United States
Environmental Protection
Agency

Research and Development

Water Engineering Research
Laboratory
Cincinnati OH 45268

EPA/600/S2-85/051 June 1985

EPA

Project Summary

Investigations of Existing Pressure Sewer Systems

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Fifteen pressure sewer systems were visited to evaluate operation and maintenance history and wastewater treatability. This report details design, construction, and operation and maintenance (O&M) characteristics at these sites, and it highlights common problem areas. Reliability of equipment, frequency of repair, treatment considerations, costs, and organization models are also discussed.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The number of pressure sewage collection systems has increased because smaller communities need low cost solutions for collection and treatment of wastewater. The many advantages of pressure systems include: lower construction costs associated with less expensive piping, excavation, dewatering, and shoring; lower construction costs in areas with rock formations close to the surface, hilly terrain, or high groundwater; increased development opportunities because homesite units need be added only when a homeowner decides to build; and greatly reduced infiltration and inflow (I/I) as a result of sealed sewer lines. However, pressure systems are more mechanized than gravity systems and potentially have more maintenance requirements.

Treatment considerations for pressure sewer systems may differ from conventional gravity systems. One type of pressure system sends a reduced organic load to the treatment plant because of pretreatment by a septic tank. These reduced loads may result in higher treatment plant capacity when conventional design criteria are used. However, another type of pressure system usually has a higher organic loading than does a gravity system because the flow volume is not increased by I/I.

To gather data on existing pressure sewer systems, 15 systems at 9 sites were visited. The sites were chosen because their variations in terrain, equipment, age, and treatment methods represented a good cross-section of the present use of this technology. Interviews were held with system operators, contractors, pump repairers, state and local officials, and major pump manufacturers.

Design

There were two types of pressure sewers—septic tank effluent pump (STEP) systems and grinder pump (GP) systems. The STEP units consisted of an interceptor (septic) tank, pumping chamber with an effluent pump, and several appurtenances, including piping, valves, level control system, alarm, and electrical service lines. GP facilities used similar appurtenances but had a pumping chamber/storage tank with a grinder pump instead of a septic tank. Most manufacturers offered packaged units of both types, but savings were sometimes possible with individually designed packages.

The full report discusses in detail the materials of construction, equipment specifications, and site-specific installation features of onsite units. Most notable were certain common design problems: corrosion of coated steel, cast iron, and brass appurtenances, and failure of pressure switches used for level control. Proper ventilation and use of plastic, bronze, and stainless steel were the best preventive steps for corrosion control. Mercury float switches were used in newer installations and were more reliable than previously used pressure switches. Gas and odor usually were not a problem when proper ventilation was used.

Several methods were used for sizing the pumps and piping, based on one or more of the following criteria:

- elevation of each pumping unit;
- estimated number of pumps running at any given time;
- peak water demand curves;
- minimum scouring velocity of 3 to 5 fps;
- friction headloss;
- head delivered by pumps; and
- hydraulic grade lines.

Mainline sewer system designs were straightforward, with short branches and few changes in direction. A positive head was maintained on all pumps to prevent grease and solids buildup, air lock formation, and pump siphoning. Precise topographical surveys were not critical because pressure sewers allowed for more flexibility during construction than did gravity sewers. Pipe locator systems and color coding were recommended to avoid mistaken cross connections and to aid in repair and maintenance.

Air release valves were required at all high points in the system to vent gas accumulation and avoid pressure buildups and air locks. Several operators suggested using more air release valves because changing sewage velocities changed the points at which air accumulated. Manual valves are less expensive than automatic valves, but they are time-consuming to operate and maintain; automatic valves were therefore recommended to reduce O&M costs.

Cleanouts and in-line shutoff valves were included in the mainline sewers to aid in cleaning and maintenance. The use of cast iron valves in the mainline sewers did not lead to any corrosion problems.

Some problems occurred in systems that were started up at only 5% to 10% of design capacity. Problems were more severe in GP systems because slow velocities allowed grease and detergent deposition. In STEP systems, slow velocities meant longer residence time in sewers and greater chances for gas and odor formation. Possible solutions included combination gravity and pressure sewer systems and flushing stations to supplement low flows.

