MAINTENANCE TECHNICAL SUPPORT CENTER / MAINTENANCE POLICIES & PROGRAMS ENGINEERING / UNITED STATES POSTAL SERVICE

maintenance management order

UNITED STATES POSTAL SERVICE™

SUBJECT: Non-Chemical Cooling Tower Water Treatment

DATE: October 29, 1999

NO: MMO-066-99

TO:
1. All Maintenance Capable Offices
2. Area Office Manager Maintenance Support
3. Area Office Environmental Coordinator
4. District Office Environmental Coordinator

FILE CODE: P

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This Maintenance Management Order (MMO) supersedes MMO-010-81, Non-chemical (Magnetic, Electrical, Electronic) Water Treatment Devices, dated January 9, 1981 and allows the use of Non-Chemical treatment products in cooling towers. Following the guidance in this MMO is recommended.

This MMO is also a response to the following activities:

- Non-chemical water treatment manufacturers have increased sales effort to install this type of equipment in Postal facilities. The Maintenance Technical Support Center (MTSC) has received questions concerning this technology. Some Postal facilities have purchased this type of equipment.

- One of Environmental Management Policy (EMP) goals is to reduce the amount of chemicals in Postal facilities.

In 1995, MTSC began a series of water treatment tests in cooling tower systems to determine the success of non-chemical systems. This MMO is an effort to assist EMP in the reduction of chemicals and provide test results to Maintenance and Environmental groups.

Although this MMO allows the use of non-chemical treatment systems in cooling tower systems, it should be realized <u>there is some risk</u> in using a non-chemical system.

NOTE

Using chemical water treatment is still the recommended method for treating cooling tower systems. Chemicals are still required for other HVAC systems. i.e. steam and hot water boilers, closed loop systems (chilled and hot water), etc.

Tests conducted by MTSC have shown that some non-chemical systems can successfully operate in cooling tower systems. Some test sites required a return to some chemicals for the treatment to be successful, but there was a pronounced decrease in the amount of chemicals used.

Attachment 1 contains the water treatment final analysis summary and general information. Attachment 2 contains a summary of non-chemical water treatment system tests at seven (7) different USPS sites. Water treatment tests for hot water or steam boilers and the closed loop of a chilled water system were not included. Attachment 3 contains examples of coupon racks for monitoring corrosion. Attachment 4 contains a suggested Scope of Work (SOW) to be modified to fit your situation and/or facility.

Problems encountered included scale build-up to the point it shut the equipment down. Sometimes this happened over a very short period of time (3 days); other times it happened over a longer time (2 to 3 months). It pointed out the need to monitor the system closely.

These non-chemical systems are not maintenance free. If you are providing maintenance for a chemically treated system as required in MS-24 and MS-1, then there should be little or no increase in maintenance work-hours for the typical non-chemical system. If you are not providing the level of maintenance as outlined above, there will be an increase in work-hours. The maintenance effort for a non-chemical system will likely be very different, requiring training from the manufacturer, and a close watch of the system.

Before a decision is made to change to a non-chemical system, an analysis of the economics must be done. This analysis should include a Return on Investment (ROI). Reducing or eliminating chemicals in the facility should be a goal, but the decision should be based on the best use of USPS funds. A commitment by maintenance management and craft is a major factor in the successful operation of a non-chemical system.

Direct any questions or comments concerning this bulletin to the HelpDesk, Maintenance Technical Support Center, P.O. Box 1600, Norman OK 73070-1600; telephone FTS 2000 (405) 573-2123 or toll free (800) 366-4123.

Rex M. Gallaher
Manager
Maintenance Technical Support Center
Maintenance Policies and Programs

Attachments:
1. Water Treatment Final Analysis; Executive Summary
2. Summary of Non-Chemical Water Treatment System Tests
3. Coupon Test Racks for Corrosion Monitoring
4. Scope Of Work for Non-Chemical Water Treatment Systems for Cooling Towers

ATTACHMENT 1

WATER TREATMENT FINAL ANALYSIS
EXECUTIVE SUMMARY

The purpose of this project was to evaluate commercially available alternative water treatment systems for cooling towers as compared to current Postal policy of allowing only chemical treatment.

Seven (7) Postal facilities using five different water treatment systems participated in the tests. Some of the tests have been operating for 2 years.

Cooling tower water treatment is considered successful when all of the following conditions are achieved:

1. Scale is not visible or impeding heat transfer in the cooling tower or chiller condenser.
2. Bleed/blowdown water is kept to a minimum without causing scale or corrosion. This provides maximum water conservation.
3. Corrosion is kept equal to or less than 5 mils per year for mild steel and 2 mils per year for copper. (In some cases this may not be possible as the fresh water being supplied may have a higher corrosion rate than 2 mils per year.)
4. Biological substances are not present in any form that will impede cooling tower operation or present a danger to humans.

The anticipated results of these tests included a large reduction or the elimination of chemicals used in cooling tower water treatment, a reduction of maintenance work hours, and a reduction in water usage.

There have been some successes and some failures. All of the sites that are continuing to use non-chemical systems have eliminated or greatly reduced the use of chemicals. Maintenance work-hours either remained the same or increased. Obtaining water usage information was difficult. In those sites where it was obtained, no difference was noticed.

All sites that are continuing to use the non-chemical systems have some attributes in common. These included a commitment by both maintenance management and maintenance craft to have the test be successful and a commitment by the manufacturer or their representative to provide the support and training required. Problems occurred at all of the sites where there were personnel changes in management and/or craft.

As shown in Attachment 2, the ROI (Return On Investment) varied from 5 years to none. Some sites had an increase in costs over chemical systems. Either an increase in maintenance work-hours or the cost of a maintenance contract for the non-chemical system caused this increase in costs.

Calculating the ROI included the following items, if they were available: cost of current chemical contract; cost of current yearly maintenance by USPS employees; cost of water used for the year before the test; and any other associated costs (some cities charge extra for introducing chemicals into the sewer). Divide that number by the cost of the non-chemical system, cost of

yearly maintenance by USPS employees during the test (or the cost of a maintenance contract), the cost of water used during the test, and any other associated costs.

Savings from any efficiency increases are difficult, if not impossible to prove. Because of this, any proposed energy savings should not be used in an ROI calculation. Correspondingly they should not be used in any purchase decision.

Training for maintenance employees can be done on the job. In most cases, it cost less for USPS employees to maintain the non-chemical system than the cost of a maintenance contract. In all cases a comparison between leasing or purchasing should be considered. Some of the manufacturers did not offer a lease on their equipment.

There are other types of non-chemical water treatment systems that were not tested. The companies that provide these technologies can show examples of their success. The decision to change from chemical to non-chemical carries some risk. This risk can be minimized by investigating the technology, developing a proper contract, and making the commitment to follow through to make it work.

General Information

The results of these tests are not to be construed as definitive. Currently, there are changes being made to some of the systems that are not operating successfully to correct the problems.

Water quality is a major concern when starting a water treatment program. At each test site a water analysis was conducted. The results of this analysis are included in each test site summary.

There is neither enough time nor resources to research all of the different companies and water treatment technologies. The ones chosen for this project were based on systems that MTSC was aware of, years in business, and positive answers to the questions below from current customers of the respective companies.

