CECTI November 6-7, 2025, Short School

Non-contact Level: Ultrasonic VS Radar VS Laser

1. Creator: Mariusz Pietranek Credit: Getty Images
Accessed 15 Mar 2023

Introduction

Brittany Baker; Regional Sales Manager

- Municipal background (Water & Wastewater)
  - BS Civil Engineering
  - 10+ years in manufacturing (water analyzers & instrumentation)
- 2.5 years at ABB Inc.
- Located: Denver, CO (by way of Boston)
- Territory: Rocky Mountains

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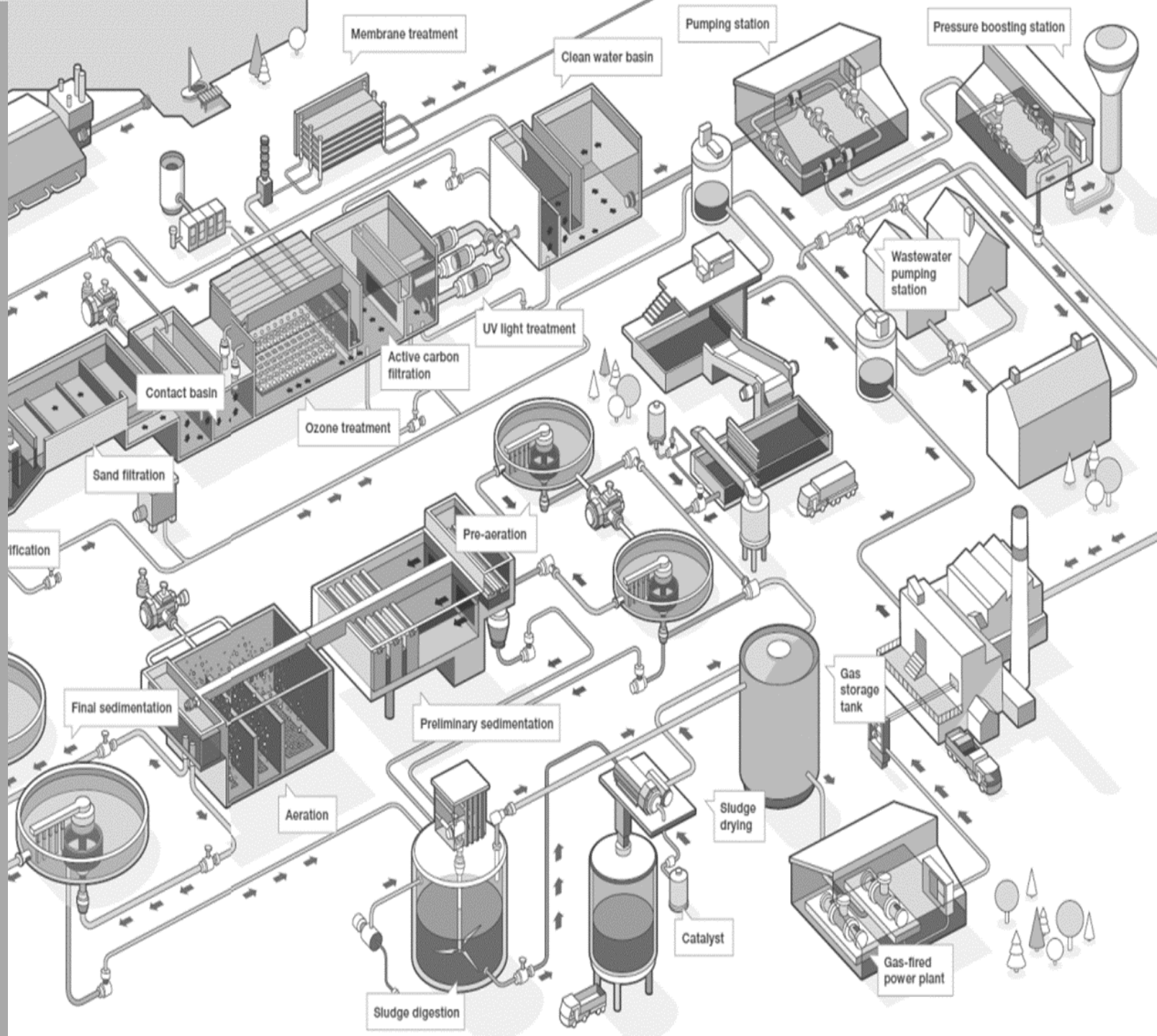
Discussion Topics

Identifying applications for non-contact level measurements

Recognize common technologies used in non-contacting level applications

Review principals of operations, advantages & disadvantages, and installation guides

