Ames Procedural Requirements

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COMPLIANCE IS MANDATORY

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DOCUMENT CHANGE LOG

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Baseline	0	12/14/2018	New Chapter

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PREFACE

P.1 PURPOSE

a. This manual sets forth safety and health policy and procedures and instructions for the Ames community in an effort to prevent injury and illness in the workplace.

P.2 APPLICABILITY

a. This directive applies to all Ames employees, Ames contractors and grantees as specified in their contracts or grants; and to other organizations (i.e., commercial partners, other Federal agencies, international parties, and Ames tenants) as specified and described in written operating agreements.
b. In this chapter, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms: "may" or "can" denote discretionary privilege or permission, "should" denotes a good practice and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.
c. In this chapter, all document citations are assumed to be the latest version unless otherwise noted.

P.3 AUTHORITY

a. NPR 1800.1, NASA Occupational Health Program Procedures
b. NPR 8715.1A, NASA Occupational Safety and Health Programs

P.4 APPLICABLE DOCUMENTS

None

P.5 MEASUREMENT/VERIFICATION

a. Verification and measurement for compliance to this directive will be tracked through Agency triennial audit and Ames Safety Accountability Program (formerly Ames Annual Voluntary Protection Program (VPP) self-inspections).

P.6 CANCELLATION

None

Eugene Tu
Director

DISTRIBUTION STATEMENT:

APR 8715.1 Ames Health and Safety Manual Chapters shall be made available via procurement website to anyone bidding a job here at Ames. The exceptions are Chapter 7 – Ames Radiation Safety Guide, Chapter 10 – Pressure Systems Safety, Chapter 12 – Explosives Safety and Chapter 23 – Control of Narcotics and Other Controlled Drugs including Alcohol, which shall not to be made public but can be viewed onsite.

CHAPTER 56 LEGIONELLA CONTROL

56.1 Overview

56.1.1 This document identifies risk reduction methods and techniques to help prevent Legionella disease propagation within the NASA Ames water systems. It provides specific technical data for the design and operation of new and existing water systems in buildings, cooling towers and other points of use. It addresses medical management related to the control of Legionella bacteria. The Appendices are applicable to the extent referenced in the body of this APR.

56.2 Roles and Responsibilities

56.2.1 Supervisors shall:

a. Monitor industrial conditions that aerosolize liquids that can be inhaled, such as water sprays or machine shop cutting fluids, and maintain liquids and systems to manufacturer's requirements.

b. Assign personnel with engineering, operation, safety, health and environmental knowledge to prevent Legionella disease propagation within the NASA Ames water systems.

56.2.3 Facilities Engineering Branch (Code JCE) shall:

a. Evaluate and implement physical corrections to water systems including; domestic water systems, cooling systems, fire systems, DI systems, tanks, etc.

b. Ensure all PMs comply with legionella control measures.

c. Develop cost estimates for corrective actions.

d. Direct and manage disinfection actions and procedures. (Appendix E provides guidance on the means and methods utilized).

e. Manage implementation of the requirements contained in this document for facilities under NASA ARC's control and for clearly assigning all responsibilities for required activities.

f. Develop restart procedures for dormant buildings.

56.2.4 Plant Engineering Branch (Code JCM) shall:

a. Retain a competent water treatment contractor to provide cooling tower chemicals and services capable of attaining the performance criteria established in Appendix D.

b. Perform drinking water quality investigations upon requests.

c. Implement corrective actions and disinfections based on this document.

d. Provide support during Legionella source inspections.

e. Make repairs as required.

f. Conduct maintenance required for control of Legionella in all water systems, in accordance with sections 56.3 and 56.4.

g. Support all maintenance requirements that contain elements for Legionella controls.

h. Provide oversight verification of adequate controls on all cooling towers.

56.2.5 Cooling Tower Operators (Entry Systems and Technology Division, Code TS, Wind Tunnel Division, Code AO, Arc Jet, etc) shall:

a. Provide support, maintenance and oversight for scale, corrosion, biofilm and bacteria control in cooling towers.

b. Follow guidance applicable to wind tunnels in 56.2.4 and elsewhere in this document.

56.2.6 Environmental Management Division (Code JQ) shall:

a. Maintain a Community Water System permit for the Ames water distribution system from the California State Water Resources Control Board's (SWRCB's) Division of Drinking Water (DDW) and comply with all SWRCB-DDW regulations.

b. Provide consultation and minor Legionella sampling support to Occupational Safety, Health and Medical Services Division (Code QH) and the Legionella support staff in the Plant Engineering Branch (Code JCM).

56.2.7 Occupational Safety, Health and Medical Services Division (Code QH) shall:

a. Provide sampling data and risk assessment as required. Provide consultation to the Legionella support staff in the Plant Engineering Branch (Code JCM).

b. Ensure the health unit provide public notice to employees, when required.

c. Provide medical surveillance and management of all employee health issues through the Health Unit. Follow Appendix J guidance. Review project designs for Legionella risk reduction controls.

d. Provide oversight review and assessment of contractors' safety plans for treatment activities.

e. Provide communications to employees on the status of Legionella remediation work projects. Maintain information on Legionella controls for employees.

56.3 Cold and Hot Water

56.3.1 General Management

a. All directly connected water uses and system alterations shall be coordinated through the Ames Permit Review Board.

b. All modifications to the water system will be managed by Facilities Engineering and Real Property Management Division (Code JC).

c. All plumbing changes and maintenance will be implemented under control of either the Facilities Engineering Branch or the Plant Engineering Branch (Codes JCE or JCM).

d. The goal of this legionella management program is attainment of the performance criteria detailed in Appendix D.

e. Design and maintenance should comply with OSHA, California Plumbing Code, ASHRAE Guideline 12-2000 and ANSI/ASHRAE Standard 188-2015.

f. Design and modifications must aim to preserve supply water quality, prevent microbial growth, eliminate or reduce formation of aerosols and minimize corrosion.

g. Occupational Safety, Health, and Medical Services Division (Code QH) will conduct sampling in accordance with Appendix L, Sampling Protocol. Corrective actions take precedence over additional sampling, wherever Legionella is already known to exist within a system.

56.3.2 System Design and Controls (Facilities Engineering Branch, Code JCE)

56.3.2.1 Controls

a. Provide water temperatures of 20°C (68°F) or less in cold water storage and distribution systems. Provide hot water temperatures of 60°C (140°F) leaving the hot water storage vessels or heaters and a minimum of 49°C (120°F) in distribution systems and delivery to water service outlets.

b. Make adequate provisions for monitoring and control of domestic water systems to assure compliance with all relevant design and operating criteria. These provisionss may include regular equipment inspections, recording of water temperatures and selected control procedures. A typical schedule for monitoring checks and control procedures are given in the section titled Operation and Maintenance.

c. Temperature monitoring and, where appropriate, control equipment shall be provided to assure specified water temperatures are maintained. Where applicable, thiscontrol equipment shall be fully integrated with the building management system.

