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THE PRECISION DIGITAL MAGAZINE

Q1
2016

LEVEL MEASUREMENT TECHNOLOGIES
In The Process Control Industry

Your Top 10 Customers of 2015 Will Not be Your Top 10 of 2016
☑ What You Should Do

How to MEASURE FLOW RATE with Level Sensors

Two Birds with One Stone
Level Indication & Pump Control

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Reader's Brief

Our first issue of 2016 is entirely dedicated to level measurement. Learn about various topics on the subject including how to measure flow rate using level sensors, level indication and pump control using one device, and an introduction to level measurement technologies to guide you in selecting level instrumentation.

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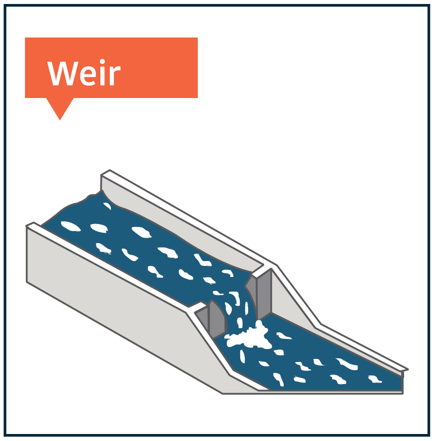
How to MEASURE FLOW RATE with Level Sensors

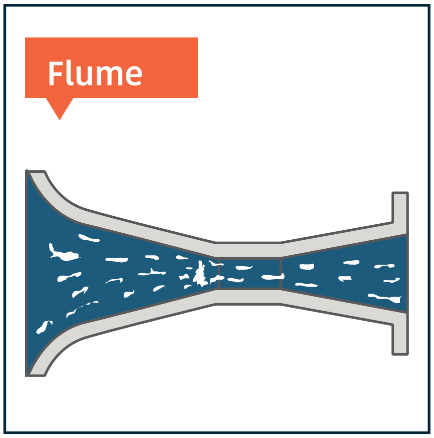
Level sensors are capable of measuring more than just level. Flow rate measurement in an open channel, such as a stream, irrigation canal, or unpressurized sewerage pipe, can be accomplished using hydraulic structures known as weirs and flumes. These measure flow rate using the same technologies often applied to tank level measurement, such as bubblers, radar, and ultrasonic level transmitters.

Both weirs and flumes function by constricting the flow of the channel and measuring how the fluid level is affected. Their physical characteristics, and therefore their effect on fluid flow, are known variables, so equipment that measures level upstream from the structure can use a series of mathematical equations to determine the flow rate.



Weirs function very similarly to dams in that they span the length of the channel and constrict flow. There are many styles of weirs, each meant for a different application, but they all allow fluid to escape through an opening and continue downstream. Fluid level is measured upstream from the weir.

Flumes, on the other hand, typically consist of three sections: a constricting end, a throat, and an expanding end. The flume is partially submerged in the channel. The throat constricts the flow and the fluid level is measured at the constricting end.



