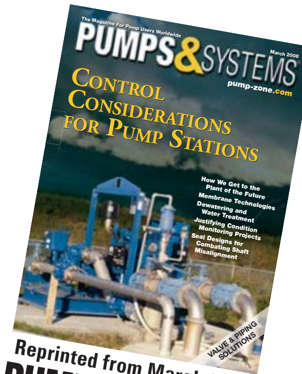
The Semi-Positive Displacement Grinder Pump for Wastewater Applications



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PUMPS&SYSTEMS

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Explore the characteristics of SPD grinder pumps and learn how to select the best pump for the job.

A grinder pump station stores, grinds and pumps wastewater under pressure to a treatment site or central sewer, depending on the location. Because the output is pressurized, the wastewater can typically be transported horizontally over two miles, or uphill 185-ft vertically. Because the system does not rely on gravity to carry the waste, it provides more options for siting and building, as well as system renovations in geotechnically challenging conditions.

The geometry of the pump not only produces a near vertical pump curve, but also allows passage of ground solids without clogging. The progressing cavity pump itself is based on the Moineau principle. A rotor turns within a stator, creating a sequence of sealed chambers. The rotor moves wastewater through these chambers at a nearly constant flow, over a wide range of conditions—from negative to abnormally high heads.

Basic Characteristics of SPD Grinder Pumps

The significance of a semi-positive displacement (SPD) pump is not immediately apparent except to those experienced and skilled in the art of pump design and application. The SPD characteristic means that the flow (Q) from the pump is very nearly constant, no matter what the back pressure (H).

In practical terms, in a pressure sewer system, it means that when a pump is turned "on," it will deliver a useful amount of flow into the system, no matter where it happens to be within its allowable range of operating pressure. The flow volume will be, for all practical purposes, independent of pressure in the system. The maximum pressure may temporarily exceed the steady state normal rating by up to 50 percent with no harm to the pump or piping.

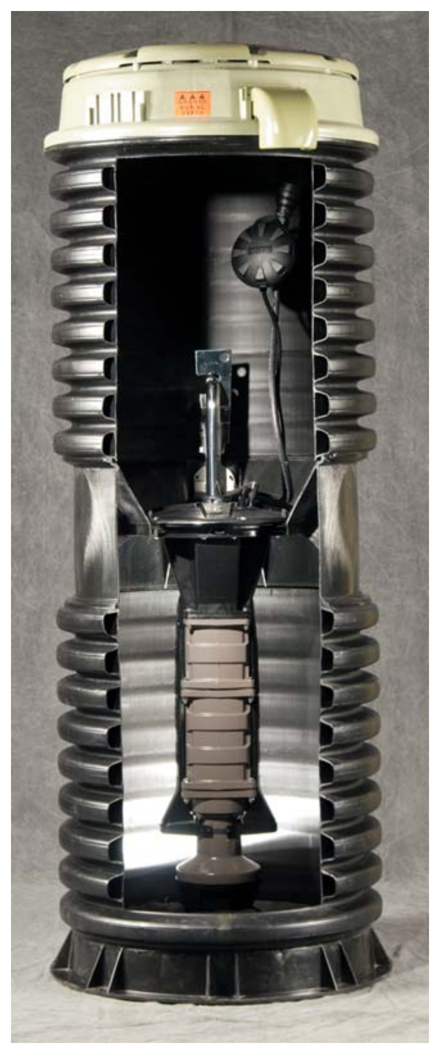

Figure 1. Grinder pump station, cutaway view

This reserve capability offers great advantages in handling intermittent or abnormal hydraulic conditions, including:

- More pumps "on" simultaneously than planned (design assumptions non-critical)
- Temporary, greater-than-planned resistance to flow (obstructions or gas pockets)
- Fewer than planned number of pumps connected (oversized pipelines)
- Additional pumps added to an existing system (planned or unplanned growth)
- Undersized pipelines (unexpected growth in customers connected)
- Lower than planned velocities in pipes (fewer customers than planned)
- Scouring pipelines that are temporarily oversize (auto-sizing phenomena)
- Ability to operate far above the point where centrifugals shut off

The choice of the semi-positive displacement principle was made with input from the ASCE Staff and Steering Committee more than 35 years ago based on these irrefutable hydraulic fundamentals. The development of the wastewater pump began with no vested interest in any particular technology, so the developers were free to start from the "ground floor" and devise a unique class of pump, tailored in every respect to the specific needs of pressure sewer systems. The wisdom of that decision has become more evident with each passing year of successful operation.