56.3.2.2 Pipe and Fittings

a. Wherever possible, potable water supplies should be taken directly from the mains; a backflow prevention device is required on all new installations.

b. Cold water pipe should be adequately insulated where necessary and located away from heat sources including domestic hot water pipes so that the cold-water temperature is maintained at 20^{o}C (68^{o}F) or less.

c. Dead legs, low-flow areas and long pipe runs should be eliminated.

d. Rubber washers and fittings, including water hammer arrestors, thermostatic mixing valves, expansion vessels and rubber hoses with spray attachments shall be replaced when degradation is noticed.

56.3.2.3 Water Storage

If water storage inside a facility's water system is unavoidable, a single storage tank should be used. More than one tank placed in series is not allowed without the Facilities Engineering Branch (Code JCE) approval.

56.3.2.4 Hot Water

Hot water storage vessels, direct-fired hot water service boilers and heaters must be designed to ensure adequate control of water temperatures. For very large tanks with stratification, destratification pumps should be installed. New tanks shall have a drainage facility at the lowest point. Heating elements shall be as close as possible to the lowest point to facilitate control of stratification.

56.3.2.5 Drinking Fountains

Sufficient drinking water service outlets should be provided and suitably sited for the number of occupants of the building. Water from drinking fountains should be chilled.

56.3.2.6 Backflow Prevention

Any connection to a process or utility system must be isolated from the drinking water supply by a backflow prevention device. Backflow prevention devices provide an opportunity for malicious interference with water quality due to the test points installed and shall be installed in a secure location.

56.3.2.7 Drawings and Records

Layout drawings must be provided for all new cold and hot water services. These should be updated periodically to account for all modifications and extensions.

56.3.3 Chemical Treatment

a. Chemical treatment is only permitted with the prior approval of the NASA ARC Environmental Management Division (Code JQ).

b. Systems must be disinfected in accordance with California Title 24, Uniform Plumbing Code or AWWA/ANSI C 651-99 Standards for Disinfecting Water Pipes whenever new connections are made.

c. If chemical treatment agents are deemed necessary, they must be approved for use in potable water. Chemicals should be dosed either into the tank or the cold supply pipe downstream. Dosing can be accomplished using a pump or controller, introducing the chemical as a liquid concentrate, or using a slowly dissolving solid. It may be necessary to treat either the entire building or a part of the building drinking water supply.

d. The water treatment program must control corrosion, scale deposition and microbial contamination; and water treatment for non-potable water.

e. Adequate safety precautions must be observed during disinfection procedures, including hazard communication and if required respiratory protection (refer to Appendix H of this document).

56.3.4 Operations and Maintenance (Plant Engineering Branch, Code JCM and Area Supervisors)

56.3.4.1 Cleaning and Disinfecting

a. A potable water system component shall be cleaned, flushed and disinfected if it is a new installation, if inspection shows it to have become badly contaminated while in service, if major system modifications are carried out, or following identified cases of Legionnaires' Disease linked to that system. This shall be carried out in accordance with the Uniform Plumbing Code or AWWA/ANSI C 651-99 Standard for Disinfecting Water Pipes. Disinfection should be carried out using dilute solutions of sodium hypochlorite following the recommendations in Appendix E.

b. When disinfection is carried out, precautions must be taken to ensure that heavily chlorinated water is not ingested by occupants of the building. Where applicable, all areas shall be secured where service outlets exist and suitable hazard warning notices posted.

c. Tanks, hot water heaters and services must be inspected, cleaned and disinfected as required by the positive Legionella sample results schedules in Appendix D and the Routine Maintenance Schedule below.

56.3.4.2 Temperature Maintenance

Maintain water temperatures of 20°C (68°F) or less in cold water storage and distribution systems. Maintain a maximum hot water temperature of 60°C (140°F) at the hot water storage vessel outlets and a minimum in distribution and delivery to the water service outlets of 49°C (120°F). Reference Table 2-2 "Temperature Summary – Hot Water Systems".

56.3.4.3 Pasteurization

Pasteurization can be used in heating vessels on a regular basis to control microbial proliferation or when required to decontaminate equipment. When pasteurization or disinfection is carried out, precautions must be taken to ensure that very hot or heavily chlorinated water does not come into contact with occupants of the building. Where applicable, all areas shall be secured where service outlets exist and suitable hazard warning notices shall be posted. Appendix E provides cleaning and disinfection procedures.

56.3.4.4 Filters

Drinking water filters must have NSF Standard 53 certification. Filters shall be replaced according to the manufacturers recommended maintenance frequency.

56.3.4.5 Routine Maintenance Schedules

a. Monthly maintenance procedures should include, at a minimum, the following:

1. Activate eyewash stations and emergency showers in accordance with the ANSI Z358.1 standard. Verify mechanical operation and water availability. The area supervisor is responsible for this activity and may assign these responsibilities to responsible occupants.

b. Annual maintenance procedures should include, at a minimum, the following:

1. Check temperatures of hot water in storage tanks and in the building distribution at the most distal point from the hot water storage tank. If hot water recirculation systems remain for long periods below 49°C (120°F), thermostat settings shall be changed or proper maintenance conducted on the system to assure temperatures above 49°C (120°F) at the most distal point after operating for

two minutes. Record the temperatures read at the water heater and the most distal point on the preventative maintenance work order.

2. Inspect and flush hot water heaters and hot water storage tanks of 40 gal capacity and greater and building distribution services by suitably trained personnel. Documentation shall be maintained. Disinfect when required by the Environmental Management Division, Code JQ. The preferred disinfection method is to pasteurize domestic hot water heaters by removing the heaters from service and raising the temperature of the stored water to 70^{o}C (160^{o}F). Water shall then be drained from the bottom of the heater until it flows clear at this temperature. After 3 hours, the heater may be returned to service at its normal working temperature.

3. Ensure that proper personal protective equipment (PPE) is worn during all maintenance procedures. For each job, a Hazard Analysis Safety Plan (HASP) should be approved and call out the specific PPE to be worn for each job.

