CALIFORNIA
ENERGY
COMMISSION

CALIFORNIA ENERGY COMMISSION STAFF COOLING WATER MANAGEMENT PROGRAM GUIDELINES For Wet and Hybrid Cooling Towers at Power Plants

MAY 17, 2004

DRAFT GUIDELINES

NOVEMBER 2005
CEC-700-2005-025

Arnold Schwarzenegger, *Governor*

DRAFT

CALIFORNIA ENERGY COMMISSION STAFF COOLING WATER MANAGEMENT PROGRAM GUIDELINES for Wet and Hybrid Cooling Towers at Power Plants May 17, 2004

A. Introduction

Legionella is a type of bacterium that is ubiquitous in natural aquatic environments and is also widely distributed in man-made water systems. It is the principal cause of Legionellosis, otherwise known as Legionnaires' Disease. Recent studies have shown the potential for bacterial growth to occur in power plant cooling towers, including Legionella (1, 2, 6, 8, 10, 15, 20).

In order to minimize the risk to the public associated with potential health effects from excessive growth of Legionella in power plant cooling towers, Commission staff typically recommend that each plant owner develop and implement a cooling tower Biocide Use, Biofilm Prevention, and Legionella Control Program to ensure that cooling tower bacterial growth is controlled.

Commission staff are therefore providing these guidelines as one example of a biocide application and monitoring program designed to control microorganisms, to the maximum extent feasible, within cooling towers using open recirculating water systems (8, 11, 12). Please note that, since every facility and cooling tower is somewhat different, staff recognize that the contents and details of any management program, such as the choice of and applied dosage of biocides, should reflect each facility's specific operating conditions and needs, and may vary from the examples cited here. Staff recommend that such a cooling water management program be part of a power plant's overall risk management/risk reduction program. The goals are to minimize biofilm growth, biofouling, and Legionella and reduce the potential health hazard to workers and the public.

References to individual companies and products are provided for informational purposes only and do not constitute endorsement by Commission staff.

B. Background

Untreated or inadequately treated cooling systems in the United States have been correlated with outbreaks of Legionellosis. These outbreaks are usually associated with building heating, ventilating, and air conditioning (HVAC) systems, but it is possible for growth to occur in industrial cooling towers. Legionella bacteria have been found in drift droplets. The U.S. Environmental

Protection Agency (EPA) published an extensive review of Legionella in a human health criteria document (8). The EPA noted that Legionella survival is enhanced by symbiotic relationships with other microorganisms, particularly in biofilms, and that aerosol-generating systems, such as cooling towers, can aid in the transmission of Legionella from water to air (8, 9). In fact, a recent outbreak of Legionaires' Disease in a community near a chemical company in France has been reported to be due to Legionella growth in the plant's cooling system (34).

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (1, 10, 15) states that good preventative maintenance is very important in the efficient operation of cooling towers and other evaporative equipment. Preventive maintenance includes having effective drift eliminators, periodically cleaning the system if appropriate, maintaining mechanical components in working order, and maintaining an effective water treatment program with appropriate biocide concentrations. The following management strategies are directed at minimizing colonization/amplification within the cooling tower system:

- Avoid piping that is capped and has no flow (dead legs).
- Control input water temperature to avoid temperature ranges where Legionella grow. Keep cold water below 25° C (77° F) and hot water above 55° C (131° F).
- Apply biocides in accordance with label dosages to control growth of other bacteria, algae, and protozoa that may contribute to nutritional needs of Legionella. Rotating biocides and using different control methods is recommended. These include thermal shock, oxidizing biocides, chlorine-based oxidants and ozone treatment.
- Conduct routine periodic "back-flushes" to remove bio-film buildup on the inside walls of the pipes.

