ULTRASONIC LEVEL DETECTORS

CONSIDER THESE EXPERIENCES WHEN MAKING A SELECTION

ABSTRACT

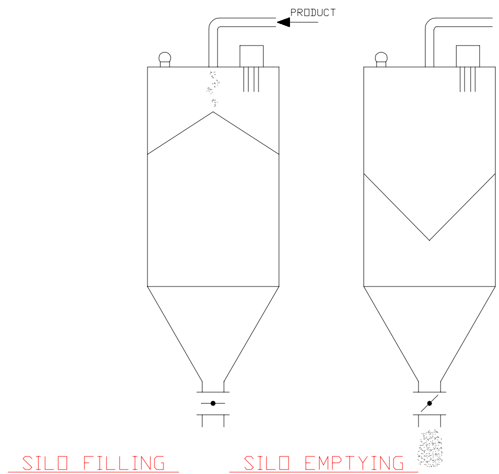
Ultrasonic level detectors. These instruments use high frequency sound bounced off a surface to determine distance. They are often used as level detectors in tanks and silos. Long-lived, useful service depends on configuration of the tank roof and internals, material of construction compatibility with process chemicals, position on the roof, stillness and orientation of the surface being measured. Keywords, silo, calibration, location, dip pipe.

Ultrasonic level detectors (ULD's) work on the principle of measuring the time delay between emitted high frequency sound and its reflection from a surface. In many applications these devices have been used successfully as level detectors. However in the situations discussed below they did not give satisfactory long-term service.

POWDERED PRODUCT SILOS

One application that proved difficult for the model of ULD selected was in measuring the level of powdered product in vertical silos. It appeared that the dust created during filling caused interference with the reflections and resulted in false level readings. The dust also coated the surface of the detector, thereby causing intermittent spurious readings during the normal operating mode.

A further complication that occurred in the silo was the inversion of the product surface shape. This situation arose because the product experienced core flow as it was removed from the bottom of the silo. Figure No. 1 highlights the change in surface geometry from conical pyramid to inverted cone as the product was removed from the bottom of the silo.



Drawing No 1. Ultrasonic level detector in a silo.

FLAT ROOF TANKS

Fictitious levels have been experienced when ULD's were installed in the roof of a flat roof, liquid storage tank. The same model sensor, when used in the roof of a conical roof liquid storage tank, produced reliable results. Figure No. 2 shows a method that proved successful in overcoming the spurious results. It was to mount the sensor at the apex of a fabricated cone sitting over the tank manway entrance.

When the same cone mounted sensor idea was used on a flat top reactor vessel the results were mixed. The major difference between applications was that the liquid surface in the storage tank was still, while in the reactor the liquid surface was undulating and turbulent with a great deal of vapor generation. This environment did not appear suited to the use of ULD's. Putting the detector at the top of a dip pipe may have improved the situation by removing the turbulence and reducing some of the generated vapor.

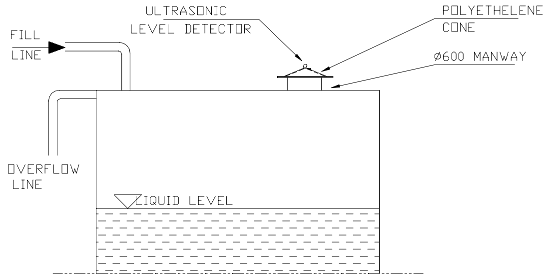


Figure No. 2. Ultrasonic level detector in a flat top roof

RADAR LEVEL DETECTORS

ABSTRACT

Radar level detectors are becoming a popular technique for tank level detection of liquids. The radar sends a sub-millionth of a second pulse from an emitter and the return signal is detected at a receiver. The reflection's time lapse is measured and electronically converted to a distance from the liquid surface. Installation peculiarities need to be understood and appreciated in order to provide a reliable operating set-up. Keyword: antenna, spurious reflection, reference plane, emission cone.