Two Birds with One Stone

Level Indication and Pump Control with the PROVU® Series

by *Simon Paonessa*

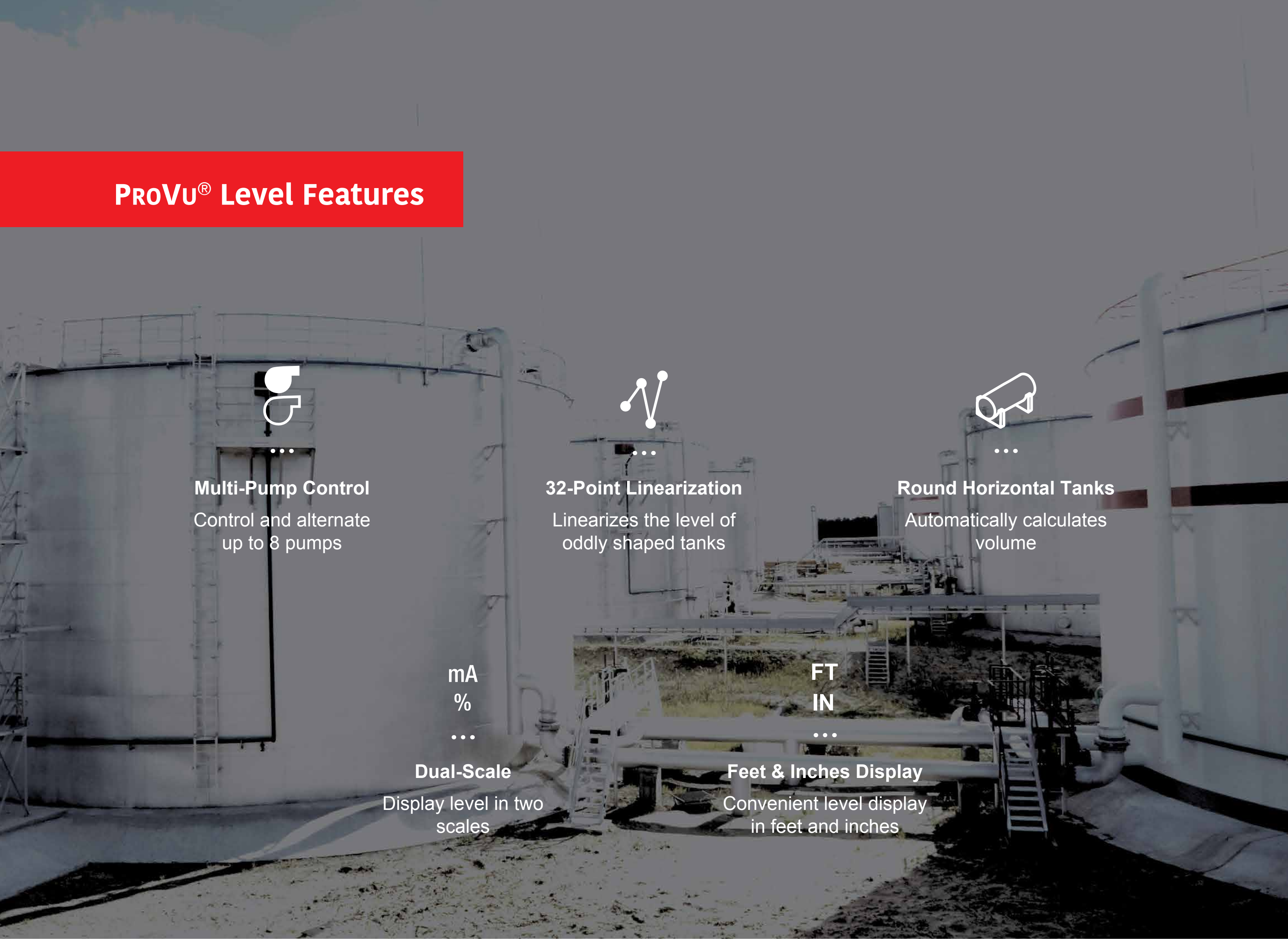
For more information on multi-pump controllers visit:
pumpcontrol.com

Level measurement and pump control go hand-in-hand, whether it is making sure that your tanks stay full or that they don't overflow. Traditionally, however, these two processes required separate devices, a pump controller and a level indicator. Precision Digital's PROVU® Series combines both level indication and pump control into one device. Not only that, they also offer advanced multi-pump alternation control functionality which can help maximize the life-span of your pumps.

The PROVU® PD6000 is a bright, easy-to-read digital panel meter that accepts either a current (0-20mA, 4-20 mA) or voltage (±10 V, 0-5 V, 1-5 V) analog input from any analog output level transmitter. The PD6001 provides convenient level readings in a format operators are used to seeing, feet and inches. Both models feature multi-pump alternation control for up to eight pumps, advanced 32-point linearization for oddly shaped tanks, and automatic round horizontal tank volume calculation.

As a level indicator, the PD6000 and PD6001 offer easy-to-read, dual-line displays with optional SunBright LEDs which can be read in direct sunlight. The secondary display can be used to show level measurement units, volume, or percent full. They are available with up to four onboard mechanical relays and 4-20 mA analog output for signal retransmission or output of some other variable. An available external expansion module brings the total available relays to eight.

As a pump controller, the PD6000 and PD6001 can use the available eight relays to alternate the usage of up to eight pumps at programmed high or low



ProVu® Level Features

Multi-Pump Control
Control and alternate up to 8 pumps

32-Point Linearization
Linearizes the level of oddly shaped tanks

Round Horizontal Tanks
Automatically calculates volume

mA
%

Dual-Scale
Display level in two scales

FT
IN

Feet & Inches Display
Convenient level display in feet and inches

set points. When the level reaches the first set point, the controller will activate the first pump. When the level then reaches the associated reset point, the active pump will be deactivated. The next time this set point is reached, the controller will activate a different pump in the group. This spreads the amount of system wear evenly among the pumps, rather than constantly utilizing a main pump and leaving the backup pump to remain unutilized and deteriorated over time, potentially failing when it is needed most.

