HYDROSTATIC WATER LEVEL - MEASUREMENT & CONTROL

Case #1
Bore Hole Water Level Monitoring:
Taking Advantage of a 3/8" diameter high integrity Level Sensor

Case #2
Sewage Lift Stations:
Reducing Maintenance Costs with Level Transmitters

PMC ENGINEERING

Case #1 Bore Hole Water Level Monitoring:

Taking Advantage of a 3/8" diameter high integrity Level Sensor

Rob Knowles, PMC Engineering LLC

The Hydrostatic Level Transmitter is a small but vital component for water well monitoring and control

Introduction

With the current awareness and concern over the environment there are increasing demands for the monitoring and control of the planets water. One of the most common methods is by the use of deep wells drilled into aquifers. Some of these may be many thousands of feet below the surface although most are only a few hundred feet. Such wells can be purely for water monitoring or considered as production, where water is pumped out for human or Industrial consumption. The purpose of this short article is to focus on the level measurement which over time can lead to valuable information regarding the capabilities of the well, changes in gradients or flow direction and the aquifer condition. The cost to instrument a well can vary from a few thousand to tens of thousands of dollars depending on the measurements required. The initial cost of actually drilling the well is one thing but installing and extracting the instrumentation remains an additional cost often requiring special equipment. Therefore the ease of changing measuring instruments is important but long term reliability is even more so.

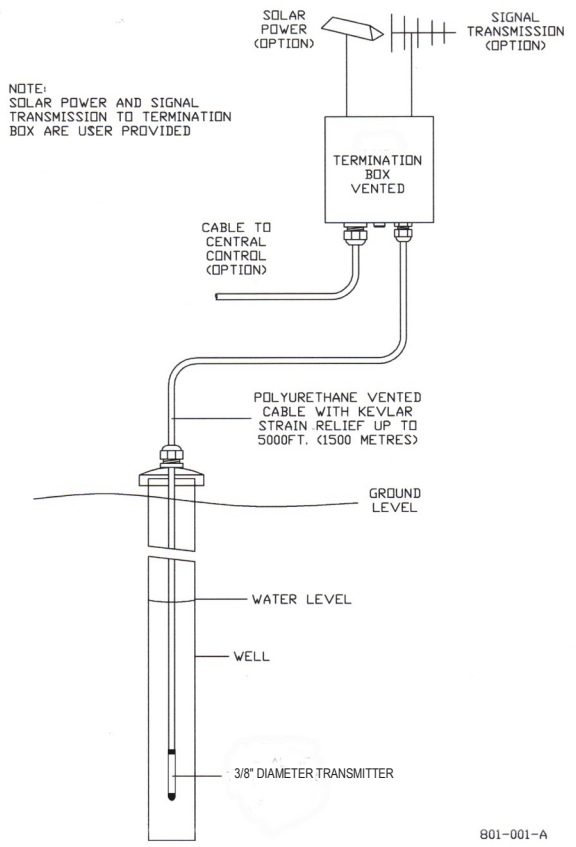

Figure 1: Schematic of a deep well installation featuring the depth/level transmitter and termination.

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Hydrostatic level measurement using a specially designed pressure sensor is perhaps the easiest method to make these measurements. However while it seems simple, the design and reliability of these sensors have in recent years been called into question by users making poor selections based on low cost. Long term reliability of more than 10 years can easily be obtained by selecting an appropriately designed sensor and following the correct installation methods. Such sensors are traditionally 1" diameter or more although in recent years diameters of 3/4" have become more popular. However, due to the cost and the desire to provide more instrumentation in the well, space can often be at a premium, thus driving the sensor manufacturers to even smaller sizes. Sensors are now available with diameters of 3/8" which permit installation into 1/2" diameter bore holes. They can also be installed into existing larger diameter bore holes which already contain instrumentation with limited space available. A typical schematic for a deep well installation featuring the level sensor (pressure transmitter) and its associated hardware is shown in Figure 1.

The Level Sensor

The purpose of the level sensor is to provide an electrical feedback to the pressure recorder or data logger and/or pump for monitoring of production wells. Traditionally, floats, tapes and often bubbler systems have also been utilized although the latter create increased maintenance challenges with the requirement of a continual gas flow. Today there are many sensor technologies for measuring liquid level such as radar, ultrasonic and conductive. However, these are either high in price or unreliable due to the operating environment. In recent years, submerged hydrostatic pressure transmitters have been developed to withstand the environmental conditions and provide continuous monitoring for enhancement of the control with increased long term reliability.