When selecting the companies that would provide these products, an attempt was made to use companies that had been in business for a minimum of 5 years. To try to determine if the product met the claims of the company, phone calls were made to a list of customers these companies provided. The questions asked included:

1. Was the product still in use?
2. Was it successful? (Did it meet the requirements listed above?)
3. Were there any additional maintenance costs?
4. Were there any additional energy costs?
5. Was a maintenance contract purchased or did your maintenance department assume responsibility?
6. How many years have you had the product in use and was it successful for this entire time?
7. What parts have failed, what did they cost to replace, and was it done under a warranty?

Of the many types of non-chemical water treatment devices available, only a few were selected for testing. They include the following:

1. Permanent Magnets

2. Mixed Oxidant Generator (The patent on this product has been sold to another company and is being marketed under a different name. The company name and address is:
   Pureline Treatment Systems
   17151 Gillette Ave.
   Irvine, CA 92614
   The product is now called a Chlorine Dioxide Generator.)
3. Electro-Magnetic
4. Ozone Generator

The Maintenance Technical Support Center supplied funding for equipment at San Antonio, TX (Mixed Oxidant Generator), City of Industry, CA (Mixed Oxidant Generator), and Oklahoma City, OK (Permanent Magnet). MTSC also supplied funding for the modifications to a previously installed system in Fresno, CA (Permanent magnet). The equipment located at other sites was purchased locally. These other test sites were identified as a result of initiating the test in San Antonio, TX.

When using any water treatment technology, chemical or non-chemical, it is necessary to test the water in almost the same manner you would as if it were a chemical treatment system. The necessary tests include:

- pH, to see if the water is becoming acidic
- Chlorides, to determine the Cycles of Concentration and adjust bleed water to the lowest acceptable rate for maximum water conservation. This means the COC's will be as high as possible with no scaling or corrosion.
- Corrosion testing with coupons, to keep the corrosion level as low as possible (acceptable industry level is 5 mils per year or less for mild steel).
- Totally Dissolved Solids (TDS) to maintain a level that helps prevent scale and control electrolysis.

These tests should be part of any treatment system contract.

GENERAL OBSERVATIONS

Mixed Oxidant Generator

The results of using the Mixed Oxidant Generator indicate the following:

This equipment produces a Chlorine Dioxide gas that is injected into the water. Chlorine Dioxide is a very effective biocide.

Positive items:

1. Biological growth has not been a problem at either test site.
2. Corrosion levels at both sites are within accepted industry levels.
3. The equipment is computer controlled and has a modem that reports any problems back to the manufacturer's office.

Negative items:

1. Scale formed in the condenser requiring acid cleaning. This equipment also causes the production of a loose scale. This collects in the cooling tower, requiring some method of cleaning. The type of system used at both sites that helps keep the tower clean includes a side stream centrifugal filter, with a motor operated ball valve that operates off a time clock. It also has a piping system installed in the cooling tower basin to keep the water agitated, thus keeping the loose scale from settling, allowing it to be circulated into the filter for removal by the flushing action caused when the motorized valve opens. This adds $3,000 to $7,000 to the system.
2. Maintenance vigilance is critical. If the equipment is not operating correctly, hard scale develops quickly normally within 3 days.
3. There are no trained National Technical Support Personnel. The Company is located in California and does all support from there. They have done a good job of support at San Antonio and City of Industry.

Linear Kinetic Cells (Electro-Magnetic)

This system was unsuccessful. The manufacturer was in the process of changing the system to overcome the failure when the decision was made by USPS to go back to chemicals. The manufacturer of the equipment came up with this name (Linear Kinetic Cells); it is nothing more than an electro magnet.

Permanent Magnet

There are three permanent magnet systems installed.

1. Descal-A-Matic is a side stream system with a cartridge type filter.

This system has not performed successfully, and the site has returned to chemical treatment system. A copper/silver ion stick is being used to control biological growth.

2. Superior Water Conditioner is a combination of a side stream treatment system and a full in the line system.

This system operated successfully only after the addition of the full in-line magnets. Scale did form in the condenser and in the tower, but was easily brushed out at the end of the year. An algaecide is being used to control biological growth.

3. Magnetizer Group Inc.

   This is a clamp on the outside of the line magnetic system. This system has been successful for two years. A swimming pool chemical is being used for biological control.

Additional Information about Magnetic Treatment

Magnetic water treatment may not control scale in all water. Analyzing the water before purchasing a system is necessary. There are some water conditions that are considered unsuitable. Below is a list of conditions where magnetic treatment may not work.

(The following information is from a few manufacturers and may not be valid for others.)

1. High silica can cause problems. Silica content should be less than 10% of total hardness (CaCO3) because silica scale can form on its own. Example; if total hardness is 300 ppm, silica should not exceed 30 ppm.

2. Magnets can be affected by electrical interference. They must be installed at least 48 inches from any three-phase systems. It is also recommended that if the electrical system is grounded to the same pipe the magnets are in, (on), the ground wire be removed and connected to a separate properly installed ground rod or system.

3. To help control corrosion, make-up water pH must be at least 7.0.

4. Iron content equal to or higher than 1 ppm will require additional maintenance. The iron will collect on the magnet and will have to be removed for proper treatment to take place. Using an iron filter will usually provide satisfactory water for proper treatment to occur.

5. In most cases some type of biological control will have to be used. It has been noted the amount of chemicals necessary for this are usually reduced when compared to conventional chemical treatment.

6. In water where sulfates in ppm exceed total alkalinity in ppm, magnetic treatment should not be used.

7. If total hardness exceeds 2,250 ppm, magnetic treatment should not be used.

Ozone

This test was successful for keeping scale from developing in the condenser and in the cooling tower. The treatment system was turned off and the site returned to chemical treatment when the ozone level in the mechanical room was discovered to be above the Permissible Exposure Level (PEL) allowed by OSHA.

A major concern with ozone is the control of corrosion. Without the use of coupons for corrosion monitoring, it is impossible to make a decision concerning the rate of corrosion.

Another major concern is safety. Any Ozone system should have an initial evaluation of Ozone exposure levels. Also a forced exhaust system with an ozone level detector and a warning system should be installed with all ozone systems.

Additional Information

The Federal Energy Management Program (FEMP) is a Department within the U.S. Department of Energy. They produce a publication titled "Federal Technology Alert". (FTA) Two FTA's of interest are available from their web site and should be read if non-chemical water treatment is being considered. The first is titled "Non-Scale Technologies for Scale and Hardness Control". The second is "Ozone Water Treatment". To access the web site:

1. www.eren.doe.gov/femp
2. Go to search site
3. Go to Alphabetical Subject Index
4. Go to Alerts Federal Technology
5. Go to Non-Chemical Technologies for Scale and Hardness Control
6. Go to Non-Scale Technologies for Scale and Hardness Control.

The publishing of a "Federal Technology Alert is not an endorsement of a particular product as FEMP has not independently verified performance data provided by manufacturers."

The following is a summary of this Federal Technology Alert on Ozone Water Treatment.

The control of biofilm and scale is essential in maintaining cooling tower heat transfer efficiency. There is a belief within the industry that under certain conditions ozone acts as a descaling agent. The premise is that ozone oxidizes the biofilm that serves as a binding agent adhering scale to heat exchange surfaces. Ozone kills the bacteria that are causing the biofilm. Ozone can loosen and remove the scale if the biofilm is present, but if the biofilm is not present the ozone may be ineffective in removing the scale. Biofilm may not be the dominant fraction of scale where the temperature of the heat exchanger is in excess of 135°F (This temperature is very possible if water cooled air compressors are in the loop). It is a known fact the higher the temperature of the water the easier it is for scale to form.

