Wave 2.0™

Water Treatment Guide for Open Loop Cooling Systems

Supplements:

a.) Compatible chemicals and their use with Wave
b.) Seasonal layup
Welcome! This **Wave Water Treatment Guide** provides instruction based on sound industrial water treatment principles for Scale, Corrosion & Biological control and Griswold Water Systems application experience in open-recirculating and similar systems using a unique physical treatment process.

We believe that the Wave™ offers a complete and effective water treatment solution based on a site’s unique water supply – without chemical supplementation and with reduced environmental impact as compared to conventional technologies.

We hope this guide helps the new Wave owner plan for a success and avoid common pitfalls associated with poor system start up and initiate “steady-state” operation. Beyond chemical avoidance, our customers find many other benefits including:

- Reduced cost of operation; low life-cycle costs.
- Water savings by reducing blowdown in most evaporative systems.*
- Reduces the sediment & dirt-loading in evaporative cooling systems.*
- Discharge to storm drain (with regulatory approval due to lack of chemical additives).

* As compared to chemically-treated systems

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**Simple Installation Qualifiers:**

- Newly treated systems should be free of contaminants such as oils, debris, and scale deposits to permit effective evaluation.
- The Wave will not treat standing water; No flow = No treatment.

**Basic Operating Practices:**

- Institute routine circulation.
- Provide a load that produces calcium-carbonate saturation which is essential to corrosion and bio-control.
- Maintenance and service inspection of the automatic blowdown system and, where applicable, the filtration equipment.
- Inspect water chemistry regularly.

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**Service:**

A GWS Certified Service Partner should be utilized to regularly analyze makeup and system water samples and monitor the effectiveness of the treatment program.

GWS offers continuing agreements and factory support of all installed products.

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Every Wave includes InstAlert, a cellular-based remote monitor that provides piece-of-mind between site visits.
WAVE Treatment Principles, an overview

The Wave™ generates an electrodynamic field generation (EDFG) treatment signal; it’s an electrically-based, unique physical-treatment process that provides superior scale-corrosion-bio-control when the cooling system is operated above the calcium-carbonate saturation point. Thus, unlike traditional chemical-based processes that depend on the action of many substances working in a difficult to control balance of actions, the Wave requires only a power supply and an operating load to work well – it’s that simple.

Calcium Carbonate Deposit Control (Avoiding Scale):
The WAVE signal removes static charges on the suspended particulate and, calcium preferentially precipitates on the suspended solids rather than a heat exchange surfaces. Dissolved calcium is no longer present in the bulk-water at concentrations that can produce mineral scales. During this non-adherent “powder” generation process, microscopic and suspended powder is removed through the automatic blowdown system. When powder is circulated multiple times through the system, it can become larger and capable of settling in a low velocity tower basin or it can be captured in a filter. When powder is visible, it is non-adherent and has the appearance of very fine sand.

Solids Management: GWS recommends the IntegraClean filtration system, Wave + centrifugal separation + CleanSweep basin sweeping, to promote efficient operation and reduce cleaning maintenance. When abundant amounts of powder are predicted, the IntegraClean system can reduce water consumption in the tower system.

Biological Control; Bacteria count target: < 10,000 CFU/ mL; typical WAVE systems are 300 - 2,000 CFU/ mL

Direct Method: The WAVE signal damages bacteria in free-floating in the water.

Indirect Methods: At saturation, the WAVE encapsulates bacteria into a powder. Available food supply is reduced with powder and agglomeration of dirt particles. Nutrient depletion avoids the growth of biofilm and eradicates biofilm in existing systems.

General Corrosion Control: Operating with alkaline cooling water allows ferrous and non-ferrous metals to form natural patinas and corrosion resistant films. In WAVE systems, corrosion control is enhanced when calcium levels are controlled in the bulk water and natural carbonates form protective, non-insulating microfilms. In open systems, we consistently achieve excellent results on steel corrosion coupons (< 1 mils/ yr.) and promise < 5-mils steel/ < 0.35 mils copper (ASTM rating: good) with no damaging localized corrosion in systems.

The primary keys to an effective WAVE treatment program:

- Operate above the saturation point of calcium-carbonate; this permits the formation of Wave powder that prevents scale formation and imparts the secondary method of bio-control.
- Rotate equipment frequently to allow contact with WAVE treated water.
- Use automatic blowdown and centrifugal-separators to remove and control the solids in the system.
- Retain a trained, GWS Certified Service-Partner to inspect the water chemistry, coordinate daily or seasonal operation adjustments particular to every site, and maintain the WAVE and ancillary systems.
Key terms & sample chemistry

**Conductivity.** A measure of the electrical “resistance” of water. As the mineral content of water increases, the electrical resistance decreases and the conductivity increases. It is reported as mmhos/cm or similar equivalent.

**Cycles of Concentration (COC) or Cycles.** Dissolved minerals, originating in the makeup water, begin to concentrate in the bulk water when water vapor exits the cooling tower during evaporation. “Cycles of Concentration” is a term commonly used in the water treatment industry to describe water use efficiency; it describes the number of times the minerals have concentrated in the cooling water as compared to the makeup water. Example: When the concentration of dissolved minerals in the system water is twice the makeup, it is said to have “2 COC or 2-cycles.”

**Target COC:** A target value is usually a conservative, minimum efficiently value. The permissible water use efficiency is based on the site’s makeup water analysis and considers several other factors such as the operating temperature; the PSI scale (Practical Scaling Index); a powder generation estimate in lbs. 1000-gallons of makeup; and our experience with similar operating systems.

**Saturation.** The condition of a solution at a given temperature when a substance which can no longer be dissolved. In an untreated cooling tower, evaporation concentrates calcium and other minerals originating in the makeup water. Calcium together with bi-carbonate (tested as alkalinity) are the first substances to reach saturation and with concentration pushed further, calcium-carbonate a.k.a. “scale” precipitates on hot heat transfer surfaces.

