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Ask Tom! Column

In Control Part III - Liquid Level Measurement

by Dan Capano, DTS, Inc.

Level measurement is one of the most common types of process measurement in common use. In this article, I will discuss the various methods of measuring a liquid level, presenting the key features of each. Level measurement is important for several important reasons. The most obvious is the need to determine the amount of liquid in a vessel, such as a tank, in order to control inventory or regulate a process. In the wastewater industry, level measurement is used in such applications as maintaining the levels in chemical day tanks. In this type of application, a level measurement device would monitor the level of chemical and initiate a filling device, such as a pump, when the level reaches some pre-determined low level. The device signals when the tank is full or at a chosen high level, shutting down the pump.

Level devices can be either continuous or “point-level”; the devices may be active or passive. Continuous level monitoring refers to a method whereby the device measures level on a constant basis, displaying or transmitting the actual level of the liquid as it changes. Knowing the volume of a tank allows an operator to calculate back how much liquid (in gallons or pounds) is present at any given time in the vessel. This is extremely useful information in managing inventory or in gauging process performance. Devices that fall into this category are: Admittance, Ultrasonic, Magnetic, Radar and Differential Pressure.

Point-level devices measure liquid at specific points within the tank. As a liquid level rises and falls, it passes through definite points during it’s transit. If tight process or inventory control is not required, point level is a simple way to monitor and control level. Point level monitoring is perhaps the oldest type of level monitoring and control in use. Devices that fall into this category are: Floats, Displacement, and immersion switches. Continuous level devices can typically be programmed to output alarms at specific points within the range of the device in addition to transmitting a continuous level measurement.

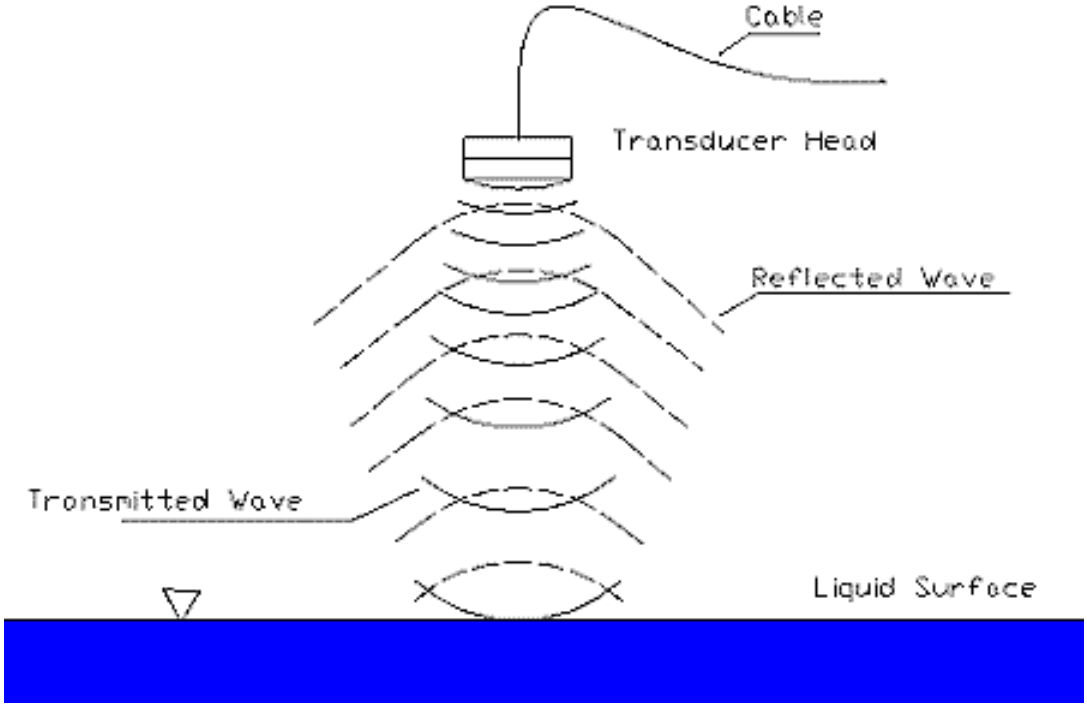
Active devices are those that expend energy in some fashion in order to exploit that device’s unique method of operation. Most continuous devices, with the exception of magnetic, use either a transducer or energized cable system to interact with the material being measured. Both Radar and Ultrasonic devices emit electromagnetic energy in order to detect the level of the liquid at that second. Admittance devices use an energized cable immersed in the liquid to continuously monitor level.