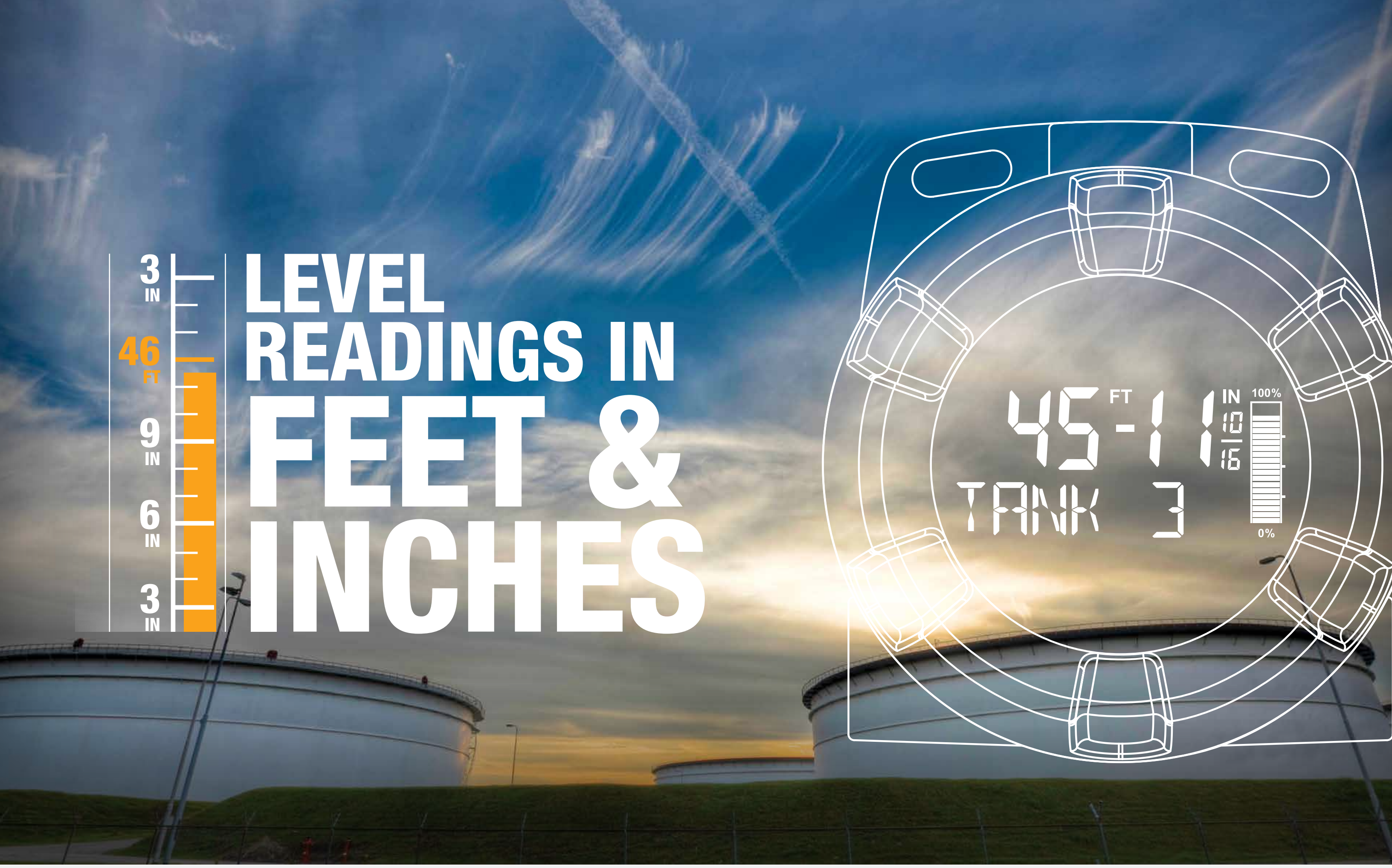
If a pump does not function properly or the rate of change is more than a single pump can keep up with, the next set point will activate a second pump. This will continue until all pumps associated with the pump controller have been activated. Additional relays on the controllers can be used to activate external alarms or other systems if, for example, the level measurement reaches an emergency condition.

> *"[The] ProVu® Series combines both level indication and pump control into one device… they also offer advanced multi-pump alternation control…"*

The advanced pump control and level indication features of the ProVu® PD6000 and PD6001 make combining level indication and pump control a breeze. They help not only by providing easily readable level indication and convenient pump control, but also by extending the life of your pumps by way of spreading out system wear.

PD6000
Level Indicator and Pump Controller

by Simon Paonessa - Technical Writer
Precision Digital Corporation



LEVEL READINGS IN FEET & INCHES

Many tanks are manually gauged in feet and inches and that is often the way operators are used to seeing the data. Unfortunately, many digital meters can only display in decimal format. Precision Digital's new Feet & Inches meters solve that dilemma by providing the tank level in the way that operators are used to dealing with it: in Feet and Inches!

Benefits

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Benefits and features vary by model and/or options available.

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Letter from Sales

by *Chuck Arcovitch*
US Distribution Sales Manager
Precision Digital Corporation

Your Top 10 Customers of 2015 Will Not be Your Top 10 of 2016

☑ What You Should Do About It

A Message for Precision Digital Distributors

Your business is changing, and you need to make sure you are promoting the products, services, and selling techniques that will keep you growing in 2016.