Construction

Proper construction of onsite facilities was extremely important to ensure overall system success. Improper installation allowed I/I and debris to enter the system and caused numerous onsite problems. Ease of maintenance, proximity to power supplies, freezing conditions, and aesthetics were all considered at good installations.

Mainline pressure sewer construction was similar to water main installation and allowed more flexibility than conventional sewer construction. However, good jointing and careful bedding were essential to system success. Common causes of later problems were poor pipe bedding, installation at improper depths, and allowing dirt or debris to enter the lines during installation.

Operation and Maintenance

The full report details site-specific O&M practices and problems for several systems. Although most O&M is related to onsite units, maintenance of these units was minor, and all of the types of pumping units showed good reliability. Improper installation, homeowner misuse, malfunctioning level control and alarm systems, air-binding of pumps, plugging of pumps and piping, and motor burnout were the most common problems. Reliability was defined as the mean time between service calls (MTBSC), which was the mean time interval, in years, that system components lasted without service calls. The MTBSC for pumps ranged from 1.2 to 19.6 years, based on systems with 1 to 8 years of operational experience.

A problem common to all GP units at all of the sites was failure of the pump's stator or boot. Failure was usually caused by dry-running, excessive solids, or abnormally high discharge pressure caused by grease buildup.

Most common problems with onsite appurtenances related to valves. Although several sites reported no valve difficulties, larger and older systems had problems such as grease plugs in check valves, frozen check valves, leaking check valves, and corrosion. Every system using cast iron valves experienced corrosion problems, and several systems had trouble with corrosion of brass valves. Polyvinyl chloride valves were tried in some systems, but they were not widely used because of a high incidence of stres cracking. Heavy-duty bronze valves wer the most resistant to corrosion.

Operation and maintenance of mainline sewers was minimal, and other than grease accumulation, most problems were related to construction and installation. Most designs provided the capability of flushing the pressure sewer lines, but operators only did so when a blockage occurred. Providing this maintenance only on an as-needed basis is not recommended. Allowing a system to run until failure from blockage could lead to more expensive solutions than flushing.

Odor control was a problem at several of the locations visited, but usually at lif stations and not at onsite units or treatment plants. In addition to good ventilation, several methods (including hydrogen peroxide addition) were used t overcome odor problems.

Routine preventive maintenance of b onsite units and mainline facilities reduced the frequency of emergency breakdown maintenance. Annual or semi-annual inspections of onsite facilities, lif stations, and air-release valves was recommended. Routine flushing of all line was also recommended.

A final O&M concern that put a grea demand on an operator's time was super vision and coordination of on-lot installa tions. Several operators reported that 1 to 33 percent of their time was spent o this activity, which was usually no included in the original O&M budget.

Treatment

Compared with gravity-collected sew age, GP wastewater was typically 25 t 50 percent more concentrated because o the exclusion of I/I; it also containe smaller particles as a result of the grind ing action of the pumps. GP wastewate was noted to be anaerobic when enterin the treatment plant. No problems wer reported in treating these wastes, but i was suspected that higher mixed liquo suspended solids would have to be main tained because of greater primary efflu ent organic concentration.

STEP wastewater was generally les concentrated than gravity-collected sew age because of the pretreatment by th septic tank. Only one plant was visite that treated 100 percent STEP waste and that plant produced a high qualit effluent. Treatment and disposal of sep tage also had to be considered for STE systems.

Both types of wastwater contained li tle or no I/I, and neither required a co minutor at the treatment plant. There were no reports of problems with flow variations at the treatment plants.

Costs

The use of pressure sewers has increased because of significant cost savings in certain areas such as low-density developments, lakefront communities, slow-growth developments, and areas with hilly terrain, shallow bedrock, and high groundwater.

The report cited actual costs or engineering estimates for many systems that showed capital cost savings of 25 to 90 percent over gravity systems. Total on-lot capital costs during the 1969-77 construction period ranged from $700 to $2100 per dwelling. The pumping unit made up to 40 to 70 percent of the on-lot costs. Mainline capital costs varied widely because of local construction conditions. Treatment plant costs were not significantly different from the costs of gravity sewer treatment plants, though some savings should result from the lack of I/I volume.

