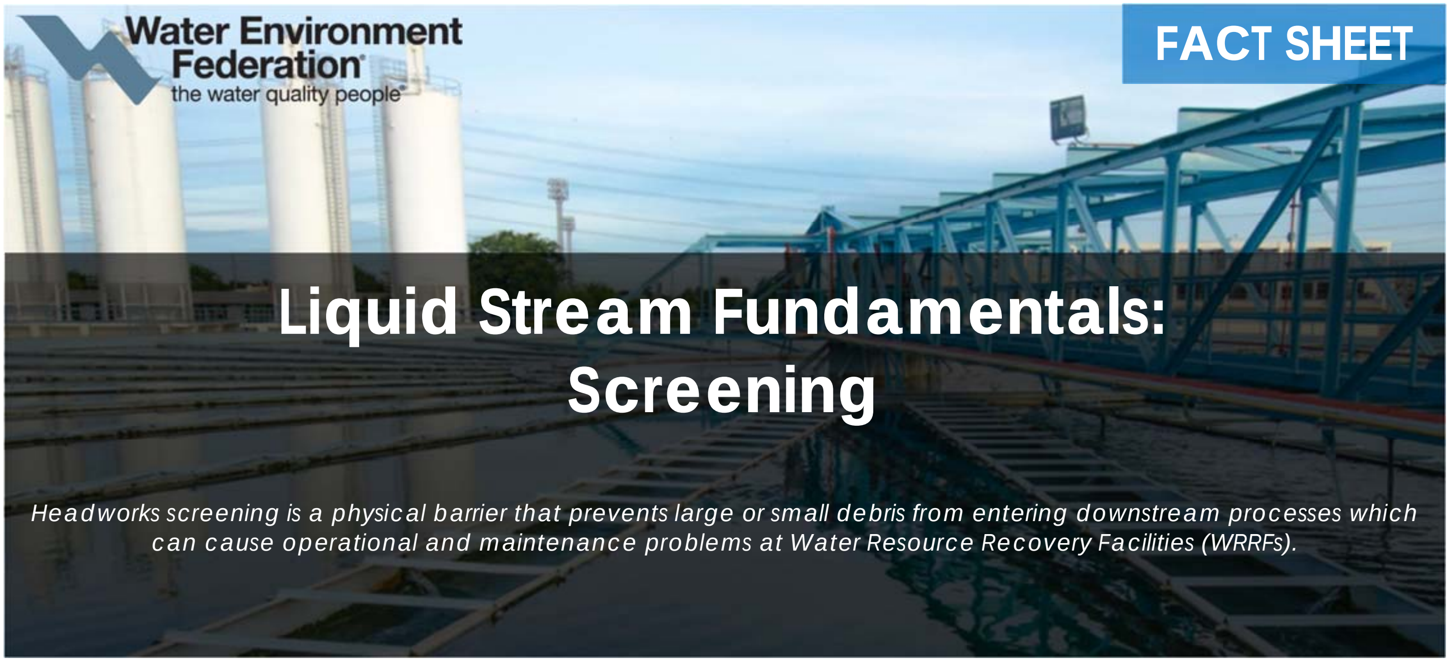

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FACT SHEET

Liquid Stream Fundamentals: Screening

Headworks screening is a physical barrier that prevents large or small debris from entering downstream processes which can cause operational and maintenance problems at Water Resource Recovery Facilities (WRRFs).

Abstract

Wastewater contains large solids and rags (screenings), abrasive inert material (grit), floating debris, and grease. These constituents can cause operational problems with downstream processes or increase maintenance of downstream equipment, piping, and appurtenances. To minimize problems, preliminary treatment is required for Water Resource Recovery Facilities (WRRFs) to remove, reduce, or transform wastewater constituents in the raw influent.

Headworks screening and grit removal are parts of the preliminary treatment of municipal wastewater. This fact sheet focuses only on screening while grit removal is described in a separate WEF fact sheet. Screens can be used to remove large objects that could damage influent pumps or block flow in raw sewage channels and piping systems. They can also remove fine objects to protect sensitive downstream equipment including membrane systems, fabric filters, or suspended media used in integrated fixed-film activated sludge and moving bed biofilm reactor systems. This fact sheet presents the types of screens, screening media, methods of screen cleaning, and design consideration for screening.

