



FLYGT

Engineering & Expertise

Designing pump sumps

Large submersible centrifugal pumps



Total solution engineering increases operational efficiency

Introduction

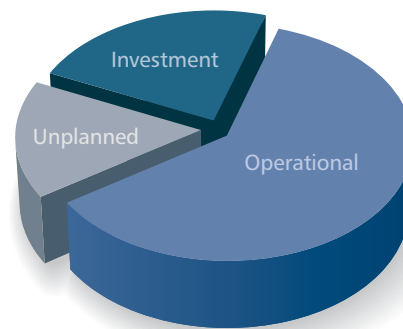
The proper design of the pump sump is critical in order to optimize pump inflow and, thereby, pump station efficiency. The number, type and arrangement of pumps, variable flow conditions in the approach area, the geometry of the structure itself and other site-specific factors must be evaluated on a case-by-case basis to identify their influence on the pump sump design.

Determining the best pump sump for a site therefore requires engineering and expertise. We will provide general guidance for the design of pump sumps using large centrifugal pumps. Methods and procedures are given for handling various inflow conditions, avoiding solids buildup and arranging multiple pumping units in order to achieve an efficient, well-designed pump sump.

For more detailed information and design requirements, please read our engineering brochure "Design recommendations for pump stations with large centrifugal Flygt wastewater pumps".

Achieving lowest total cost of ownership

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



■ Investment costs

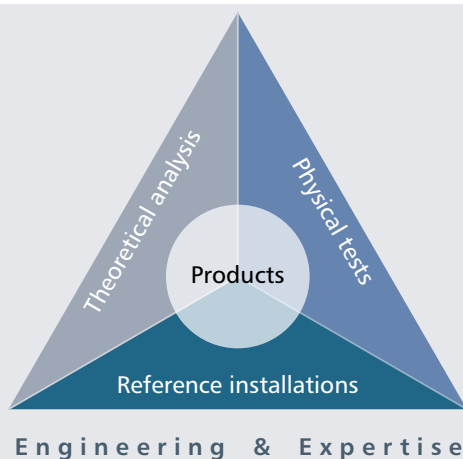
Costs associated with design, excavation, civil work, product purchases, installation and commissioning.

■ 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.

Reliable pump station designs

Flygt large centrifugal pumps with self-cleaning technology are highly effective, compact pumps that can be submersed directly into the liquid to be pumped or dry installed.

Because the motor and hydraulics are integrated into one compact unit, these pumps have a much smaller installation footprint than their non-submersible counterparts. This enables the design of more compact, easier-to-build pump stations. Key features are:

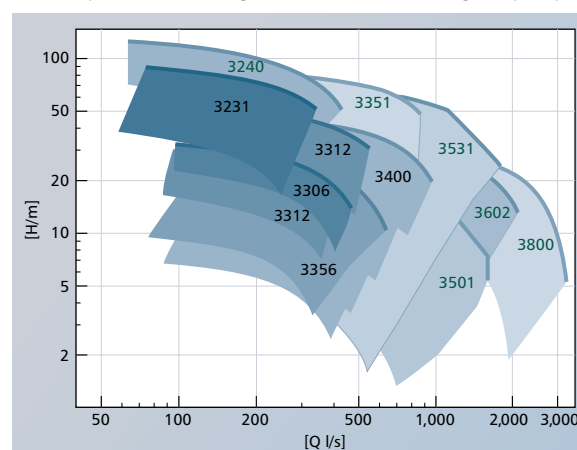
- Sustained high efficiency
- Self-cleaning capabilities
- Compact, modular design
- No separate lubrication system
- Low noise and vibration levels
- Flood-proof pump stations
- Quick and easy installation
- Minimal station superstructure
- Reliability, easy to service

Flygt large centrifugal submersible pumps operate in various applications such as:

- Wastewater pumping
- Raw water pumping
- Cooling water
- Stormwater
- Flood control
- Seawater pumping
- Industrial effluent handling
- Irrigation
- Process water



General performance range. We offer a broad range of pumps.



Achieving lowest total cost of ownership

Correctly designed stations will ensure minimal sedimentation and/or accumulation of debris, thereby reducing planned services and maintenance. A well-designed pump station optimizes hydraulic conditions for the pumps, thus ensuring reliable pump operation and specified performance. We assure optimal sump size, making it as small as feasibly possible without compromising on reliability or efficiency.