Passive devices react to level only when directly contacted or physically moved by the liquid. All passive devices fall into this category. Level devices also fall into either the non-contact or contact type of device. Contact type devices, such as floats and admittance devices, actually contact the liquid being measured in order to operate correctly. Non-contact devices, such as Radar and Ultrasonic, do not require contact with the measured liquid in order to perform properly.

Ultrasonic Level Measurement

Ultrasonic (U/S) energy is electromagnetic phenomena, actually sound waves, which exist in the range of sound above the audible range of sound. These waves share the common property of electromagnetic waves of reflecting back toward their source after contacting a medium more dense than air. This border between two media, i.e. air and water, is called an interface. This interface, of course, represents the level of the liquid being measured.

Ultrasonic Level System



Ultrasonic systems are accurate within a range of approximately 30 feet. A typical installation consists of two parts:

- A Transducer, consisting of both a transmitter and receiver. Ultrasonic energy is transmitted from the “head” in the direction of the liquid surface. When the ultrasonic waves contact the surface, they are reflected back to the receiver in the head.
- Electronics, which produce, control and time the ultrasonic pulses which are transmitted and received by the head. The electronics also transmit control signals to remote monitoring devices such as displays and process control systems.

Measurement is accomplished by timing the delay between the instant when the pulse is transmitted and subsequently received at the head. This delay is converted to units calibrated to the range being measured. Because of the inherent tendency for U/S waves to spread, a cone is usually attached to the head to improve the accuracy of the transmitted energy. Most U/S devices have a means of self-calibration such as a target located a short distance from the head , usually within the cone. Most installations also include a “zero target”, which is a reflective surface at the zero of the desired range. In tank installations, the zero target is usually the floor of the tank. In flow measurement applications, such as a weir, a plate is place directly below the head at the level corresponding to zero flow (See InControl # 2). U/S devices are susceptible to problems due to coating of the transducer face, foaming of the process liquid and internal tank structures. False echoes may cause headaches in some closed tank installations. The non-contact nature of these devices allows ease of installation and maintenance and avoids, in most cases, operator contact with toxic materials.

