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USER GUIDE

Ozone Water Treatment System for Cooling Towers: User Guide and Specifications

by
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Innovative Ideas for the Operation, Maintenance, & Repair of Army Facilities

Foreword

This study was conducted for the U.S. Army Center for Public Works under the Facilities Engineering Application Program (FEAP). The technical monitor was Malcolm McLeod, CECPW-ES.

The work was performed by the Materials Science and Technology Division (FL-M) of the Facilities Technology Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Vincent F. Hock. Dr. Ilker R. Adiguzel is Acting Chief, CECER-FL-M and Donald F. Fournier is Acting Operations Chief, CECER-FL. USACERL technical editor was Linda L. Wheatley, Technical Information Team.

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COL James T. Scott is Commander and Dr. Michael J. O'Connor is Director of USACERL.

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1 Executive Summary

Background

It has been observed that a major cause of scaling in cooling water systems can be attributed to the biological and organic content of the system. Traditionally, cooling water has been treated to prevent corrosion by addition of corrosion inhibitors, scale control chemicals, and biocides. Some common chromate additives are phosphorus, chlorine, and zinc compounds. Frequently, several different biocides are used in conjunction because a given organism can develop an immunity to a single biocide. In 1990, the U.S. Environmental Protection Agency (EPA) banned the use of chromates in these water systems, and other maintenance practices involving additive use, such as blowdown, are regulated because the discharge can carry harmful chemicals and hot water into publicly owned treatment works.

The ability of ozone (O_3) to disinfect water has been known and used for years. Using ozone to treat cooling tower water is a relatively new procedure, however. Because of its promising energy saving and environmental benefits, its popularity is growing. Ozonification has been used for years to reduce the biological contaminants in the cooling tower water that is recycled in a closed system for building cooling. This technology is an alternative to the use of chemical biocides, which require maintenance and monitoring. The cost savings associated with this technology come mainly from labor savings, from the elimination of chemical treatment requirements to meet EPA clean water standards, and the low cost of installation.

Further, industry experts claim ozone is a more effective biocide than chlorine and effectively destroys disease-causing bacteria such as the strains linked to Legionnaire's Disease. Moreover, because it is a short-lived compound that rapidly reverts to diatomic oxygen (O_2), ozone eliminates the concentration of traditional biocides in cooling water. In addition, some experts have reported that ozone can control certain kinds of corrosion and scale.

A new cooling tower system installed at the U.S. Military Academy, West Point, NY, has used ozone as a standalone treatment for two cooling seasons. A typical cooling tower operation is shown in Figure 1.

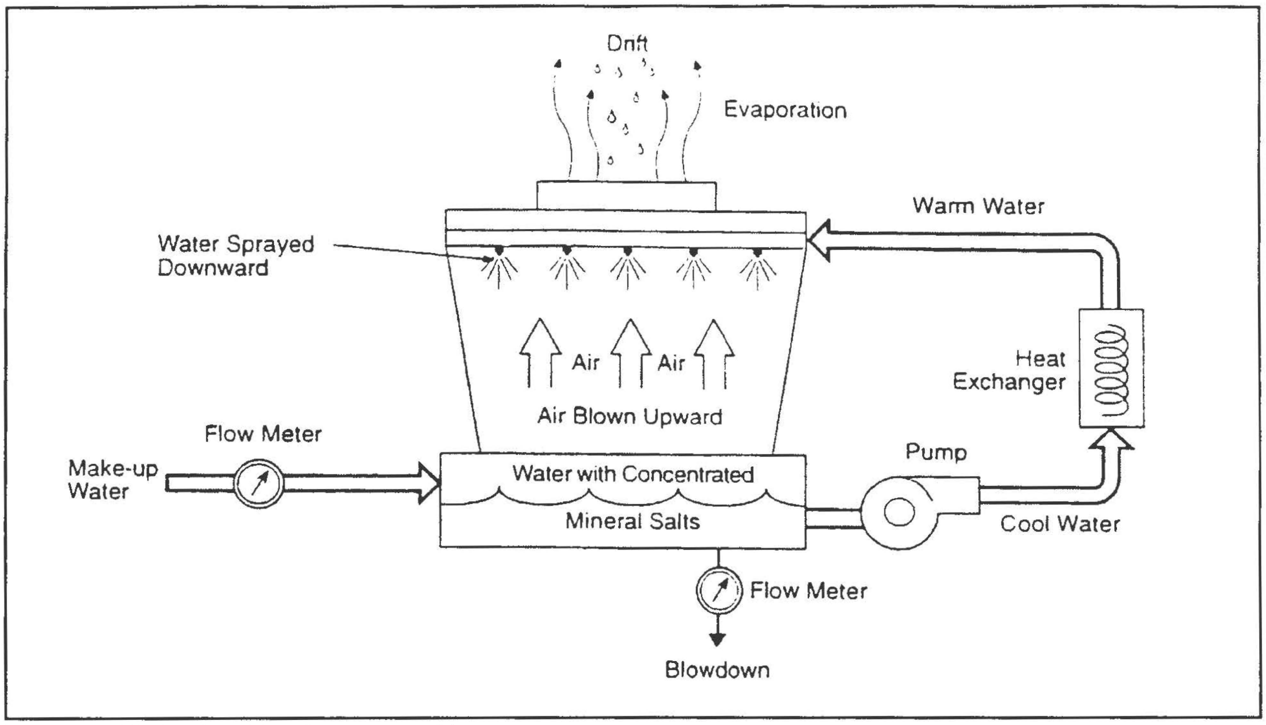

Figure 1. Typical cooling tower operation.