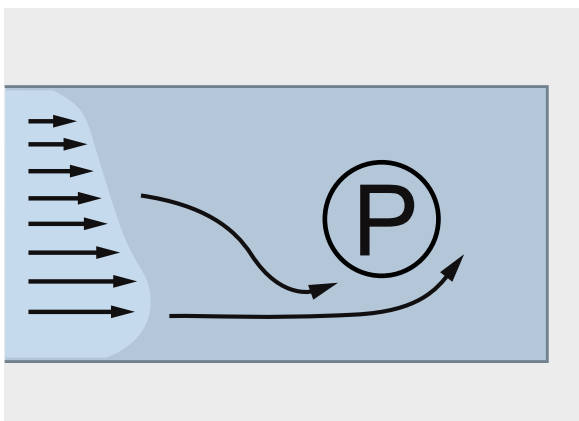
Adverse hydraulic phenomena

According to the Hydraulic Institute: “Ideally, the flow of water into any pump should be uniform, steady and free from swirl and entrained air. Lack of uniformity can cause the pump to operate away from the optimum design condition, and at a lower hydraulic efficiency. Unsteady flow causes the load on the impeller to fluctuate, which can lead to noise, vibration, bearing problems and fatigue failures of pump shafts.”

To ensure the expected pump performance and long service intervals, it is important to design the pump sump to prevent adverse flow conditions.

Excessive pre-swirl

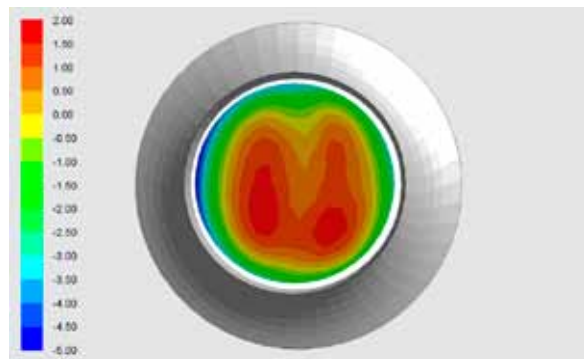
Pre-swirl changes the flow conditions at the pump inlet, which results in a change in the relative impeller speed. This, in turn, causes a change in pump performance, which can lead to overloading the motor or reduced pump performance. Excessive pre-swirl can also result in bearing wear and cavitation across the impeller area. Pre-swirl usually originates from an asymmetric velocity distribution in the approach channel, which evolves into a pre-swirl at the pump inlet. The Hydraulic Institute recommends a pre-swirl angle that does not exceed 5°, calculated from the ratio between the tangential velocity and the axial velocity.



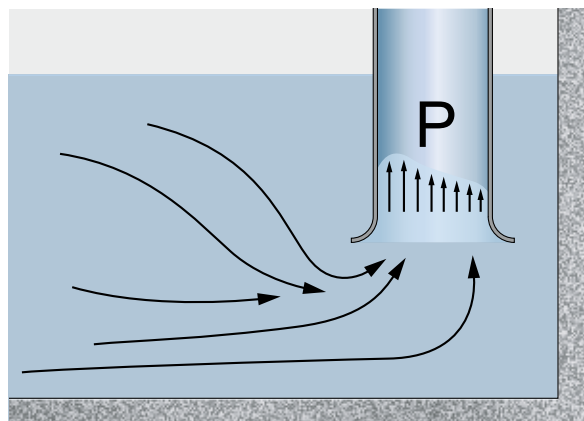
A non-uniform approach inflow leads to pre-swirl, which can overload the motor or reduce pump performance.

Uneven velocity distribution at the pump intake

Uneven velocity distribution can result from different types of phenomena and disturbances. While some unevenness in velocity distribution is inevitable and does not harm the pump, variations that are greater than 10% at the pump intake can have severe consequences and should be avoided. A large variation results in an uneven load on the impeller and bearings. Unsteady flow causes the load on the impeller to fluctuate, which leads to noise, vibration, bearing loads and increased risk of fatigue failures.



CFD simulation of the flow distribution at the impeller plane.

