Archimedean Screw Pumps

The (Archimedean) screw Pumps are well-known for their excellent qualities such as the Simple & Rugged design, the high efficiency, the capacity to pump raw water (even when it contains an amount of solids and debris) and their lifetime reliability.

Spaans Babcock has a worldwide reputation of being the oldest and the largest manufacturer of Archimedean Screw Pumps with a track-record of more than 26,500 screw pumps installed.

Screw Pumps can be used for capacities from 15 litres/sec up to max 11 m3/sec and come in 3 basic forms: built in the traditional concrete trough, with steel trough liner and the prefabricated, 'ready to install' compact units.

Advantages of screw pumps

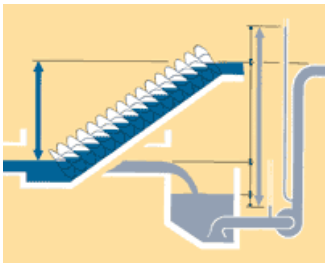
Why do engineers select Archimedean Screw Pumps instead of centrifugal pumps?

+ Slow Speed, Simple and Rugged design

Probably the main and overall advantage of a screw pump is its superb reliability. The simple design, open structure and slow rotation speed makes it a heavy duty pump with minimal wear that operates for years without trouble.

+ Pumps raw water with heavy solids and floating debris

Because of the open structure and large passage between the flights a screw pump can pump raw sewage without the need for a coarse screen before the pump. Both floating debris and heavy solids are simply lifted up. This saves considerably on equipment costs for a coarse screen or maintenance!



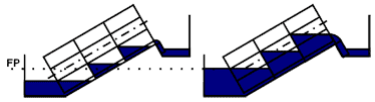
+ No collection sump required = minimum head

A screw pump 'scoops' the water directly from the surface and does not need a collection sump. This keeps the pump head to a minimum.

+ 'Gentle handling' of biological flock

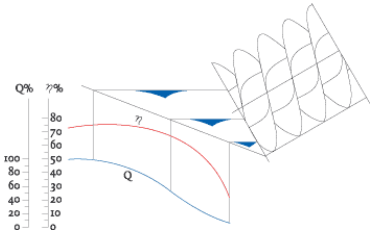
The activated return sludge on STP's is a delicate biological substance. Because of the low rotational speed and large opening between the flights, screw pumps do not damage this biological flock (whereas the high speed rotating centrifugal pumps will completely shred the biological flock).

+ Long lifetime (> 20-40 years)
Screw pumps with typical lifetimes of between 20-40 years are not unusual.



+ **Pump capacity is self-regulating with incoming level**
When incoming water-level goes down, at dry weather flow, the screw pump 'automatically' pumps less water. Ergo: no control system required to adapt pump performance.

+ **Easy maintenance (no 'high skilled' staff required)**
A screw pump requires very little maintenance. Compared to (submersed) centrifugal pumps it is next to nothing. Besides that no 'highly skilled' maintenance staff are required which makes this type of pump very suitable for remote locations.



+ Constant high efficiency with variable capacity
The efficiency-curve of a screw pump is flat on the top. Due to that efficiency characteristic, the screw pump offers even high efficiency when it works at 50% of its capacity.

+ Can run without water
A screw pump can operate even when there is no water in the inlet. Therefore it is not necessary to install expensive measures (level control etc) to prevent 'dry-running''. The lower bearing does not need cooling.

Disadvantages of Propeller / Centrifugal Pumps

The comments below were received independently from various clients/engineers who operate both Screw Pumps and the (Submersed) Propeller Centrifugal system.

- **High speed = increased wear**
The relatively high operational speed (450 - 950 rpm) causes wear and damage in the pump housing, this is particularly so when pumping waste water containing sand and stones. This wear results in regular expensive repairs to the housings.

- **Possible blockages at reduced capacities**
At reduced capacities the speed in the vertical pipe reduces to such an extent that the solids fall out of suspension to the bottom of the pipe causing blockages which eventually stop the pump.