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2 Pre-acquisition

Description of Technology

Ozone is a powerful and effective biocide that can oxidize many organic and inorganic substances. Figure 2 shows the basic ozone water treatment process for cooling towers. The major components of this system include: an air dryer, an air compressor, water and oil coalescing filters, a particle filter, ozone injectors, an ozone generator, and a monitoring/control system. In this system, ambient air is compressed, dried, and ionized in the generator to produce ozone, which is then introduced into the cooling water through a side stream of the circulating tower water.

Life-Cycle Costs and Benefits

Based on the field investigations made at West Point, reduced scaling allows tower pumps to run more efficiently and with less maintenance. Increased efficiency of equipment lowers energy requirements and electrical use. Less scale buildup in the

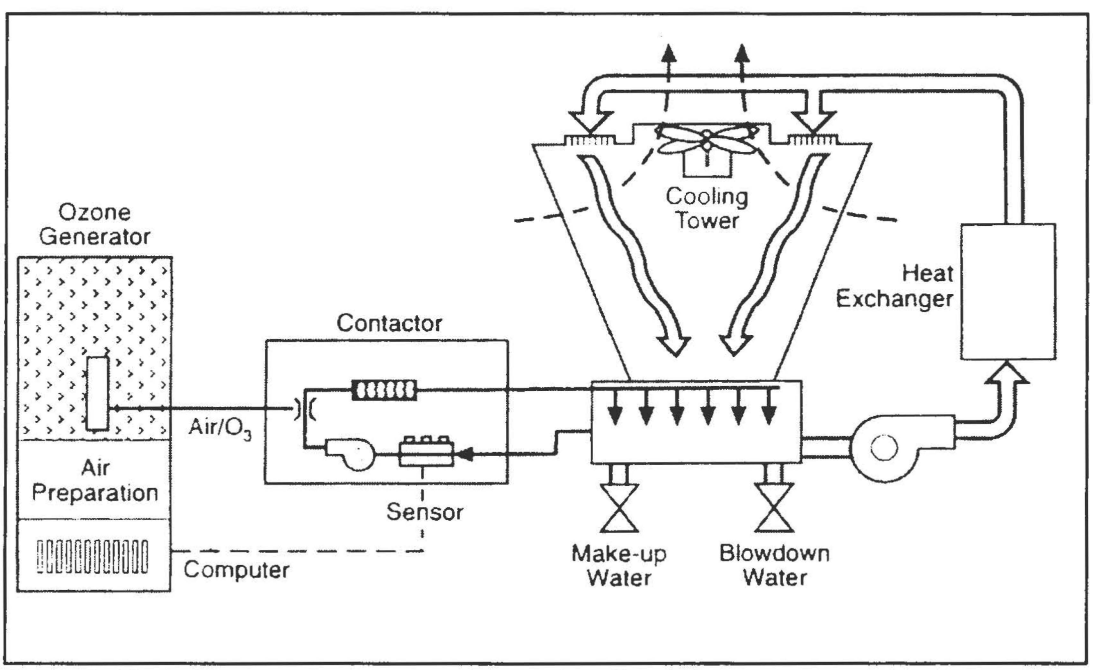

Figure 2. Typical process for ozone treatment of cooling tower water.

lines also allows increased heat transfer. In addition to increased heat transfer and reduced energy needs, the use of chemicals is reduced, and the amount of makeup water is reduced. In the analysis presented herein, the data sources are the field experiment at West Point, and the Federal Energy Management Program (FEMP) study "Ozone Treatment for Cooling Towers." By blending West Point operational data with qualified "estimates" based on data provided by the FEMP consultants, reasonable projections for savings at West Point were obtained. Thayer Hall ozone treatment capital cost was $23,200. This cost includes ozone generating and monitoring equipment. The annual savings for the West Point application is estimated to be approximately $5,558, as shown in Table 1. This annual savings was determined by applying the cost data worksheets contained in Appendices A and B of this user guide.

Table 1. Estimated annual savings for Thayer Hall, West Point.

	Savings ($)
Baseline Chemical Operation	17,924
Ozone Capital Cost	23,200
Savings	5,558
Simple Payback (10-yr payback at 5% discount) 2-3 yr	42,908

Most of the savings are from the reduction in water usage and higher cycles of concentration. Chemicals for reduction of scaling and corrosion are still added to the water, so some additional blowdown is required. Ozonification can save money in relation to its costs, with an estimated payback in 2 to 3 years, assuming proper maintenance. This payback depends on sizing, climate, and water quality evaluation. Payback will increase in climates that demand a longer operating cycle.

