Continuous Rotating Belt Filtration for Primary Treatment and Combined Sewer Overflows

Miguel Gutierrez

An effective equivalent to screening and primary settling, rotating belt filters enable a design with minimal footprint, as well as implementation at a fraction of the life cycle cost of conventional technologies. Existing wastewater treatment plants needing an upgrade can implement these filters to expand primary clarification, relieve solids loading to the secondary system, or provide treatment for combined sewer overflows (CSO). The associated hair and grit removal provides a high level of protection for membrane plants.

There are multiple drivers for rethinking conventional settling and clarification, including footprint, level of treatment, and the power demands for operations. Rotating belt filtration is becoming an accepted solution to several distinct challenges in clarifying wastewater in municipal and industrial applications and the prevalence of use has grown, particularly in Europe, over the past two decades. With hundreds of plants around the world utilizing this technology, it is worthwhile to take a closer look at the design considerations.

Real estate can often make or break the feasibility of a wastewater system upgrade or expansion. Many plant expansions are halted, slowed, or come with astronomical costs due to lack of space. Upgrades, including the expansion of design flow to the facility of process redesign to incorporate biological nutrient removal (BNR), are examples of situations that would benefit from rotating belt filters (RBFs).

The RBFs can being integrated to gain back space. They require 5 percent of the footprint of a conventional clarifier and offer higher levels of primary treatment, including grit removal. Existing primaries can be expanded or changed over completely with RBFs, and the real estate previously occupied can be reallocated for secondary treatment. This strategy is being considered and applied throughout the United States, the South Pacific, and Asia. Figure 1 illustrates the relative footprint savings of RBF technology when compared to conventional primary clarification of the same performance capacity; the rendition on the left illustrate a nominal 3-mil-gal-per-day (mgd) footprint, while the rendition on the right illustrates a nominal 100-mgd comparison.

Designing RBFs as primary treatment in new plants will save capital expenditure in equipment and civil works. With a smaller footprint, there are potential savings in excavation, engineering, piping, and many other aspects of the capital project. The compact footprint and low life cycle cost make this technology a desirable method for treating sewer overflow.

Another beneficial aspect of treatment with RBFs is that the technology provides a physical rather than hydraulic sequestration of particulate and hair, which can create havoc in the secondary system. A range of activated sludge and fixed film secondary systems benefit from the mitigation of hair, as do membrane systems. Multiple membrane manufacturers around the world are transitioning to RBFs for primary and pretreatment in membrane plants to extend membrane life.

The RBFs are appealing from a life cycle cost standpoint as well. Implemented at a fraction of the construction cost of conventional primary tanks, is has a big up-front savings. Power usage savings, both in the primary treatment system as well as in downstream aeration, help provide a life cycle cost comparison that is one-fifth of the conventional costs associated with primary settling.

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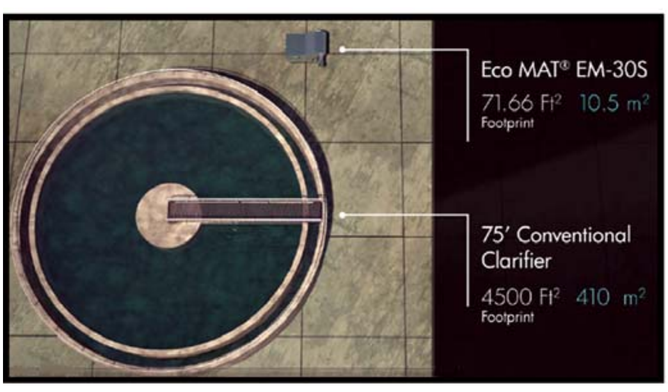
Method of Treatment

The RBFs remove solids through the use of a continuous-loop fine mesh belt screen. A side-view sketch of a RBF unit is shown in Figures 2. The belted screens move linearly, directed by filter headloss input to a programmable logic controller. As the screen moves, it acts as a conveyor and carries captured solids out of the incoming wastewater. A



