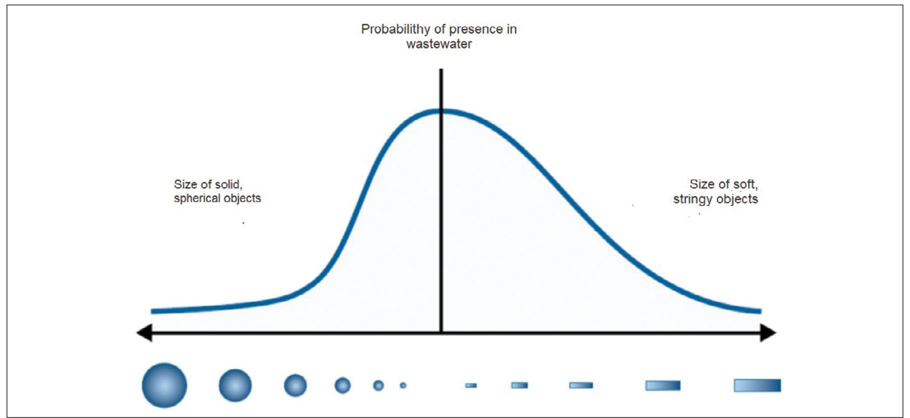
The truth about wastewater pump clog resistance

The biggest issue with the throughlet rule is that it focuses on large and hard objects as the main culprits behind pump clogging and impeller damage. But a lot of research by Xylem shows that these are not the source of clogging problems.



A diagram showing the probability of finding different sizes and types of objects in modern wastewater, from large solids on the left to stringy materials on the right.

The number one requirement of a wastewater pump is its ability to pump wastewater without clogging, hence the importance of a pump's wet-end design for achieving clog-free operation. Xylem research has long established that a pump's throughlet size is a misleading parameter in specifying clog resistance. The traditional definition of throughlet size refers to the free passage of matter through a pump impeller. It is determined by the largest diameter of a hard, solid, spherical object that can pass through the pump. The concept is old, dating back to 1915, and was developed at a time when energy costs were not of significant importance. Wastewater pump manufacturers intuitively believed that pump clogging could be avoided simply by ensuring that a wastewater pump's throughlet size was equal to or larger than a toilet outlet pipe.

Decades of research and development, along with experience from hundreds of thousands of pump installations, however, have proven that this simplistic logic is incorrect and misleading, yet it remains prevalent in wastewater pump procurement specifications.

Pump manufacturers achieve large throughlet sizes by opening the pathway through the impeller. There are two main impeller-design options to maximize this throughlet size: single-vane impellers, open or closed; and vortex impellers, which are known as recessed impeller or torque-flow impellers. Both designs suffer from drawbacks. Single-vane impellers, unless they are being used to pump clean water, have a relatively low efficiency since pumps with more impeller vanes can deliver significantly higher efficiencies. Also, significant rotating radial forces cause high shaft and bearing loads, as well as increased vibration and noise. They are also difficult to balance – the impeller is water-filled during operation – and impeller trimming often leads to further imbalance. Vortex impellers, on the other hand, have low hydraulic efficiency due to the large open area between impeller and volute.

Investigations and studies of modern wastewater have shown that it rarely contains hard, solid, spherical objects. Objects that are truly solid and hard – such as stone, brick or steel – are rare, and these items seldom reach the pump because they will be trapped on a flat horizontal surface where the liquid is stagnant, or the flow velocity is low.

By far the most common solids found in municipal wastewater are organic and often consist of long and stringy materials such as fibres. Modern wastewaters also contain a higher amount of synthetic cloth and artificial fibres. The vast new array of household cleaning products, such as tissues, wipes, and dishcloths are to blame. Many consumers flush them down the toilet, thus adding synthetic fibres to the wastewater stream.

The diagram alongside shows the probability of finding different types of solids in wastewater. The left side shows hard spherical objects (stone, gravel, sand, grit, silt, etc.) and the right side shows objects of various sizes and shapes, from circular to large and elongated. The distribution curve shows that there is a very low probability of finding large, hard objects compared to small, hard particles and various small and large soft and stringy organic objects.

How traditional hydraulic designs are affected

Stringy objects tend to get caught in traditional impeller types even if the throughlet size is large. The problem point is the leading edge of the impeller vanes. All impeller designs have one or more vertical leading edges. Soft, strong and elongated objects in wastewater are continuously fed into the pump and some of these will meet a leading edge on one of the impeller vanes. The fibres tend to wrap around the edge and fold over on both sides of the vane. On straight and moderately curved leading edges, the debris will not dislodge, leading to accumulation.

