Siemens Water Technologies

Sludging it out

Improving circular clarifier efficiency

Jeff Schneider

The circular clarifier is a major component of the operation of almost all water and wastewater treatment plants. Yet because of its quiet demeanor and perceived minimum maintenance requirements, it is often passed over in the plant's annual process review and mechanical inspections. However, as with all mechanical assemblies, circular clarifiers require annual maintenance to maintain and extend their service lives and to prevent future operational problems. Clarifiers also require a check of their original design capacities against the plant's current flow patterns – some clarifier designs are flow-sensitive.

Additionally, many innovations and refinements to the design of clarifiers have been made over the years to increase flow capacities and improve efficiency in the settling and collection of settled solids. When conducting evaluations of existing systems, it's helpful to know what new options exist to decide if it's time for a change.

Circular clarifiers fulfill a variety of functions in the scheme of a treatment plant, including grit collection, primary collection, secondary fixed-film or activated sludge collection, thickeners, and more. Because of the complexity of all of the different mechanisms, this article focuses on the secondary clarifier in an activated sludge process. Read on for an operator's guide to structural items to check during annual inspections and some insights into the innovations and upgrades available to improve clarifier performance.

Annual inspection checklist

To ensure a circular clarifier's continued proper maintenance, annual inspections are needed. Examine each of the major components within the clarifier, paying particular attention to the drive unit and structural components at the water line.

Drive unit. Drive unit configurations vary greatly between different clarifier manufacturers. This discussion is based on a cast-iron, split-gear, pier-supported drive unit that is furnished by several manufacturers.

First, review the manufacturer's manual for items unique to the drive unit on hand. Then, while the clarifier is still in operation, investigate the unit for any unusual noises or vibrations. Noises most commonly originate from the motor fan or a poorly lubricated or loose chain-and-sprocket arrangement.

To use a simple, old-time method of checking for vibration, stand or sit on the drive housing while it runs for a full revolution. If vibration occurs, note the position of the main tank skimmer. While the interaction of the rotating skimmer assembly with the fixed scum beach/trough might be the cause, it should not be a point of concern. However, the skimmer assembly may have fallen out of proper adjustment. A severe vibration accompanied by a "snap, crackle, pop" noise might be caused by a broken ball in the main bearing, in which case the original equipment manufacturer should be called for repair options.

Once the mechanism is properly shut down and locked out, drain the oil and visually inspect it for signs of water contamination. Water can appear in the oil or grease for many reasons, ranging from a simple collection of condensate to corroded dust shields. Because contaminated oil and grease is the main cause for deterioration of service life, study periodic oil samples to determine a proper maintenance schedule.

Also check sprockets for signs of "barreling" – the enlargement at the root of the sprocket tooth caused by pin-bushing wear of the chain (see photo, p. 62). Inspect all exposed shaft seals for signs of leakage and the shaft itself for grooving. Clean the gear reducer vents so they remain operational.

Center pier and cage. The center pier and cage of circular clarifiers usually have areas of corrosion at the water line due to the fluctuation of water level and exposure to the atmosphere. Often, a significant reduction in the material occurs at the upper influent port areas of the center pier.

When assembling clarifiers, the pier usually is the first component to be erected; this means that nearly the entire mechanism must be disassembled for the pier to be replaced. It is sometimes more cost-effective to replace the entire unit than to fully disassemble the existing one. For instance, if the pier is corroded beyond repair, the high cost of disassembly and reassembly labor would warrant investing in a new mechanism.

Inspect the individual angle members of the center cage structure for signs of corrosion at welded joints or deformed members. Examine bolted connections to the drive, manifold, and truss arms for both corrosion and tightness of bolts.

Settled-sludge collection device. Clarifiers feature many different methods of sludge collection, including using a hydraulic sludge header with manifold, a riser-pipe clarifier with pipes, V-plows and a sludge box, a spiral scraper, and others.

With hydraulic removal systems, one critical component to check is the condition of the seals that allow transfer of the collected sludge in the rotating mechanism to a fixed withdrawal point. When these seals fail, the suction head is significantly reduced from the collection arm, thereby prohibiting uniform pickup along the entire length of the arm. It is important to regularly examine the condition of these seals, following recommendations in the manufacturer's operation and maintenance (O&M) manuals.

The shiny areas at the root of the sprocket illustrate wear. Siemens Water Technologies

Skimmer arrangement. Inspect the existing skimmer assembly and scum blade arrangement for deformed members, broken connections, and corrosion. Also check and replace skimmer wipers. Evaluate the operation of the skimmer traveling up the scum beach and over the trough, and, if needed, adjust the mounting for smooth operation.

Access bridge. Inspect and assess the access bridge support structure, as well as the walkway material, checkered floor plate or grating, and handrail. Additionally, pay special attention to the structure's underside, as this is where moisture collects and corrosion is common.