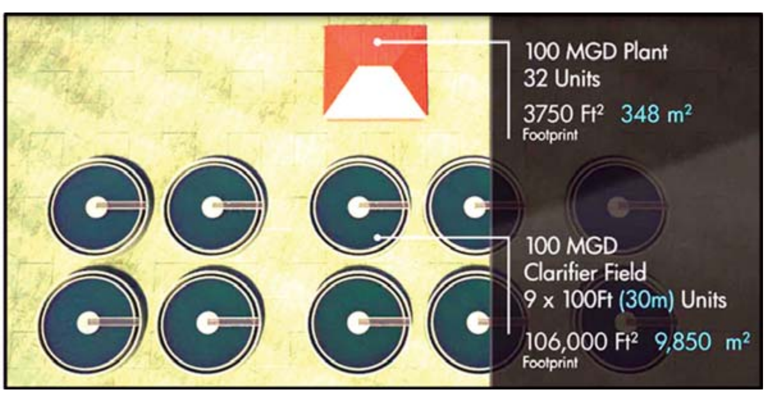


Figure 1. Scale Comparison of Rotating Belt Filters to Conventional Clarification With the Same Performance Capacity

capable cleaning system is a critical aspect of RBFs as the cleaning system is responsible for removing collected solids and providing a clean surface for treating incoming water. Solids from the belt screen are discharged and deposited into a screenings hopper.

The solids drop into a hopper and the screen is cleaned as it moves past the rollers. High-pressure water spray is use to dislodge the remaining solids off the belt. For applications with oil and greases, periodic hot water high-pressure washes are implemented to re-dissolve the oil and grease and to consequently regain the porosity of the belt. This method has proven highly effective over air backwash techniques, which tend to cook the oil and greases right into the pores of the belt. A screw press dewaters the collected screenings that have between 20-40 percent dry solids, while screened wastewater continuously passes through the unit. Dewatering screens pass a paint filter test, which is approved by the U.S. Environmental Protection Agency (EPA, 9095B) and helps determine if the dewatered solids have any free liquids after a predetermined sample is placed in a standard conical paint filter with a 60-mesh rating. If any portion passes through the filter in a five-minute period, the sample is deemed to have free liquid, making it unsuitable for landfill application.

The RBFs remove between 40-70 percent total suspended solids (TSS) and 20-40 percent biochemical oxygen demand (BOD) from

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Table 1. Performance Data: Plummer Wastewater Treatment Plant

Stats	TSS (mg/L)			BOD (mg/L)			Auger T.S.
	Influent	Effluent	Removal	Influent	Effluent	Removal	%
Average	260	86	67%	275	172	38%	31%
Min	125	19	33%	241	164	37%	27%
Max	485	125	87%	320	185	46%	37%
No Samples	30	30		7	7		7