- **Heavy solids cannot be pumped**
Heavy solids cannot be pumped; the sump eventually fills with the solids which have to be removed by hand by maintenance staff. Alternatively a coarse screen would need to be installed which increases the total equipment costs!

- **Floating debris is not pumped**
Floating debris is not removed; this collects in the sump and has to be removed by hand. At lower water levels in the sump when the spirals of the pump are not completely covered, floating (wooden) debris can enter the conical spiral causing the pump to block. Repair is difficult necessitating complete dismantling of the pump.

- **Dry running is fatal**
A centrifugal pump will be severely damaged when running dry; it is therefore necessary to install expensive measures (level control etc) to prevent 'dry-running'.

- **High friction losses in pipes**
High speed is required in the vertical discharge pipe in order to lift the solids with the waste water, obtaining this high speed requires the use of small diameter piping. Using small diameter piping causes high friction losses in the pipe which increases energy consumption.

- **Mechanical seals need regular adjustment**
The mechanical seal between the pump and motor requires regular adjustment or replacement which is time consuming (isolation and wash down required) and hence expensive.

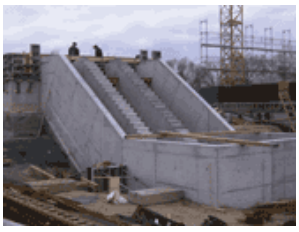
- **Lifting facilities required with each maintenance**
Even low capacity pumps (100 l/s) are too heavy to lift by hand, therefore every time repair is required a mobile crane must be used or permanent lifting facilities must be installed - either option being expensive.

- **Higher skilled maintenance staff required**
The submerged pumps and motors require higher educational skill of both operators and maintenance staff.

- **Submerged motors cause more trouble than dry motors**
The nature of the design requires the use of submerged motors; problems are encountered with leakage and short circuiting.

Screw pumps basic forms

Screw Pumps come in 3 basic forms:



Screw Pump in a Concrete Trough
The classic and most common form is the arrangement of the screw pump in an open concrete trough where the screw, suspended between the upper- and lower bearing, rotates free from the trough with a minimal gap of only a few millimetres.
In order to achieve the perfect trough that is just a few millimetres larger in diameter than the screw pump, the trough is formed (screeded) with the help of the slow rotating screw itself which has been temporarily provided with a screed-strip; while soft concrete is poured in the trough, the rotation of the screw forms a perfect 'imprint' of the screw.

Spaans Babcock has several experienced supervisors available to assist with installation and screeding anywhere in the world.

Screw Pump with a Steel Trough Liner

Although this type requires a similar civil construction as the previous described 'concrete trough', there is however no screeding to be done!; instead a prefabricated steel trough liner is backfilled with concrete. Spaans Babcock prefabricates the trough (either in steel or stainless steel) at the exact diameter and ships it together with the pump.

The steel trough liner increases the wear resistance of the trough in situations where lots of stones and pebbles come to the inlet.

Compact Screw Pump (ESP: Encased Screw Pump)

For this type there is no civil construction required! A prefabricated self-supporting steel construction with integrated inlet-section, outlet-section, trough, screw pump and drive unit is preassambled in our factory and shipped in one piece, ready for immediate installation. The only civil requirement is a support in the inlet channel and a support on the outlet channel. The compact screw pump is ideal for small capacities but is also applied for capacities up to 5 m3/sec.

Parameters for screw pumps

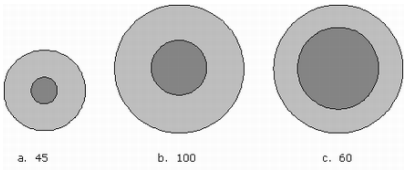
Design & construction

The actual performance of a Screw Pump depends on several parameters which are all related to each other. The selection of the right combination of these parameters therefore is an essential but specialized task since it will be decisive for the performance and life-time of the pump. But do not fear! Spaans Babcock will make the right selection for you. You just tell us the required capacity and lift.