Make-up water that is high in mineral content or dissolved solids may not be conducive to effective treatment; testing should take place before a system is installed and on a periodic basis during operation. A side-stream filter may be required on cooling towers that are operating with make-up water that has calcium hardness in excess of 150 ppm, (as CaCO3). In cases where hardness is in excess of 500 ppm as CaCO3, or sulfates greater than 100 ppm, ozone can be eliminated as a viable cooling tower water treatment.

Ozone treatment failures are usually related to an inadequate quantity of applied dissolved ozone which can be caused by excessive organic material in the water or high operating temperature, therefore, ozone treatment should be avoided in the following situations:

1. High organic loading from air, water, or industrial processes that would require a high chemical oxygen demand; the ozone will oxidize the organics and insufficient residual may remain for the water treatment.

2. Water temperatures that exceed 110°F (high temperatures decrease ozone residence time and reduce overall effectiveness of the ozone treatment).

3. Make-up water is hard (greater than 500mg/L as CaCO3 or dirty make-up water).

4. Long piping systems which may require long residence time to get complete ozone coverage.

Problems can and do occur in the field. The following precautions are not always covered in the manufacturers' instructions but are recommended:

1. Preparation of the inlet air is very important for the efficient operation of an ozone unit as well as for the longevity of the unit. The preparation of the gas includes removal of dust (particle sizes >1 μm), moisture (dewpoint < 76°F =99.98% moisture removed) and removal of oil. This requires that the pre-treatment system be checked periodically by properly trained personnel and that the appropriate monitoring equipment for the pretreatment process is installed.

2. Make-up water should be free from noticeable sediment, mud, and discoloration, and should not have extremely high levels of sulfates (< 100 ppm) or hardness (< 500 ppm as CaCO3). These values may be determined by having the water tested by a qualified lab.

3. Material in the ozone treated system should be compatible with ozone. The ozone distribution line from the generator to the gas/water contactor carries the highest concentration (1 to 4% by weight of ozone); therefore, the line material should be constructed of stainless steel or PVC.

4. For efficient operation the ozone generator should be located in an air-conditioned area. Excessive heat (greater than 90°F) could damage the system or reduce generation capacity.

5. The actual capacity of the ozone generator should be certified by the manufacturer and checked yearly by the ozone vendor or a qualified maintenance contractor.

Corrosion coupons for copper and steel should be placed in the system and checked at least every 6 months.

Summary:

None of the non-chemical systems tested were considered fully successful, but some of them were successful enough that the maintenance department at those sites kept them. Other sites went back to chemicals.

Of the successful sites, there were two things common to all:

- Both maintenance management and maintenance craft were committed to the test. This means proper record keeping, water testing, and active observation were provided.
- The manufacturer or their representative provided support with site visits and training. In many cases the manufacturer paid to acidize the equipment, when needed, or installed additional treatment equipment at no additional cost to us.

It was very clear that **if** we, the USPS, did not insist on testing the tower and make-up water in the same manner testing would occur if chemicals were being used, it would not have been done. This activity is critical in determining if the water is being properly treated to prevent scale and corrosion. Most of the companies did have some type of testing that they considered

adequate. Many times this did not include corrosion testing using coupons; and this kind of test should always be done even when using chemicals. Providing a proper bleed to control Totally Dissolved Solids (TDS) by installing a conductivity meter and solenoid valve should also be included. None of these non-chemical systems is maintenance free. The maintenance requirements are different from chemical systems, but are necessary.

ATTACHMENT 2

SUMMARY OF NON-CHEMICAL WATER TREATMENT SYSTEM TESTS

San Antonio, TX

Technology: Mixed Oxidant Generator

Company: Electrocel Technology Systems
12041 Mora Drive
Santa Fe Springs, CA 90670
562-946-7474 Fax 5911

In business since: 1989

Electrocel Technology Systems is out of business. The technology for its system is now owned by:
Pureline Treatment Systems
17151 Gillette Ave.
Irvine, CA 92614

Cost of equipment at time of purchase: $19,999.00. Current price, as of 2/21/97, is $25,000.00.

San Antonio was chosen as a test site because of the problems chemical companies have had in keeping the scale out of the cooling tower and chiller condenser tubes.

An agreement was made with this Company to test their equipment in San Antonio for a 90-day period. No commitment was made to purchase at the end of the 90 days. The agreement included full technical support from the company and a training program for USPS Building Equipment employees.

Analysis of city water: January 1995.

Conductivity:	450 μmhos/cm
pH:	7.9
Total Alkalinity	280 ppm
Chloride	30 ppm
Calcium Hardness	260 ppm
Total Hardness	280 ppm (this fluctuated up to 740ppm)
Silica	10 ppm
Sulfate	20 ppm

Initial Observations: The USPS maintenance department was informed that the initial effect on the system would be a loosening and falling off of the existing scale. This would require maintenance to closely watch the system to keep condenser screens and cooling tower distribution pans clean. Time required for this scale removal process was estimated at 30 to 60 days, after which, no more scale would be found in the system, just clean water.

(The above statement in one form or another was made by all of the companies with respect to their technologies)

After two years, many modifications, and much discussion, the system has rendered the following effect:

Scale formed inside the condenser very slowly. It took 2 years for the scale in the condenser to get thick enough to become a problem. Then it required acid cleaning.

This technology also has the effect of taking the dissolved minerals in the water (in particular calcium) and turning them into small particles of loose scale. These particles vary from pencil eraser to talcum powder in size. The higher the level of dissolved minerals in the make-up water, the more loose scale will be produced. This loose scale collects in the cooling tower, primarily in the fill of the tower. It collects to the point that the fill is plugged and must be cleaned. The key is, that this scale is loose. It is easily cleaned by flushing with a hose and shoveling it out. If the Generator malfunctions, the scale will quickly harden on all surfaces, requiring an acid cleaning. When scale begins to form on surfaces, it happens quickly. (Usually less than 3 days, and the scale is very thick, 0.75 inches or thicker). This happened twice in the 2 years the Generator has been on line.

During the first 18 months, the scale build-up occurred so quickly, the tower needed to be cleaned every 2 to 3 weeks. Maintenance work-hours increased from 12 hours per year per tower to 8 hours per tower every 3 weeks. In an effort to reduce the maintenance requirements for the cooling tower, a centrifugal filter with an automatic flushing system has been installed. The filter has been successful in reducing tower cleaning to an acceptable level of once a year.

Water quality is the reason for the scale problem. Calcium levels in the make-up water at San Antonio vary from 260 ppm to 740 ppm. The manufacturer (after this experience in San Antonio) is recommending a centrifugal filter with an automatic flushing system when the calcium level in the make-up water exceeds 300 ppm. Additionally, when the calcium level is above 300 ppm they recommend the use of acid to keep the pH between 7.8 to 8.2 when a cycles of concentration (COCs) above 4 is desired. In an effort to maintain COCs at 4, acid was introduced at this test site. The most accurate way to measure COCs is by measuring chlorides in the make up water and in the tower water; COCs should not be found by measuring Totally Dissolved Solids (TDS).