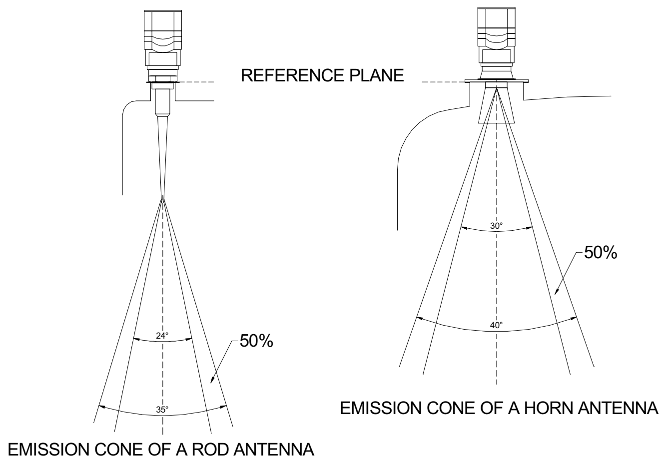


FIGURE 1 Rod and horn style radar detectors

Usually the radar is mounted in a flanged nozzle or socket welded to the roof. It can also be mounted in a pressure-balanced standpipe in those tanks with undulating surfaces. The radar can be mounted directly to the roof provided the liquid full height is below the bottom of the antenna. If the antenna gets below the liquid surface false indication results.

Care must be taken to position the radar to prevent unwanted reflections off tank internal structural beams, wall welds, rivets, etc. Spurious reflections can be electronically separated from the true level reflection but this introduces programming complications better avoided if possible.

Keep the receiver below the bottom of the nozzle so that it is in clear space. Pulses can bounce off the nozzle walls to the receiver and produce false signals.

Foam on the liquid surface deadens the return pulse.

If located inside vigorously agitated tanks the risk exists that the opening of the antenna cone can get blocked by splashed product. This is a problem with products that sublime (evaporate then solidify on surfaces) like sulphur or that crystallise.

Check material compatibles and chemical resistance. Especially over many years so that you don't have reoccurring operating problems.

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TEMPERATURE SENSING ELEMENTS

ABSTRACT
Temperature sensing elements. The temperature of a process is an important measure to know as it indicates whether or not the process is in control. When high temperatures exist and accurate measurements are needed thermocouples and Resistance Thermal Devices (RTD) are two commonly used industrial temperature sensing methods. Keywords: temperature range, instrument, response time, spanning.

The selection of the temperature sensing method depends on -

- the required temperature range
- the measuring accuracy required
- the speed of response needed from the control system
- the process chemicals and conditions

Changing temperatures produce proportionate changes in the properties of materials. These changed properties can be measured and used to indicate the temperature. The thermometer used at home to measure room temperature can be a filled system type, where trapped liquid or gas expands or contracts, or a bi-metallic strip device, where two dissimilar metal are coiled together and the length of each metal changes at a different rate and moves a pointer. These same devices, though more refined, are also used in industry. Their temperature range is generally -50°C to 600°C.

THERMOCOUPLES

Thermocouples consist of two wires of dissimilar refined metals in contact at both the sensing and the measuring ends. A difference in temperature between the ends produces a proportional electric current that can be measured. Thermocouples respond quickly to temperature changes with the speed of response being affected by the wire thickness. They are used at temperatures from –200°C to 2000°C depending on the metals selected for the wires.

RESISTANCE THERMAL DEVICE

In a Resistance Thermal Device (RTD) temperature changes produce a proportionate electrical resistance in a length of refined metal wire that can be measured. They are used at temperatures from –250°C to 600°C. The sensor is a fine wire wound around an insulated core and the lot is encapsulated in epoxy resin or glass and protected by an outside sheath of stainless steel.

Encapsulating the wire significantly increases the response time (lag time) and makes RTD's less favourable for control purposes where process temperature changes quickly.

RTD's can be damaged by being subjected to excessive temperatures, by being chemically attacked by the process chemicals and from physical damage.

RTD SPANNING TIP

An RTD is designed to cover a span of temperature and emits a signal in proportion to the temperature. This signal is then converted into a 4 – 20 milliamp electrical signal that is transferred to a process computer to display on the operator panel and to control the process. The signal converter must be of the same temperature span range as the RTD. For example if the RTD measures 0 – 100°C so must the converter. If the RTD was for a 0 – 100°C span and the converter were for a 0 - 150°C span, the signal going to the process computer would be 33% in error. The computer would display 50°C but the actual temperature would be 75°C.

Mike Sondalini – Maintenance Engineer

Using manometers for measuring pressure.

ABSTRACT
Using manometers for measuring pressure. A U-tube manometer is the simplest of the pressure measurement devices. Its name comes from the U-shape formed when the two ends of a flexible tube full of liquid are raised to keep the liquid from coming out the ends. A U-tube manometer is a 'liquid' balance. By using liquids of different densities a range of pressures can be measured simply by measuring the height difference of the liquid columns. Keywords: process pressure, vacuum pressure, specific gravity, relative density.

