CASE STUDY – LEVEL SENSORS IN PUMPING STATIONS

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33rd Annual Qld Water Industry Operations Workshop
Indoor Sports Centre, Carrara – Gold Coast
3 to 5 June, 2008

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ABSTRACT

The technologies used to measure the level in pumping stations have been traditionally hydrostatic pressure, ultrasonic, or simply switching (on/off) sensors. You may also add to these radar, which is fast becoming a preferred solution to many water and wastewater authorities. With the availability of these varied options which one is best?

The selection of the level sensor for best performance is determined by many factors including; range, type of product to be measured, ambient and process conditions, plus mounting position. Each technology has features that will be suited (or may be not suited) to the final application.

It is crucial to have an understanding of the principle of operation of these styles of measurement in conjunction with good installation and commissioning by trained personnel. With all factors taken into consideration a reliable level sensor (or sensors) can be installed every time.

1.0 INTRODUCTION

In all level monitoring and control applications, but especially pumping stations, there are three important factors to achieve a successful level measurement:

- Selection of the right technology for the application
- Correct mounting position
- Commissioning by a trained person

2.0 DISCUSSION

2.1 What Is A Sewage Pumping Station?

A sewage pumping station is an integral part of a sewage network. Its primary role is to collect wastewater and then pump it from one location to another. The site usually has one or more large, deep wells where wastewater can enter from an network of incoming pipes.

A level measuring sensor determines the height of wastewater in the well and sends a signal to a controlling system. The controlling system starts and stops large pumps which empty the well and transfer the wastewater on its journey towards a sewage treatment plant. Often a line of several sewage pumping stations are needed to transfer the wastewater from long distances away.

2.2 Why Control The Level?

It is important to accurately measure and control the level in SPS's primarily to ensure that the sewage does not get too high where spills will occur which can harm the environment. Conversely the level cannot get to low as the pumps are designed to allow fluids only and if too much air is injected then damage to the pumps can occur. Much care is taken in the selection of level sensors in SPS's to be accurate, reliable, and repeatable.

The control of the level is usually between about 15...30% to ensure there is enough capacity in the well in case of failure of the pumps.

As a backup to the primary level sensor there is usually high and low emergency float switches which will take over if the level sensor reading is offline.

2.3 How Is The Level Controlled?

The level of wastewater in the wells is measured using a level transmitter. Several different types can used based upon location, conditions, or sometimes simply users preference. Non contact sensors like ultrasonic or radar transmitters can be mounted at the top of the pit. Hydrostatic pressure or conductive probes can be inserted into the medium.

A signal from the level transmitter goes to a controlling and monitoring system which is programmed to start and stop pumps when the level reaches critical points, for example, start the pump at 30% full and stop the pump at 15% full.

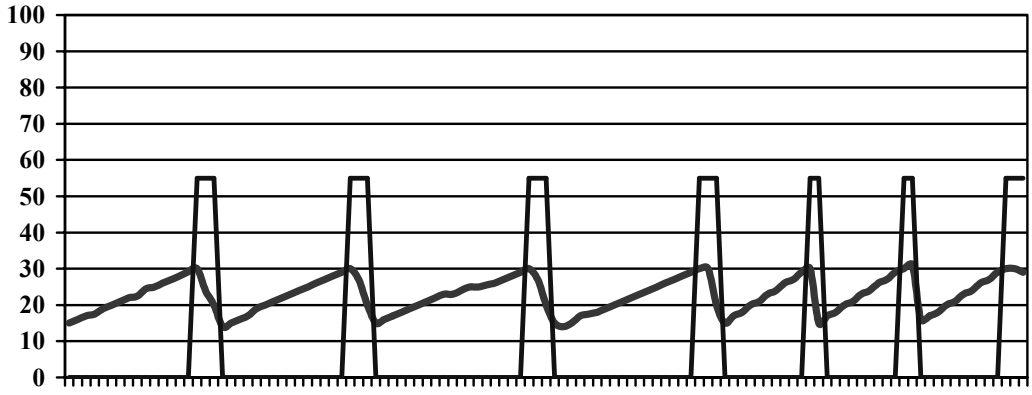

Figure 1: ***Trend showing level sensor output and pump on/off action***

2.4 The Level Sensors

Ultrasonic Level Transmitters

This type of technology uses sound waves to measure distance. A system usually comprises a sensor which mounts at the top of the pumping station with either an integral or remote transmitter.

The transducer of the ultrasonic sensor transmits short high frequency ultrasonic pulses to

the measured product. The speed of the sound pulses is about 330m/sec. These pulses are reflected by the product surface and received again by the transducer as echoes.
The running time of the ultrasonic pulses from emission to reception is proportional to the distance travelled and hence the level. The determined level is converted into an appropriate output signal and transmitted as a measured value.