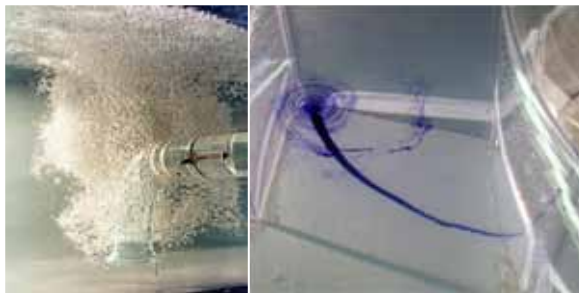


Uneven velocity into the pump inlet leads to noise, vibration and bearing wear.

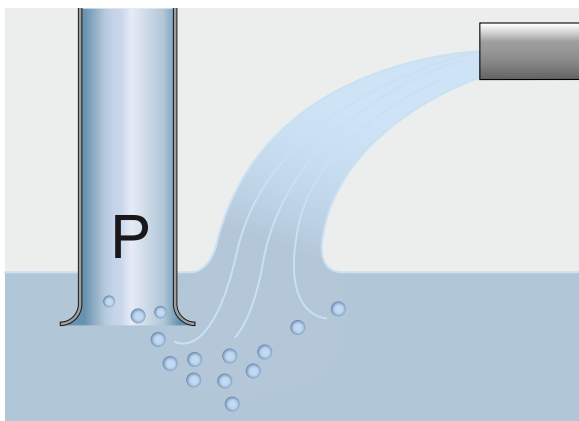
Entrained air

It is widely known that even minor air entrainment, of some 3.4% of the volume, will lead to a clear reduction in pump performance and loss of efficiency; the severity depends upon the quantity of air entrained and the pump type. The expansion of ingested air bubbles within the impeller may result in mechanical imbalance, vibration and acceleration of mechanical wear. Normal design practices recommend the exclusion of any air entrainment in the approach flow to the pump intake. In addition, entrained air leads to increased corrosion.

While air bubbles may be present in the liquid for a variety of reasons, their presence is usually due to cascading of the water as it enters the sump from a weir, culvert or incoming pipe located above the surface water level in the sump.



Entrained air and vortex shown in scale model test.



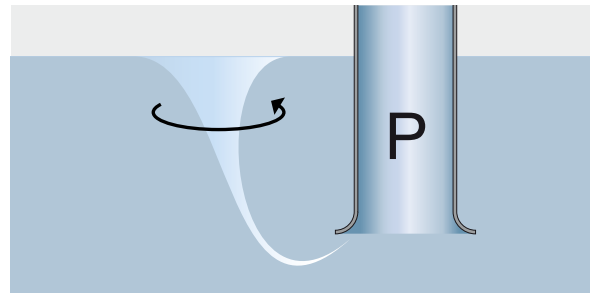
Entrained air can cause reduction in discharge and loss of efficiency.

Vortices

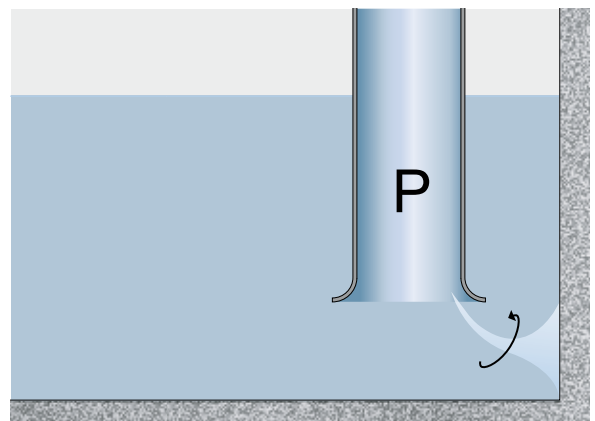
Unlike excessive pre-swirl, vortices appear locally with higher intensity and are a major hindrance to proper pump operation, resulting in cavitation, uneven load, noise and vibration. There are several different types of vortices.

The most commonly known type is the free surface vortex, which can have varying degrees of intensity – from weak surface vortices to fully developed vortices with a continuous air core that extends from the surface into the pump.

Less well known, but just as common is the vortex that originates under the surface from the sump bottom, walls or between two pumps, and extends to the pump inlet. This type of vortex can achieve high rotational speeds with high subpressures and cavitations.



Strong surface vortex with an air core will result in cavitation, uneven load, noise and vibration.



Strong submerged vortex.

Sediment, floating debris and clogging problems

In addition to preventing the occurrence of adverse hydraulic phenomena, it is also important to design the station to minimize build up of sediment at the bottom of the sump and accumulation of floating debris.

