The challenge, and solution, of equipment sizing in modern wastewater treatment plants

How treatment plants can reduce capital and maintenance expenditures and improve process protection through precise equipment design.

By **Jay R. Conroy**

Evolution of wastewater treatment

The wastewater industry as a whole is trending towards tighter effluent standards due to stricter environmental regulations and advancements in treatment technologies. These improvements in treatment technologies demand finer and more efficient screening. As process equipment becomes more sophisticated, and in turn more sensitive to foreign material, it is becoming commonplace that the main process at the plant either dictates or plays a significant role in determining the specific type and opening size of the screening equipment that precedes it.

Many new treatment technologies such as membrane systems, cloth filters, IFAS and MBBR systems rely heavily on the performance of the fine screens upstream for protection from debris that can cause the process to fail or be damaged. These advancements are able to treat higher volume flows, but require proper attention to each stage of the improved processes. Some processes even require screens ahead of them of a specific Screenings Capture Ratio and maximum opening size for warranty validity.

Preliminary Treatment: Designed for influent characteristics, downstream processes, or both?

Engineers, operators and maintenance personnel alike have long since realized the benefits in removing inorganic and settleable solids as early in the treatment process as possible, but preliminary treatment equipment has conventionally been selected more on the requirements of downstream processes than influent characteristics. As these processes increase in sophistication and sensitivity, plant design is driven towards finer upstream screening protection without further investigation into the type of solids presented to the plant. Generally, this can result in higher capital outlays, larger headworks structures and frequently increases disposal of the organic and fecal material the plant is designed to treat.

As can be expected, finer screens are much more sensitive to variations in flow conditions, quantities of solids in the waste stream and fluctuations in water levels. Under-sizing a screen increases blow-through of screenings, reduces screenings capture and degrades the ability of the equipment to unload. Oversizing equipment increases capital costs and footprint as well as electrical and wash water requirements of the system. A screen that is not properly sized for an application could be plagued with excessive wear from overuse, fail due to structural deficiencies under hydraulic forces, cause flooding of headworks structures, cause solids deposition upstream of the screen, or a number of different problems for a plant and its surrounding environment.

Through testing with Hydro-Dyne's proprietary Hammerhead Onsite Screen Sizing technology, the solids loading characteristics of an individual plant can be expanded from generalized TSS or BOD ranges to stratification of solid sizes present in the waste stream. Analysis of this data helps identify proper screen openings and capture ratios required by downstream processes while determining the appropriate screen type, size and operational sequence determined by the unique inputs to the individual plant.

The challenge with traditional headworks screen sizing

Just as each plant has its own characteristics that dictate the amount of screening protection it requires, every collection system and the waste flow it receives are unique as well. The design of a collection system, local industries feeding the plant, size and number of pumping stations, storm water infiltration and variations in flow have a direct impact on the quantity, size and consistency of screenings in the influent flow of any given treatment plant.

Manufacturers generally size screens using industry standard blinding factors based on a screen's Screenings Capture Ratio (SCR) – the measurement of the percentage of screenings a screen captures equal to or greater than its opening size. Thompson RPM, an independent testing facility based in the United Kingdom and currently the only independent company actively engaged in testing screening equipment, recently published its findings on tests of SCR for more than 40 different screens designs. Figure 1.1 illustrates maximum, minimum and average SCRs for various types of screening technologies tested at the facility. Their study[1] tested screens of five different families (band, fine, screw, step and slot) by 18 different manufacturers with opening sizes from 1 to 7mm and gives an accurate representation of the types of capture to be expected from screens of different families.

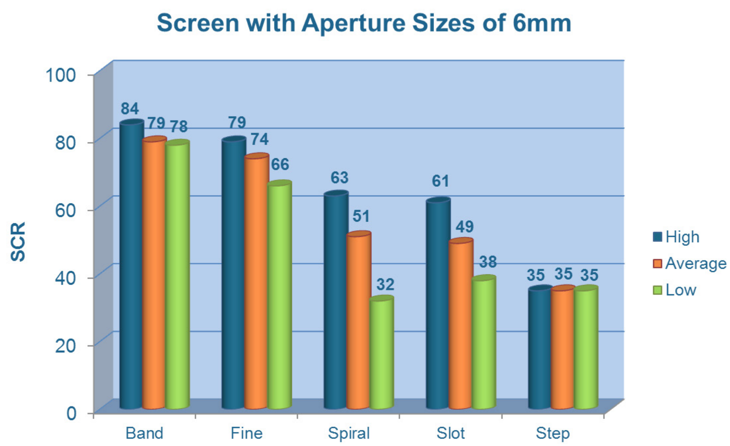

Figure 1.1

Screen opening size should not be the only factor considered when determining the proper screen for an application. Not all screens of the same opening size are created equal. As shown in Figure 1.1, even screens with the same opening size can have drastically different SCRs. For example, the 6mm opening size recorded an SCR as low as 32% for a spiral style screen and as high as 84% for a center fed band style screen.

