Engineering & Expertise
Operational optimization

PUMP CONTROL

FLYGT
a xylem brand

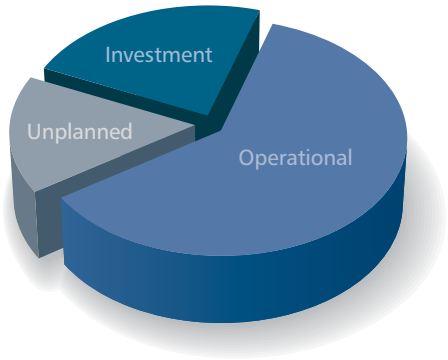
Total solution engineering increases operational efficiency

Introduction

Determining the right control philosophy for pump operation is a critical factor to ensure the lowest life cycle cost of the entire pump system. Proper management reduces the risk of physical impediments, such as sedimentation, clogging and floating debris, as well as cuts energy costs and increases equipment service life.

Engineering expertise is required in order to realize energy, operation and maintenance cost-savings through proper pump control. We will provide guidance for the design of pump control systems based on pump control theory as well as years of experience from a number of applications. Various control philosophies are discussed in order to achieve an efficient pump control.

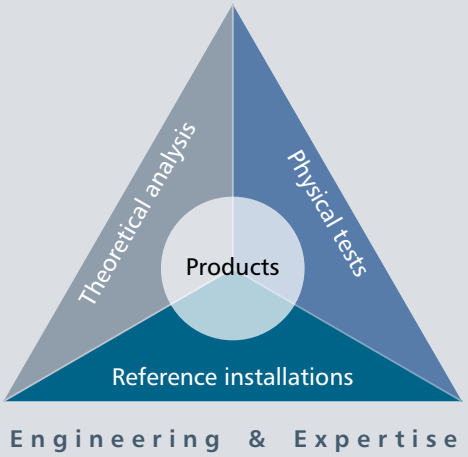
Achieving lowest total cost of ownership
When providing pumping solutions, Flygt prefers to take the total cost of ownership into consideration.



■ *Investment costs*
Costs associated with design, excavation, civil work, product purchases, installation and commissioning.

■ *Operational costs*
Over time, energy usage and maintenance costs are often the major contributors to the overall costs along with the cost of labor required to run the system.

■ *Unplanned costs*
When things go wrong, such as pump failures stemming from problematic station design, costs can skyrocket. Unexpected downtime can cause sewer backups, overflows, basement flooding and untreated effluent. On top of that, you have to repair pumps and take corrective measures regarding the station design.



Engineering & Expertise
Thanks to our engineering expertise, we can lower your total cost of ownership. We can analyze your system using state-of-the-art computational programs. We can test your pump station using scale models if required. We can also provide you with reference installations that are similar to your project. All of this together with our premium products provides you with an optimized design.

Understanding the importance of pump control

Poorly designed pump control systems can have adverse effects on the entire pump system. This can lead to the increased risk of sediment buildup in pipes and sumps as well as clogging of the pumps. Incorrect operating levels in the sump and velocities in the pipes that are too high can significantly increase energy consumption and costs. Equipment lifetime may also be reduced due to transient effects that result from high pressure at pump stops as well as reduced pump motor lifetime due to starting and stopping.

Flygt pump control
To optimize pump system operation, we take a comprehensive approach to supplying complete water and wastewater systems, including a broad range of pump monitoring and control systems for various pumping applications. These pump control solutions are designed to deliver substantial energy savings, by offering increased protection against pump failure due to clogging and sedimentation, lower maintenance costs and increased operational efficiencies.

With our pump control philosophies, we offer different levels of control and corresponding functions through the Flygt pump control portfolio of products. These levels range from local equipment control to full control throughout the system and ultimately to multi-site control of the entire plant. The broad range of Flygt pump controls available within the portfolio enables us to tailor a pump control solution to meet the specific requirements of various applications.

