EDITOR’S FOCUS

A Compact Solution for CSO Treatment

In December 2002, the city of Toledo, Ohio, signed a consent decree with the U.S. Environmental Protection Agency (EPA) that required the city to update its sewer and wastewater treatment facilities to stop wet weather bypassing of untreated wastewater into the Maumee River. To achieve regulatory compliance associated with combined sewer overflow (CSO) events, it was determined that the Bay View Wastewater Treatment Plant (WWTP) must increase its total treatment capacity from 200 to 400 million gallon per day (mgd), or approximately 5.3 times the average dry weather flow rate.

Prior to the final design, pilot testing of high-rate clarifier technologies was conducted from December 2002 to February 2003 to determine the feasibility of using this technology to achieve the required effluent criteria for both primary and CSO wastewaters. Based on the results of the pilot study, the DensaDeg high-rate solids contact clarifier, manufactured by Infilco Degremont, Inc., was chosen for the full-scale installation.

Based on the design parameters, it was determined that the facility would need six of these clarifiers. In November 2006, the construction of the largest high-rate clarification system for CSO treatment was completed. The overall layout can be seen in Figure 1, and a picture of the constructed facility is shown in Figure 2. The maximum design capacity for the facility is 232 mgd with each of the six high-rate clarifiers having the capacity to treat 38.7 mgd at a surface overflow rate of 47 gpm/ft².

The clarifier

The DensaDeg clarifier is a high-rate solids contact clarifier that combines optimized flocculation, internal and external sludge recirculation and lamellar settling to achieve very high hydraulic loadings and treatment efficiencies. It is well proven in the field of physical and chemical treatment of wastewater and drinking water and has been employed for a wide range of municipal and industrial applications.

The DensaDeg 2D-100 for physical and chemical treatment of raw municipal wastewater, CSO and sanitary sewer overflows (SSO) combines coagulation, flocculation, static and lamellar clarification, scum removal and sludge thickening in a single treatment unit. Optimized flocculation and solids contact through internal and external sludge recirculation produces dense floc with an extremely high settling rate (typical design rates are 40 gpm/ft² with the hydraulic capacity to accommodate rise rates up to 60 gpm/ft², with a moderate reduction in treatment efficiencies) without adding ballast materials such as sand.

The process

Rapid mix. The first step in the clarifier process, coagulation, takes place in a single vessel. A coagulant, either aluminum or iron salt, is injected directly into the inlet pipe, or if possible, upstream in the feed channel. Mechanical mixers cause an intense bulk fluid motion for coagulant dispersion and mixing. The flow then passes to the reactor vessel.

Reactor vessel. The reactor vessel is where particle flocculation and densification occurs. The flocculation reaction is optimized in the reactor vessel through the combined effects of internal sludge recirculation, high solids concentration and efficient mixing. A high concentration of solids is maintained in the reactor through external recirculation of settled solids from the clarifier/thickener vessel. Internal recirculation is achieved through an axial flow impeller/draft tube arrangement. Polymer, usually a high molecular weight anionic type, is injected either directly beneath the impeller blades or in the sludge recirculation line. Polymer aids in the flocculation and densification of the coagulated particles.

Clarifier/thickener vessel. Quiescent conditions exist in the clarifier/thickener vessel, where the dense floc particles formed in the reactor vessel are allowed to settle and thicken. A circular, picket fence-type scraper mechanism collects...
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Fox Metro plans to install two additional AquaDiamond sand filters, while backwashing less. The AquaDiamond filters with 80’ long AquaDiamond retrofitted three of its nine existing 16’ x 112’ traveling bridge sand filters within the same footprint. The AquaDiamond filters easily retrofits into existing traveling bridge sand filters while providing higher hydraulic and solids loading rates in a smaller footprint. This filter media filtration in a lower profile, diamond configuration. This filter filters provide a peak flow capacity of 72 MGD, which is a perfect match for the Bay View WWTP facilities; weather Bay View WWTP. Based on the incoming flow and status of the equalization basin volume, multiple modes of operation are available. The excess flows can be directed to the high-rate clarifiers, and effluent produced can then be sent to the activated sludge system. Or, during high flow events, HRC effluent can be directed to the equalization basin, and when the basin reaches design capacity, the flow is then directed to the dedicated wet weather disinfection system and blended with the plant effluent from the dry weather facilities before it is discharged into the Maumee River. The four main operational scenarios are summarized in Table 1.

### Smaller Footprint

The AquaDiamond® filter offers the benefits of OptiFiber™ pile cloth media filtration in a lower profile, diamond configuration. This filter easily retrofits into existing traveling bridge sand filters while providing higher hydraulic and solids loading rates in a smaller footprint.

### Plant Profile

Fox Metro Water Reclamation District, located in Oswego, Illinois retrofitted three of its nine existing 16’ x 112’ traveling bridge sand filters with 80’ long AquaDiamond® cloth media filters to solve its ongoing maintenance and performance issues. The three combined AquaDiamond® filters provide a peak flow capacity of 72 MGD, which is almost 2.5 times the hydraulic capacity of the original three sand filters, within the same footprint. The AquaDiamond® filters have also proven the ability to perform under higher solids loading conditions than the sand filters, while backwashing less. Fox Metro plans to install two additional AquaDiamond® filters in 2007, resulting in a total of five filters with a combined peak flow capacity of 120 MGD.

