Wastewater Lift Station Measurement Challenges

Lift stations in wastewater collection system are challenging to monitor, control and operate for a variety of reasons—but solutions are available to deal with these issues.

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Ideally, flows of wastewater from collection points at residences, offices and commercial establishments to wastewater treatment plants would be powered completely by gravity. However, this is rarely possible because of economic or physical limitations, with the most common being flat terrain which can't easily be graded to promote wastewater flows.

Therefore, lift stations must be employed to move wastewater to a higher elevation, and eventually to a wastewater treatment plant (Figure 1). A typical wastewater collection system in a county or large city will have hundreds of lift stations, with smaller lift stations feeding into larger master lift stations, which in turn feed wastewater to the treatment plant.

Figure 1, wastewater treatment plant. This treatment plant receives wastewater from a network of lift stations, each of which must be controlled and monitored to assure correct operation.

Pumps are installed at each lift station to draw wastewater from the lift station's wet well, the wastewater receiving point, and transfer it to a higher elevation. Typically, each lift station is equipped with two or more pumps, with operation alternating between the pumps to increase reliability. In high flow situations such as heavy rain, multiple pumps can be operated simultaneously, thereby increasing flow from the wet well. Pumps can be mounted on the floor of a wet well, or in a dry pit adjacent to the well.

Monitoring and control of these lift stations presents many challenges, primarily with respect to measurement of process variables in these harsh environments.

Measurement and Control in Lift Stations As shown in Figure 2, pumps are typically installed below the lowest point of the incoming wastewater feed pipe. Smaller lift stations might have a single 4-inch feed pipe, while larger stations can have multiple feed pipes each up to 36 inches in diameter.

When the wastewater level reaches a critical point, a control system starts one or more pumps to prevent wastewater from overflowing the well, which could contaminate ground water or local waterways. These spills could also negatively impact local residents and require costly cleanup.

Wastewater often contains grease and solids, and foam is frequently produced due to turbulence in the lift station. These solids and foam can impair standard measuring techniques and instruments, causing reliably issues rates and requiring frequent maintenance. Conditions inside lift stations are not instrument-friendly due to high moisture levels, condensation and sewer gas.

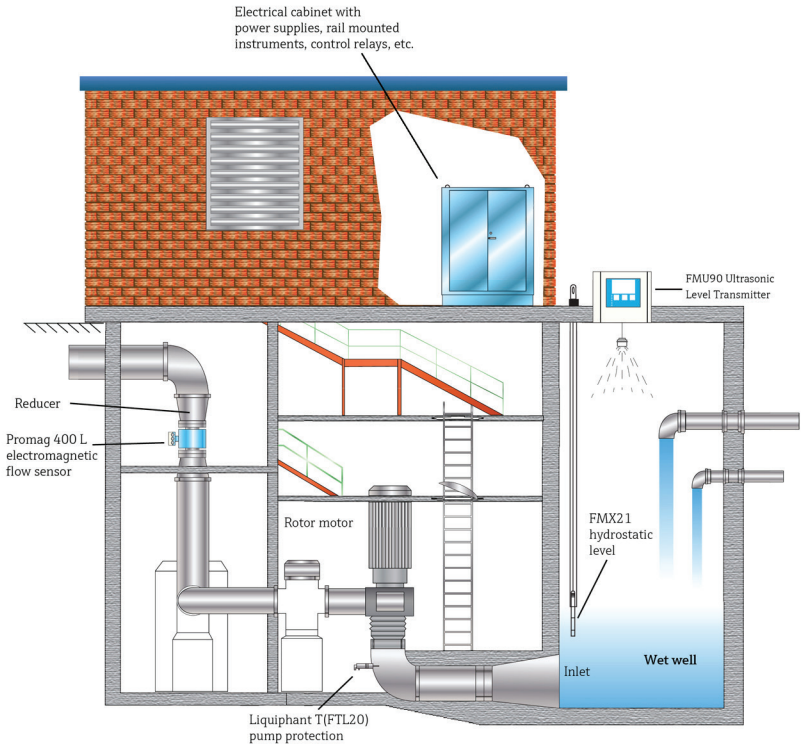

Figure 2, lift station diagram. This diagram depicts a typical lift station. Key components include the wet well, the pumps, the instrumentation, and the automation system used for control and monitoring of the station.

Each of the parameters listed in the Table are measured in a pump station with an instrument, either a transmitter or a switch. A transmitter continuously measures a parameter across a wide range, for example 0 to 15 feet of wastewater level in a wet well. The transmitter then sends a signal proportional to the measured value to the control system.

A switch simply measures an on-off condition, for example whether or not a certain level has been reached by wastewater in a pipe. The switch then sends an on-off signal to the control system.

The control system in a lift station is typically a Programmable Logic Controller (PLC), which uses inputs from the instruments along with its internal programming to control operation. The PLC is often integrated with a central supervisory control and data acquisition (SCADA) system at the wastewater plant to provide enterprise-wide connectivity and visibility.

For smaller and/or very remote lift stations not monitored by a PLC/SCADA system, paperless data recorders are often installed. These recorders accept lift stations signals from instruments, and provide alternating pump control, and also record and store relevant data.

Level Measurement Challenges Wet well level is the most critical measurement parameter in a lift station because level information is used to start and stop the pumps. Older lift stations often use a simple float switch to start and stop a single pump. But, this technology is often unreliable because the switches tend to stick due to grease build up and accumulation of debris.