Application-specific products
Good pump station design takes into account all the individual system components – including pumps, sump, pipe installation and operating controls – as well as the interaction among these. This ensures that all components work in unison to deliver highly efficient operation at the lowest possible total cost of ownership. As a single reliable supplier, Flygt offers application-specific products – from level switches to advanced SCADA control systems – to ensure the most suitable type of pump control for every application.

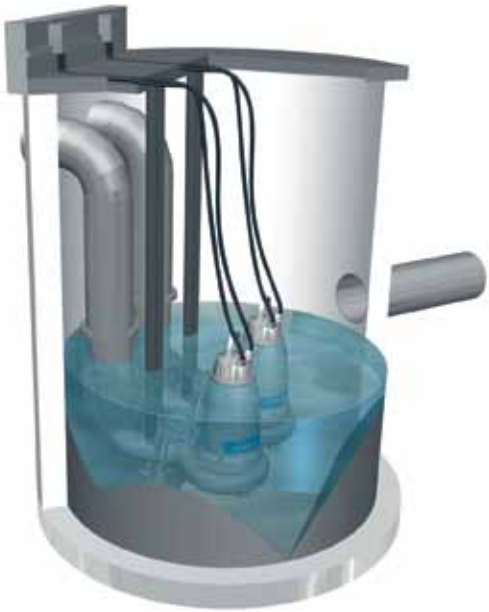
Pump control affects the entire system

Pump control affects the operational efficiency of the entire pump system – from the inlet, through the sump and to the pump and the force main or rising main. It is therefore important to understand the interaction of all components with the pumped fluid. Risk factors such as transients, clogging, floating debris and sedimentation buildup must be taken in account. Our pump control philosophies solve the challenges related to each part of the system by offering different levels of control and corresponding functions selected from within the Flygt portfolio of pump control products.

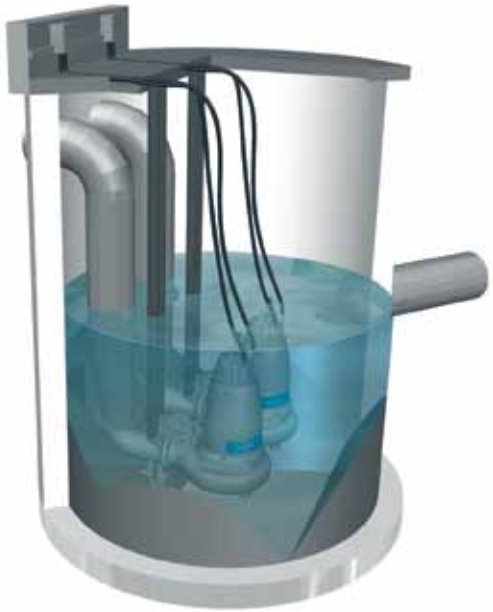
Inlet

Challenges
When deciding upon control strategy the inlet pipe's vertical position must be taken into consideration. If the inlet pipe is submerged during periods of operation the fluid velocity will decrease and there will be an increased risk for sedimentation. On the other hand, when fluid levels in the sump are too low, the static head will increase, thereby increasing energy costs.

Solutions
To ensure the selection of the right start level, it is important to understand the approach conditions of the system prior to the station. The right start level will prevent flooding in other parts of the system, and reduce the energy consumption related to the static head and number of operating hours. Our expertise and experience ensure that the right controller is selected to deliver reliable, energy-efficient pump operation.



Non-submerged inlet.



Submerged inlet.

Pump

Challenges
Proper submergence of the pump inlet must be fulfilled to prevent the risk of fully developed surface vortices. Cavitation problems due to insufficient available net positive suction head (NPSH) also have to be avoided when choosing the stop level. These phenomena can lead to vibrations and wear on the pumps, shortening their lifetime. Stopping all pumps at the same time should be avoided in large systems with long force main pipes since this instigates unnecessary pressure transients.