In 2000, the Cooling Technology Institute (CTI) issued a report and guidelines for the best practices for control of Legionella (6). To minimize the risk from Legionella, the CTI noted that consensus recommendations included minimization of water stagnation, minimization of process leads into the cooling system that provide nutrients for bacteria, maintenance of overall system cleanliness (13, 14), the application of scale and corrosion inhibitors as appropriate, the use high-efficiency mist eliminators on cooling towers, and the overall general control of microbiological populations. The British Health and Safety Executive had previously published similar guidelines for the control of Legionellosis in water systems in 1998 (24) and an evaluation of those guidelines was published in 2003 (25). Further reports and recommendations were issued in 1998 (29, 30, 31). Japan published a Code of Practice in 1994 (32) and the International Standards Organization developed ISO-1171 in 1998 (27) containing recommendations for Legionella testing. Australia has been very active in this area and developed guidelines for Legionella control in cooling towers in 1989 (28) and recommended that Risk Management Plans be prepared for cooling systems (33). Although the Occupational Safety and Health Administration (OSHA) has not developed a specific standard for Legionnaire's disease, it has published a technical manual providing informatio0n and guidance in assessment and control of Legionella (21). Finally, ASTM

Standard D 5952-02 presents a comprehensive approach for inspecting water systems for Legionella and investigating possible outbreaks (23).

This need for microbial control and reduction of the potential for Legionella growth was also recognized by the California Department of Health Services, which adopted a regulation addressing this issue (5). The California Code of Regulations, Title 22, Section 60306 states, in part, that whenever a cooling system, using recycled water in conjunction with an air conditioning facility, utilizes a cooling tower or otherwise creates a mist that could come into contact with employees or members of the public, the cooling system shall comply with the following:

1. A drift eliminator shall be used whenever the cooling system is in operation.
2. A chlorine, or other, biocide shall be used to treat the cooling system recirculating water to minimize the growth of Legionella and other micro-organisms.

C. Protocol

1. Selection of Biocide - The cooling water management plan shall describe the biocide(s) selected and the reasons for their selection.

It has been demonstrated that, in most cases, the use of halogen-based oxidants as the routine biocide in the cooling system is the most effective treatment for control of microbial growth. Examples include sodium hypochlorite, liquid stabilized bromine (16, 18), or a solid halogen donor (e.g. hydantoin). The preferred biocide for new applications is sodium hypochlorite. Some technicians state that hydantoin or liquid stabilized bromine may be used on small towers (20). Non-oxidizers such as isothiazoline, glutaraldehyde, and Dibromonitrilopropionamide (DBNPA), may be used on a contingency basis, but this is discouraged, due to the development of resistant microbes. If a non-oxidizing biocide is used, it should be changed periodically (at a maximum yearly) to avoid resistance occurring. If a biofilm forms, a biodispersant should be added, as per the manufacture's recommendations, with the halogen until microbial testing indicates the system is back in control (refer to criteria specified below in section 3: Microbial Testing).

2. Biocide Control Ranges - The cooling water management plan shall describe how the biocide is to be administered (continuous or intermittent feed, level of residual concentrations, etc.)

For example, continuous feed of halogen is one of the most significant factors in controlling Legionella (2, 20). The biocide manufacturer's recommended chlorine residual is intended to control biofilm growth. Free chlorine residual examples listed below are recommended ranges for most systems and may vary depending upon factors such as the use of alloy or copper pipes and pH. The best determinant of an

effective free chlorine level is microbial testing demonstrating that the system is under control.

- Hypochlorite can be fed to continuously to maintain in most cases 0.3 - 0.7 ppm free chlorine residual by the Diethly-p-phenylenediamine (DPD) or the dimethyl-substituted form (DDPD) method.

- Stabilized bromine products (e.g. hydantoin) can be fed to continuously maintain 0.5 -1.0 ppm total halogen (as ppm $C1_2$) residual.