3 Acquisition/procurement

Potential Funding Sources

U.S. Army installations can use the Maintenance and Repair "K" account funds to procure the ozone water treatment system for cooling towers.

Technology Components and Sources

Each installation requiring the use of this technology will be responsible for the acquisition and assembly of the components required for the application of ozone treatment. Appendix B of this user guide lists the technical specifications of ozone treatment system components used at West Point. Vendors for this technology include:

Finnegan and Associates LLC
15 Oakwood Drive
Wayne, NJ 07470
201-628-2988

03 Associates
258 Yale Avenue
Kensington, CA 94708
510-524-3371

Ozonia North America
P.O. Box 70145
Richmond, VA 23255-1145
804-756-0500

Procurement Documents

USACERL Draft Technical Report, *Demonstration of Ozone Treatment for Cooling Towers at Thayer Hall, U.S. Military Academy, West Point, NY* (due for distribution in FY 98) evaluates the effectiveness of the application of ozone treatment to cooling towers as a standalone water treatment. Appendix C contains the FEAP Ad Flyer for "Ozone Cooling Tower Water Treatment."

Procurement specifications from the West Point project titled *Project Manual for Cooling Tower Installation above Power Plant Bldg. 604 for Thayer Hall, Bldg No. 601 at U.S. Military Academy West Point, NY* were prepared by Baker Engineers of New York, Inc.

Procurement Scheduling

The lead time required to implement the ozone treatment system is approximately 6 months mainly because of the time needed to procure the parts. Installation of the system typically can be accomplished within 30 days of parts procurement.

4 Post-acquisition

Initial Implementation

Before the installation of an ozone treatment system is pursued, a site evaluation should be conducted to assess the feasibility and effectiveness of the treatment system to a particular arrangement. Appendix A provides a decision tree, which should help to increase the payback for any particular installation interested in the ozone treatment system. A cooling tower engineering data worksheet, which was developed by the FEMP, follows the decision tree in Appendix A and is used for estimating preliminary operation and cost information. This worksheet should be used in comparison with existing treatment programs.

Operation and Maintenance

Preventive maintenance requirements are highly recommend. Performing this recommended maintenance at the suggested frequencies will ensure the proper operation of equipment and extend the life of components. Ozone system components may require specialized maintenance. Therefore, some installations may require the maintenance to be performed by contract. A typical maintenance contract should include inspections, adjustments, and sampling. Not maintaining the ozone equipment causes breakdown or shutdown and immediately eliminates any possible payback. Table 2 lists some recommended preventive maintenance and frequencies for a typical system arrangement.

Service and Support Requirements

Typically, the system can operate with voltages from 120 volts single-phase, 230 volts single- and three-phase, and 440 volts single- and three-phase at a frequency of 60 Hz. Circuit breakers are system mounted. The necessary piping and circulation pumps must be provided to connect the system to the cooling tower water sump.

Table 2. Preventive maintenance for ozone water treatment systems for cooling towers.

Frequency	Preventive Maintenance
3 months	Check/Change Filters
6 months	General Cleaning Remove Dust from Transformers Check Cooling Water System Check Low-Pressure Safety Cut-out Switch Change Brushes on Powerstat Control
Annually	Check Dielectrics Clean High Voltage Bushings Change Humidity Sensor General Inspection for Water Leaks Check Relief Valves for Proper Operation
Miscellaneous	Check Air Compressor System (if requiredd) Change Air Dryer Desiccant (if used)

Performance Monitoring

In addition to the recommended maintenance, a monitoring and control package, which can include integral alarms, will assist in the monitoring of system performance. As stated by the Electric Power Research Institute (April 1992), ozone systems require precise maintenance to be effective, just as do chemical treatment systems. For maximum effectiveness, the system should be designed with the aid of experts in cooling water chemistry and the electronic equipment used to generate ozone and monitor the system. Establishing the correct ozone dosages is important. If an insufficient amount is applied, ozone will be ineffective in treating the cooling water. Excessive amounts of ozone can pose risks to materials susceptible to oxidation, such as rubber fittings, gaskets, and certain kinds of metals and alloys. For these reasons, system monitoring is important. Some ozone system suppliers offer monitoring and telecommunication systems that access and report water quality and ozone generation parameters to a remote location in order to maintain properly functioning systems. Careful monitoring of water temperature is also required to assure effective treatment because the solubility of ozone decreases with rising water temperature, as illustrated in Figure 3. Ozone is ineffective in water temperatures greater than 120 °F.

Use of too much ozone may result in an off-gas that is irritating and toxic. The U.S. Occupational Safety and Health Administration (OSHA) has established an ozone exposure limit of 0.1 ppm in air over an 8-hr shift. Accordingly, ozone is best used in an outdoor or well-ventilated setting under conditions where ozone off-gases cannot accumulate in confined spaces. Ambient monitoring around the generator and cooling tower is important to assure that ozone levels in air do not exceed health-based standards. Moreover, because high-voltage equipment is required to produce ozone, appropriate isolation and security measures are recommended to limit access to system components.