1. In January of 1997, the chillers were taken apart to do the yearly tube brushing. There was some scale on the tubes that brushing cleaned out.
2. To determine heat transfer efficiency, log sheets were checked for condenser approach. Condenser approach is the difference between condenser refrigerant temperature and condenser water out temperature. This was found to be the same as it was just after tube brushing, which means clean conditions.
3. Corrosion, checked weekly, was between 2 and 2.5 mils per year for mild steel and 1 to 1.5 for copper.
4. COCs have been fluctuating greatly and are presently at 3 to 4. This is the same COCs achieved when using chemicals.
5. There was no apparent biological growth.

Conclusions:

1. This technology was not successful in keeping scale from adhering to heat transferring surfaces in the condenser. In both test sites, a chemical treatment is being used to prevent scale.
2. It also seems to produce a scale-like material that collects in the cooling tower and must be physically removed, increasing maintenance requirements or requiring additional equipment (centrifugal filter) to remove it.
3. Maintenance vigilance is critical for a successful operation. Scale forms very quickly if the Mixed Oxidant Generator is not working correctly.
4. A contract with the manufacturer for maintenance may be necessary, if this technology is purchased. Approximate cost quoted by the manufacturer is $1.00 per ton per month. If San Antonio took this option, it would cost them $600.00 per month.
5. Maintenance requirements for the Generator are approximately 3 work-hours per week. This time includes a chemical analysis of the water. This is the same amount of time used with the chemical contract.
6. San Antonio has decided to keep this system.
7. This is not a non-chemical system, as acid is being used. They did eliminate the need for biocides and some of the other chemicals previously used in the cooling tower.
8. Water usage has remained about the same as when chemicals were being used.
9. ETS is not charging the Postal Service to provide support at this site, but they have not agreed to this situation at any future sites.
10. The savings to the Postal Service by not having a chemical contract is approximately $4,000.00 per year. ROI based on this chemical contract 5 years.

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Fresno, CA

Technology: Permanent Magnet; Zero Bleed System

Company: Superior Manufacturing Division
Magnatech Corporation
2025 Calhoun St. P.O. Box 13343
Fort Wayne IN 46868-3343
219-456-3596 1-800-348-0999 Fax 219-456-3598

In business since: 1964

Analysis of city water: July 1996

Conductivity:	454 μmhos/cm
Alkalinity:	190 ppm
Hardness	175 ppm
Silica	60 ppm
Chlorides	25 ppm
pH	7.37

The city of Fresno has some very restrictive waste water requirements. In an effort to comply with these requirements, a totally non-chemical treatment system was purchased. The manufacturer makes no claim that the product will control biological growth, but said they have some installations where it has not been a problem after the installation of their product. They recommend no chemicals for biological growth, until it is found necessary.

Cost of equipment at time of purchase: $45,000.00 plus additional magnets $28,000.00 for a total $73,000.00.

This permanent magnetic technology is an in-line type of magnetic water treatment where the water comes in contact with the magnet as compared with magnets that clamp on the outside of the pipe.

Initial Observations :

The USPS maintenance department was informed that the initial effect on the system would be a loosening and falling off of the existing scale. This would require maintenance to closely watch the system to keep condenser screens and cooling tower distribution pans clean. Time required for this scale removal process was estimated at 30 to 60 days, after which, no more scale would be found in the system, just clean water.

This treatment is set up as a side stream, permanent magnet system that has a centrifugal filter for removing large particles in the water (down to 7 microns) and a bag filter for small particle removal (down to 0.5 microns). It is designed for zero bleed as the flushing of the centrifugal filter is trapped in a separation chamber that lets the particles settle for removal and the water is returned to the circulating cooling tower water. The bag filter requires changing based on a water pressure differential. The frequency of bag filter changing depends on the quality of the water.

Fresno is located on an old Pre-Historic Ocean bottom. Because of this they get a lot of dust, calcium, and salts caught in the cooling tower. To remove the dust (now mud), they installed

two (2) centrifugal filters with motorized automatic ball valves in the condenser water lines, one for each chiller. The motorized ball valves operate off of time clocks and are set to flush the filters on a time schedule. These filters were part of the condenser water system before the magnetic water treatment system was installed. This prevents the new magnetic water treatment system from being a fully zero bleed system.

To determine heat transfer efficiency, log sheets were checked for condenser approach. Condenser approach is the difference between condenser refrigerant temperature and condenser water out temperature. This check can show the loss of heat transfer caused by scale. Approximately 6 months into the first year of operation, the condenser approach indicated that chiller tubes were becoming covered with scale. The system was acid cleaned, and new procedures were developed to operate the maintenance of the bag filter. In an attempt to keep cost down, they were cleaning the bag filter and re-installing it. The new procedure was to replace the filter and throw away the dirty one. The manufacturer was also concerned about what they considered to be a loss of treatment to the water because of the turbulence cause by the centrifugal filters in the condenser water lines, but thought the change in bag filter procedures might take care of the problem. After a second scaling and cleaning, the manufacturer recommended additional magnets be installed at the entrance of each condenser to overcome the loss of treatment caused by the in-line centrifugal filters. This required the addition of 2 more magnet devices. The manufacturer proposed to supply one device if we would purchase the other. We agreed to this and the additional magnets were installed at an additional cost of $28,000.00.

At the end of the second year, the condenser was opened and found to be lightly scaled, but this time the scale was easily removed by brushing the tubes.

Chemical treatment is being used for biological growth in this system.

Conclusions:

1. At the end of the second year, the condensers were opened and there was a slight coating of scale that was removed by brushing.
2. Cooling tower was in the same condition as the condenser.
3. Corrosion was not monitored during the test, but a coupon rack is being installed for future monitoring.
4. Maintenance vigilance is critical to successful operation. If the bag filter is not properly maintained, the water is not treated by the magnet in the side stream system and scaling occurs rapidly. Maintenance work-hours are approximately the same as when chemicals were used.
5. The maintenance department is not fully satisfied with the results and is still working with the manufacturer to change some of the operating procedures to produce an acceptable outcome. A controlled bleed system is being considered because of a high silica levels.
6. The use of a chemical to treat for biological growth prevents this project from being called fully successful.
7. Water usage at this site has decreased by approximately 25%. A major contributor to this savings is the Zero bleed system.
8. The Postal Service paid a chemical contractor $14,630.00 for services and materials in 1993. The USPS has not had to pay that since, but the anticipated cost of the biocide for

1997 is $1,050.00. This results in a savings in 1997 of $13,580. The ROI based on the last chemical contract is 5.4 years

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Stockton, CA

Technology: Permanent Magnet; Zero Bleed System

Company: Descal-A-Matic International
4855 Brookside Court
Norfolk VA 23502
757-858-5593 Fax 757-853-3321

Local Sales: MC2 Resource Management
6245 Golf Link Road
Hilmar CA 95324
209-634-4900
Don McClellan

In business since: 1969.

Analysis of city water:	March 1996
pH	7.6
Totally Dissolved Solids	390 μmhos/cm
Total Hardness	260 ppm
Silica	55 ppm
Iron	0.015 ppm

Cost of equipment at time of purchase: $13,500.00

This permanent magnetic technology is an in-line type of magnetic water treatment where the water comes in contact with the magnet as compared with the clamp on the outside of the pipe type.