### Benefits

- Unique OptiFiber™ pile cloth media
- Reuse quality effluent
- Higher solids loading per ft² of media
- Reduced backwash water volume
- Higher hydraulic loadings
- Reduced footprint
- Less maintenance
- Disk and drum configurations also available

### Applications

- Municipal and Industrial
  - Tertiary filtration
  - Reuse/recycle
  - Phosphorus removal
  - New plants and retrofits

### Operational Strategy

One of the unique features that the DensaDeg facility provides is the ability to treat both primary and CSO wastewaters. In order to incorporate this flexibility of operation, an operational guideline was created for the Bay View WWTP. Based on the incoming flow and status of the equalization basin volume, multiple modes of operation are available. The excess flows can be directed to the high-rate clarifiers, and effluent produced can then be sent to the activated sludge system. Or, during high flow events, HRC effluent can be directed to the equalization basin, and when the basin reaches design capacity, the flow is then directed to the dedicated wet weather disinfection system and blended with the plant effluent from the dry weather facilities before it is discharged into the Maumee River. The four main operational scenarios are summarized in Table 1.

### Table 1: Operational Strategy Summary

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Operational Strategy</th>
<th>Operational Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q = 0 to 130 mgd</td>
<td>All flow is treated by the dry weather Bay View WWTP facilities.</td>
<td>• Up to 160 mgd is treated by the dry weather Bay View WWTP facilities;</td>
</tr>
<tr>
<td>Q = 130 to 190 mgd</td>
<td>Up to 160 mgd is treated by the dry weather Bay View WWTP facilities;</td>
<td>• 30 mgd is directed to the high-rate clarifier (HRC) facility—HRC effluent is routed to the activated sludge system;</td>
</tr>
<tr>
<td>Q &gt; 190 mgd</td>
<td>Excess flow are directed to the HRC facility;</td>
<td>• 30 mgd of HRC effluent is routed to the activated sludge system;</td>
</tr>
</tbody>
</table>

### Performance Testing

Based on the required operational flexibility of the Bay View WWTP, the performance testing was formulated to simulate the various operational scenarios. Each clarifier was tested individually to assess performance.
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### TABLE 2: Performance Test Summary - Average Removal Efficiencies and Average Concentrations*

<table>
<thead>
<tr>
<th></th>
<th>TSS</th>
<th>CBOD</th>
<th>Total P</th>
<th>Influent TSS</th>
<th>Effluent TSS</th>
<th>Influent CBOD</th>
<th>Effluent CBOD</th>
<th>Influent Total P</th>
<th>Effluent Total P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary treatment performance level</td>
<td>83%</td>
<td>54%</td>
<td>89%</td>
<td>121</td>
<td>17</td>
<td>116</td>
<td>50</td>
<td>2.9</td>
<td>0.29</td>
</tr>
<tr>
<td>Wet weather treatment performance level 1</td>
<td>79%</td>
<td>53%</td>
<td>86%</td>
<td>102</td>
<td>21</td>
<td>105</td>
<td>46</td>
<td>2.9</td>
<td>0.41</td>
</tr>
<tr>
<td>Wet weather treatment performance level 2</td>
<td>70%</td>
<td>46%</td>
<td>72%</td>
<td>96</td>
<td>29</td>
<td>90</td>
<td>52</td>
<td>2.5</td>
<td>0.53</td>
</tr>
</tbody>
</table>

*Concentrations are in mg/L.
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The first level of performance testing required the units to operate at a flow rate of < 27 mgd (SOR = 32.9 gpm/ft²), the second level of testing required a flow rate of 31 mgd (SOR = 37.5 gpm/ft²), and the third level a flow rate of 38.7 mgd (SOR = 47 gpm/ft²).

During the testing of each performance level, samples were taken during each hour of operation to measure TSS, CBOD, and total phosphorus. Each clarifier was tested for a six-hour period and figures 3 and 4 (page 19) show representative runs for an individual DensaDeg unit. Table 2 (page 19) provides a summary of the average removal efficiencies and average concentrations achieved during of the full-scale performance testing.

Conclusion

The system recently constructed at the Bay View WWTP is the largest high-rate clarification system for CSO treatment in North America. As seen in the performance test data, the DensaDeg can achieve removal efficiencies in the range of 70 to 95% for TSS, 55 to 70% for total CBOD and 70 to 95% for total phosphorus, while operating at high surface overflow rates.

These full-scale results confirm those achieved during the pilot testing and meet the design requirements of the facility. This demonstrates that based on the high-rate design of the process, large CSO treatment capacity can be achieved in a relatively moderate site area (232 mgd within a 43,500 ft² area), thereby providing municipalities with a compact solution for CSO treatment.

References


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