**Saturation with Wave treatment:** Minerals in the makeup concentrate the same way under Wave treatment but, at the point of saturation, the WAVE’s EDFG signal causes calcium to precipitate as a harmless powder on suspended dirt particles. A Wave water chemistry analysis will always show slightly depressed calcium and alkalinity values upon attaining saturation since the solid (no longer dissolved) powder isn’t detectable in the wet chemistry test. Cooling Towers should always be maintained above the calculated saturation point under Wave treatment to employ the best corrosion and biological control.

**How this differs from traditional chemical treatment:** Calcium levels are usually a limiting factor to concentration and, chemicals are designed to artificially modify the saturation point and/or keep calcium dissolved. The Wave “takes-away” the limiting factor rather than trying to control it. Chemical treatment has always had issues with calcium-phosphate, calcium-sulfate and many other deposits; however, when the Wave produces a calcium-based powder, the traditional problems aren’t an issue.

**Set Point (Conductivity).** The conductivity set point is selected based on an evaluation of a site’s makeup water chemistry. GWS’s exclusive powder production matrix (GPPM) establishes:

- **Calculated Saturation (calcium-carbonate):** This is the minimum recommended operating conductivity.
- **Start-up Set-Point:** A conservative set point used to accommodate minor mineral changes since the initial water sample was taken and, it is used to verify the GPPM mathematical calculations against the actual field conditions. As the system operates under load, the set point is adjusted as necessary to meet the operating objectives for water use efficiency and system cleanliness.
**CAUTION:** The initial or start-up set-point may not apply to the start-up and conditioning of new galvanized cooling towers and components. When galvanized metal is present, it’s best to determine the current makeup water pH and set a conductivity set point that avoids pH escalation above pH 8.0 (pH 8.3 is the maximum permitted pH for unconditioned (“non-passivated”) galvanizing.

**Sample water chemistry.** The following chart is used to demonstrate the effects of Wave treatment with makeup water from southern California. It is based on a GPPM and actual site conditions.

A.) Saturation occurs at 2.5 Cycles of Concentration according to the GPPM. As the tower operates, the Wave will soon begin producing a non-adherent powder that prevents the deposition of scale or alternately, chemical water treatment must be added to keep scale minerals in solution.

B.) At 4 COC with Wave, the PSI scale is considered “safe” and the Precipitate (powder generation) is benign.

C.) At 6 COC with IntegraClean, the PSI is still “safe” due to the increase in precipitate which is easily captured by the CleanSweep basin sweeping system.

D.) Without Wave, the system water is stressed and desires to form scale. Barring the addition of dangerous acid, even the best chemicals probably couldn’t achieve operation at 6 COC.

E.) At this actual site, the operation has been shown to operate with no scale formation at 7 COC. Lab and field bacteria counts are 1000 cfu/ mL or less.

<table>
<thead>
<tr>
<th>COC @ 98 F</th>
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<th>B.</th>
<th>C.</th>
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<td></td>
<td>Makeup</td>
<td>2.5 COC, Saturation</td>
<td>3 COC Wave</td>
<td>4 COC Wave</td>
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<td>Calcium</td>
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<tr>
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<td>0.11</td>
<td>0.36</td>
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Uniquely different under Wave treatment compared to chemically treated water

- COC are measured with chloride (the ASHRAE approved method), not with conductivity.
- Calcium and Alkalinity appear depressed due to becoming a solid.
- Conductivity escalation is not linear since Wave powder depresses the dissolved hardness.

* The values provided for Saturation, Set Point, Target COC etc. in this Guide are based on the water sample initially supplied for the project or similar data from the local geographic area. The CSP and/ or the Owner should compare the makeup water analysis with the actual water onsite at the time of start-up and while servicing. Notify GWS and supply a new makeup water analysis when the values are significantly different.
Transitioning to Wave treatment should be fairly straightforward and, we suggest working with a Certified Service Provider (CSP) to discontinue the any existing treatment feeds and oversee the conversion.

**A Clean Slate for a New Way of Treatment.** To experience the best that the Wave has to offer:

- **Existing systems with fouling.** It’s best to remove existing deposits and foulants manually so the cleanup process can be controlled. The Wave is known to break down biofilm, sometimes very quickly, and we suggest avoiding a scenario that leads to strainer or exchanger clogging. Both GWS and the CSP can assist with cleanup recommendations and procedures.

- **Existing systems with chiller/ tower replacements (minor piping).** Newly installed piping should be free of dirt and debris prior to installation. Flush new piping, chillers and other heat exchangers with clean water then chemically clean all new heat exchangers (since many are shipped with corrosive hydrotest water present). Review the section on Galvanized Cooling Towers for special requirements when present.

- **Existing systems with major work.** It’s best to, and usually simple to follow the guidelines provided for *Planning to fill and chemically clean a newly constructed system & System Cleaning Procedures* although the need to flush oxides and contaminants is usually lessened in intensity.

- **New sump/ basin filtration.** At minimum, flush out the mud out of the pan/ tank and the hanging fill (if present) to prevent it from re-suspending upon startup of the new filtration system. Avoid the chance of the mud ending up in the heat exchangers or lodging in the tower distribution header or fill pack.

- **All systems.** Once the system is clean, please review the Post-Startup System Operation section to review system flow requirements and suggested BAS programming.

**Transitioning to Wave with chemically treated system water present.**

Wave performance warranties are based upon a makeup water analysis, not the system water plus chemical supplements. Only specific chemicals that will not interfere with the Wave’s physical-treatment methods are permitted so, it’s best to eliminate existing chemical treatments before transitioning.

- All cleaning agents applied to clean foulants or new equipment must be completely flushed with clean water to drain.