Q & A



Level – Applications

Pump Stations

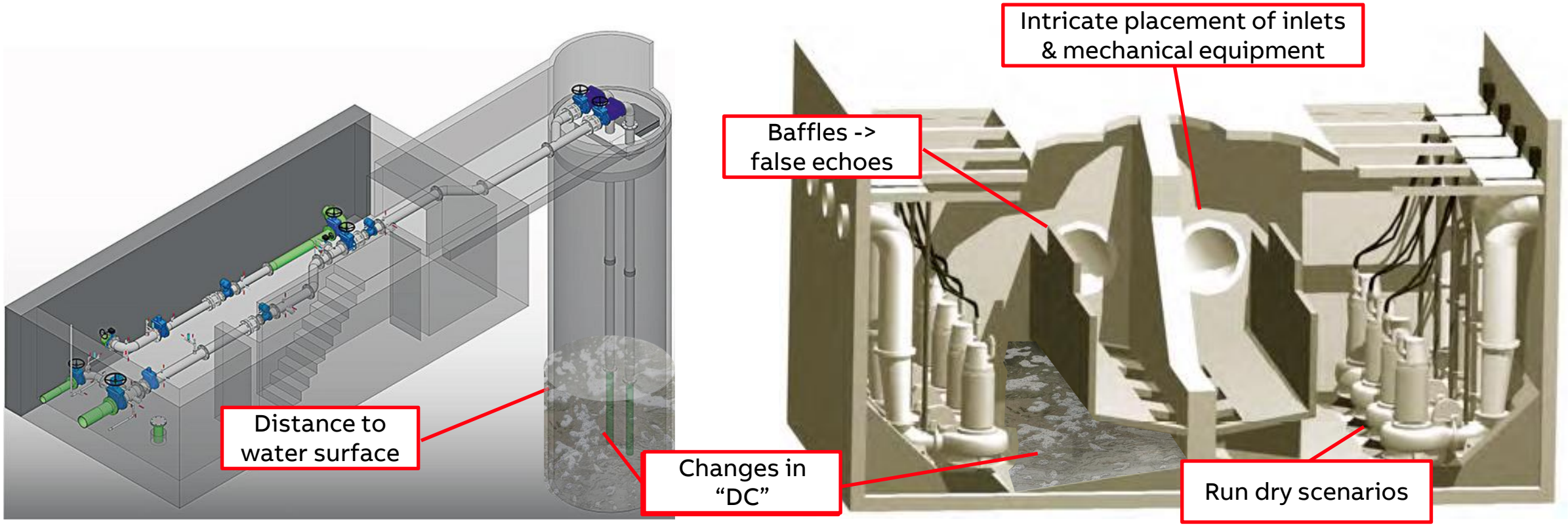
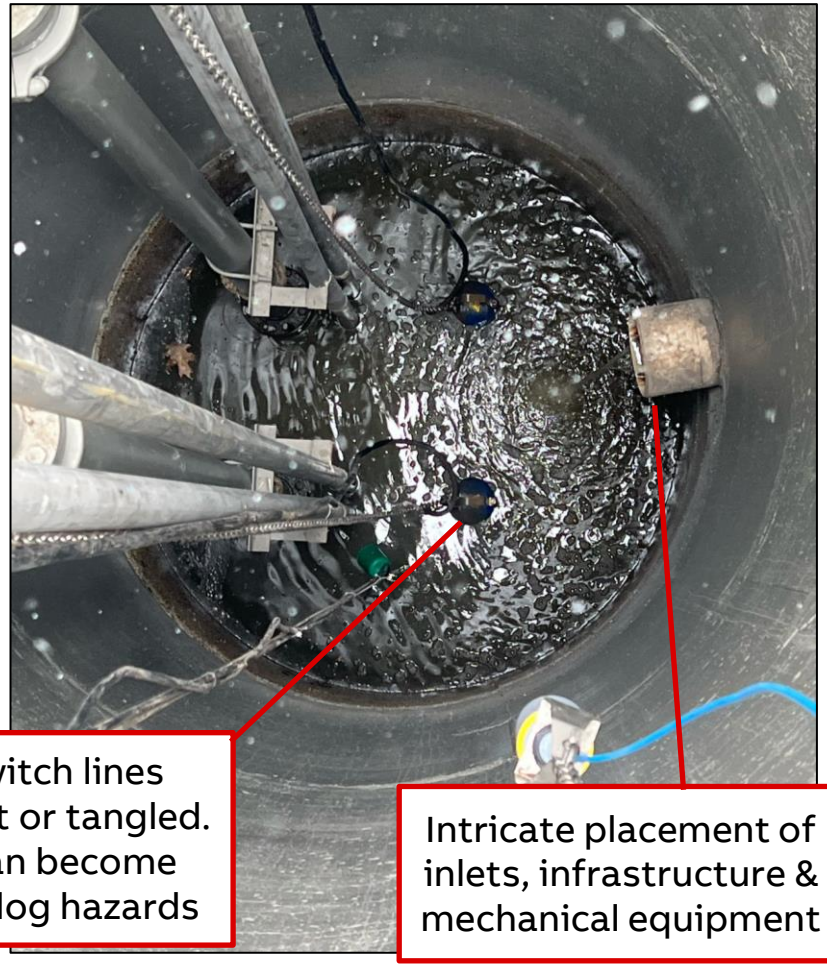


Image sources: https://www.scribd.com/document/331483148/Large-Submersible-Pump-Station-Design-Guide & https://www.hydrogroup.biz/fileadmin/_processed_/c/9/csm_pumpwerk-3d-grafik_9340881abb.jpg