The Gap

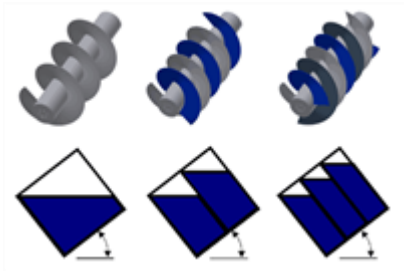
The screw, suspended between the upper and lower bearing, is rotating above the trough with a minimal gap of only a few millimetres between the flights and the trough. Some water will flow back through this gap, however this is marginal as long as the gap remains within allowable limits. The smaller the gap, the better the pump efficiency.

On the other hand the gap must allow for some deflection of the pump body! The optimum gap depends on the size of the pump (a large pump requires a larger gap) but is always in between 4 and 8 mm. In order to maintain an even and accurate gap along the total length of the screw it is important that the deflection of the screw pump is kept to a minimum.



D/d = Outside diameter and Centre tube diameter

The outside diameter of the screw pump in combination with the diameter of the centre tube are essential factors for the capacity of the pump. For long screw pumps a larger centre tube will be required (figure c) to control the deflection, but this will have an effect on the effective capacity.



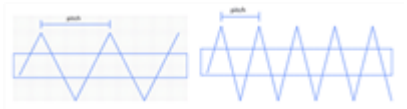
Number of Flights

The effective filling between the screw blades increases with the number of flights. However the price of the pump will also be influenced by the number of flights. For some situations a 1-flight screwpump will be sufficient.

Installation Angle

As you can see from the simplified sketch below: the lower the angle of inclination with the horizontal axis, the better the effective filling >ergo> the better the pump efficiency. However, when the required lift is rather high, we need to increase the angle in order to keep deflection of the screw within allowable tolerances.

Spaans Babcock has standardized angles at 30º, 35º and 38º. Other angles are possible on request or recommendation from Spaans Babcock but will always be between 22º and 40º.