56.3.5 Summary Schedules

56.3.5.1 Summary Frequency Schedule

Table 3-1

SUMMARY FREQUENCY SCHEDULE

Hot and Cold Water Systems

Task	Minimum Frequency
Safety, Health and Medical Services Division (Code QH)	
Provide sampling data and consultation to the program manager, Facilities Engineering Branch (Code JCE).	As needed
Environmental Management Division (Code JQ)	
Evaluate drinking water quality concerns. Define when disinfection of systems needs to be performed.	As requested
Plant Engineering Branch (Code JCM)	

Task	Minimum Frequency
Clean and disinfect systems if modifications have been made or if directed by the Environmental Management Division (Code JQ).	As needed
Flush eye wash stations and emergency showers.	Monthly
Check and set temperatures of hot water in storage and most distal point in distribution systems.	As needed
Test backflow preventers.	Annually
Inspect, flush and maintain hot water heaters and storage tanks of 40 gallon capacity and greater. (Performed by the Plant Engineering Maintenance Contractor, PM Checklists C12-514, C12-515A, C12-515B, and C12-515C. See Legionella Manual Supplement)	As needed
Inspect and certify backflow preventers	Annually
Disinfect hot water tanks when directed by the Environmental Management Division, Code JQ.	As requested

56.3.5.2 Temperature Summary

Table 3-2
TEMPERATURE SUMMARY
Hot Water Systems

Water temperatures in Hot Water Systems should be as follows:

- Storage Vessel Outlet:

Minimum: 55° C (131°F)
Maximum: 60° C (140°F)

- Distal Points

Minimum: 49°C (120°F)
Maximum:55° C (131°F)

- Hot Water Return:

Minimum - 49°C (120°F)
Maximum - 55° C (131°F)

Note 1: Temperatures should be measured with a calibrated electric resistance thermometer or thermocouple with an accuracy of ± 1 degree. At the distal points on a system, the temperature shall be measured after flushing the outlet for about 2 minutes or when a stable temperature is obtained.

56.4 Cooling and Humidification Systems

56.4.1 Open Evaporative-Cooling System

56.4.1.1 General Requirements

a. Designs for systems incorporating evaporative cooling towers must have the prior approval of NASA ARC, Facilities Engineering Branch (Code JCE).

b. New chemical dosing and control systems should be automatic. Accurate logs shall be kept for existing batch fed and partially automated feeder systems.

c. Aerosol emissions from cooling towers must be dispersed safely. New cooling towers may not be installed within 25 feet of a buildings outdoor air intake or operable window.

d. All operational cooling towers shall be provided ongoing chemical treatment and cleaned annually at a minimum.

e. Provide water treatment regimes to meet the performance requirements of Appendix D.

f. Provide SDSs for all chemicals and keep readily available on-site to all employees.

56.4.1.2 System Design (Facilities Engineering Branch, Code JCE)

a. Locate new cooling towers as far away as is practicable from air-conditioning and vent inlets. Locate in such a way that aerosol emissions are directed away from windows, ventilation inlets and occupied areas. A minimum separation distance of 25 feet is required for all facility areas from new cooling tower installations.

b. Designs should ensure that water spray is retained within the cooling tower. Spray nozzle distribution systems should be avoided so as to minimize the generation of very small droplets. Provide new and refurbished cooling towers with high efficiency drift eliminators wherever feasible. Tower designs that minimize the impact of direct sunlight on water surfaces are preferred.

c. Materials used in the construction of cooling towers shall be corrosion resistant, nonporous, easy to clean and resistant to chemicals from treatment, cleaning, and disinfection systems utilized.

d. Schematic drawings and commissioning data (e.g. system volume and operating regime) must be provided for all new open evaporative cooling systems. These should be updated periodically to take account of all modifications and extensions.

56.4.1.3 Water Treatment (Plant Engineering Branch, Code JCM, Entry Systems and Technology Division, Code TS and Wind Tunnel Division, Code AO).

a. Water treatment is essential for open cooling systems to control corrosion, scale deposition, sludge accumulation and microbial contamination. Control of scaling and corrosion are necessary for proper water treatment programs. Scale and corrosion inhibitors are effective if microbial fouling and biofilm development are properly controlled.

b. The preferred method of biocidal treatment for new systems is the continuous application of an oxidizing biocide to attain a free residual of 0.5 to 1.0 ppm free chlorine in the recirculating water. Once adequate levels of control have been established, including control of biofilm, the continuous addition of oxidizing biocide may be reduced to between 0.2 and 0.5 ppm free chlorine. Where appropriate, a biodispersant may be of use in minimizing biofilms. The oxidizing biocide should be backed-up with an occasional shot dose of non-oxidizing biocide with proven efficacy against Legionella (see Appendix I of this document and Legionella Manual Supplement). All biocides used on cooling water systems are regulated under FIPRA and must be registered for the particular application, with the dosage rate conforming to the manufacturer's labeling instructions.

c. When used in the above systems, non-oxidizing biocides should be added proportional to the system volume, with an allowance for losses due to blowdown and hydrolysis to maintain a minimum inhibitory concentration in the system water for at least 6 hours. The non-oxidizing biocides should be alternated on a regular basis. Microbiological activity shall be controlled within the specified limits outlined in Appendix D of this document. For an approved list of biocides, please refer to Appendix I of this document. Quaternary ammonium and poly-quaternary ammonium compounds are not acceptable. Magnetic devices, both fixed and electromagnets, ultra-violet light systems, and any similar non-chemical devices are not acceptable for use on NASA systems without the prior approval of the Plant Engineering Branch (Code JCM).

d. Provisions shall be made for safe storage and handling of all chemicals which must be accompanied by SDSs. All chemicals must be environmentally acceptable and be approved by NASA Environmental Management Division (Code JQ).

e. Regular bleed-off of the cooling water is necessary to control the build-up of dissolved and suspended solids. Regular water testing is an integral part of any water treatment program. Water tests shall include specific control parameters as specified by the chemical supplier. These should include treatment reserves; total colony counts by dip slide, pH, electrical conductivity, hardness salts, alkalinity, chlorides and metals.

56.4.1.4 Dosing, Monitoring, and Control (Plant Engineering Branch, Code JCM, Entry Systems and Technology Division, Code TS and Wind Tunnel Division, Code AO)

a. Chemical dosing and bleed-off equipment is available from specialist suppliers and should be automatic in operation to minimize operator involvement, as required under OSHA hazardous materials handling regulations. New systems should be designed for automatic operation. Chemical storage tanks shall be placed inside secondary containment vessels with a capacity of at least 125 percent of the primary storage vessel capacity.

b. Corrosion and scale inhibitors and deposit-controlling chemicals should normally be dosed in proportion to makeup flow measured by a meter on the makeup line. If this is not practicable, dosing may be controlled by a timer with adjustable frequency and duration facilities, although this is not the preferred approach.

c. Oxidizing biocides, such as chlorine- or bromine-based chemicals, should be dosed automatically. Dosing interlocked to the circulation pump or intermittent dosing using a timer with adjustable frequency and duration facilities may also be used. Non-oxidizing biocides should be dosed intermittently using a timer with adjustable frequency and duration capability.

d. Bleed-off should normally be controlled by means of an automatic valve, which is controlled by an in-line conductivity-monitoring device. If this is not practicable, it may be controlled by a timer with adjustable frequency and duration.

e. Final selection of dosing and bleed-off equipment is dependent upon the type and operation of the cooling system, variation in cooling load, make-up water quality, and sensitivity of the cooling system.

f. Adequate provisions must be made for routine monitoring of evaporative cooling systems to ensure compliance with the performance criteria specified in Appendix D of this document. These provisions shall include annual inspection of cooling towers, water sampling and analysis, corrosion monitoring, and equipment checks.

