



NSF International Protocol

NSF P453 - 2017

Cooling Tower Water Systems -
Treatment, Operation, and Maintenance
to Prevent Legionellosis

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Cooling Tower Water Systems – Treatment, Operation, and Maintenance to Prevent Legionellosis

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Foreword

Legionella bacteria occur naturally in rivers, lakes, and streams, and can enter buildings through a number of ways. In the case of cooling tower water systems, these sources include the makeup from the municipal water supply and from scrubbing dirt and debris from the air. In the absence of control, *Legionella* can amplify in building water systems and then be released into the air in *Legionella*-contaminated aerosols. Based on data from the Centers for Disease Control and Prevention (CDC), the greatest number of outbreaks of Legionnaires' disease investigated between 2000 and 2014 were associated with premise plumbing (56%), followed by cooling tower water systems (22%)¹. Because relatively more cases were associated with cooling tower outbreaks, the total number of outbreak cases from premise plumbing and cooling towers were roughly equivalent. Each building water system is important and should be addressed by comprehensive water management programs. This Protocol specifically addresses the treatment, operation, and maintenance of cooling tower water systems to prevent Legionellosis from these systems.

Cooling towers remove heat from recirculating water used in water-cooled chillers, heat pumps, air compressors, and other equipment. Heat is rejected from recirculating water in the cooling tower primarily through evaporation. Under certain conditions, the water-associated piping, heat exchangers and other component surfaces, and the bulk water in cooling towers can become contaminated with microbes, including pathogenic bacteria such as *Legionella*. Appropriate treatment, operation, and maintenance practices can control microbial contamination, amplification, and transmission, and help prevent waterborne disease, such as Legionnaires' disease, associated with cooling tower water systems.

The technology of evaporative cooling water systems has advanced steadily since its origin over 100 years ago. Drift has been reduced, fan efficiency has improved, and fill effectiveness has increased. Cooling towers are now lighter and more corrosion resistant than ever before. Cooling towers offer significant environmental benefits over alternative heat rejection systems, such as air-cooled systems, in terms of total system energy savings, carbon footprint, space, and capital cost. These benefits are enhanced by appropriate treatment, maintenance, and operation consistent with the provisions of this NSF Protocol.

This NSF Protocol provides auditable requirements including means, methods, and frequencies for treating cooling towers using readily available chemicals that are identified by their generic names. It provides simple, easy-to-implement procedures as a minimum benchmark. Alternative practices are allowed by this Protocol so long as there is independent, documentary evidence demonstrating that such alternatives can achieve at-least-equivalent efficacy to the benchmark performance of the processes and procedures set forth here.

In some jurisdictions, there are rules, regulations, and codes that cover owners and operators of buildings that are equipped with cooling tower water systems. Where there are differences between the requirements of this Protocol and such rules, regulations, and codes, the more stringent or specific shall apply.

Throughout the development process of NSF P453 *Cooling Tower Water Systems - Treatment, Operation, and Maintenance to Prevent Legionellosis*, NSF International has worked closely with experts from a number of organizations, including government agencies, academic institutions, and the private sector; however, the viewpoints expressed in the document do not necessarily represent the official position of the organization, agency, or institution. This Protocol has benefitted from the public comment process. All comments were carefully considered, and many adjustments were made accordingly.

1 Garrison LE, Kunz, JM, Cooley LA, et al. Vital Signs: Deficiencies in Environmental Control Identified in Outbreaks of Legionnaires' Disease – North America, 200-2014. MMWR Morb Mortal Wkly Rep 2016; 65: 576 – 584

NSF International recognizes and is grateful for the efforts of the Protocol review committee below in the development of NSF P453 *Cooling Tower Water Systems - Treatment, Operation, and Maintenance to Prevent Legionellosis*:

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NSF Protocol 453 —

Cooling Tower Water Systems – treatment, operation, and maintenance to prevent Legionellosis

1 Purpose

The purpose of this Protocol is to set forth minimum practices required for treatment, operation, and maintenance of cooling tower water systems, including requirements for documentation, recordkeeping, validation, and auditing in order to prevent Legionellosis.

2 Scope

This Protocol covers all owners and operators of buildings and other premises that are equipped with cooling tower water systems, including all building-associated cooling towers used in connection with HVAC systems and all industrial cooling towers and evaporative condensers used in connection with process cooling. This Protocol does not cover hyperbolic towers.

In order for the owner of a cooling tower water system to comply with this Protocol, all of the applicable requirements of this Protocol shall be met.

In some jurisdictions, there are rules, regulations, and codes that cover owners and operators of buildings and other premises that are equipped with cooling tower water systems. Where there are differences between the requirements of this Protocol and such rules, regulations, and codes, the more stringent or specific shall apply.

3 Definitions

3.1 analysis of the cooling tower water system: The systematic, step-by-step evaluation of potentially hazardous conditions associated with the cooling tower system.

3.2 authority having jurisdiction (AHJ): An organization, governmental office, or agency responsible for enforcing codes, rules, or regulations covering the matters to which this Protocol pertains.