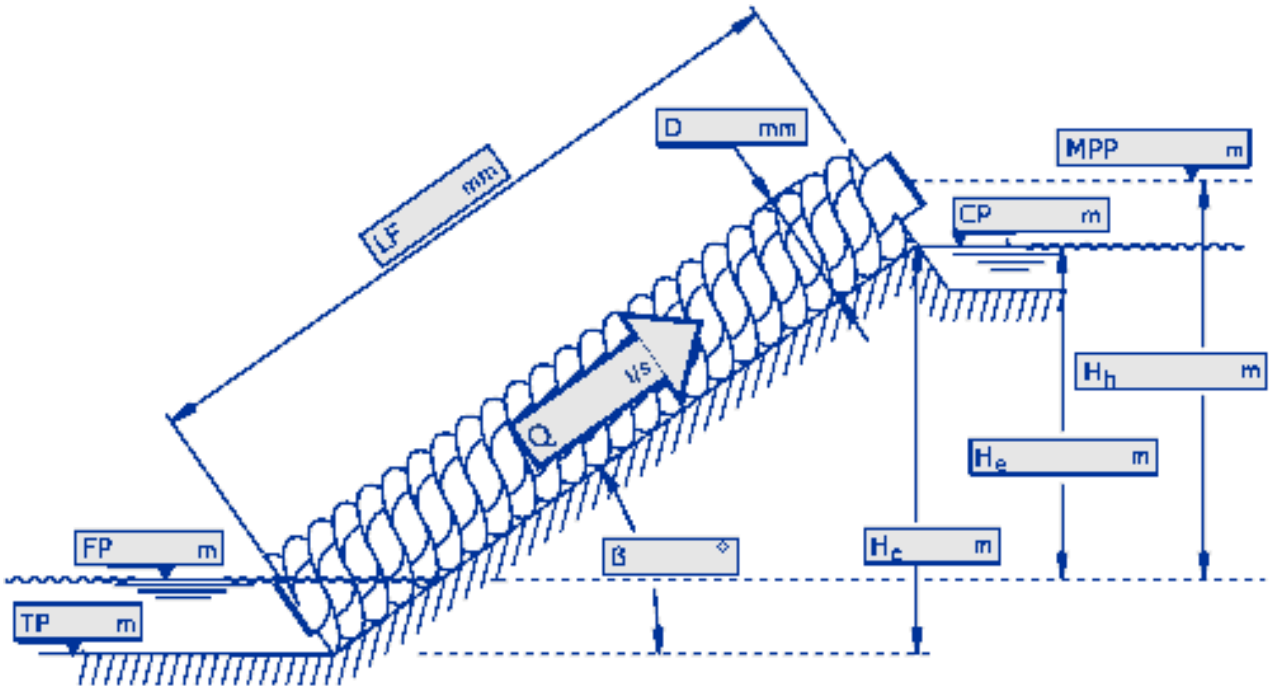
Pitch

The pitch is another parameter which will affect the capacity of the pump; Spaans Babcock does not follow a fixed rule (e.g.: pitch=D) however elects different pitches for various angles.

Rotation Speed

Each specific pump has its own optimum speed. Spaans Babcock uses the formula of ir. Muyskens to determine the optimum speed. Although a minor variation in speed is possible, the speed may not exceed 108% of its ‘optimum design speed’ – if that limit is exceeded the water will be thrown out of the trough and pump efficiency will drop.

Quick selection



TP	Touch Point	D	Diameter
FP	Fill Point	LF	Length of Flights
CP	Chute Point	Hc	Head, civil
MPP	Max. Pumping Point	He	Head, effective
ß	Angle of Inclination	Hh	Head, hydraulic
Q	Capacity		

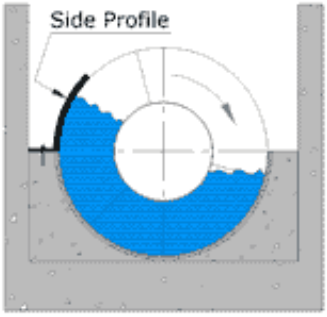
Outside Diameter [mm]	30° Q [l/s]	30° Lift FP-CP [m]	35° Q [l/s]	35° Lift FP-CP [m]	38° Q [l/s]	38° Lift FP-CP [m]
400	24	3,1	18	3,7	16	4,0
500	39	3,6	31	4,2	28	4,6
600	62	3,9	48	4,5	42	4,9
700	90	4,5	68	4,8	61	5,6
800	148	4,1	116	5,3	100	5,2
900	192	4,6	152	5,3	128	6,0
1000	250	4,6	195	6,0	166	5,7
1100	310	5,0	245	6,5	207	6,5
1200	380	5,5	300	7,4	250	7,0
1400	540	6,4	430	7,3	360	7,9
1600	745	6,3	586	7,7	500	7,7
1800	980	6,7	770	8,1	650	8,2
2000	1250	7,0	980	9,2	870	8,7
2200	1550	7,9	1200	9,5	1000	9,7
2400	1900	8,3	1500	9,2	1280	10,0
2600	2300	8,0	1800	9,6	1500	9,8
2800	2700	8,3	2100	9,9	1800	10,2
3000	3200	8,6	2500	10,3	2160	10,5
3200	3750	8,9	2950	>10	2500	>10
3400	4300	9,1	3350	>10	2900	>10
3600	4900	9,4	3900	>10	3300	>10
3800	5600	9,7	4400	>10	3750	>10
4000	6350	9,7	5000	>10	4250	>10
4500	8300	>10	6500	>10	5600	>10
5000	10600	>10	8300	>10	7100	>10

Screw Pump components

Bearings, drive units, materials, coatings and other details

Material of construction

Screw pumps are generally made of normal mild steel with a special epoxy coating. A suitable coating system will be selected for each specific application. Spaans Babcock can also manufacture screw pumps of all sizes in stainless steel. References are available on request.