56.4.1.5 Operation and Maintenance (Plant Engineering Branch, Code JCM, Entry Systems and Technology Division, Code TS and Wind Tunnel Division, Code AO).

a. Equipment suppliers must provide clearly written operating and maintenance instructions. These instructions should be incorporated into the site water management manual.

b. All maintenance procedures must be undertaken by properly trained personnel. Safety issues are addressed in Appendix F.

c. Monthly Maintenance Procedures should include, at a minimum, the following:

1. Testing of the system water by the water treatment supplier, including a minimum testing suite of Conductivity
--pH

--Chemical feed rates

--Cycles of concentration factor

--Copper

--Blow-down where metered

2. The water treatment supplier should compile a report detailing system conditions, compliance/non-compliance with control limits, and advice on corrective actions, as required.

3. Checking of chemical dosing equipment operation by the water treatment supplier or resident government support service contractor, including adjusting, as required, replenishing chemical dosing containers, ensuring supply lines are not blocked or damaged, and recording chemical consumption and stock levels. A report should be compiled detailing findings and remedial action as necessary.

4. Checking by the water treatment supplier or resident government support service contractor that automatic bleed equipment is operating correctly, cleaning, and if equipped, recalibrating the conductivity and REDOX cells.

5. Check clarity of water. Ensure no algae buildup. Visually check the system for physical growths, deposits, etc. The condition of the sumps and any accumulated deposits or increase in deposits and growth should be noted.

6. Recording of make-up/blow-down meter readings.

7. Alternate duty on recirculation pumps, where standby pumps exist.

d. Annual Maintenance Procedures should include, at a minimum, the following:

1. Draining and physically cleaning cooling towers and associated system pipe work and equipment in accordance with the requirements outlined in Appendix E of this document. Cleaning should be carried out by either an approved specialist contractor or by suitably trained in-house personnel wearing suitable protective clothing (see Appendix H). The pre and post disinfection procedures outlined in Appendix E shall be performed on individual towers when directed by Plant Engineering Branch, Code JCM or Environmental Management Division, Code JQ.

2. Visual checks of the operation of sprays, fans, and drift eliminators. Where operation is found to be defective, remedial action should be taken immediately to prevent excess carryover of water droplets.

3. Prior to draining a cooling tower and associated system pipe work and equipment, the water must be tested against the permit requirements of the appropriate industrial waste water treatment facility and an Incidental Sewer Discharge permit application shall be submitted to the Environmental Management Division, Code JQ for approval by the industrial waste water treatment facility.

e. Other routine tasks, which should be undertaken, include (Plant Engineering Branch, Code JCM, Entry Systems and Technology Division, Code TS, and Wind Tunnel Division, Code AO)

1. Checking the level of water in the cooling tower sump whenever water samples are collected.

2. Checking the system for abnormal water losses when meter readings are collected.

3. Checking the operation of sump immersion heaters, if applicable.

4. Checking the operation of trace heating circuits, if applicable.

5. Inspecting the interior and exterior of the cooling tower for evidence of bacteriological growth (e.g. slime, fungi, algae, etc.) whenever the system is sampled. In addition, the cooling tower pack and sump should be inspected in relation to scale and deposition buildup. Any noticeable buildup of bacteriological growth or deposits should be reported and remedial action carried out as advised by the water treatment supplier.

6. Outside the "cooling season", the system can be left filled with water under a suitable water treatment regime recommended by the water treatment supplier. Prior to startup, the procedures outlined in Appendix H are to be followed if directed by Plant Engineering Branch, Code JCM or Environmental Management Division, Code JQ.

7. The cooling towers and associated systems shall be disinfected when major modifications are made to the system, or if the system is idle for longer than 4 weeks. Every other disinfection is to be the full off line disinfection (Appendix E), if the tower has not accumulated significant debris or sludge, the on-line disinfection (Appendix E) can be used on every other occasion.

56.4.1.6 Summary Frequency Schedule

Table 4-1
SUMMARY FREQUENCY
Open Evaporative-Cooling Systems

Task	**Minimum Frequency**
Plant Engineering Branch, Codes JCM, Entry Systems and Technology Division, Code TS and Wind Tunnel Division, Code AO	
Measure and log the treatment reserves in the recirculating water	Monthly
Record make-up/blow-down meter readings, where available.	Monthly
Check all water dosing chemical equipment to ensure that chemical dosing containers are full, that dosing pumps are operating correctly, and that chemical supply lines are not blocked or damaged.	Monthly

Task	Minimum Frequency
Check the bleed-off control equipment to ensure that it is operating correctly.	Monthly
Alternate duty of recirculation pumps and standby equipment.	Monthly
Visually check the system for physical growth, deposits etc.	Monthly
Monitor and record the following for System water: - oxidizing biocide residual and feed rate - corrosion inhibitor feed rate - pH - conductivity - temperature - cycles of concentration - Copper	Monthly
Check chemical dosing equipment operations	Monthly
Visually check the operation of sprays, fans and drift eliminators. Where operation is found to be defective, remedial action shall be taken immediately.	Annually
If specifically required by Code JQ, collect water samples and have an independent AIHA accredited laboratory perform bacterial analysis as a standard to compare dip slide results.	Annually
Drain and physically clean cooling towers and associated system pipe work and equipment in accordance with Annual Preventive Maintenance Procedures.	Annual

* Where automatic monitoring and control equipment is installed the frequency of monitoring may be decreased to monthly.

56.4.2 Humidification Systems

56.4.2.1 General Requirements

a. The scope of Section 3.2 includes evaporative coolers such as are used on the roof of building N239. (“swamp coolers”)

b. Designs for systems incorporating recirculation water-type humidifiers must have the prior approval of the NASA ARC Facilities Engineering Branch (Code JCE).

c. The operation and maintenance program must be in accordance with Preventive Maintenance Checklists C16-518 as included in the Legionella Manual Supplement.

d. Biocides and scale and corrosion inhibitors must **not** be used unless specifically made for humidification systems and approved by the Environmental Management Division (Code JQ).