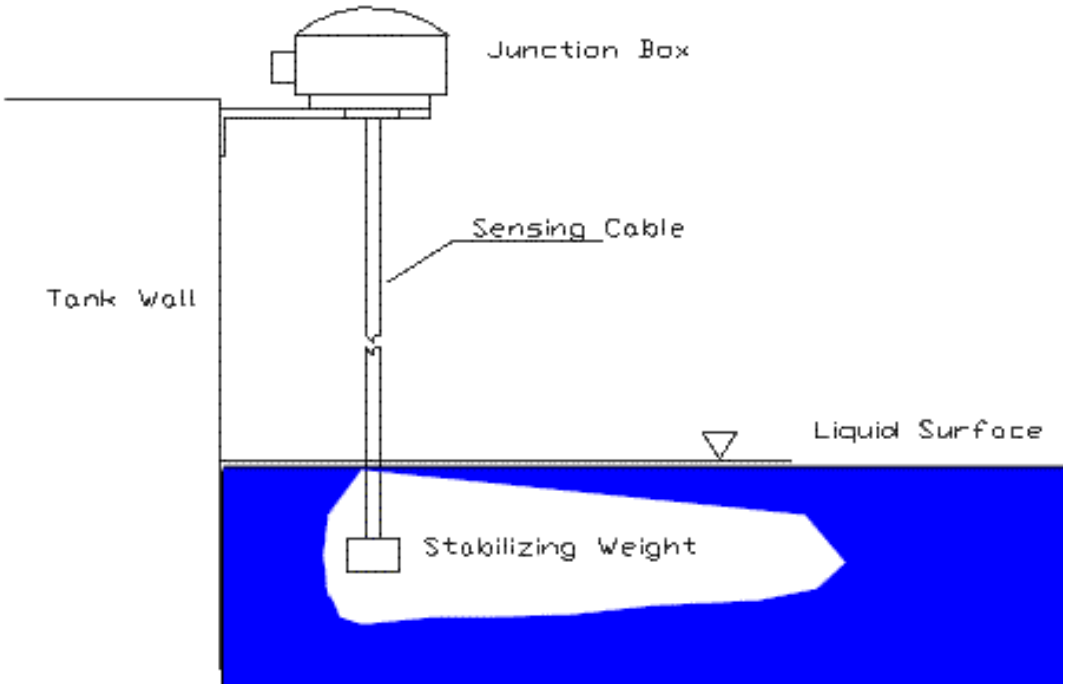
Radar

Radar is an acronym for RAdio Detection And Ranging. British scientists invented radar during WW2 to monitor the English Channel for Nazi bombers. Radar technology is very mature and a relatively late entry into the commercial level measurement market. . Operating much like ultrasonic systems, radar waves bounce from a reflective interface in order to accurately measure liquid level. Radar has much higher penetration, is highly directional and is not plagued by false echoes caused by foaming.

Admittance

This type of device operates by using the electrical relationship between the measured liquid and an energized cable immersed in the liquid. As the liquid level rises and falls, the capacitance between the cable and tank changes proportionately. The capacitance causes a change in an oscillator located in the system electronics, which is converted into units calibrated for the range of the instrument. Sensing cables are fitted with a weight at the bottom of the cable in order to provide some stability from movement, which could have an adverse effect on accuracy if excessive.

An Admittance



Probe Coating of the cable can degrade performance and many cables have become fouled in mixers or rakes; The application of this instrument should be thoroughly reviewed with the vendor or rep prior to installation. Admittance devices are extremely accurate and reliable requiring no maintenance except for an occasional calibration.

Magnetic

Magnetic level devices come in many different configurations. The most popular is a sight glass arrangement, which contains metallic flags that indicate the level of the liquid being monitored. This is accomplished by the use of a magnetic float inside of a tube that is part of the sight glass. As the magnet rises and falls with the liquid level, it causes the metallic flags to flip and expose a different color, indicating the level. The system is simple and requires no maintenance under ordinary circumstances. Improperly applied, these devices can become fouled causing the magnetic float to jam or stick in the measuring tube. These devices are available with continuous monitoring equipment, allowing both a local visible indication as well as an external signal for remote monitoring.

Floats

Floats have been used for liquid level control since time immemorial. Floats can be as simple as a hollow ball (as used in a home toilet) or relatively sophisticated as in displacement types. In the former, the float is a sealed metal or plastic ball which floats on the liquid surface and rises and falls accordingly. If the ball is connected to an arm, the arm may be attached to an indicator or to a switch, allowing monitoring and control in a

low-tech way. Tip-up floats are sealed metal or plastic capsules available in many shapes and colors. Tip-up floats use mercury switches (banned almost everywhere in the U.S.) or metal slides, which may or may not be magnetic. The cable attached to the float is anchored at some point, allowing the float to tip up and trip an internal switch at the desired level. Most tip-up floats are equipped with DPST (double pole, single throw) switches, allowing operation in both the rising and falling directions.

