Selection Criteria for Wastewater Pumps

By Bayard Besserman, P.E. and Paul Behmke, P.E.

Editor's Note: The second half of this article will appear in the October issue. It gives estimated costs of pumping stations as well as recommendations for selection.

With various types of wastewater pumps available, this paper discusses criteria that may be used by sanitation agencies in selecting the type of wastewater pump for a particular project or application. Capital cost, operation and maintenance (O&M) costs, and other relevant criteria are evaluated. The evaluation included investigating wastewater pumping station design and O&M procedures at 15 cities or sanitation agencies in the United States having more than 2,700 pumping stations among them. More than 50 pumping stations were visited and observed.

Several types of wastewater pumps are available:

- Single-stage, dry well, horizontal and vertical configuration (commonly referred to as "conventional" wastewater pumps). See Figure 1.

- Single stage, wet well, solids handling, submersible pumps. Some submersible motors also are suitable for continuous duty in air for dry well installations. See Figure 2.

- Single- or two-stage, vertical turbine-type solids handling pumps with driver mounted above grade. See Figure 3.

In determining the type of pump to use, life-cycle economic costs are a major (although not the only) factor for the analysis. Data will be presented in the following sections on estimates for initial construction costs for pumping stations using these three types of pumps and estimates of O&M costs. The data on O&M costs was determined from interviews with users of operating facilities.

Description of Pump Types

Reference [1] provides a detailed discussion and description of these pumps. The following are brief summary descriptions.

- **Conventional dry well pumps** (also known as non-clog or solids handling) were developed to pump liquids containing soft solids and stringy material without plugging or needing frequent service and cleaning. Separately coupled, non-clog pumps are available for vertical or horizontal mounting. Vertically mounted pumps may be driven by a motor installed on the pump frame or by a line shaft to a motor installed on a floor above the pump. See Figure 4.

- **Submersible non-clog pumps** are equipped with motors designed to operate immersed in the wastewater. Since they are installed directly in the wet well, pump stations with submersible pumps do not require a dry well. The may not have any above ground construction except for a concrete slab and a small housing for the control center. The construction costs are therefore less than those of dry well stations (Figure 5).

On the other hand, submersible pumps are not readily accessible for inspection and service, give less warning of incipient problems, and may require shipment to qualified service centers for motor or seal repair.
This tends to lead to higher service and maintenance cost and longer turnaround times. Statements about low maintenance costs can be misleading when based on short-term (e.g., two years or less) experience.

In wet well installations, submersible pumps can be installed with fixed discharge piping and can be supported by a tripod or a similar device mounted on the wet well floor. This type requires draining of the wet well for any kind of inspection, service or maintenance. A more popular method for installing submersible pumps is the pull-up design in which the discharge piping is connected to a special elbow that is permanently mounted on the wet well floor. The elbow and the pump discharge nozzle are equipped with a self-locking coupling. Because the pump mounting bracket slides up and down on two rails, it can be raised from the wet well or lowered onto the elbow by a crane and a cable with no need for personnel to enter the wet well or to drain it.

Some pumps with submersible motors must be immersed for continuous operation for external-cooling purposes and can run only for intermittent periods of time if exposed to air. Other submersible pumps have motors with internal cooling systems and can run continuously at full load without immersion. Pumps with internally cooled motors also are available for dry well installation where they have the advantage of being resistant to damage if the dry well is accidentally flooded. However, this pump comes at higher capital cost (Figure 6).

- The vertical turbine-type solids handling pump combines the advantages of the classical solids handling pump with the vertical turbine pump concept. This type of pump is the latest in nonclog pump technology (Figure 7).

The pump is installed on top of the wet well and requires no dry well. The driver, either a motor or an angular gear, is mounted on top of the pump.
Submersible Solids Handling Pump in a Wet Well

U.S. Sanitation Agencies
A great amount of data on O&M costs and practical experience with the three types of pumping stations was determined as part of a study [2] that included conducting telephone interviews or personal interviews with operations and maintenance supervisors and chief engineers at 16 public sanitation agencies. In addition, six more agencies having vertical turbine-type solids handling pumps were contacted to discuss their experience with this particular type of pump. The 15 agencies had more than 2,700 raw sewage pumping stations among them. Based on these interviews, four large agencies having more than 1,000 pumping sta-

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- Raw sewage pumping stations are heavy-duty service types of facilities. They are definitely not light or medium-duty facilities. This is especially true of submerged equipment in raw sewage pumping stations. Raw sewage pumping stations require a degree of ruggedness and reliability in equipment that can be met only by manufacturers and suppliers who understand these requirements.