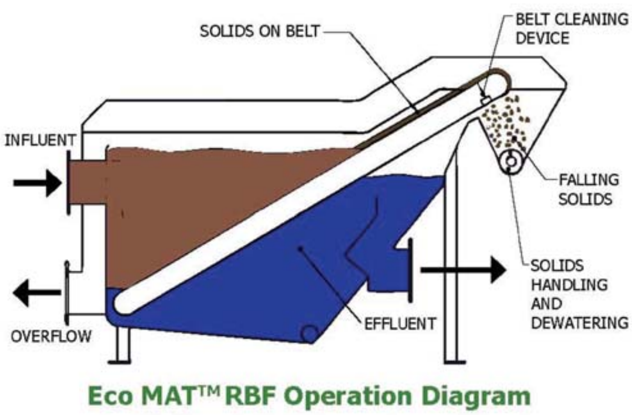

Figure 2. Rotating Belt Filters, Side-View Sketch

Figure 3. 1.7 mgd Capable Unit Tested at Plummer Wastewater Treatment Plant

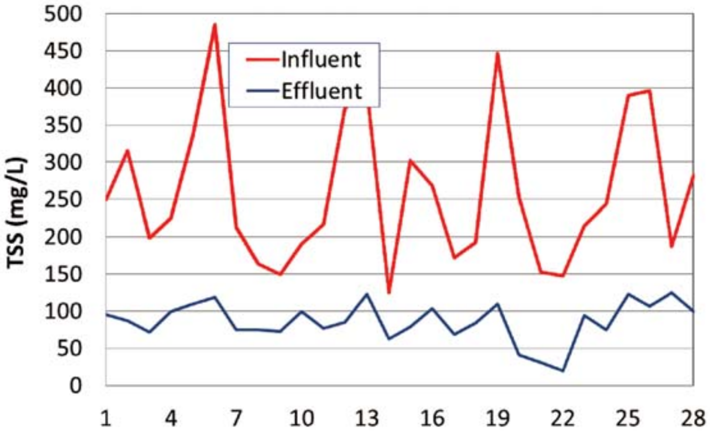

Figure 4. Total Suspended Solids Performance Data

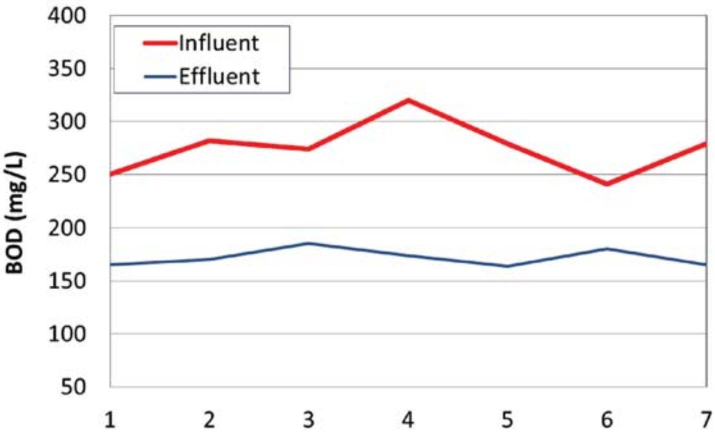

Figure 5. Biochemical Oxygen Demand Performance Data

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wastewater and the unique design allows for removal of organic and inorganic solids as fine as 15-30 micron. Removal efficiencies are affected in part by the ability to vary the belt speed. A slower belt speed results in higher capture rate of solids, creating a mat that not only results in a lower TSS effluent, but also shifts the particle size distribution for removal of smaller particulates. At higher belt speeds, the opposite effect seems to correlate; furthermore, the ability to control the belts' speed and porosity allows a relative customization of a particular BOD performance to increase the efficiency of downstream biological digestion processes.

The RBF units are compact, completely enclosed, low-maintenance solutions for wastewater. The integral odor containment of the design allows for indoor installation in a clean environment, and some models are even designed for food-grade compatible maintenance regulated by the Food and Drug Administration (FDA). Three manufacturers in the industry offer standard equipment, ranging in sizes suitable for small communities to large cities. There is no limitation in flow capacity designs.

Multiple engineering firms around the world have had an opportunity to study the umbrella of primary treatment technologies, and their reports deserve a studious look. To date, this technology has been installed on every continent around the globe. Case history, design considerations, and lessons learned from implementation of this treatment technology will highlight some of the residual benefits and operation and maintenance (O&M) savings to a municipality.

Primary Treatment Expansion with Capital Affordability: City of Plummer (Idaho) Wastewater Treatment Plant

The City of Plummer, Idaho, is a small community of approximately 1,000 residents. Having commissioned a wastewater treatment plant in 2010 for advanced nutrient treatment to discharge less than 0.05 mg/L, it has struggled with the headworks configuration of its facility, primarily with grease and solids plugging the installed screens. The City's most effective option to reduce O&M costs was to test a self-cleaning RBF unit that can effectively handle variable influent quality and levels. Figure 3 shows the RBF unit tested at the facility.

The performance modeling completed during the summer of 2012 shows consistent removal of TSS between 33 and 87 percent and particulate BOD between 37 and 46 percent. The flow tested averaged 363 gal per minute (gpm), ranging from 283 to 434 gpm. Table 1 summarizes the overall results and Figure 4 and 5 depict the data graphical representations for TSS and BOD performance. This system will mitigate past O&M expense associated with the old headworks and screening configuration. Performance charts illustrate a dampening effect on influent condition extremes. The level of TSS and BOD delivered to the biological portion of the plant is more consistent following the RBF, leading to a more stable biomass in the secondary system.

City of McHenry, Ill.

The wastewater division maintains and operates the City of McHenry's two wastewater treatment plants and 19 wastewater lift stations. Its goal is to efficiently maintain these facilities and to produce plant effluents meeting both state and federal standards. The division regularly performs testing to operate the plant and to report to the state EPA.

