Water Environment Federation
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FACT SHEET

Sanitary Sewer Systems: Lift Stations and Data Management Fact Sheet

Lift stations contain several components including the pumps, valves, piping, electrical and instrumentation control system necessary to move raw sewage from lower elevations to higher elevation, making them an essential component of many municipal sewer systems. This fact sheet provides young engineers, operation & maintenance staffs, utility managers, practitioners and educators the basics of lift station types, design basis, operation and maintenance, data management, and published reference materials currently available.

Introduction

Pumping stations in sanitary sewer collection systems, also called lift stations, are designed to move raw sewage from lower to higher elevations when the use of gravity conveyance will result in excessively deep excavation and higher construction and operational costs. Sewage flowing through underground gravity pipelines is collected in an underground chamber called a wet well. The wet well is equipped to monitor the level of sewage present so that when the sewage level rises to a predetermined point, a pump is started and conveys the sewage through a pressurized piping system called a force main. The force main carries the sewage downstream and typically discharges into either a nearby gravity manhole, another force main known as an interceptor force main, or directly to a wastewater resource recovery facility (WRRF) for treatment.

The topography of the area has a significant influence on the configuration of the system and the requirement of lift stations. The collection system is carefully planned to take advantage of the topography of the area to minimize the number of lift stations required. For areas where there is elevation relief, the gravity sewers are planned to utilize the elevation drop in the collection systems and fewer lift stations are required. In many coastal communities there is often very little elevation relief, which makes it necessary to incorporate many more lift stations and longer force mains.

Lift Station Strategies

There are several different types of wastewater lift stations. These include the following: single family (home) grinder pumps; low pressure force main systems which also include grinder pumps; lift stations which discharge to gravity via a force main and can be accomplished using suction lift or submersible centrifugal pumps; wet pit/dry pit which typically would have a longer force main and would discharge to a larger pressure pipe called an interceptor force main, or could also discharge to a gravity interceptor both carrying flow to a WRRF. The last pumping station to be discussed is a vacuum (pressure differential system) station, in these stations wastewater from each resident flows to a vacuum collection tank and is then transferred to a pumping station by differential pressure. Each of these will be discussed further.

Single Family Grinder Pumps

This type of station services homes which are remote and far from the gravity main located in the City/State right-or-way/easement. In these cases, the gravity sewer system would have to be considerably deeper to service the home which would be very costly to provide gravity service to these homes. The centrifugal grinder lift station lifts sewage and conveys the flow via a force main to the gravity system located in the right-of way/easement. Another use for the centrifugal grinder pump is to pump to an on-site septic system. In this example, many municipal utility departments require home owners to install and maintain these installations.

Low Pressure Force Main Systems

Low pressure force mains convey wastewater flow from many homes using centrifugal grinder pumps to a gravity collection system, another lift station or to a WRRF.

Wet Well Lift Stations

There are two types of lift stations which have been used in several locations across the country. First, is a centrifugal suction lift pump, which lifts the wastewater from a wet well each time the pump starts. These pumps have a mechanism which keeps the wastewater at the pump impeller and typically lifts wastewater to another gravity system.

The second type of lift station uses a centrifugal submersible pump in the wet well of the lift station. In this application, the pump is submerged in the wastewater in the wet well and lifts the wastewater from the wet well via a force main either to another gravity system or to an interceptor force main.

Dry Pit/Wet Pit Stations

Figure 1—Cut away of a Centrifugal Pump (Photo provided by: P. Hubbard, HRSD)

In these stations, the dry well and the wet well are separated by a concrete wall. Wastewater is discharged to and pumped from the wet well via suction piping connected to the centrifugal pumps that are located in an adjacent dry well. There are a few configurations for motor installations. The first is by using a centrifugal submersible pump and motor which is close coupled and are called dry pit submersibles even though the pump is not submerged in liquid. The motors are cooled in one of three ways; air cooled, oil cooled or liquid cooled via wastewater recirculated through the pump motor coupled to the centrifugal pump.

Another configuration is where the motor is decoupled from the pump but is still in the dry well. The motor is directly attached to the pump with a shaft. The motor is some distance above the pump and mounted on a base with a connector to the pump shaft.

The third way is to have the motor mounted a greater distance from the pump with extended shafts to connect the two together. In this arrangement, there will be universal joints which connect the motor to the pump shaft.