This creates big lumps or bundles of solid organic material sometimes called rag balls. As these accumulate in a traditional impeller, the following become likely:

- The flow rate of the pump decreases as the solid objects start to constrict the free passage of liquid, usually leading to decreased efficiency. This phenomenon is called soft or partial clogging because although the pump continues to operate, it takes longer to pump down the sump with a constricted impeller.
- The input power increases when accumulated objects make contact with the volute. This is due to drag, which leads to lower efficiency and the risk of a trip due to motor overloading. The solids act as a brake, which increases the required input power. Once the running current exceeds the trip current, the pump shuts off due to hard clogging.

With decreased pump efficiency, the operational cost for the end user is increased because the pump has to operate for a longer time to handle the inflow. A motor overload or pump trip also adds cost for the end user because it requires a service technician to visit the pumping station in order to clean and restart the pump.

For pumps operating intermittently, back flushing will occur naturally every time the pump is turned off. This can clean the leading edges of the impeller and flush the accumulated solids back through the pump's suction and into the sump. This flushing phenomenon also occurs in systems with check valves, which all wastewater pumping stations must have.

Some hydraulic designers claim that their impellers are self-cleaning because back flushing frees the impeller of solids. In practice, however, this is not the case. Even if the back flushing frees the impeller from the stringy objects, they return during normal operation, again leading to a significant decrease in efficiency and higher energy bills.

Modern pump hydraulic design

Today there are better and more advanced hydraulic designs available to increase a wastewater pump's clog resistance and to maintain pump efficiency over time.

Xylem's N-technology self-cleaning design, with substantially horizontal backswept leading edges and a relief groove, has proven to be the answer to most clogging problems.

This was followed by Adaptive N-hydraulics, a Xylem innovation that further improves the N-technology's self-cleaning characteristics for small pumps. Wastewater pumps with Adaptive N-technology offer unmatched clog-free performance and high sustained efficiency. This is achieved through a patented axial movement of the Adaptive N-impeller on the pump shaft.

The Adaptive N-impeller moves axially away from the insert ring when an extra heavy load of solids is detected, allowing the bulkiest rags and toughest debris to pass through. After the debris is pumped out, the impeller automatically returns to its normal operating position, restoring clog free efficiency.

The axial movement of the impeller also reduces stress on the shaft, seals and bearings, thereby extending pump life. The reliable, clog-free performance that a Xylem Flygt Adaptive N-technology pump delivers results in peace of mind and minimal maintenance. All in all, Adaptive N-hydraulics assures reliable and economical wastewater pumping.

Modern impeller design now separates the transportation of liquids from the function of transporting solids. A self-cleaning approach prevents the accumulation of typical stringy and fibrous contaminants present in modern wastewater. Solids that land on the leading edges of the impeller are continuously pushed out through the pump discharge.

To avoid clogs, do not focus on the throughlet size. Large objects are not the problem; buildup of fibres are the leading causes of clogs. The right impeller design makes all the difference, keeping wastewater pumps running at their best for longer.

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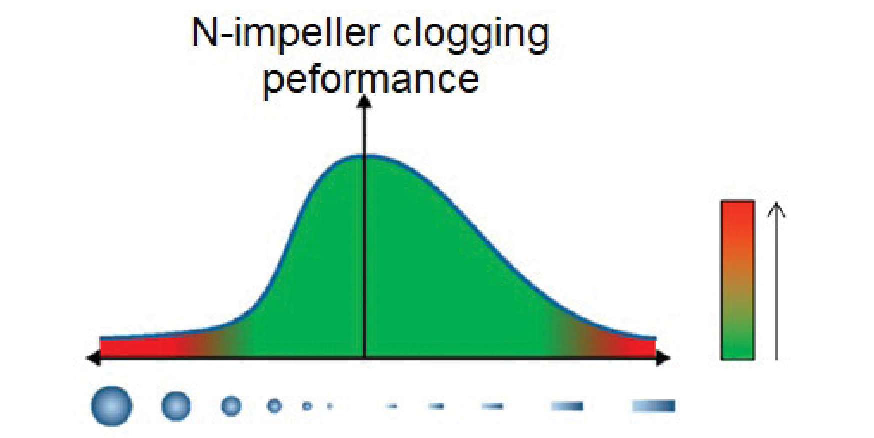

The modern self-cleaning design of the Xylem Flygt Adaptive N impeller. Inset: The green area indicates much better performance with respect to clogging.

Xylem Flygt pumps with Adaptive N™ technology can prevent clogging while delivering better energy efficiency and reducing unplanned maintenance.