At the time I am writing this, the price of a barrel of WTI oil is $38.50. A year ago, the price was $56.50; and even higher before that. While not everyone may be touched by this kind of change, I am sure that other changes such as municipal budgets, new technologies, or even winter weather patterns will affect your business.

Jonathan MacDonald, founder and speaker for TEN (Thought Expansion Network) is commonly quoted for his message: “Today is the slowest pace of change we’ll ever experience.” Not only is this true for people, marketing firms, and high tech companies, but for your business as well. What it means for your business may not all be clear, but one thing that is for certain is that you cannot count on your top 10 customers of 2015 being the top ten customers of 2016, and you cannot count on the same selling methods and sales calls resulting in the same business.

As the U.S. Distribution Sales Manager, I try to help our distributors figure out what to do about this. How do you, as a distributor, plan for change?

My answer to that question is that you have to simply do more. You have to visit new customers, knock on new doors, and show existing customers new products. How many of your customers have seen a Precision Digital demo? How many of them have been walked through a catalog? Of your top customers, how many of them have you toured and discussed their processes with them on the plant floor, catalogs in-hand? You need to be able to answer these questions, and you must be motivated to change those numbers.

The only way to change with the changing world of 2016 and beyond is to change your approach. It’s no longer good enough to sell the same products to the same people. Precision Digital can help you. We can provide you with the tools, the messaging, and the products you need in order to grow your sales in a changing market by helping you promote new products for your existing customers’ applications. We can also open up new applications for you with existing customers. We make a great discussion point for bringing value directly to the operators at new facilities.

So, how do you plan for the changes of 2016? You have to make a commitment to doing more, and changing how you sell. If you do, you’ll find some great changes can come this year to your bottom line.

LEVEL MEASUREMENT TECHNOLOGIES

In The Process Control Industry

Few things are as ubiquitous in the process control industry as the need to measure the level of a process material in a container. Whether that material is water, waste water, petroleum, sugar, or any other form of liquid or solid, level measurement accuracy can be a determining factor in both profit margins and safety. On December 11th 2005, malfunctioning level gauges were partially responsible for a massive explosion at the Hertfordshire Oil Storage Terminal in Hertfordshire, England. According to the Health and Safety Executive that investigated the blast, "the tank was full, but gauges and safety devices did not work."[1] A high level switch that should have detected the petrol level and cut off flow to the tank failed to operate and workers didn't notice that the tank was overflowing[2]. This resulted in a 32-hour inferno which injured 43 people and left many families homeless.

> ***"Instances of level measurement and control failure... can lead to tragic and costly consequences...."***

Because of the importance of accurate level measurement and the myriad of different process materials requiring level measurement, an almost equal number of unique methods for detecting level have been developed. Selecting the correct level measurement technique for a particular application can seem like a daunting task in the face of so many options. All level measurement systems rely upon certain characteristics of the process material, such as density, capacitance, temperature, etc., and each has its own particular advantages and disadvantages. It is important to understand the fundamental mechanics of the level measurement technologies being considered in order to correctly specify the appropriate method (or methods in the case of redundant systems) for the application.

Categorizing Level Measurement Technologies

A good way to reduce the number of level measurement options is to categorize them into two broad categories: contact and non-contact. Then you can filter choices by the type of material they can measure.

Contact and Non-Contact

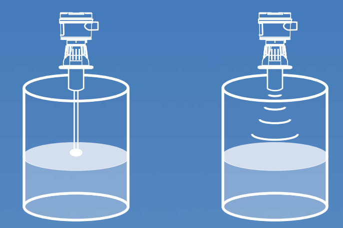
The characteristics of the process material being measured, such as tank size and shape, the pressure and temperature that the process requires, amount of material agitation, available power, etc., must be taken into account when determining if a contact or non-contact approach is the right option. One must consider whether the material is corrosive or tacky and could possibly cause damage to the measuring device, whether it is volatile and a contact sensor might create a safety hazard, whether the agitation, temperature, or pressure of the process material could affect the reading of or damage the contact sensor, and any other troublesome possibility. On the other hand, non-contact solutions may be outside of the budgetary constraints of the project or not provide the necessary level of precision.

Type of Material Measured

Process materials that need level measurement can generally be classified as liquids, granular solids, slurries, and interfaces. Liquids vary greatly in density and can be under a wide range of pressures and temperatures, depending on the process. These factors influence the types of level sensors that can be used. Interface level, or the point at which two liquids of different densities meet, requires special consideration over typical liquid level measurement. A lot of the sensor technology that can be successfully employed in measuring liquid will be unwieldy or simply unusable when measuring granules such as loam and stone dust, or slurries such as cement. For these reasons, it is important to understand the type of process material (at all stages of the process) you are dealing with prior to looking into level measurement options.