As part of the inspection, scrutinize the expansion–contraction slip-type connection located either at the tank wall or at the drive unit to verify that movement from fluctuations in ambient temperatures can occur. Otherwise, thermal movement in the bridge can pull or push the center pier out of plumb, causing skimmer-to-scum trough issues, interference with the mechanism and basin floor, and related stress on the structure and drive unit.

Plant flows. Review the plant's original O&M manuals for the original design flows of the clarifier. Compare these flows to current plant flows. Over the years, changes in incoming flows, pumps, or the plant's process sometimes significantly alter the loading to the clarifier. These changes, especially higher or lower return activated sludge (RAS) rates, can reduce the effectiveness and efficiency of a hydraulic sludge removal system.

Upgrades and conversions

Significant improvements have been made to the performance of circular clarifiers during the last 20 years. Many early designs with shallow sidewater depths of 2.6 to 3 m (8 to 10 ft), along with outboard effluent channel designs, led to elevated levels of solids in the effluent, especially at high flows. Now, however, alternate methods to introduce flow into the basin and collect the settled solids in an efficient and uniform manner have helped improve clarifiers' overall performance.

Energy-dissipating inlets. Flows that enter a clarifier with too much kinetic energy can resuspend settled solids and deteriorate effluent quality. Oversized center pier ports and increased influent-well diameters alone do not sufficiently reduce inlet kinetic energy and related flow vectors within the body of the clarifier.

This fact led to the introduction of energy-dissipating inlet (EDI) baffle systems which, as the name indicates, dissipate influent energy. Some systems also promote particle contact. The combination of both promotes lower effluent suspended solids and higher RAS solids concentrations. Numerous designs are available, many of which can be added to existing clarifier mechanisms.

The addition of these baffle systems can have a positive effect on the performance of all clarifiers, including those with shallow sidewater depths and even primary clarifiers.

Some important design factors to be considered when evaluating an EDI system include the following:

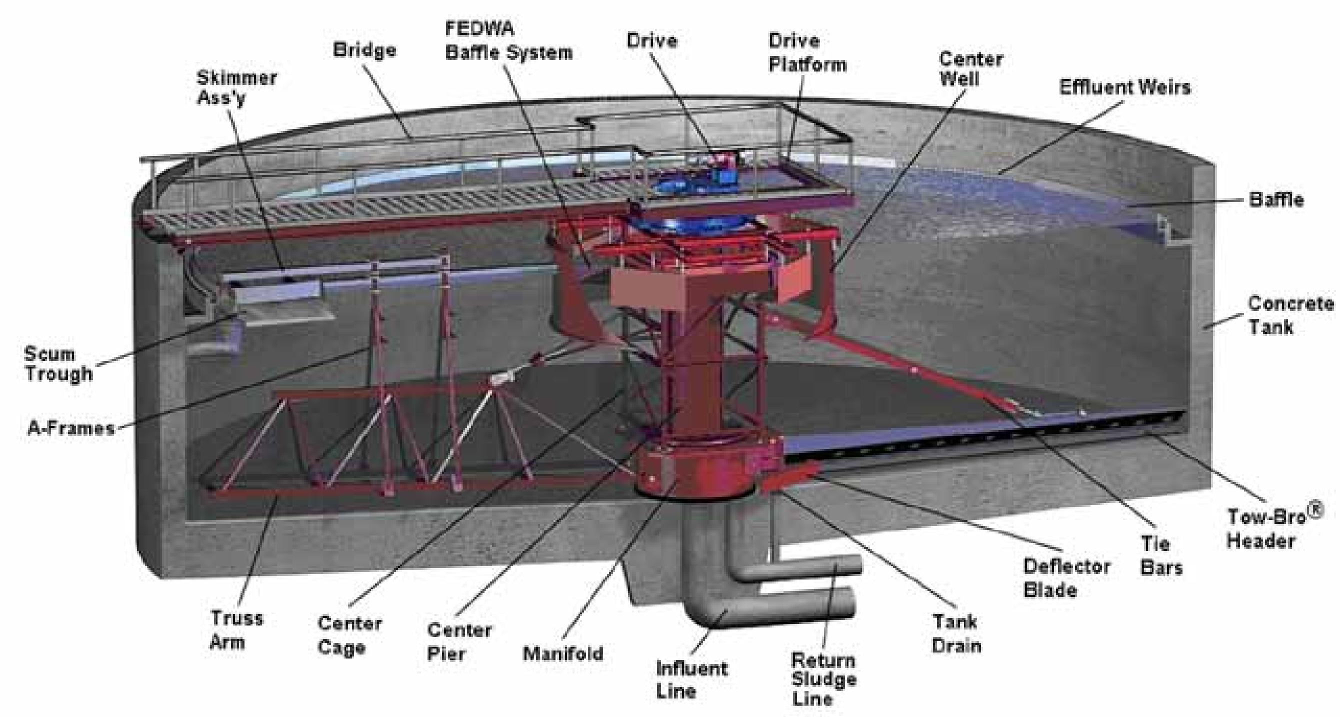
- Each time the flow changes direction before entering the influent well, kinetic energy is consumed. More redirections are better.
- Be mindful of each individual port's effect on reducing the incoming velocity, as well as possible clogging issues.
- When influent flows double back on themselves, they create mixing and passive flocculation, which promotes better settling.
- Avoid "dead" areas in the EDI baffle system that could lead to solid deposition and septic conditions.
- Within the basic arrangement, consider the degree of field modifications to the existing clarifier structure and the ease of assembly, both of which affect overall costs.
- Before purchasing equipment, verify the manufacturer's design calculations, paying particular attention to overall reduction of velocities and required headlosses.