Types of Screens

Screening devices are typically classified into four categories based on screen opening size.

Trash Racks and Bypass Screens

Trash racks are bar screens with large openings 36 to 144 mm (1.5 to 6 in.) that prevent logs, timbers, stumps, bricks, and other large, heavy inorganic debris from entering treatment processes. Trash racks are commonly used in facilities receiving wastewater from combined sewer systems that can contain large objects. They are typically followed by screens with smaller openings. Bypass screens typically have openings between 24 to 48 mm (1 to 2 in.). They are used for emergency screening in the event that the mechanically cleaned coarse or fine screen must be taken out of service.

Manually cleaned trash racks and bypass screens typically are mounted 45 to 60 degrees from the horizontal to facilitate cleaning using a rake and perforated plate drain pan. The depth should not be more than what can easily and safely be racked by operators. Mechanically cleaned trash racks are available and are mounted 75 to 80 degrees from the horizontal. As facility size increases, it becomes unmanageable to use manual bypass screens because of the larger volume of screenings retained and the potential for channel overflows due to blinding. Most mechanical coarse screens are suitable for use as a trash rack. Some plants use basket-type trash racks that are manually hoisted and cleaned.

Coarse Screens

Coarse screens are devices with openings 6 to 36 mm (0.25 to 1.5 in.) that remove coarse screenings such as rags, sticks, leaves, food particles, bones, plastics, bottle caps, and rocks. Historically, coarse screens have been the most commonly used standalone screens because they provide sufficient screening without removing excessive volumes of organic materials, which minimizes the need for a washer and compactor. However, coarse screens with smaller openings can still remove organic material. For these screens, washer and compactor should be considered. Coarse screens are commonly used today in dual-stage screening processes to provide protection and reduce blinding of fine screens. Coarse screens are cleaned mechanically, which allows the screening media to be mounted in a more vertical position,

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typically 70 degrees or more from the horizontal. The most common types of mechanically cleaned bar screens are listed and compared in **Table 1**.

TYPE OF SCREEN	ADVANTAGES	DISADVANTAGES
CHAIN OR CABLE DRIVEN SCREENS 	• Design in the market for many years • Simple channel construction • High screenings loading rate • Insensitive to Fat, Oil, and Grease (FOG) • Low headroom required	• Submerged components subject to wear and tear
RECIPROCATING RAKE SCREENS	• No critical submerged components • Widely used	• Low screening loading rate • High overhead clearance, particularly at deep channels
CONTINUOUS SELF-CLEANING SCREENS	• Medium to low headroom required • Allows a pivot design for servicing the unit above the channel	• Several moving components • Components subject to wear and tear
ARC SCREENS	• Simple design • Lower capital and operational cost • No drive parts under water • Utilizes 100% of channel width	• Limited to small to medium flow plants • Not suited for deep channels

Table 1—Comparison of Coarse Screens (WEF, MOP 8, 2017) (Photos: Courtesy of Duperon Corporation)

Fine Screens

Fine screens are devices with openings 0.5 to 6 mm (0.02 to 0.25 in.) that remove coarse screenings along with a higher degree of rags, wipes, stringy material, and organic matter. A washer and compactor, either integral to the screen or standalone, must be used with fine screens. If the fine-screening facilities remove solids equal to or less than 3 mm (1/8 in.), then it is a common practice to provide coarse screening before fine screening. Additionally, grit removal before the fine screens is also a common practice in this case.

Fine screens have more elaborate cleaning mechanisms compared with coarse screens since attached organic material is more difficult to remove from smaller openings. Mechanical cleaning of these screens is essential. The smaller the opening, the more critical cleaning performance is for proper operation. Water sprays or brushes are typically used for cleaning these screens. Brush cleaning can have a lower capture performance compared to water cleaning because over time the bristles may bend or may become wrapped in screenings. Hot water provides better cleaning results than cold water because it helps to remove grease that has adhered to the surface. The common types of fine screens are listed and compared in **Table 2**.

Microscreens

Microscreens are devices with opening less than 0.5 mm (0.02 in.) to retain fine, screenable particles and stringy material (such as hair) in the wastewater. They are typically used as a replacement for processes that required fine particle removal (such as certain membranes) or as a replacement for primary treatment processes. Some microscreens are configured similar to drum screens but use a fine mesh fabric as their screening media and are capable of removing solids from 0.1 to 6 mm (0.004 to 0.25 in.) on average. It is recommended that a coarse screen be installed upstream to protect the microscreen.

