = 2.307 * 12 = 27.684

h = (C * P)/SG

h= (27.684 * 6.5 psi)/1.2

h = 150 inches (381 cm)

## Zero Suppression in an Open Tank



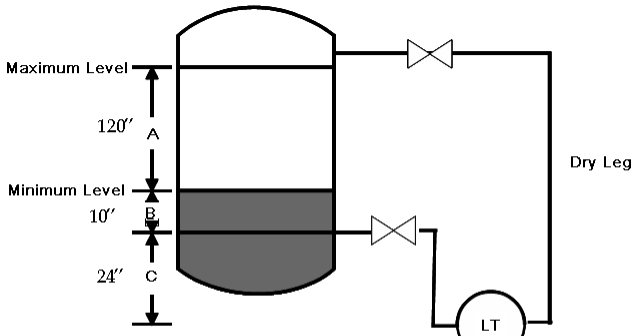

NOTE: Specific gravity = 1.0

A is the measurement span

B is the distance of minimum level above the instrument connection

C is the distance of the instrument connection above the instrument

## Zero Suppression in a Closed Tank



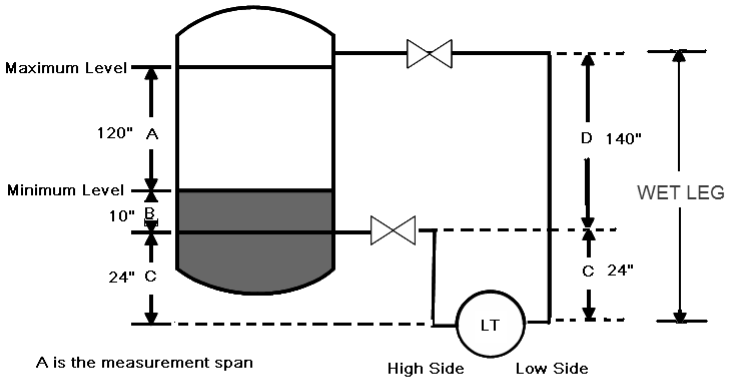

A is the measurement span

B is the distance of minimum level above the instrument connection

C is the distance from the high side connection to the instrument

Note: SG = 1.0

## Zero Elevation in a Closed Tank




A is the measurement span

B is the distance of minimum level above the instrument connection

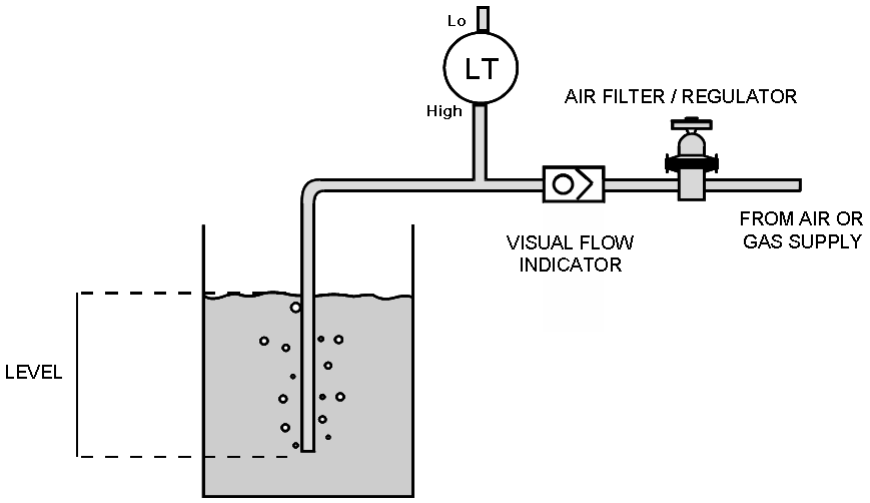
C is the distance from the high side connection to the instrument

D s length of wet leg to instrument high side take off

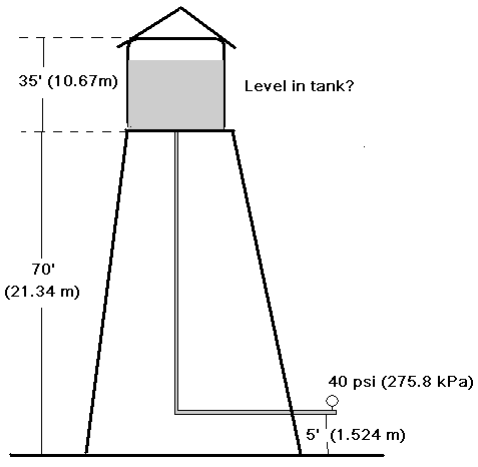
Note: SG = 1.0

| Instrument | High | Low | Diff |
|---|---|---|---|
| 100% | 154" | 164" | -10" |
| 0% | 34" | 164" | -130" |