How to Narrow Down Options

Contact | **Non-Contact**



Liquids
Materials that are in a liquid state and can have different densities

Granulars
Materials that are in a solid state and small enough to be stored in tanks

Interface
A surface boundary between two liquids or chemical phases

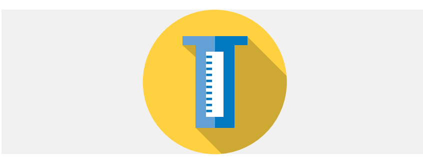
Slurries
Semiliquid mixtures of liquid and fine solid particulate

An Overview of Level Measurement Technologies

Because for the sheer number of level measurement technologies, the following overview is not meant to be all-inclusive nor is it meant to cover every intricacy of the technology in question. It is meant instead to give a very high-level synopsis of some of the different types of technology available and how each functions as a measurement device. More detailed information regarding a specific measurement device can be found in the manufacturer's documentation and should always be consulted prior to purchase as every device uses level measurement methodology differently. That being said, a broad understanding of how each technology category is meant to function will give you a proper head start when specifying level measurement sensors.

Contact Sensors

Level Sight Gauge



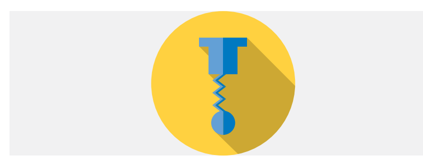
The first type of level measurement device to be considered here is also the simplest. A level sight gauge typically consists of a tube connected at openings near the top and bottom of the tank. The tube has a transparent face so an operator can see the level of the process material. This is technically a non-contact measurement because there is no sensor making contact with the process material. However, many of the same concerns about contact sensors should be taken into account, such as agitation, corrosiveness, tackiness, temperature, pressure, etc., which could damage or obscure the viewing area.

Though this method of level measurement may be considered the most trustworthy because the material level can actually be seen by the operator, pressure or temperature differentials between the tank and the viewing area can have an effect on measurement accuracy[3]. When measuring an interface, the top opening of the gauge must be submerged at the level of the top liquid and the bottom opening must be at the level of the denser liquid or else the level measurement will be incorrect. Level sight gauges can only be used when measuring liquids, as granules and slurries cannot move fluidly through the gauge. There is also no way to incorporate any type of automation into the process using this type of measurement device.

Float

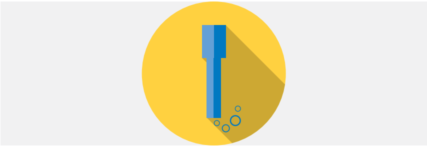
Other devices, such as floats and displacers, rely on the material's specific gravity (density) to measure level. They often use a gauge similar to the sight level (a tube connected to the side of the tank towards the top and bottom).. Magnetic floats, a specific type of float level sensor, typically rely on reed relays placed lengthwise within the tube. When the float passes these relays the magnetic field trips them. Therefore, the accuracy of such a sensor is limited by the number of reed relays placed in the gauge. Other float sensor types rely on the measurement of the extension and retraction of a connected cable. This type of sensor, in principle, requires no power to operate but is susceptible to failure from float jamming or clinging.

Displacer



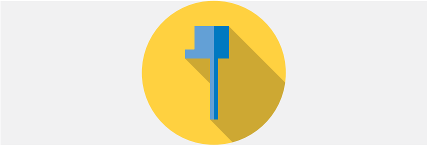
Displacers are dissimilar from float devices in that they are denser than the process fluid and suspended by a spring. They rely on Archimedes' Principle to detect changes in buoyancy force, which is equal to the weight of the displaced fluid, caused by a rise or fall in level. A sensor at the top of the gauge measures the change in apparent weight of the displacer body. The level measurement is therefore a product of the length of the displacer body covered by the process material and the specific gravity of the material[4]. Both displacers and floats require much of the same considerations as mentioned previously with level sight gauges and special considerations for interface measurement.

Bubble Tube



Bubble tube level measurement relies on the specific gravity of the process material as well. With this type of contact sensor, a tube is submerged into the process fluid and air or nitrogen is pumped through the opening, near the bottom of the tank. The resulting back pressure is proportional to the liquid level and density[5]. In instances where submerging a tube into the process liquid is impractical, air can be pumped in through an entry at the side of the tank. This type of sensor can only be used to measure the level of liquids. If the process liquid in which the tube is submerged remains at a constant level, any change in backpressure is due to a change in density or interface level, thus allowing for measurement of these variables[6].

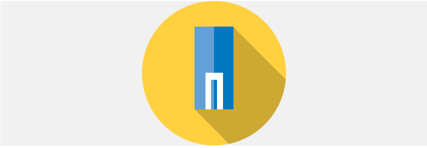
RF Capacitance



RF Capacitance level sensors use the same operating principle as an electronic capacitor in order to gauge level. An electronic capacitor consists of two conductive metal plates separated by some kind of insulating material. Capacitance is the measurement of the amount of energy a capacitor can store. Using a method that is very similar to that of an electronic capacitor, the capacitance of a process material can also be measured and then correlated to the level.