Solutions
For standard sump configurations, the recommended minimum submergence requirements can be found in "Design recommendation for pump stations" for all Flygt pumps. It is also important to ensure that the NPSH requirement is met.

In a multiple pump station, the pumps can be stopped at sequential stop levels or with a time delay between stops depending on the station conditions. It is especially important with time delays between the stops in large systems, in order to prevent high immediate flow changes from developing into pressure transients in the force main pipes. The Flygt controllers have different built-in functions and can be adapted to different types of systems, including multiple pump installations.

Pumps with variable frequency drives

Challenges
Pumps with variable frequency drives have an increased risk of clogging in the pump due to the decreased impeller speed during pump operation. The decreasing impeller speed at ramp down also drastically reduces the self-cleaning effect that occurs naturally when backflushing, a phenomena that occurs when the pump comes to a hard stop.

Solutions
To prevent clogging in pumps with variable frequency drives, an impeller cleaning cycle is recommended. Integrated logic enables monitoring of the pump for signs of clogging. Upon detection of clogging, the pump automatically stops and begins to operate in reverse rotation to remove the blockage. Pump cleaning cycles are integrated into Flygt pump drives.

(Note: Pump cleaning cycles are not applicable on Flygt propeller pumps, which are not designed for reverse rotation).

A clogged pump.

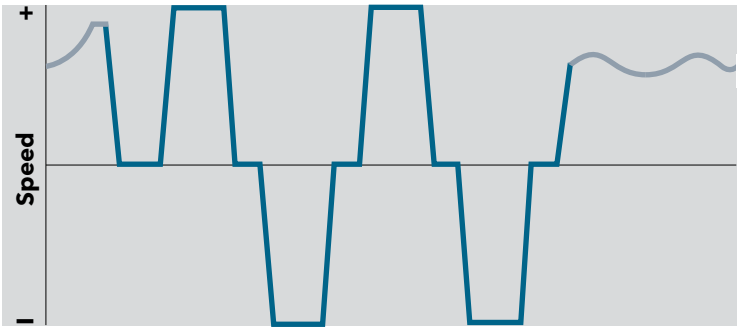


Illustration of the cleaning cycle.

Sump

Challenges
To keep the sump clean it is crucial that everything entering the sump is pumped away. Low flow regions create stagnation zones in the sump where bottom sediments and floating debris build up.

Solutions
Alternation
Automatic duty pump alternation is one method to prevent stagnant zones in the sump. Alternation of pumps implies equal running hours for all pumps and reduces the number of start and stops per hour. Alternation is also a good way to frequently exercise all pumps installed. The alternation function is built into Flygt pump controllers.

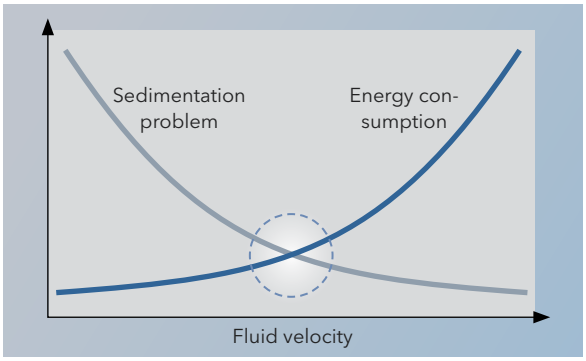
Sump cleaning cycles
Sump cleaning cycles are used to prevent odor and the buildup of floating debris in the sump. It is important to clean the sump on a regular basis. Frequent cleaning cycles are recommended, where the sump water level is pumped down below the normal stop level until the pumps are snoring. All floating debris will then be removed from the sump by the pumps. Cleaning cycle functions are built into Flygt pump controllers.