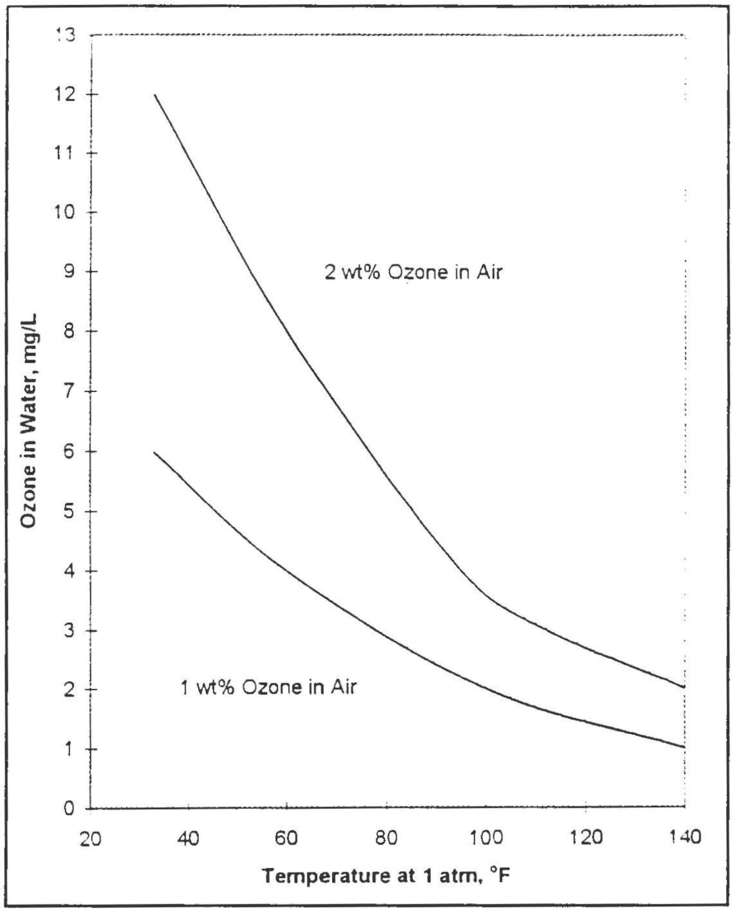

Figure 3. The solubility of ozone in water.

References

Information Brochure, *Ozonation of Cooling Water, An Alternative Treatment Technology*, Electric Power Research Institute, April 1992.

U.S. Department of Energy, "Ozone Treatment for Cooling Towers," *Federal Technology Alert* (Federal Energy Management Program, December 1995).

Appendix A: Decision Tree and Cooling Tower Engineering Data Worksheet

OZONIFICATION DECISION TREE FOR ECONOMIC APPLICATIONS:

Given the fact that the decision to use ozone in cooling towers is not always a winning economic situation, we can suggest the following decision tree to allow a better chance to have a positive payback. Note that the Cooling Tower data worksheets used at the end of the tree are developed by the DOE Federal Energy Management Program, and should be used in the final step to justifying ozone applications.

INVESTIGATE:

WATER QUALITY: If scaling is prominent, and chemicals do not totally remove scale, THEN consider the cost of a water softening system.	MECHANICAL SYSTEMS: If heat exchanger is copper or stainless steel, go to considering an ozone system.	CHEMICAL TREATMENT: If primary rationale for water treatment is biocide, consider ozone.
IF extensive metallic corrosion is present, then limit ozone use to biocide.	IF pumps, seals, and joints contain significant amounts of organic compounds, i.e. teflon, rubber, or silicone, decrement the ozone payback savings by 25% for degradation.	IF chemical labor costs are high, then consider ozone alternate. If moderate, do detailed economic analysis.
IF water softening will aid in scale reduction and lower chemical use, then implement.	IF piping is largely PVC or rubber in nature, consider replacing with copper, or add three times replacement cost to economic cost over 10-yr maintenance cycle.	IF facility environment is health related, i.e., hospital, AND temperature is below 104 °F, then definitely consider ozone.
IF water softening is too expensive, or chemical residue builds up too fast in blowdown water, or cycles of concentration increase too high, then	IF piping from ozone generator is PVC, replace cost should be added to first cost, since pipe will default first season.	IF water costs are high due extensive blowdown, consider using ozone to reduce the chemical residue, and thereby dumping costs reduced.
DO NOT DEPEND ON OZONE ALONE TO ELIMINATE SCALE; ANTICIPATE NEED FOR SOME CHEMICALS.	IF heat exchanger tubing of etched copper with mini-fins, do not use ozone, as failure rate will increase.	IF staff is available to minimally monitor ozone and water quality, ozone may save some labor, but not eliminate it totally.