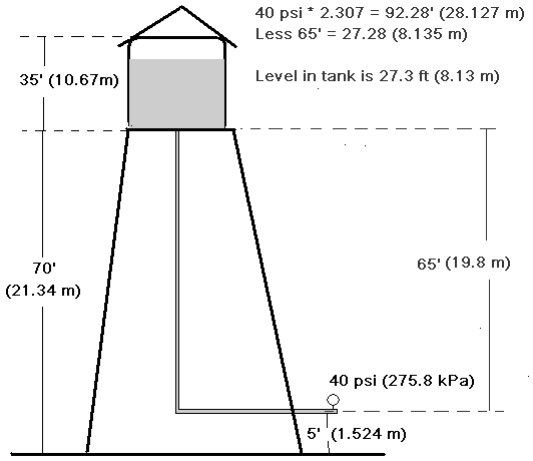
## Air Bubbler System




## Level Application



## Level Application (cont'd)




## Review of Key Points

- Head Pressure Measurement
- Hydrostatic Pressure Applications
  - Open-tank Pressure Measurement Sensors
  - Closed-Tank Head Pressure Measurement Sensors
- Dip Tube

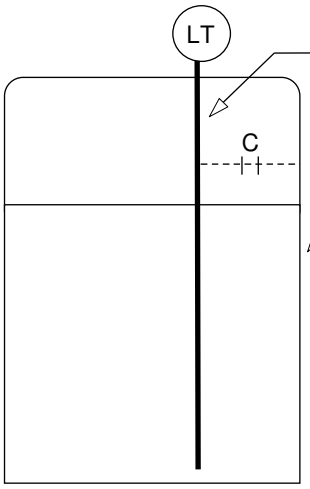
## Live Question and Answer Session

- During Q&A, questions may be asked via your telephone line.
- Press the *1 key on your telephone key-pad.
- If there are no other callers on the line, the operator will announce your name and affiliation to the audience and then ask for your question.
- If other participants are asking questions, you will be placed into a queue until you are first in line.
- While in the queue, you will be in a listen-only mode until the operator indicates that your phone has been activated. The operator will announce your name and affiliation and then ask for your question.

## Section 3: Electrical Level Measurements

- Electrical Level Sensors:
  - Capacitance
  - Conductivity
  - Resistance
- Ultrasonic Sensors:
- Radar Sensors