- Dosages of non-oxidizing biocides should be empirically derived for each specific cooling tower system. Typical non-oxidizing biocide dosages may include:
  - Isothiazoline (1.5%) - 75 ppm shock
  - Glutaraldehyde (45 %) - 100 ppm
  - DBNPA (20%) - 40 ppm

In all cases, follow manufacture's instructions on dose. If ammonia is present in significant concentrations or the pH is >8.0, Betz Dearborn Technical Bulletin 73 (2) provides recommendations which may be helpful.

3. Microbial Testing - The cooling water management plan shall document the microbial testing protocol to be used by the plant owner.

Microbial testing has been shown to be an effective measurement of the efficiency of control methods (2, 3, 4, 7, 17, 22, 26) and is recommended by Australia, Betz-Dearborn, CTI, and Shell Chemical Company (3, 18, 19, 26). Dip-slides with a 24-48 hour incubation period is a useful test method and other methods are described in references 26, 27, 28, and 32 .

- The cooling water can be tested for total microbiological (MB) counts (aerobic planktonic bacteria, 48 hr incubation) once per week, or more frequently as necessary. Acceptable results indicating good microbial control would be less than or equal to 10^4 CFU/ml (Colony Forming Units per milliliter). Results showing levels between 10^4 and 10^5 CFU/ml indicate that the system may be going out of control and should serve as a cautionary warning. Levels $>10^5$ CFU/ml indicate a cooling system out of microbial control.

- If the source of the cooling water is high in nutrients or if the microbial count is $>10^5$ CFU/ml for a month, the cooling water should be tested for total anaerobic sulfate-reducing bacteria (SRB's).

4. Upsets – The cooling water management plan shall describe how the system will be returned to normal microbial control following an upset.

When the system is found to be out of microbial control as specified in section 3 above, or if upsets occur, the following procedures may be used to return the system to normal control. [Note: If emergency entrance into the cooling system is required for unscheduled repairs, the use of appropriate Personal Protective Equipment (PPE) shall be required.]

- Shock treatment with a halogen-based biocide is recommended when any of the following conditions apply:

  1. The free or total halogen lower limit has not been met for 48 hours or more;
  2. There are two total MB count test results greater than10^4 CFU/ml in a row; or
  3. The anaerobic test result comes back "positive".

- Shock treatment may consist of increasing the free residual chlorine to1- 2 ppm chlorine for 4 hours. If microbial testing was the reason for the upset condition, testing should be redone within 24 hours of the shock treatment. If free residual chlorine of 1-2 ppm can not be achieved, or the new microbial test result is still > 10^4 CFU/ml, or the anaerobic test result is still "positive", the system may be shock treated with a non-oxidizing biocide and microbial testing should be conducted again after two days. Shock treatment should be continued with the non-oxidizer every two days until the free chlorine residual is maintained at 1-2 ppm. If microbial monitoring tests are still not under control, the dosage and/or frequency of the non-oxidizer should be increased. The free residual halogen should also be increased to 0.8 — 1.2 ppm. Microbial testing should be conducted again after two days. Note that an increase in biological populations might be seen 1-2 days after the use of oxidizing biocides, because they may contain surfactants that can disperse the biofilm layer.

- If the above measures are not successful, or if the system continues to require a high level of biocide for control, further corrective measure must be implemented. These measures include visual inspection for leaks and/or subsequent shut down and repair. The area around the tower should be restricted and PPE required for entrance into the restricted area until microbial control is re-established. Following correction and recovery from the problem, disinfection will be required. Two weeks after this, the cooling water should be sampled for Legionella (see section 6 below).

5. Cooling Tower Shutdown, Startup, and Maintenance - The cooling water management plan shall describe cooling tower shutdown, startup, and maintenance procedures.

- If a tower not under microbial control is to be entered, or if reclaimed water is used, the tower should be disinfected first by shocking the system with a non-

oxidizing biocide two days before entrance and then shocking with a halogen to double the usual free chlorine residual one day before entrance.