Figure 2: MTM3000 level sensor in titanium laser-welded housing and molded cable termination - 3/8" diameter

The Technology

A number of manufacturers such as PMC Engineering have developed dedicated sensors for this application. An example of this is the MTM3000 as shown in Figure 2. There are many features which have been specifically designed into this level/pressure transmitter to overcome the challenges faced in long term water monitoring.

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As many wells are located in very inaccessible places the overwhelming requirement is for high reliability and low maintenance. This requires a clean design with high integrity seals. The use of highly developed piezoresistive sensing technology provides an excellent long term performance in a small size while having the ability to achieve high accuracy, better than 0.1%, for measurement of water levels of just a few inches. The technology also provides a very high overpressure of at least 3x the rated range without any degradation of the sensor performance. This protects the transmitter against damage due to flood conditions resulting in very high levels – an excellent feature in difficult situations. The laser welded 3/8" diameter housing is generally made from titanium to avoid any possibility of corrosion, and is often supported with a 5 year warranty.

A further design feature is the electrical connection. It is important to avoid O rings which will generally flow (change size) over time when sealed against polymer based materials such as that used in the connecting cable. One of the most reliable solutions is to incorporate a custom molded cable utilizing thick walled polyurethane which becomes integral to the transmitter and can be supplied to any length up to 5000ft. This cable not only incorporates the electrical connection but also houses a nylon breather tube and Kevlar strain relief. The Kevlar will support over 200 lbs. breaking force and will not stretch until 97% of its breaking load is applied. This is a very valuable feature if the transmitter has to be removed. Various electrical outputs are required including the most popular 4-20 mA 2-wire loop power. Other outputs include 1-5 Volts or even digital such as Hart®. In some cases users wish to adjust the level transmitter and this can be achieved via digital communication featuring a full scale range turndown to 10% of the originally specified range. These transmitters can be provided with a full scale preset range to suit any depth/level requirement.

Cable Termination

The cable termination at the wellhead is also important, not only to provide a connection for onward transmission, but also to facilitate an outlet for the breather tube to atmospheric pressure. This is vital to ensure the correct operation of the transmitter which would otherwise be affected by changes in barometric pressures. This reference breather tube must be protected from ingress of moisture to enhance the long term reliability of the transmitter. There are many techniques for this, such as the use of desiccant within the termination enclosure.

Figure 3: MP 11 zero maintenance moisture protection reference volume

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PMC has developed a sealed Mylar enclosure which requires zero maintenance and does not rely on the use of desiccants or consumables, see Fig. 3.

The sensor is generally positioned a few feet from the bottom of the well, or at least at the lowest anticipated level, and is relatively light in weight; it is fairly common to use sink weights. These can be fixed to the front while maintaining the small diameter.

Pressure Recorder (Data Logger)

As previously mentioned, deep wells are often located in remote areas which are not so easy to access. Power to the transmitter can be provided by solar as depicted in Fig. 1. However, with the advancement of battery technology it is becoming more common to use battery powered pressure recorders or data loggers. When coupled to a cellular network a huge amount of time and cost is saved by the user. Manufacturers such as Telog[1] offer a pressure recorder, see Fig. 4.

Figure 4: PR-32 pressure recorder connected to MTM3000 level sensor

These can operate for up to five years from user replaceable D Cell Lithium batteries. The pressure recorder, which can store up to 80,000 interval statistics, uses a low power small m2m cellular modem certified for operation on most popular networks. The modem, antenna, sensor signal conditioner, data recorder and battery are housed within a small NEMA 4x enclosure suitable for mounting at the well head, as shown in Fig. 5. Cable lengths up to 600ft can be supplied between the sensor and the pressure recorder.

[1]Telog, a Trimble Company

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Summary

The high integrity well developed submersible pressure transmitters of today provide very reliable, zero maintenance, level monitoring and pump control for deep well applications. These hydrostatic level measuring transmitters are continually monitoring the water level, and with the enhancements in the associated control systems, provide valuable information related to the environment. Through the addition of products such as the MP 11 breather termination and PR-32 pressure recorder these level sensors can be installed with anticipated zero maintenance operation for up to 5 years, and then only required a battery change. The high initial accuracy of the transmitter and excellent long term stability provided by the piezoresistive technology also minimizes the need for recalibration, previously considered to be an annual event.

Figure 5: MTM3000 located in aquifer and PR-32 pressure recorder at well head with wireless communication

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Case #2 Sewage Lift Stations:

Reducing Maintenance Costs with Level Transmitters

Rob Knowles, PMC Engineering LLC

The Level Transmitter is a small but vital component in a Sewage Lift or Pump Station to maintain system integrity and avoid unwanted spillage.