Peripheral feed, peripheral overflow clarifiers. Skimming wasn't always a given. Some treatment plants have large-diameter, pier-supported, side-fed clarifiers that were designed and installed before skimming became a priority. The inlet pipe on these units is supported from the access bridge, making it almost impossible to add a skimming arrangement.

One way to add skimming to these units is to excavate around and under the tank and basin floor and bury an inlet pipe to convert the unit to a siphon center feed. Another, less labor-intensive option is to retrofit the clarifier to operate as a peripheral feed, peripheral overflow design.

With a peripheral feed, peripheral overflow clarifier, influent is introduced through a hydraulically designed channel that extends around the entire circumference of the basin. This channel must be designed to include orifices in the floor. These orifices should have specific diameters and spacing to accommodate a plant's current flow requirements. In addition, proper baffles for the orifices and skirt baffles are necessary to obtain optimum clarifier efficiencies. The clarifier effluent is collected by an additional peripheral channel located adjacent to the influent channel.

Introduced in the late 1960s by Siemens Water Technologies (Warrendale, Pa.), this concept can provide greater hydraulic efficiency – 50% to 80% more than a center feed clarifier. The combination of influent/effluent channels can be fabricated steel or poured-in-place concrete that has been doweled to the basin wall.



The main components within a secondary clarifier can be seen in this cutaway model of a center feed, peripheral overflow clarifier.
Siemens Water Technologies

The existing clarifier mechanism requires few modifications if it is still in good working order. With this concept, conventional main tank skimming is available, along with numerous influent channel skimming options.

Riser-pipe clarifiers. In the 1970s and 1980s, many treatment plants were furnished with a "riser pipe" design clarifier consisting of two truss arms located at the basin floor. The design also included a series of V-plows and sludge suction pipes that terminated at a sludge box located beneath the clarifier drive unit. Each suction pipe had a flow control device within the sludge box that enabled the operator to fine-tune the withdrawal process, depending on flow rates.

In reality, due to the number of devices and frequency of flow fluctuations, the control devices were seldom adjusted after their initial setting at startup. Other issues included clogged pipes, broken pipe elbows (from rodding out plugged pipes), and, at higher withdrawal rates, "rat holing" of clearer liquid through the sludge blanket at the sludge pipe inlets.

For settled-sludge collection, a tapered tube design offers an alternative. This design uses tubes spaced no more than 760 mm (30-in.) apart with various sized orifices. It is hydraulically designed to uniformly withdraw settled sludge along the entire radius of the basin. With this design, the available suction is spread evenly along the tube to prevent "hot spots" of suction. Internal velocities also must be uniform and sufficient to prevent solids from settling within the tube itself.

Additionally, there are several other methods of retrofitting riser-pipe clarifiers with a sludge collection header. Most require replacing the mechanism. In some cases, the drive unit and/or the access bridge can be reused to keep costs to a minimum.

If the RAS rate is controlled from outside of the basin – through the use of telescopic sludge valves in a pit or variable-speed pumps – a new settled-sludge collection system can be installed easily. Typically, only core drilling the basin's center or cutting and replacing some concrete is needed to install a new RAS sump.

However, if the only available RAS control is in the clarifier – through the use of the individual control valves located in the riser-pipe return sludge box – then an alternate mechanism, complete with a sludge collection header, a single vertical riser duct with one control device, and a sludge well, would be furnished. This arrangement would not require any concrete modifications.

Due to variations in clarifier basin and piping construction, plant personnel should request that their selected manufacturer evaluate the most practical and cost-efficient method of upgrading the clarifier.

Many different models of circular clarifier mechanisms are available for water and wastewater treatment. Regardless of the specific model or which application it is used for, basic knowledge of the major components within a clarifier is essential. Routine maintenance and general troubleshooting can be performed through a combination of looking at and listening to the units, referencing the O&M manual, and consulting equipment manufacturers. And when it comes time to upgrade or replace a clarifier, it's important to be aware of the many innovations and upgrades available to enhance performance.

Jeff Schneider *is an application engineer at Siemens Water Technologies (Warrendale, Pa.).*