Level – Applications

Lift Stations

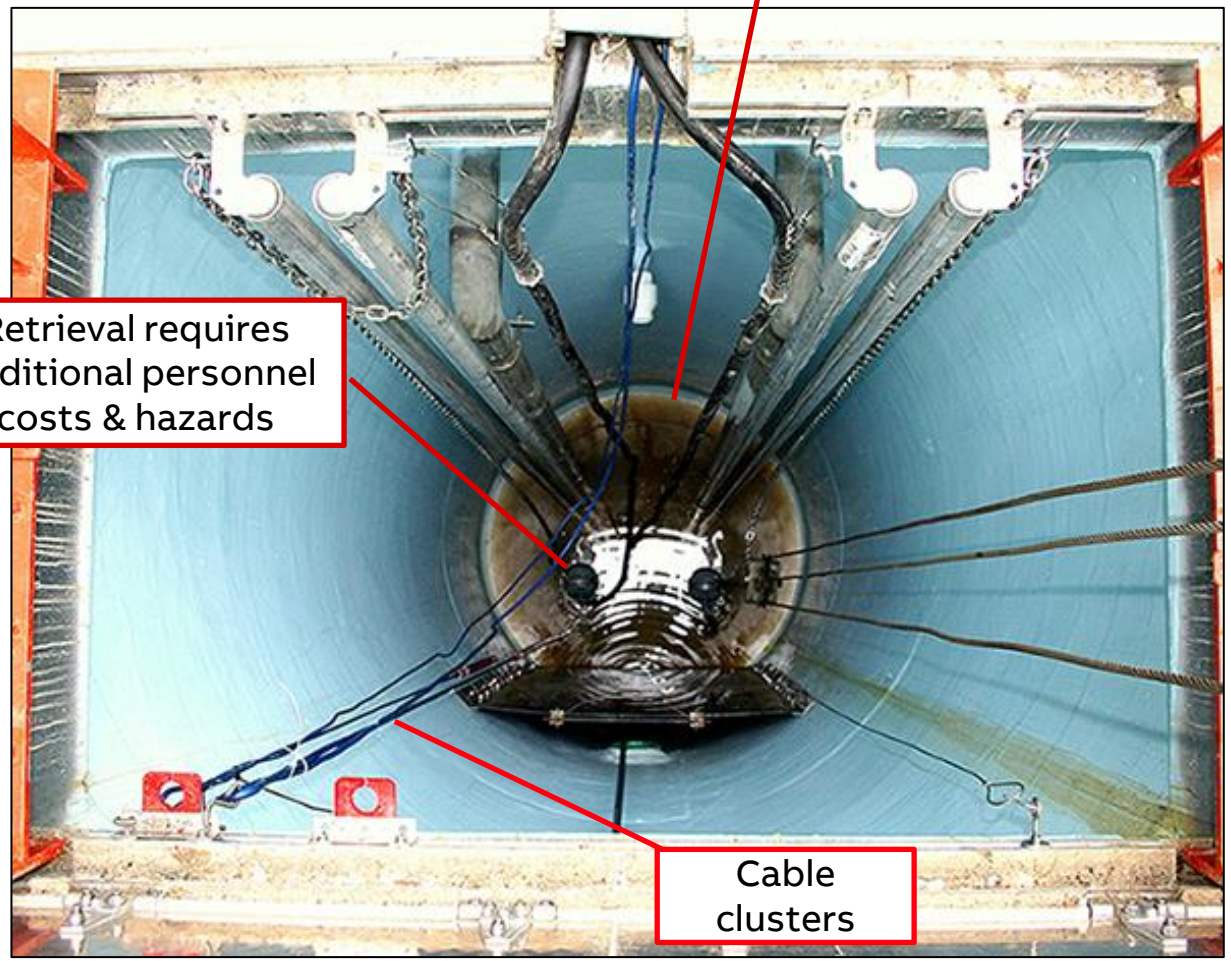


Float switch lines getting cut or tangled. Floats can become debris & clog hazards

Intricate placement of inlets, infrastructure & mechanical equipment

Run dry scenarios for motors & pumps from false high readings

Retrieval requires additional personnel costs & hazards



Cable clusters

Image source: https://www.linkedin.com/in/steve-mccuskey-14244224/recent-activity/shares/
Image source: http://romtecutilities.com/wp-content/uploads/2019/09/good-wet-well-deflector-panel.jpg

Level Applications

Regulatory Requirements – Lift Stations

1. Colorado Department of Public Health & Environment
   - 5 CCR 1002-22
2. Design Criteria for Domestic Wastewater Treatment Works
   - Policy Number: WPC-DR-1

Key Features:

- Design capacity
- Location
- NFPA 820 (C1- DI or DII)
- Accessibility + OSHA

Source: https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=8775&fileName=5%20CCR%201002-22#:~:text=(c),deemed%20appropriate%20by%20the%20Division.

https://drive.google.com/file/d/1AbOidMfAfqEuTYgZKxXW2mxNfvUSdOhO/view

Image source: https://acschultesnc.com/wp-content/gf-uploads/2022/05/preview-m/5-0.jpg?t=1653914432

Level
Quick Technology Overview

Ultrasonic Level

Radar Level

Laser Level

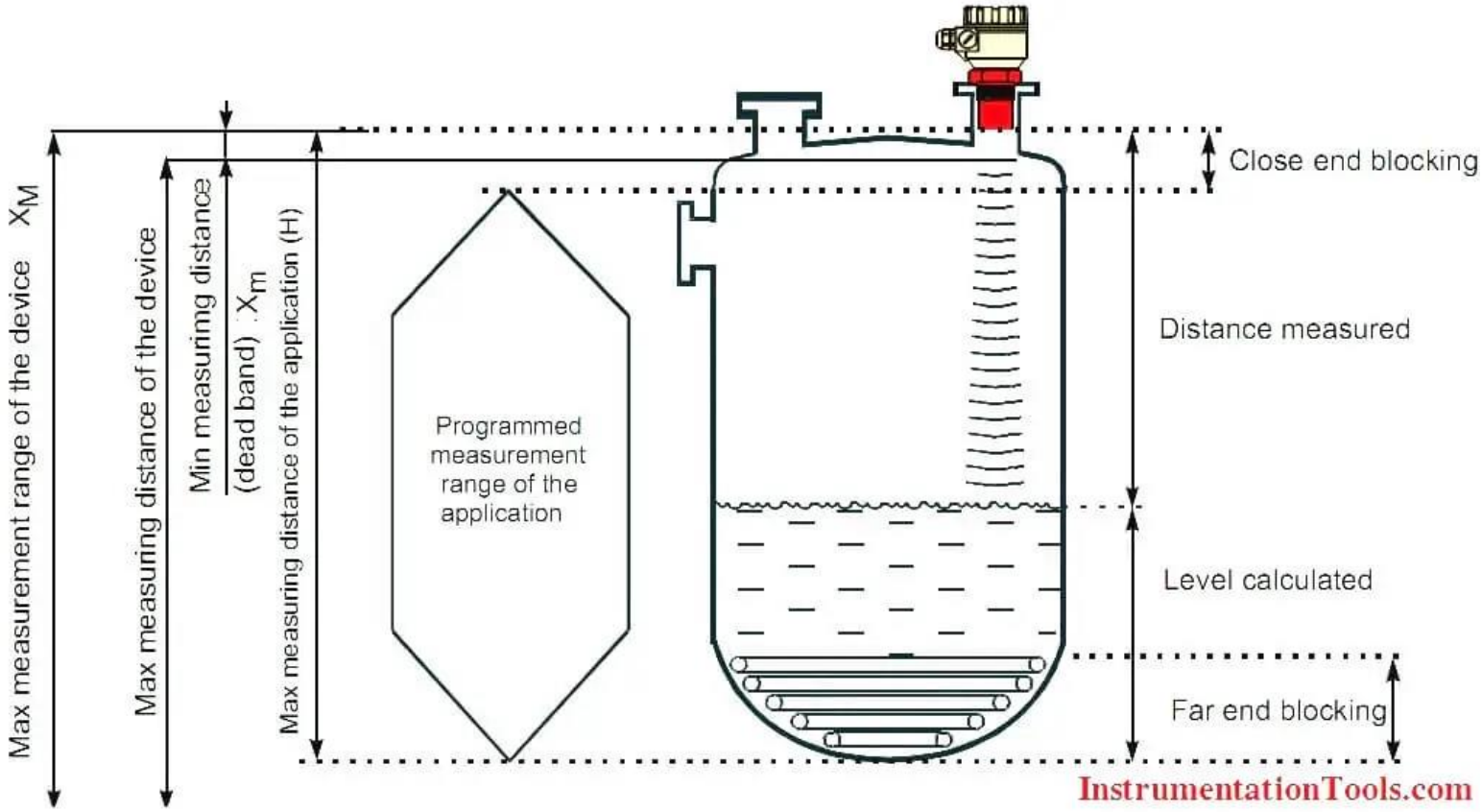
Image Source: https://encrypted-tbn2.gstatic.com/shopping?q=tbn:ANd9GcSrn6kLN3tAZAKS4m3-o5wIqjmPm1A2sydf0sIQMGScoYMf_eqGaJJGQJKvBdSpfOEUn03tQmNqtLEn5Y0APrWq__jzLDPZNrZZX6wIEDLq1Ien2gVKbBtw
Image source: https://www.vega.com/-/media/images/products/sensors/devices2020/o-vegapuls-64.png?rev=bd7b318980a24f8f9794d48fb0ce6455&mw=800&mh=800&hash=EC852321CC332A5930AD66D39C4D1FCF
Imagine source: https://webimages.imagebank.abb.com/public/v2/7d5e6dfe-9151-43b5-98e2-88e09ddefff9/presentation.jpg