Bottom sediments

Too low a velocity will result in low shear stresses on the bottom floor and build up of sediments. Cleaning bottom sediments is a costly and time consuming process. In addition, problems with odors are likely to occur when sediments build up.

When designing a sump, it is important to avoid any low velocity regions within the sump. This can be achieved through the use of benching and a sloping floor to direct the bottom sediments toward the pump inlet. If the bottom sediments are evenly distributed over time into the pump, no clogging problems will arise in the pumps.

Floating debris

Low velocity regions also create floating debris on the surface of the sump. Again, cleaning is costly and time-consuming.

Floating debris can be avoided with good station design by ensuring that the velocities in sump are maintained and by not making the sump too large. It is also important to use a “wastewater” control philosophy and ensure functions, such as alternation between all pumps and automatic cleaning cycles, to minimize floating debris.

During a cleaning cycle, the water level is pumped down to a lower level until the pumps are snoring. All floating debris will then be removed from the sump by the pumps.

Clogging

If large mats of floating debris accumulate on the surface in the sump, significant increases in the flow rate can release huge portions of the mats, which may clog the pump or system components.



Bottom sediment buildup shown in a scale model test.



Pump station with accumulation of floating debris.

Verified design

We have designed, developed and verified standard Flygt branded pump stations. Extensive physical tests, applications expertise and years of experience have been utilized to optimize the design of Flygt pump stations.

Proven installations

Today there are thousands of pump stations in accordance to the Flygt standard in operation all over the world. These have a proven track record of preventing sedimentation, clogging, floating debris and adverse hydraulics. Experience from existing Flygt pump stations is also a critical success factor when designing new pump stations.

Scale model testing

When there is little or no prior experience, we use physical model testing to ensure the reliability in the design. A model is built to scale, typically at a 1:10 scale, on the basis of Froude number similarity, to preserve the laws of physics, and operated as a real installation. Analysis from the physical tests will show if the design is reliable and effective, and provides a solution to ensure safe pumping operation.

Computational fluid dynamics

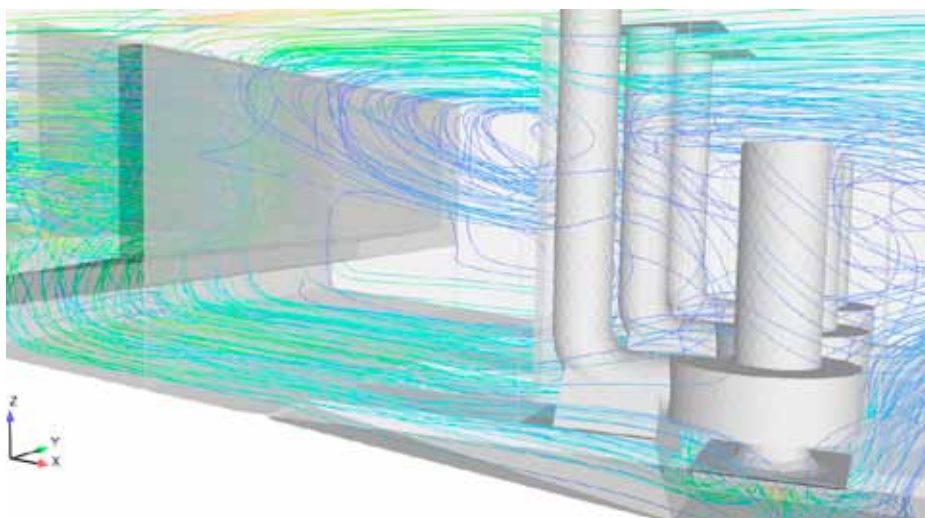
Another method we use to verify design is computational fluid dynamics (CFD), a mathematical modeling of the design where the flow pattern can be observed.



Centrifugal pump sump design verified by a scale model test.

Flygt pioneered the use of CFD to verify sump design, and we have been using CFD for many years. Depending on the complexity of the installation, CFD can complement physical model testing or replace it entirely.

We have a number of standard Flygt sump designs, all of which have been tested extensively through physical model testing, verified through CFD and proven through installations in use around the world. These sump designs have proven to minimize accumulation of sediments and debris and prevent adverse hydraulic conditions. When using standard Flygt designs, within the limits of our recommendations, there is no need for additional physical model testing or CFD.



Centrifugal pump sump design verified through computational fluid dynamics (CFD).