A spring balance used in the kitchen weighs a load by matching the force produced by the weight of the load with the force produced from the tension of the balance spring. The change in length of the spring is a measure of the load's weight and is shown on a graduated scale by a pointer attached to the spring. Similarly a U-tube manometer is used to balance the weight of the liquid in one leg of the 'U' against the pressure introduced into the other leg. The difference in height between the two legs of liquid represents the pressure pushing the liquid down one leg and up the other. The height difference is measured on a graduated scale.

PRESSURE IN A COLUMN OF LIQUID OR GAS

Invention of the U-tube manometer allowed the early investigators into fluid mechanics to confirm that pressure was directly related to the sum total of the forces acting on a surface. If you were to stand on the seashore, the pressure on you would be the weight of the air column directly above you. That pressure has been given the name of 'one atmosphere'. If you were to dive to a depth of 10 meters (about 32 feet) there would now be an added pressure on you of the weight of water above plus the weight of the air column.

By international agreement (a convention) 'absolute' pressure includes the pressure of the column of air whereas 'gauge' pressure does not. Gauge pressure is the pressure showing on a pressure indicator dial and is one atmosphere less than absolute pressure.

The pressure of 1-m depth of water is found from the formula –

Pressure = Density x Gravity x Height of liquid column

$$P = \rho\ g\ h$$

The unit is a Pascal. Gravity has the value of 9.8 m/sec^2 at sea level. For simplicity of multiplication the value 10 m/sec^2 will be used. The density for water is 1,000 kg per cubic meter at 20 ^oC.

Putting all the know values back into the pressure equation gives –

$$P = \rho\ g\ h = 1000\ kg/m^3 \times 10\ m/sec^2 \times 1\ m = 10{,}000\ Pa = 10\ kPa$$

The calculation shows that 1-meter of water is equal to about 10 kPa, which means 30 meters of water produces a pressure of nearly 300 kPa. One atmosphere of air pressure at sea level is 101 kPa. This means the pressure at 30 meters depth below sea level is 300 kPa gauge pressure or about 400 kPa absolute pressure. The same formula can be used to calculate negative, or vacuum, pressures.

HOW TO USE A U-TUBE MANOMETER

Figure No. 1 shows three manometers open to atmosphere. The left one has the same pressure in both legs and the liquid levels are the same on both sides. The U-tube in the center shows a pressure applied to the left leg of 100 kPa. The water level in the left leg has gone down and the level in the right leg has gone up. The difference in the height of water between the two legs is 10 meters. Since the liquid is water, each meter height represents 10 kPa and a 10 meter high water column represents 100 kPa gauge pressure. The remaining U-tube shows a pressure of 100 kPa as well but this time mercury is used in the tube. The height of mercury is now 750 mm. The density of mercury is 13.6 times that of water. Because mercury is so much heavier than water the same pressure raises a correspondingly lower column of liquid.

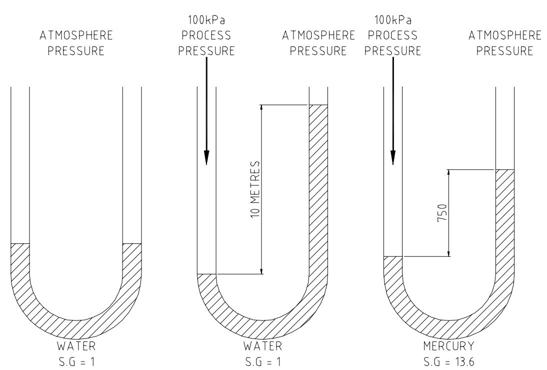

Figure No. 1 U-tube Manometers with Water and Mercury

If a manometer were used to measure a vacuum the column of liquid would be drawn up toward the vacuum and the difference in the height of liquid between the two legs would be a measure of the vacuum pressure below atmospheric pressure.

MAKING A U-TUBE MANOMETER

To make a U-tube manometer requires a clear plastic tube mounted in the shape of a 'U' onto a board marked with a graduated scale. The pressure to be measured determines the selection of the liquid used in the tube. The U-tube liquid's density and the pressure being measured determine the height of the liquid column and the corresponding height of the backing-board.