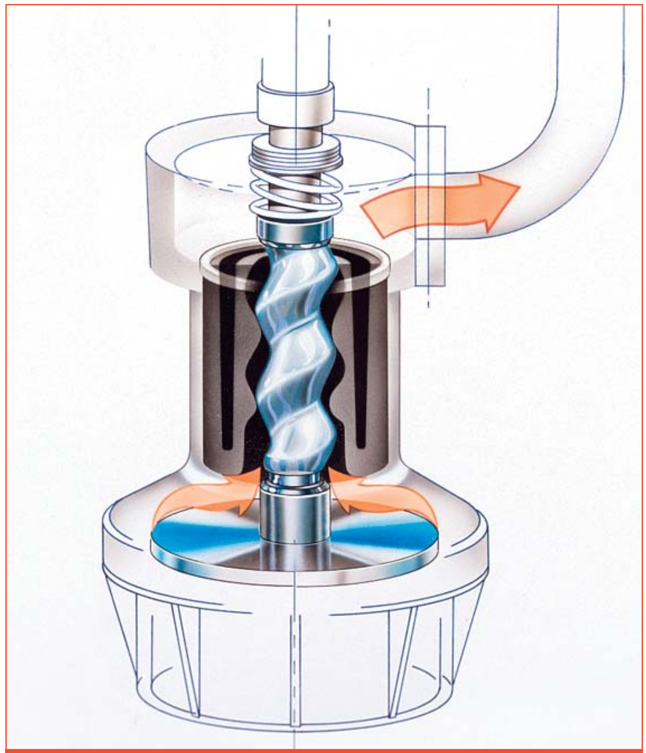

Figure 2. The Moineau principle. A rotor turns within a stator, creating a sequence of sealed chambers. The rotor moves wastewater through these chambers at a nearly constant flow, over a wide range of conditions.