As the speed of sound can vary depending on the temperature, a temperature sensor is installed in the transducer to compensate for the changes.

Radar Level Transmitters
This type of technology uses microwaves to measure distance. A system usually comprises a sensor which mounts at the top of the pumping station with an integral transmitter.


There are two types of radar level sensor. FMCW (frequency modulated continuous wave) and pulse radar. In the pulse radar sensor the antenna of the instrument emits short radar pulses with a duration of approximately 1nS. The speed of the microwave pulses is about 300,000km/sec. Similar to an ultrasonic, these pulses are reflected by the product and received by the antenna as echoes. The running time of the microwave pulses from emission to reception is proportional to the distance travelled and hence the level. The determined level is converted into an appropriate output signal and transmitted as a measured value. The microwaves from a pulse radar have an average power of only about 0.002mW, so are quite suitable for use around people and machines.

Hydrostatic Pressure Transmitters
This type of technology measures pressure. A system usually comprises a submersible pressure sensor with a length of cable which is terminated outside the pumping station.

The pressure forced against a diaphragm is the sum of both the air pressure plus the water pressure pushing down. This causes a movement in the measuring cell at the sensor via the diaphragm. The variable atmospheric air pressure is compensated for via a capillary, which runs all the way down the cable to the back of the measuring cell. The two air pressures (one at the front and one at the back) cancel each other out so only the liquid level is considered. The sensor element is a measuring cell with rugged ceramic or thin film metallic diaphragm. Measuring cells are often equipped with a temperature sensor for compensation. Often this temperature change can also be converted into an output

signal.

Adjustable and non-adjustable range versions are available, as well as lots of different length cables to best fit the dimensions of the pumping station.

2.5 Which One To Select?

Each application is different which is why there are often multiple solutions available. In a standard wet well you could easily mount an ultrasonic, radar, or hydrostatic pressure sensor in the well and create a successful measurement. In reality there are usually obstacles that make installing some devices unadvisable. Examples may include high turbulence, no line of sight to the product, or foam. With each application it needs to be considered which technology will be the best and how/where to install it.

Installation Position

With both contact (hydrostatic) and non-contact (radar/ultrasonic) sensors, careful consideration needs to be given to the location so a reliable measurement can be achieved The best location for a level measuring will differ with the technology selected, fixed structures in the vessel, and accessibility.

As contact type sensors are in the liquid they need special care to avoid mechanical damage to the transducer. Avoiding pump suction lines and float switches, etc is important. A stilling tube can be advantageous.

As non-contact type sensors are above the liquid special care must be made to minimise collision between the emitted pulses and any fixed structures in the vessel like the tops of pumps or landings. Preferably a direct path for the signal to be transmitted is best although a false echo suppression function is available in both radar and ultrasonic sensors.

Foam?

Often in a sewage pumping station, the surface of the liquid has a layer of foam. This can affect ultrasonic and sometimes radar sensors.

With ultrasonic sensors the sound waves that are emitted towards the product can be absorbed by foam, which will reduce the magnitude of the echo that is reflected. Consider the walls in a sound-proof room.

With radar sensors the microwaves that are emitted towards the product can be scattered by foam, which also reduces the magnitude of the echo that is reflected. Consider a disco ball with a light shining at it. With some low frequency radars the longer wavelength of the microwave is such that it can penetrate some layers of foam with little or no effect on the echo.

2.6 Commissioning Level Sensors

On-site commissioning of level sensors is becoming more easy as technologies and industry tools improve. The traditional method of commissioning level sensors was the tedious process of emptying and filling the vessel several times to set and check the adjustments.

In recent times the use of smart instruments and software can greatly assist in commissioning by offering fast set-ups without the need to empty and fill the vessel.
A hydrostatic probe for example can be programmed to the well dimensions and lowered to the correct point, and the output will read correctly straight away. A radar or ultrasonic transmitter can be programmed after installation using known dimensions. Potential "false echoes" that can occur with these technologies can easily be identified and suppressed using the software.

Generally speaking the most important functions to enter when programming are the minimum and maximum ranges.

Commissioning Tools
Most sensors and signal conditioning instruments use supplier specific software where a database of known sensors is stored in a technicians computer. These are polled to detect which unit/s are connected and specific parameters for that model will become available for adjustment or monitoring. These DTM's (device type managers) or EDD (extended device descriptors) are both highly informative and user friendly.

An interface modem is usually required to connect the technicians computer to the instrument. Different connection methods can be utilised, HART or proprietary buses are often both available.

3.0 CONCLUSION

The three important factors when obtaining a successful level solution in a pumping station are always; correct selection of the sensor for the application, ideal mounting position, and commissioning by trained persons. With these factors adhered to a successful level solution can be found for each application.