

## Design Energy Efficient Pumping Stations with PIPE-FLO

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*Fluid piping software can be used to design highly energy efficient and cost effective pumping systems. Roy Lightle of Engineered Software Inc. explains how PIPE-FLO® Professional software could facilitate the design of wastewater lift stations, booster stations in water distribution networks, treatment facilities, and any other piping systems.*

### ***Using Fluid Piping Software to Design Energy Efficient Pumping Stations***

The need for water and wastewater capacity is continually growing on a global scale, and with rising energy costs and a greater emphasis on being green, the users and designers of pumping systems in this industry are realizing the need for more efficient designs and practices. It is estimated that water/wastewater facilities account for 35% of municipal energy usage (1). With pumping systems being responsible for much of this power consumption, design optimization can result in significant energy savings.

In fact, a considerable number of users, suppliers, and designers in all industries, as well as government agencies and industry consortiums are developing and implementing strategies to improve the energy efficiency of industrial equipment. In most cases, the potential savings is significant. A 1998 DOE market assessment of U.S. industrial motor driven systems estimated an average savings of 11 to 18% with the implementation of energy efficient technologies and practices. Other studies, specifically of pumping systems, have indicated savings as much as 30 to 50% (2,3).

With the number of pumping stations found throughout water distribution and wastewater collection systems, there are many opportunities for improving energy efficiency. However, with the seemingly endless variety of design options, finding the optimal solution can be daunting. Fortunately, for the modern engineer, fluid piping software provides the necessary analysis to design an efficient pumping system or evaluate current installations for potential improvements.

Fluid piping software packages typically allow the user to evaluate a system under different design and operating conditions, as well as determine operating costs for various pump models and configurations. Some even allow the user to perform a complete life cycle cost analysis, taking into account capital, operating and maintenance costs in order to assess the true cost of the system. Fluid piping software is a powerful tool with which the user can evaluate pumping system designs and determine the most efficient and cost effective approach with relative ease. The following is a list of typical fluid piping software features.

- Accurately model any pumping system with as much design detail as necessary.
- Evaluate the model under various design conditions (e.g. pipe size, system configuration).
- Evaluate the model under various operating conditions (e.g. tank level, pump operation).
- Evaluate different pumping configurations (e.g. single or multiple configurations, variable speed drives).
- Select a pump from manufacturers' electronic catalogs to immediately determine how it will operate in a system.
- Compare different pumps from various manufacturers.
- Calculate and compare the operating cost of the various designs for any duration.

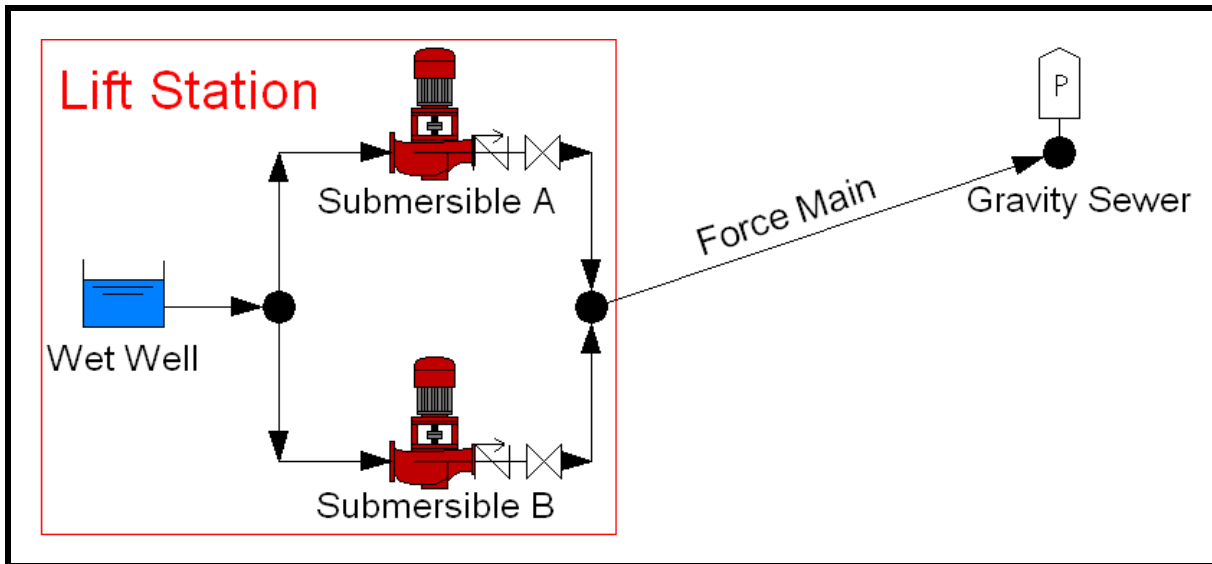


Figure 1. PIPE-FLO lift station model diagram.

