Is Your Cold Lime Softener Effective?

Loraine Huchler, P.E.
MarTech Systems

If your plant's utility system is experiencing problems, the culprit may be the clarifier. Understanding how to diagnose and correct off-spec clarifier operation will allow downstream units to function more efficiently and reliably.

Maintaining the reliability of a plant's utility system is critical to support production and manufacturing. These systems do not generate a direct profit, and investments in manufacturing process improvements invariably take precedence over utility system improvements. Deferring investment in utility systems, however, ultimately increases the risk of failure and unplanned outage.

This article deals with the "front end" of the plant — influent water systems. Plants that draw water from a nearby watershed use a clarifier to remove suspended solids and make the water suitable for use in cooling or prepare it for additional purification. Changes in raw water quality are not the only reason for poor-quality clarifier effluent; more likely, the clarifier performance has deteriorated.

The most common gravity-clarification process is cold lime softening. This article first covers how gravity clarifiers work, some of the chemicals used in clarification, proper chemical feeding procedures, and clarifier equipment designs. It also explains how cold lime softening works, and provides guidance on maintaining system reliability.

How clarifiers work

Clarifiers are usually the first unit in water purification. Gravity clarifiers remove suspended (insoluble) contaminants, such as silica (dirt) and organics, from water to prevent blinding of downstream equipment.

This article is excerpted from "Influent Water Systems," by Loraine Huchler, P.E., CMC ©2007 Gulf Publishing, Inc., the first of a four volume series, "Operating Practices for Industrial Water Management."

Removal of suspended solids is a three-step process:

• *coagulation.* All suspended solid particles have a negative charge on the surface (known as the zeta potential) that causes particles to repel each other. An inorganic or organic chemical (a coagulant) that has positively charged molecules will neutralize (most of) the negative charges on the particles, allowing the particles to move closer to each other. Coagulation requires a rapid mixing process and occurs in the first chamber of the clarifier or immediately upstream of the clarifier.

• *flocculation.* Flocculation involves the addition of a chemical (a flocculant) that causes the particles to stick together or agglomerate and form larger particles. It occurs in the second reaction chamber of the clarifier, where the linear water velocity is much lower than in the first chamber. The flocculant acts as a bridge between particles.

• *settling.* As the size of the particles increases and the bulk water velocity decreases, settling occurs in the bottom of the clarifier by gravity.

Chemicals for clarifiers

Inorganic metal salts, such as alum, ferric sulfate and ferric chloride, can function as coagulants and flocculants. They are very effective, and are the least expensive option for influent gravity clarifiers. However, they will reduce the pH of the finished water and form large volumes of floc (sludge), which can be difficult to dewater. In addition, carryover of soluble aluminum or iron may occur and interfere with the proper operation of downstream equipment.

Aluminum-based chemicals are very versatile coagu-

Comparing Coagulants

To compare sludge handling costs of alternative coagulants, use a ratio of 25 lb of sludge formed for each 1 lb of metal salts fed.

A Day Tank is a *Day* Tank!

Day tanks should hold no more than a 24-h supply of solution, because productivity decreases after one day of storage.

lants. Sodium aluminate, an inorganic metal salt, and polyaluminum chloride (PAC), an organic polymer with an aluminum functional group, form a smaller and denser floc than other metal salts and do not reduce the pH of the effluent water. Lime, an inorganic coagulant, will partially soften or reduce hardness as well as remove suspended solids.

Organic polymers or polyelectrolytes can act as coagulant or flocculants. Coagulant polymers have the advantages of reducing sludge volumes and improving the sludge dewatering characteristics compared to metal salts. Coagulant polymers are aqueous solutions, have cationic charge properties (positively charged molecules), and exhibit better performance at lower pH conditions. Three types of coagulant polymers are used for influent water clarification:

- poly (diallyl dimethyl ammonium chloride [DADMAC]) or poly (dimethyl diallyl ammonium chloride [DMDAAC]), which have molecular weights of 250,000–500,000 units
- quarternized polyamines, which have molecular weights of 10,000–500,000 units
- polyamines, which have molecular weights of 1,000–1,000,000 units.