If measuring a non-conductive material, that material is used as the insulator part of the capacitor and the tank wall acts as the second conductive plate; if measuring a conductive material, the probe body is shielded with an insulator and the material acts as the other conductive plate[7]. In either case, a rise in the level will correlate with an increase in the measured capacitance (over that of air). This technology can be used for either point-measurement level switches or continuous level measurement. Variations of this technique can be used to measure liquids, granular solids, slurries, and interface levels[8].

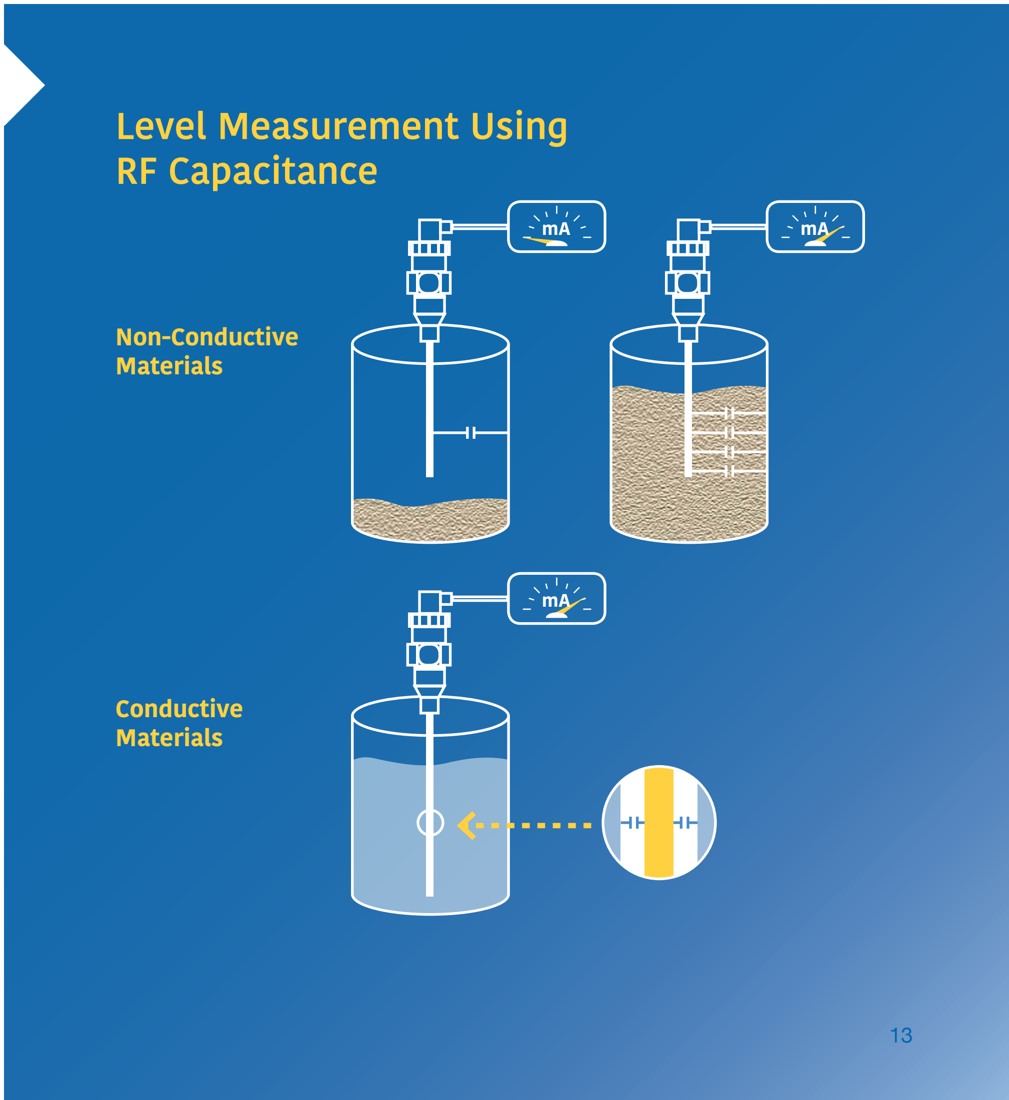
Resistance Tape



The mechanical force of a process liquid can be used to measure level using what is known as resistance tape. Two wires, one attached to a voltage source and the other to a precision resistor, are contained within a shielded, flexible probe. Hydrostatic pressure pushes on the probe body and shorts out the submerged length of wire. The change in resistance is correlated with the level of the process liquid. These types of contact probes tend to be very delicate and changes in density can have a minor effect. They are typically used to measure liquids and slurries[9].