56.4.2.2 System Design (Facilities Engineering Branch, Code JCE)

a. Humidifiers of the direct type should be selected whenever possible. Steam injection units are preferred, but other direct-type systems can be considered after approval by the NASA Facilities Engineering Branch (Code JCE).

b. Reference should be made to ASHRAE Guideline 12-2000 or ANSI/ASHRAE 188-2015.

c. Humidification systems should be designed to prevent microbial contamination, to minimize health risks, and to control corrosion and scale/deposit accumulations. Design considerations should include: type, size, and operation of humidifier equipment (steam or hot water greater than 60^{o}C injection units are preferred); use of corrosion-resistant materials; fitting of baffles or eliminator plates to control aerosol carryover; pretreatment and bleed-off requirements; drain connections; air break protection and discharge provisions; access for cleaning and disinfection; and provision for monitoring and control.

d. Adequate provisions must be made for ready access to internal components of humidifier equipment to facilitate periodic cleaning and disinfection. Inspection points should also be considered for critical equipment to which access for routine inspection is difficult.

e. Recirculating water systems should be designed to ensure that stored water should be turned over at least once per 24 hours, whether or not the humidifier equipment is operational. Equipment, which is to be out of use for more than a week, should be drained and stored dry.

f. Schematic drawings and commissioning data must be provided for all humidification systems. These should be updated periodically to account for all modifications and extensions.

56.4.2.3 Water Treatment (Plant Engineering Branch, Code JCM or Facility Owner)

a. Biocides and scale and corrosion inhibitors must not be used except as noted above, as these can be carried over into the air stream and inhaled.

b. Control of microbial growth is achieved by the regular program of off-line cleaning and disinfection.

c. Regular bleed-off should be provided for water storage humidifiers to control the levels of dissolved and suspended solids. Control options are discussed in this document.

56.4.2.4 Dosing, Monitoring, and Control (Plant Engineering Branch, Code JCM, or Facility Owner).

a. Monitoring and control of equipment cleanliness and water conditions are essential to ensure compliance with specified operating criteria. This should include regular equipment inspections.

b. The operation and maintenance program must be in accordance with Preventive Maintenance Checklists C16-518 as included in the Legionella Manual Supplement.

56.4.2.5 Operation and Maintenance (Plant Engineering Branch, Code JCM or Facility Owner)

a. All maintenance procedures must be undertaken by properly trained personnel. Protective clothing, including respiratory protection, must be used during cleaning and disinfection (see Appendix G of this document).

b. Annual maintenance procedures for spray humidifiers shall include, at a minimum, the following:

1. Visually checking on the operation of sprays and integrity of aerosol eliminator plates/baffles in recirculation-type units. If sprays or aerosol eliminator plates/baffles are found to be operating incorrectly, remedial action shall be taken immediately to prevent excess carryover of water droplets into the air stream.

2. Checking the operation of the bleed-off system if applicable.

3. Draining, physically cleaning, and disinfecting the humidifier equipment in accordance with the requirements of Appendix E of this document. Protective clothing, including respiratory protection, must be used during the cleaning and disinfection operation. The disinfection should only be carried out when the humidifier equipment is off-line.

4. If applicable, water and air filters shall be cleaned and flushed

5. Descaling.

6. Cleaning and disinfecting condensate collecting trays.

56.4.2.6 Summary of Frequency

Table 4-2

SUMMARY FREQUENCY

Humidification Systems

Task	Minimum Frequency
Plant Engineering Branch, Codes JCM, Entry Systems and Technology Division, Code TS and Wind Tunnel Division, Code AO or Facility Owner	
Clean and disinfect humidifiers	Annually
Water and Air filters cleaned and flushed	Annually
Check blow-down or drain control equipment to ensure it is operating correctly	Annually
Visual check of the system for growth, deposits, etc.	Annually
Clean and disinfect condensate collecting trays	Annually

APPENDIX A. DEFINITIONS

Alkalinity. The concentration of alkaline salts or bases present.
Base Exchange Softening. An ion exchange process involving the removal of calcium and magnesium ions from the water and their replacement with sodium ions, thereby softening the water.
Biocide. A chemical used to prevent or limit microbial growths in a system (see oxidizing biocide).
Bleed Off. The removal of part of the water of a cooling system to prevent over-concentration of solids or other agents in the water.
Blow down. Water removed from a system to reduce the level of total dissolved solids in the water to remove sludge and debris.
Calcium Retention. A measure of the proportion of calcium held in solution in a systemcirculating water defined by: ((Ca in circulating water / Ca in make-up)/(Concentration Factor)) x 100
Chelant. An organic chemical causing a substance that would normally be insoluble to be held in solution or to pass into solution.
Coliforms. A specific group of bacteria associated with water contamination by sewage or vegetative matter.
Combined Condenser Cooling and Chilled Water System. A water system, part of an air-conditioning plant, where the water is circulated in a closed chilled water circuit or bypassed over an open cooling tower depending upon climatic conditions. Also known as a "free cooling" system.
Complexing Agent. See Chelant.
Concentration Factor. The ratio of the concentration of a selected chemical species in a system circulating water to the concentration of the same species in the makeup water.
Conditioning. The addition of chemicals to the water of a system to prevent corrosion, scale formation, and microbial contamination or fouling.
Corrosion. The destruction of a metal by chemical or electrochemical reaction with its environment.
Cycles of Concentration. See Concentration Factor.
Dealkalization. The removal of calcium and magnesium bicarbonates by ion exchange.
Deposit. Any one or combination of materials that have settled on the waterside surfaces of water distribution systems or equipment. The deposit may consist of corrosion products, scale, sludge, live or dead organic matter, silt, or even water-soluble salts left behind by evaporation of water.
Dispersant. A chemical used to disperse deposited materials and to prevent the accumulation of deposits within a system.
Dissolved Solids. The solids in solution what would remain were the water to be evaporated.
Drift. The system water lost due to water droplets entrained with the out flowing air from a cooling tower.
Erosion. The mechanical wearing away of a metal by the action of a liquid, gas, or solid.
Fecal Coliforms: A specific group of bacteria associated with water contamination by sewage. The presence of fecal coliforms is used as an indicator to determine the potential presence of enteric pathogens in a water supply.
Filtration. The physical removal of suspended solids.
Foaming. The formation of bubbles at the water surface; may lead to carryover in steam boilers.