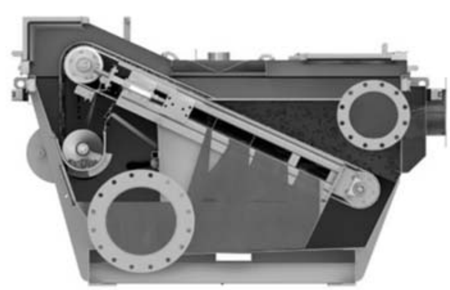

Figure 1— An Illustration of the Microscreen (Photo: Hydro International)

An illustration of the microscreen is shown in **Figure 1**. Special systems for cleaning these screens are typically provided and should be coordinated with the screening manufacturer based on the application required. Typically, high-pressure, water-jet cleaning is used. If the wastewater contains high concentrations of grease or scum, a hot water unit should be considered as part of the cleaning cycle for the screen.

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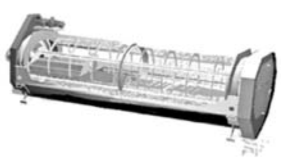
TYPE OF SCREEN	ADVANTAGES	DISADVANTAGES
CONTINUOUS ELEMENT SCREENS 	• Proven technology • High screenings capture rate • Allow a pivot design for servicing the unit above the channel • Suitable for high flows and deep channels	• Numerous moving parts • Submerged components subject to wear and tear • High headloss • High potential for grease blinding • Require additional motor/spray bars for cleaning • Potential screenings carryover
MULTIPLE RAKE SCREENS	• Widely used • High screenings loading rate • Low headroom requirements • Suitable for high flows and deep channels	• Submerged components subject to wear and tear • Medium headloss • High potential for grease blinding
STAIR SCREENS 	• Low headloss • Allow a pivot design for servicing the unit above the channel	• Stringy solids can pass through the screen • Not recommended when rocks or excess grit loads are expected • Require considerable footprint for installation
BAND SCREENS 	• Low screenings carryover • Well suited for expanding capacity without increasing the channel size	• Require pressure water for cleaning • Require special provisions for removing the unit from the channel • Difficult to access and maintain • Large solids removal may be an issue
DRUM SCREENS 	• Low screenings carryover; • Recommended for downstream processes sensitive to screenings (Membrane bioreactors (MBRs), integrated fixed-film activated sludge (IFAS), etc.)	• Require considerable footprint for installation • Require special hydraulic provisions for installation • High headloss required (pumping is usually required)
HELICAL BASKET 	• Low screenings carryover • Provides screenings washing / compaction in a single unit • Recommended for downstream processes sensitive to screenings (MBRs, IFAS, etc.)	• Requires significant footprint for installation • Not suitable for deep channels
STATIC SCREENS	• Minimal or no moving parts • Well suited for smaller facilities	• High headloss • Operator intensive • Susceptible to fast blinding

Table 2— Comparison of Fine Screens (WEF, MOP 8, 2017) (Photos: Courtesy of Huber Technology, Inc., Vulcan Industries, Headworks®, Baycor Fifre-Tech, Inc.)

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Types of Screening Media

Typically, there are four types of screening media used, which are bars, wedge wire, perforated plate, and mesh as shown in **Figure 2**.

Bar screen media is the most commonly used, especially for coarse screens and trash racks. The shapes of bars include rounded, rectangular, trapezoidal, and teardrop. Rounded bars have low capture efficiency and are only used on large opening bar racks. Trapezoidal bars have increasingly wide openings, allowing solids that pass through the narrowest opening at the front of the screen to pass through without getting trapped between the bars. Teardrop bars combine the benefits of the trapezoidal bars with better hydrodynamic flow characteristics, which minimize the headloss through the screen. Long vertical or horizontal gaps between bars can allow the passage of long and thin objects.

Wedge wire is a refinement of the trapezoidal bar screen, and is used in much finer screening applications. The same narrow-to-wide opening profile is used to prevent trapping solids between the openings. The narrower openings of wedge-wire screens result in much thinner media, which is why they are called "wires" instead of "bars". Wedge-wire screens also have long, vertical gaps and are not recommended by some manufactures of membrane bioreactor facilities because of the need to keep long and thin objects such as hair from accumulating on the membranes.

