Practical “Do’s and Don’ts” of Differential Pressure Sewer Design and Construction

[Draft]

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Purpose

This memorandum is intended to convey practical design and construction “lessons learned” resulting from experience with the use of low pressure and vacuum sewer systems in the northeast U.S.. This information is not intended to replace or supersede comprehensive, project-specific design standards or operation and maintenance requirements specified by manufactures or designers of sewer systems utilizing differential pressure.

Background

There are two basic types of differential pressure sewer systems in use today; the vacuum system and the low pressure system. These systems differ from the traditional gravity sewer system because they rely on the use of mechanical pumps to provide the necessary differential pressures to transport sanitary sewer wastes from their initial sources to treatment, whereas the more traditional system relies on gravity to perform this function.

Vacuum systems have been in use for many years but have been generally limited to specific segregated or isolated structures where a gravity system would be infeasible or impossible to construct such as; ships, trains, aircraft, marinas, and commercial buildings. Over the last several decades, this application has expanded to include municipal collection systems capable of servicing entire neighborhoods.

Low pressure systems (LPS) were originally developed in the 1960’s and slowly became accepted in the industry starting in the 1970’s when EPA sponsored demonstration projects in several states and regulatory agencies began issuing permit approvals. In the 1980’s, most individual state guidelines, and the “Ten State Standards” adopted low pressure systems as an acceptable means of sewer collection.

Application/Advantages

There are several key advantages to a differential pressure system over the traditional gravity system. These advantages include; a reduction in the required amount of water needed to flush the sewerage, the potential reduction in the amount of infiltration and ex-filtration between the system and the environment, and usually cost savings realized during construction because of the smaller pipe sizes required and the minimal depth of burial needed compared to a gravity system. The latter is especially true when dealing with vast flat terrain where gravity systems cannot take advantage of sloped ground and therefore become very deep, or when there is shallow bedrock and/or groundwater in the region which becomes very costly to excavate within.

Basic Features

Gravity sewer systems often use larger mains (typically starting at 8-inch diameters even for very small flows) that are installed in relatively deep trenches, wherein differential pressure sewer pipes may be as small as 2-inches in diameter and follow the contour of the land.

Pressure sewer systems use small-diameter pipes and grinder pumps, which are often installed at each home. These grinder pumps collect the wastewater from the individual homes and grind it into slurry prior to discharging to a relatively small forcemain in the street where it is combined with other home effluent. Valves ensure that positive pressure is maintained in the system to eventually force the sewerage downstream to a larger sewer main or directly to a wastewater treatment plant.

Vacuum sewer systems use small-diameter pipes for transmission in conjunction with rotary vane vacuum pumps located within the central vacuum station to generate (below atmospheric) negative operating pressure. Sewage from each house flows by gravity into a collection sump typically located on the property. Once a predetermined fill-level inside this sump is reached, a pneumatically operated interface valve will open - the resulting differential pressure is the driving force to transport the wastewater towards the vacuum station. Sewerage from the vacuum station collection tank is pumped into a local gravity system or directly to a treatment facility.

Operation and Maintenance

Low Pressure systems: maintaining a low pressure sewer system typically only requires periodic flushing of the system. To facilitate this potential effort, adequate flushing facilities should be spaced approximately 500-feet along mains, at every branch connection, and at the terminus of lines. To save costs, the flushing connections can be combined with the air release valves. These flushing facilities are comprised of the following components: a hose connection for pressure water flushing, an isolation valve that also serves as the manual air release valve, and a connection that can be opened to pig the system if needed. Manual air release valves are preferable to automatic valves to eliminate the potential for clogging. It is important to keep yard air vents clear of obstructions and anything that could cause blockages. Cracked main should be repaired or replaced immediately.

Vacuum Systems: Vacuum stations should be visited at least once a week to carry out a visual inspection. Experiences have shown that a well-designed vacuum station will not need more than one visible control and short check once a week. Operating hours and power consumption of the pumps should be checked regularly. Mechanical and electrical maintenance, cleaning of the vacuum tank, briefly a total check of the vacuum station, should at least be done once a year including an oil-change and filter change of the vacuum pumps. Air valves that remain stuck in the open position require immediate response to correct the loss of vacuum in the system. Pneumatic valves/controllers and isolation valves should be exercised at least quarterly in areas with seasonal populations. As with low-pressure sewers, cracked main should be repaired or replaced immediately.