- Plan on discontinuing scheduled chemical feeds 1-day prior to the transition and, reduce the conductivity set point by 50% to allow the makeup to dilute the existing system water.

Upon startup, the CSP will adjust the conductivity to the appropriate setting for the system’s current makeup water chemistry. The set point will be reviewed against the calculated chemistry upon future visits.

"*Why is my conductivity set point lower?*
- I thought the Wave would save me water.*"

When the Wave causes dissolved calcium to form a harmless powder, the conductivity decreases because the new, true solids cannot be measured with a conductivity meter.

Thus, even at a lower conductivity, the Wave reduce can still reduce tower water use as compared to a conventional program. However in most instances, the conductivity will be at least equal and usually higher since dissolved calcium – the primary contributor to scale – has been reduced to a non-visible or free-flowing powder.
Planning to fill and chemically clean a newly constructed system

Filling a new cooling system shouldn’t happen haphazardly. A purposeful, thought out plan of action should be implemented with the following goals:

- Minimize the risk of fouling and adverse corrosion.
- Minimize water use and chemical additives.
- Reduce labor for cleaning.
- Provide the Owner with the clean system with minimal damage to the piping and equipment.

In spite of a chemical-free operating environment, the Wave will not remove construction contaminants or prevent corrosion in idle system water. However, the sometimes intensive and long-lasting cleaning processes can be minimized by taking a few planned measures.

Some makeup waters are especially corrosive due to low mineral content and other factors making the system at for the formation of “red water” – the result of rapid flash corrosion forming on steel surfaces without passive protection. When GWS is aware of the risk, we’ll advise the installer to review the Red Water Avoidance section of this document and take additional precautions.

**Purposes of Chemical Cleaning.** New piping systems require clean-water and chemical aided flushing to remove mill-scales, instable oxide films, dirt, and contaminants introduced through the manufacturing and fabrication processes. This necessity is generally recognized and a procedure is supplied in most engineer specifications.

Most modern cleaners contain corrosion inhibitors that aid in helping the system metals to form helpful passive film and deter the formation of red-water. The cleaner will usually also contain wetting agents and other substances that lift dirt and oils from the system surfaces. When a good cleaner is used and especially when hydrostatic test corrosion inhibitors are applied, the risk of flash corrosion is usually reduced and the installer will spend less time and resources on system flushing.

**Hydrotest and temporary corrosion inhibitors.** Applying a corrosion inhibitor during hydrostatic testing is specified by some engineers and is a cost-effective way of preventing excessive oxidation and rust-colored water. The final flush for the chemical cleaning is often less labor intensive and the water clears sooner.

- Apply a hydrostatic test inhibitor whenever the risk of red-water is present and when the cleaning will not occur within one-week of the first fill.
- Inject the corrosion inhibitor in proportion to the water fill or apply it after the system is filled – assuming it can be circulated.
- The need for hydrostatic test inhibitor is diminished when the fill and then cleaning process is expedited.

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**Two primary dangers of filling too soon**

**Rapid corrosion.** New piping has little to no passive oxide layer present making it susceptible to rapid rusting and the formation of tubercles in idle conditions. Low mineral content makeup and the presence of contaminants places the system at event greater risk.

Tubercle deposits can form in as little as 24-hours following the addition of water. When circulation is initiated, thin shelled tubercles can break up making metal particulate and exposing fresh, non-passivated steel – red stained water often results. Pitted metal frequently occurs on the underside of the structure.

**Bacteria & biofilms.** Longer periods of stagnation permit the formation of bacterial-biofilms that can cause aggressive surface corrosion and result in pitting. Biofilm is known to harbor Legionella bacteria, a potential health hazard.
Timing the Chemical Cleaning. The installer should plan on flushing and performing a chemical cleaning within one week of startup to minimize the formation of biofilms and to deter the formation of rust when ferrous metals are present. Apply a hydrostatic testing inhibitor whenever the time of having untreated water in the system will exceed one-week.

Minimize the time between the cleaning and startup as much as possible to a period not exceeding one-week. The duration of the operation should minimize standing water and not exceed two-weeks.

- In ferrous systems, adding a corrosion inhibitor is a practical consideration immediately following the chemical cleaning and, it will be a necessity whenever standing water or a lack of load will exist for two-weeks or more.
- Any system which will remaining idle for a period of a three-weeks or more, or a near design-capacity load will not be placed on it, will require the addition of a corrosion inhibitor and a biocide unless an exception is sought by reviewing the application with Griswold Water Systems.

Post-cleaning temporary chemical-based corrosion inhibition. In locations with a high to moderate risk of forming red-water after the flushing, the CSP will frequently supply a one-time dose of inhibitor as a courtesy. The dose helps to maintain visibly clean system water while the evaporative load builds and achieves calcium-carbonate saturation – a condition in which the Wave can employ natural corrosion resistance for the system metallurgy.

The one-time dose is not a substitute for good planning which delays the flushing until a load will be available and, a chemical supplementation should not substitute for poor field cleaning or startup practices. The installer should purchase additional quantities when the system cannot be operated sufficiently to produce calcium-carbonate saturation.

Unavoidable Soft- Starts. Large and multi-phase projects can prevent the tower from operating under load which permits the rapid formation of natural corrosion inhibition. Under these circumstances, additional applications of corrosion inhibitor and possibly chemical biocide may be required. Please review the Red Water Avoidance section for specific recommendations.
System Cleaning Procedures

**Newly constructed systems & equipment.** The cleaner must be a liquid and safe for the metallurgy present. Acidic cleaners are prohibited. Avoid the use of phosphates and alkaline cleaners when galvanized metal is present – use pH neutral cleaner.

**Existing systems requiring cleaning.** Walk the project with a CSP to determine the foulants present, to determine the correct type of cleaner, and to determine a cleaning procedure for the application.