Introduction

There are more than 2 million sewage Lift or Pump stations in the US. All work on the same principle and with the same objective of moving sewage from one level to a higher elevation. Their installation costs range from $150,000 (20 gallons per minute) to $1.5M (100,000 gallons per minute) generally based on capacity and complexity. Of course the pump technology has come a long way in recent years, but the purpose of this article is to focus on a small component which has also received significant development in the past few years and is essential to the pump control and reliability of the station. This is the level sensor. A typical schematic for a sewage lift station featuring the level sensor (pressure transmitter) and its associated hardware is shown in Figure 1.

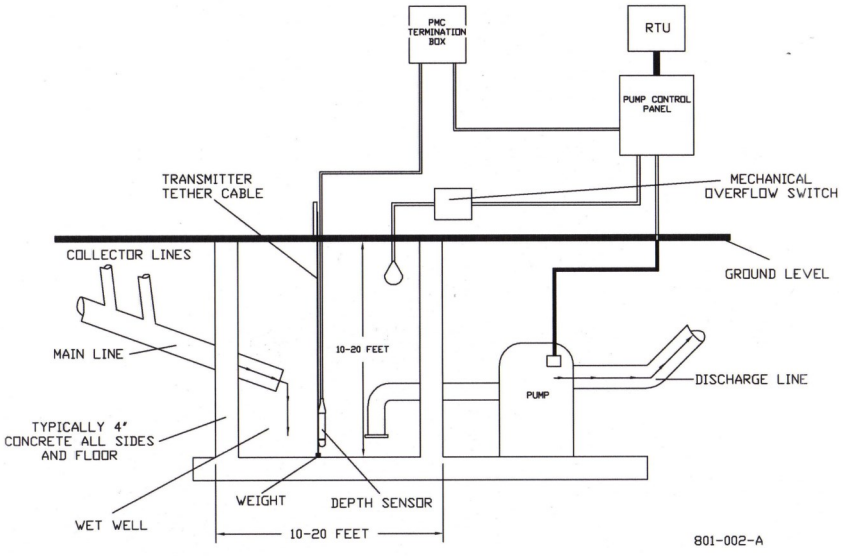

Figure 1: Schematic of a typical Lift Station featuring the depth/level sensor and control system

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The Level Sensor

The purpose of the level sensor is to provide an electrical feedback to the pump as to when to switch on and off. Traditionally, floats have been used which simply provide an on and off signal to the pump at the high and low levels. Bubbler systems have also been utilized although they create increased maintenance challenges with the requirement of a continual gas flow. Today there are many sensor technologies for measuring liquid level such as Radar, ultrasonic and conductive. However, these are either too high in price for a relatively simple lift station or unreliable due to the operating environment. In recent years, submerged hydrostatic pressure transmitters have been developed to withstand the environmental conditions and provide continuous monitoring for enhancement of the control with increased long term reliability.

The Technology

A number of manufacturers such as PMC Engineering have developed dedicated sensors for this application. An example of this is the VL2000 as shown in Figure 2. There are many features which have been specifically designed into this level/ pressure transmitter to overcome the challenges faced in sewage lift stations.

As many lift stations are located in very inaccessible places the overwhelming requirement is for reliability. This requires a clean design with high integrity seals. Due to the nature of the effluent, the sensing element must be exposed to avoid clogging.

Figure 2: VL2000 Open Face Level Transmitter for Wastewater

This problem is also becoming more important due to the increase in FOG (fats, oil and grease) associated with fast food restaurants. The use of ceramic capacitive sensing technology provides a rugged open face sensor while having the ability to achieve high accuracy, better than 0.1%, down to sewage levels of just a few inches of water. The technology also provides a very high overpressure of at least 3x the rated range without any degradation of the sensor performance. This protects the transmitter against damage due to overflow or back pressures. The laser welded 1" diameter housing is generally made from 316L stainless steel, although titanium is often preferred where the effluent is more corrosive.

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A further design feature is the electrical connection. In is important to avoid O rings which will generally flow over time when sealed against polymer based materials such as that used in the connecting cable. The most reliable solution is to incorporate a custom molded cable utilizing thick walled polyurethane which becomes integral to the transmitter and can be supplied to any length up to 5000ft. This cable not only incorporates the electrical connection but also houses a nylon breather tube and Kevlar strain relief. The Kevlar will support over 200 lbs. breaking force and will not stretch until 97% of its breaking load is applied. This is a very valuable feature if the transmitter has to be removed and is buried in the sludge at the bottom of the tank. Various electrical outputs are required including the most popular 4-20 mA 2-wire loop power. Other outputs include 1-5 Volts or even digital such as Hart®. In some cases users wish to adjust the level transmitter and this can be achieved via digital communication featuring a full scale range turndown to 10% of the originally specified range. These transmitters can be provided with a full scale preset range to suit any sewage lift station. In lift stations where hazardous gases exist, transmitters can be certified FM intrinsically safe for use in Class I, II & III, Div. I, Groups A, B, C, D, E, F & G.