Mike Sondalini – Maintenance Engineer.

Orifice plate meter flow measurement.

Abstract

Orifice plate meter flow measurement. An orifice meter is a circular piece of metal plate placed between flanges in a pipe. In it is a square-edged round hole machined 0.5 to 0.8 pipe diameter in size. Pressure tapping points are placed either side of the plate at specified distances. The orifice causes a flow restriction and produces a pressure drop from one side of the hole to the other. The amount of pressure difference is proportional to the flow of fluid through the hole. The flow is calculated from the pressure difference and flow areas using accurate mathematical formulas. Keywords: differential, static pressure

Effect of a restriction on fluid flow

When an object is put in the way of a flowing fluid (gas or liquid) in a pipe its presence obstructs the passage of the fluid. The fluid is forced to go around it. The flow diversion requires energy to power the motion and it is supplied from the fluid by its pressure falling as it squeezes past.

The smaller the hole, the less that can get through it, and the greater the back-pressure in the pipe. That is how a faucet (a tap) controls the flow of water into a drink cup when it is opened. Just cracking the tap open produces a trickle. The high back-pressure in the pipe forces a small amount of water out of the tiny opening. As the tap is opened further, the hole gets bigger and the flow increases. The back-pressure in the pipe falls as the restriction is removed.

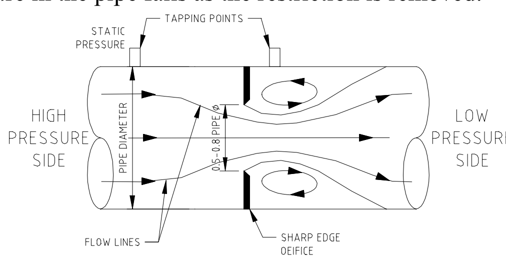

Figure No. 1. Orifice Plate Flow Meter.

By knowing the size of the hole and the pressure difference from one side to the other it is possible to calculate the flow through the hole. An orifice plate flow meter uses the differential pressure principle to determine the flow. Figure No. 1 shows a cross-section view of an orifice meter with its pressure tapping points and stylised flow lines.

Static Pressure and Velocity Pressure

The pressure in a pipe of still fluid and the pressure in the same pipe with the fluid now moving are different. If a pressure gauge were mounted on the pipe it would read a higher pressure when the fluid was still than when it was flowing through the pipe. When a fluid is in motion the static pressure drops and the velocity pressure rises.

An example of static pressure is the pressure of the air in a room with the windows slightly open while outside there is a howling gale. If you go into the gale you would feel the pressure of the wind on you. That pressure is the velocity pressure of the moving wind. At the same time you would experience the static air pressure acting on you. On the windward side you would experience the static pressure plus the velocity pressure. Behind you there would only be static pressure (less a small amount of vacuum pressure). The static pressure is all around you, whereas the velocity pressure is only in the direction of the wind.

The same situation develops in a pipe full of fluid. Where the static pressure is high, velocities are low and where velocities are high static pressure is low (Recall the change in back-pressure in the kitchen pipes as the tap is closed and opened).

Measuring pressure across the orifice

In order to read only static pressure in a pipe the tapping hole must not be exposed to the velocity component of the flow. Usually a pressure gauge is mounted in a hole drilled through the wall, square to the wall. At the inside wall of a pipe the velocity is zero and only static pressure is present.

An orifice plate flow meter uses static tapping points located at either side of the orifice. By convention the upstream static tapping is one pipe diameter up from the orifice and the downstream tapping is half a pipe diameter from the orifice at the location of the 'vena contracta' where the flow lines are most narrow.

The pressure difference between the two points is proportional to the flow and once the pressure difference is known it is put into an equation to find the velocity. From the flow velocity and cross-sectional areas of pipe and orifice, the volume of product flowing can be calculated.

Limitations of orifice plate meters

The accuracy of an orifice plate flow meter depends on the square edged remaining round and sharp. Wear or damage will produce errors in the pressure reading. It is also necessary to insure that no partial blockages occur upstream of the orifice that produce changes to the flow profile and pressure gradient. Blockages can occur in the sensing lines from the orifice to the transmitter or pressure gauge. The position at which the meters are located should be where the flow pattern in the pipe is straight and no turbulence exists.

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Reference: Elementary Fluid Mechanics, Fifth edition , J K Vennard, R L Street, John Wiley & Sons.