Active sump volume
The active sump volume is the volume between the start and the stop level. When analyzing the active sump volume, it is important to ensure that the volume is sufficiently large enough to prevent the pumps from starting too often. However, each time the pumps are stopped they are backflushed, cleaning the pump which is desirable. The active sump volume should therefore be large enough to ensure that the pumps do not start too often, but small enough to ensure that the pumps are cleaned frequently.

Force main

The fluid velocity in the force main affects both the degree of sedimentation and the energy consumption, where the two are contradictive. At high velocities the energy consumption increases but the risk of sedimentation problems are low. In contrast, when the velocity is low the energy consumption will be low but the risk of sedimentation is increased. Both the risk of sedimentation and energy consumption should be considered when deciding on control philosophies.

Example of rugs and soft solids developing a surface mat.



When determining the optimal fluid velocity, it is important to consider both sedimentation problems and energy consumption.

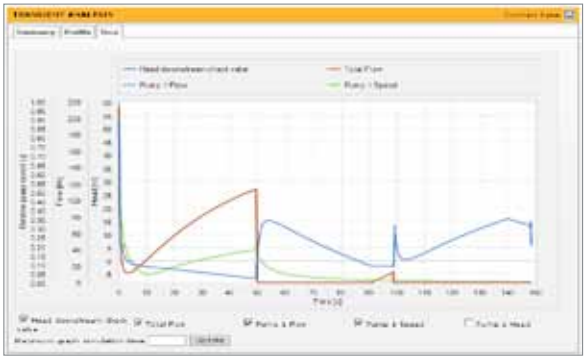
Complete system

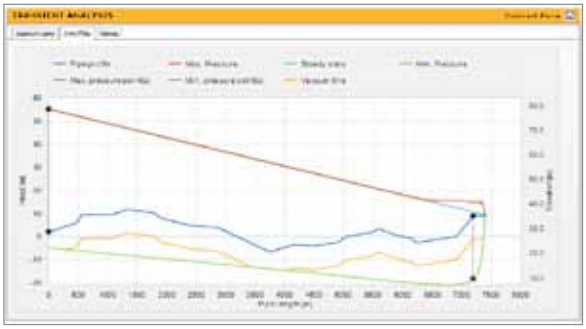
Challenges
In addition to the steady state pump duty analysis, it is important to analyze the pump system with start calculations and water hammer analysis. This will ensure a sufficient starting torque, properly dimensioned backup power supply, reliable pump duty and protection against water hammer.

Solutions
Start calculations
Start calculations are recommended for large pumps, and especially for propeller pumps due to their torque characteristics. Start calculations will indicate if there is sufficient torque margin between the motor torque and the system load torque. The calculations will also show if the motor is overloaded during start. We design and manufacture our own motors and have complete knowledge of their motor characteristics, which implies very accurate start calculations.

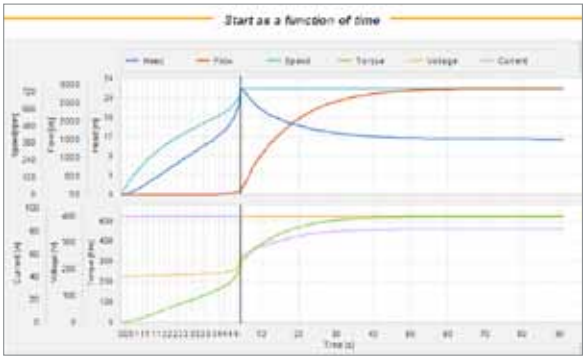
Duty analysis
To ensure sufficient NPSH, adequate rated motor power and high pump efficiency, it is necessary to conduct duty analysis. A duty analysis presents scenarios where different pumps are running over the system's range of static heads, with various levels of regulation and at varying speeds. This is important in order to save energy and increase reliability. We have developed our own tools to suit our pumps and applications for basic and advanced duty analysis.

Water hammer analysis
To determine whether a system is susceptible to the effects of water hammer, it is necessary to conduct a water hammer analysis and, if required, to evaluate the different methods of protection and select and install the right methods. We can perform accurate water hammer calculations, thanks to our extensive testing of Flygt pumps and vast experience with state-of-the-art mathematical modeling.