Reliable, cost-effective pumping

Our engineering expertise and vast experience contributes to pump station designs that together with Flygt equipment ensure reliable and cost-effective pumping. Because the pump station is a complex system, it is important to consider every critical aspect during the design phase. Pumping system efficiency depends not only on the efficiency of the pumping units, but also on the prevention of adverse hydraulic phenomena as well as sedimentation, floating debris and clogging problems.

Objectives

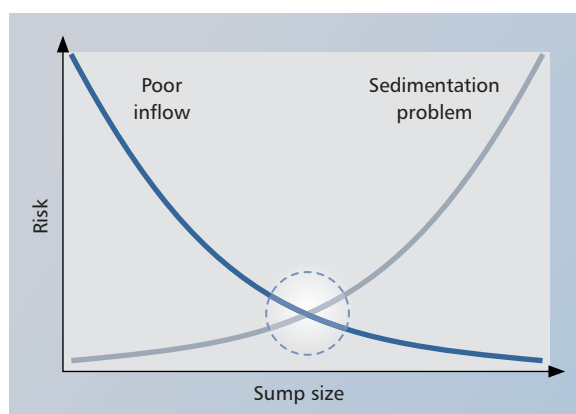
Ideally, the design of a pump station aims to achieve:

- Smallest possible footprint with the lowest possible cost
- Elimination of sedimentation and buildup of other debris
- Reliable handling of variable inflow
- Necessary operating conditions for optimal pumping
- Ease of installation, maintenance and repair

When designing a station, it is also important to consider other factors that can have an impact on operations, such as site conditions, type of media and local regulations and practices.

Optimal sump sizing criteria

Other important factors to consider are the dimensions and capacity of a sump. Designing a sump that is too small carries a low risk of sedimentation problems but a high risk of poor inflow. In contrast, designing a sump that is too large will create low flow regions, which implies a high risk of sedimentation problems, while at the same time a low risk of poor inflow. These criteria must be taken into consideration to determine the optimal sump size.



Optimal sump size depends on criteria, such as poor inflow and sedimentation problems.

Methods of installation

To reduce installation costs, standard Flygt pump packages with key pump station components are available to facilitate site-specific installation. We have all the accessories and components required to meet your specific needs.



- P**
- Semi-permanent wet well installation
 - Twin guide bars on a discharge connection



- S**
- Semi-permanent free-standing installation
 - Transportable with pipe or hose connection



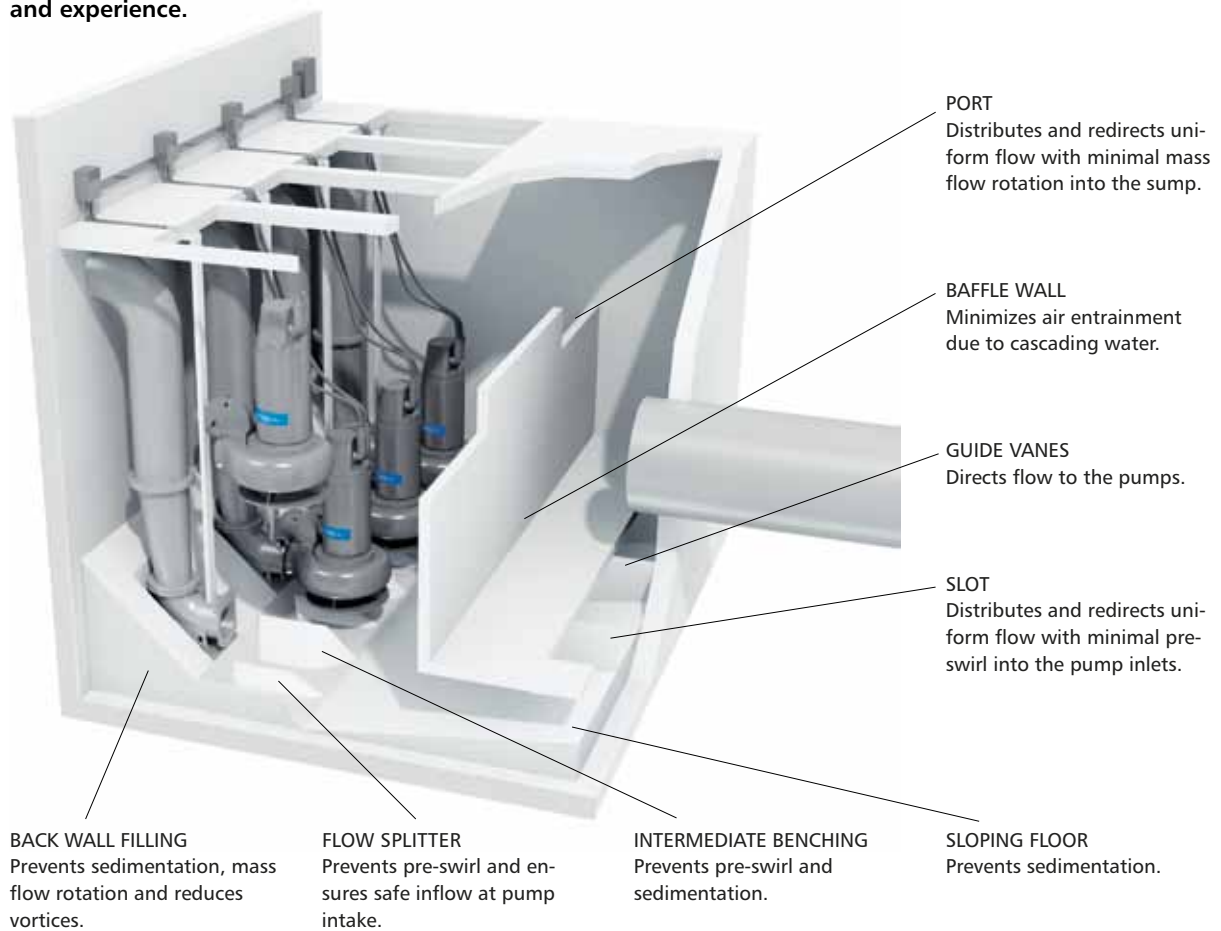
- T**
- Vertically mounted
 - Permanent dry well or in-line installation
 - Flange connections for suction and discharge pipework