Contacting Ultrasonic

Vibrating or ultrasonic level switches work under the principle that the sensor will vibrate at its resonant frequency when not submerged in process material. If the frequency is dampened, the material has reached the level of the switch. This technique works with liquids, slurries, and granules, although consideration should be made for coating or corrosive materials. Vibrating level switches will typically only be used for point level measurement, as opposed to continuous level measurement, and trigger high and/or low alarms. The sensors themselves tend to be fragile because of the level of precision necessary[10].



Contact and Non-Contact Level Measurement Comparison

	Type	Liquids	Granulars	Interface	Slurries	Corrosiveness	Agitation	Tackiness	Single-Point Level	Continuous Level
		Material				Suitability			Measurement	
Contact	Level Sight Gauge	•		•						•
Contact	Float	•		•					•	•
Contact	Displacer	•							•	•
Contact	Bubble Tube	•		•					•	•
Contact	RF Capacitance	•	•	•	•				•	•
Contact	Resistance Tape	•			•				•	•
Contact	C Ultrasonic	•	•		•				•	
Non-Contact	Radar	•	•		•	•	•	•	•	•
Non-Contact	NC Ultrasonic	•	•		•	•	•	•	•	•
Non-Contact	Load Cells	•	•		•	•	•	•	•	•
Non-Contact	Nuclear	•	•		•	•	•	•	•	•

Recommended applications

"All level measurement systems rely upon certain characteristics of the process material..."

Non-Contact Sensors

Radar

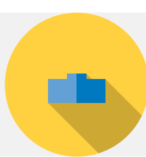
Radar is a technology which was first extensively developed and deployed during the second World War as a means of detecting aircraft, ships, and other large objects. Since the technology was introduced to the civilian sector, many peacetime usages of the technology have been established, including level measurement. Radar typically works by emitting electromagnetic pulses in the direction of an object, waiting for that pulse to reflect off the object and return to the source, and measuring its time-of-flight. The distance between the pulse source and the object can be calculated as the product of one-half the time-of-flight and the speed of light.

For use in level measurement, a radar transceiver is suspended from the top of the tank and measures the distance to the top of the process material. The overall length of the tank body can then be used to calculate the level. As a non-contact sensor, radar has the distinct advantage of not being affected by the process material's state, such as agitation, corrosiveness, tackiness, temperature, pressure, etc. Radar can be used to measure liquids, slurries, and granular solids. However, materials with high conductivity tend to be better candidate for radar level measurement because they reflect more of the emitted radio signal. As such, conductive materials other than the process material within the tank, such as agitators, can cause interference with the radar signal.

Non-Contacting Ultrasonic

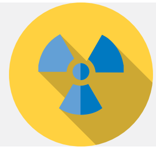
Non-contact ultrasonic level sensors use a very similar method as radar sensors to measure level. However, instead of using radio waves they use sound waves and the distance is calculated as the product of one-half the flight time and the speed of sound. Unlike the speed of light, the speed of sound is temperature dependent, so the temperature of the tank must also be measured and taken into account[11]. Like radar, they can also be used to measure liquids, slurries, and granular solids. Process materials that produce a stronger sonic reflection are more applicable to this type of measurement. Condensation, dust buildup, and presence of additional objects within the tank can all cause measurement inaccuracies[12].

Load Cells



Load cells, sensors normally used to measure weight, can be used to gauge tank level. These sensors are attached to the support columns of a tank and measure the downward force applied on them by the mass of the container above. By taking into account the weight of the tank when empty and assuming that the tank has straight sides, any change in the weight measured by the load cell can be correlated with a change in level. Load cells can be used to detect the level of liquids, slurries, and granular solids, but require the process material to be of constant density. Load cells typically are not used to measure interface level.

Nuclear



Nuclear type level sensors use radioactive isotopes, typically either cobolt-60 or caesium-137, to emit gamma radiation into a storage container and sensors on the opposite side to measure the attenuation, or change in frequency modulation, of that radiation. *Isotopes* are atoms that have the same chemical behavior as one another but a different number of neutrons. *Radioactive isotopes* are those isotope variations which are unstable under normal conditions and decay into other elements. When these atoms decay, they emit three different kinds of radiation (alpha, beta, and gamma) which can be picked up and measured by special sensors. Gamma radiation is used for the purposes of level measurement because, of all three kinds, it is the best at penetrating materials[13].

This technology can be used in both single-point and continuous level applications. In single-point measurement, such as high and low alarms, a sensor is typically installed parallel to the source of radiation on the opposite side of the tank and any change in frequency modulation over a certain threshold triggers an alarm. Since radiation is released from all directions from a radioactive element, continuous level measurement involves using sensors along the length of the tank on the opposite side. Using the attenuation detected through an empty tank as a baseline, any change detected by a sensor is attributed to the level being at or above that sensor. Though this technique is affected little by the physical state and properties of the material, it is typically only used when all other options have been exhausted due to the dangers and expense of using radioactive material and the stigma associated with it.