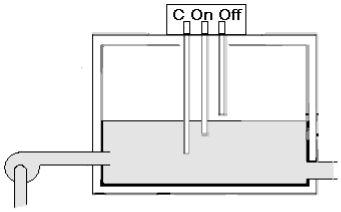
## Capacitance Probe




**PROBE ONE:**
PLATE OF
CAPACITOR

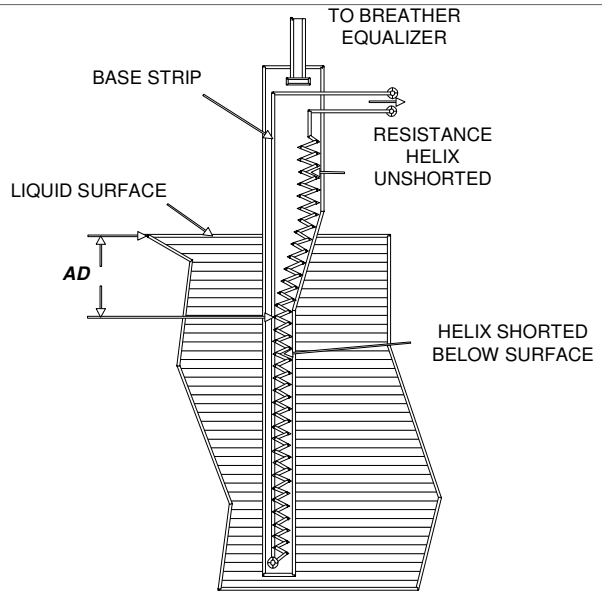
**METAL WALL:**
OTHER PLATE
OF CAPACITOR

## Conductivity Level Sensors

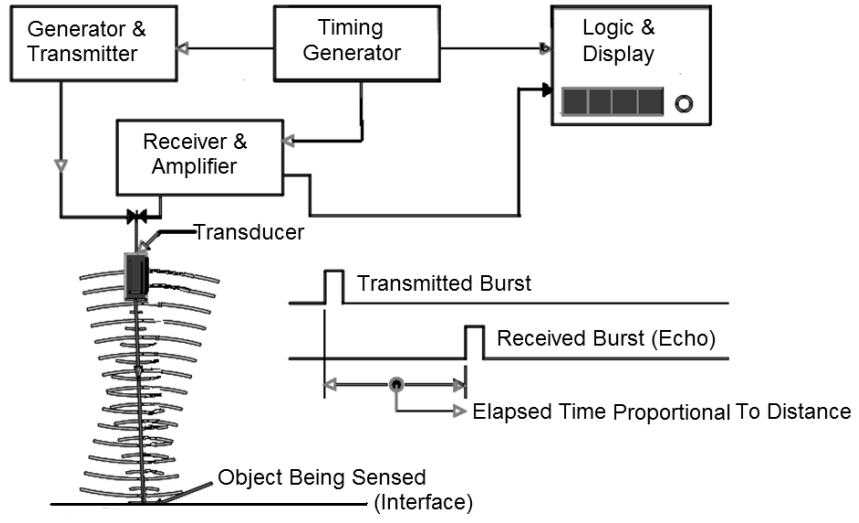



C is common
When conductivity is detected only between C and On the pump will stay on. When conductivity is detected between C and Off then the pump will be truned off. When conductivity is lost between C and On, the pump is again turned on.