Perforated plates are more effective at capturing solids than bars or wedge wire when fine screening (such as hair removal) is required. The technology for perforated-plate is constantly advancing with the lower size limit currently at 1 mm. It has higher headloss due to decreased effective openings area, orifice losses, and increased blinding compared to bar or wedge wire media.

Mesh is used for fine screens 1 mm and smaller because of manufacturing limitations of perforated-plate media. Mesh media is more fragile and can result in "stapling" of solids within the media, which interferes with release of captures solids by the removal mechanisms. To avoid clogging the mesh, high-pressure, water-jet cleaning is recommended. Opening sizes in the mesh media is defined by the side-to-side distance.

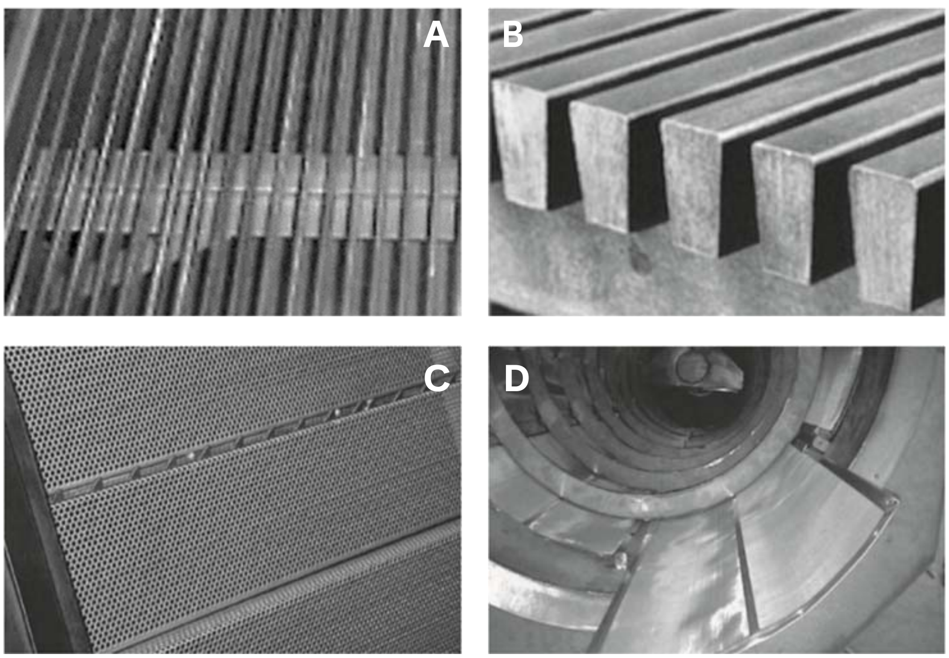

Figure 2— Type of Screen Media

(A) Bar Screen Media (WesTech); (B) Wedge Wire Screen Media (Industrial Screen Products, Inc.); (C) Perforated Plate Panels (JWC Environmental); (D) Mesh Media in Drum Screen (Baycor Fibre Tech, Inc.)

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Methods of Screens Cleaning

A mechanically cleaned screen is almost always specified for new facilities of all sizes, especially in combined systems where high quantities of storm water debris and screenings are needed to be handled. However, manually cleaned screens are still an appropriate alternative for smaller plants with few screenings. The method of cleaning the screens, manual or mechanical, are compared in **Table 3**.

	MANUALLY CLEANED SCREENS	MECHANICALLY CLEANED SCREENS
ADVANTAGES	• Low equipment costs • Little or no equipment maintenance	• Improved flow conditions and screening capture • Lower labor costs Reduced nuisances
DISADVANTAGES	• Flow surges and lower solids-capture efficiency during manually cleaning • Increased labor costs	• Higher equipment maintenance cost • High equipment costs

Table 3— Comparison of Screens Cleaning Methods

Design Considerations

The location of screening devices varies at different the treatment facilities. Screens can be located either upstream or downstream of influent pumps, because many common, and particularly larger, raw wastewater pumps are capable of pumping screenings. Screens are typically located upstream from the grit removal system. When fine screens are used, they could be located either upstream or downstream of grit removal, depending on the screen opening size provided and the anticipated impact on grit concentration equipment.