Flocculant polymers are typically anionic (negatively charged molecules) or non-ionic (slightly negatively charged molecules), and they are not as sensitive to pH as metal salts. Flocculant products form two-phase solutions that require specially designed chemical-feed systems. The requirement for flocculants is system-dependent — a plant may feed flocculant continuously, intermittently as needed, or not at all. Flocculants often improve the dewatering characteristics of the floc, especially in systems that use metal salts. Two types of flocculant polymers are used for influent water clarification:

- hydrolyzed polyacrylamides, which are anionic and have molecular weights of 1,000,000–2,000,000 units
- non-ionic polyacrylamides, with molecular weights of 1,000,000–20,000,000 units.

Selecting the polymer with the correct molecular weight and charge density, and determining the proper dosage and feed rate requires onsite jar testing. Retesting to adjust dosage is required when the influent water quality changes; some plants must test as often as every four hours. Waters with low concentrations of suspended solids may require the addition of clay or recycled sludge.

Emulsion Polymers Don't Like to Get Wet!

Powdered or dry emulsion polymer products will cake when exposed to moisture; liquid products will gel when contaminated with water. Even small amounts of water can result in caking or gelling. To prevent problems, storage tanks should be equipped with desiccant vents.

Chemical feeding

Coagulants are aqueous solutions. The coagulant feed point must be located in the raw-water supply line upstream of the clarifier, or in the first fast-mix zone, depending on the design of the clarifier. Some plants dilute coagulant chemicals in a day tank and use a positive displacement feed pump. Other plants feed coagulant chemicals undiluted (or neat), directly from the bulk storage tank, in which case, the use of an in-line or static mixer downstream of the feed point can improve the effectiveness of the coagulant.

Flocculant feed occurs in the first section of the clarifier or the slow-mix zone, depending on the design of the clarifier. Most flocculants are emulsion polymers, and are thick, viscous liquids that are not fed directly to clarifiers because they are not very soluble in water. Diluting the flocculant to a 0.5–1.0%wt concentration and "aging" it allows the long-chain polymer to uncoil (or invert) to maximize the effectiveness of the flocculant.

Some flocculants are powders that must be mixed with water and aged. When dry polymer products are improperly wetted, undissolved globules of polymer will form, appearing as "fish eyes" in the solution tank. Fish eyes represent wasted polymer and can plug chemical feed pumps.

A day tank with a pump to continuously recirculate the solution is the ideal polymer feed system. Plants have had limited success with in-line paddle-type mixers for flocculants.

Controlling the chemical feed rate. The coagulant feed rate will depend on the flowrate and conditions (temperature, pH, concentration of suspended solids, color) of the influent water. For example, when the water temperature drops, the coagulation process slows down. Simply increasing the coagulant feed rate in response may not sufficiently reduce the turbidity of the clarified water to meet specifications because of insufficient system volume and reaction time.

Operators use a jar test (Figure 1) to determine the required coagulant feed rate. The water treatment service representative or the clarifier manufacturer should supply a test procedure that models the clarifier with the appropriate durations and speeds of the fast-mix and slow-mix segments. Each sample of influent water receives a slightly different

Watch the Weather!

Monitoring the weather for approaching storms and proactively increasing the coagulant dosage can minimize the effects of increased turbidity in the surface water. Be sure to reduce the coagulant feed rate to the original rate after the storm event.

dosage of coagulant and is subjected to rapid mixing for 1–2 min; then the standard dose of flocculant is added and slow mixing is carried out for 3–5 min. After allowing an additional 5–15 min for settling, the water near the surface of the liquid is sampled and its turbidity is measured.

Turbidity is a measurement of the amount of light passing through a sample, which correlates to the concentration of suspended solids. Some plants use a visual assessment of the turbidity; most plants, however, use a bench-top turbidity analyzer. Other parameters of interest are sludge height or volume, and color.