A number of factors must be addressed when determining the proper screen for an application. The first step in this process is to recognize the limitations of the plant and narrow the applicable technologies. In all applications, consideration must be given to channel dimensions, hydraulic conditions, budget, screenings handling requirements and site restrictions when determining the proper screen for an application.

Factors affecting waste stream solids loading and particle size

The design of a collection system, constituents feeding the plant, stormwater infiltration and variations in flow all have a direct impact on the quantity, size and consistency of screenings in the influent flow of any given treatment plant.

WEF, in co-operation with ASCE, conducted a study[2] of the screenings volume relative to flow collected at 39 U.S. wastewater treatment plants. Their results proved that plants screenings are so unique they differ by a factor of 70 times. Even conservative sizing methods used by most screen manufacturers cannot properly account for fluctuations in screenings of this magnitude when calculations are based on peak flow and opening size alone. Influent at industrial wastewater treatment plants can have flows with solids content of even greater variations in quantity and content. Solids in these applications can include corn husks, tree pulp, animal hides, algae, wood chips and a variety of other material. Having more detailed information about the contents of the waste flow in these applications is critical in properly determining the correct screen type, grid and size for the application.

Factors affecting fluctuations in the quantity, size and consistency of screenings in the wastewater influent of a municipal wastewater treatment plant can include:

Collection system

- Inflow and infiltration
- Area of collection system and length of sewer lines
- Number and size of pump stations
- Type of pumps and presence of coarse screening or grinding at stations
- Equalization or storage basins
- Septage and grease hauler dumping

Population

- Density
- Hotels/resorts/laundry facilities/hospitals/sports stadiums
- Correctional/Institutional facilities
- Local industry

Headworks design

- Pumped to or gravity fed
- Length and slope of influent channel
- Number of channels and flow distribution
- Pretreatment such as coarse screening or grit removal

Flow variations

- Infiltration and Intrusion
- Weather conditions like drought or heavy precipitation
- Water use restriction

[1] UK Water Industry Research in *National Screen Evaluation Facility Inlet Screen Evaluation Comparative Report* (1999-2011)
[2] WEF Manual of Practice No. 8

The importance and benefits of properly-sized screens

The primary purpose of screening is to remove as much non-organic material from the influent flow as possible to protect downstream processes from damage and excessive wear. It has been shown that fine screening at the head of a plant will significantly reduce maintenance costs and extend equipment life of downstream processes across a plant. Ideally, the goal would be to remove nearly all non-organic material at the head of the plant to reduce the strain on the equipment downstream. However, limitations in allowable headlosses, channel sizing, screening equipment capabilities and equipment cost prevent this from being a realistic option at most plants.

Proper screen selection, sizing and operation directly impact all downstream processes. If a screen is not protecting subsequent equipment as intended, maintenance costs can increase substantially while the life of that equipment can be reduced dramatically. Improper screening can also remove more organic material than desired. This can starve biological plant processes of the nutrients they were designed to treat while concurrently creating a screening disposal problem.

Thorough analysis of influent flow to a treatment plant provides an excellent return on investment. With focus on preliminary treatment, and screens in particular, the benefits extend from initial operation through the lifecycle of the equipment selected. The advantages of understanding the characteristics of solids in the waste stream begin with proper screen sizing to balance capital expense with long term operation. To handle peak flows, a screen must be large enough to present enough open area to maintain appropriate water levels in the channel and velocities through the equipment. The screen must operate at sufficient speed and frequency to clean and present new clean filtration media as solids blind the available open area. The life of a screen's wear parts are determined by the speed and frequency in which the equipment is operated; therefore, a larger screen operated slower and less frequently will outlast a smaller screen operated faster and more often. Flow analysis is an essential tool in determining the appropriate size screen to balance initial capital outlay and long term screen operating costs.

The benefits of a properly designed screen include:

- Maximized Screenings Capture Ratio
- Reduced maintenance and extended operating life of headworks screens due to proper balance of idle versus run time
- Decreased maintenance across a plant
- Decreased capital costs attributed to oversized equipment and channels
- Proper design and sizing of screenings handling units

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