White Paper – Hydrostatic Level Measurement

One of the most common elements of process automation and environmental applications, such as hydrographic surveys, is the measurement of the amount of a liquid that may be present. There are many level measurement technologies available. Not all will be appropriate for your application. ADM Instruments has decades of experience in this field and has published this white paper to discuss what Hydrostatic pressure is, how ESI's Hydrostatic level measurement technology works, typical applications it is suited to, some examples of where it could be used and how it compares to other technologies.

What is Hydrostatic pressure?

Hydrostatic pressure is commonly described as being the pressure exerted by a fluid at equilibrium at a given point within the fluid, due to the force of gravity. A liquid column above the pressure sensor creates a hydrostatic pressure, which is a direct indicator for the liquid level. Generally, the standard unit of measurement is calibrated in meters of water gauge (mWG).
mWG may sometimes be referred to as meters of water column (mWC), or meters of H_2O (mH_2O). Other countries may use different units of measurement, such as inches of water column ("WC) and pounds per square inch (psi) in the USA.

How does an ESI Hydrostatic level sensor work?

The measuring cell of the pressure sensor detects small changes in hydrostatic pressure, which increases or decreases according to the filling level. The sensor element is a gauge reference and calibrated to 1 atmosphere.

The ESI sensor is powered by a permanently fitted vented cable and is submerged into the liquid to be monitored. A vented cable is required because; in order to provide accurate electrical measurement it is important that the sensor element is subjected to the same atmospheric pressure as that acting on the liquid. This is particularly important for the measurement of low levels of liquid, where changes in barometric pressure can significantly affect the true reading of level. For example, at high altitude where low atmospheric pressure is present.

The sensor converts the acting pressure into an electrical signal. Most users will typically require a 4-20mA output, enabling signals to be transmitted over long distances. In most applications the liquid is subjected to atmospheric pressure. Therefore, it is important that readings are compensated to allow for any changes in atmospheric (barometric) pressure. This compensation is achieved by using a vented cable. The vented cable allows the ESI sensor to "breathe" to the atmosphere. This is done through a small nylon tube located inside the cable. This ensures that the output reading is relative to atmosphere.

In order to calibrate the device, a factor is used to convert bar to mWG. This ensures the accuracy of the reading. As previously mentioned, the standard unit of measurement is calibrated in meters of water gauge (mWG).

1mWG = 0.0980665 bar. Therefore, 1 bar is equal to 10.2mWG.

ESI can calibrate and label sensors in units of measure determined by particular applications. For example in a diesel tank application the sensor can be calibrated in meters of diesel.

How does an ESI Hydrostatic level sensor interface with the system?

In most applications the sensor can be connected to a system via a simple IP67 rated terminal box, with glands to prevent water ingress. In certain applications, where over a long period of time moisture from high humidity may enter the vented tube it is advisable to use a desiccant filter. The desiccant absorbs moist air, preventing any moisture travelling to the sensing element and causing a short circuit. The desiccant filter will last approximately 12 months and can easily be replaced. Such terminal boxes and desiccant filters are available from ADM Instruments.

Is an ESI Hydrostatic Level Measurement sensor suited to your application?

Hydrostatic level sensors can be permanently immersed in boreholes.
For example, measuring the depth of the water table.
The water table is the underground depth at which the ground is totally saturated. Deep boreholes with an average diameter of 25mm are drilled and left to fill to the level of the water table. A small diameter submersible pressure sensor is lowered down the borehole to accurately measure this level. In this type of application the control system would normally incorporate a barometric sensor, which is used to compensate for changes in atmospheric pressure.
Figure 1.