Though fluid piping software has been in existence for over twenty-five years, it has only recently received considerable attention. This software allows engineers to conduct the type of rigorous design evaluations that they have not previously been able to perform. In the past, we have often relied on standard designs for new pumping system installations. For example, typical design practice for lift stations has involved specifying a duplex pumping arrangement in which each pump is sized for peak capacity. The units alternate operation to ensure even wear and the duplex configuration allows one pump to be taken offline for maintenance. This basic design has not changed much in the past 50 years, and for good reason, it works and provides redundancy to avoid major failures (4). Clearly, the inherent design is sound, but with the proper software solution, we can look at ways of improving the system, which will lead to greater energy efficiency and lower maintenance and operating costs.

Let's consider a case where we have an existing lift station and would like to look at ways to optimize the design for improved energy efficiency. The current system includes a wet well lift station with two 40 hp submersibles pumping into a 5000 ft, 8-inch force main. There is an elevation gain of about 55 ft from the discharge of the submersibles to the inlet of the gravity sewer. Figure 1 shows a schematic of the lift station model created with Engineered Software's PIPE-FLO Professional. The daily capacity of the system is approximately 320,000 gallons and the pumps are sized for a peak design flow rate of 800 gpm at 101 ft of head. Currently, the average pump operation is about 6.7 hours per day. Assuming a power cost of \$.10 per kWh, the annual energy usage and cost to operate the lift station is 56,931 kWh and \$5,693, respectively.

By modeling the lift station in PIPE-FLO with all necessary design information and operating conditions, we can quickly identify where the inefficiencies lie. At the peak design, flow rate of 800 gpm there is an excessive head loss of 57 ft through the force main, which can essentially be thought of as wasted energy that has been put into the pump. From Figure 2 we can see that the head loss in the force main can be drastically reduced by lowering the flow rate, a result of the characteristic second order relationship between head loss and flow rate in a pipe. Considering the pump only needs to be capable of delivering the peak flow rate a few times throughout the day, by operating the lift station at a reduced flow rate we can significantly lessen energy usage and operating cost. To accomplish this, some lift station designers are employing the use of a jockey pump, which is typically less than 10 hp and is included in addition to the traditional duplex pump configuration. The main duty pumps are run

only a few times a day during peak hours while the jockey runs most of the day to pump the off peak inflow to the lift station (4).