General Guidelines for Differential Pressure Sewer Design and Installation

1. Involve the manufacturer of the system in the design process. Benefit from their experience of putting a "total system" together. They will recommend piping type, fittings, air release locations etc. The pump unit is important, but understand that it is a system with many components. Have the appropriate system manufacturer review the design before it is finalized.

2. Minimize pipe diameters as much as practicable. Doing so will reduce the retention time of sewerage in the system and maximize scouring velocities. Particularly in seasonal communities where many houses will be unoccupied for extended periods of time thereby reducing inflow to the system and naturally increasing retention time.

3. Consider different pipe installation methods proposed by Contactors, such as directional drilling, which may result in some cost effective options.

4. Have discussions with the customers and DEP on pump ownership and maintenance. There are different rules on this from the DEP depending on how the project is funded. For example, if the pumps are supplied and installed as part of the contract then the town usually will have to provide maintenance. It very important to have a clear plan prior to presenting this to the public so things will go smoothly. Will the municipality maintain? Will the homeowners be individually responsible?

5. Educate future customers early in the design phase on what to expect during power outages which can be an emotional issue. Establish a consensus on system components to include in the backup system such as: Will the grinder pump control box have a plug that can be connected to a portable generator? Are there any features that can be provided for the interior of the house such as a loss of power alarm for the pump or a battery backup high water alarm during an outage?

6. Establish an emergency response plan for power outages.

7. Decide how the pumps procurement will be handled. Will it be left in the hands of the contractor or will a pre-purchase/propriety specification be adopted so the town and the design engineer can evaluate the best option for the town?

8. Investigate extended warranties and/or service contracts for the pump units – on a project basis it may be only a nominal cost to get extended warranties up to 5 years.

9. Use Contractors and Sub-Contractors (esp. electrical) with experience in the proper installation of differential pressure sewers.

10. Make sure the construction inspectors are properly trained in construction issues related to differential pressure sewers.

11. Confirm that every system component is installed per manufacturer's recommendations to ensure warranties will be in effect.

12. Test all piping prior to the system going on line.

13. Design vacuum sewers for final build-out conditions – expanding the system beyond original design parameters is not recommended.

14. Closely follow the pipe profiles for vacuum systems as designed, since deviations may lead to water sags causing temporary blockages and pressure drops causing additional head losses. In worst case situations, this can lead to a failure of the system.

15. Design vacuum systems with provisions for odor control at the vacuum station (normally associated with the vacuum pump exhaust) – either include within original design or make provisions to facilitate the addition of odor in the future if needed.

16. Consider biofilters for odor control

17. Plan for power outages. Vacuum systems typically have standby generators incorporated into the vacuum station design. Pressure systems typically have transfer switches located at each house for connection of a portable generator.

18. Consider pneumatically operated alarms for actuators.

19. Establish a central management entity, be it public or private, to be responsible for operation and maintenance of the on-lot facilities.

20. Educate the local building inspector, electrical inspector, and even plumbing inspector on the proposed system to be adopted so they may provide knowledgeable oversight and guidance during the permitting and inspectional phases.

21. Engage communities experienced with similar sized systems for experience feedback - what worked for them and what they learned they could do better.

Cautionary Notes on Pressure Sewer Design and Construction

1. Don't hire inexperienced contractors that haven't been properly trained in installation of pressure system

2. Don’t use non-standard equipment – make sure all components are proven standard products.

3. Don’t let system units be buried so they can’t be accessed or found like under structures, in driveways or lawns.

4. Don’t install isolation valves in streets where auto parking would limit access during emergencies.

5. Don’t minimize the importance of installation oversight and startup testing.

6. Don’t use 90° fittings within the piping network which will potentially lead to blockages within the system and may create water hammers (with temporarily pressure drops affecting the equipment). Never use tee fittings in a vacuum system.

7. Don’t allow the deliberate introduction of non-sewerage flows such as storm water, surface water, groundwater, roof leaders, sump pumps, swimming pool drainage, A/C condensate, etc.

8. Don’t reduce a pipe size in the direction of flow (i.e. using reducers to put in smaller valves than the line size).