Total pumping head

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Total differential pumping head is composed of three parts: the static head (water surface differential between the wet well and the receiving chamber), the friction losses associated with the piping, and the minor (localized) losses due to valves, fittings, and other nonuniformities in the flow.

The figure below illustrates each of these components of differential head. Any of these segments can be a dominant or negligible component of total pumping head. Their importance depends on the system layout and geometry.

Similarly, any of these segments can represent a dominant component or a negligible component of total energy use, since energy use and power input are directly proportional to pumping head.

Static head

The static head usually is one of the best-defined aspects of a pumping operation, because elevations can be measured and known quite accurately.

In some cases, adjustment may be possible in the normal operating levels within a wet well or receiving chamber. For example, if the normal operating level in a wet well is increased by 0.3 m (1 ft), energy use drops by a factor of 3.14 kWH / $e_p e_m e_{vfd}$ for each million gallons pumped. (See "Performance under pressure" in the July 2012 issue of *Water Environment & Technology* for a complete discussion of pumping energy and power requirements.)

Of course, such an energy-saving adjustment should only be implemented if it will not adversely affect the primary mission of the facility. In this example, this would mean verifying that the higher wet-well elevation would not risk a backup of upstream buildings or facilities.

For existing wastewater pumping facilities, the possible energy savings through static head adjustments usually are relatively small.

Friction losses

The friction loss within a wastewater force main or discharge-piping system can significantly affect energy usage. The friction loss in a force main will vary approximately with V^2 (Darcy–Weisbach, or Manning) or $V^{1.85}$ (Hazen–Williams), depending on the empirical formula used for estimating. In either case, friction loss is quite sensitive to velocity and flow rate.

For long force mains, the friction loss can be the dominant component of the total pumping head. For very short or low-velocity force mains, the friction loss may be quite small, even insignificant, compared to the other components of pumping head.

Particularly for longer distances, selecting a pipe diameter requires balancing two opposing constraints. On one hand, to accommodate peak flows, a force main should have a relatively large diameter. This keeps friction losses, pumping heads, motor sizes, and energy costs from becoming excessively large. On the other hand, normal daily flows, which the facility will experience most of the time, would benefit from a smaller diameter to more easily keep velocities greater than 0.61 to 0.91 m/s (2 to 3 ft/s). This velocity helps keep solids in suspension.

Sometimes, several sizes may be realistic candidates for a force main. To make the final decision, the different energy costs associated with the different pipe sizes, along with the different capital costs, should be reflected in the economic analysis comparing the alternatives.

Minor losses

Minor losses often are concentrated within the lift station or pumping facility, rather than the force main. Most valves and fittings – including check valves, isolation valves, reducers, increasers, tees, wyes, and bends – are situated near the pumps and header piping.

Also, valves and fittings (like the pumps themselves) tend to be of smaller diameters than the main discharge pipe or force main. Since head loss is proportional to the square of the flow velocity, the smaller valves inside a station create significantly higher losses than the larger valves in the force main.

Because of their high loss coefficients, check valves, in particular, often contribute the largest amount of minor losses. Designers should take care to avoid check valves that are unnecessarily small for the flow rate.

Even larger energy losses can occur if isolation valves are throttled to a part-closed position to reduce flow. This situation imposes an artificially high system head curve. It almost always increases energy use proportionally unless this condition is offset by a large improvement in efficiency at the pump's new operating point.

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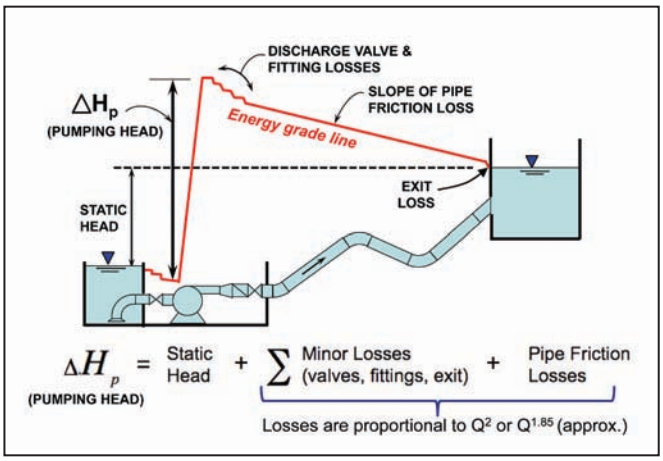
The components of total pumping head