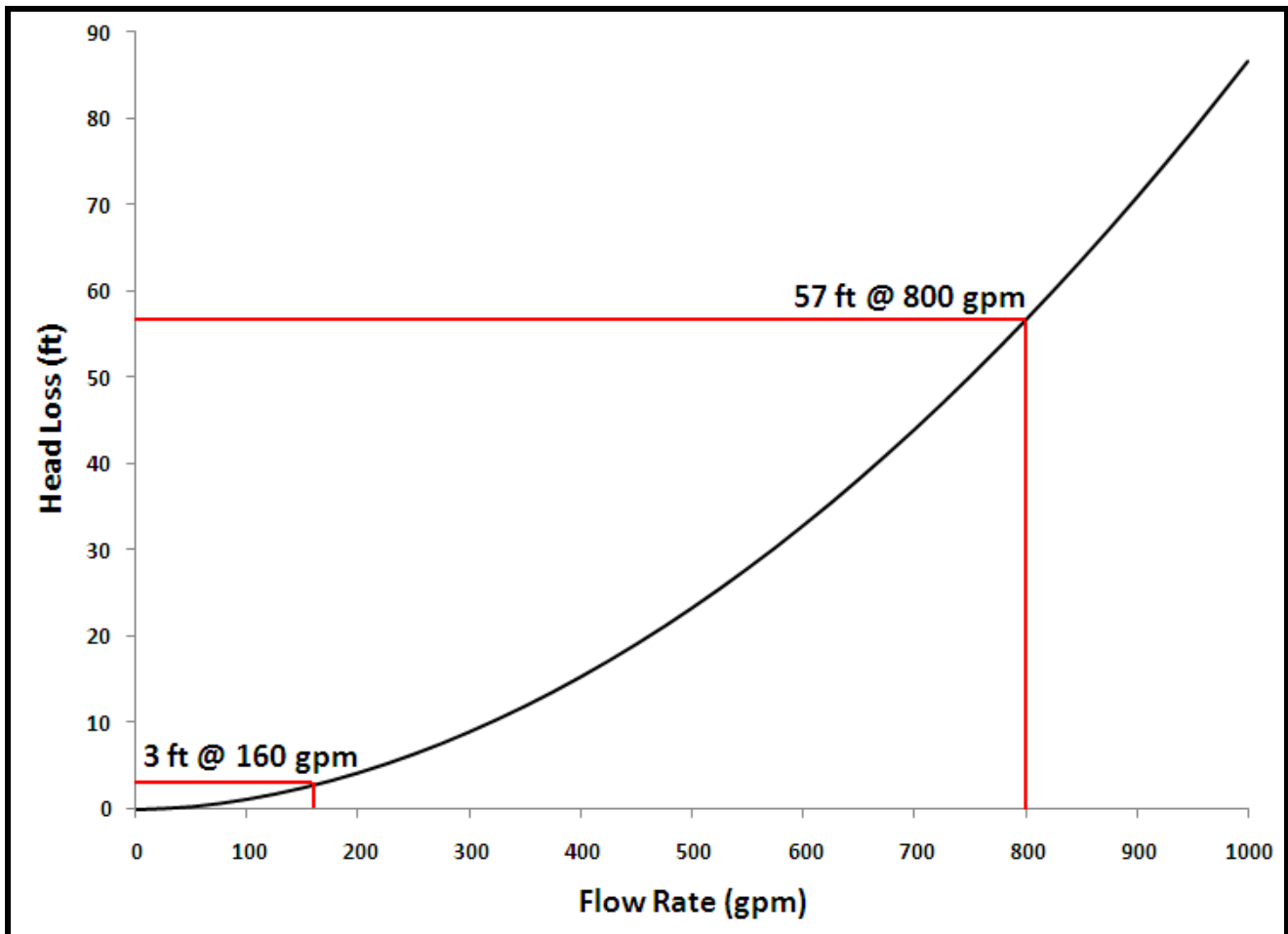


Figure 2. Force main resistance curve indicating duty and jockey pump operating points.

Using PIPE-FLO it was determined that a flow rate of about 160 gpm for the jockey pump would be sufficient for off peak operation and would reduce the head loss in the force main from 57 ft to 3 ft, as shown in Figure 2. The jockey pump will run for about 18.3 hours per day at the design flow rate and the duty pump will run about three hours per day. A 3 hp jockey pump was selected from within PIPE-FLO by digitally searching a manufacturer's catalog for pumps that satisfied the design specifications of the lift station model.

Looking at the system resistance curve plotted against the pump curve in Figure 3, we can see that the pump will be operating just to the left of its BEP. Certainly, a pump with higher overall efficiency that intersected the system resistance curve closer to the pump's BEP could have been found, but for the example, only a single manufacturer's catalog was utilized. Regardless, the chosen pump is operating at an efficiency of 72.3 % and the flow rate falls within 88 % of the BEP flow, which should help to ensure prolonged life.