Level Technology

Ultrasonic Principal of Operation

- Ultrasonic level measurement is the most widely used non-contact technology
- Ultrasonic level sensors work by the "**time of flight**" principle using the **speed of sound**
- The sensor emits a high-frequency pulse, generally in the 20 kHz to 200 kHz range
- The pulse is transmitted in a cone, usually about 6° at the apex
- The pulse impacts the level surface and is reflected back to the sensor, now acting as a receiver, and then to the transmitter for signal processing.

$$Distance = \frac{Speed\ of\ Sound\ \times\ \Delta Time}{2}$$



Source: https://instrumentationtools.com/ultrasonic-level-transmitter-working-principle/

Level Technology

Ultrasonic – Technology Advantages

Low cost & many manufacturers to choose from

Controllers/transmitters capable of full pump control

Up to 30-ft measurement range

Accuracy of 0.2 % of full span

30-ft depth, accuracy is ±6-inches

Beam angle as low as 5˚

Beam spread at 30-ft = 26 inches

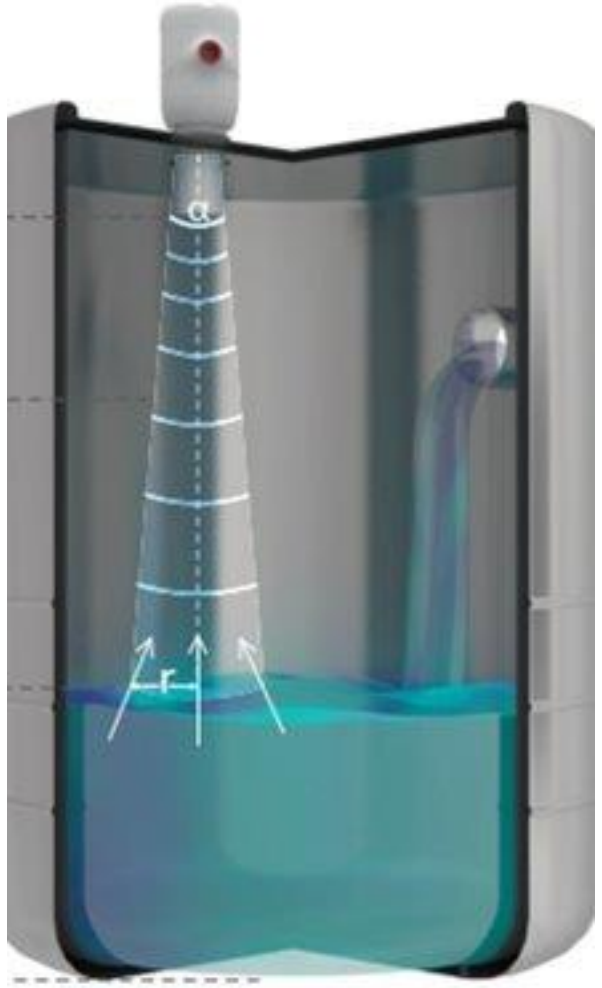


Image source: www.Foxboro.com

Level Technology

Ultrasonic – Technology Disadvantages

Accuracy loss from changing DC due to grease, foam, debris, temperature

Mounting considerations

Inconsistent errors resulting in longer diagnostics

Sensor face condensation buildup

Image From: http://romtecutilities.com/wp-content/uploads/2019/10/lined-wet-well-interior-with-conductive-probe-level-sensor.png
Image from: https://www.lesman.com/media/catalog/product/5/0/500-siemens-hydroranger-200-hmi-ultrasonic-controller.jpg?quality=80&bg-color=255,255,255&fit=bounds&height=500&width=500&canvas=500:500
Image from: https://new.abb.com/products/measurement-products/level/ultrasonic-level-transmitters-and-switches

Level Technology

Ultrasonic – Installation Considerations

All Non-contacting level transmitters are based on the time-of-flight principle. In the case of ultrasonic it's sound waves.