**Helpful best practices:**
- Circulate at peak flow rates through all piping and all equipment.
- Vent air from all equipment (install vents on all heat exchangers when not present).
- Avoid standing water – surface pitting and corrosive damage may occur.
- Delay the cleaning to within 2-weeks of startup.

**Typical Cleaning Procedure for Newly Constructed Water Systems**
1. Fill and flush the system with clean water removing dirt and loose sediment and until the flush water is visibly clean.
2. Add a CSP supplied cleaner and follow the supplied instructions.
3. Circulate the cleaning chemical for the specified period of time, typically a minimum of 4 hours.
   - Circulate at design velocity and through all equipment and piping.
   - Circulate for the recommended period without interruption.
4. Immediately dump and flush the system as quickly, and as completely, as possible to ensure effective removal of suspended solids. Blowdown dead legs and low-flow areas. Hose and flush settled debris from the tower pan, remote sumps, or similar equipment.
5. Refill, circulate for 1 hour. If the system water remains turbid with suspended dirt or contaminants, dump the system a second time. Flush sediment from equipment and dead-legs and similar trap areas.
6. Initiate a bleed after completely purging the air from the loop to remove minor suspended particulate. Make sure that the bleed rate is not greater than the system’s make-up potential.
7. Keep the CSP informed of the progress; they may wish to test the system water to verify the cleanliness or to take other actions.
8. If a temporary corrosion inhibitor is applied, circulate it a minimum of one-hour. Plan to put a load on the system to initiate natural corrosion control using the makeup chemistry. Avoid stagnation in the system by following GWS’s minimum circulation requirements.
Red Water Avoidance

Ferrous metals may be susceptible to a flash-corrosion condition upon the initial fill and after startup due to low makeup hardness and other factors. This short-lived oxidation isn’t harmful to the ferrous piping in the long term but, it is unsightly making the cleaning and flushing efforts appear to have been poorly performed. When not promptly controlled or the particulate promptly removed, metal surfaces can stain, sometimes permanently on galvanizing.

The following precautions are recommended:

- Avoid allowing untreated water to remain in the piping prior to startup and consider using a corrosion inhibitor during hydrostatic test periods.

- Perform a required chemical cleaning of the system within a few days of startup.

- In ferrous systems, adding a corrosion inhibitor is a practical consideration immediately following the chemical cleaning and, it will be a necessity whenever standing water or a lack of load will exist for 2-weeks or more.

- Following the cleaning, immediately place a full system load on the system. Rotate any standby chillers and other equipment into service every other day, at a minimum, to allow contact with treated water.

- Any system which will remaining idle for a period of a three-weeks or more, or a near design-capacity load will not be placed on it, will require the addition of a corrosion inhibitor and a biocide unless an exception is sought by reviewing the application with Griswold Water Systems.

- Notify the Water Treatment Service-Partner sufficiently prior to startup. They may supply or add a one-time treatment.

- Polyamine Treatment Caution: Never use amine treatments with new galvanized cooling towers that have not undergone conditioning; they will prevent the formation of a natural passive curing and possibly lead to the formation of white-rust as the pH naturally escalates in the tower.

"I continue to flush. Why isn’t my water clearing?"

Stop! Consult with the CSP immediately. The cooling system may require a dose of corrosion inhibitor to prevent oxygenated makeup water from further attacking the interior surfaces. Please prepare to review the plans for applying a sufficient load that employs natural inhibition.

Corrosion Inhibition with Environmentally-friendly products

Sodium-Silicate. A natural food-grade & drinking water supplement for corrosion control that is permissible for discharge to (in approved) storm water blowdown applications.

Polyamines. A new cooling tower treatment chemistry that directly coats the interior surfaces of the operating system. They are environmentally-friendly as compared to most traditional treatments are phosphate-free and have beneficial biostatic properties.
Soft Starts; Operating a Wave Program with Temporary Chemical Treatment

GWS’s goal is to operate each system with no chemicals or limit their use whenever possible. However, we understand that may large projects may require filling and only a partial load – one that doesn’t permit the attainment of calcium-carbonate saturation. There are three general courses-of-action that can be taken to ensure the integrity of the customer’s system is maintained through this transition period.

1.) Small systems (typ. < 200 tons); full load within one month. Powdered calcium-chloride, available from pool supply stores, can be mixed by hand in water before adding to a cooling loop.
   - Advantages: Green chemistry. Inexpensive, usually a local supplier available. Wave is permitted to achieve bio-control through both electroporation and encapsulation.
   - Disadvantages: Labor intensive manual mixing limits the application to small quantities. Difficult to direct third parties about periodic testing and application guidelines.

2.) Small to large systems (typ. < 600 tons); full load within 1 – 1.5-months max. Manual addition of liquid corrosion inhibitor and biocide.
   - Advantages: Material available from a CSP. Liquid is easy to dose and mix with system water. Green corrosion inhibition chemistry is available.
   - Disadvantages: System may require toxic biocide although less toxic materials are available. Not compatible with blowdown to storm drains.

3.) All systems; indefinite time to loading. Chemical treatment including liquid corrosion inhibitors and biocides application until discontinued.
   - Advantages: Availability. Direct control over application and delivery to system.
   - Disadvantages: Toxicity application, storage, and handling concerns. Capital equipment purchase. Customer is seasoned to chemical-based application requirements.

When load-based circulation is delayed or when achievement of calcium-carbonate saturation will not occur for a period greater than 1-week due to “soft” (low mineral content) makeup water:

1. Select the appropriate chemical with the assistance of GWS or the CSP.
2. Follow responsible industrial practices and apply the treatment as needed until the system water achieves 50 – 75% of the value of the calcium-carbonate saturation point.
3. Continue loading the system until achieving the saturation point which employs the Wave’s natural inhibition methods.