- Z**
- Horizontally mounted
 - Permanent dry well or in-line installation
 - Flange connections for suction and discharge pipework

The proper design of the pump sump is crucial in order to achieve an optimal inflow to the pumps. We can provide you with standard solutions for sump design based on our engineering expertise and experience.

These standard wet well sump designs have been verified by computational fluid dynamics (CFD) and physical scale model testing, and have been applied in thousands of pump stations around the world.



Standard sump design

Standard sump designs recommended by Flygt may be used "as is" or with appropriate variations to meet the requirements of most installations. These design recommendations are valid for use with two, three or four pumps, installed either in a semi-permanent wet well or permanent dry well.

A sump designed in accordance with our recommendations is smaller than a conventional sump; naturally, the pump capacity must match the extreme inflows to minimize the risk of flooding. The design should

therefore consider all critical aspects of operation, correct operating levels and efficient pumping cycles for reliable pumping.

For more information on basic principles, dimensioning and installation tips, please read our publication "Design recommendations for pump stations with large centrifugal Flygt wastewater pumps".

Standard wet well designs

Basically, we have three standard pump station designs that are applicable for use with either submersible or dry-installed Flygt pumps. These designs are capable of being adapted to meet most installation requirements.

Rectangular sump with high front-entry inlet

The standard rectangular front-entry sump is the most common sump design. A specially designed inlet chamber with baffle wall minimizes air entrainment due to cascading water.

The flow from the inlet pipe strikes the baffle wall and then flows down into the inlet chamber through the slot in the baffle floor. The slot distributes the flow toward all pump inlets. The baffle wall is sufficiently high to prevent flow from surging over it. Although the flow in the inlet chamber is highly turbulent, various materials can collect there. In such cases, side overflow weirs or side gaps may be used to carry away debris to prevent debris accumulation. The top of the baffle wall, or portions of it, should be below the highest start level of the pumps to allow transport of floating debris into the pump chamber which is then evacuated by the pumps.



Rectangular sump with high front-entry inlet shown with submersible pumps.



Rectangular sump with high side-entry inlet shown with dry-installed pumps.