Water hammer analysis graphs from the Flygt Engineering Tool.



Start calculation graphs from the Flygt Engineering Tool.

Optimizing pump control systems

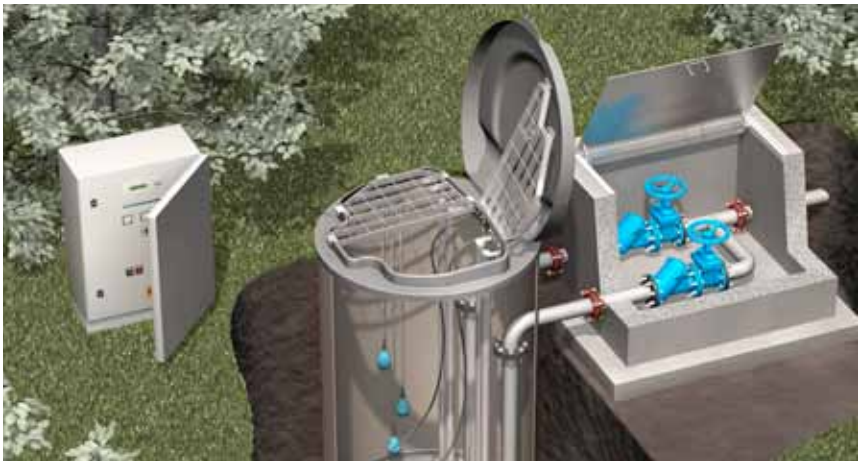
To provide the optimal solution for pump control systems, it is necessary to take a total systems engineering approach. We have the advanced engineering software to assist with the conceptual design of the control system, the practical know-how and facilities for physical testing of the control system as well as the engineering experience and comprehensive portfolio of Flygt pump control products.

Theoretical analysis
We develop our own engineering software, which enables simulation of the pump system before it is installed and commissioned. Simulation of the start and stop of the system is critical from many perspectives, such as pressure transients and sufficient motor torque. With our knowledge and our tools, we can help design reliable, energy-efficient systems. For large custom designs or troubleshooting we perform a computational fluid dynamics simulation study when necessary to gain the complete picture of the flow patterns inside the sump.

Physical testing
We have vast experience gained from testing different control philosophies in a controlled environment through small-scale model tests. When designing large custom stations, it may be necessary to conduct specific small-scale model tests to analyze the control philosophy and ensure that no adverse hydraulic issues arise.

Premium products
We offer comprehensive solutions for pump control based on our broad portfolio of Flygt pump control hardware and software. Depending on the application, our offerings range from standard setups to programmable custom solutions and systems for use in hazardous environments. These include, but are not limited to, the following functions and alarms:

- Alarm logs
- Start and running time counters
- High and low level alarms
- Power failure
- Personal alarms
- Pump capacity calculation
- Random start levels
- Dry run protection
- Constant level control
- Communication with SCADA, radio, ethernet cellular systems and telephone lines



Proven worldwide

Flygt has applied our pump control philosophies together with our premium products on thousands of installations around the world. Engineering expertise and years of experience have resulted in the success of these installations. Two such cases are described below.

Sweden: Pump station

Challenge
Eighteen Flygt pump stations transport wastewater at a popular recreational and amusement area in central Stockholm. One of the pump stations handles restaurant wastewater containing fats, oils and grease. The liquefied oil and grease in high-temperature dishwashing water solidifies after transportation to the pump station. This caused severe odor problems and grease build-up on the pump station walls, sump water surface, Flygt CP3102 pumps, guide bars, level sensor and other pump station equipment, increasing the risk of failure in the station. Expensive maintenance procedures had to be carried out every two to three months in order to remove accumulated sludge and clear the station of greasy buildup.