- At startup, the tower should again be disinfected, first with shock treatment with hypochlorite, followed by a non-oxidizing biocide when halogen residuals return to normal.

- The tower basin should be cleaned (sludge removed) whenever the whole tower is down, corresponding with major turbine maintenance periods (usually every 3-5 years).

- Drift eliminators should be inspected for cleanliness and gaps/bypassing on a quarterly basis by visual inspection. Inlet distributors should be inspected for plugging during shutdowns.

6. Legionella Monitoring - The microbial testing protocol required in section 3 shall include Legionella monitoring.

Testing for Legionella should be conducted whenever an upset condition as described in section 4 above occurs or at least every 6-months. Useful test methods are described in ASTM Standard D 5952-02 (23) and ISO 11731 (27).

- When sampling for Legionella, obtain the water from the tower basin away from where makeup enters the basin.

- If testing shows Legionella at <10 CFU/ml, the system is under control and no further action is required (as per OSHA guidelines found in reference 21, Appendix III:7-5).

- If testing shows Legionella at 10 - 100 CFU/ml, the cooling tower must be disinfected per section 5 and re-sampled for Legionella after 2 weeks.

- If testing shows Legionella at >100 CFU/ml, access to the area around the tower shall be controlled to those wearing appropriate PPE. An emergency disinfection procedure shall be implemented and a process risk assessment shall be prepared to identify the causal or contributing factors to the Legionella proliferation. Methods shall be implemented to minimize these factors. The tower shall be re-tested for Legionella after two weeks.

7. Record Keeping – A description of documents relating to maintaining the microbiological control program shall be provided in the management plan.

Log sheets should be designed to keep the information such as that listed below. Sufficient historical data should be readily available to the on-site operator.

The following data should be kept on a daily log sheet, preferably an electronic one:

- Biocide residual test results
- Biocide feed rates
- Biofilm monitor results
- Legionella testing
- Date, time and quantity added of biodispersants and non-oxidizing biocides
- Date and time of shock treatment
- Date and time of any shutdown or cleaning including the disinfection procedure

REFERENCES

1. ASHRAE 1998. American Society of Heating, Refrigeration, and Air Conditioning Engineers. Legionellosis: Position Paper. June 25.

2. Betz Dearborn Technical Bulletin 73, 2000. "Chemical Water Treatment Recommendations For Reduction of Risks Associated with Legionella in Open Recirculating Cooling Water Systems."

3. Betz Dearborn web-site, www.betzdearborn.com, "Information About Legionnaires' Disease that May Help Minimize Risk, A Discussion in Question and Answer Format."

4. Broadbent, Clive R. 1999 "Control of Legionnaires' Disease—An Australian Perspective." ASHRAE Transactions: Symposia, SE-99-3-3.

5. California Department of Health Services (DHS) 1995. "Minimizing The Risk of Legionnaires' Disease in Public Buildings." November.

6. Cooling Technology Institute (CTI) 2000. Guidelines: "Best Practices for Control of Legionella."

7. Davenport, Ken. 2003. "Real-Time Biological Monitoring." Presented at the 2003 Cooling Technology Institute (CTI) Annual Conference.

8. Environmental Protection Agency (EPA) 1999. (EPA-822-R-99-001) "Legionella: Human Health Criteria Document." November.

9. EPA March 2001. EPA-822-B-01-005 "Legionella Drinking Water Health Advisory."

10. Geary, David F. 2000. "New Guidelines On Legionella," ASHRAE Journal, September

11. Gregory, Jay S. 1999. "Who Should Be Responsible for Legionella," Water Treatment Practical Guide, May.

12. Hennon, Ken and Wheeler, David. 2003. “Cooling Tower Emissions Quantification Using the Cooling Technology Instutute Test Code ATC-140.” Presented at the 2003 Cooling Technology Institute (CTI) Annual Conference.