THEN

COMPARE EXISTING SYSTEM OPERATION COST TO ALTERNATE APPROACH	COMPARE OZONE SYSTEM OPERATION COST TO EXISTING SYSTEM, AND ABOVE ENVIRONMENT

USE ANALYSIS FORMAT SHEETS ATTACHED TO COMPARE ECONOMIC RESULTS FOR OZONE IMPLEMENTATION

Cooling Tower Engineering Data Worksheet

This worksheet is for estimating preliminary operation and cost information. It should only be used for order-of-magnitude comparisons with existing treatment programs. Contact manufacturers or sales representatives to obtain more specific information. (Defaults are provided, although actual data should be used.)

Existing System Worksheet

(A) circulation rate = 3 * (cooling tower capacity in tons) = 3 * _____ = ______ gal/min
Note: default is 3x tower capacity

(B) evaporation rate = 0.008 * A = 0.008* ________ =_______ gal/min
Note: default is 0.8% of circulation rate

(C) drift rate = 0.001 * A = 0.001 * _______= _______ gal/min
Note: default is 0.1% of circulation rate

(D) concentration ratio =_______
Note: default is 5, if actual is unknown

(E) operating load factor = _____
Note: default is between 0.25 and 0.50, if actual is unknown

(F) average blowdown rate = B/ (D -1) = _______ / (___ - 1) =_____ gal/min

(G) make-up water = (B + F) * (8,760 * 60 * E) = (_____+____) * 8,760 * 60 *________
=_______ gal/yr

(H) make-up water cost = (water cost in $/gal) * G = ______ *_________=______ $/yr
Note: default $3.08/1,000 gal, if actual water cost is unknown

(I) blowdown cost = ((disposal cost in $/gal) * F - C * 8,760 * 60 * E) =_______*______
* 8,760 * 60 *_____ = ______ $/yr
Note: default is $5.48/1,000 gal if actual disposal costs are unknown

(J) chemical treatment cost = F * 8,760 * 60 * E * ($2.50/1,000 gal) =
_____ * 8,760 * 60 * 0.5 * ($2.5/1,000 gal) = _______ $/yr.

(K) annual total cost = H + I + J =_______ + ________ + _______ = ________$/yr.

This worksheet is for estimating operation and cost information of a cooling tower system using the ozone water treatment technology. It should only be used for order-of-magnitude comparisons with existing treatment programs. In any of these calculations, if the actual number is available, it should be used instead of the estimate provided. Contact manufacturers or sales representatives to obtain more specific information.

Ozone System Worksheet

(L) new concentration ratio = _____

(M) proposed blowdown amount = B/ (L - 1) =________ / (____ - 1) =______gal/min

(N) proposed make-up water = (B + M) * (8,760 * 60 * E) = (______ +______) *
(8,760 * 60 *_____) =__________ gal/yr

(O) ozone system size (in grams per hour) = 0.023 * A = 0.023 * ______ = ______g / hr
Note: to convert to Ib/hr divide N by 454.

(P) proposed make-up water cost = (water cost in $/gal) * N =__________*_________ = ________ $/yr
Note: default is $3.08/1,000 gal if actual cost of water is unknown

(Q) proposed blowdown cost = (disposal cost in $/gal) * M - C * 8,760 * 60 * E = __________*_____
8,760 * 60 *_____ = ________ $/yr
Note: default is $5.48/1,000 gal if actual disposal costs are unknown

(R) ozone system cost = (600 * O) + 10,000 = (600 *_____) + 10,000 = ________ $
Note: use 450 instead of 600 if O > 200 g/hr.

(S) ozone unit energy consumption = 114 * O = 114 *______ =_________ kWh/yr

(T) ozone electricity cost = (electricity cost in $/kWh) * S =______ *_________ = ______$/yr

(U) proposed ozone operating cost = P + Q + T =________+______+_______=________ $/yr

Appendix B: Thayer Hall Cooling Tower Engineering Data Worksheet

Thayer Hall Cooling Tower Engineering Data Worksheet

This worksheet is for estimating preliminary operation and cost information. It should only be used for order-of-magnitude comparisons with existing treatment programs. Contact manufacturers or sales representatives to obtain more specific information. (Defaults are provided, although actual data should be used.)

Existing System Worksheet

(A) circulation rate = 3 * (cooling tower capacity in tons) = 3 * **900** = **2700** gal/min
Note: default is 3x tower capacity

(B) evaporation rate = 0.008 * A = 0.008* **2700** = **21.6** gal/min
Note: default is 0.8% of circulation rate

(C) drift rate = 0.001 * A = 0.001 * **2700** = **2.7** gal/min
Note: default is 0.1% of circulation rate

(D) concentration ratio = **5**
Note: default is 5, if actual is unknown

(E) operating load factor = **0.50**
Note: default is between 0.25 and 0.50, if actual is unknown

(F) average blowdown rate = B/ (D -1) = **21.6** / (**5** - 1) = **5.4** gal/min

(G) make-up water = (B + F) * (8,760 * 60 * E) = (**21.6** + **5.4**) * 8,760 * 60 * **0.5**
= **7,095,600** gal/yr