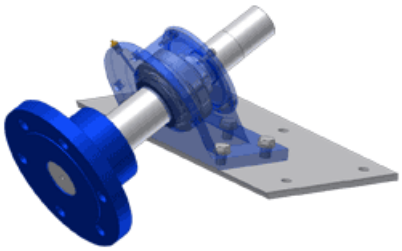
Side profiles

Due to the rotation of the screw the water is slightly stowed up to one side of the open trough. To prevent the water from flowing back and to increase the efficiency of the screw, a side profile is mounted at one side of the trough.

Protective Epoxy Coatings

In close cooperation with Ameron International (a renowned manufacturer of industrial coatings) Spaans Babcock developed a specialized range of protective coating systems for several applications:

System nr.	Application	Composition
1 - standard	Normal sewage / Activated sludge / drainage water / storm water	2-pack epoxy system
2 - auto-cure	Normal sewage / Activated sludge	Zincrich primer + 2-pack epoxy system
3 – heavy duty	Waste water with higher content of sand	Zincrich primer + Sealer + 2-pack epoxy system
5 – cover guard	Aggressive waste water / Sewage inlet screw pumps under closed covers and H_2S rich environment.	2-pack epoxy system (chemical resistant)



Upper bearing

The screw pump is suspended from the upper bearing. This means that almost all the load is hanging from the top!

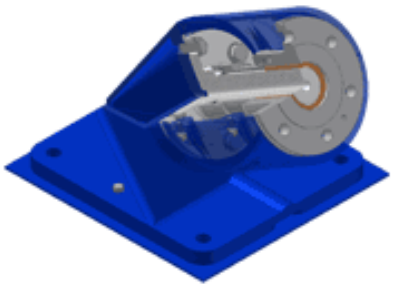
The Spaans Babcock upper bearings therefore are specially designed to take up both the axial force as well as the radial force.

The Spaans Babcock standard upper bearings are pedestal mounted because installation and pre-alignment are much easier than with the wall-mounted upper bearings.

Lower bearings

The lower bearing of a screw pump is a very important component. Its role is to keep the pump aligned and to maintain the accurate gap between screw and trough. Although it carries only a small portion of the load of a screw pump, it has to do its duty under harsh conditions: submerged in dirty water.

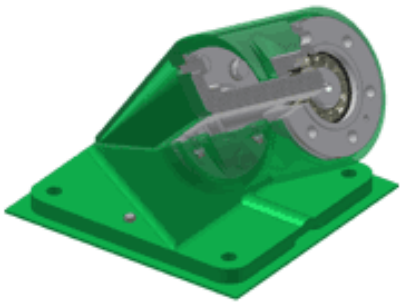
Spaans Babcock has developed during the last 50 years a large range of lower bearings; the most used types are shown below:



Spaans Babcock LGO (conventional lower bearing)

The traditional lower bearing is based on a non-rotating stub shaft that is rigidly mounted to the bottom of the inlet and a bronze bush sleeve bearing, mounted to the lower end of the screw pump, that is rotating around the stub shaft to ensure that eventual wear will occur evenly distributed.

A very small amount of grease is constantly pumped into the bearing by a grease pump that is installed at the top.

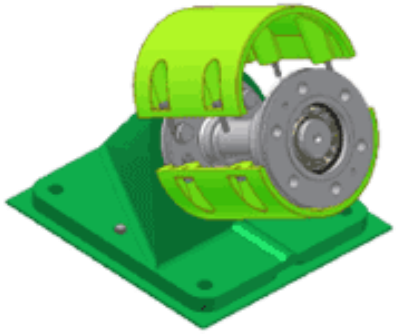


Spaans Babcock ECO (totally enclosed lower bearing)

Spaans Babcock developed in cooperation with SKF the ECO bearing: a totally enclosed lower bearing that is based on roller bearings. This bearing does not need any external lubrication and can be operated without grease pump. The advantages are:

- no grease into the water
- no possibility of human error (nobody can forget to fill up the grease!!)
- no consumption of grease and electricity.

The calculated operational lifetime of this bearing is in excess of 100,000 hours.