Fouling Factor. The reduction (expressed as %) in heat transfer coefficient caused by deposition on the heat transfer surface.
Galvanic Action. Usually refers to a form of corrosion caused by dissimilar metals in contact with each other.
Half Life. The period of time required for the concentration of a particular chemical in a system to fall to half its original concentration. Normally only relevant when shot dosing biocides into evaporative cooling systems.
High Temperature Hot Water (HTHW) System. Systems operating at 110 oC and above, and at pressures up to 10-bar gauge.
Langelier Saturation Index. Indicates if a water is corrosive or scale forming and is calculated from the pH of the water minus the pH at which the water would be saturated with calcium carbonate.
Legionellae: Bacteria responsible for Legionnaires' Disease and Pontiac Fever.
Low Temperature Hot Water (LTHW) System. Systems operating at temperatures notexceeding 80 oC and with capacities greater than 150 kW.
Makeup. A term used to distinguish that portion of water that is added to a system to compensate for water that is lost. Makeup may be raw or treated water.
Medium Temperature Hot Water (MTHW) Systems. Systems operating at between 80 oC and 110 oC, and at pressures up to 10-bar gauge.
Microbial Contamination. Microscopic, mainly plant life together with some animal life which thrive in water systems. These include algae, bacteria, and fungi.
Milligram per Liter (mg/L). A unit of concentration in dilute solutions, equivalent to parts per million (ppm).
Oxidizing Biocide. A chemical for microbial control containing oxidizing agents.
Non-Alkaline Hardness. Hardness in water caused by chlorides, sulfates, and nitrates of calcium and magnesium.
Non-Carbonate Hardness. See Non-Alkaline Hardness.
Parts per Million. See Milligram per Liter.
Permanent Hardness. See Non-Alkaline Hardness.
pH: A numerical indication of the intensity of acidity or alkalinity of a solution. The scale is from 0 to 14, with 7 being neutral. pH values below 7 are acidic and above 7 are alkaline.
Pitting: Highly localized, severe corrosion resulting in deep penetration in only a few places.
Pitting Propensity Rating. Indicates the propensity of any particular water to initiate pitting in susceptible copper pipes.
Precipitate. An insoluble solid formed by the interaction of substances dissolved in the water or by the action of heat on alkaline hardness salts.
Regeneration. The process of treating an ion exchange unit, such as a base exchange softener, with a chemical solution, such as salt, to restore its softening or exchange capacity.
Reserve. Quantity of conditioning chemicals necessary in a water system for satisfactory treatment to continue.
Ryznar Index. Indicates where a water is corrosive or scale-forming and is calculated from twice the pH at which the water would be saturated with calcium carbonate minus the actual pH of the water.

Scale. A hard deposit on heat transfer surfaces caused by reactions at the point of deposition. Hardness salts come out of solution directly onto the metal surfaces as a result of temperature or because of over-concentration.
Sludge. Suspended or precipitated solids formed in the main body of the water in steam boiler and cooling systems by reaction with hardness treatment chemicals. Some are mobile and free flowing, while others agglomerate.
Softening. The removal of hardness salts from water.
Suspended Solids. Solids contained in water that may be removed by filtration, coagulation, or sedimentation.
Windage. See Drift.

APPENDIX B. ACRONYMS

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
APR	Ames Policy Requirement
ARC	Ames Research Center
AWWA	American Water Works Association
Code AO	Wind Tunnel Division
Code JC	Facilities Engineering and Real Property Management Division
Code JCE	Facilities Engineering Branch
Code JCM	Plant Engineering Branch
Code JQ	Environmental Management Division
Code QH	Safety Health and Medical Services Division
Code TS	Entry Systems and Technology Division
DI	de ionized
HASP	Hazard Analysis Safety Plan
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirement
NSF	National Standards Foundation
OSHA	Occupational Safety And Health Administration
PM	preventative maintenance
PPE	personal protective equipment
REDOX	reduction-oxidation reaction
SDS	Safety Data Sheets
VPP	Voluntary Protection Program

APPENDIX C. REFERENCES

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3. ANSI/ASHRAE Standard 188-2015, Legionellosis: Risk Management for Building Water Systems
4. “ASTM G4-01(2014) Standard Guide for Conducting Corrosion Coupon Tests in Field Applications”, American Society For Testing and Materials (ASTM).
5. “ANSI/NSPI–2 1999, American National Standard for Public Spas”, American National Standards Institute (ANSI) /National Spa and Pool Institute (NSPI).
6. “Standard Methods for the Examination of Water and Wastewater, 23rd edition”, L. S. Clesceri, A. E. Greenberg, and A. D. Eaton (eds.), American Public Health Association, American Water Works Association, and Water Environment Federation (2017).
7. “Procedures for the Recovery of Legionella from the Environment,” Centers for Disease Control and Prevention (2005).
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10. “Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) 7 United States Code s/s 136 et seq.” United States Environmental Protection Agency, (1972).
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20. “Standard for Emergency Eye Wash and Shower Equipment”, ANSI-Z358.1, American National Standards Institute.
21. “Standard for Disinfecting Water Pipes” AWWA/ANSI C 651-99

APPENDIX D. WATER TREATMENT PERFORMANCE CRITERIA, TESTING STANDARDS AND ACTION LEVELS

D-1.0 CORROSION CONTROL - ALL SYSTEMS

Corrosion rates should be monitored. Satisfactory corrosion control must be achieved for all system metals.

D-2.0 DEPOSIT CONTROL - ALL SYSTEMS

Satisfactory deposit control must be achieved such that all critical internal surfaces are maintained in a scale-free condition. Deposit control should be assessed by regular inspection of equipment and systems.

D-3.0 MICROBIOLOGICAL CONTROL AND ACTION LEVELS

The only tests required for non-potable water are total bacterial colony counts, when specifically mandated by Environmental Management Division, Code JQ. Where health problems are confirmed or specific operational problems e.g. corrosion encountered, an assay could include any or all of the following tests:

-- *pseudomonads*

-- sulfate-reducing bacteria

-- nitrate-reducing bacteria
-- algae, protozoa, amoebae
-- *Legionella (see Section 3.5 for further considerations)

D-3.1 Open Evaporative Cooling (Cooling Towers) and Humidification Systems

D-3.1.1. Total colony count (defined as the number of colonies developing on nutrient agar after incubation at 20-22°C for 3 days, Standard Method SM 9215 spread plate method) should not exceed 10^5 cfu/ml in any one test or 10^4 cfu/ml in four consecutive tests. An alternate method of testing process (cooling) wastes is available, using adenosine triphosphate (ATP) monthly. One unit (Bioscan tm) measures ATM in relative light units (RLU) and equates 10^4 cfu/ml to 140 RLU and 10^5 CFU/ml to 300 RLU though each system should be individually calibrated.

D-3.1.2. Sulfate-reducing bacteria should be absent. Where nitrite is used as a corrosion inhibitor, nitrite-reducing bacteria should be monitored and should be absent.

D-3.1.3. If total colony counts exceed the stated levels, the following actions should be taken:

1) At counts in excess of 10^5 cfu/mL (bioluminescence ATP reading of 300 relative light units [RLU]), the system may be out of control and immediate action to reduce levels is required by the water treatment supplier.

2) At counts of 10^4 to 10^5 cfu/mL (bioluminescence ATP reading of 140 to 300 RLU), accurate bacterial checks should be carried out. Action is required by the water treatment supplier to reduce levels if counts remain in excess of 10^4 for four consecutive weeks. If nitrite- or sulfate-reducing bacteria are detected, action should be taken to reduce the bacteria level. Microorganisms associated with biofouling, including algae, yeasts, molds, and protozoa, must be controlled so as to ensure effective and efficient system operation. If biofouling is found to be excessive, the water treatment program should be reviewed independently of the water treatment supplier. In-line monitoring systems are now available and, although not yet fully assessed, may be used to indicate biofouling trends.