- The public is not usually very aware of the services provided by public sanitation agencies and also is probably not too aware of the quality of design and construction required to provide such service reliably. However, when the service sometimes fails (as it inevitably does from time to time), the public also is not interested in hearing excuses.

- All sanitation agencies in the United States are under financial pressure to do more (or at least do the same) with less money. While greater efficiency in terms of using the public’s revenues is always a goal, it should be kept in mind that actions resulting in seemingly significant short-term financial savings can actually result in increased long-term financial expenditures. This can be particularly true if cheaper, lower-quality equipment is selected instead of more expensive but more reliable equipment.

### Construction, O&M and Life Cycle Cost Estimates

Opinions of probable construction costs were developed for the various alternative pumping station designs. These opinions of probable construction did not include costs for site-specific items such as massive earthwork, unusually extensive landscaping and extensive access roads. An allowance was included to account for a “normal” amount of site grading, landscaping, fencing, paving, and drainage. The data for construction costs are taken from References [1], [2] and [3]. These construction cost estimates represent costs likely to be encountered in urbanized areas and are thought to be conservative in that they probably represent above-average costs.

It was not possible to establish absolute O&M costs for most of the alternatives. None of the sanitation agencies contacted or visited had precise data on O&M costs per pumping station or for various types of pumping stations. However, all these agencies did have some idea of the differential costs in terms of repair costs and maintenance labor efforts between conventional dry well/wet well pumping stations and submersible pumping stations. These differential O&M costs were used in developing comparable life cycle costs that could be used in the analysis.

### Mechanical Screening Systems

In theory, mechanical screens are installed to...
Remove large objects that might clog the pumps; and

Remove large items that might adversely affect the performance of processes in the wastewater treatment plant into which the sewage is pumped.

In reviewing the practices at various sanitation agencies in the United States, we were not able to find that screens are really necessary at most wastewater pumping stations. The ten sanitation agencies contacted had approximately 2,700 raw sewage pumping stations between them. Only 10 to 15 percent of these stations had mechanical screening or grinding systems of any kind. Only one agency required mechanical screens or grinders at all pumping stations. This agency reported that they consistently get large quantities of construction debris (pieces of brick and masonry, lumber, drill bits, bolts, nails, etc.) in their sewage and therefore need to have screens or grinders ahead of the pumps in order to avoid excessive high wear and tear on the pumps with the associated high maintenance costs. This does not appear to be a typical or common occurrence in municipal sewage systems in the United States, although it may be a more common problem in Latin America and Asia.

The general consensus of most maintenance supervisors at these agencies in the United States is that mechanical screens are usually not necessary at raw sewage pumping stations; and

- Mechanical screens are high maintenance and cost items and should be avoided if possible.

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It is felt that the above observations are relevant to wastewater pumping stations constructed in North American and Europe, where control methods and regulations are reasonably well developed. Wastewater pumping stations constructed in Asia and Latin America most likely should incorporate mechanical screening systems. Incorporating mechanical screening systems into conventional wet well/dry well pumping stations typically increases construction costs by about 25 percent as shown in Table 1.

**O&M Aspects of Deleting Screens**

O&M costs could be increased or decreased with this alternative because of the following reasons:

- In theory, pump maintenance costs could increase because additional large pieces of solid matter entering the pumps. In practice, this does not seem to occur in North America. As previously discussed, only one agency of the 15 investigated reported that screens were necessary to protect the pumps and reduce the O&M costs associated with them. Most agencies felt that having mechanical screens resulted in increased overall O&M costs because of the effort required to maintain the screens.

- O&M costs associated with mechanical screens would decrease by eliminating the associated labor and replacement parts costs as well as the HVAC costs associated with the screening room.

**REFERENCES**


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*ENR CCI value approximately 4,500. Costs are taken from data presented in References [1], [2] and [3].

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### Table 1: Probable Construction Costs of Conventional Pumping Station Layouts

<table>
<thead>
<tr>
<th>Pumping Station Capacity (mgd)</th>
<th>Opinions of Construction Cost for Conventional Pumping Station with Mechanical Screens</th>
<th>Opinions of Construction Cost for Conventional Pumping Stations without Mechanical Screens</th>
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<td>$4,900,000</td>
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