The USPS maintenance department was informed that the initial effect on the system would be a loosening and falling off of the existing scale. This would require maintenance to closely watch the system to keep condenser screens and cooling tower distribution pans clean. Time required for this scale removal process is nine months to a year with the process beginning within 30 to 60 days, after which, no more scale would be found in the system, just clean water.

Initial Observations :

This system operated as a true Zero bleed system during the entire 1996 operating year. There was no bleed water at all. This caused Total Dissolved Solids to be so high they could not be measured by conventional test equipment.

The system is a side stream installation with a filter to remove solids down to 5 microns. It is designed in a manner that if the filter becomes plugged or partially plugged, water is not being treated by flowing through the magnet. This requires maintenance to be diligent with their actions to ensure water flow through the magnet so treatment is occurring.

This installation ran for the entire 1996 cooling season. A new galvanized steel cooling tower was installed before the beginning of the cooling season and the contractor felt he needed to

run some acid in the system to prevent white rust and passivate the new galvanizing. Citric acid was used first. This causes a sticky film on surfaces that impaired heat transfer. Maintenance had to remove the end covers on the condensers and punch the tubes to keep the system operating. This happened twice. A change to muriatic acid stopped the sticky condition but a hard scale covered the tubes shortly after its introduction. This required another cleaning. The contractor theorized that the muriatic acid created the hard scale. At the end of 3.5 months, all use of acid was discontinued.

The chiller was monitored for condenser approach during the year and found to operate in what was considered to be a normal condition. The approach temperatures were taken with an infrared thermometer. Log sheets were not complete enough to cross check the temperatures recorded by the infrared thermometer.

The end covers on the condensers were removed in December 1996 and the condenser tubes were found to be covered with a thin layer of scale. This was a hard scale that had to be removed by acidizing the system. This scale should have showed up with approach readings, but approach temperatures did not show the increase expected when scale is present. If log sheets had been properly recorded, this approach temperature may have shown the expected changes.

The contractor that is providing manufacturer's support for this installation is of the opinion a true Zero bleed system will not work unless in conjunction with a strictly enforced maintenance regime and has asked that a Totally Dissolved Solids (TDS) control be put in along with a method to bleed system water to prevent the TDS from getting above 2,100 ppm. This was being done in July 1997. The operation at this site for the 1997 cooling season that began in May included a test of the TDS using a hand test kit and manually adjusting the bleed to keep the TDS at 2,100 ppm. Operation so far this year has been satisfactory.

Biological control is being provided by a copper/silver ionizer. This unit operates by putting a small current through the copper and silver ion sticks. That causes the metals (copper & silver) to dissolve at a very slow rate into the water. The manufacturer provides a test kit so adjustments can be made to keep the copper level at 0.15 ppm. The copper kills the algae and the silver kills bacteria. The ion sticks usually last one year and for systems up to 700 tons cost approximately $300.00. According to the manufacturer, both copper and silver levels can be maintained well below EPA levels for standard drinking water and still be effective.

The magnitic system was take off line and chemical treatment was started in July of 1999. The Stockton maintenance department had been required to clean the condensers at least twice a year to keep them operational. Scale was building up causing the chillers to shut down because of high head pressure.

Conclusions:

1. At the end of the year, the condensers were opened and there was a coating of scale that was removed by acidizing.
2. Cooling tower was in the same condition as the condenser.
3. Corrosion was not monitored during the test, but a coupon rack is being installed for future monitoring.
4. Maintenance vigilance is critical to successful operation. If the filter is not properly maintained, the water is not treated by the magnet in the side stream system and scaling occurs rapidly. Maintenance work-hours increased from 1.5 per month to 15 per month.
5. The Ion system has been effective in controlling algae.
6. Water usage in 1995 was 112,478 gallons. Water usage records for 1996 was not available.
7. Cost for the chemical contract for the 1995 year was $3,800.00. The Postal Service has saved that much per year since 1995, in addition to the cost of the water. The ROI based on the last chemical contract and the increase in maintenance work-hours is negative. We had a loss of $1,209.04 per year.
8. Scale build-up occurred often with this system.
9. Stockton returned to 100% chemical treatment in1999.

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City of Industry, CA

Technology: Mixed Oxidant Generator

Company: Electrocel Technology Systems
12041 Mora Drive
Santa Fe Springs CA 90670
562-946-7474 Fax 5911

Electrocel Technology Systems is out of business. The technology for its system is now owned by:
Pureline Treatment Systems
17151 Gillette Ave.
Irvine, CA 92614

Analysis of city water	May 1994
pH	7.9
Conductivity	500 μmhos/cm
Total Hardness	180 ppm
Calcium Hardness	100 ppm
Magnesium Hardness	80 ppm
Total Alkalinity	200 ppm
Chlorides	50 ppm
Silica	15 ppm
Sulfate	25 ppm

This is the same technology and company used in San Antonio. This test was done at the request of the company because of the difficulty in San Antonio.

Initial Observations :

It has been observed, that this technology, Mixed Oxidant Gases, has the effect of taking the dissolved minerals in the water (in particular calcium) and turning it into a loose scale. Thus, the higher levels of dissolved minerals in the make-up water, the more loose scale will be produced. This loose scale collects in the cooling tower, primarily in the fill of the tower. It collects to the point that the fill is plugged and must be cleaned. The key here is that this scale is loose. It's easily cleaned by flushing with a hose and shoveling it out. This scale build-up occurs so quickly, the tower needs to be cleaned every 2 to 3 months.

If the Generator malfunctions, the scale will quickly harden on all surfaces, requiring an acid cleaning. When scale begins to form on surfaces it happens quickly, usually in less than 3 days and the scale becomes very thick - 0.75 inches or thicker. City of Industry has not had this happen.

City of Industry has water cooled air compressors, and the water used to keep the compressors cool is circulated with the condenser water through the cooling tower. The air compressors operate at a much higher temperature than the condenser. Because of the higher temperature, a scale build-up occurred in the cooling coils of the air compressors and plugged them. <u>It should be noted that this same condition occurred while using chemicals</u>. Future plans call for new air compressors that are air cooled to alleviate this problem.

1. In December of 1996, the chillers were taken apart to do the yearly tube brushing. There was light scale on the tubes.
2. To determine heat transfer efficiency, log sheets were checked for condenser approach. Condenser approach is the difference between condenser refrigerant temperature and condenser water out temperature. This was found to be the same as it was just after tube brushing, which means under clean conditions.
3. Corrosion, checked weekly, was between 2 and 2.5 mils per year for mild steel and 1 to 1.5 for copper.
4. COC's has been fluctuating greatly and is at present around 3 to 4. This is the same COC's achieved when using chemicals.
5. There was no apparent biological growth.
6. The cooling tower requires cleaning about every 3 months to remove the loose scale that has collected in the fill. The time it takes to do this is about 3 hours. The scale is easily removed.
7. Because of the maintenance required to keep the tower clean and the scale found in the condenser, a decision was made to go back to chemicals to control scale and continue using the ETS system for biological control. This combination appears to be working.

