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WHITE PAPER

Retrofitting Wastewater Pump Stations for Enhanced Reliability and Efficiency

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Pump stations are an integral part of a municipality's infrastructure. The public depends on them to efficiently transport water and sewage to support residential, commercial and industrial demands. Many utilities face the need to upgrade these outdated pump stations, automate certain aspects, and make them more reliable and effective.

Many existing pump stations in the U.S. are decades old, do not comply with current design standards and code requirements, and may lack appropriate safety features. Upgrading these pump stations can boost efficiency, increase capacity, meet regulatory requirements, and provide enhanced reliability, security and safety. Given these factors, this white paper discusses retrofitting wastewater pump stations.

It is important to first evaluate an existing pump station and collection system to decide whether rehabilitation or building a new pump station would be better in the long run. Cost is often a driver, and retrofitting an existing pump station can be less costly than constructing a new one. A thorough analysis of a facility can help utilities identify appropriate solutions. Engineers should be aware of many factors that are important to analyze during pump station evaluation and condition assessment. All can factor into developing viable long-term and cost-effective solutions.

Hydraulic Capacity Assessment

Analysis of hydraulic capacity is a critical starting point for any pump station rehabilitation project. It is a best practice to understand the upstream collection system and inflow to the pump station. Sometimes it is domestic sanitary flow, sometimes it is industrial flow, or quite commonly a combination of both. Most, if not all, utilities deal with inflow and infiltration (I/I) in their collection systems. It is important to have a good understanding of the upstream collection system hydraulics and to build a hydraulic model to analyze the impact of various storm events, determine the problem areas and what the peaking factors are. To understand what the required capacity of a pump station needs to be, it is vital to obtain accurate flow data. This should be done by placing flow meters and rain gauges at strategic locations within the collection system to record wet-weather events and simulate real-world hydraulic conditions.

The general design of a pump station depends on different components such as power supply source, storage, pumping capacity and piping. Analyzing the hydraulic capacity of these components — by factoring in average dry weather flow and peak wet weather flow — will assist in building or retrofitting a pump station.

Additionally, be aware of future projects planned in the area that could have impacts on flow tributary to a pump station, such as a new refinery or industrial facility. Understanding potential 20-year build-out will help in designing and rebuilding a pump station equipped to meet existing needs and future demands.

Hydrogen Sulfide (H_2S) Buildup

Buildup of H_2S is common in sanitary collection systems. It is extremely corrosive and can damage the concrete, valves, piping and electrical components, leading to expensive repairs. It condenses on surfaces and turns to sulfuric acid. Not only can it cause damage to facilities, but it can cause sickness and even death at high concentration.

On one of our recent pump station rehabilitation projects, the original concrete wet well wall had been 12 inches thick when constructed. However, 6 inches of concrete had been lost because of H_2S attack. On another rehabilitation project, a pump station that was just 10 years old had started accepting sanitary flow from an adjacent sewer district. This flow contained high levels of H_2S, which had damaged the entire piping system, and within three years the utility had to replace all the pipes, valves and fittings.

An H_2S gas logger installed in a pump station will record fluctuations in the airborne levels of H_2S. This device hangs in the wet well, typically underneath the access hatch. After the monitoring is complete, the gas logger can be removed easily. Influent sampling should be conducted in conjunction with gas logging to record the level of sulfides in the wastewater, as well as temperature and pH level. This information helps determine if an H_2S treatment system, such as chemical injection, should be utilized to protect the pump station. H_2S concentrations are normally higher in warmer months, such as July and August, making that a good time to monitor.

Force Main and Wet Well Sizing

Force main assessment is important to determine the level of corrosion and deterioration and the current wall thickness. The internal diameter of the force main can also constrict over time due to slime layer build-up and tuberculation causing reduced capacity. These reports can assist in the decision-making process and highlight whether fixing the existing force mains is a better option than replacing them entirely. Often, force main replacement is unavoidable because the existing force main does not have the capacity to transmit a higher flow rate if pumps are upsized.

The existing wet well must be analyzed to see that there is sufficient storage space for proper operation of the specified pumps. If storage is undersized for the pumps, that can cause pump short-cycling and cavitation issues. The wet well should be designed to eliminate odors and trapped air, and avoid solids deposition. If it is a wet well submersible pump, utilities must consider the space requirements to see if the new pumps will fit into the existing space.

Physical Space Requirements

When retrofitting a pump station, understanding the space requirements is imperative. The process should begin with a discussion to set the right expectations before getting into the design. Is there enough space to accommodate replacement pumps and piping in the existing wet well and valve chamber? Is a larger generator required for more capacity? Is there space for safety upgrades and electrical equipment without cluttering? Discussing these questions at the outset of the project is beneficial to establish reasonable expectations.

Three-Phase Power and Secondary Power Feed

Pump stations are connected to the power grid and require a continuous supply of electricity to run. A smaller pump can be powered through a single-phase power feed; however, larger pumps require a three-phase power feed and need a backup power source during a power outage. The electrical utility can sometimes run a secondary power feed, or standby generators can be utilized.