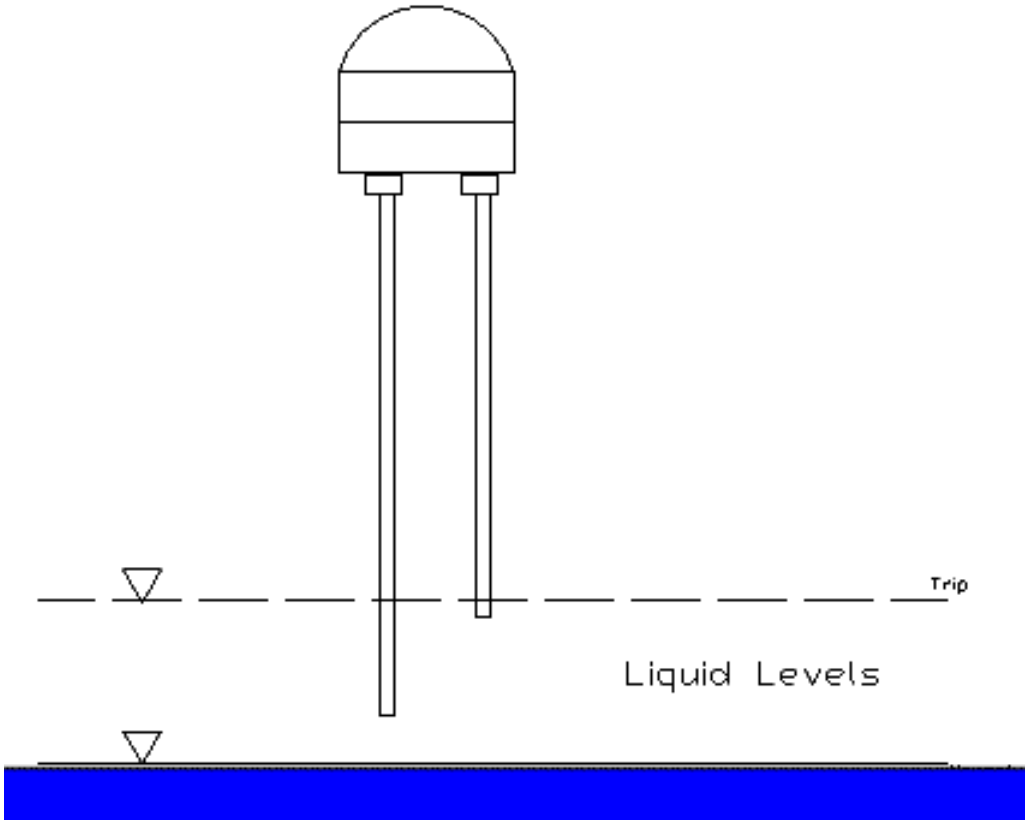
Displacement Float Switch

Displacement floats are somewhat more complicated. A series of calibrated floats are hung on a single cable, which is then hung within the vessel to be measured. As the liquid rises, the weight of each floats is displaced, allowing a slight movement of the suspension cable. The cable moves a pre-determined amount for each float immersed in the liquid. At the point of suspension, a switch can be set to react to each successive movement of the cable, either in the up or down direction. This type of device is very sensitive to the amount of suspend-ed matter in the liquid and is typically used for clean water or chemical applications. Fouling by debris or heavy particulate make application of this device limited in the wastewater field.

Immersion Switches

Immersion switches are simply two conductive rods or probes that form a circuit when a liquid bridges a gap between them. The energy used to create the electrical circuit is limited in current to avoid any accidents. These devices are inexpensive and reliable and require no maintenance save for an occasional cleaning. Typical applications are high level alarms in containment areas or in large open receiving tanks.

An Immersion Switch



Differential Pressure

Differential Pressure, or DP, is a method of monitoring level using the differences between two pressures to determine the level of the liquid being monitored. The most common technique used is to measure the static head of the liquid as compared to atmospheric pressure. This relationship is straightforward; each foot of water exerts a pressure of .433 pounds per square foot (psi) or .036 pounds per inch. By monitoring pressure, one can easily determine the level of liquid in a tank. Of course, density varies with the type of liquid, so instruments must be calibrated for the correct range of pressure/level. DP instruments are usually mounted in a flange or threaded port near the bottom of the monitored vessel. These instruments require periodic calibration and accuracy can suffer from buildup of sediment or debris. Pressure type of instruments vary from a simple pressure gauge, with widely varying accuracies to high-quality electronic pressure transmitters capable of transmitting a signal to a remote location.

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Welcome to Ask Tom!, a monthly column by our resident water treatment guru, Tom Keenan of National Environmental Services Agency (NESA). Tom addresses the issues that bug you the most. And Tom knows!! With 35 years experience in providing environmental support services to public and private sector clients on a wide range of environmental issues.

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