The formation of pin floc may indicate excessive charge neutralization, *e.g.,* overfeed of coagulant. Pin floc, which looks like snow in the clarifier basin, consists of very small, dispersed floc particles that persist in the clarified water, despite optimization of the chemical treatment dosage and clarifier operation. Effluent turbidity often meets the plant specification even when pin floc is present. The typical remedy is to change the chemical treatment program.

Depending on the application, the optimal dosage is based on the test sample with the lowest turbidity and/or color. The actual dosage required in the clarifier is usually slightly different from that determined by the bench jar test, so operators need to understand the bias between the jar test and the clarifier's performance and be able to translate the results to changes in feed rate.

Some plants run these tests daily to confirm coagulant feed rate. Other plants run these tests only when the feed water conditions change or the clarified water turbidity is high.

Clarifier equipment designs

Gravity clarifiers work best at steady flows; rapid changes in throughput, or operation above the rated throughput, will cause carryover of solids into the effluent stream. Highly variable demand for water may require a storage tank for clarified water to satisfy the demand without disrupting the steady clarifier operation. The following characteristics and parameters are critical to the successful operation of any gravity clarifier.

Rise rate. This is the rate of water flow through the clarifier divided by the surface area. Most gravity clarifiers operate best between 0.75 gal/min/ft^2 and 1.25 gal/min/ft^2 (0.26 L/min/m^2 and 0.44 L/min/m^2). In general, large, dense floc tolerates higher rise rates than small, fluffy floc.

Mix speed. The rapid-mix speed in the fast-mix zone is a function of the chemical treatment program and nature of the floc. In some clarifiers, polymers may require external mixing to perform optimally; consider injecting the coagulant polymer into the suction side of the primary influent feed pump. Adjustment of the mix rate in the slow-mix zone allows efficient settling of floc and yields low-turbidity water in the clear well.

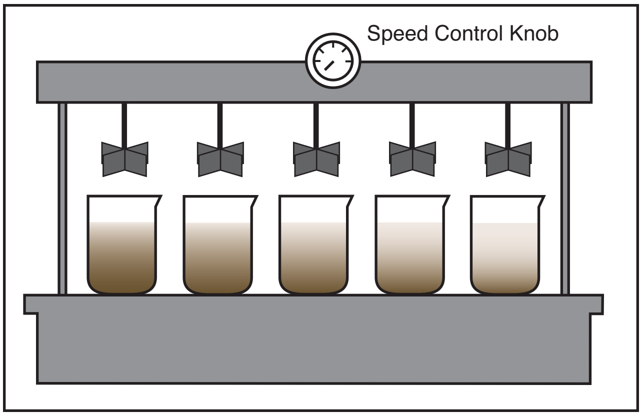


Figure 1. Jar tests are used to select the proper polymer, determine the correct dosage and feed rate, and adjust operations in response to changing influent water quality.

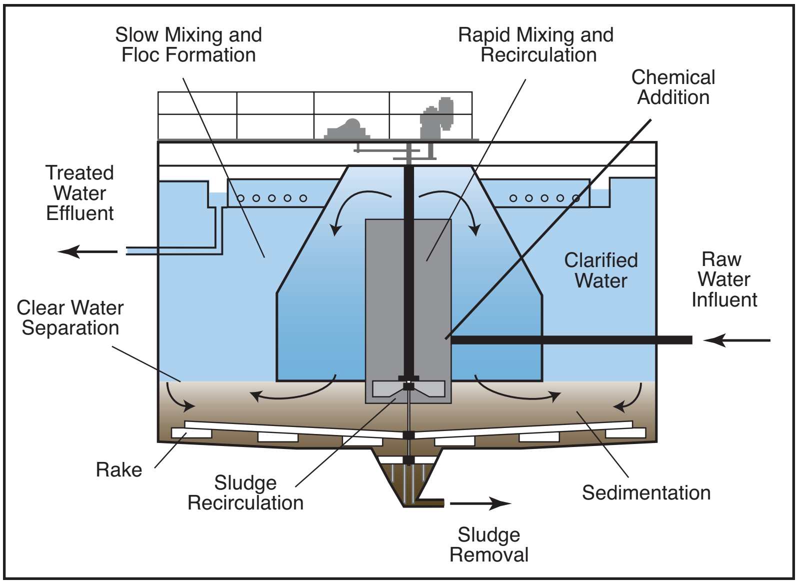
Rake. The rake at the bottom of the clarifier directs the sludge toward the blowdown take-off and controls the height of the sludge bed. An incorrect rake speed will compromise the settling rate — an excessively high rake speed causes the bed to fluff, while an excessively low speed reduces the contact of the newly formed floc with the sludge bed.