The performance modeling completed during the spring of 2013 shows consistent removal of TSS between 24 and 63 percent and particulate BOD between 22 and 49 percent. The flow test averaged 169 gpm, ranging from 125 to 225 gpm. Table 2 summarizes the overall results. The level of TSS and BOD delivered to the biological portion of the plant is more consistent following the RBF technology, leading to a more stable biomass in the secondary system. Figure 7 and 8 depict the TSS and BOD achieved with the RBF unit

Figure 6. 0.5 mgd Capable Unit Tested at City of McHenry Wastewater Treatment Plant

Table 2. Performance Data: City of McHenry Wastewater Treatment Plant

Stats	TSS (mg/L)			BOD (mg/L)			Auger T.S.
	Influent	Effluent	Removal	Influent	Effluent	Removal	%
Average	122	60	49%	252	171	31%	45%
Min	82	43	24%	198	132	22%	43%
Max	201	75	63%	390	198	49%	47%
No Samples	9	9		9	9		7

Primary Treatment of Inflow and Infiltration and Combined Sewer Overflow Conditions: City of Glendale, Ore.

During heavy rains and snow melts, the City of Glendale inflow and infiltration (I&I) inflow results in the bypassing and discharging of raw sewage to nearby Cow Creek. To demonstrate the effectiveness of RBF technology as the appropriate solution, the treatment objectives of operations were to remove a minimum of 50 percent TSS and 30 percent BOD. Treatment objectives were safely met during the pilot demonstration. As a less expensive alternative to a complete plant upgrade, the RBF unit cost ranges from $0.05-$0.10 per gal/day treated. Installation requires little civil work

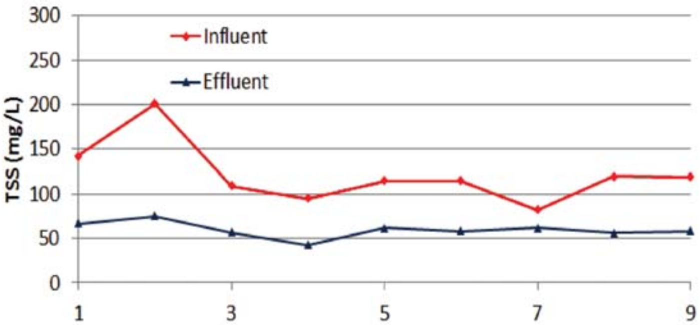

Figure 7. Total Suspended Solids Performance Data

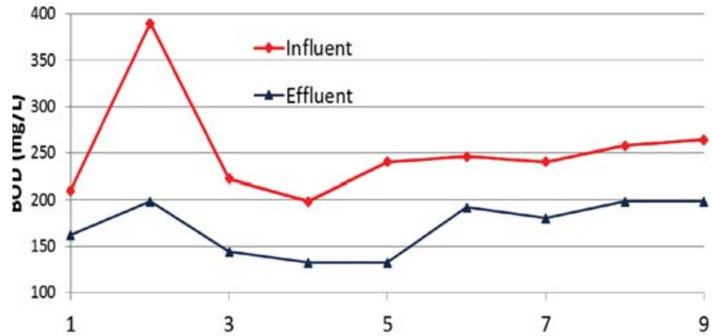

Figure 8. Biochemcial Oxygen Demand Performance Data

and construction, and the unit requires roughly the footprint of an automobile to treat the peak flows that Glendale experiences.

Demonstration Site Description

The design capacity of the Glendale wastewater treatment facility is 0.451 mgd, or 313 gpm. Subunits of the plant process are as follows in order of water flow:

- Wet well immediately upstream of headworks. This gives operators the ability to bypass the plant during washout level flows and direct water to the outfall (Cow Creek).
- Raw sewage pumping station through headworks.
- Activated sludge treatment consisting in aeration, reaeration, and clarification.
- Tertiary sand filtration.
- Disinfection with liquid hypochlorite.
- Waste activated sludge (WAS) is routed to the aerobic digester and thickened utilizing a waste reduction unit.

The filtered effluent is discharged year-round to Cow Creek through a single outfall. The Glendale wastewater treatment facility receives an average of 100,000 gal per day (gpd), or 69 gpm, and 1 mil gal per day (mgd), or 690 gpm, under typical peaking conditions. According to the Glendale treatment plant staff, the plant produces approximately 117,000 gal of sludge per year, and the sludge is land-applied from June through October. By implementing RBF technology, Glendale would be able to bypass the existing plant during periods of peak flow without discharging raw sewage to Cow Creek. As the testing demonstrated, a very high level of solids and BOD removal can be accomplished. Combined with disinfection, the RBF technology can help facilities like Glendale minimize the environmental impact observed during peaking flow conditions.