D-3.2 Cold and Hot Potable Water

D-3.2.1 Total colony count should not exceed 10^5cfu/mL. Review and adjust operations and maintenance when action levels are exceeded. Drinking water should comply with the following:

1. Total colony count should not exceed 500 cfu/mL (3 days, 20-22 ^oC).
2. Total coliforms should not exceed 1 per 100 mL.
3. Total *E. coli* should not exceed 0 per 100 mL.

D-3.2.2 Total colony counts are quoted as guide levels given in the "WHO Guidelines for Drinking Water Quality", World Health Organization, relating to the quality of water intended for human consumption. Although no maximum admissible concentration is given for this parameter, it is practice to accept total colony counts for drinking water service points, which are not appreciably in excess of the incoming mains water quality. Samples of at least 100 mL should be collected in sterile containers and 0.1 mL of 1.8% sodium thiosulphate added for each 100 mL collected. Samples should be sealed, refrigerated and transported to an approved laboratory for analysis within 24 hours.

D-3.3 Legionella Bacteria Testing for All Systems

D-3.3.1 Cooling Towers and Humidifers:_Testing is advisable for open evaporative cooling towers and humidifiers where:

1. Significant deficiencies in control regimes are suspected; or

2. Visual inspection or monitoring suggests significant biofouling or deposition.

Legionella bacteria testing is required following an outbreak of Legionellosis prior to any remedial actions.

The above tests shall be performed when specifically requested by Environmental Management Division, Code JQ.

D-3.3.2 All Systems

1. Whatever the reason for Legionella testing, (Appendix L for policy) it must be stressed that a negative result does NOT guarantee that a system is free from contamination. Normal vigilance cannot be relaxed. Samples should be as large as practicable, preferably greater than one liter, collected in sterile containers from the deepest, "dirtiest" parts of the pond, tank, etc., disturbing any deposits. Analysis should be

performed following the method set down in the Centers for Disease Control and Prevention "Procedures for the Recovery of Legionella from the Environment." Results are normally obtained within 10-15 days.

2. If Legionella bacteria are detected, inform the NASA ARC Safety, Health, and Medical Services Department (Code QH) immediately and provide a written plan in accordance with Table D-1 below.

3. The "Performance Goal" for all Legionella sample results is <10 cfu/ml, with a limit of detection of 1 cfu/mL.

D-3.4 Response Actions for All Systems

The following actions are required by Plant Engineering Branch, Code JCM or division responsible for humidifier, evaporative cooler or cooling tower following receipt of a confirmed Legionella count:

TABLE D-1

COOLING TOWERS AND INDIRECT EVAPORATIVE COOLERS

Legionella Concentration	**Action**
Less than 10 cfu/ml	**System under control:** Continue with routine maintenance program.
10 cfu/ml to 100 cfu/ml	**Investigate Problem and Review Water Management Program** Add an extra dose of biocide as recommended by chemical suppliers. Retest the system again after 7-14 days. Notify Safety, Health, and Medical Services Division, Code QH.
100 cfu/ml to 1,000 cfu/ml	**Investigate Problem and Review Water Management Program** Immediately perform an on-line disinfection of the system (Appendix E). Retest the system again after 7-14 days. Notify Safety, Health, and Medical Services Division, Code QH.
Greater than 1,000 cfu/ml	**Investigate Problem and Review Water Management Program** Immediately shut down system and perform offline cleaning and disinfection (Appendix E). Bring system back on line and ensure dosing equipment is functional. Retest the system again after 7-14 days.

	Notify Safety, Health, and Medical Services Division, Code QH.

Note: All personnel performing the remediation work on systems must use personal protective equipment (refer to Appendices F and K).

TABLE D-2

POTABLE HOT WATER SYSTEMS

Legionella Concentration	Action
Less than 1 cfu/ml to 10 cfu/ml	**System Under Control:** **Continue with routine maintenance program.**
10 cfu/ml to 100 cfu/ml	**Investigate Problem and Review Water Management Program:** Disinfect (thermal preferred) (refer to Appendix E). Check operating temperatures and bring unit back on-line upon completion of disinfection. Retest system again 7-14 days after disinfection.
Greater than 100 cfu/ml	**Investigate problem and Perform a review of the Water management Program:** Turn off showers. Perform thermal disinfection (refer to Appendix E). Check operating temperatures and bring unit back on-line after disinfection. Super Chlorinate building. Retest the system again after 7-14 days.

Note: All personnel performing the remediation work on systems must use personal protective equipment (refer to Appendices F and K).

TABLE D-3

RECIRCULATING WATER AIR WASH HUMIDIFIERS AND DIRECT EVAPORATIVE COOLERS

Legionella Concentration	Action
Less than 1 cfu/mL	**System under Control:** Continue with routine maintenance program. Retest system in accordance with the schedule.
1 cfu/mL to 10 cfu/mL	**Investigate Problem and Review Water Management Program:** Clean and disinfect system at 1 to 2 ppm free halogen for 10 hours, on line. Retest the system again after 7 to 14 days.
Greater than 10 cfu/mL	**Immediately Submit Report.** **Investigate Problem and Review Water Management Program:** Immediately take system off line; isolate area supplied and clean and disinfect system off line (refer to Appendix B). Bring unit back on line upon completion of remedial action. Perform a third-party review of the water management program. Retest the system again after 7 to 14 days.

Note: All personnel performing the remediation work on systems that have tested positive for Legionella bacteria must use personal protective equipment (refer to Appendices F and K).

APPENDIX E CLEANING AND DISINFECTION PROCEDURES (Plant Engineering Branch, Code JCM or facility owner of system)

Prior to any cleaning and disinfection work being performed at NASA Ames, a health and safety work plan must be developed in accordance with Ames Health and Safety Manual, APR 8715.1.

E-1.0 COOLING TOWERS

This applies to open loop systems and cooling tower portions of closed loop systems.

E-1.1 Offline Cleaning and Disinfection Protocol for Cooling Towers

E-1.1.1 Introduction

This disinfection protocol details the procedures to be followed for the off line cleaning and disinfection of cooling towers at NASA Ames Research Center at Moffett Field. The cleaning and disinfection program will consist of physical/mechanical cleaning using the Plant Engineering Maintenance Contractor's Preventative Maintenance Checklist 16-513 as listed in the Legionella Manual Supplement. When directed by Environmental Management Division, Code JQ, the following cleaning and disinfection procedures shall be applied:

1. Pre-clean disinfection of the cooling tower system.
2. Manual cleaning of cooling tower system.
3. Post–clean disinfection of the cooling tower system.

More extensive chemical cleaning may be required if scale deposits or corrosion debris are distributed through pipe work and heat exchangers. Personnel experienced in these works should carry this out.

E-1.1.2 Health and Safety

Refer to Appendices F and K.