When routine, chemical treatment is employed, see guide section: Existing Systems Transitioning to Wave.
Galvanized Cooling Tower, or Galvanized Tower Components

**WARNING!** The city water of many municipalities may damage galvanized metal upon first contact due to recent changes in the municipal treatment processes. At no time should a cooling tower be filled with water before notifying the Certified Service Partner. The water may require pH modification to prevent a “white rust” condition and permanent damage.

The following actions will increase the risk of damage:

- Circulation without functional, programmed automatic-blowdown equipment in place.
- Failure to flush a system with ferrous piping and perform a chemical cleaning to remove oxides and oils.
- Placing a heat-load on the operating system.

**Overview:** The sacrificial zinc cathodic-finish applied by the cooling tower manufacturer is subject to rapid depletion if the makeup water pH exceeds 8.0 or the pH of the cooling tower bulk-water is allowed to climb above 8.0 (Note: galvanizing is resistant to white rust up to a pH of 8.3 but for practical purposes, the pH should not be allowed to exceed 8.0). Rusting of the base-metal will result if conditioning requirements are ignored.

The prevention of a white-rust condition can be addressed in one of two ways:

- Preferred: Program a set point in the automatic blowdown controller which prevents the pH from natural escalation. The setting is usually temporarily lower than the final set point for Wave operation and may negatively impact water use efficiency for the duration of the procedure. The makeup water chemistry may prevent the use of this preferred option.
- The temporary application of a sulfamic acid in conjunction with the use of pH control equipment. A temporarily low set-point may be employed to decrease the risk associated with feeding acid.

In geographic areas with known high-risk conditions, GWS suggests purchasing a cooling tower constructed of stainless steel or non-ferrous metal rather than one with galvanized wetted surfaces.

**What is white-rust?** The term “white-rust” describes a condition that occurs when a porous and voluminous zinc-carbonate/ zinc-hydroxide forms on the surface of the galvanizing instead of a tightly adhered, non-porous protective layer. The voluminous formation is a direct result of continual contact with water of a pH exceeding 8.3. If the condition is left unchecked, the zinc layer depletes, water penetrate the deposit to the base metal, and oxidization (red-rust) results. White rust will feel similar to candle wax and can be scrapped with a fingernail as compared to a calcium scale which is usually abrasive and tightly adhered.

**Correction & Remediation:** When detected, it is critical to act quickly to prevent permanent damage. Freshly formed superficial white rust can undergo the normal treatment program (< 8.0) and should form the desired non-porous surface. When deposits have made deeper penetration into the zinc layer, modify the bulk water to the correct pH for 1 – 2-weeks before gently removing the deposits and then continuing the pH control program.
Extensive, voluminous deposits may require initial treatment with a stronger acid followed by the commencement of the conditioning program. Lastly, damaged spots may require touch-up zinc-rich paint after conditioning and serious cases will require a complete surface refinishing.

Precautions & Tips:

- The actual length of the procedure will be determined by the observation of metal after 6-weeks (assumes continually wetted). Some cooling towers may require a longer conditioning period for unknown reasons. Leave conditioning equipment in place and increasing the pH of the system slowly verifying that no white rust forms. If it begins to form, decrease the pH and follow the procedure for at least another 2-weeks.
- Place the system pump(s) on HAND for the duration of the procedure rather than attempting start/stop operations which contribute to the formation of evaporation-to-dryness salt deposits.
  - Flow must be at full capacity; partial capacity may not fully wet hot-decks and later cause oxidation at former low water line.
- Start the conditioning early since a heat load will increase the pH. Maintain communication with the Service Partner since the heat-loading may require counteraction with a lower set point (water waste) or additional acid application.
- Temporarily increase the pan water level above the “normal operating level” to protect the finish at the water line.
- When the makeup exceeds, 8.3 pH, place a temporary splash-guard at the makeup water float to prevent the water from splashing on the side walls.
- During the conditioning, use a soft non-metallic bristled brush to gently sweep any settled solids from the sump or deck. Loose oxides or slag will stain the tower metal and excessive dirt will slow the conditioning process.
- The internal fan shrouds within a forced draft cooling-tower and the side walls of many cooling towers are difficult to protect since the surface is neither continually wetted nor submerged. Mixed results are common and white-rust may form along with encapsulating evaporation to dryness type deposits. Although possibly unsightly, these surfaces rarely have the ability to decrease the longevity of the unit.
- Following the conditioning, the pH of the bulk water may be allowed to increase up to 9.0 pH. Follow the tower manufacturer’s recommended cleaning and maintenance schedule. Avoid cleaning the surface with a concentrated pressure washer stream, harsh detergents and acids, or stiff bristle brushes.

GWS can make recommendations for the prevention of a “white-rust” condition however; specialized services that include the addition of acidic and other chemicals are outside the scope of the WAVE treatment program. The installation of temporary application equipment may be required at additional cost.
Mechanical/ Electrical/ Controls Requirements Prior to Startup

Commissioning/ Start-up Checklists. Pre- and Post-Start Up checklists contain helpful installation and start up items originating from the Wave Installation & Operation Manual (IOM). We suggest that the installer review and complete all items on the list prior to scheduling start up. A GWS representative will complete the lists at the appropriate time. If factory-start up is purchased, please provide at least a two-week notification.

Checklists are enclosed in the Documents Section.

Failure to perform a complete installation or meet all start up requirements including but not limited to system cleanings and one-time procedures may cause system damage and void written and implied performance warranties for the Wave and/or IntegraClean system.

Prior to start-up. Complete the following (including field piping, electrical, and control terminations):

- System chemical cleaning and flushing
- Galvanized cooling tower: conditioning ongoing or have an established plan to avoid tower damage
- Wave in place and pre-installation test performed
- All automatic blowdown components in place
- IntegraClean & all GWS supplied filtration components in place, unit flooded and power terminated

BAS Programming of Operating Systems.