Sludge bed. The sludge bed serves an important purpose by providing a filtering effect for floc, contributing to improved effluent quality. The optimal sludge-bed height (or depth) is an important control parameter, as is the sludge recirculation rate for solids-contact units. The height of the sludge bed is dependent on the specific clarifier design, chemical treatment program and operating dynamics. To control the bed depth, sludge is removed through manual or automatic blowdown. Operators establish the blowdown schedule (frequency and volume) empirically, based on the characteristics of the system.

Settling solids. The settling volume of the solids in the centerwell or fast-mix zone is another important control parameter.

The three main types of clarifiers are sedimentation clarifiers, inclined-plane settlers, and solids-contact clarifiers.

Sedimentation clarifiers rely on chemistry and adequate residence time to allow the coagulation and flocculation reactions to form large particles. These are larger and require more space than the other types of clarifiers. Inclined-plane settlers operate as many small sedimentation clarifiers by allowing the settling reaction to occur in small



■ Figure 2. A solids-contact clarifier may have a sludge recirculation design …

increases in the inlet water, operators must compensate by increasing the blowdown rate.

The retention time in these systems is only one or two hours, allowing a smaller retention basin than other clarifier designs. The coagulant feed point is typically located far upstream of the clarifier to provide sufficient reaction time. The high degree of sludge contact with newly formed floc reduces the need for a long rapid-mix period.

The primary shortcoming of these units is poor response to the loss of sludge inventory. During upsets or periods of very low influent turbidity, sludge "borrowed" from a nearby plant's clarifier can restore clarifier efficiency.

A unique slurry recirculation clarifier (Figure 4) uses specially designed microsand to provide surface area for floc formation and to act as a ballast to improve settling. These units have a smaller footprint and operate with high overflow rates and shorter retention times than conventional slurry-recirculation clarifiers.

compartments, such as between parallel plates or within small-diameter tubes. They have the smallest footprint of all of the clarifiers.

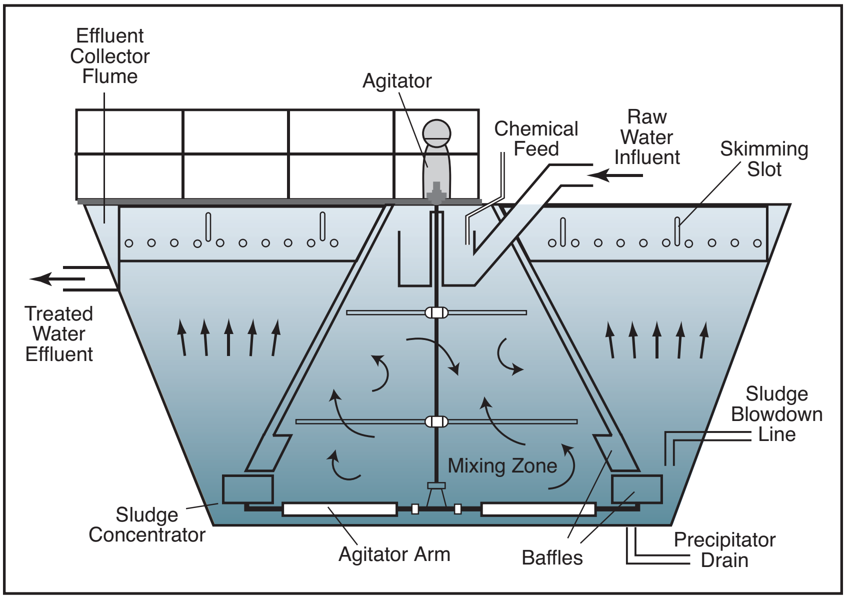
Lime softening is done in a solids-contact gravity clarifier to optimize the efficiency of the lime softening reaction. Solids-contact clarifiers combine chemical mixing, flocculation and clarification in a single unit and use a high concentration of solids to form a bed or blanket of sludge. They have a lower demand for chemicals than other designs and produce the highest quality (*i.e.,* lowest turbidity) effluent.