Summary

The technologies described here barely scratch the surface of those available to the industry (not to mention variations of these technologies). Due to the nearly countless number of process materials and conditions in all of the industries that require level measurement for their processes, an almost equal number of methods for measuring level have been devised. However, understanding the differences between and limiting factors attributed to contact and non-contact sensors, as well as the fundamental operating principles of some of the more common level sensor technologies, should help when specifying what technique is best suited for a particular application. Instances of level measurement and control failure, such as the events that unfolded at the Hertfordshire Oil Storage Terminal, can lead to tragic and costly consequences that could have been avoided. A level perspective is vital to maintaining accurate process control and ensuring continuous safety.

by Simon Paonessa - Technical Writer
Precision Digital Corporation

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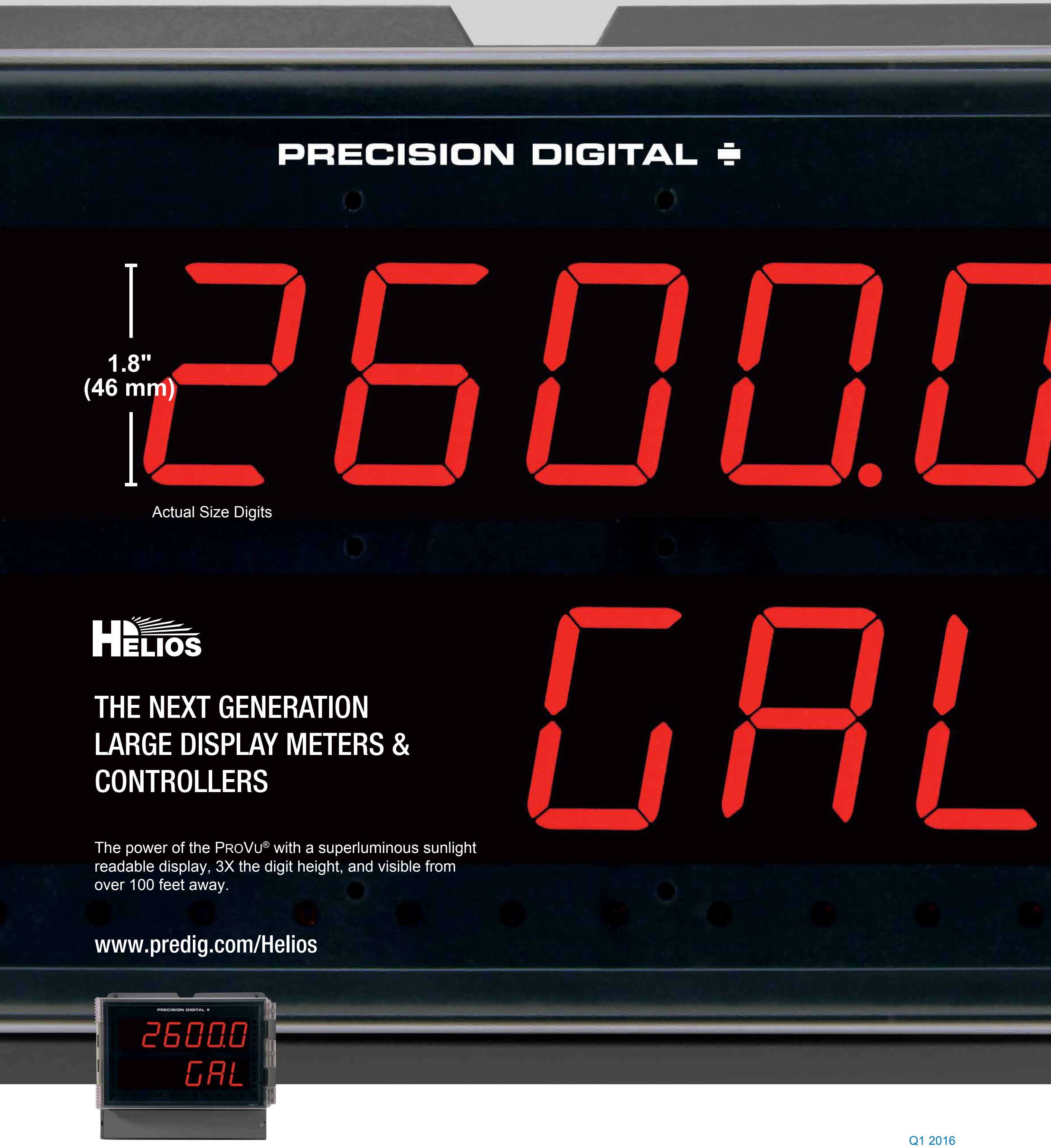

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