Traditional Installations; i.e. chillers, heat pump and similar configurations.

- Program the system to circulate Wave “treated” water throughout the system:
  - At least One-Hour Daily or,
  - Three-Hours Every Three Days.
- Circulate throughout all installed equipment including standby units. (It is not necessary for the unit to carry a load.) Circulate at the design flow-rate or as close as permissible.
- Maintain flow through heat-exchangers for 5-minutes after process stops to dissipate heat from the unit.
- Weekend and occasional system shutdowns are permitted. Consider that systems undergo the best water treatment when routinely circulated; Stagnation encourages damaging localized corrosion and poor biological control.

Complete System Redundancy; typically data centers and mission critical installations.

- Better treatment results occur when the first system operates for three-to-four-days before switching the load to the second system and operating for the next three-to-four-days.
- Initiate flow in the idling system at least one-time for at least one-hour while in standby mode.
- Weekend and occasional system shutdowns are permitted. Consider that systems undergo the best water treatment when routinely circulated; Stagnation encourages damaging localized corrosion and poor biological control.
**Fluid coolers/ Evaporative condensers.** Due to the low water volume, a lack of exposed mild steel, and a lack of biological hideout areas, the basin water can withstand longer idling than a traditionally piped hydronic system (subject to local environmental factors).

- Circulate systems without a load at least for at least three-hours/one time per week.
- When a fluid cooler is idle for longer than two-weeks, consider draining the unit to prevent stagnation.*

* When an IntegraClean, basin filtration system is present, circulating this unit can occur in lieu of operating the tower spray pump. See the following section on IntegraClean systems.

**GWS IntegraClean, Integrated Wave and Basin Filtration** (when applicable): We recommend circulating the filter at all times regardless of the system operating status. Benefits:

- Provides a volume of Wave “treated” water available to mix with the system water.
- Maintaining flow through the basin helps avoid stagnation.
- Aids in eliminating or reducing algae growth.
- Continue to maintain system circulation per the above BAS recommendation.

**Important notes regarding CleanSweep basin filtration.**

- Install the supplied 0 – 15 psi pressure gauge at the inlet to the tower.

**Crossflow Cooling Towers (and others as applicable)**

- The sump water level may require adjustment, to a level above the tower manufacturer’s “recommended water level” sticker to prevent vortexing air into the filter supply piping upon startup.
- After adjusting the sump level, shut down the circulation pump to determine the standing water level in the tower. In rare cases, a rubber pipe coupling (supplied by others) may need to be installed on the overflow pipe(s) to prevent water loss upon shutdown.

**InstAlert, optimum cellular signal**

- Cellular signal can be compromised when installing units in basements or without line-of-sight to the sky.
- Antenna extension cables up to 100’ are available as a courtesy from the factory to assist in placing the cellular antenna in a more suitable location.
Variable Frequency Pump Drives (VFD’s).
Traditional system design produces a flow rate in the range of 3 – 6 feet/ second with 5 fps the ideal average. Good water velocity supports the dispersion of suspended particulate and promotes predictable uniform corrosion. It should be recognized that low water velocity promotes accelerated general corrosion and the settling of suspended particles leading to the mixed effects of fouling and the formation of localized deposits. Each system will vary depending on load variations and water characteristics.

- Griswold recommends maintaining a water velocity of at least 2-feet per second or and at least 2 gpm/ ton in centrifugal chillers. (Flows lower than 3 feet per second may be tolerable in large diameter piping for short periods).

Potential negative effects of low and varying flows on the operating system:
- Chiller tube sheets which are already susceptible to low velocity at the tube entry and exit points are even more susceptible to impaction with solids and the development of deposits.
- Accelerated powder collection or settling in low-flow areas. In chillers, granular, cookie-crumble like powder can settle but it will not be insulating like a traditional scale – continued high flow should push the powder away or it can be easily brushed during an annual cleaning.
- Accelerated evaporation to dryness deposition and a dirty appearance of the cooling tower.
- Formation and fallout of “eggshell” like films in cooling tower film fill due to poor water distribution.
- Partial flooding of tower pipe headers increasing iron-based particulate and iron-throw in the long term.
- Increasing particulate collection in strainers and plate heat-exchangers.
Post-Startup System Operation

Wave treatment simplifies many of the complexities associated with traditional water treatment while providing better, more consistent results. Lasting success frequently involves a few key factors. Be sure to review and maintain the Mechanical/Electrical/Controls Requirements Prior to Startup.

**Maintain routine flow of treated water.** The industry adage, “No-Flow equals No-treatment” remains true; any component remaining idle is subject to preventable corrosion and stagnation or fouling. Circulate through all parts of the system regularly to maintain oxygen and remove settled solids. The most frequent contributors to operating problems are changes in the flow rate (VFD adjustments) or equipment is in standby mode without flow for too long a period.

**Check water chemistry, keep equipment calibrated and programmed.** The chemistry of makeup water frequently changes – sometimes seasonally, sometimes in subsequent years. It’s important to have both the makeup and the system water tested so the correct set point (and calibration) can be maintained in the automatic blowdown controller.

**System maintenance.** Although the Wave and the lack of chemical nutrient additives helps to maintain a very clean system, GWS still recommends that operators continue to clean and service cooling towers and heat exchangers at their respective factory recommended intervals. Other pointers:

- Correct seal leaks and avoid over lubricating cooling tower fans.
- Maintain cooling tower floats, avoid overflows.
- Inspect filter purge valves, clean strainers at regular intervals.
- Exercise and lubricate all mechanical parts per OEM recommendations.
- Consult with the CSP for geographic-specific seasonal or environmentally based requirements.

**Winterizing.** GWS doesn’t provide specific advice in freeze prone climates and, each customer should utilize protections customary and necessary for their unique situation.