There are two primary designs — sludge recirculation (Figure 2) and sludge blanket (Figure 3). Both maximize the reaction or contact time for solids to agglomerate and form larger, faster-settling particles. Sludge blanket clarifiers force the raw water to travel through the layer of sludge, optimizing the agglomeration reaction. All of the sludge in a sludge blanket clarifier is fluidized. A sludge recirculation clarifier seeks to accelerate the agglomeration reaction by seeding the rapid-mix zone with recirculated sludge.

A solids-contact clarifier is a good choice for processes that produce a heavy floc, such as cold lime softening. Operators must carefully balance the sludge removal rate (blowdown) with the concentration of the solids entering the unit to preserve the inventory of solids (bed height or volume). When the concentration of suspended solids (*i.e.,* turbidity)

How cold lime softening works

In most raw waters, alkalinity is in the form of bicarbonate (HCO^{3-}) and carbon dioxide (CO_2). Cold lime softeners use lime (CaO or $Ca(OH)_2$), or lime with sodium aluminate ($Na_2Al_2O_4$) and/or soda ash (Na_2CO_3), to remove hardness by precipitation and suspended solids by coagulation and flocculation. The addition of lime increases the calcium concentration above the solubility limit, causing precipitation of



■ Figure 3. … or a sludge blanket design.

calcium carbonate, the least-soluble and most-commonly occurring calcium compound in natural water. By adding other chemicals, operators can remove other contaminants, such as soluble calcium, soluble magnesium, soluble and particulate iron, soluble and particulate manganese, turbidity, color, organics and oil.

As shown in Eqs. 1–3, when lime ($Ca(OH)_2$) is added to water, it disassociates to the Ca^{2+} and OH^- ions. Then a two-step reaction occurs: the formation of calcium bicarbonate (($Ca(HCO_3)_2$), then the formation of calcium carbonate ($Ca(CO_3)_2$):

$$Ca(OH)_2 \leftrightarrow Ca^{2+} + 2OH^- \quad (1)$$

$$Ca(OH)_2 + 2CO_2 \leftrightarrow Ca(HCO_3)_2 \quad (2)$$

$$Ca(OH)_2 + Ca(CO_3)_2 \leftrightarrow 2CaCO_3 \text{ (precipitate)} + 2H_2O \quad (3)$$

The reaction product, calcium carbonate, is very insoluble compared to lime, resulting in precipitation, which reduces the calcium concentration in the water. Cold lime softening is also known as partial softening because the typical minimum effluent concentration of calcium hardness is about 35 mg/L $CaCO_3$.

Reduction of the silica and magnesium concentrations requires the addition of $Na_2Al_2O_4$, which increases the reduction of magnesium hardness and creates a floc that adsorbs silica.

Reduction of the silica and non-carbonate calcium hardness concentrations requires the addition of soda ash (Na_2CO_3):

$$Ca^{2+} + Na_2CO_3 \leftrightarrow CaCO_3 \text{ (precipitate)} + 2Na^+ \quad (4)$$

This process reduces the non-carbonate calcium hardness, such as calcium sulfate or calcium chloride, and removes about 20% of the silica from the influent water. Downstream units (*e.g.,* softeners, demineralizers, reverse osmosis units) remove the remaining hardness as required for the end use of the clarified water.

