The Fine Art of S

Historically, coarse screens have been used to protect downstream pumps and unit processes from being damaged by large debris within wastewater collection systems. Because the space between bars ranges from 12 to 50 mm (0.5 to 2 in.), some debris is able to pass through the openings and collect in the downstream processes or piping systems. This debris accumulates in corners or dead spots of unit processes and becomes malodorous. Furthermore, the debris causes premature wear and tear on pumping equipment and valves if it enters pumping systems. Debris also clogs pipelines, requiring additional maintenance and further reducing pumping capacity, which increases energy costs. Operation and maintenance (O&M) costs to clean up the debris that passes through screens can be substantial.

Recently, there has been a trend toward replacing coarse screens with finer screens that have openings of 6 mm (0.25 in.) or less to prolong the life of downstream equipment, improve solids quality, and enhance screen compatibility with several small-footprint and high-rate technologies. With membrane bioreactors, for example, fine screens of 1 to 3 mm (0.04 to 0.12 in.) are essential to maximize performance and membrane longevity. While a range of 1 to 6 mm (0.04 to 0.25 in.) for fine-screen openings may seem insignificant, the associated O&M cost impacts can be considerable.

Numerous companies manufacture fine screens, which can be grouped into four main categories (see Table 1, p. 54). Selection of a fine screen brings into play a new set of critical design considerations and challenges. For example, solids-handling facilities must be designed to accommodate the increase in material that will be removed. It is necessary to review the critical considerations associated with the design of new fine-screening facilities or the retrofit of existing treatment plants with fine screens. These include overall facility layout, hydraulic constraints, depth limitations, minimum number of screens, handling of screened material, and normal versus intermittent operations.

Overall Facility Layout

Several important features should be considered when designing an in-channel fine-screen facility. The first is the angle of screen installation. Most in-channel fine-screen installations, regardless of type, are inclined 60 to 80 degrees from the channel floor, with the optimum angle being 75 degrees. Because of this requirement, fine screens generally are not installed in vertical applications without a modification to the existing structure. As a result, it generally is cost-prohibitive to retrofit a facility with a vertical coarse screen.

As for advantages, fine-screening facilities offer ease of maintenance and elimination of confined-space entries. Fine screens can be rotated out of screening channels for preventive maintenance and service. Most fine screens are designed with a pivot point to allow the screen to be rotated into a position that is parallel to the operating floor. This eliminates the need to enter the screening channel from the operating floor. A pulley system or winch can be provided to aid in rotation. Enough space, however, is needed in the overall facility to allow the screen to be rotated out of the channel. This will increase the facility cost, because both the substructure and superstructure in front of the screen must be expanded; however, the tradeoff is reduced mainf Screening

Use of a fine screen conjures up a unique set of design considerations and challenges

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tenance costs, because O&M personnel do not have to work in a confined space when servicing the screens. Space allotment downstream of the fine screens is similar to that for coarse-screen applications — space should also be provided for collection, transportation, and washing or compacting of the matter that is removed by the screens.

Hydraulic Constraints

With untreated wastewater entering most fine-screen facilities, in-line screening channels must be designed with an approach velocity of 0.6 to 1.2 m/s (2 to 4 ft/s). Velocities must be greater than 0.3 m/s (1 ft/sec) and less than 1.4 m/s (4.5 ft/s) at low and peak storm flows, respectively. This will prevent solids and grit disposition at low flows and screening material from being forced through the fine screen at peak flows. However, one drawback of using a fine screen is increased head loss, as the effective opening area of a fine screen is significantly reduced. As the opening size decreases, head loss increases (see Table 2, p. 54).

Head losses through various-size openings at the same flow based upon minimum and maximum approach velocities are shown in the figure on p. 55. As shown in the graph, a head loss allowance of 0.3 to 0.8 m (1 to 2.5 ft) through the screen and its associated channel is required. At smaller openings, as much as 0.9 to 1.5 m (3 to 5 ft) of head loss may occur. Therefore, an additional 0.3 to 0.6 m (1 to 2 ft) of head loss should be expected in a new facility versus a traditional coarse-screen installation, which typically is designed with 0.3 m (1 ft) of head loss. The additional head loss may prohibit a fine screen from being installed in an existing facility that already has limited hydraulics.

Another challenge in retrofitting facilities is designing a screen channel within the minimum and maximum velocities. With a deep channel and smaller screen-opening sizes, channels have to be wide enough to maintain the 0.3- to 1.4-m/s (1- to 4.5-ft/s) velocity. The width requirement also affects the overall facility cost, as well as the cost of the stainless steel screen.