The cable termination is also important, not only to provide connection to the control system and pump, but also to provide an outlet for the breather tube to the atmospheric pressure. This is vital to ensure the correct operation of the transmitter which would otherwise be affected by changes in barometric pressures. However, this reference breather tube must be protected from ingress of moisture. There are many techniques for this, such as the use of desiccant within the termination enclosure, to enhance the long term reliability of the transmitter. PMC has developed a sealed Mylar enclosure which requires zero maintenance and does not rely on the use of desiccants or consumables.

Because the transmitter is relatively light in weight and it is preferred to position the transmitter a few inches from the tank bottom, it is fairly common to use sink weights. An example of this can be seen in Figure 3. This type of sink weight is sometimes called a “bird cage” and, in the case of the PMC transmitter, can be removed from the transmitter if necessary. In other cases, the “bird cage” is integral to the transmitter.

Figure 3: SW2000 sink weight (bird cage style) incorporating submersible level transmitter

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Deep Groundwater Wells

As a spin off to the custom designed submersible transmitters for sewage level described above, the same technology can be applied to deep wells for the monitoring of groundwater. In this case, the transmitter is usually slightly smaller in diameter, 3/4", and more likely to be contained within a titanium housing to protect against the possibility of corrosion caused by brackish water. An example of such a transmitter is shown in Figure 4 and a typical installation in Figure 5. It can be seen that the one additional feature of these transmitters is a protective nose cone. This not only avoids damage while lowering the transmitter into the well - and this can be up to 5000 feet - but also protects the sensor from harm due to water hammer, a phenomena often created in close proximity to a down hole pump.

Figure 4: VL4000 3/4" diameter submersible level transmitter with nose cone for deep well groundwater monitoring

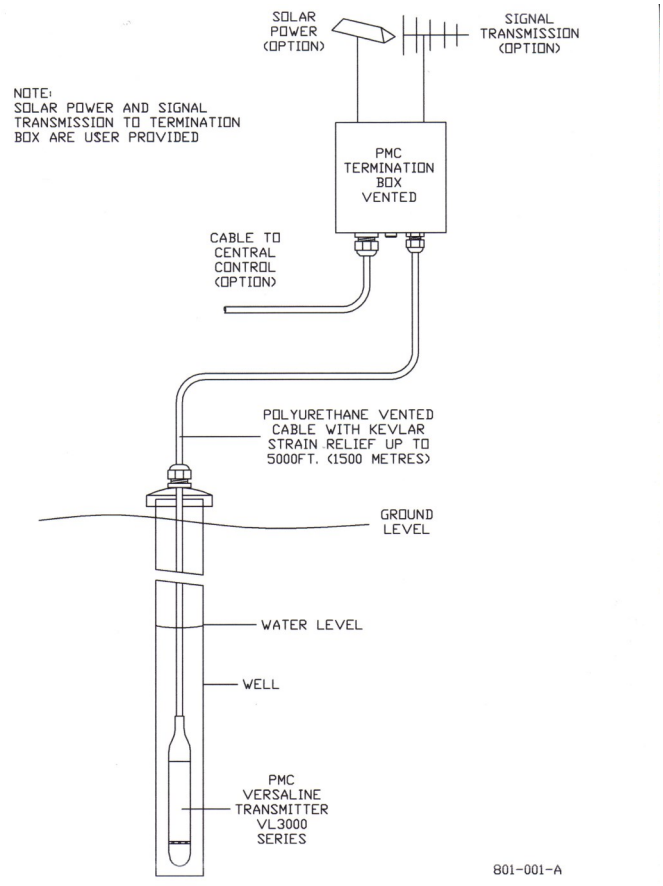

Figure 5: Schematic of a deep well installation featuring the depth/level transmitter and termination

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Summary

The high integrity well developed submersible pressure transmitters of today provide very reliable, zero maintenance, level monitoring and pump control for sewage lift stations and deep well monitoring. These hydrostatic level measuring transmitters are continually monitoring the sewage level, and with the enhancements in the associated control systems, provide information related to pump performance and general health monitoring of the facility.

About PMC Engineering

PMC has been manufacturing level transmitters in Danbury, CT USA for more than 50 years. The engineering and application specialists at PMC have been developing level measurement for ground water, surface water, sewage, remediation, and oceanography for more than 30 years. For more information on PMC products please call 203 792-8686 or go to www.pmc1.com.

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