The magnesium concentration is typically reduced by 10% of the inlet concentration. Overfeeding lime will remove a higher concentration of magnesium. The practical minimum effluent calcium hardness using lime-soda treatment is 20 mg/L as $CaCO_3$ in lime softening clarifiers. Remember that when the influent alkalinity is higher than the total hardness concentration, soda ash is not effective at removing hardness.

Post-precipitation results in a continuation of the reaction that precipitates calcium carbonate in the transfer lines at the outlet to the clarifier. This accumulation of calcium carbonate scale can reduce the diameter of the transfer lines so dramatically that the downstream systems must be de-rated due to loss of water volume. Some plants feed dilute acid at the discharge of the cold lime softener to dissolve precipitated calcium carbonate and prevent scaling in the transfer piping.

Maintaining system reliability for gravity clarifiers

Operators should visually inspect the physical integrity of the following gravity clarifier components for corrosion or physical damage:

- weirs
- troughs
- strainers and launderers that route clarified water out of the unit
- drive motors for the agitators and rake.

The rake at the bottom of the vessel is not visible because it is embedded in the sludge layer. Failed rakes are one of the most common problems, causing an accumulation of sludge over several weeks that increased blowdown rates cannot correct. The sludge will compact in the bottom of the clarifier, reducing the working volume, increasing the likelihood of high turbidity in the effluent, and ultimately forcing a repair and mechanical removal of the sludge.

Increased sludge bed depth is one of the few symptoms of a failed rake. Another symptom of a failed rake is a change in the power (current) draw of the motor driving the rake — increased current draw can indicate highly compacted sludge or a failing drive motor, while decreased current draw can indicate a decreased load due to a failed rake. The appearance

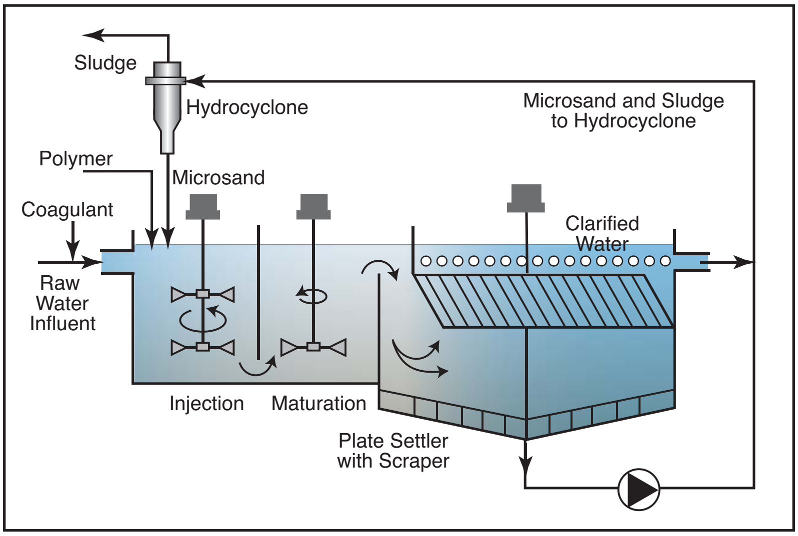


Figure 4. One type of slurry recirculation clarifier uses microsand to provide surface area for floc formation.

Table 1. Routine chemistry-control parameters for a cold lime softener.

Chemical Treatment	Parameter*	Monitoring Frequency	Industry Guidelines
Lime only	2P–M pH	Once per shift	5–15 ppm as $CaCO_3$ 10.0–10.4
Lime and soda ash	M–TH	Once per shift	20–40 ppm as $CaCO_3$
Lime and soda ash — high influent magnesium	2(M–P)	Once per shift	20–40 ppm as $CaCO_3$

* P = P Alkalinity, as measured by phenolphthalein indicator
M = M Alkalinity, as measured by methyl orange or methyl purple indicator
TH = Total Hardness = the sum of calcium hardness and magnesium hardness.
2P–M, M–TH and 2(M–P) are algorithms based on carbonate and bicarbonate alkalinity measurements that allow control of lime softening reactions to maximize either calcium removal, magnesium removal or silica removal. The actual value of each algorithm depends on the ratio of these ions in the raw water, the type and dosage of coagulation chemicals used (dolomitic lime, hydrated lime, unslaked lime, soda ash, alum, etc.), and the desired effluent quality.

