DESIGN TIPS FOR FLOOD CONTROL PUMPING STATIONS

By Mick Eriksen

Reducing the overall long-term costs of flood control pumping stations

The pointers given below are used by Grundfos staff when analyzing the requirements of new pumping stations. Although useful, they are generalized recommendations only and cannot replace individual, job-specific advice. This article will review the general considerations required when designing a flood control pumping station, followed by more specific design examples.

Considerations When Designing Pump Stations

Carefully going through all of these steps will create an effective foundation for success and will help keep overall costs to a minimum:

- Review the head and flow calculations, paying close attention to how they are calculated. Check the expected minimum, average and peak flows. One also should determine whether the head requirement varies; this will have a profound influence on the duty point of the pump.
- Check the site physically to confirm flow and head if possible—particularly if it is a replacement job. Things may well have changed significantly since the station first was designed.
- Determine the number of pumps needed from the specified flow and head requirements.
- Determine the pump type to be used.

Choosing a Pump

Generally speaking, propeller pumps are recommended for low-head applications, and mixed-flow pumps are ideal for medium-head applications. Installing submersible pumps in columns can have substantial advantages over other pump types—for example, when long-shaft turbine pumps are used in flood control applications.

These advantages include:

- Reduced civil costs;
- No shaft alignment problems;
- Reduced installation time and cost;
- Less floor space occupied;
- Silent operation;
- Flood-proof;
- Fewer auxiliary elements required;
- Increased reliability;
- Reduced superstructure required;
- Reduced maintenance, including reduced maintenance costs;
- Greater flexibility; and
- High efficiency.

The best choice of installation often is the one that offers scope for lower construction costs. The flexibility of column-type installation allows for everything from free outflow (above or below water level) to pressurized solutions. Column-type installations also can be inclined.

The sump design has a crucial impact on the pump's total lifespan. A less-than-optimal sump design potentially could result in poor performance and/or mechanical strain due to vibrations and cavitation at the inlet to the pump(s). A poor design can lead to sedimentation of sand and rags, which in turn can cause additional cavitation and vibration problems.

The main design requirement for a sump design is to provide optimal inlet conditions for the pumps. The flow being delivered to the pump units should be uniform, steady and free of swirls or entrained air.

Column-installed pumps are high volume, making them sensitive to suction chamber conditions; great care must be taken to ensure safe and long-lasting operation. The dividing walls—and the positioning of the pumps—must be conducted in a manner that avoids surface vortices, air ingestion and entrainment, and turbulence.

The following factors should be considered:

- The velocity and distribution of the fluid in the inlet channel should be of a uniform flow. The angle of the bottom should have an inclination of 10 to 15 degrees.
- The velocity of the water in the inlet channel should be less than 1.2 meters per second (m/s).
- The overall velocity of the water in the pumping station should be between 0.3 and 0.5 m/s.
- The effects of flow disturbances should be dissipated as far as possible from the pump intake.
- Stagnation regions should be avoided. If the design creates such stagnation regions, they should be filled with concrete before operation commences.
- Care should be taken to avoid suction vortices in connection with pump immersion. As a rule of thumb, the immersion of the pump should be between one to two times the pump diameter, depending on flow rate. Specific recommendations must be obtained from the manufacturer in each case.
- The free distance between the pump and the sump bottom also must be observed. The distance should never be less than half the pump diameter in order to avoid cavitation.
- The pump and column installation should be placed symmetrically in the pump sump while ensuring that there is sufficient distance from the outer diameter of the pump to all walls of the sump. The distance should be at least half the pump diameter.
- With more pumps in parallel, it is recommended to have separation walls between the pumps so that they are not influencing each other and the water is channelled uniformly to each pump.
- The complete design should be subjected to careful analysis—this includes taking a careful look at screens and the possible need for a sludge pump.

Beating cavitation. Cavitation—and the noise and vibrations associated with this process—can be prevented by fitting an anti-cavitation cone below the pump. When installed just beneath the suction bowl, the cone prevents cavitation and can also prevent vortices and fluid separation.

Fasten all chains and cables. Having chosen a tube installation, always make sure that chains and cables are securely fastened as they are placed in the flow of the pump. They must never be allowed to move with the flow. Loose chains or cables will be subject to wear and damage resulting in premature failure.