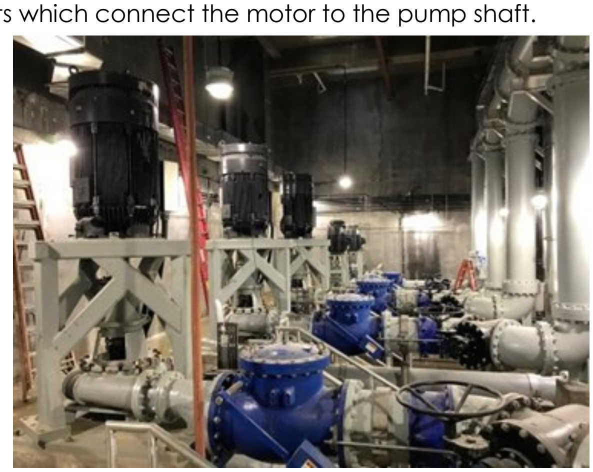

Figure 2—Wastewater Pump Station
(Photo provided by: P. Hubbard, HRSD)

Vacuum Sewer Systems

Vacuum sewer systems work on differential pressure. There is a central wastewater pumping station that has several different components from the other types of pumping stations mentioned above. First, there are vacuum pumps which create a lower than atmospheric pressure inside the connecting pipes as far as several miles in either direction from the pumping station on flat terrain. These pipes are installed in a saw tooth manner and can be installed from 3 to 6 feet in depth. This is compared to gravity sewer which can range from 3 feet to more than 20 feet in depth. There is a collection tank inside the pumping station which collects the wastewater, and once the depth reaches a set level, a centrifugal pump then evacuates the wastewater and lifts it to another pumping station or to a force main for transport to a WRRF.

Connected to the piping network are vacuum pits which can collect wastewater from up to 4 homes. The wastewater from the houses to these vacuum pits flows by gravity and collects in the pit. A vacuum valve located in each pit serves as the control interface between the vacuum piping and the pits. Once approximately 10 gallons of wastewater accumulate in the pit, the interface valve opens and differential pressure pushes the wastewater toward the pumping station. The interface valve is completely pneumatic and requires no power. The system is analogous to drinking from a cup with a straw with a lid. Atmospheric pressure is inside the cup and when we sip through the straw, we are creating a lower pressure using our mouth and the atmospheric pressure pushes the water up the straw and into our mouth. This is the same concept of vacuum sewer in that it creates a much lower pressure than atmospheric pressure

Data Management

The data monitoring, collection, and management often referred to as Supervisory Control And Data Acquisition (SCADA) system and Computer Maintenance Management Systems (CMMS) options available these days are almost limited only by one's imagination. At lift stations, data can be collected such as; influent flow rate, force main flow rate, pump status (on/off), pump pressure (suction/ discharge), force main pressure, sewage temperature, weather conditions (accumulated rainfall and rate, wind speed, temperature), power condition (line or generated, voltage, phase), etc. All of this data can be used to understand both the day to day as well as the long term operation of the pump station.

Data management is not a lift station specific issue, but rather a global issue within a utility. The collection system is the point of beginning of all data for the utility, the lift station is the first point in the collection system where we can really put our arms around collecting data that we can then leverage to our operational, planning, design, compliance, emergency response and forensic advantage. Much of the lift station data can inform the decisions that also affect the rest of the collection system, treatment plant, customers, administration, regulatory compliance, and staffing.

Utility managers must understand what information is or is not needed and how to keep it in a useful, organized manner once it has been collected. The thoughtful planning, design, implementation, management, and utilization of pump station data can be the first step in giving the utility the knowledge base for making the best decisions for its future.

Operation and Maintenance

The proper O&M of a lift station is a series of tasks that are considered, designed and implemented with the goal of assuring that the facility will function efficiently, safely, reliably and without fail given foreseeable conditions and events. By performing these tasks successfully, the utility fulfills the goals of protecting public health and safety and the environment.

The design of a lift station incorporates all the features necessary to ensure its safe, efficient and robust operation. The design parameters of a lift station are established to define the confines or constraints under which the pump station can and will operate (e.g. flow rates, head conditions, power). The maintenance routines of the lift station are established to ensure that the first two elements, design and operations, can and will continue as designed.

A lift station must be visually checked (on-site) on a regular, short interval schedule. That schedule should be set based upon several factors including location (e.g. rural or urban, above ground or below), reliability of power supply (continuous uninterrupted clean power vs unpredictable and irregular power), system redundancies (e.g. multiple pumps, backup power supply, emergency overflow facilities), remote monitoring capabilities and remote control capabilities. A typical on-site inspection schedule can be daily for high priority stations to weekly for lesser priority stations with remote monitoring capabilities.

During site inspections a check list of tasks should be routinely performed and recorded. Things such as a check of the communications and control systems, alarm sensors, recording run time meters, cycle counters totals, valve condition and position, wet and dry well condition, site security, vandalism, odors, should be included in the higher frequency lists of tasks. Daily, weekly, monthly, quarterly and annual maintenance tasks should be provided, performed and recorded to ensure that the level of attention necessary for the continued successful operation of the station is provided. Maintenance tasks can include replacing seals, lubricating the bearings, and coating of piping and structures.