Pointers for outdoor installed automatic blowdown controllers and components:

- Install drain valves at low points.
- Drain the piping associated with the automatic blowdown control system.
- Clean the conductivity probe.
- Place a plastic bag or other covering over conductivity controller to protect from snow and ice.

**Long-term or Seasonal Layup.**

- Where bypasses are not installed, the standing water should be at saturation at minimum and a chemical based layup treatment is recommended. The drained, air-exposed piping requires additional protection. Request the guide supplement: Seasonal Layup.
- Consult GWS and the Water Treatment Service-Partner for recommendations specific to the site system design and operation characteristics.

Water testing protocols.

<table>
<thead>
<tr>
<th>Pre-start up laboratory analysis</th>
<th>Routine field makeup analysis</th>
<th>Routine field system water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH Specific Conductance (uSiemens/cm)</td>
<td>pH Specific Conductance (uSiemens/cm)</td>
<td>pH Specific Conductance (uSiemens/cm)</td>
</tr>
<tr>
<td>Total Alkalinity (m-Alk as CaCO₃)</td>
<td>Total Alkalinity (m-Alk as CaCO₃)</td>
<td>Total Alkalinity (m-Alk as CaCO₃)</td>
</tr>
<tr>
<td>Calcium Hardness (as CaCO₃)</td>
<td>Calcium Hardness (as CaCO₃)</td>
<td>Calcium Hardness (as CaCO₃)</td>
</tr>
<tr>
<td>Total Hardness (as CaCO₃)</td>
<td>Chloride (as Cl⁻)</td>
<td>Chloride (as Cl⁻)</td>
</tr>
<tr>
<td>Chloride (as Cl⁻)</td>
<td>Silica (as SiO₂) if a limiting factor (rare)</td>
<td>Silica (as SiO₂) if a limiting factor (rare)</td>
</tr>
<tr>
<td>Sulfate (as SO₄)</td>
<td>Phosphate (as PO₄) (rare)</td>
<td>Phosphate (as PO₄) (rare)</td>
</tr>
<tr>
<td>Silica (as SiO₂)</td>
<td>Iron (as Fe) if source is well water</td>
<td>Iron (as Fe) if source is well water</td>
</tr>
<tr>
<td>Phosphate (as PO₄)</td>
<td>Practical Scaling Index (PSI) GWS’s GPPM calculation</td>
<td>Practical Scaling Index (PSI) GWS’s GPPM calculation if major mineral fluctuation occurs (by CSP)</td>
</tr>
<tr>
<td>Periodic PSI calculation GWS’s GPPM calculation</td>
<td>Periodic PSI calculation</td>
<td>Periodic GPPMS system water calculation (by CSP)</td>
</tr>
<tr>
<td>Note that GWS doesn’t include metals such as Iron and Copper in routine system tests; they don’t provide practical data and, these tests can’t predict localized corrosion – the true cause of system failure. But in our experience, test results are often better than in similar systems with conventional treatments.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Corrosion Coupon testing. A Wave program setup and maintained by a responsible CSP, in conjunction with good operator actions, will prevent adverse corrosion and prevents the formation of biofilm – even eliminating them entirely. Corrosion control is greatly simplified since the primary causes of localized corrosion events such as pitting (caused by biofilm or chemical application) and under-deposit processes (which are caused by scale and chemical deposits) are all eliminated under Wave treatment. And achieving minimal general corrosion, which is uniform metal loss and the purpose of corrosion coupon measurement, is a unique byproduct of the Wave’s control of calcium and alkalinity through “powder production” in the bulk water. Since there’s no metering of chemicals, maintaining a corrosion resistant environment is dependent on what are largely routine practices by the operator – limiting system water loss so that calcium-carbonate saturation is maintained and by making sure that circulation occurs routinely. Thus, the Wave prevents adverse general corrosion and eliminates the potential causes of localized corrosion and fouling. Recognized metallurgists and cooling water consultants will agree that once the localized events are prevented, the rate of general corrosion is a mute issue when compared to the life-expectancy of the operating system as a whole.

Corrosion coupon testing is important to the chemical treatment industry.

Since the chemical treatment industry is accustomed to applying a mix of chemicals to system water, it makes sense that operators and the treatment company might want to verify the effectiveness and shortcut the negative effects of bad ones (or the misguided actions of field technicians). Some chemical treatments may be more effective than others and the over-application of some chemicals can cause deposition or initiate corrosive activity like pitting. And the chemical treatment industry has to prevent mixed effects of applications such as under-deposit corrosion and supplying a nutrient load for organisms to digest.
We recommend that an operator wishing to verify the effectiveness of the Wave program should first clearly define the purpose of the test and then, perform the test(s) according to uniform standards publicized by the American Society of Testing Materials (ASTM). Referencing document D 2688 05:

- State the purpose of testing and why the testing is important.
- Flow rates in coupon racks should be representative of the system flow rate.
- Maintain an order of nobility for the metals used to fabricate the rack, the supply piping, and the coupons. No yellow metals should be used upstream of the rack’s steel coupon holder.
- Use gloves when handling coupons to about leaving fingerprints with contaminating oils.
- Use a reputable, independent laboratory to clean and process the coupons.
- Coupons which have localized corrosion are not suitable for determining general corrosion rates. (Correct the cause of the localized corrosion event and then perform additional test(s).)

In the experiences of GWS: We recommend using a 1” rack over a ¾” rack which minimizes the possibility of the coupon coming to rest on the inside of the rack after installation. Use a reputable laboratory or company to supply and process the coupons. We’ve seen unscrupulous parties use “passivated coupons” when they desire results in their favor and, we’ve found companies using uninhibited coupon cleaning solutions to provide a falsely high rate.

**Bio-coupon testing – verifying “no biofilm”**. GWS has recently pioneered the creation of a standardized test for the measurement of biofilm with a well-known industrial water treatment consultant for the purposes of proving our claims of having “no sustainable biofilm” (emphasis added) in cooling systems. Our scientific standard was published and presented to the Cooling Tower Institute in February 2014, paper TP14-18.