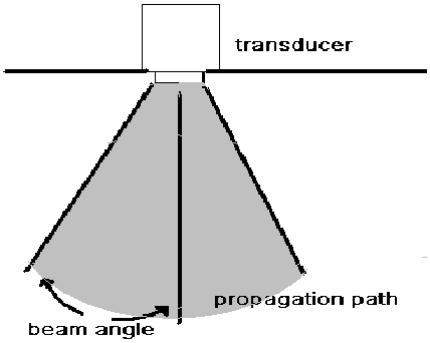
## Resistance Tape Level Sensor



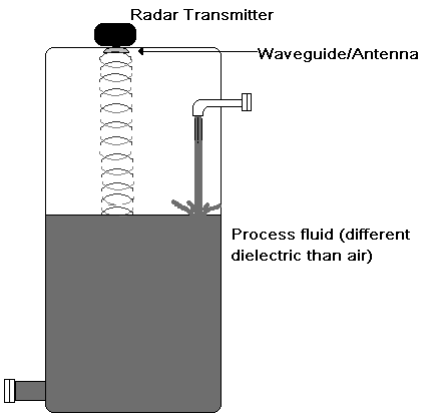

## Ultrasonic Measurement



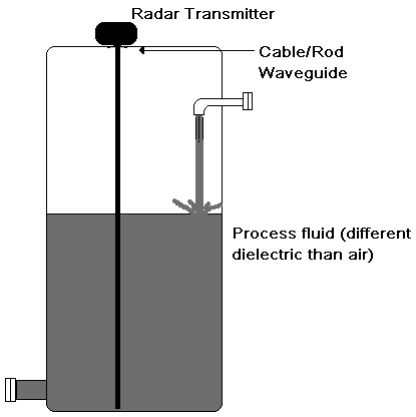
## Ultrasonic Parameters



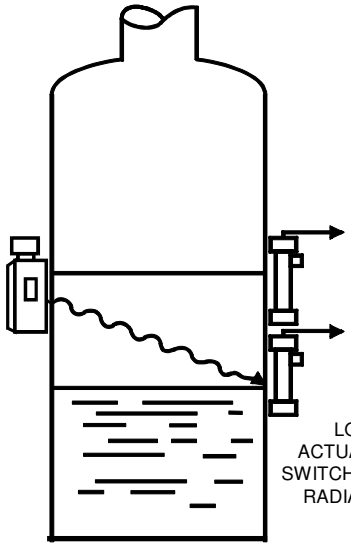

## Radar (non-invasive)



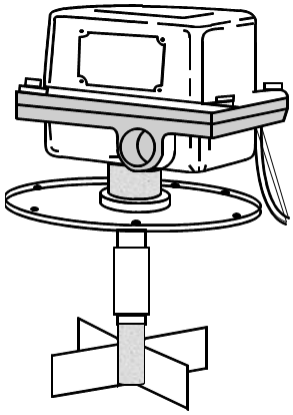
## Radar Guided Wave

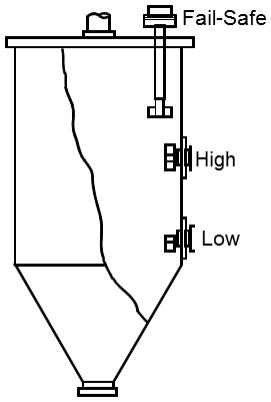



## Radiation Point Measurement

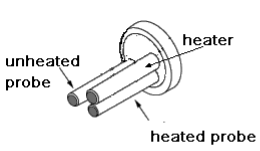


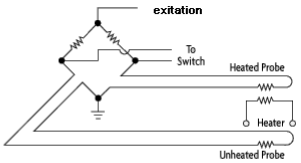
## Rotating Paddle






## RTD Thermal Switch

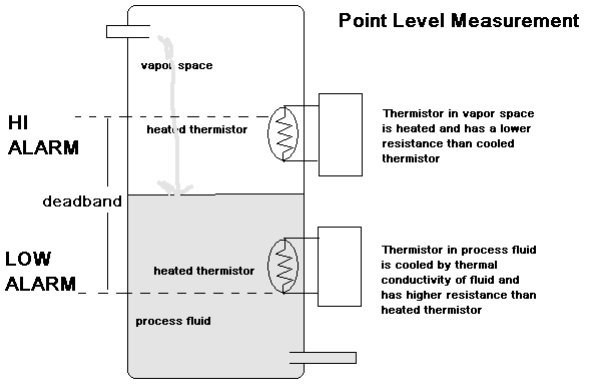


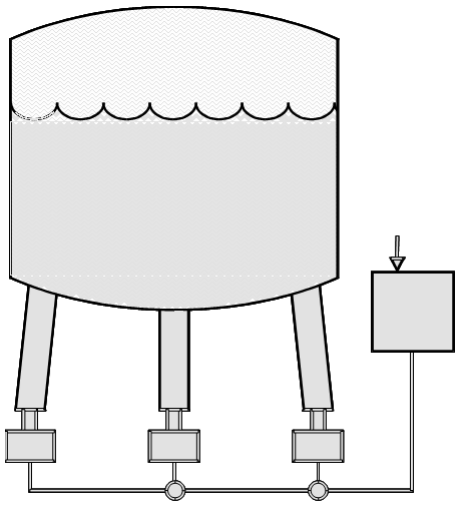

based on graphic in Omega catalog

Using RTD sensors in a bridge arrangement to detect presence of liquid

## Heated Thermistor Level Switch




## Level Measurement by Weight



## Load Cell Trade-Offs

- **Advantages**
  - Non- Intrusive
  - Mass measurement
  - Ok for liquids, granulars, and slurries
  - High accuracy in weight
- **Disadvantages**
  - Best specified when vessel is ordered
  - Usually requires free standing structure
  - Only weight measurement, not level; requires temperature compensation
  - May be affected by ice, snow, and wind loading
- Applications
  - Continuous
  - Liquids
  - Granulars
  - Slurries

## Review of Key Points

- Electrical Level Sensors:
  - Capacitance
  - Conductivity
  - Resistance
- Ultrasonic Sensors:
- Radar Sensors
- Rotating and Vibrating Paddles
- Thermal Sensing Level Measurement
- Resistance Tapes
- Nuclear Devices
- Gravimetric Level Measurement

## Live Question and Answer Session

- During Q&A, questions may be asked via your telephone line.
- Press the *1 key on your telephone key-pad.
- If there are no other callers on the line, the operator will announce your name and affiliation to the audience and then ask for your question.
- If other participants are asking questions, you will be placed into a queue until you are first in line.
- While in the queue, you will be in a listen-only mode until the operator indicates that your phone has been activated. The operator will announce your name and affiliation and then ask for your question.

## How Many People Are at Your Site?

- Poll Slide
- Click on the appropriate number indicating the number of people that are at your site.

## Related ISA Courses

- **FG07** Introduction to Industrial Automation and Control
- **TC05** Tuning Control Loops
- **TS00** CCST Review Course

- All ISA courses are available any time as on-site training
- For more information: www.isa.org/training
  or (919) 549-8411

## ISA Certifications

- Certified Automation Professionals ® (CAP ®)
  - www.isa.org/CAP
- Certified Control Systems Technician® (CCST®)
  - www.isa.org/CCST

- Please visit us online for more information on any of these programs, or call (919) 549-8411.

## Please take our Web Seminar Survey via Zoomerang

The seminar survey was sent to you via email during the seminar. Please do not forget to complete the Zoomerang survey.

## Conclusion

This is the end of:

Introduction to Level Measurement