Conclusions:

1. This technology did not keep scale from adhering to chiller (condenser) heat transferring surfaces.
2. It also seems to produce a scale-like material that collects in the cooling tower and must be physically removed.
3. Maintenance vigilance is critical to successful operation. Scale forms very quickly if the generator is not working correctly.
4. A contract with the manufacturer for maintenance may be necessary, if this technology is purchased unless an agreement is made with the manufacturer to train USPS employees. The increase in maintenance work-hours would have to be included in the ROI calculation.
5. At this site, maintenance requirements for the generator and cooling tower system are approximately 3 work-hours per week. This is the same amount of time spent when chemicals were being used.
6. This system does control biological growth.
7. Water usage has remained approximately the same as when chemicals were being used.
8. The cost of the last chemical contract was $5,963.00. ETS is charging the Postal Service $750.00 per month of operation for servicing this site. This system runs about 12 months a year costing $9,000.00 at a loss to the Postal Service of $3,037.00 per year when compared to chemicals. Maintenance management is in the process of having USPS employees trained to reduce this loss.
9. Maintenance Management is satisfied with this system.
10. Chemicals are being used to control scale.

Phoenix, AZ

Technology: Linear Kinetic Cells (electro-magnetic) Zero Bleed System

Company: Water Dynamics Inc.
1126 S. E. 213th Ave.
Gresham OR 97030
1-800-635-1576 Fax 503-669-0896

In business since: 1988 .

Analysis of city water: December 1996

pH	7.47
Conductivity	810 μmhos/cm
Total Hardness	220 ppm
Total Alkalinity	180 ppm
Chlorides	120 ppm
Silicon	7.4 ppm
Total Magnesium	25 ppm
Total Calcium	48 ppm
TDS	470 ppm

Cost of equipment at time of purchase: $60,000.00.

Initial Observations :

Phoenix has 3 chillers and typically operates them in a lead-lag fashion.

This water treatment system has a series of Linear Kinetic Cells installed in different locations in the condenser water circulating network. It also has a sand filter as part of the system that requires a back flush. This filter uses about 500 gallons of water daily. The use of this back flush water prevents the system from acting like a true Zero bleed system.

During a 4 month operating period, head pressure slowly increased. The condenser covers were removed to inspect the tubes. They were found to be scaled so badly that the system needed to be acidized. The water treatment equipment manufacturer had this done at their cost. New operating and maintenance procedures for the water treatment system were developed to preventing a recurrence of the scaling problem. After the chillers were on line again, condenser approach temperatures showed that scaling was taking place once more. The approach increased from 3°F to 13°F over the next 3 months. Again the manufacturer acidized the system to clean it up.

Conclusions:

1. At the end of the year the condensers were opened and there was a coating of scale that was removed by acidizing. This was paid for by the manufacturer of the water treatment system. This was the third time cleaning was required.
2. Cooling tower was not as bad as the condensers but still had some scale.
3. Corrosion was not monitored during the test.
4. Because of the problems encountered, as listed above, the maintenance department made the decision to turn off the non-chemical water treatment equipment and return to a chemical type system.

Manchester, NH

Technology: Ozone Generator

Company: Rez-Tec International
15 Oakwood
Wayne NJ 07470
Worcester MA
1-800-770-8554 Fax 508-435-8722

In business since: 1991.

Cost of equipment at time of installation: $30,000.

Analysis of city water: August 1995

pH	7.07
Alkalinity	8 ppm
Chloride	16 ppm
Hardness	14 ppm
Calcium	4.31 ppm
Magnesium	0.87 ppm
Sulfate	15 ppm

Initial Observations :

Installed in Spring 1994 and operated until mid 1996. Log sheets showed no increase in condenser approach temperatures over this time period.

The manufacturer recommended the system be operated with Cycles of Concentration (COCs) as high as possible without scaling occurring to conserve water. The system was operated at the same bleed rate used with chemicals. This means maximum water conservation was not attempted.

Condenser covers were removed at the end of the cooling season in both 1994 and 1995. There was no scale apparent in the tubes. Corrosion was monitored using a pH probe and maintaining pH above 7. Other methods of corrosion monitoring such as using coupons have not been done.

This facility has the sump of the cooling tower located in the mechanical room. During the summer of 1996, it was discovered the ozone level in the mechanical room was above the Permissible Exposure Level (PEL) allowed by OSHA and the ozone water treatment system was turn off. The decision was made at that time to return to chemical water treatment. At this time, there is no effort being made to return to the ozone treatment system.

Conclusions:

1. At the end of each year the condensers were opened and found to be free from scale.
2. Cooling tower was in the same condition.
3. Corrosion was not monitored by coupons during the test. Monitoring pH by itself is not an acceptable method of monitoring for corrosion.
4. Maintenance vigilance is critical to successful operation. Maintenance work-hours for this system were the same as those used for the chemical contract.
5. The maintenance department was fully satisfied with the results.
6. Possible water conservation by decreasing bleed was not attempted.
7. Dangers of over exposure to ozone are possible and proper sensors with a warning system should be included with any use of this kind of system.

ROI based on last chemical contract is 5 years.

Oklahoma City, OK

Technology: Permanent Magnet Clamped on the outside of the condenser water pipes.

Company: The Magnetizer Group Incorporated
Box 1000 Point Pleasant Pike
Gardenville, PA 18926
215-766-8660 Fax 7320

Contact: George Gakoumis
Northlink
1768 Kimball Ave,
Willow Grove, PA 19090-3808
215-659-6983 Fax 6982

In business since: 1979.

Cost of equipment at time of installation: $14,000.00.

Analysis of city water :
Oklahoma City receives its water as a mixture from 3 sources. The following analysis is an average of those sources.

pH	8.6
Alkalinity	46 ppm
Chloride	109 ppm
Hardness	202 ppm
Calcium	59 ppm
Magnesium	13.76 ppm
Sulfate	190 ppm
Silica	3.36 ppm

Initial Observations :

This system was installed in August 1996. Operation of the chillers has shown no detrimental effects. Log sheets indicate condenser approach is holding at the same level as when the chiller was first started up in a clean condition.

At the end of the 1996 operating year, the condenser end bells were removed for inspection and cleaning. The condenser tubes were free of scale, but they were partly plugged from pieces of rust. Corrosion was not monitored, but a coupon rack has been installed and for the 1997 season corrosion will be monitored.

At the beginning of the 1997 season, the condenser water strainer filled-up with large pieces of rust and scale. This slowed water flow down and the flow switch turned off the chiller. The manufacturer of this system had warned that this would occur after approximately 6 weeks of operation. After a period of time this stopped.

Algae control is being provided by using a basket with chlorine tablets to maintain a level of 0.5 ppm. The BEMs are testing the water weekly and adjusting the number of tablets in the basket to maintain this level.

A TDS monitor has been installed to provide automatic bleed. The target level is 2000 μmhos/cm.

This system ran 2.5 months in 1996, and the entire 1997 season. Log sheets indicate condenser approach is staying at a steady level. Corrosion coupons show 3.7 mils per year for mild steel and 0.57 for copper.