Rectangular sump with high side-entry inlet

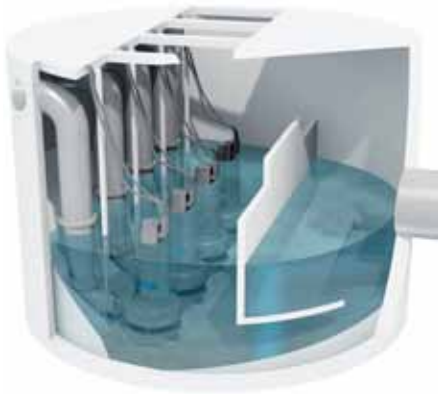
If the piping system and the sump location do not allow for a front-entry inlet, a side-entry inlet with a modified baffle wall with ports may be used. Lateral inlet naturally induces mass flow rotation into the pump sump, here the baffle wall redirects the incoming flow and uniformly distributes the flow towards the pumps through the baffle wall ports. With a high inlet, it is recommended that ports be positioned along the inlet baffle chamber floor to dissipate the energy of the cascading inflow when the water level in the station is low. Correct location and size of these ports are also important.



Rectangular sump with low side-entry inlet shown with submersible pumps.

Rectangular sump with low side-entry inlet

If the sewer is below the normal water level in the sump or if an open channel supplies the sump, a rectangular sump with a straight baffle wall is recommended. In the absence of cascading flow in the approach, no intense entrainment of air takes place. As a result, the inlet chamber can be greatly simplified because its only task is to distribute flow uniformly to the pumps. In a dry-installed pump installation, vertical baffles between the suction pipes are recommended to prevent mass rotation in the wet well.



Circular sump shown with high front-entry inlet.

Alternative wet well designs

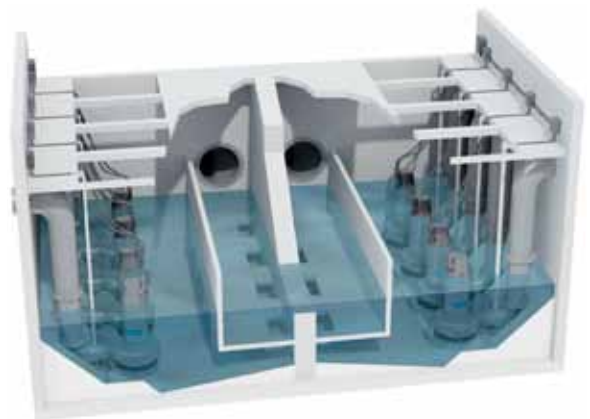
When the three standard sump designs prove to be inappropriate to the site conditions, we have alternative sump arrangements that can also be adapted to the specific requirements.

Circular sump

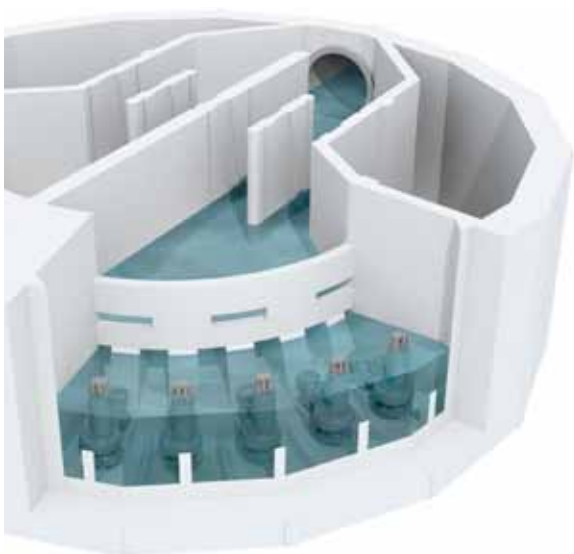
For deep sumps, the use of a circular outer structure offers distinct advantages. Inside such a structure, individual pump sump modules similar to those used for compact sumps can be accommodated. This smaller installation footprint significantly reduces construction costs.

Double sump

When there are more than four pumps required in a sump, it can be difficult to achieve uniform flow distribution to all pumps across the width of a sump. In such cases, a double sump may be used to ensure uniform flow distribution. Another advantage is that the station is split into two, enabling one part of the station to continue to function while the other part is shut off, thereby simplifying maintenance.



Double sump shown with high side-entry inlet and submersible pumps.



Large circular sump distribution chamber shown with pump discharges towards the center.

Large circular sump

For large structures, it is often beneficial to install the pumps in a circular formation rather than in a linear manner. This makes it easier to direct the flow and obtain a more compact station. The discharges can also be oriented either towards the center or towards the periphery, depending on the site constraints and discharge conditions. Location and correct sizing of the distribution ports are of importance as well as the infill forms in the vicinity of the pumps, this generally requires a specific study.