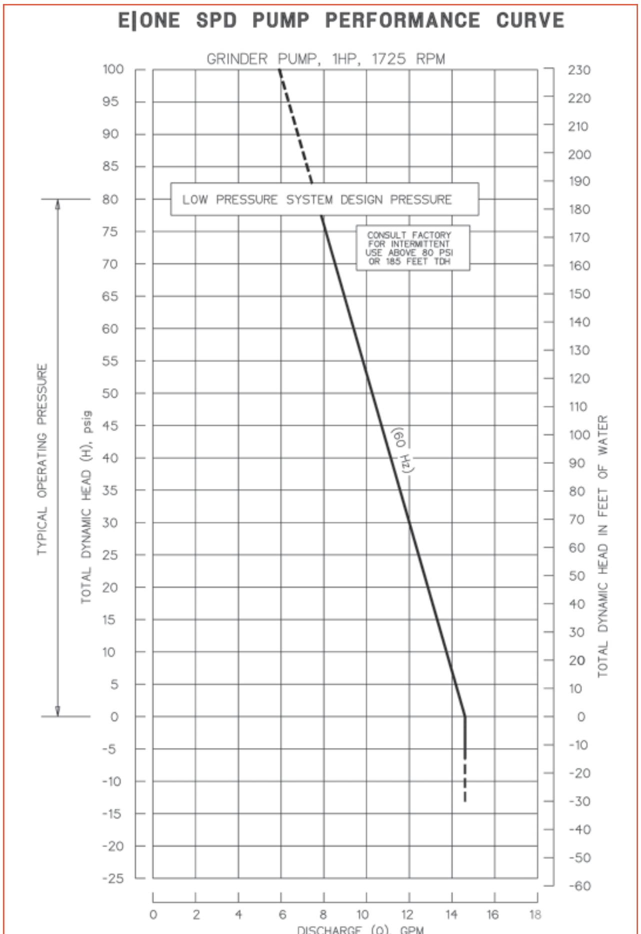

Figure 3. Typical pump performance curve

None of these advantages can be attributed to centrifugal pumps. As a class of hydraulic machinery, centrifugals accomplish perhaps 80 percent of the world's pumping tasks, but they work satisfactorily only in the simplest, smallest pressure sewer systems. Centrifugal pumps have been "forced" into low-pressure sewer (LPS) applications, whereas the SPD pump was adapted specifically for this purpose.

Pump Selection and System Design

In evaluating the equipment for use in pressure sewer systems, the designing engineer should begin with two main choices: first, select the pump characteristic (H–Q curve)—either centrifugal or semi-positive displacement; second, select the equipment manufacturer based on additional pump characteristics, including:

- Performance features
- Reliability and track record in the "field"
- Ease of installation

- Serviceability
- Preventive maintenance requirements
- *Real* estimates of operating and maintenance costs
- Initial cost

A rational "system" design cannot proceed beyond the crudest preliminary stage until the pump characteristic is selected. Indeed, neither pumps nor piping network alone constitute a system. Only when they are considered together can an integrated harmonious design be created.

To realize the inherent economy of pressure sewer systems compared to other alternatives, the designer must:

- Fully utilize the head capability of the pumps to eliminate or minimize the use of large lift stations
- Minimize the tank size needed at each site

In evaluating the merits of positive displacement versus centrifugal pumps in light of these two requirements, it is important to remember that the prime function of the LPS system is to remove sewage from the home whenever it is required. There are an almost unlimited number of combinations of pump rate and tank volume that will, theoretically, perform satisfactorily. Large flow rate pumps can use very small tanks, while low-rate pumps require larger tanks to handle peak flows. Installation costs are sensitive to tank volume, which should be minimized.

However, once a tank size is chosen, there is a definite relationship between pump flow rate and the ability of the storage tank to handle peak inflows. Figure 4 illustrates this relationship for a typical grinder pump station with a nominal 60-gal capacity normally used for a single-family residence.

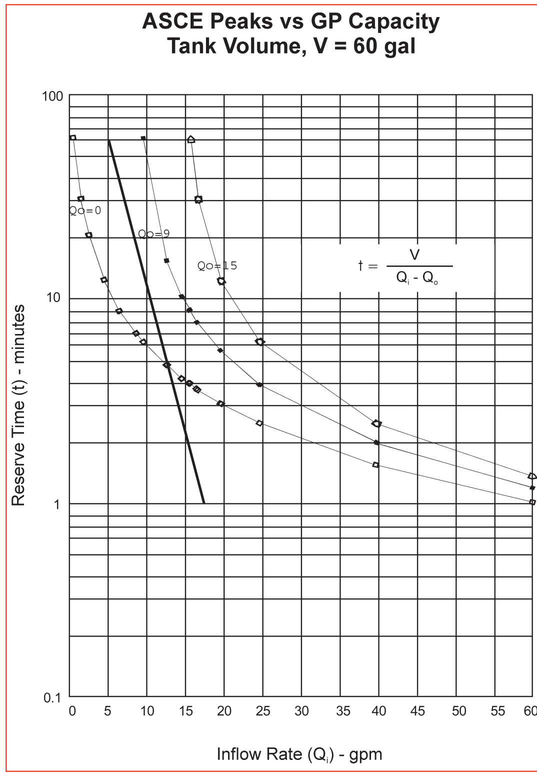

Figure 4. The SPD characteristic means that the flow (Q) from the pump is very nearly constant, no matter what the back pressure (H).

The curves marked Q_o=9 and Q_o=15 relate the inflow rate to the time available from pump "turn on" to overflow. The straight line summarizes thousands of test points taken from two different studies reported in the ASCE Pressure Sewer Project. These define the maximum duration of peak inflow rates from single family homes. For example, with a pump out rate of 9-gpm, inflow at the rate of 15-gpm can take place continuously for 10 minutes before the storage volume is filled.