3.3 basin (collection basin): Vessel within the tower where cooled water is collected and contained after its interaction with the air flow.

3.4 biocides: Substances that kill bacteria. Biocides include oxidizing biocides (e.g., chlorine) and non-oxidizing biocides (e.g., glutaraldehyde). Biocides may be used alone or in combinations.

3.5 blowdown: Blowdown is the total of all non-evaporative water losses from the cooling tower. When water evaporates from a cooling tower, dissolved solids (such as bromides, calcium, magnesium, chlorides, carbonate, sulfate, and silica) are left behind in the bulk water. As more water evaporates, the concentration of dissolved solids increases. If the concentration gets too high, the dissolved solids can precipitate, cause scale deposits and contribute to corrosion and microbial growth. The concentration of dissolved solids is

controlled by “blowdown”, the process of discharging water containing high concentrations of dissolved solids, and replacing it with “make-up” water containing relatively lower concentrations of dissolved solids.

3.6 bleed off: The process of removing system water with makeup water.

3.7 building: Any structure used or intended for supporting or sheltering any use or occupancy. The term shall be construed as if followed by the phrase “structure, premises, lot or part thereof” and shall include the site, unless otherwise indicated by the text.

3.8 chiller: A chiller is a device that transfers heat from one medium to another by means of vapor compression or absorption-refrigeration cycles. The liquid may be re-circulated through a heat exchanger that uses water. In cooling tower water systems, the heat from a refrigerant is transferred to water; the heat is then rejected from the heated water by means of evaporation from the cooling tower. The cooled water, plus make-up water added to replace the water lost to evaporation (and to other, non-evaporative losses), is returned to the chiller and the process is repeated.

3.9 combined halogen residual: The halogen species in the water bound to nitrogen-containing molecules, such as amines. The halogen in covalent bonds with nitrogen comprise the “combined halogen residual.”

3.10 conductivity: Conductivity is a measure of the capacity of ions in water to carry electric current. Results of conductivity measurements are expressed as microsiemens/cm ($\mu\text{S}/\text{cm}$) or mmho/cm. Both measurements are temperature dependent. Conductivity measurement is used to estimate the amount of total dissolved solids (TDS) in the recirculating cooling water. Conductivity is used to initiate blowdown, thereby managing TDS levels and determining cycles of concentration. Proper control of blowdown based on measurement of conductivity is essential to effective control of the cooling water system.

3.11 control limits: A maximum value, minimum value, or a range of values to which a chemical or physical parameter associated with a control measure must be maintained in order to reduce the occurrence of a hazardous condition to an acceptable level.

3.12 control location: A point where a physical, mechanical, operational, or chemical control measure is applied in order to reduce the occurrence of a hazardous condition to an acceptable level.

3.13 control measure: A practice or procedure used to maintain the physical or chemical conditions of water in a cooling tower or associated components to within parameters that reduce the occurrence of a hazardous condition to an acceptable level.

3.14 cooling capacity: The amount of cooling a cooling tower can provide and is rated in tonnage. A ton is a unit of power used to describe the heat extraction capability of a chiller. A ton refers to the approximate amount of cooling power a ton of ice would provide if it melted over a 24-hour period. A refrigeration ton is equal to 12,000 BTU/hr. A refrigeration ton is the heat rejected by the associated chiller while 15,000 BTU/hr is the heat rejected by the cooling tower when producing cooling.

3.15 cooling tower: Open cooling tower, closed-loop cooling tower, evaporative condenser, or fluid cooler that is part of a recirculated water system incorporated into a building's cooling, industrial process, refrigeration, or energy production system. A cooling tower may be comprised of individual cells. Multi-cell crossflow or counterflow towers can run on variable speeds, utilizing multiple piping and cell configurations.

3.16 cooling tower water system: One or more cooling towers and all associated equipment, such as chillers, condensers, and piping with shared water where shared water is defined as water within a closed circuit with shared treatment.

3.17 cooling tower program team (Team): One or more persons to whom the owner delegates authority and responsibility for the actions required by this Protocol.

3.18 corrective actions: Procedures that must be implemented within a specified time period when the parameters associated with control measures applied at a control location deviate from control limits.

3.19 cycles of concentration: The ratio of make-up water volume to blowdown water volume. Cycles of concentration can be approximated from the ratio of the conductivity of the blowdown water to the conductivity of the make-up water.

3.20 dead leg: An unused pipe or section of pipe with no flow in which the length is greater than six times the inner-diameter of the unused pipe. This also includes redundant or backup equipment with only periodic flow during system operation.

3.21 dissolved solids: Soluble materials in the water, either formed from constituents of the water itself (hardness, salts, etc.) or from the local environment (airborne particles, insects, salts, etc.). The amount of dissolved solids is expressed as mg/L.

3.22 DPD: *N,N*-diethyl-*p*-phenylene diamine is a chemical indicator used in the colorimetric determination of the concentration of oxidizing biocides. DPD reacts with oxidizing biocides, including chlorine and bromine. The DPD method can be used to determine free and total halogen concentrations; combined halogen residual is the difference between total and free halogen.