The condition of equipment design, climate and odor control needs should be evaluated to determine whether the screens should be in an enclosed area. A heated enclosed structural should be provided in climates with freezing temperature. The screen rake and discharge chute areas should be covered in windy areas. Regardless of whether the screening equipment will be housed, drive mechanisms of a mechanically cleaned bar screen should be enclosed. Designer should also follow manufacturer's recommendations for channel dimensions, capacity ranges, upstream and downstream submergence, power requirements, headloss information, and screening retention.

When designing a manually cleaned screen, relatively shallow screening channels are needed to allow manual cleaning with a rake. A drainage plate is provided to allow drainage of the screenings before shoveling. The container used to carry the screenings to a truck or other transport may range from a wheelbarrow to a bin carried by an overhead crane or monorail. Whatever the means of conveyance, designer should pay special attention to operator safety, including nonslip platforms and railings.

Adequate safety factor for determining peak screening quantities must be carefully considered in the design of screening, washer and compactors. Previous studies suggested peaking factors from 4 to 6 up to 15. Mechanically-cleaned screens must withstand instantaneous peak screening loads and careful coordination with the screen manufacturer are necessary for an adequate mechanical and structural design. Flow-paced variable frequency drives can be used to minimize wear on the collection equipment while preventing excessive headloss during instantaneous peaks.

Other design considerations include:

- Equipment height and footprint
- Discharge height to accommodate screenings conveyed or washer/compactor equipment
- Construction materials and coatings for overall unit
- Spare parts
- Provisions for removing the screen for maintenance, including pivoting designs and building skylights
- Provision of redundant screen or bypass manual screen
- Access for futures screen replacement
- Water access for cleaning and maintenance
- Hazardous classification of buildings and ventilation requirements
- Washing and compacting requirements
- Screen cleaning mechanism and availability of wash water if necessary

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Fine screens require exceptional design considerations because the high capture rate of these screens makes them more susceptible than coarse screens to blinding and damage from large objects. Main design considerations include if (1) screening is required before influent pumping, (2) coarse screening is required prior to fine screening, (2) grit removal is required before fine screening, and (3) grease/scum removal is also required for proper operation. It is good practice to include coarse screening before fine screening, particularly in a combined sewer system. Determining whether to include coarse screening is site specific. Below are the key factors should be considered when making that determination.

- The type of sewer system. Compared with sanitary sewers, combined sewer systems carry larger objects that could be difficult to remove or even cause damage to some types of fine screens. Combined sewers also have higher first flush solids loads that could affect screening equipment.
- The type of fine screen. There are certain types of fine screens that are more likely to operate with no problems without coarse screening ahead of them. For example, multiple rake screens and stair screens have proven to work properly in these conditions. In contrast, perforated plate fine screens are more likely to require coarse screening because these screens are more prone to damage by large objects. Microscreens rely on coarse screening systems being installed upstream for proper operation.

Performance

The screen retention quantity is a function of wastewater characteristics. Unwashed, uncompacted screenings can contain 10% to 20% dry solids with a bulk density ranging from 600 to 1100 kg/m3 (40 to 70 lb/ft3). Typical performance specifications for washer/compactors are 90% reduction in organic content and an increase to 50% in dry solids.

Transport, Storage and Disposal

In mechanically cleaned units, rakes or the screen media move screenings up the screen to above-deck where they discharge to a conveyor, sluicing troughs, washer and compactor, or removable containers. Some dewatering of the screenings typically occurs as they are lifted from the wastewater. When discharging screenings directly from screen to container, sufficient clearance under the discharge chute must be available for easy placement and removal. Belt conveyors are the most common method of screenings transportation. Screens discharging to conveyors should be provided with enough clearance to allow use of a container if the conveyor malfunctions. Screw augers are typically used in an enclosed system that required odor control. Sluice channels are only used in conjunction with a washer or compacter.

To complete the handling of screenings, the material must be transported for disposal in accordance with local, state, and federal regulations. Disposal of the screenings is typically in municipal landfills. However, restrictions are becoming increasingly strict. United States Environmental Protection Agency (U.S. EPA) Method 9095B (known as the Paint Filter Liquids Test) has historically been used to regulate maximum moisture in the screenings being landfilled, requiring no free water to be present. Designer should follow these rules for screenings disposal.

References

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Acknowledgments

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