Diesel-, natural gas- and propane-fueled generators are commonly used for emergency power generation at a pump station site. Diesel and natural gas are more common than

	NATURAL GAS GENERATOR	DIESEL GENERATOR
ADVANTAGES	No need to fill/refill tanks.	Because fuel is stored on-site, the ability to operate in an emergency is not affected by outside factors.
	Lower capital cost compared to diesel generators.	Sturdy and reliable; used in many industries/ applications. Parts and service are readily available.
	Cleaner-burning and quieter engine noise level.	Diesel engines generally have a longer life spans than natural gas engines.
DISADVANTAGES	If local codes require on-site storage of backup fuel, natural gas generators are not practical.	Potential for spills during filling operations or tank failure.
	Requires a minimum gas pressure and volume, depending on generator size.	Requires filling/ refilling diesel storage tank. Diesel fuel deteriorates over time.
	Natural gas might not be available if a power outage affects the gas utility as well. Gas lines may rupture, causing a service interruption.	A permit for diesel tanks is typically required by the fire marshal.

***FIGURE 1:** Advantages and disadvantages of natural gas and diesel generators.*

propane, and each generator type has pros and cons; in the end it is about preference and identifying the one that meets the client's needs or preferences.

Although diesel generators are quite common, if a natural gas connection is available in the proximity of the pump station and adequate pressure is available, a natural gas generator might be preferable because it makes less noise and is typically more economical than diesel. (See Figure 1 for a comparison.)

Hazardous Area Classification

Standards change over time, and when a utility decides to retrofit a pump station, it must comply with the current requirements and guidelines. Some existing components might be functioning smoothly but may not comply with the required codes and industry standards. Keeping up on the latest rules and regulations is vital for utilities.

Older pump stations may not have clear physical separation from the wet well, electrical room and other equipment. Therefore, it is important to classify what can cause a hazardous condition in the pump station. Regulatory agencies such as the National Fire Protection Agency (NFPA) and the National Electric Code (NEC) define hazardous conditions triggered by vapor, leading to explosions generated by a spark in electrical equipment. Installation and operation of equipment must comply with the NFPA and NEC guidelines, particularly by retrofitting the pump station with intrinsically safe barriers on electrical connections.

Strategies to Manage Inflow

The following strategies can be useful in managing pressure and flow and optimizing the pump station's performance:

Redundancy

Installing redundant pumps provides continuous service in the event of a failure or while performing maintenance or upgrades. The primary advantage of this system is if one pump goes offline or is shut down for maintenance, the other pump or pumps can handle the flow. Additionally, during a sudden surge in the inflow rate the pumps can work simultaneously to avoid placing excess strain on either one. This system extends the life of each pump by preventing continuous operation and allowing time for regular maintenance.

Soft Starters and Variable-Frequency Drives (VFDs)

The frequent starts and stops of the motor generate heat that can damage and reduce life of the motor and other equipment. Soft starters and variable-frequency drives (VFDs) are used for ramping the power feed up or down on pumps. VFDs can vary the speed of the motor, while a soft starter only controls starting and stopping.

Both help pumps operate smoothly. Some utilities prefer soft starters because they are cost-effective and smaller in size, and they assist in controlling speed during motor startup. Others may prefer to reduce power costs and control the motor's speed during the start, stop and throughout the cycle with the help of VFDs. Figure 2 highlights the differences between soft starters and VFDs.

Bypass Pumping System

The quality of different components of pump stations deteriorates with time and use. To maintain service throughout the project duration, a temporary bypass pumping system can be created. Working with specialists helps to quickly respond to challenges and create contingency plans to mitigate potentially disruptive events and see that service is not hampered.

SOFT STARTERS	VFDs
Reduce starting current and motorized stress.	Support adjustable speed.
Increase life of starter contactors.	Control starting, stopping and acceleration.
Support swift starting and stopping.	Allow complete or partial control when required.
Provide efficient operation at evaluated speed.	Reduce energy consumption.
Provide modifiable acceleration time.	Provide dynamic force control.

***FIGURE 2:** A comparison of soft starters and VFDs.*

SCADA Considerations and Requirements

Utilities operating and maintaining pump stations have to regularly visit the site to monitor operation and check other components of the system. Integrating new technologies, such as telemetry, allows the stations to record and transmit useful data to operators, reducing the need for site visits.

Telemetry refers to programmed recording and transfer of data for remote monitoring and analysis of the system. Integrating technology such as supervisory control and data acquisition (SCADA) into pump stations provides better control and enhances performance. With technology changing rapidly, it is important to understand the existing telemetry system of a pump station to identify gaps, then deploy appropriate solutions. These systems can trigger an alarm during an equipment failure or motor temperature fluctuations and transmit flow data, which helps in monitoring the pumping system. Most of these tools did not exist 20 or 30 years ago. Now, one can monitor different components of a pump station from a mobile phone, for instance. These solutions assist in timely maintenance and require less human intervention because of automation.

Conclusion

Pump stations across the U.S. play a crucial role in wastewater management. A wide range of factors, from hydraulic capacity and buildup assessment to different tools and remote monitoring systems, can play vital roles in designing a robust pump station. Retrofitting existing stations to meet industry standards and integrate technology can be expensive, but this investment can increase reliability and efficiency, improve operator safety, and decrease maintenance costs, saving money in the long run. While upgrading pump stations, utilities should adopt a holistic approach, because each component of a pumping system is important for smooth functioning.

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