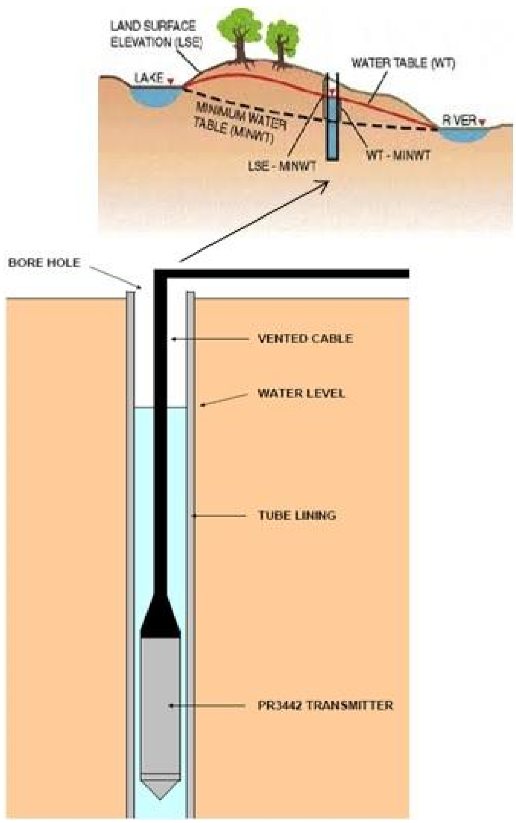

Figure 1.

ESI sensors are IECEx certified and therefore, can be used in similar circumstances where there is a risk of explosion. For example, monitoring the water levels in coal seam gas wells. Cable can be supplied in continuous lengths of up to 500m.

ESI Hydrostatic Level sensors are also well suited to measuring the levels of fluids in storage tanks. The pressure existing at a certain depth within a liquid is directly proportional to the column of water above. Therefore, the level of the liquid in the tank is determined by using a Hydrostatic level sensor to take a reading at the bottom of the water column. The sensor is lowered to the bottom of the tank via an access hole in its top. The sensor cable is then connected back to a monitor, data logger, or PLC.

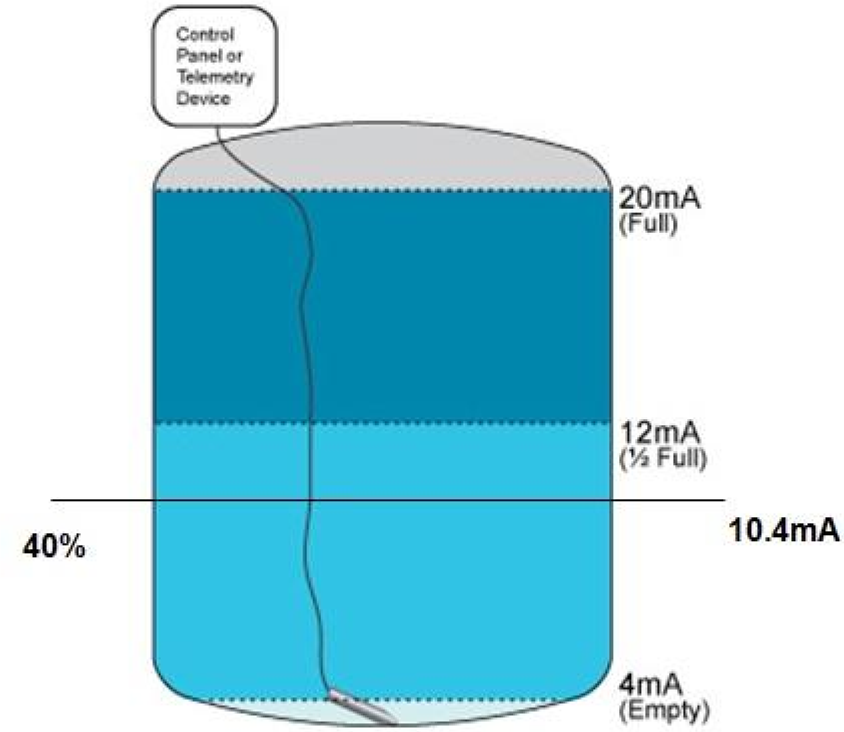

Figure 2.

You can either calculate the current % content of the tank, or the current volume of liquid in the tank.