(H) make-up water cost = (water cost in $/gal) * G = **$1.86 / 1000 gal** * **7,095,600** = **13,198** $/yr
Note: default $3.08/1,000 gal, if actual water cost is unknown

(I) blowdown cost = ((disposal cost in $/gal) * F - C * 8,760 * 60 * E) = **$1.66 / 1000 gal** * **2.7**
* 8,760 * 60 * **0.5** = **1,178** $/yr
Note: default is $5.48/1,000 gal if actual disposal costs are unknown

(J) chemical treatment cost = F * 8,760 * 60 * E * ($2.50/1,000 gal) =
5.4 * 8,760 * 60 * 0.5 * ($2.5/1,000 gal) = **3,548** $/yr.

(K) annual total cost = H + I + J = **13,198** + **1,178** + **3,548** = **17,924** $/yr.

This worksheet is for estimating operation and cost information of a cooling tower system using the ozone water treatment technology. It should only be used for order-of-magnitude comparisons with existing treatment programs. In any of these calculations, if the actual number is available, it should be used instead of the estimate provided. Contact manufacturers or sales representatives to obtain more specific information.

Thayer Hall Ozone System Worksheet

(L) new concentration ratio = **9**

(M) proposed blowdown amount = B/ (L - 1) = **21.6** / (**9** - 1) = **2.7** gal/min

(N) proposed make-up water = (B + M) * (8,760 * 60 * E) = (**21.6** + **2.7**) * (8,760 * 60 * **0.5**)
= **6,386,040** gal/yr

(O) ozone system size (in grams per hour) = 0.023 * A = 0.023 * **2700** = **62.1** g / hr
Note: to convert to Ib/hr divide N by 454.

(P) proposed make-up water cost = (water cost in $/gal) * N = **$1.86 / 1000 gal** * **6,386,040**
= **11,878** $/yr
Note: default is $3.08/1,000 gal if actual cost of water is unknown

(Q) proposed blowdown cost = (disposal cost in $/gal) * M - C * 8,760 * 60 * E = **$ 1.66 / 1000gal** * **0**
8,760 * 60 * **0.5** = **0** $/yr
Note: default is $5.48/1,000 gal if actual disposal costs are unknown

(R) ozone system cost = (600 * O) + 10,000 = (600 * **22**) + 10,000 = **23,200** $
Note: use 450 instead of 600 if O > 200 g/hr.

(S) ozone unit energy consumption = 114 * O = 114 * **62.1** = **7,079.4** kWh/yr

(T) ozone electricity cost = (electricity cost in $/kWh) * S = **0.069** * **7,079.4** = **488** $/yr

(U) proposed ozone operating cost = P + Q + T = **11,878** + **0** + **488** = **12,366** $/yr

Appendix C: Ozone Water Treatment System Component Specifications

15650-2.5 WATER TREATMENT*

2.5.1 Description of Ozone Generating Equipment

1. It shall produce 7 pounds** per day of ozone at the rated concentration.
2. The rated concentration shall be at a minimum of 2% by weight in air.
3. It shall be designeu to operate at a minimum of 16 pounds per square inch gauge.
4. All parts of the ozone generating assembly in the electric discharge field shall be constructed of 321 stainless steel to inhibit corrosion by ozone and cooling water. All other parts of ozone generating assembly shall be constructed of ozone resistant materials.

2.5.2 Operating Conditions

The ozone generator shall produce sufficient ozone pressure per 24 hours of operation, continuously without cleaning for at least twenty four months when operated under the following conditions:

1. The electrical power input shall be 460 volts, 3 phase, 60 cycles. The- main breaker size to which the ozonation system shall be connected shall not exceed 15 amps. All control circuits for the ozone generator shall be 115V, 60 cycles and shall be provided as an integral part of the ozone generator.

2. Oil-free, clean, dry air at a maximum dew point of -60°F shall be provided to the ozone generator at a rate of 3.5 SCFM.

3. Clean cooling water at a maximum temperature of 70°F shall be provided at a rate of not less than 1.8 GPM. The temperature rise of the cooling water shall not exceed 10°F.

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* Excerpted from the Project Manual for Cooling Tower Installation above Power Plant Bldg. 604 for Thayer Hall, Bldg. 601 at U.S. Military Academy, West Point, NY. Michael Baker, Jr., Baker Engineers of New York, Inc., September 1990.

** 7 pounds per day is acceptable for Thayer Hall, Bldg 601. The following formula will provide an estimate for ozone production in grams per hour: (0.023) × (circulation rate in gal/min).

2.5.3 Ozone Generator Transformer:

A high voltage transformer shall be incorporated with the ozone generator. The transformer shall be rated at not less than 5% above maximum anticipated KVA. The secondary voltage shall not be in excess of 10KV to insure that the glass electrode will not fail due to high voltages.