The majority of system O&M costs related to onsite O&M. These costs varied depending on the level of maintenance required for the on-lot units, and they ranged from $48 to $180 per dwelling per year. The level of maintenance required was related to the forethought given to O&M during design and to the extent of a preventive maintenance program. O&M costs for effluent pumps were estimated to be less than those for grinder pumps because of fewer moving parts. Mainline sewer O&M costs were estimated to be about one-fourth those of gravity sewer O&M costs.

Individual home electrical costs were very low and were comparable to the cost of using a coffee maker. Treatment plant energy costs were similar to gravity system plants, but some savings should be realized from lack of I/I volume.

System Organization Models

Mainline pressure sewers and treatment facilities were owned and operated by one of three organizational units: a government authority (such as a sewer district, municipal utility district, city, or county), a private utility company, or a cooperative or homeowner's association. Under government or private utility organizations, onsite facilities could be owned by either the homeowner or the central authority. Generally, maintenance of onsite units was the responsibility of the party who owned the unit. Some central authorities contracted out for O&M services, while others performed all work in-house.

Under cooperative arrangements, the individuals owned and maintained the pump units. An elected homeowner's association board oversaw the system and dealt with calls from the homeowners. For mainline repairs, the homeowners called the association, who in turn called a local contractor. For on-lot repairs, the homeowner was free to call either a local contractor or to enter into some type of maintenance contract.

All system operators interviewed during the course of the study recommended an overall comprehensive management system that offered perpetual maintenance on the complete system with emergency service charges built into the monthly user fee.

Systems with formal maintenance organizations had fewer complaints and fewer system problems. Moreover, customers showed more interest and were kept better informed about system operation. Where homeowners lacked formal assistance, many expressed an interest in securing help from a formal, centralized entity.

Conclusions and Recommendations

Design and Construction

- Pressure systems should be used only if there is a clear and significant cost-effectiveness over conventional gravity systems. Slight capital cost advantages will probably not outweigh higher O&M costs.
- Grinder-pump pressure sewer systems designed for future use that is significantly greater than present use have problems resulting from insufficient scouring velocities.
- Because corrosion is a major problem, especially in STEP systems, plastic, bronze, and stainless steel should be used for valve materials.
- Mercury float switches should be used instead of pressure switches for level control.
- Automatic air release valves should be used instead of manual air release valves to reduce O&M requirements.
- Alarm systems should be provided to alert the homeowner to malfunctions.
- Systems should use pipe locaters and color-coded pipe to aid maintenance and to avoid accidental breaks and cross-connections.

Operation and Maintenance

- Both GP and STEP pump units showed acceptable reliability.
- Onsite pumping units that are light enough for one person to lift are easier to service.
- Annual or semiannual inspection of pumps and sewer system components results in less emergency breakdown maintenance.
- All sewer systems shutoff valves and air-release valves should be inspected and manually operated at least twice a year.
- Odors can be a problem, but these usually occur at lift stations and not at onsite units or treatment plants.
- Significant operator time is spent on supervising and coordinating installation of new onsite units, and O&M budgets should reflect this time.

Treatment, Costs, and Organization

- GP sewage has higher organic loads than gravity-collected sewage because of the absence of I/I. STEP sewage is less concentrated than gravity sewage because of pretreatment in the septic tank.
- Both types of pressure sewage are amenable to conventional wastewater treatment.
- Installed costs of onsite units ranged from $1000 to $2000 for STEP units and from $1300 to $2500 for GP units.
- Systems with a formal, central maintenance organization had fewer customer complaints and fewer system problems. Customers showed more interest and were kept better informed about system operations. Where such organizations did not exist, homeowners showed an interest in obtaining help from a formal, centralized entity.

The full report was submitted in fulfillment of Contract No. 68-03-2600 by Rezek, Henry, Meisenheimer and Gende, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

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The complete report, entitled "Investigations of Existing Pressure Sewer Systems," (Order No. PB 85-197 044/AS; Cost: $14.50, subject to change) will be available only from:
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☆ U.S. GOVERNMENT PRINTING OFFICE: 1985—559-016/27086

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