Total Suspended Solids and Biochemical Oxygen Demand Compliance

The equipment ran smoothly without upsets, and maintained good performance throughout. Challenges with I&I and CSO peak wet weather flows included treating a diluted influent and dealing with the added volume that is typically much higher than plant capacity. Typical raw wastewater to municipal plants ranges from 200-450 mg/L in TSS. During periods of I&I, the TSS is significantly diluted to 50-150 mg/L. Diluted water streams are typically harder to treat with desired efficiency. The data set from this demonstration suggest that the RBF technology can maintain the minimum treatment efficiency of 50 percent TSS removal, easily meeting the challenges posed by peaking flows due to I&I. For this demonstration, influent TSS analysis contained no outliers and averaged 222 mg/L. Figure 9 illustrates the influent TSS consistency as separated from the filtration belt.

Variable operations beyond plant control

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Figure 9. Influent Total Suspended Solids off the Belt by Nonmechanical Cleaning System

Table 3. Performance Data: Glendale Wastewater Treatment Plant

Stats	Flow	TSS (mg/L)			BOD (mg/L)			Auger T.S.
	(gpm)	Influent	Effluent	Removal	Influent	Effluent	Removal	%
Ave.	95	222	51	68.5%	212	75	53%	36.7%
Min	65	137	28	50%	141	44	39%	36%
Max	155	411	92	91%	415	113	89%	37%
No.		12	12		12	12		

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occurred during the demonstration, resulting in influent levels a little higher than desired for influent infiltration or CSO applications and were handled effectively by the RBF unit. The unit treated a flow of 95 gpm on average and the flow ranged from 65 gpm to 155 gpm. Effluent TSS averaged 51 mg/L, which corresponds to a 68 percent removal of TSS. Removal of BOD was likewise very efficient; influent averaged 212 mg/L and the effluent averaged 75 mg/L. This corresponds to a reduction of 53 percent. Table 3 summarizes the performance achieved. Figure 10 depicts the percent removal of TSS and BOD as it corresponds to the flow range tested.

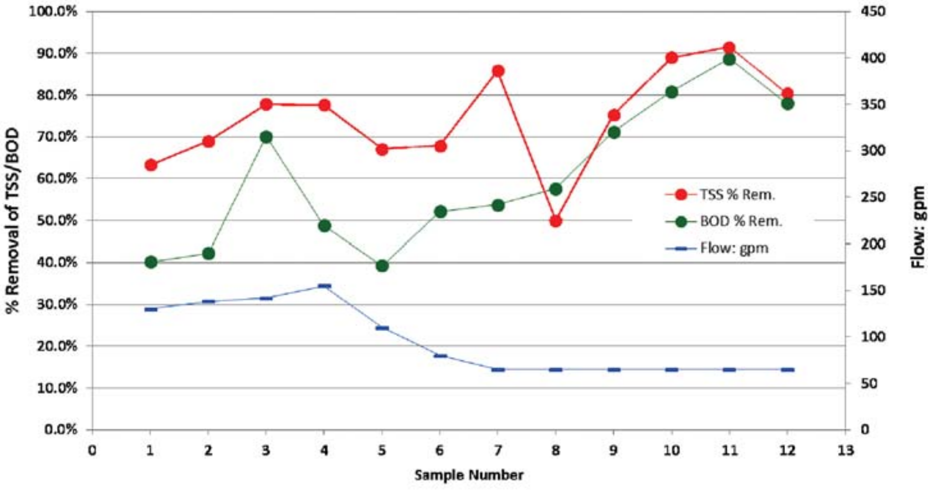

Figure 10. Percent Removal for Total Suspended Solids/Biochemical Oxygen Demand and Flow Rate Range at Glendale Wastewater Treatment Plant

Maximum BOD values were noted and were due to upstream dischargers such as restaurants or other industries. The level of treatment was nonetheless maintained during each day of operation. Composite of influent and effluent wastewater were also sampled for laboratory analysis. Results were very positive and showed slightly higher removal than that shown in grab samples. The TSS removal was 77 percent and BOD removal was measured at 67 percent. This demonstrates a reliable and sustainable process over an extended period of time during which influent conditions are constantly in flux. The equipment was operated at slightly lower hydraulic loading in order to get the highest removal possible for I&I and CSO applications. As a design parameter, the requirement of 50 percent TSS removal and 30 percent BOD removal could be comfortably achieved. This would allow the City of Glendale to treat wet weather flows to the levels outlined for discharge compliance.