Even when working correctly, a float switch only provides a single-point measurement, as opposed to a transmitter which gives much more informative continuous indication of wet well level. Bubbler level transmitters are an older technology used for this continuous level measurement, but they require a constant air supply and utilize tubes which can become easily clogged.

Modern lift stations instead use vibrating tuning fork point level switches for emergency backup, and employ newer continuous level measurement technologies instead of bubbler level transmitters, namely hydrostatic and ultrasonic instruments.

Hydrostatic level transmitters can be safely submersed in wet wells, and effectively avoid the aforementioned float switch and bubbler issues. Hydrostatic level transmitters measure water pressure within the wet well, and infer level from changes in this head pressure.

A ceramic pressure measurement cell is typically used with a hydrostatic level transmitter as it resists abrasion, scratching and denting. Ceramic cells are sensitive enough to perform properly in the harsh environment of a wet well, and provide accurate measurements even with the buildup that can occur on the cell.

Ultrasonic level measurement instruments are non-contact devices that measure level by sending an ultrasonic signal down from the top of the wet well to the surface of the wastewater. A transducer mounted inside the lift station at the top of the wet well sends and receives the ultrasonic signal. The signal bounces back from the wastewater, and the instrument uses this time-of-flight information to infer level.

Condensation inside the lift station accumulating on the face of the transducer can be a potential problem. A self-cleaning sensor will detect the buildup of condensate, automatically increase the amplitude of the excitation signal, and knock the condensation off the face of the transducer without interrupting the measurement signal.

Figure 3, ultrasonic level transmitter. This ultrasonic level instrument can be used to provide reliable and accurate measurements of wet well level in lift stations.

Because wet well levels are a critical measurement, master and other larger lift stations often use both of these technologies simultaneously to provide redundant wet well level measurement.

Additional Points of Measurement Improve Operation Centrifugal pumps are commonly used in lift station applications and can be damaged if they run dry. This issue can be avoided by installing a liquiphant or a point level switch in the pump suction pipe.

Leak detection in dry pit designs is a common concern, and a point level probe is a leading solution as it provides millimeter accuracy for detection of water in the dry pit. The contacting point level probe is typically mounted a few inches above the dry well concrete floor. Tuning fork technology is an excellent choice for this application as it requires no calibration.

Another commonly measured parameter in lift stations is output flow from the pumps, or from the entire lift station. Many flow measurement technologies are susceptible to errors created by the harsh lift station environment. Wastewater solids and grease create inaccuracies or maintenance problems for insertion-style or ultrasonic clamp-on.

Electromagnetic flowmeters, or mag meters, are typically used in lift station applications as they overcome these and other issues. Mag meters have no moving parts, zero pressure loss and are very accurate (0.2%) of rate and extremely repeatable. Modern designs employ a high-impedance amplifier to eliminate problems often associated with electrode fouling and run self diagnostics on a continuous basis to check the meter's overall health.

For the large pumps often used in master lift stations, the output signal from the mag meter is often used as the process variable input signal to a PLC or PID controller. The controller compares the actual flow to the desired flow setpoint, and adjusts the pump speed via a variable frequency drive. This saves a considerable amount of energy and reduces pump maintenance compared to running the pump at full speed, and allows for greater control of flow within the entire wastewater collection system.

Smart versus Analog Instruments Level transmitters, pump flow switches and transmitters can be one of two basic types: analog or smart. Analog instruments simply output a signal corresponding to the parameter sensed, an on-off signal in the case of a switch, or a 4-20mA signal in the case of a transmitter.

Smart instruments have a high-speed, two-way digital communications link to the control system. For switches, diagnostic information can be sent to the control system in addition to on-off information in order to show if the switch is working properly.

Smart transmitters communicate not only the main process variable, but also other variables and information to the control system, and can receive calibration information. Data sent to the control system includes diagnostic information, and other process variables in addition to the primary measured variable, such as temperature from a level transmitter or conductivity from a magnetic flowmeter.

Lift station operation is relatively simply and well understood, but problems often arise due to errors in the measurement of wet well level, pump inflow, pump outflow and other parameters. Installing the right instruments for each of these measurement points ensures reliable lift station operation, and keeps wastewater flowing from collection points to the treatment plants without overflows or spills.

Bio: Alan Vance began his career with Fischer & Porter, where he worked for seven years as a product manager. From there, he went on to work for an instrumentation rep firm for 22 years, where he focused on the water/wastewater, power, mining, and food and beverage industries.

Alan then joined Endress+Hauser, where he's responsible for the water industry including strategic planning and marketing. He's also in charge of many operational activities including training, working with field representatives and customer relations.

Table, Parameters Measured in Lift Stations

- Continuous level measurement in wet well
- Continuous pressure measurement in pump suction pipes
- Point level measurement in pump suction pipes
- Point level measurement in dry pit
- Continuous flow measurement from the lift station or individual pumps

Figures, all courtesy of Endress+Hauser

Figure 1 wastewater treatment plant. This treatment plant receives wastewater from a network of lift stations, each of which must be controlled and monitored to assure correct operation.

Figure 2 lift station diagram. This diagram depicts a typical lift station. Key components include the wet well, the pumps, the instrumentation, and the automation system used for control and monitoring of the station.

Figure 3 ultrasonic level transmitter. This ultrasonic level instrument can be used to provide reliable and accurate measurements of wet well level in lift stations.

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