The operator should not be required to create the O&M protocol for pump stations on their own. Including design engineers as well as the manufacturers of equipment in the pump station involved is a very useful strategy to developing a robust and competent program. The O&M manual and equipment manual should be included in every pump station. This will provide the pump station's role in conveying sewage and enlightening you to the needs of the station with regards to its continued care and maintenance

Industry Guidelines

The major industry references related to sanitary sewer lift stations have been identified and listed in the table below. The table includes the resources and descriptions of 10 States Standards, several different cities and counties guidelines, as well as public agency references such as EPA (Environmental Protection Agency), HI (Hydraulic Institute), WEF (Water Environment Federation), WERF (Water Research Foundation), and ASCE (American Society of Civil Engineers).

List of References

Design Specification & Requirements Manual. 2010. London, ON: Environmental and Engineering Services Department (EESD).

Pumping Station Design – Revised Third Edition, Garr M. Jones Editor in Chief, Co-Editors, Robert L. Sanks, George Tchobanoglous, Bayard E. Bosserman II, 2008.

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Additional Resources

Resource	Description
EPA Wastewater Technology Fact Sheet In-Plant Pump Stations (https://www3.epa.gov/npdes/pubs/in-plant_pump_station.pdf)	This EPA Fact Sheet briefly described the two most commonly uses types of pump stations, their applicability, advantages and disadvantages, performance, costs, operation and maintenance.
Hydraulic Institute (HI), Wastewater Treatment Plant Pumps: Guidelines for selection, Application, and Operation (https://estore.pumps.org/Guidebooks/WWPDF.aspx)	This guidebook is intended to assist in the understanding of the general layout, components, and operation of a typical wastewater treatment plant. The intention is to provide the guidance necessary to select pump types, pump materials, and auxiliary components so the pumping system performs effectively, efficiently, and reliably in the various plant operations. This single resource contains practical information for those who are new to specifying treatment plant pumping systems and equipment, as well as for those who are experienced, but desire to enhance their knowledge-base for these systems and proper pump selection.
Hydraulic Institute (HI), Pump Systems Assessment: Body of Knowledge (http://pumps.org/BOK.aspx)	The PSABOK outlines and describes the knowledge, skills and abilities necessary to perform the specific tasks professionals must apply in order to conduct successful and quality pump system assessments.
Water Environment Federation (WEF), Design of Wastewater and Stormwater Pumping Stations (Manual of Practice No. FD-4 Facilities Development) (https://www.e-wef.org/Store/ProductDetails.aspx?productId=3684)	This manual has been prepared to assist the practicing engineer in the design of wastewater and stormwater pumping stations and is for the experienced designer rather than the novice. The publication covers the similarities between wastewater and stormwater pumps, pipes, valves, and controls, and covers the differences in station hydraulics and operational considerations such as the intermittent operation of a stormwater pumping station. Chapters include pumping station capacity, configuration and design, piping systems and hydraulic considerations, electrical and instrumentation design, odor control, special structures, and more.
Water Environment Research Foundation, Optimization of Wastewater Lift Stations for Reduction of Energy Usage and Greenhouse Gas Emissions (WERF Report INFR3R11) (http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=IN)	This project and report introduces capabilities of new generation hydraulic models and supervisory control and data acquisition systems. The use of hydraulic modeling to identify energy efficient operating conditions is demonstrated. The project illustrates the integration of hydraulic modeling into the development of optimal control strategies for lift stations. The report provides guidance on improving energy efficiency and reducing greenhouse gas emissions of wastewater lift stations.
10 States Recommended Standards for Wastewater Facilities (http://www.10statesstandards.com/wastewaterstandards.pdf)	The design criteria in these standards are intended for the more conventional municipal wastewater collection and treatment system. They are intended for use as a guide in the design and preparation of plans and specification for wastewater facilities. Users should be cognizant of locally adopted standards and applicable federal requirements. Member states and province include Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Ontario, Pennsylvania and Wisconsin.
City of Houston, Engineering Design Manual for Submersible Lift Stations, 2016 (https://edocs.publicworks.houstontx.gov/documents/design_manuals/2016_coh_design_manual_submersible_lift_stations.pdf)	Houston Water has 39 wastewater treatment plants that collect and treat an average of 250 million gallons of wastewater per day. Over 6,100 miles of sewer lines and 383 lift stations comprise Houston's sanitary sewer collection system. The Design Guidelines Manual for Submersible Lift Stations provides requirements, criteria, and considerations for the consistent and uniform design of lift stations and force mains for the City of Houston (COH).
Los Angeles County, Sewer Maintenance Districts, Maintenance and Operations Manual (https://dpw.lacounty.gov/smd/smd/maintenanceandoperationmanual.pdf)	The Districts' system includes over 4,600 miles of sanitary sewer, 154 pump stations, and 4 wastewater treatment plants. This manual describes a proactive maintenance program consisting of mandating minimum design standards for construction, regular inspection of the sewer system combined with as-needed cleaning, timely detection and repair of damages and other problems, and good safety practices.