Soundwaves are prone to disruption caused by the following:

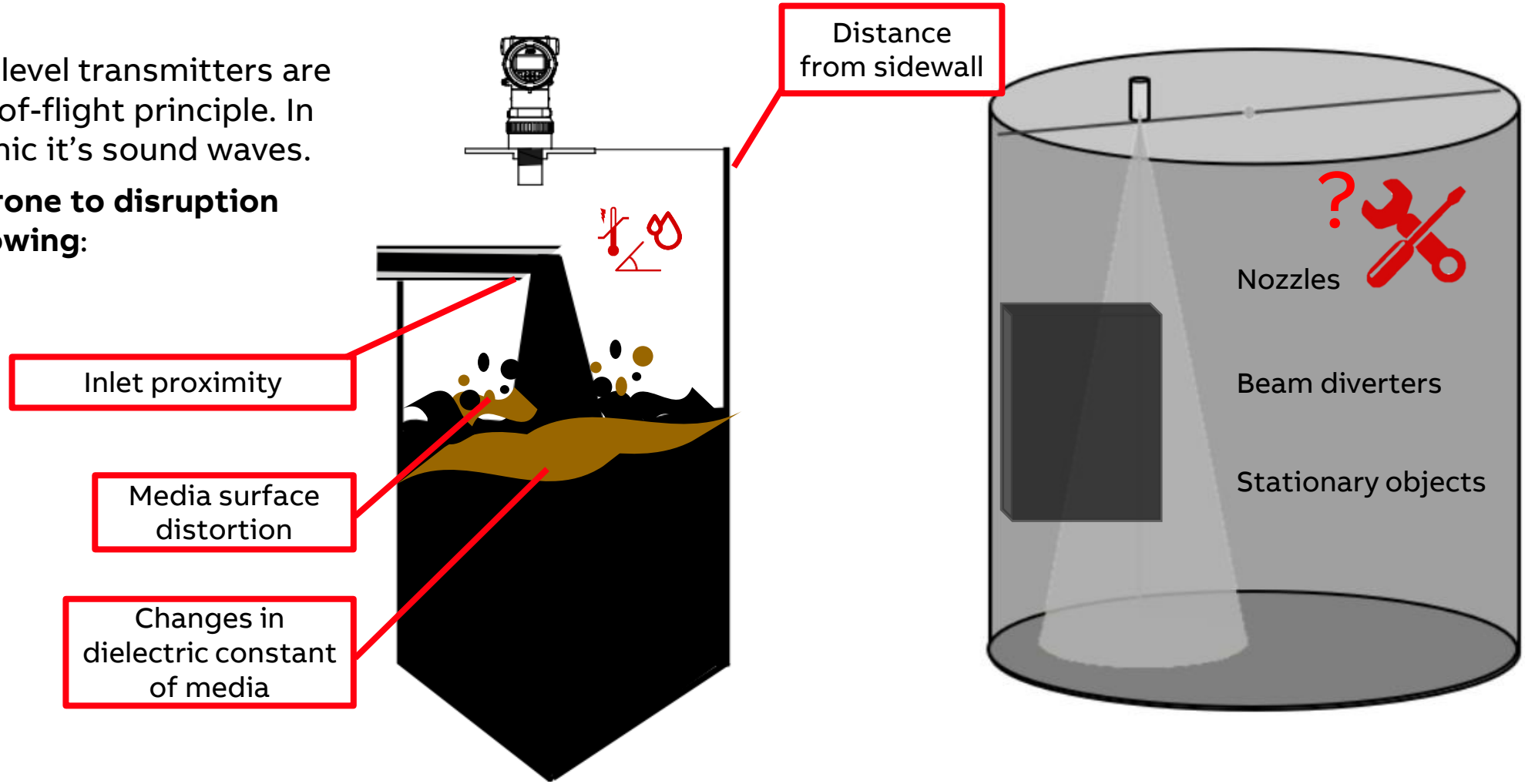
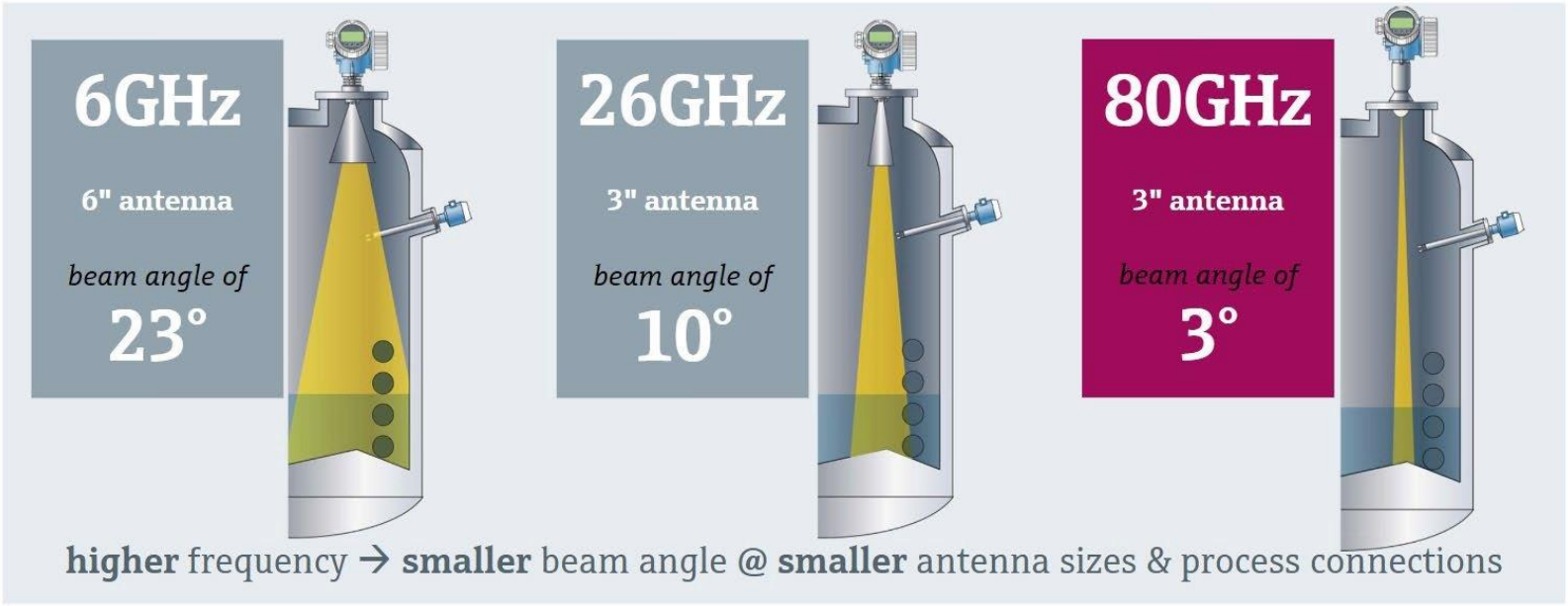


Image from: https://search.abb.com/library/Download.aspx?DocumentID=DS%2fLST300-EN&LanguageCode=en&DocumentPartId=&Action=Launch

Level Technology

Radar – Principal of Operation

- A radar level transmitter contains a radar antenna (or a transducer) that emits high-frequency electromagnetic waves (radar waves) towards the surface of the material being measured.
- These waves are typically in the microwave frequency range, which can be several gigahertz (GHz)
- The radar waves travel through the air (or another medium) until they reach the surface of the material. When the waves encounter the surface, they are reflected back towards the radar transmitter.