Table 2. Tests for cold lime softeners.

Parameter	Industry Guidelines	Comments
Inlet (raw water) turbidity and temperature	—	Important historical information
Effluent total hardness	Minimum: 35 ppm as $CaCO_3$	Depends on the influent hardness concentration, chemical dosages and precision of control of operating parameters
Effluent turbidity	<5–15 NTU	Adsorbed on sludge
Effluent iron and manganese	<0.1 ppm as Fe or Mn	Precipitated as $Fe(OH)_2$ and MgO_2
Effluent pH	—	Important historical information
Effluent free chlorine	—	Chlorine is typically fed at the clarifier effluent and monitored downstream
Effluent color and organics	—	Adsorbed on sludge
Effluent oil	—	Maximum of 40 ppm oil removed

of small muddy areas in the basins, or local concentrations of sludge, may be a symptom of severe localized corrosion or structural failures of chemical feed lines or baffles.

Every five years, inspectors should drain the clarifier and inspect all of the components, especially the integrity of chemical feed lines, partitions, blowdown lines and water transfer lines. Chemical storage vessels, feed pumps and transfer lines require annual maintenance to prevent plugging by precipitates. In many plants, there is only one clarifier, forcing a complete plant outage to conduct this inspection. Installing a rental clarifier can reduce the length of an outage. Some plants use a diver to avoid an outage; however, accumulated sludge may prevent a visual inspection.

Key monitoring parameters for gravity clarifiers

Effluent turbidity is the primary measure of performance for all clarifiers. An online turbidity analyzer is a standard method to maximize the effluent quality. However, turbidity measurements may not indicate the presence of pin floc. Online turbidity analyzers require weekly maintenance for reliable operation. The visual appearance of the clarity and color of the water in the basin can provide additional information about the effectiveness of the chemical treatment.

Most plants have pressure filters downstream of the clarifiers to accommodate dynamic operating changes. However, these filters can only compensate for small fluctuations in clarifier effluent turbidity.

Effluent hardness is a routine measurement for all clarifiers. Only lime softeners that reduce the hardness concentration of the influent water have online hardness analyzers on the effluent stream.

Chemical feed rates require adjustment based on changes in influent water flow and quality. Most chemical feed systems have proportional control to correct for

Table 3. Key control parameters for cold lime softeners.

Parameter	Comments
Agitator speed Blowdown frequency Blowdown length (sec) Chemical feed rate Polymer solution concentration Sludge bed depth Sludge recirculation rate	Specific to the clarifier, chemical treatment program and operating dynamics
Percent solids in centerwell	Industry standard: 10–25%wt solids
Rake speed	Depends on sludge density
Raw water flowrate and range	Important historical information

changes in influent flowrates, but few systems have automated control for changes in influent quality. The standard manual method to match chemical feed rates to changing influent water quality is a jar test.

The use of a streaming current detector (SCD) allows automated control of the chemical feed rate for changes in influent water quality. Some waters are not suitable for an SCD; successful application requires an empirical assessment of the type and concentration of contaminants.

An SCD determines the relative amount of charge on the suspended particles in the raw water. A mechanical plunger creates a locally high water velocity, forcing the particles past each other at high velocity in a confined space. The force of the water strips the electrons from the surfaces of the suspended particles. These electrons create an electric current that dissipates when the electrons move through the water and find a grounded surface. The strength of this transient electrical current is proportional to the zeta potential. SCD applications require extensive tuning upon commissioning, as well as a comprehensive online cleaning and maintenance protocol.

The use of online analyzers and automated control systems reduces the amount of trial and error required to control system performance. Operator experience, however, continues to be an important part of optimizing system perform-

Table 4. Common problems in cold lime softeners.