ERGO-guard®:
Spaans Babcock is the only manufacturer that gives the screw pump and lower bearing maximal protection by using guards / shrouds around the lower bearing. By using this cover the possibility of items such as rags, ropes, cables and other debris wrapping around the bearing will be eliminated.

Originally this cover was made of cast iron (and often too heavy to handle) but the new ERGO-guard®, made of strong industrial compound plastic, is not heavier than 25 kg whilst having the same or even better characteristics than cast iron.

Flexible coupling
To absorb shock-load and torque during startup and operation, a heavy duty flexible coupling is used between the drive shaft of the screw pump and the output shaft of the gearbox. Selection of the type and size of coupling is done by experienced engineers.

Drive units
Spaans Babcock developed a range of drive unit arrangements for all type of screw pumps and all sizes.
Although there are many different arrangements, they all consist at least of:

- motor (mostly electric motors however diesel motors are also possible)
- gearbox (to reduce the speed of the driving motor)
- base plates & support frame
- connection between motor and gearbox (see below)
- safety guards

The drive units come pre-assembled on a steel support frame for easy installation and simple alignment.

Motor-Gearbox connection

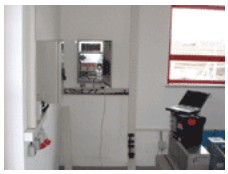
The connection of the electric motor and the gearbox can be:

- direct connection
- v-belt connection

The advantage of the direct connection (with a flexible coupling or fluid coupling between motor and gearbox) is that it does not require re-adjustment. The disadvantage is that speed-reduction (= speed of the screw pump) can only be done within the available range of reduction ratios from the gearbox supplier.

Advantage v-belt connection is that a first reduction can be achieved before entering the gearbox. The actual outgoing screw speed can be exactly matched to the theoretical optimum.

Condition Monitoring



Background

Most engineers are aware of the advantages of condition based maintenance: reduced operating costs, increased asset availability and minimized maintenance costs. With the ongoing reduction of in-house manpower throughout the water industry, Spaans Babcock have recognized the need for a suitable system, which for minimum initial outlay and without the need for continual operator intervention fulfils these requirements.

The solution

Traditional condition monitoring techniques, the majority of which are based around vibration monitoring technology, work very well on equipment which operates at relatively high speeds. Archimedean screw pumps which operate at low speeds (20 - 90 rpm depending on screw diameter) do not lend themselves to monitoring in this manner. Spaans Babcock, having experimented with various types of condition monitoring equipment have now opted to utilize condition and performance monitoring equipment based around Acoustic Emission (AE) sensors.

AE sensing is concerned with the detection of naturally occurring energy waves which are generated by processes associated with friction, impacts and metal removal. These become more prominent and frequent as the machinery degrades. The processing technology ensures that the system is able to detect this degradation even at very slow rotational speeds such as encountered on an operating screw pump.

Advantages of the Spaans Babcock CM System:

The applied technology - based on acoustic emission – is suitable for monitoring low speed (<100 rpm) applications. No other monitoring technology can measure the condition of a screw pump bearing as reliably as the CM system from Spaans Babcock. Of course the system is also a perfect tool for measuring high speed applications. The acoustic emission technology can detect bearing problems at a very early stage, before bearing damage occurs. The technology is suitable to monitor rolling bearings as well as plain bearings.

Applications are not limited to bearing monitoring only. An example is monitoring the performance of mono pumps pumping a dry medium. The generated noise of the pump is registered by the sensor, telling us the pump is in operation. If there is no flow to the inlet of the pump noise level will decrease generating an alarm.

The Spaans Babcock CM system operates continuously online, including 24 hour alarm features.

Reports are available on the internet and are supplied through Spaans Babcock. The customer does not need to invest in man hours to gather and analyze the measured data. There is no special training needed to work with the system. Price setting is competitive compared to other online systems available on the market.

Besides bearing condition the Spaans Babcock condition monitoring system can also log other machine parameters to identify the complete machine performance. Therefore the system is equipped with the possibility to log conventional parameters from a local PLC, like power, flow, running hours etc. This feature makes the system a unique "all-in monitoring system".