For a pump out rate of 15-gpm, the system would be in equilibrium, and the tank would never overfill. By contrast, the straight line defining peak flow shows that the longest 15-gpm peak recorded lasted only two minutes. Obviously, overflow is not even approached under these conditions. The curve can be interpreted similarly for any inflow rate, and the general conclusion drawn is that any "pump-out vs. volume" curve that lies to the right of the ASCE peak (straight line plot) will never result in overflow.

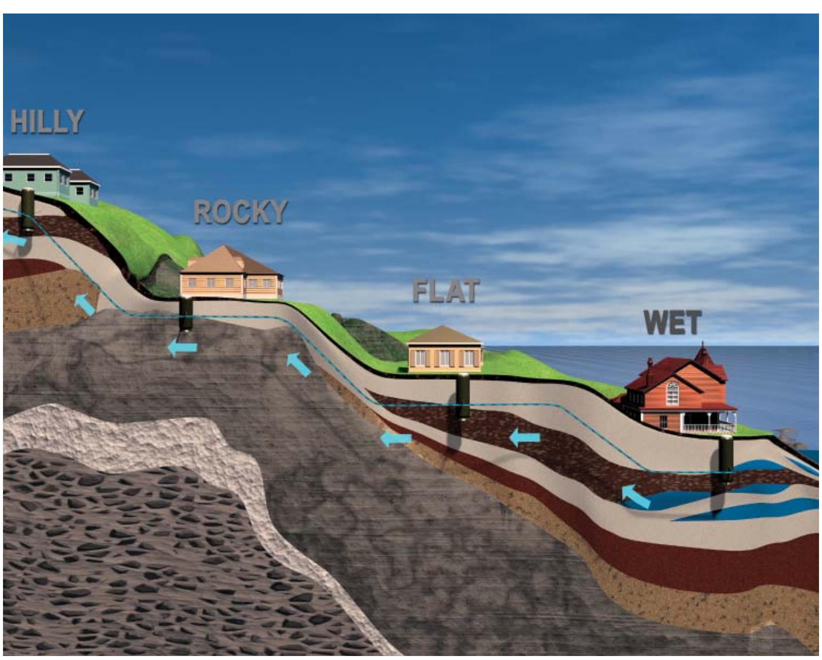

Figure 5. The semi-positive displacement pump is ideal for flat, wet, rocky and hilly topographies.

If a pump is used that can be driven

to shutoff (as all centrifugals can), the curve marked $Q_o = 0$ should be used. The intersection with the ASCE peak line indicates that overflow would begin in less than five minutes. To build a reasonable degree of safety into a system with hundreds of pumps, a minimum pump rate should be specified at some head in excess of the nominal maximum.

Applications

Semi-positive displacement grinder pumps have been gaining popularity since the 1970s in a variety of terrains—notably rocky, hilly, and wet or high water table areas. Many of these projects are in lower density residential communities where the cost of conventional gravity sewer would not be economical.

For instance, Great Sky, GA—located at the foothills of the Blue Ridge Mountains—offers recreation and breathtaking views, but the hilly terrain proved challenging for a gravity sewer system. The gravity sewer system would have required 20 lift stations, whereas the LPS system reduced that number to three. The shallow trenching for an LPS system also lowered excavation costs and required less environmental disruption.

In Port Orchard, WA, the community was faced with an urgent problem: septic tanks were failing, creating a serious health issue and impacting the oyster and clam beds of Puget Sound. The proximity of the coast also meant a high water table. The LPS system has saved critical time and cut the cost of replacing the failing septic tanks. The estimate for a gravity system was approximately $6.5 million. The LPS system was estimated at $3 million—a 58 percent savings.

Semi-positive displacement grinder pumps are now being deployed worldwide. As prime tractable land becomes scarcer for new development and existing communities migrate from failing septic tanks to central sewer, the opportunities for this pump will continue to grow.

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R. Paul Farrell is one of the founders of Environment One Corporation. This year he celebrates 50 years of membership in the Water Environment Federation.

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