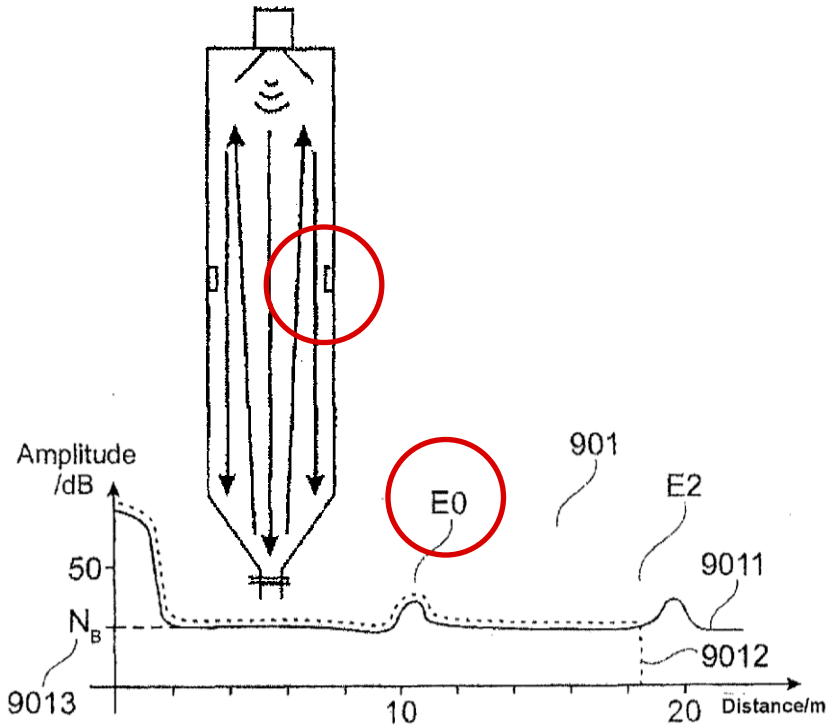
$$Distance = \frac{Speed\ of\ Sound \times \Delta Time}{2}$$

Image source: https://www.my.endress.com/_storage/asset/3093270/

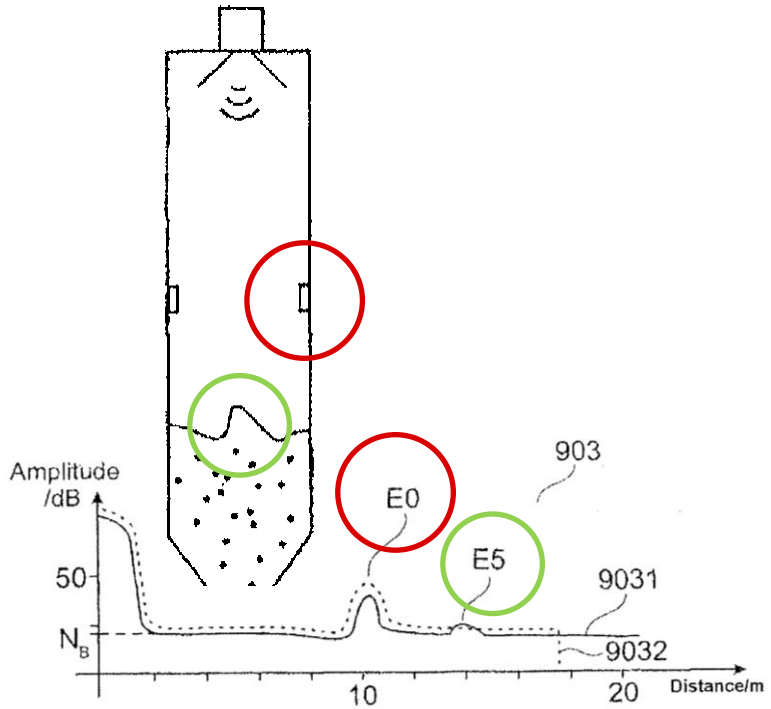
Level

Radar Level – False Echo Tracking

Echo profile



Live reading



Algorithm evaluation

ID	Echo position/m	Echo amplitude/dB	False echo evaluation
E0	10	30	100%
E5	13	26	0%

Image from: https://patentimages.storage.googleapis.com/fa/ba/c0/7a4ca193659be8/US20110238352A1-20110929-D00006.png

Level Technology

Radar – Technology Advantages

Cost has decreased in recent years. Tighter beam models (higher GHz) being more costly. Wider beam models (lower GHz) do not pick up low dielectric constant materials.

Up to 100-ft measurement range for liquids

Accuracy of 0.2 % of full span or 2mm (0.7-in)

Beam angle as low as 4˚

Image from: https://www.linkedin.com/in/steve-mccuskey-14244224/recent-activity/shares/

Level Technology

Radar – Technology Disadvantages

- **Accuracy loss from changing DC due to grease, foam, debris, temperature**
- **Mounting considerations**
- **Inconsistent errors resulting in longer diagnostics**
- **Recalibration requirements**
- **External pump control is commonly required**

Image From: http://romtecutilities.com/wp-content/uploads/2019/10/lined-wet-well-interior-with-conductive-probe-level-sensor.png
Image from: https://www.lesman.com/media/catalog/product/5/0/500-siemens-hydroranger-200-hmi-ultrasonic-controller.jpg?quality=80&bg-color=255,255,255&fit=bounds&height=500&width=500&canvas=500:500
Image from: https://new.abb.com/products/measurement-products/level/ultrasonic-level-transmitters-and-switches

Level Technology

Radar – Design Considerations

All Non-contacting level transmitters are based on the time-of-flight principle. In the case of Radar, it's **radio frequency waves.**

RFW are not immune to disruption caused by the following:

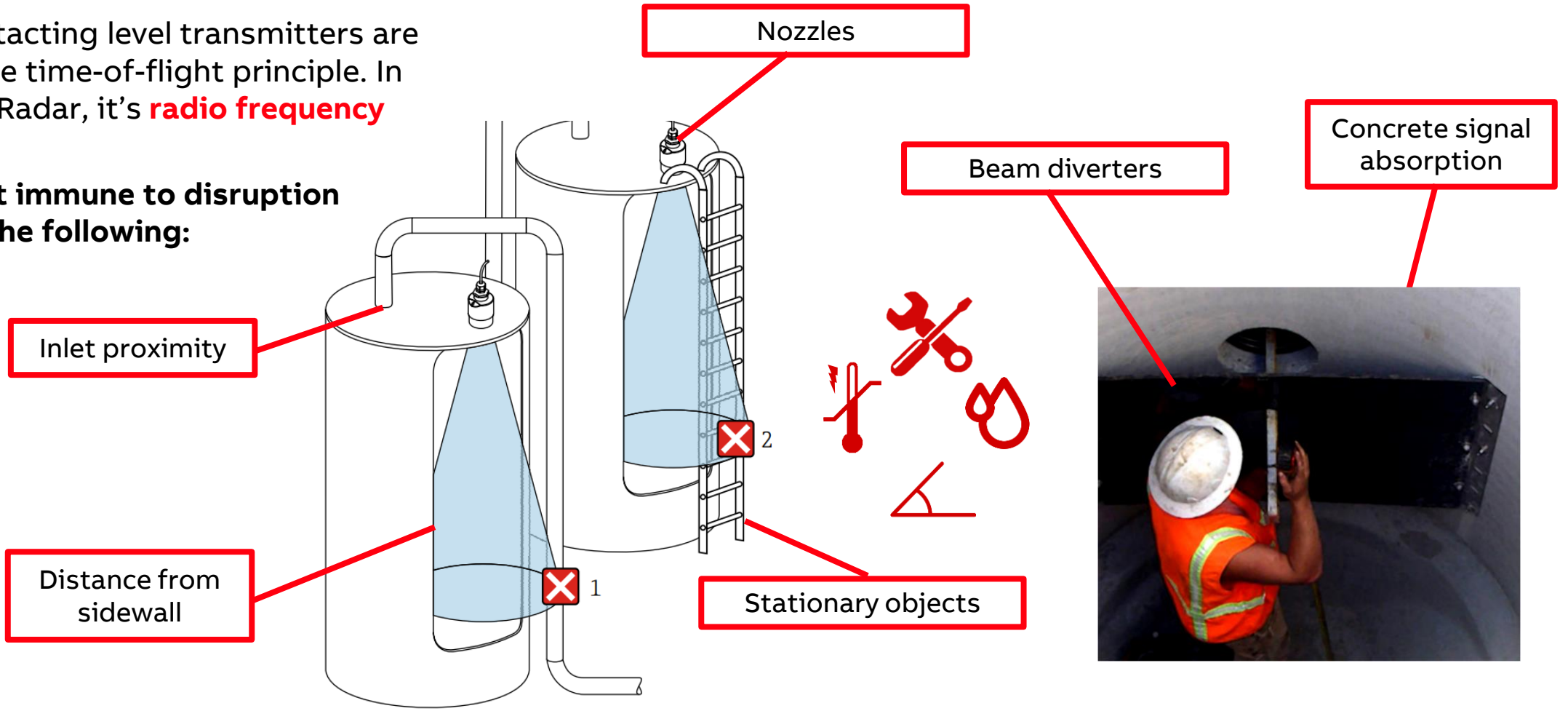


Image from: https://search.abb.com/library/Download.aspx?DocumentID=DS%2fLST300-EN&LanguageCode=en&DocumentPartId=&Action=Launch

Level Technology
Laser Principal of Operation

- Laser level technology is another time-of-flight measurement.
- High speed laser pulses are emitted towards the measured medium and is reflected back to the instrument where it is detected by an optical receiver.
- Travel and reflection time is proportional to distance.
- Laser for level was first introduced for solids indication as it is not susceptible to dielectric constant changes, thus the use for laser has expanded to liquids measurement.

$$Distance = \frac{Speed\ of\ Sound\ \times\ \Delta Time}{2}$$

Image source: Mohit Manglani, ABB

Level Technology

Laser – Technology Advantages

Limited relays. Controller / PLC / SCADA required for full pump automation

Up to 632-ft measurement

Accuracy of 0.5mm across entire span

Beam angle 0.3˚ smallest of any non-contacting technology, allows for tight space measurement.

Devices can be installed close to side walls & do not have to be installed in vaults.