In order to calculate the current % content the sensor has an output of 4-20mA. 4mA is the zero reading (tank empty) and 20mA is the 100% reading (tank full). This means the span range is 16mA. In an example where the sensor is giving an output of 10.4mA this would indicate that the tank is 40% full. This is calculated as follows:

Output reading – Zero (4mA) x 100 / Span Range = % Full

or

10.4mA – 4mA = 6.4mA x 100 / 16mA = 40% Full

With the ESI sensor connected to a suitable panel meter or control system a Hydrostatic level sensor can be used to calculate the actual volume of the liquid in a tank for this the following formula is used:

$V = \pi r^2 h$

Firstly an accurate measurement of the radius and the height of the tank is required.

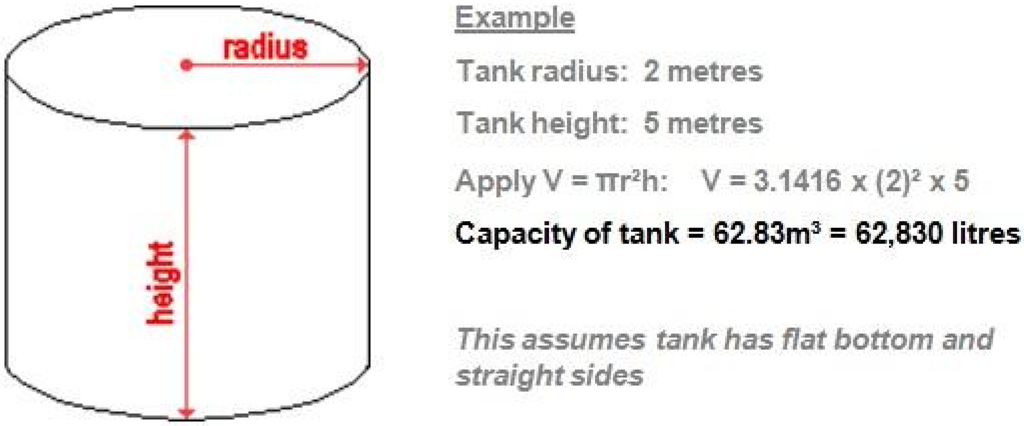

Figure 3.

In this example the tank is 5 metres high and has a radius of 2 metres.
Applying the above formula we can calculate that the capacity of the tank is 62,830 litres thus:

$V = 3.1416 \times (2)^2 \times 5$ Capacity of the tank = 62.83m^3 or 62,830 litres.

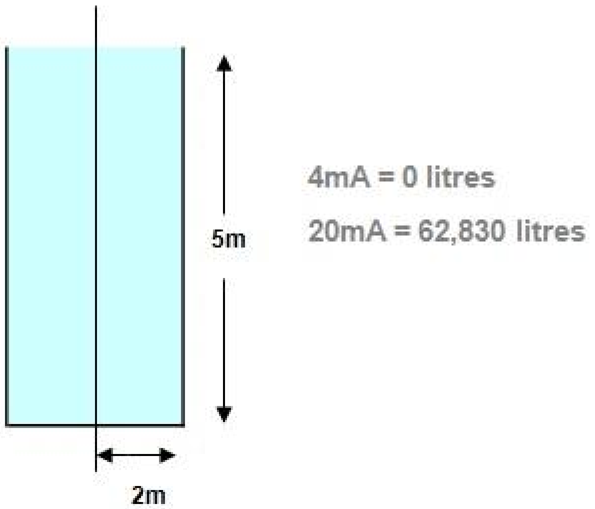

Figure 4.

Therefore, 4mA will be the zero reading (0litres) and 20mA will be the full reading (62,830 litres).

This presumes the tank has a flat bottom and straight sides. If the tank has a dished bottom, then it is necessary to mount the sensor directly above the dished section at the base of the tank.