Depth Limitations

Fine screens generally are limited to being installed at a depth of 7.6 to 9.1 m (25 to 30 ft). Installing a fine screen at a 75-degree angle at this depth necessitates a longer facility and, therefore, increases costs. Because fine screens are made of stainless steel, these costs are significant due to the need to strengthen the frame and structural members. For deep installations, providing an intermediate floor where the screening material may be removed will help reduce the screen cost. However, removing the filtered screened material from the intermediate floor will increase O&M costs.

Minimum Number of Screens

Most states' minimum design requirements call for a complete redundant screen that can meet peak hourly flow rates. Therefore, a minimum of two screens is required in any installation. In lieu of providing a redundant screen, a bypass channel with a manual bar rack can be installed. Another factor affecting the minimum number of screens is the potentially large flow range that occurs between the low nighttime flows and peak storm events. As previously

Table 1. Fine Screen Types

Type	Drum	Step	Center flow (band)	Bar rack
Advantages	Effective screenings removal Low head loss Available in 1- to 6-mm sizes	Effective screenings removal Handles grease	Effective screenings removal Available in 1- to 6-mm sizes	No submergence of mechanical parts Possible to install vertically
Disadvantages	Perforation more prone to clogging with grease	High head loss Shallow or wider channel required Only 6-mm size available	Perforation more prone to clogging with grease High screenings removal means more material	High head-room requirements Not as efficient as other screens Only 6-mm size available

Table 2. Available Fine-Screen Openings and Effective Open Areas

Hole Spacing	Area Open
9 mm (0.375 in.)	55%
6 mm (0.25 in.)	40%
3 mm (0.125 in.)	35%
1 mm (0.04 in.)	31%

mentioned, minimum and maximum velocities have to be maintained in the upstream channel. Due to hydraulic limitations and channel width and depth requirements, it may be necessary to provide multiple screens if the screening facility must treat a broad range of flows. This will allow minimum and maximum velocities, as required.

Several design features can be incorporated to mitigate the impact of high flow variations and possibly minimize the number of screens. Installing baffles or providing concrete fill in the upstream screening channel, or raising the influent channel can help accommodate flow variations. Baffles or concrete fill in the corners of the upstream channel reduces the channel area, which will increase velocity during low flows. However, during peak-flow storm events, the flow will rise above the reduced area. The maximum design velocity can be maintained during high flow events due to the increased channel volume.

The second option is raising the upstream channel. In Rogers, Ark., a new headworks facility is being designed with only two 6-mm (0.25-in.) screens for a flow variation from 18,900 to 181,700 m^3/d (5 to 48 mgd). An overflow weir to an equalization basin has been provided upstream to limit the maximum flow. Raising the upstream channel has minimized the channel depth to better accommodate low flows. At peak-flow storm events, the screen will be more submerged; however, the increased channel depth will prevent the peak flow from exceeding the maximum allowed velocity.