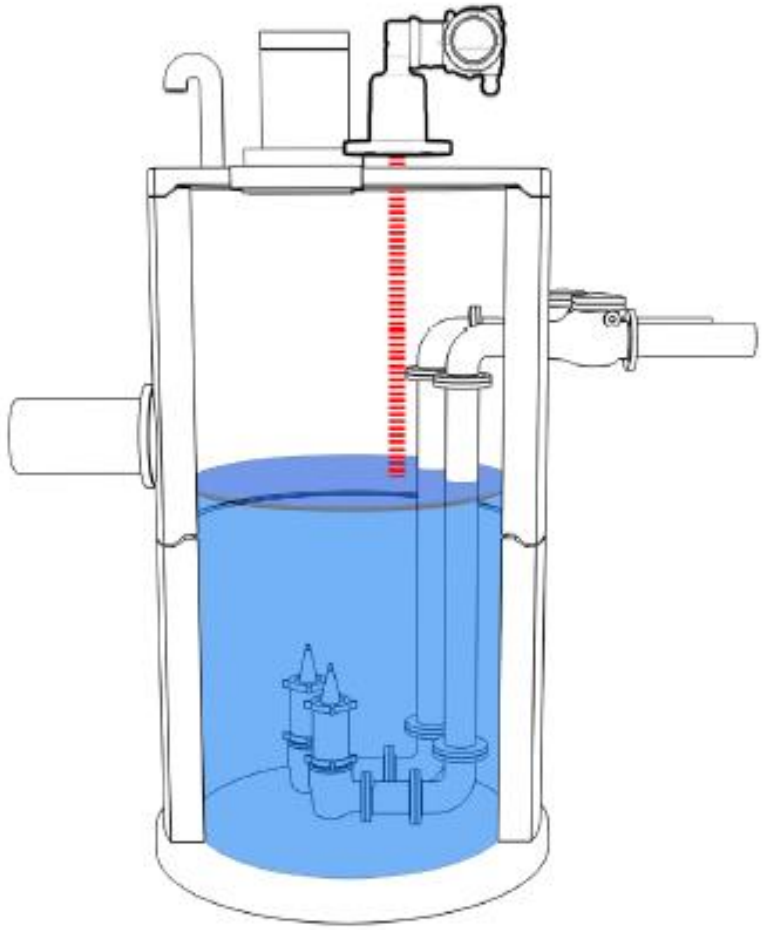


Image from: www.abb.com

Level Technology

Laser – Technology Disadvantages

- **Capital invest costs when compared to other technologies**
- **Application limitations: heavy foam or vapors, surface “glass-like” potable water**
- **Additional wiring (if applicable)**
- **Additional of air purge (if applicable)**

Image source: Trey Himes, ABB

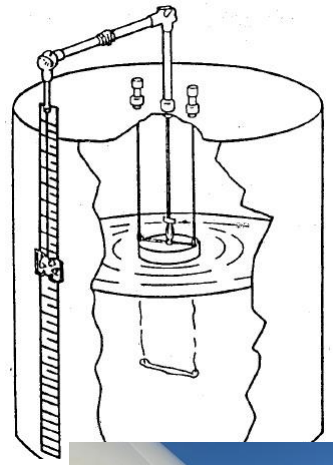
Level Technology
Laser Level Installations

Image source: Mohit Manglani, ABB

Digester

Positioning levels

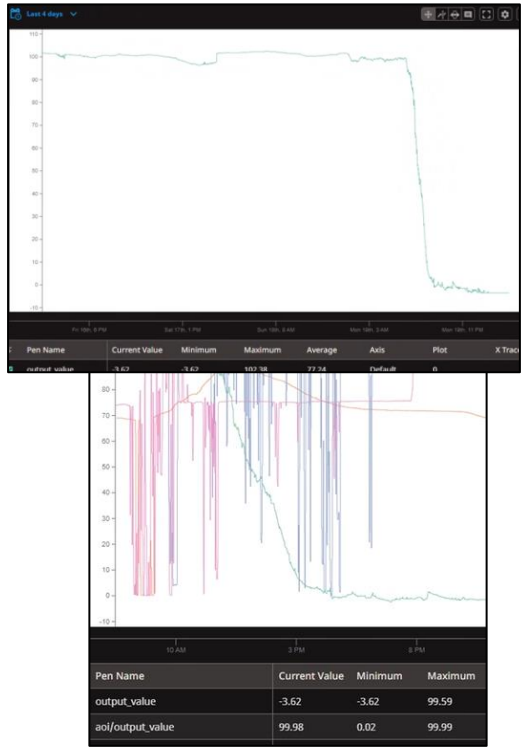
Existing Tape Gauge



Positioning Measurement

Laser Implementation

Performance Difference

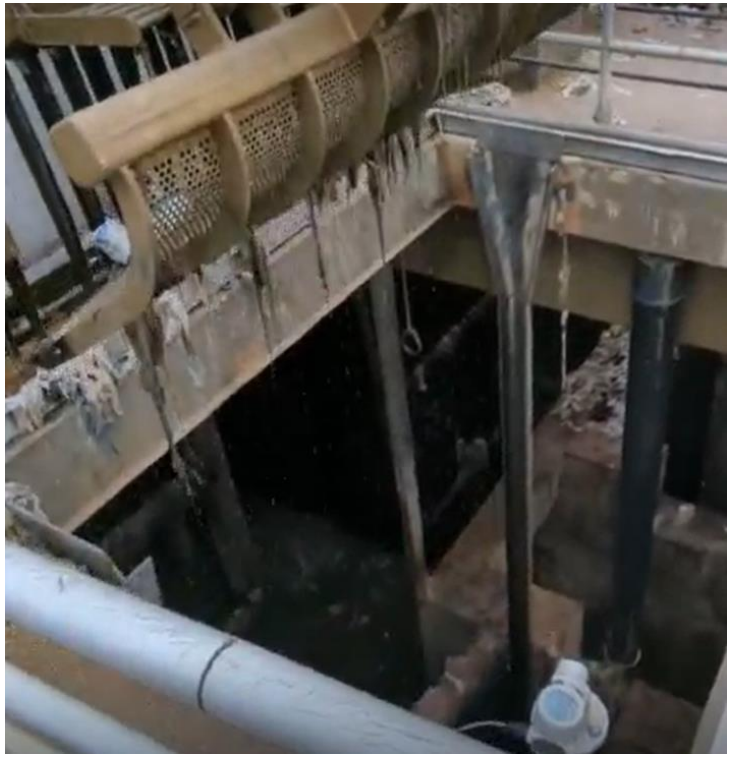


Installations

Flexibility on applications

Sump level

Bar screen automation



Bio-gas balloon

Level

Laser VS Radar VS Ultrasonic – a Quick Review …

Applications	Laser	Radar	Ultrasonic
Long range	✓	✗	✗
Built in relay switches	✓	✓	✓
Presence of obstructions, agitators	✓	✗	✗
Any type of vessel shape, even conical bottoms	✓	✗	✗
Presence of waves and turbulence	✓	✓	✓
Any solid material surface angle	✓	✗	✗
Presence of foam	✗	✗	✓
Low dielectric constant materials	✓	✗	✓
Fast changes, abrupt changes <1s	✓	✗	✗
Heavy dust & fog	✗	✓	✓

Always consult with the manufacturer of any level device to ensure the correct model code & application use.

Level
Food for Thought

- Budget
  - New build or existing infrastructure?
  - Replacing technology?
- Communication & power requirements (SCADA, pump controls, etc.)
- Regulatory requirements
- Location of level transmitters (personal access)
- Level source (FOGs, debris build-up, foam or steam)
- Infrastructure design

Will this technology work for our application?

Image Source: ABB, Inc. Retrieved September 17, 2024

Questions?