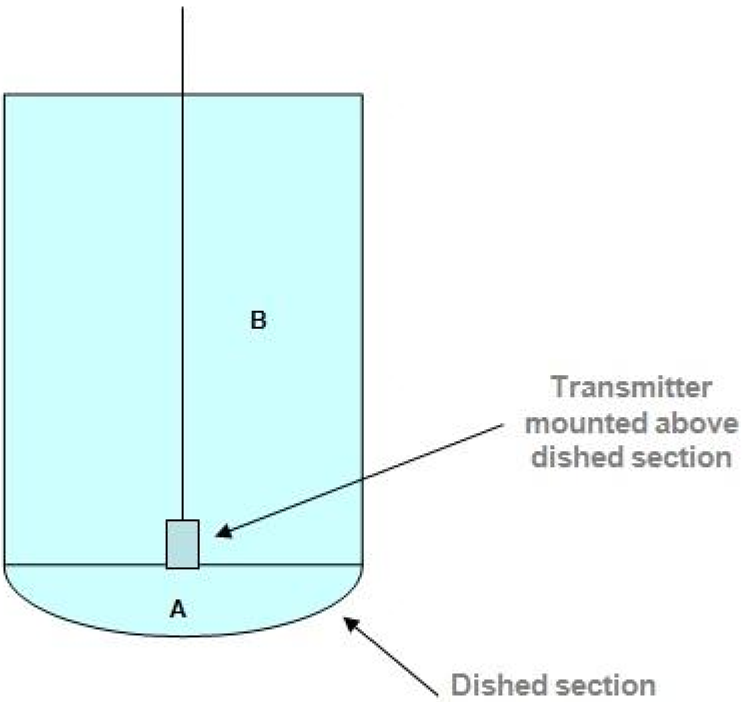

Figure 5.

In order to give a true volume of the tank., it is necessary to know the volume of the liquid in the dished section (A). The volume of section B is measured with the Hydrostatic sensor. We know that the capacity of a 5m high tank with a 2m radius is 62,830 litres. If the volume of the dished area is 5000 litres, then the total volume of the tank increases to 67,830 litres. The volume of the dished area is added to the final reading of the ESI sensor using an intelligent panel meter or PLC. In this case 4mA would be 5000 litres, rather than 0 litres.

Other areas where Hydrostatic level sensors can be effectively used are in the measuring of the level of water in rivers and reservoirs.

Hydrostatic level sensors are typically manufactured from 316l stainless steel. This makes them suitable for immersion in most media. Other materials such as plastic, titanium and hastalloy C may be used to ensure compatibility with a medium being measured, where stainless steel is not suitable. A polyurethane jacketed vented cable ensures excellent media compatibility, with oil for example. Other materials, such as nylon and PTFE may be used if the medium requires it.

How do ESI's Hydrostatic level measurement devices compare to other level measurement technologies?

The advantages of using an ESI Hydrostatic level measurement sensor are that the vessel does not need to be disturbed or adapted to fit a level sensor. There is no need to install tank wells or sight glasses, etc. It allows levels to be measured under difficult conditions, such as down a deep shaft. The probe is easily retracted for cleaning and maintenance purposes. It is a highly reliable and robust solution.

There are many other technologies available that are promoted to measure the level of liquids in storage or environmental situations.

Ultrasonic: Non-contact, sound reflecting technology. It is expensive and time consuming to install. It can be adversely affected by foam, temperature and moisture. It is more suited to sensing solid media types.

Radar: This is a non-contact, microwave reflecting technology. Again it is expensive and time consuming to install. Is suitable for some specific applications such a molten steel. It is not affected by high temperature and moisture. This technology is commonly used in collision avoidance applications to protect equipment.

Capacitance: Uses probe or sensors that measure the conductivity of the medium present. Is suitable for liquids, solids and slurries at high temperatures. Is not affected by top vacuum pressure. Its use can be restricted in deep level measurement applications. It needs to be calibrated or tuned to media type.

Float: Mechanical and magnetic versions exist. It is suitable to control switching levels. Its scope is somewhat restricted, especially with viscous media types that can adhere to the mechanical sensing devices and adversely affect their function. Mechanical devices are also more prone to failure than non-mechanical devices.

To find out more E-mail ADM Instrument Engineering
Or call 1300 236 467