Conclusions:

1. By monitoring condenser approach it appears that scale has not formed in the condenser.
2. The cooling tower has some surface scale on the edges of the fill but no scale has formed in the distribution pans or inside the fill. Algae is being controlled with chlorine tablets.
3. Corrosion is considered to be in the Good range. Chlorine levels have been higher than the target level of 0.5 ppm. This by itself can cause higher corrosion. Training is being conducted to get the chlorine levels down.
4. This is not a chemically free system as they are using chlorine.
5. Maintenance work-hours have remained the same as those used with chemicals.
6. Some equipment to test the water and to provide a controlled bleed has been purchased.
7. Training in the use of the above equipment was part of the purchase contract.
8. The last chemical contract cost $200.00 per month. Using only that figure, the ROI is 8.75 years. Oklahoma City is charging the Post Office a fee for the chemicals being introduced into the sewer system. This amount has not been included in the ROI yet because the Post Office wanted to see if they are going to keep the Magnetic system before going to the City to change the sewer bill.

ATTACHMENT 3

COUPON TEST RACKS FOR CORROSION MONITORING

Figure 3-1 is an example of a two (2) place coupon rack that can be used for monitoring corrosion. Typical coupons would include copper and mild steel. Mild steel should be the same type of steel used in steel pipe.

Figure 3-2 is an eight (8) place coupon rack as an example only to demonstrate that more places can be included if additional types of coupons are desired.

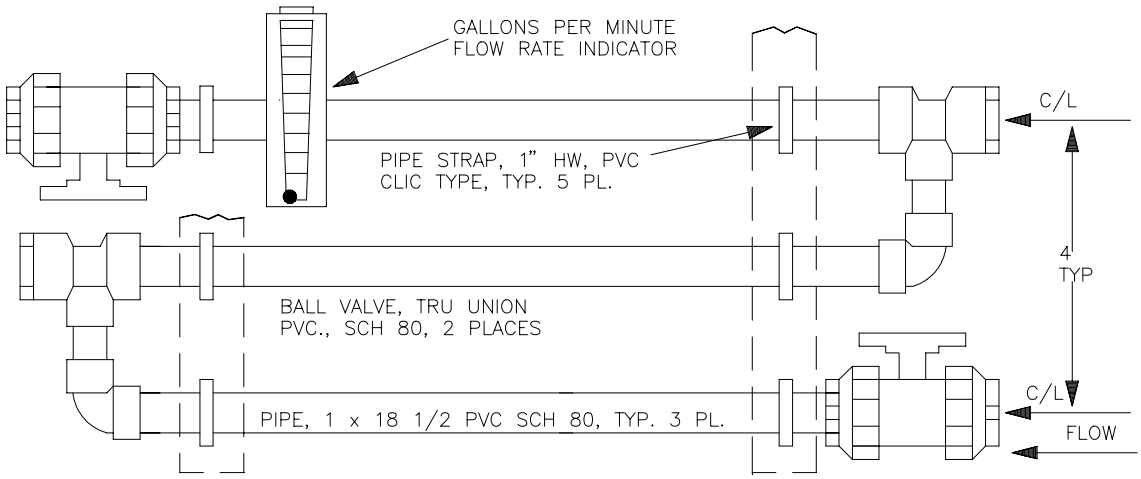

Figure 3-1. Two (2) Place Coupon Rack

Corrosion coupon racks should have a water flow rate of 8 to 12 gallons per minute (gpm) and should include isolation valves. Coupons must be arranged so as to expose steel coupons first, followed by copper coupons to avoid plating copper onto mild steel and galvanized surfaces.

Typical monitoring period is one to two months after which the coupons are sent to a lab for analysis.

Examples of corrosion rates for the expected life of Standard 6" Schedule 40 Steel Pipe in years:

Corrosion rate in mills per year	Years of life	This is considered
0 to 2	over 70 years	Excellent
2 to 5	70 to 28 years	Good
5 to 8	28 to 17 years	Fair
8 to 10	17 to 14 years	Poor
Over 10	Less than 14 years	Intolerable

Examples of corrosion rates for the expected life of Standard 16 gauge copper condenser tubing in years:

Corrosion rate in mills per year	Years of life	This is considered
0 to 1	over 65 years	Excellent
1 to 2	65 to 32.5 years	Good
2 to 3	32.5 to 21.66 years	Fair
3 to 4	21.66 to 16.25 years	Poor
Over 4	Less than 16.25 years	Intolerable

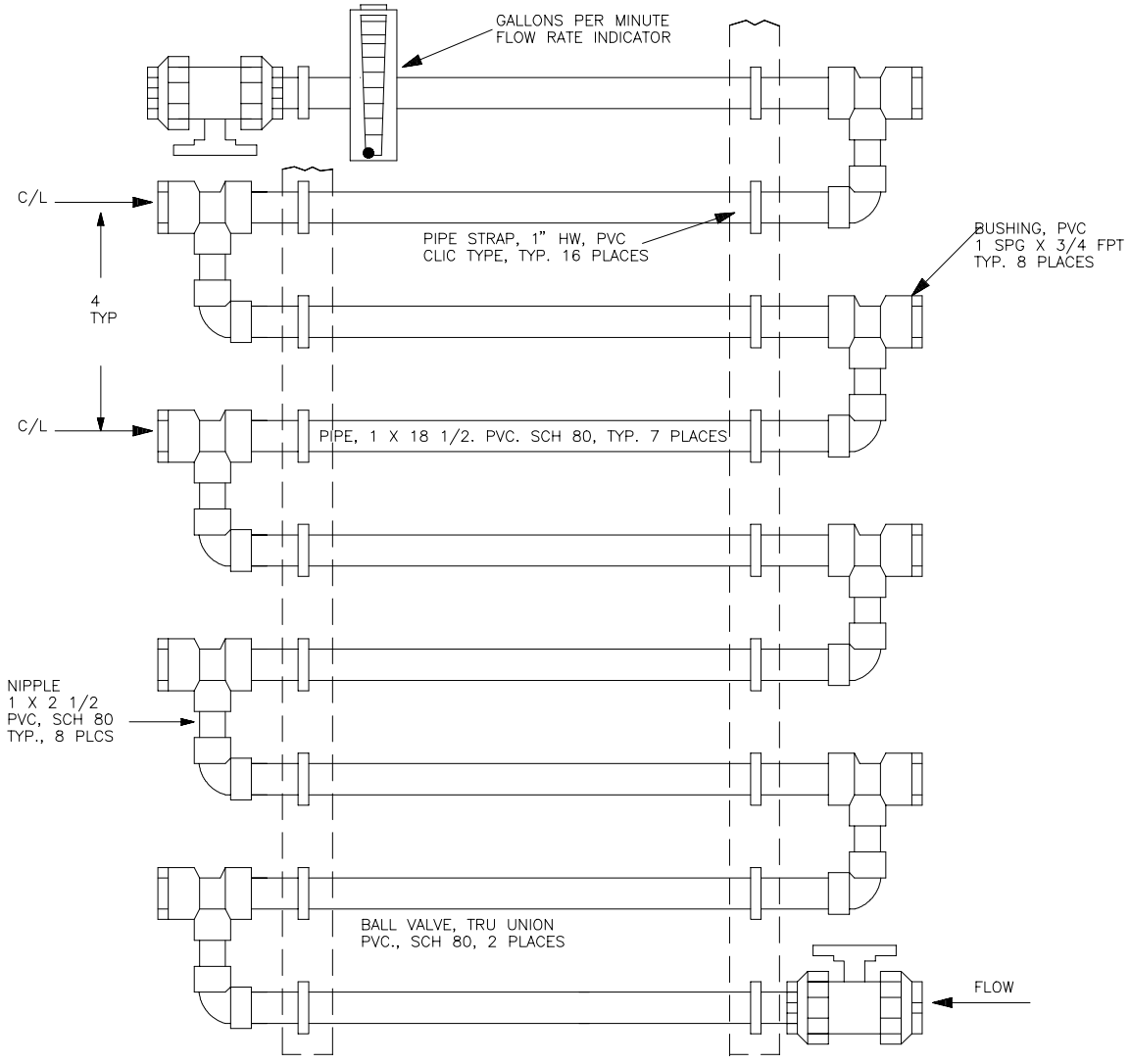

Figure 3-2. Eight (8) Place Coupon Rack

References for the above drawings and corrosion information: Blake, R.T. , "Water Treatment for HVAC and Potable Water Systems" McGraw Hill, NY 1983, pp 126-127.