2.5.4 Ozone Generator Controls:

The ozone generator shall be provided with the following controls:

1. A switch or switches on the control panel of the ozone generator to do the following:

   a. Activate and deactivate the ozone generator and air prep unit.
   b. Allow for the activation and deactivation of the ozone generator from a remote control station.
   c. Allow for the operation of the air preparation unit only.

2. A control to manually adjust the output of the ozone generator electrically in a linear range of 10% to 100% of rated output. Turn down of the ozone generator by variations of the air preparation train shall not be deemed as acceptable.

3. A switch to allow either manual or automatic control of the ozone generator in a linear range of 10% to 100% of rated output.

2.5.5 Ozone Generator System Protection:

The ozone generator shall include the following:

1. A main power circuit breaker which shall be sized to protect the ozone generator and air preparation unit.

2. Protection against power surges, brownouts, and blackouts.

3. A 5 second start-up delay shall be incorporated in the ozone generator to delay the production of ozone after the unit is activated or an interlock cleared. (This delay also shall allow for start-up of the ozonator with the main power line).

4. Protection against excess internal pressure.

5. Ozone Generator shall be fitted with a cabinet refrigeration unit completely piped, wired and duct connected (if required) as part of the work of this section.

a. The electrical work shall be wired to the same power that feeds the Ozone Generator.
b. The moisture condensate trap and piping (1" type 'M' copper tubing) shall be provided and shall be run to the nearest floor drain. Vapor barrier foam rubber insulation shall be provided over moisture condensate piping.
c. Cabinet refrigeration unit shall be suitable for cooling the ozone generator to permit rated output at ambient temperature conditions not exceeding 125°F, and shall be so stipulated by the vendor of the Ozone equipment.
d. Rating of the cabinet refrigeration unit shall be no less than 1200 BTU/Hr directed to the Ozone generator when air cooled by ambient air no less than 110°F. Unit shall operate on 115 volts A.C., 60HZ, 1 ph. power.

2.5.6 Ozone Generator Instruments:

The ozone generator shall include the following instruments:

1. A flowmeter which shall measure the air flow rate to the ozone generator. It shall read in SCFH.

2. A pressure gauge which shall measure the pressure in the ozone generator cell.

3. A humidity sensor which shall monitor the moisture content of the air leaving the dessicant dryer, and shall close a contact to indicate excessive dew point.

2.5.7 Ozone Generator Interlocks:

The ozone generator shall have safety controls which do not allow the production of ozone under certain conditions. A separate red pilot light shall glow when an interlock is activated and a fail contact shall close to allow for the sounding of a remote alarm in addition to shutting down the ozone generator when any of the following conditions exist:

1. Any panel or door on the ozone generator is open or ajar.
2. When there is insufficient air flow.
3. When the dew point of the feed gas is excessive.
4. When cooling water flow falls below 50% of the rated flow.
5. When the temperature of the ozone leaving the ozone generator is excessive.
6. There shall also be provisions for an external interlock which can perform a function such as one of the following:

    a. Shut down the ozone generator when there is excessive ozone in the ozone generator room.
    b. Shut down the ozone generator when there is no exhaust air flow in the ozone contact chamber.

c. Shut down the ozone generator with the application of a closed contact which shall indicate that a condition which may cause unsafe or improper operation of the ozonation system exists.

Interlock lights shall be LED type for high reliability. One switch to test all lamps shall be provided.

2.5.8 Ozone Generator Remote Signals:

The ozone generator shall have dry contacts to allow the remote indication of the f allowing:

1. ON - The ozone generator is producing ozone.

2. OFF - The ozone generator is not producing ozone.

3. FAILURE - The ozone generator is not producing ozone when it is "ON".

These contacts shall be rated for 2 amps, 250 volts A.C.

2.5.9 Operation:

The ozone generator and air preparation unit shall produce ozone under the following conditions:

1. The main power circuit breaker is on.

2. No interlocks are activated.

3. The ozonator selector switch is in the "ON" position or the ozonator selector switch is in the "Remote ON/OFF" position and the remote contact is closed.

The ozone generator shall be capable of operating in either an "Automatic" or Manual" control mode. In the "Automatic" mode the ozone output shall be capable of being controlled by a remote current analog signal. In the "Manual" mode it shall be controlled manually at the ozone generator control panel by a potentiometer.

Shutdown of the ozone generator shall include a purging with air of the ozone generator after the ozone generator is turned "OFF" at the ozone generator front panel or the remote control panel. When the ozone generator shuts down because of an ozone generator failure, the fail contact shall case to trigger a remote alarm.

2.5.10 Ozone Feed System:

The ozone system utilizes an ozone-lift mixing system. The ozone-air mixture from the generator is fed into a venturi that draws water from the tower sump and lifts it into a mixing chamber. A vent from the mixing chamber to the top of the tower allows residual gas to escape to the atmosphere.

2.5.11 Ambient Ozone Monitor:

The ozone generating system shall have ambient ozone monitors for personnel safety. It shall have audible and visual alarms alerting the operator of abnormal ozone concentrations.

