ickling filters have been the workhorse of the wastewater treatment industry for over 100 years, and this trend will continue well into the future. These filters consist of a fixed bed media fill through which wastewater is “trickled.” The term trickling filter can be a bit misleading as no physical filtration actually occurs in a trickling filter system. Rather, the filter serves as a host for microorganisms that grow on the media fill to form biofilm. It is the biofilm which biochemically extracts pollutants from wastewater: as wastewater comes into contact with the biofilm and air, pollutants are diffused to the biofilm and are converted into harmless compounds. Trickling filters drain at the bottom, and the effluent is sent to clarifiers where the solids can settle out. A modern trickling filter in operation is shown in Figure 1.

### Relevancy of Trickling Filter Technology

Contemporary trickling filters can be built up to 40 feet tall and contain high-performance, structured-sheet plastic media, in combination with modern distribution and ventilation systems. The treatment capacity of these filters has been significantly increased in comparison with earlier mid-century filters. The applications of trickling filter technology have also been greatly expanded beyond early biochemical oxygen demand (BOD) roughing filters to include secondary carbon oxidizing and tertiary nitrification filters.

Trickling filter technology is both simple and reliable. With fewer moving parts than activated sludge systems or other treatment options, trickling filters require significantly less maintenance and operational oversight. Trickling filters are also known to have better resistance to shock loadings due to the nature of attached growth.

Trickling filter technology is a green technology that requires less energy than other treatment options. Typically only requiring power for pumping and, in some cases, fans, energy consumption for trickling filters is much less than the power hungry aeration blowers used in activated sludge systems. When installed and operated properly, trickling filters are reported to use 30–50 percent less energy than the activated sludge process.

In other words, trickling filter technology is still very relevant today.

### Key Components of Trickling Filters

A typical trickling filter consists of a distribution system, filter media, an underdrain, a ventilation system, containment and, in some cases, a dome. Figure 2 displays the components of a modern trickling filter.

**Distribution System:** This system provides for even distribution of wastewater over the media. Modern trickling filters commonly use rotary type distributors, which consist of two or more horizontal pipes suspended above the filter media. The horizontal pipes are called distributor arms and rotate a few inches above the media, distributing wastewater through the orifices in the arm. The distributor arms can be hydraulically driven using the jet-like force of the wastewater flowing out of the orifices to allow for rotation, or it can be driven by other electromechanical means.

**Filter Media:** Early trickling filters used rocks as fill media, but poor ventilation and limitations on filter bed height due to excessive weight limited their practical use for increasing treatment capacity and performance. In the 1950s, synthetic fills – such as PVC structured-sheet media – were introduced and have been the dominant media choice for constructing new filters or upgrading older rock filters ever since. The weight of plastic media is only from two to three percent of the rock media, and the surface area for microorganism growth is from two to four times greater. The void ratio of plastic media is also much higher, which promotes ventilation and can
often provide a doubling in treatment capacity versus rock media trickling filters of the same size.

Several types of structured-sheet media have been developed for different applications. For example, vertical flow media is typically used for high strength wastewater roughing, while cross flow media is used for secondary treatment and nitrification applications. A mixed media combination of cross flow media at the top of the filter and vertical flow at the bottom can also be used for roughing applications. Media selection is driven primarily by the expected organic loading on the filter, as summarized in Table 1.

### Table 1. Trickling Filter Classification and Media Selection

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Organic Loading, lb/kcf/day</th>
<th>Removal</th>
<th>Media Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roughing Filter</td>
<td>100–220</td>
<td>40–70%</td>
<td>Vertical flow or cBOD</td>
</tr>
<tr>
<td>Oxidizing Filter</td>
<td>20–60</td>
<td>15–30</td>
<td>Cross flow media with large flutes</td>
</tr>
<tr>
<td>Nitrification Filter</td>
<td>5–15</td>
<td>&lt;10 mg/L</td>
<td>Cross flow media with large flutes</td>
</tr>
<tr>
<td>Nitrifying Filter</td>
<td>N/A</td>
<td>&lt;3 mg/L</td>
<td>Cross flow media with medium or small flutes</td>
</tr>
</tbody>
</table>

### Underdrain: Underdrain systems serve three purposes: 1) collecting treated wastewater for conveyance; 2) providing support to the media; and, 3) allowing air circulation through the media bed.

Conventional underdrains can be constructed with concrete piers or beams. An underdrain system consisting of field-adjustable plastic stanchions and fiberglass reinforced grating, as shown in Figure 3, is often used as an alternative to conventional underdrains. This pre-engineered system is more economical and offers better ventilation than conventional underdrain systems. Therefore, it is gaining popularity in both new installations and retrofits.

### Ventilation: The BOD removal and nitrification in a trickling filter are aerobic processes that rely on sufficient air flow for optimal performance. Older open trickling filters rely on natural draft for ventilation, using gradients in humidity and temperature between inside and outside air to drive circulation.

Domes are sometimes used in modern trickling filters to reduce temperature loss in the winter months and control odor. In domed systems, low pressure ventilation fans are used to maintain air movement.

### How to Maximize Trickling Filter Performance

The key to successful trickling filter operation is to produce and maintain the proper type and thickness of biofilm on the trickling filter media surface. A healthy biofilm requires the proper amount of oxygen, water and harvesting in order to produce the most efficient waste removal rates. (In trickling filter terminology, harvesting is called “sloughing.”)

Recirculation of wastewater flow to the trickling filter is considered the principal process control for a trickling filter. Recirculation of effluent can increase dissolved oxygen, ensure adequate wetting of the media, and control biofilm sloughing.

The wetting rate is the overall application rate of wastewater to the trickling filter, including both forward and recycled flow. Wetting rates can be controlled by recirculation and typically range from 0.25–1.5 gpm/ft² depending on the treatment objectives.

Another important operational parameter is the dosing rate, or SK rate, which reflects the intensity of the wastewater application. The SK rate can be controlled by recirculation and distributor arm rotational speed. The SK rate is recorded in millimeters (mm) or inches (in.) per pass. Higher SK rates are recommended for higher organic loadings to provide the effective sloughing necessary for biofilm thickness control. For normal operations, SK rates range from 25–200 mm (1–8 in.) per pass. For period flushing, the SK rate increases to 10-600 mm (4–24 in.) per pass.

Macro fauna, such as snails, occur in trickling filters and may cause nuisance problems, most of which can be controlled by flushing. A proven method for snail control is raising the wastewater pH to approximately 10, which will result in free ammonia that is toxic to snails. Snail traps have also been used in some facilities to remove snails.

### When Should Plastic Media be Replaced?

The service life for plastic media ranges from 20 to 30 years, although the top layer may need earlier replacement as it is subjected to UV degradation and hydraulic erosion. As a trickling filter approaches the end of intended service life, it is prudent to plan for media replacement in order to avoid poor treatment or catastrophic media structural failure. Several types of media failure are shown in Figures 4a–4c.

Some good questions to ask when considering media replacement include:

- **How is the trickling filter performing?** Decreased performance is likely an indicator of plugged media, which results in less surface area for biofilm, decreased ventilation and decreased treatment.
- **How does the trickling filter look from the top and bottom?** Puddling on the top, or uneven water drainage in the underdrain area, indicate plugging of media which may cause media failure.
- **What is the wastewater type?** Nitrifying filters typically last longer than industrial roughing filters, which have high organic loadings and heavy biomass growth, accelerating filter aging.

With proper initial process design, sound structural design and installation of the media tower, and periodic maintenance through
out the service life, trickling filters can provide many years of simple, effective and low cost treatment.

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