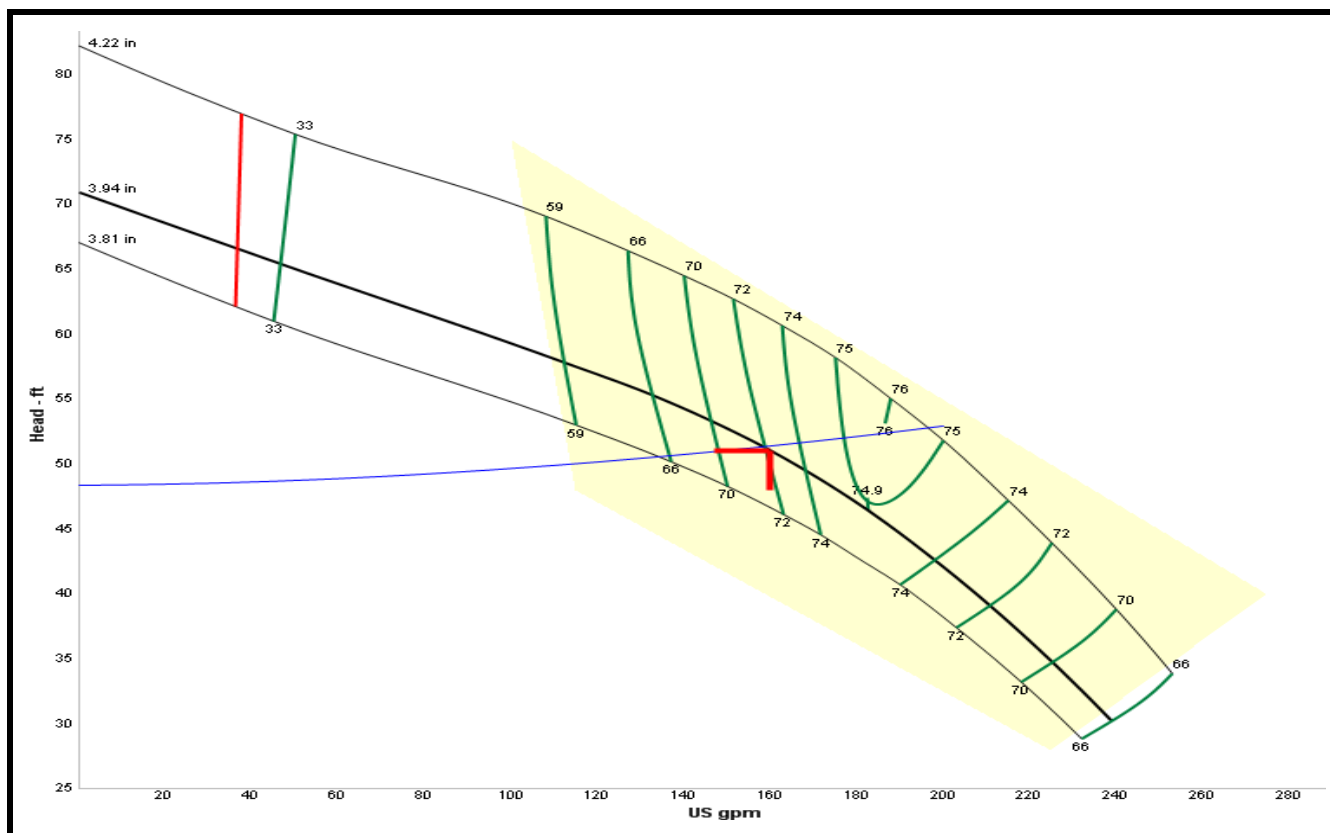


Figure 3. Jockey pump curve plotted against system resistance curve (red arrow indicates intersection).

After assessing the performance characteristics of the jockey pump, its operation in the lift station model was evaluated. The only concern encountered with using the jockey pump was a potential accumulation of solids in the force main, due to the lower flow rate. The velocity through the force main at 160 gpm is about 1 ft/sec, less than the minimum recommended 2 ft/sec for solids removal. However, the operation of the duty pump during peak hours should be sufficient to prevent clogging.

An operating cost analysis was performed in PIPE-FLO showing that the new design would consume 43,621 kWh per year with an annual cost of \$4,362. It is clear from the analysis that the use of a jockey pump will significantly reduce the energy usage of the lift station. Table 1 shows a comparison of the two designs, which indicates an annual cost savings of \$1,331 and energy savings of 13,310 kWh.

Despite the long daily runtime of the jockey pump, its low power consumption results in an overall more efficient system. The 3 hp jockey pump should not require a significant investment and the payback period would likely justify the expense. Additionally, the reduced daily run time of the duty pumps will help to increase their lifetime and reduce their maintenance costs. Since the duty pumps represent much greater capital and maintenance costs compared to the jockey pump, this design benefits from not only operating cost savings, but also should yield a significantly reduced life cycle cost for the lift station.

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<b>Design</b>	<b>Annual Power Usage (kWh)</b>	<b>Power Savings</b>	<b>Annual Operating Cost</b>	<b>Operating Cost Savings</b>
Duplex	59,631	-	\$5,931	-
Duplex w/ Jockey	43,621	13,310	\$4,362	\$1,310

*Table 1. Comparison of the power usage and operating cost for the two designs (assuming \$.10 per kWh).*

The example illustrates how fluid piping software can be used to quickly evaluate the efficiency of any pumping system. In less than an hour, I was able to model the lift station, determine the energy usage, evaluate and select a pump for the new design, and compare the energy usage and operating cost of both designs. However, where the benefit of software really becomes evident is when we compound our analysis by evaluating all design options and elements. If we were designing a new pump station we might have considered a triplex pump arrangement or the use of variable frequency drives to achieve operation at lower flow rates during off peak hours. Combine the different designs with the myriad of pump models available from a variety of manufacturers and the thought of performing the necessary calculations by hand or spreadsheet methods seems, if not impossible, considerably time consuming and error prone.

Fluid piping software enables us to easily model the different designs, quickly select the appropriate pumps from digital catalogs, and compare the energy use and operating costs of all the design scenarios. Along with the overall ease of use, the software also provides graphs, reports, and other presentation materials to aid the project. Whether designing wastewater lift stations, booster stations in water distribution networks, treatment facilities, or any other piping systems, the accuracy and flexibility of fluid piping software will certainly facilitate the design of a highly energy efficient and cost effective system.

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