A capacitance instrument determines level by measuring the amount of capacitance between two plates of a capacitor. In nonconductive applications, the measuring circuit applies a high-frequency signal to the probe, which acts as one side of a capacitance plate. The second capacitance plate can be the tank wall or a reference probe.

Capacitance devices work with slurries, foam-filled and turbulent fluids, as well as those whose density changes. In nonconductive processes, with hydrocarbon fluids, the probe acts as one capacitance plate, and the tank wall or a reference probe as the other. For conductive applications, with water-based liquids, the insulation of the probes provides the dielectric and the liquid itself, the second dielectric. For nonmetallic tanks, a process ground must be used. For tanks with curved walls, a reference must be used to create a constant distance between capacitance plates.

The capacitance (C) is equal to the area (A) of the capacitance plates covered by the given process fluid, divided by the distance (d) between them, multiplied by the dielectric (k) of the material being measured. $C = k (A/d)$

The area of the plates covered by process material depends on the fluid's, so measured capacitance is proportional to the process level.

Tank construction plays a part in the function of a capacitance system. Metallic tanks with straight walls can serve as one of the capacitance plates. Nonmetallic tanks without straight walls, such as horizontal bullet-shaped tank, require the use of a reference probe to serve as the second plate to produce a linear output. Occasionally, there may not be sufficient change in capacitance over the desired level span. In those cases, sizing can be modified to enlarge the capacitance plate, or a concentric shield can be used to shorten the distance, d.

With conductive applications, the fluid becomes the second dielectric plate and the insulation on the probes becomes the dielectric. When this happens, the basic equation is applied so that the stay dielectric constant and the area of the second plate varies. Capacitance is still proportional to level.

Using capacitance-based level measurement techniques for nonconductive media requires that the process fluid be homogenous, and that its dielectric be relatively stable. When both the level and the dielectric change, each must be considered as a variable; systems are available that compensate for these variations, but they work best with homogenous fluids.

Some process liquids tend to coat or adhere to the probe. The level will be read, up to where the coating starts. If the coating is nonconductive, its effect will be less pronounced. If the coating is even, a coating rejection circuit may be set up by driving the probe at higher frequencies or incorporating a phase detection circuit. If the coating is uneven and tends to build up near the tank wall, then the probe could simply have an inactive portion, made of a material such as polytetraflouroethylene (PTFE), built into its construction.

If the tank or holding vessel is nonmetallic, a process ground must be added. If the tank does not have straight tank walls, then a reference probe must be used to create a consistent distance between the dielectric plates.

Incorporating a concentric metal shield into the probe's construction solves both problems, providing grounding, and acting as a constant reference source. Since the shield functions as the second capacitance plate, its proximity effectively increases the sensitivity, allowing the technique to be used on materials with low dielectric.

Other options are adding a reference probe parallel to the device probe, or incorporating a "stilling well," a pipe traveling the length of the level measurement. In tanks more than 20 ft. depth, a cable is used in place of the probe.

Ultrasonic Types

Capable of making both continuous and point liquid-level measurements, ultrasonic devices measure level independent of changes in such product parameters as density and dielectric constants. They work well in clean, solids-laden viscous or corrosive fluids, and some slurries and aerated liquids. There are some distinctive differences between point and continuous devices, however.

Continuous ultrasonic level devices are noncontact instruments, attractive for corrosive process or slurries that would foul or corrode a standard process-contacting device. In addition, they contain no moving parts, and their measurements are not affected by changes in density and conductivity. To protect them from corrosive vapors, some devices can operate through a Teflon protective covering.

Because readings can be affected by the presence of dust, steam, process vapors, and higher temperatures and pressures, ultrasonic devices work best in environments where there is a clean or consistent path between the transmitter and the surface. Continuous ultrasonic devices are limited to pressure from slightly negative to about 100 psi and temperatures below 200°F.

In continuous ultrasonic measurements, a sound pulse is transmitted from the sensor to the surface of the measured material. This pulse is reflected off the process surface and returns to the sensor as an echo. The amount of time that it takes to send and receive the signal is proportional to the distance between the sensor and the material surface. The most recent device feature's microprocessor capabilities, providing echo-processing algorithms and higher energy sensors that make them easy to setup and use, and more accurate than other models.

Continuous ultrasonic level devices can be mounted on top of any tank, and can be used with liquids whose density and conductivity change, and with viscous and corrosive fluids. Today's include microprocessor capabilities and sophisticated echo-processing algorithms, as well as higher energy sensors.

Surface foam is another factor that can influence ultrasound readings, since sound waves can reflect off the foam instead of the actual liquid surface. In other cases, the foam can absorb the waves so that no signal is returned. If the surface is not horizontal, then the sound waves may not be reflected back directly to the instrument.

Turbulent surfaces can have a similar effect and can absorb the sound wave. To overcome this problem, a sitting well can also be installed to provide a more stable surface. Vortexes caused by agitation can also misdirect the echo.

To ensure a clear path between the instrument and the surface, ultrasonic devices should not be placed above a product entry point. Otherwise, if product flowing into the tank is in the path of the sound wave, the wave will reflect off the product flow. Similarly, the sensor should be placed where the sound wave path will not encounter such obstructions as ladders, floats or agitators. This is specially true if the product level drops below any of these devices and that point will be interpreted as the level measurement.