Problem	Possible Root Causes	Corrective Actions
Soluble hardness is high	• Insufficient chemical feed rates • Excessively high or highly variable flowrates • Loss of sludge bed	• Recalculate dosage of soda ash based on the inlet water hardness and compare to the current feed rate • Confirm the chemical feed rate using a pump draw-down procedure • Check sludge bed
Acidified hardness is higher than soluble hardness	• Highly variable flowrates and/or high throughput • High sludge bed level • Short-circuiting • Insufficient solids concentration in the influent water	• Recalculate chemical dosages based on the inlet water hardness and compare to the current feed rates • Confirm the chemical feed rate using a pump draw-down procedure • Ensure steady influent flowrate • Compare flowrates with OEM capacity and historical flowrates • Adjust blowdown rate and/or bed level • Review rake drive system and historical current draw of drive motor
Effluent turbidity >15 NTU	• Highly variable flowrates and/or high throughput • High sludge bed level • Short-circuiting • Insufficient solids concentration in the influent water • Damaged rake	• Ensure steady influent flowrates • Compare influent flowrates with OEM capacity and historical flowrates • Adjust blowdown rate and/or bed level • Review rake drive system and historical current draw of drive motor
Floating floc	• Air entrainment	• Check chemical feed system • Inject chemical below water surface
Lime and/or soda ash are out of range	• Inadequate reaction time	• Reduce throughput

Parameter	Range	Corrective Actions
pH	<10.2 or >10.4	• Check 2P–M; adjust chemical feed rates based on influent water quality
M – TH	<20 ppm or >40 ppm as $CaCO_3$ M – TH <20 ppm indicates overfeed of lime or underfeed of soda ash M – TH >40 ppm indicates overfeed of soda ash or underfeed of lime	• Adjust appropriate chemical feed rates and confirm feed rates using a pump draw-down procedure

ance. Recording the chemical feed rates, influent water temperature, raw-water flowrate, and influent and effluent turbidity is important to simplify the adjustments as the raw water quality changes.

Additional parameters. If a plant feeds chlorine or other chlorine-containing compounds, measurement of free chlorine concentrations in the clarifier effluent is important to protect downstream units, such as softeners, demineralizers and reverse osmosis units. Some plants may need to monitor color and pH to control the effluent quality.

Operating a cold lime softener

Whenever possible, plant personnel should use the manufacturer's operating specifications. In the absence of OEM data, use the typical specification limits and control parameters listed in Tables 1–3.

Cold lime softeners are especially sensitive to changing conditions. Rapid changes in the flow or quality of the influent water or a disruption of chemical feed can cause upset conditions. Maintaining a sludge bed at the proper depth is critical to proper operation; re-establishing a sludge bed may take several hours or several days, depending on the chemical feed rate.

Table 4 outlines some common cold lime softener problems, their causes, and corrective actions.

If those corrective actions fail to resolve the problem, request assistance from the polymer supplier in testing a broad range of products, As a last resort, the possibility of failed mechanical components requiring a diver or shutdown to confirm should be considered. CEP

LORAINE HUCHLER, P.E., CMC, is the founder and president of MarTech Systems (35 Viburnum Court, Lawrenceville, NJ 08648-4809; Phone: (609) 896-4457; Cell: (609) 865-8151; Fax: (760) 280-9823; E-mail: huchler@martechsystems.com; Website: www.martechsystems.com), an engineering consulting firm that assesses and manages risk in water-related utility systems. Previously, she worked in the technical marketing group of BetzDearborn Water Management to support chemical-treatment products for industrial water applications. She also worked as an engineer for General Dynamics and for the U.S. Naval Aviation Command. Huchler holds a BS in chemical engineering from the Univ. of Rochester, and is a licensed professional engineer in New Jersey and a certified management consultant (CMC). She is a member of AIChE, NACE International, TAPPI, and the Society of Women Engineers, where she has served three terms as the president of the New Jersey section and was honored as a SWE Distinguished New Engineer.