Screen design. When considering screen design, the dead zone should be kept as small as possible to minimize scraper travel. Screens should be divided into several vertical panels and supported by vertical piers; they should never be supported horizontally. Observing this rule maximizes the flow channel, thereby eliminating potential head increases and making it easy to clean and maintain the screens.

Handling sludge. During dry seasons, water levels recede. When this happens, the sludge in the remaining water settles in the sump. The situation can escalate by a slow inflow when additional sludge enters the sump and water evaporates. The end result may be that the impeller is buried in silt when the pump needs to start.

To keep the sump clean at all times, it is recommended to install a small sludge pump in a separate small pump sump within the main sump. This sludge pump is used to empty the main sump in periods with less or no inflow to the main sump.

Using Different Pump Sizes

The pumps used in flood control applications often are called upon to operate under normal weather conditions—not just in extreme flood situations. At the same time, the pumping station must be able to cope with much higher peak flows in flood situations. Finding the balance can be difficult because the final pumping station design may end up being quite unsuited for the two different scenarios. To overcome this challenge, the sump can be divided into two chambers—one for normal operation and another for peak flow situations. The two chambers of the sump must be divided by a low wall that allows the water to flow over it into the second sump in flood situations. The pumps used for normal operation should be relatively small, operating in cascade or by means of frequency converter, whereas the peak flow pumps should be quite big, enabling them to cope with the extreme situation.

Flood control pumps are big investments, and service and repair are relatively costly. Even when the system is designed well and the pumps used are of high quality, wear is inevitable—as is the risk of failure. Monitoring the condition of pumps helps lower the total life-cycle cost of the flood control application. Proper monitoring and control will:

- Protect expensive equipment;
- Help ensure optimum station operation;
- Reduce energy consumption;
- Help avoid overflow—and report any incidents;
- Optimize service personnel schedules for preventive maintenance; and
- Meet demand for more accurate reporting (e.g., to comply with stricter environmental regulations).

Sensors Help Alleviate Main Risks

When pumps are submerged, there is a greater risk of water entering the motor through the cable gland and shaft seal. For that reason, most manufacturers incorporate an oil chamber with double sealing and also fit a range of sensors to protect the pumps—often far more than in smaller pumps. Typical sensors in large pumps include:

- Bearing temperature sensors (lower and/or upper);
- Motor temperature sensors;
- Water-in-oil sensors monitoring the conditions of the shaft seal;
- Thermal box moisture sensors;
- Vibration sensor; and
- Winding isolation resistance.

In addition to the above pump sensor, most applications also have a sensor to keep an eye on power consumption, voltage, operating hours, etc. Typically, keeping an eye on changes in values is more important than responding to absolute value. During the commissioning stage, it often will be beneficial to experiment with different reference values to ascertain when action may be required.

A lot of know-how and experience is available from the pump supplier, which can provide value to the design of future pumping stations for flood control. WWD

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PUMP & MIXER TEAMWORK PAYS OFF

By Soren Rasmussen

Covering 58 sq miles, Stafford is the third-largest town in land area in Connecticut. A Water Pollution Control Facility (WPCF) in Stafford is benefiting from reduced downtime because of pumps, mixers and backup service.

Serving more than 11,000 residents, the facility underwent an upgrade in January 2011, when six 1.8-hp Landia mixers were installed in the anoxic tanks as part of a new activated sludge process. Three 2.4-hp Axial flow pumps, designed and manufactured by Landia, also were introduced to the aeration basins, from where they return nitrified mixed liquor to the anoxic tanks for denitrification.

In an effort to improve its maintenance program and equipment service life, plant personnel at Stafford contacted the company for assistance.

"We looked at best practice servicing methods, including mechanical seals, electrical testing, oil changes and replacement of oil sealing rings to enhance the performance and longevity of the pumps and mixers at the facility," said Kenneth E. Jacobs, Jr., the Landia service manager who visited the WPCF.

The facility staff was pleased with the service.

"When we made Landia aware of our need to reduce maintenance costs, they responded in a very timely manner," said Rick Hartenstein, WPCF chief operator. "[They] sent one of its engineers to show our maintenance staff how to best look after the pumps and mixers for our benefit, which in turn means we provide a better service to the people of Stafford. Since then, we've become more efficient, had no downtime, saved money and had no hassle."

Treated wastewater from Stafford WPCF is discharged into the Willimantic River. The collection system, which has more than 2,000 hookups, encompasses approximately 22 miles of the town and utilizes four pumping stations.

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