13. Kang, Sukjun et al. 2003. “Multipurpose Water Treatment in Cooling Towers.” Presented at the 2003 Cooling Technology Institute (CTI) Annual Conference.

14. Lane, John and Peck, David F. “Condenser Water Treatment Using Pulsed-Power.” Presented at the 2003 Cooling Technology Institute (CTI) Annual Conference.

15. Meyer, Craig. “Controlling Legionella in Cooling Towers.” ASHRAE Technical Feature, IAQ Applications, Spring 2000.

16. Nalepa, Christopher et al. "The Control of Bacteria on Surfaces: Effectiveness of Bromine-Based Biocides towards Microbial Biofilms and Biofilm-Associated Legionella Pneumophila." Presented at the 2002 CTI Annual Conference.

17. Puckorius, Paul R. “Update on Legionnaires’ Disease and Cooling Systems: Case History Reviews—What Happened/What To Do and Current Guidelines.” ASHRAE Transactions: Symposia, SE-99-3-2.

18. Puckorius, Paul R. and Diehl, Ken. “Water Reuse Experiences With Cooling Tower Systems in San Antonio, Texas.” Presented at the 2003 Cooling Technology Institute (CTI) Annual Conference.

19. Queensland Government, Workplace Health and Safety, February 2000. “Legionella Control in Airconditioning Units and Cooling Towers.” Supplement No 2 to the Plant Advisory Standard.

20. Smith, J.W. et al, Shell Global Solutions. "One Company’s Legionella Standard." Presented at the 2003 Cooling Technology Institute (CTI) Annual Conference.

21. U.S. Department of Labor, Occupational Safety and Health Administration (US OSHA). “Legionnaires’ Disease.” OSHA Technical Manual Section III, Chapter 7.

22. Wiatr, Christopher L., Buckman Laboratories. “Detection and Eradication of a Non-Legionella Pathogen in a Cooling Water System.” The Analyst, Spring 2002.

23. ASTM 2003. “Standard Guide for Inspecting Water Systems for Legionellae and Investigation Possible Outbreaks of Legionellosis”. Standard D 5952-02. ASTM International, West Conshohocken, Pa. January.

24. British Health and Safety Executive, 1998. “The Control of Legionellosis in Hot and Cold Water Systems”. London.

25. British Health and Safety Executive, 2003. “Evaluation of HSC’s ACOP and Guidance “Legionnaires Disease: Control of Legionella Bacteria Water Systems”. Research report 140. London.

26. Stonecipher, David et al. “Automating the Cooling Water Triangle.” The Cooling Technology Institute (CTI) Journal, Volume 25, No 1, date unknown.

27. International Standards (ISO) 1998. “Water Quality –Detection and Enumeration of Legionella.”

28. State of Victoria 1999. “Guidelines for the Control of Legionnaires’ Disease.” Department of Human Services, Victoria, Melbourne, Australia.

29. Health and Safety Commission (HSC) 1998. “The Prevention or Control of Legionellosis (Including Legionnaires’ Disease), Approved Code of Practice.” Her Majesty’s Stationary Office, Norwich, Great Britain.

30. Health and Safety Commission (HSC) 1998. “The Control of Legionellosis Including Legionnaires’ Disease.” Her Majesty’s Stationary Office, Norwich, Great Britain.

31. Health and Safety Commission (HSC) 1998. “The Prevention or Control of Legionellosis in Hot and Cold Water Systems.” Her Majesty’s Stationary Office, Norwich, Great Britain.

32. Building Management Education Center, 1994. “Japanese Code of Practice Under Construction: Guideline for Prevention and Control of Legionella Infections.” Environmental Health Bureau Ministry of Health and Welfare, Tokyo, Japan. March.

33. Department of Human Services, 2003. “Legionella Link: Managing the Health Risks”. State Government of Victoria, Australia. November.

34. “France Shuts ExxonMobil Plant” 2004. Chemical &Engineering News, published by the American Chemical Society. January 12.