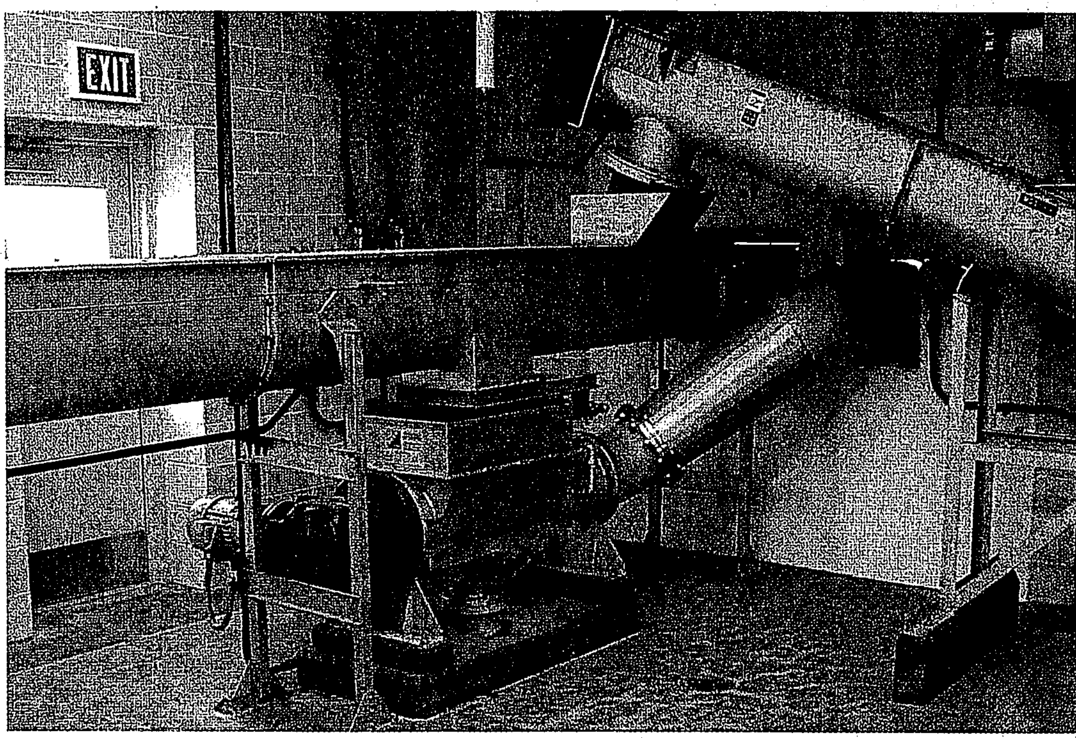
Handling of Screened Material

When configuring a solids-handling system for a fine-screen facility, the quantities and characteristics of the collected material and the final disposal location should be considered. Generally, because most screening material is landfilled, it should pass a paint filter test before being disposed. The amount of captured solids increases significantly with smaller screen openings, requiring a washer and compactor. A shaftless screw conveyor or belt conveyor should be installed to collect and transport the removed screening material to the washer and compactor. The belt conveyor option will provide additional dewatering of the removed screening matter as it is transported.

Quantifying the screenings material for various screen-opening sizes has yet to be completed, so data on the amount and characteristics of screening matter are scarce. Many equipment suppliers provide a range for the amount of material removed, based on the screen opening size. It seems that a rate of 0.4 to 0.8 m^3/ML•d (2 to 4 yd^3/mgd) is possible, and that screened matter is only about 10% to 20% of total removed material.

Normal Versus Intermittent Operations

Fine screens, like coarse screens, generally do not operate continuously. Rather, they depend on upstream and downstream water levels. However, a fine screen can be operated with a timer. Most manufacturers provide the means to determine the differential head upstream versus downstream in a screen's operating control panel. During normal flows, the screen indexes up for a few feet to allow matter to build up on the face of the screen. Many manufacturers recommend that the screen operate at a condition of being blinded



Use of a short disposal chute from the washer-compactor equipment prevents screening matter from solidifying.

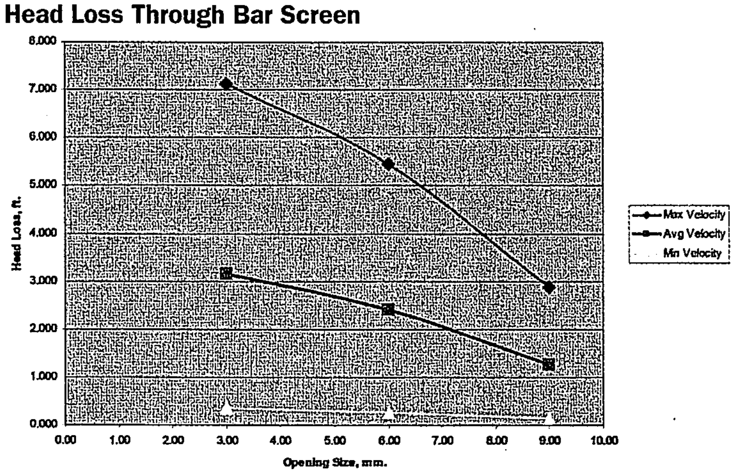
50% to 70%, which increases removal rates. As a result of the screen moving only a few feet, it will take some time to remove screening matter from the influent channel. This will enable some water to drain from the screen material. A washwater connection is recommended to facilitate removal of screened matter. During normal operation, the associated solids-handling equipment should be interlocked with screen operation.

During peak flows, however, it is important to modify operation so that collection also increases, resulting in higher head losses. Fine screens should be operated continuously during peak flows to reduce head loss. Furthermore, it is important to install a short disposal chute from the washer–compactor equipment.

Washer–compactor equipment reduces the screening matter to one-tenth of the original volume. In a continuous operation, this is not an issue. However, with an intermittent operation or peak-flow facility, with several weeks to months between operation, the screening matter will solidify within the discharge chute and become difficult to remove. Therefore, the chute should be short, or there needs to be a means to remove the material from the washer–compactor discharge chute after operation.

Selection of a fine screen significantly affects a new or existing facility. Several factors should be carefully considered and addressed in the design of a fine-screen facility and associated solids-handling equipment.

Head Loss Through Bar Screen



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