3.23 drift: Drift is the aerosolized water in droplet form carried out of the tower with the air. Microorganisms, such as *Legionella*, can be transmitted in the droplets which can be inhaled by and infect humans. Drift is different from vapor, the pure gas phase of water that is liberated by evaporation.

3.24 drift eliminator: A drift eliminator is a device used to catch and coalesce aerosolized water droplets that are discharged from the cooling tower as drift. Drift eliminators are designed to change the direction of airflow abruptly, imparting centrifugal force to separate water from the air and cause small droplets to coalesce into large droplets that fall back into the tower basin.

3.25 emergency treatment: (See: off-line remedial treatment)

3.26 FIFRA: The Federal Insecticide Fungicide Rodenticide Act is the law that provides for federal regulation of pesticide distribution, sale, and use in the United States. All pesticides, including anti-microbial biocides that are distributed or sold in the United States must be registered by EPA under FIFRA. Most States have pesticide regulations that are comparable to FIFRA and also require compliance for products sold, distributed, or used in such State.

3.27 fill: The component of the cooling tower that causes the circulating water to spread out over a large surface area, in order to increase the evaporation rate by exposing the water to a greater volume of air. There are two basic types of fill: splash and thin film. Splash fill is where the warm water splashes into smaller water droplets creating a large surface area for evaporation to occur. Film fill is where the warm water spreads over a plastic surface creating a very large area for evaporation to occur. Film fill is much more prone to biological build up and plugging.

3.28 free available chlorine (FAC) residual: The total amount of hypochlorite ion and hypochlorous acid in the system available to act as disinfectants in water. When using chlorine-based biocides, FAC residual is the portion of the total chlorine that has not reacted with constituents of the water and is therefore available for disinfection.

3.29 free residual oxidant (FRO): The amount of available hypohalite (e.g., hypochlorite, hypobromite) ion and corresponding hypohalous (e.g., hypochlorous, hypobromous) acid in the system, available to act as a disinfectant in water.

3.30 halogen: A member of the group in the periodic table consisting of five chemically related elements: fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At). A number of compounds containing halogens, especially chlorine, bromine, and iodine, have anti-microbial properties.

3.31 Hazard Analysis and Critical Control Points (HACCP): A science-based, integrated analytical and control methodology that provides for the systematic analysis and control of hazardous conditions.

3.32 hazardous conditions: Physical or chemical conditions that, in the absence of control, contribute to the potential for harmful human exposure to hazards, such as *Legionella*.

3.33 heterotrophic plate count (HPC): A method that measures colony formation on culture media of heterotrophic bacteria that can be used to measure the overall bacteriological quality in a water system.

3.34 hot water deck: The hot water deck is a feature found on cross flow cooling towers. Water flows from the distribution system across the hot water deck and down into the cooling tower fill. Also called the plenum.

3.35 Legionellosis: Condition associated with two clinically and epidemiologically distinct illnesses: Legionnaires' disease, which is characterized by fever, myalgia, cough, and clinical or radiographic pneumonia; and Pontiac fever, a milder illness without pneumonia.

3.36 Legionnaires' disease: Severe pneumonia caused by infection of *Legionella* bacteria.

3.37 long term shutdown: Whenever the cooling tower water system is shut down for longer than five consecutive days.

3.38 louvers: The part of the cooling tower that blocks sunlight but allows air to be directed onto the fill. Louvers also help retain the splash from droplets falling from the fill.

3.39 makeup water: The water added to the system to replace water lost by evaporation, blowdown, drift, and other means.

3.40 mechanically clean: The act of physically removing dirt, debris, or deposits — e.g., by using a hose with a medium-to-low pressure spray nozzle, vacuum, brush, or similar tool.

NOTE — mechanical cleaning using high-pressure water spray may damage system components.

3.41 monitoring: Monitoring is, collectively, the means, methods, and frequency specified and used to measure physical or chemical parameters associated with control measures applied at the control locations.

3.42 off-line remedial treatment: Off-line remedial treatment is a procedure used to reduce the level of microbial contamination of a cooling tower system, the implementation of which requires the cooling tower to be taken out of service.

3.43 organic dispersants: Organic dispersants (also called biopenetrants) are surfactants that promote system cleanliness by penetrating and loosening attached biofilms and associated deposits.

3.44 owner: Any person, agent, firm, partnership, corporation, or other legal entity having a legal or equitable interest in, or control of the building. In some circumstances, a tenant may be considered an owner for the purposes of this Protocol if the tenant is contractually responsible for the maintenance of the cooling tower water system.

3.45 packing: (see: fill)

3.46 parts per million (ppm): Equivalent to one milligram of solute per liter of water (mg/L).

3.47 pH: The measure of the hydrogen ion concentration of a solution on a negative base-10 logarithmic scale. A pH of 1.0 has 10 times the hydrogen concentration of a solution with pH of 2.0. The larger the hydrogen ion concentration, the lower the pH.