2.5.12 Warranty on Glass Dielectrics:

All glass dielectrics shall be guaranteed for a period of three (3) years under normal operating conditions.

2.5.13 Ozone Indicator:

The ozone generator shall include an ozone indicator that reads the ozone output. It shall be front panel mounted and shall have a linear scale of 0 to 125% of rated capacity.

2.5.14 Testing and Certification:

The ozone generator shall be tested before shipping. The testing shall be performed at the factory at the generators maximum rated ozone output for at least 24 continuous hours. During this testing period the ozone generator may be inspected by the purchaser or his representative. The ozone generator shall then be calibrated and an ozone output certification document shall be supplied. The Certification shall list all of the operating parameters under which the machine produced its rated output. A notarized certificate of compliance, signed by a company officer shall be supplied with the ozone generator.

2.5.15 Description of Air Preparation System

The air preparation unit shall provide oil free, clean, dry air at a maximum dew point of -60° F at a sufficient flow to allow the ozone generator to operate at the rated ozone output and concentration. The air preparation unit shall consist of the following components:

1. Air Filter - Air filters with cleanable inserts.

2. 3.5SCFM of 80 to 100 PSIG compressed air shall be provided to the air prep uniform the existing compressed air system where shown on Dwg.

3. Air Drying Equipment - The air drying equipment shall reduce the dew point of the feed air to a maximum dew point of -60° F. The dryer shall be fully automatic for continuous operation.

Appendix D: FEAP Ad Flyer "Ozone Cooling Tower Water Treatment"

FACILITIES ENGINEERING APPLICATIONS PROGRAM

Innovative Ideas for the Operation, Maintenance, & Repair of Army Facilities

Ozone Cooling Tower Water Treatment

Above: *Ozone generators like this one installed at West Point are readily available on the market.*

Left: *Ozone feeder pipe to cooling tower.*

Ozone Treatment Safe, Effective

PROBLEM: Treating water in cooling tower systems is costly. Treated water must meet discharge quality standards.

TECHNOLOGY: Ozone is a proven effective biocide as an alternative to chemical treatment.

DEMO SITE: United States Military Academy, West Point, NY – FY93

BENEFITS:
- Saves water by allowing more reuse cycles
- Eliminates concentration of traditional biocides
- More effective than chlorine as a biocide
- May help prevent scale and corrosion on some cooling tower applications

Ozone Reduces Chemical Hazard Downstream

A Treatment Alternative

The Army owns hundreds of cooling towers which must be protected from corrosion. Traditionally, cooling water has been treated to prevent corrosion by adding corrosion inhibitors, scale control chemicals, and biocides. Common additives are phosphorus and zinc compounds.

A major cause of scaling is the biological and organic content of cooling systems. Often several different biocides are used together since a given organism can develop immunity to a single biocide. In 1990, the Environmental Protection Agency banned the use of biocides in these systems. In addition, other maintenance practices involving additives, such as blowdown, are regulated since the discharge can carry harmful chemicals and hot water into publicly owned treatment plants.

Ozone treatment has emerged as a promising alternative to chemical biocides, corrosion inhibitors, and scale/deposit inhibitors. Suppliers claim ozone is a more effective biocide than chlorine and that it destroys disease-causing bacteria such as the strains linked to Legionnaire's disease. Moreover, since it is a short-lived compound that rapidly reverts to diatomic oxygen, ozone lowers the concentration of other biocides in the cooling water.

Ozone Demonstrated

A new cooling tower system using ozone as a stand-alone treatment was installed in Thayer Hall at the U.S. Military Academy, West Point, NY. The FEAP demonstration included monitoring the system during the second season of operation, mid-June through mid-October 1993. Data was collected on the tower water chemistry, the scaling potential, corrosion potential, and the microbiological conditions.

The treatment allowed cycles of concentration greater than would normally be allowed with conventional chemical treatment. There was no indication of scale or other deposits, no biological problems, and the circulating water was clear. As a result of the demonstration, ozone's effectiveness as a biocide has been established. The cooling makeup water at West Point is not normally corrosive or scaling. For this reason, ozone's performance as either a corrosion inhibitor or scale controller could not be demonstrated.

Benefits

Ozone treatment at West Point resulted in a higher number of reuse cycles, saving water in the cooling tower and reducing sewage treatment. The Clean Water Act, along with state and local regulations, are placing increased demands on cooling tower discharge into receiving streams. The high toxicity of ozone in water solution makes it an effective biocide. However, its rapid decomposition minimizes any downstream toxicity concerns. At West Point, the payback for ozone treatment was 2-3 years. This is based on savings in water, blowdown, and chemicals, and in a reduction of blowdown volume requiring treatment for chemical buildup.

Procurement

Ozone generators are readily available on the commercial market. Guidance for treating cooling tower water with ozone will be published by the U.S. Army Construction Engineering Research Laboratories (CERL) in a Technical Report and a FEAP User Guide, both to be released in FY97.

Points of Contact

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