Proven worldwide

Flygt has designed pump stations for thousands of installations around the world. Engineering expertise and years of experience have resulted in the success of these installations. Three such installations are described below.



United States: Wastewater lift station

Challenge

A 54,000-acre service area in a major city in Texas required assistance to handle a projected 50% increase in population and subsequent increase in wastewater processing demands.

Solution

With engineering expertise from Flygt, the city built the largest submersible pump station in the world with 14 constant-speed Flygt submersible pumps in operation. Prior to installation and commissioning, the lift station design underwent physical scale model testing to assure satisfactory flow conditions. The circular lift station design accommodates the entire facility within the confines of the restricted site and enables the use of sunken caisson construction.

This circular wastewater lift station provided estimated cost-savings of approximately 37%, saving millions of dollars. City engineering staff reports that the multiple pump facility operates reliably and cost-effectively under variable conditions.

France: Circular stormwater pump station

Challenge

One of the largest airports serving France required a stormwater treatment plant to handle the inflow from a large gravity sewer collecting water from the runways.

Solution

The pump station is set in a circular deep caisson and includes both the dry weather inflow and stormwater sumps. The storm sump includes a circular inlet baffle chamber for the stabilization and de-aeration of incoming storm flows and is equipped with 12 large Flygt CP 3602-935 submersible pumps that are capable of discharging a total of 16 m³/s (254,000 US gpm).

The pumped effluent is discharged to a grit chamber and then to a dual lagoon collecting system before it is treated through large sand filters, and cleaned water is then transferred to the nearby river.



United Kingdom: Transfer pump station

Challenge:

At one of the largest wastewater treatment plants in the Midlands, a strategic pump station was at risk of complete failure and required fast and efficient replacement within the shortest possible timeframe.

Solution:

Flygt engineers contributed to designing and commissioning, a 1300-kilowatt pump station with a capacity of 6.0 m³/s (95,000 US gpm) within a 12-month period at costs well below the project budget. The station includes two wet wells to handle inflow and maintain solids in suspension and valve chambers suspended over the wet wells to minimize installation footprint.

The first sump house has six fixed-speed pumps operating on a six-duty basis. The pumps are Flygt NP 3300.181LT units each rated at a flow of 0.2 m³/s (3,200 US gpm). When the inflow exceeds the capacity of the NP 3300 pumps, the water level will increase and eventually spill over into the second sump.

The second sump house is equipped with four Flygt CP 3531/835 variable-speed pumps rated at 0.9 m³/s (14,000 US gpm). These pumps operate on a three-duty/one-standby basis. Should inflow exceed the capacity of these pumps, the sump water level will increase and bring storm pumps that are mounted at a higher level in the sump into operation. The storm pumps are four fixed-speed Flygt CP 3531/805 units rated at 0.8 m³/s (12,700 US gpm) that operate on a three-duty/one-standby basis. This multiple pump installation provides a nominal combined output of 6.7 m³/s (106,000 US gpm) for the pump station.

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.



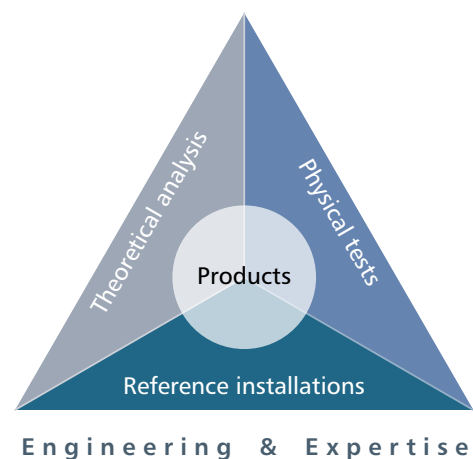
Physical testing

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.



ITT is a global provider of water handling and treatment solutions for municipal and industrial customers in more than 140 countries. The company designs and delivers energy-efficient solutions and related services for water and wastewater transport, biological treatment, filtration, and disinfection through five global brands – Flygt, Godwin Pumps, Leopold, Sanitaire and Wedeco.

The company maintains the industry's most extensive sales and service organization, operating both locally and globally to meet the needs of customers. And by combining its world-class products and engineering expertise, ITT can offer integrated and multi-discipline solutions including full process design, equipment selection and supply, installation, commissioning and operator training.

To learn more, please visit the company's website: <http://www.ittwww.com/>.

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