Solution
Our engineers recommended the installation of a Flygt APF cleaning function through an electronic device for automatic pump sump cleaning. The controller automatically initiates pump operation in order to drain sump water to the lowest possible level, thereby removing grease and dirt laying on the surface of the water. This enables the pump station to operate for a significantly longer time without requiring any sludge removal.

United Kingdom: More energy-efficient pump station

Challenge
Four high-efficiency 100 kW Flygt N-pumps operating with variable frequency drives (VFDs) deliver a total volume of 0.8 m^3/s (12,700 US gpm) and consume 1,000,000 kWh of energy per year. The customer wanted to reduce energy costs but maintain reliable, trouble-free operation without the problems of clogging, sedimentation and floating debris.

Solution
We performed an energy audit by measuring flow, head, power and analyzing the control philosophy. By analyzing the results from the measurements, we identified that adjustment of the settings on the VFDs would lead to more energy-efficient operations. Estimated energy savings amounted to between five and 15 percent.

Engineering & Expertise

To ensure reliable and highly efficient operation, we offer comprehensive support and service for pump station design, system analysis, installation, commissioning, operation and maintenance.

Design tools

When you design pump stations, we can offer advanced engineering tools to generate sump designs. Our design recommendations give you essential information regarding dimensions and layout. In short, we assist you every step of the way to make sure you optimize performance and achieve energy-efficient operations.

Theoretical analysis

Computational fluid dynamics (CFD) can provide far more detailed information about the flow field in a fraction of the time required to get the same information through physical hydraulic scale model testing. Using CFD in combination with computer-aided design (CAD) tools, it is possible to obtain a more efficient method of numerical simulation for pump station design.

To obtain a reliable, energy-efficient pumping system, it is important to analyze all modes of operation. To analyze the transient effects at pump start and stop with respect to flow and head as well as the electrical parameters such as current and torque, it is also important to have an accurate mathematical description of the pump and motor, which is gained, in part, from extensive testing in our laboratories.

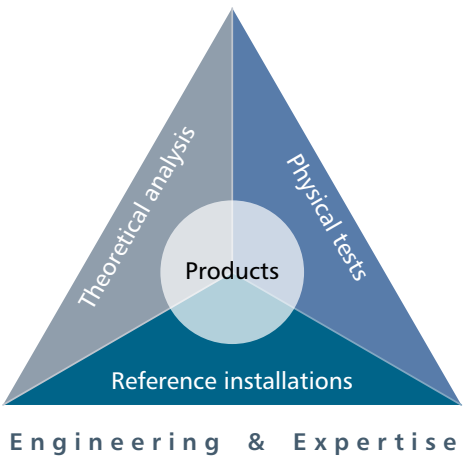
Physical testing

Physical hydraulic scale model testing can provide reliable, cost-effective solutions to complex hydraulic problems. This is particularly true for pump stations in which the geometry departs from recommended standards or where no prior experience with the application exists. Scale model testing can also be employed to identify solutions for existing installations and has proven to be a far less expensive way to determine the viability of possible solutions than through trial and error at full scale.

When our standard design recommendations are not met, we can assist in determining the need for physical testing as well as planning and arranging the testing and evaluating the results.

Reference installations

We have conducted system analysis and designed pump stations for thousands of installations around the world. Engineering expertise and years of experience gained from the design and operation of these installations have been a critical success factor when analyzing, testing and commissioning new pump installations.



Engineering & Expertise

Model test photos courtesy of Hydrotec Consultants Ltd.

Xylem [ˈzīləm]

1) The tissue in plants that brings water upward from the roots
2) A leading global water technology company

We're 12,000 people unified in a common purpose: creating innovative solutions to meet our world's water needs. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. We move, treat, analyze, and return water to the environment, and we help people use water efficiently, in their homes, buildings, factories and farms. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise, backed by a legacy of innovation.

For more information on how Xylem can help you, go to xyleminc.com.

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Let's Solve Water

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