The elimination or prevention of biofilm is important for the prevention of heat-exchanger fouling and, many customers sensitive to Legionella understand that the elimination of biofilm is an important factor in short-circuiting the chance of a potential outbreak.

Our test results make our claim provable, and the test result repeatable; we now offer the testing service to GWS customers looking to verify the cleanliness of their systems. And we’ve seen a parallel in the results when compared to laboratory heterotrophic plate count: when the plate count yields results in the lower 1000’s cfu/mL – typical for the Wave, there’s no sustainable biofilm present on the coupons.

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**A standardized test for biofilm.**

Stainless steel flat and mesh corrosion coupons are installed in standard corrosion coupon test racks for a period of 30-days. The flat coupon represents potentially smooth system surfaces while the mesh represents irregular and probably worse-than-actual system interior conditions. Following the test period, the coupon is removed, ultrasonically cleaned in a pre-measured volume of fluid and a laboratory heterotrophic plate count is then performed on the inoculated medium. After plate incubation, the plate result in cfu/mL is applied to the known surface area of the coupon to produce a cfu/cm² result.
Testing for Legionella. GWS has written a white paper titled *A High Standard of Care for the Prevention of Legionnaire’s Disease: USA* to support our position on Legionella and the ASHRAE 188 standard. The paper is available on request. In brief:

- The Wave and Wave-IntegraClean effectively fulfills all “good” treatment standards – we feel our performance is better and more effective than preventing an outbreak than conventional methods.
- GWS hold a position compatible with the US Centers for Disease Control and Prevention (US CDC): testing for Legionella as a forensic countermeasure when an outbreak occurs. GWS does not support periodic testing, except as lawfully required, since today’s best-available testing is problematic and provides inconsistent results.
- When testing is required, GWS recommends utilizing a reputable laboratory and consider splitting samples to multiple laboratories in an attempt to find consistency, to avoid incongruous results.
Building Service-based Relationships

GWS offers factory support of the Wave or Wave-IntegraClean system for all long as it’s installed. We’ll gladly respond to technical requests, troubleshoot, and provide updated operating set points.

In the US & Canada, GWS provides a comprehensive service program with Wave purchase to maintain designed performance and support customer comfort with our market disruptive technology. We recommend that all customers maintain a relationship with a factory- Certified Service Provider (CSP) after the first year. GWS offers Continuing Service Agreements that include incentives regarding warranty and other benefits.

GWS and the CSP may make recommendations about the operating system for the support of reliable and stable operation. Our customers should pay close attention to the recommendations and ask for explanation or clarification when needed.

About our Certified Service Partners. The GWS CSP selected for this project understands the principles of WAVE treatment and system operation, and assures that the benefits of WAVE treatment are achieved. The CSP has a strong history of customer support and is a leader in the local community. In addition, the CSP shares the GWS mission to reduce environmental impact and supports the success of non-chemical treatment philosophies.

Griswold urges extreme caution when utilizing an unqualified water treatment service contractor without practical experience and knowledge of the WAVE physical-treatment methods. Too often, we’ll find a non- GWS Certified contractor applying chemicals which undermine efficient system operations.

InstAlert Monitoring System and Service. The InstAlert system provides the Operator and the Service Partner with a daily “snapshot” of the WAVE system. In the event of alarm, an alert email is send which should allow the Operator and Service Partner a reasonable amount of time to respond. GWS will provide supervisory monitoring and alert the Service Partner and/ or Owner when prolonged alarm conditions occur. Service is provided for 36-months from the initial unit activation; supervisory service will continue as long as the InstAlert annual monitoring fee is maintained.

Email, text, and a web-based portal is available for owners and owner-representatives desiring information about the status of the treatment system.
Project Schedule

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### Project Installation & Startup Requirements

(Failure to complete may affect WAVE warranty).

<table>
<thead>
<tr>
<th>Installation</th>
<th>Required by</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Verification</td>
<td>By GWS Rep firm (may subcontract to CSP)</td>
<td>By GWS Rep firm (may subcontract to CSP)</td>
</tr>
<tr>
<td>Chemical cleaning &amp; flush*</td>
<td>By mechanical (CSP supervision &amp; chem. supply recommended)</td>
<td>By mechanical (CSP supervision &amp; chem. supply recommended)</td>
</tr>
<tr>
<td>Chem. cleaning verification*</td>
<td>Required by GWS; performed by CSP</td>
<td>Required by GWS; performed by CSP</td>
</tr>
<tr>
<td>Field water analysis</td>
<td>By CSP (lab results field verified on first visit)</td>
<td>By CSP (lab results field verified on first visit)</td>
</tr>
</tbody>
</table>

* CSP requires a minimum one-week notice for scheduling.

### Misc. Project Services*:

- Red Water Avoidance: Mechanical (notify Rep or CSP upon initial system fill)
- Hydrostatic Test Inhibitor Supply: Mechanical
- Galvanized Metal Conditioning**: Mechanical (if acid-feed required) or CSP (if no acid req.)

* It is recommended that the Mechanical coordinate all actions with the CSP.

** Conditioning Plan is established after makeup water is analyzed. The plan can only be finalized by having the CSP test the water onsite close to the time of tower water addition.

### Post-Startup CSP Field Services Schedule.

- **Basic Service Program Requirements for the CSP** available on request.
- Service includes testing of makeup and system water monthly.
- Standard Method “9215B or 9215E” laboratory test for bacteria tested month 3 or a month following stable operation.

### Regulatory Services.

All geographically based regulatory services for cooling towers and cooling tower systems are excluding including but not limited to New York City, New York State, Montreal and others unnamed are excluded from the scope of this service unless otherwise stated.