ATTACHMENT 4

SCOPE OF WORK FOR NON-CHEMICAL WATER TREATMENT SYSTEM FOR COOLING TOWERS

The following is a suggested Scope of Work (SOW). It may be modified to fit your situation and/or facility.

The contractor shall have been regularly engaged in the water treatment field in the areas to be serviced for a minimum period of two years. The contractor shall submit for approval, prior to award of contract, satisfactory references, proof of competency, and detailed descriptive literature of system proposed. The treatment supplied by the contractor shall be one that has been especially designed and tailor made for the water being used in each system.

The contractor shall furnish and properly install _____(insert type of equipment here)_____ water treatment equipment according to local building codes and the National Electrical Code. Installation shall include all associated piping and electrical components.

The treatment program shall prevent the development of scale, biological fouling, including slime and algae, and prevent sludge build up. Corrosion will be kept to less than 5 mills per year for mild steel and less than 2 mills per year for copper. The water treatment must constantly prevent the buildup of adherent mineral and/or silica deposits on the heat transfer surfaces to the equipment being treated. Periodic circulation of inhibited acids (acidizing for cleaning purposes) will not be considered as meeting these specifications.

The water treatment system offered shall maintain a pH factor as stated below:

Cooling Tower Systems	7.0 - 8.4

The bleed-off rate will be adjusted by the contractor to maintain the highest cycles of concentration possible without scale developing or increasing corrosion above stated requirements and should be in direct proportion to equipment load indicated by the make-up water. The contractor will provide water flow meters in the proper lines that will record gallons of make-up water and gallons of bleed water.

The contractor shall furnish a small water analysis test kit to be used by the Postal Service maintenance personnel for periodic testing of water conditions. The contractor will provide training in the use of the water analysis equipment. Treatment and services shall include a monthly analysis of the circulating water (condenser) and furnishing any additional equipment needed to inhibit scale and corrosion, prevent biological fouling, and control slime and algae in a manner to avoid deterioration of the cooling towers, chiller and the circulating water systems. A copy of the monthly analysis will be provided to the contracting officer's representative (COR) at the site.

The contractor shall prescribe the proper usage and maintenance of the treatment equipment and instruct operating personnel in their use.

Any chemicals prescribed in conjunction with the non-chemical system shall have no detrimental effect on the metallic or non-metallic materials in the equipment being treated.

Contractor shall warrant that the chemicals used in the water treatment program will not endanger the health or safety of persons coming into contact with the materials and will not damage personal or real property as long as the contractors instructions are followed.

All chemicals offered shall be described in terms of common chemical names.

Material Safety Data Sheets (MSDS) shall be provided to the Postal Service for all chemicals furnished, including those chemicals used in test kits.

If any chemicals are included with system, the compounds offered should be a single feed liquid treatment suitable for use with a ratio feeder or proportioning pump.

For any necessary chemicals, automatic feeding devices shall be furnished and installed at each location by the contractor.

The contractor shall remove and dispose, in an environmentally safe manner, all barrels and other chemical containers used in this water treatment contract.

SCALE AND CORROSION CONTROL

The treatment program shall consist of the controlled use of scale and corrosion prevention equipment and materials. The use of essentially toxic and staining corrosion inhibitors such as chromate will not be permitted. Corrosion inhibitors selected shall have been proven effective by a least one year's usage by the water treatment contractor. Polyphosphates are not considered as effective corrosion inhibitors. The use of inhibitors such as the organic phosphorous type will be permitted.

For cooling tower corrosion monitoring the contractor shall furnish and install a coupon type test rack and provide coupons for testing as specified below. The coupon rack shall be configured as shown in Attachment 3 and include all associated equipment as shown in the attachment. This coupon rack shall be installed and adjusted for flow in the appropriate condenser water line at the proper location. The contractor will provide the proper coupons for the first year. The contractor will provide for the analysis of the coupons used and provide a copy of the analysis to contracting officers representative at the site. The contractor must provide instructions as to proper installation and monitoring to USPS operating personnel. Information for having the coupons analyzed will be provided by the contractor. Coupons used for testing shall include mild steel and copper. If the cooling tower has galvanized steel in it, a coupon for galvanized steel will also be furnished by the contractor.

The use of either pH adjustment or chelating-type scale prevention treatments will be permitted. When acids are used in the adjustment of the pH, the acids shall be a dry-type when used in systems under 200 tons. Sulfuric acid may be used in other systems when pumped directly from the carboy into the system.

If chemicals are used in conjunction with the non-chemical system, the contractor shall provide a completely automatic proportional pump feed and bleed system for systems over 100 tons capacity. A proportional manual feed system or a proportional pump feed system as recommended by the contractor may be used for systems under 100 tons capacity. The system shall use an automatic device to activate the chemical feed and bleed-off. Cycles of

Concentration (COCs), as measured using chlorides, of the open system water will be maintained as high as possible without reducing treatment effectiveness to conserve the use of makeup water and chemicals.

Control shall be by means of a solid state conductivity meter and a flow-through probe sensor. The controller is to be programmed to bleed off the system and regulate a preset solution feed pump. Training of USPS operating personnel in the operating, adjusting, and maintenance of this equipment will be provided by the contractor.

When condensing temperatures, operating pressures, or other operating data, as interpreted by USPS personnel, indicate that the water treatment program is not adequate, contractor shall provide the necessary chemicals and labor to clean the equipment immediately, and thereafter modify his program to maintain condensing temperatures, operating pressures, and other factors within the limits specified by the manufacturer of the equipment (chiller or cooling tower).

Services
After the installation of the treatment system, the contractor will provide the following services for a period of one year:

The contractor shall make at least one inspection of the cooling towers and chilled/hot water circulating systems each month to check operation, instruct personnel, and collect water samples for analysis. The contractor shall furnish, monthly, to the Contracting Officer's Representative a report on form 4998 indicating:

- The general condition of the systems
- Instructions issued to operations personnel
- Analysis of the water samples together with recommendations

Contractor shall make the initial application of each material and shall furnish specific oral and written instructions to operating personnel for the maintenance and control of the water treatment program.

USPS operating personnel may obtain samples and/or other pertinent data for the contractor, provided the contractor furnishes written instructions and the necessary sampling containers, etc.

For any testing that may be required between visits by the contractor, the contractor shall furnish testing equipment, any chemical solutions required, and training in its use.

With the acceptance of this contract by the contractor, the contractor warrants that the water treatment system will perform to control scale, corrosion, and biological growth as listed above. If modifications to the treatment system must be made for the system to operate as listed above, the modifications will be made at the contractors expense with no costs to the US Postal Service.