E-1.1.3 Pre-Clean Disinfection

This initial operation is designed to provide safe entry and working conditions for site operators prior to carrying out manual cleaning.

1. Notify FSM of disinfection schedule.

2. Conduct a safety meeting to discuss the disinfection procedures and proper personal protective equipment to be worn during the cooling tower cleaning process.

3. Post warning notices and isolate the working areas with caution tape.

4. Shut off and isolate cooling tower system to be cleaned including control equipment (for example, fans, heaters, etc.) and chemical dosing equipment (for example, chemical dosing and bleed-off) following Lock Out Tag Out (LOTO) procedures.

5. Add an appropriate disinfectant and maintain effective residual concentration as specified by the water treatment chemical supplier. (For example: Add sodium hypochlorite (as commercial bleach containing approximately 10 to 15% available chlorine) to give a minimum free chlorine concentration of 5 to 10 parts per million (ppm) and pH 7 to 8 in the water system as measured by the DPD No. 1 test reagent or its equivalent).

6. Add a suitable biodispersant to the cooling tower system with or within 15 minutes of adding disinfectant to ensure a minimum product concentration as specified by the water treatment chemical supplier.

7. Run the water-recirculating pump, leaving fans turned off. Ensure that all areas of the system are online (For example: open all bypass valves to approximately 50%).

8. Measure disinfectant concentration and pH in the recirculating water immediately and thereafter every 15 minutes for the first 2 hours and every hour after that. Maintain disinfectant concentration and pH for time specified by chemical supplier. (For example: When using sodium hypochlorite, maintain a minimum residual concentration of 5-ppm free chlorine and pH of 7 to 8 in circulation for at least 5 hours).

9. Add appropriate reducing (neutralizing) agent to achieve concentrations compatible with local treatment system or discharge limits. (For example add either sodium thiosulphate or sodium bisulphite to neutralize chlorine and circulate for 30 minutes. Test recirculating water to ensure free chlorine concentration is less than 2 ppm).
10. During routine chlorination of systems options exist for reducing the period of time for which the free chlorine is circulated by increasing the concentration of free chlorine, or for reducing the free chlorine concentration and increasing the time for which it is circulated. Examples would be 25 ppm of free chlorine for 1 hour or 2.5 ppm of free chlorine for 10 hours. It should be noted that increasing the free chlorine residual will significantly increase the corrosion rate of metals (particularly cuprous and zinc based metals) in the system. For a heavily fouled system or ones with elevated Legionella concentrations the minimum free chlorine concentration should be 5 ppm.

E-1.1.4 Manual Cleaning

1. After completing pre-clean disinfection, drain the cooling tower sump. Blank off all the outlets from the sumps.

2. Remove scaling and growth by cleaning the surfaces of the cooling tower & sump working from top to bottom. Areas to be cleaned include distribution pan, distribution sprays, tower fill & support,

drift eliminators and sump. Assure proper personnel protective equipment is used (Appendix E). Cleaning methods may include hard brush with 1% hypochlorite solution, low-pressure jet washing or hosing. Minimize aerosol generation during cleaning. In some areas use of jet washers on zinc based (galvanized) towers is not permitted, use of high-pressure washers may significantly damage plastic fill and drift eliminators.

3. Remove accumulated debris in the tower sump and dispose of properly in accordance with local regulations.

4. Rinse and drain cooling tower & sump.

E-1.1.5 Post-Cleaning Disinfection

1. Refill the cooling tower and add an appropriate disinfectant and maintain effective residual concentration as specified by the water treatment chemical supplier. (For example: Add sodium hypochlorite (as commercial bleach containing 14 to 15% available chlorine) to give a minimum free chlorine concentration of 5 to 10 parts per million (ppm) in the water system as measured by the DPD No. 1 test reagent or its equivalent).

2. Run the water-recirculating pump, leaving fans turned off. Ensure that all areas of the system are online (For example: open all bypass valves to approximately 50%).

3. Measure disinfectant concentration and pH in the recirculating water immediately and thereafter every 15 minutes for the first 2 hours and every hour after that. Maintain disinfectant concentration and pH for time specified by chemical supplier. (For example: When using sodium hypochlorite, maintain a minimum reserve residual of 5 ppm free chlorine and pH of 7-8 in circulation for at least 5 hours).

4. Add appropriate reducing (neutralizing) agent to achieve concentrations compatible with local treatment system or discharge limits. (For example add either sodium thiosulphate or sodium bisulphite to neutralize chlorine and circulate for 30 minutes. Test recirculating water to ensure free chlorine concentration is less than 2 ppm).

During routine chlorination of systems, options exist for reducing the period of time for which the free chlorine is circulated by increasing the concentration of free chlorine or for reducing the free chlorine concentration and increasing the time for which it is circulated. Examples would be 25 ppm of free chlorine for 1 hour or 2.5 ppm of free chlorine for 10 hours. It should be noted that increasing the free chlorine residual will significantly increase the corrosion rate of metals (particularly cuprous and zinc based metals) in the system. For a heavily fouled system or ones with elevated *Legionella* concentrations the minimum free chlorine concentration should be 5 ppm.

5. Drain entire system where practical and refill with fresh water. Feed in a maintenance dose of treatment chemicals to bring to normal operating levels.

6. Take water samples and submit to an accredited laboratory for independent analysis of microbial activity.

7. Return plant to normal operation including chemical dosing, reinstate system blow down, etc. Continue with routine monitoring.

8. Remove warning notices.

9. Complete log of work carried out (see Table E-1, following for example).

TABLE E-1
CLEANING AND DISINFECTION LOG SHEET

Location		Supervisor	
System		Crew	
Reason for Clean		Crew	
Standard Followed		Crew	

Date	

Disinfectant Used: _____

Pre-Disinfection	Initial Disinfectant (mg/L)	pH	Time	
	Final Disinfectant (mg/L)	pH	Time	
Post-Disinfection	Initial Disinfectant (mg/L)	pH	Time	
	Final Disinfectant (mg/L)	pH	Time	

Special Precautions Taken and Safety Equipment	
Comments	

Signed by Operator	Date
Signed by Supervisor	Date

E-1.2 On-line Disinfection Protocol for Cooling Towers

E-1.2.1 Introduction

1. This disinfection protocol details the procedures to be followed for the on line cleaning and disinfection of cooling towers at NASA Ames Research Center at Moffett Field.

2. The cleaning and disinfection program will consist of the following stage:

I . Disinfection of the cooling tower system.

3. More extensive chemical cleaning may be required if scale deposits or corrosion debris are distributed through pipe work and heat exchangers. Personnel experienced in these works should carry this out.

E-1.2.2 Health and Safety

See Appendices F and K.

E-1.2.3 Disinfection

1. This operation is designed to reduce levels of bacteria in a cooling system and assist in the in the breakup of biofilm (microbiological growth attached to the surface).

2. Notify FSM of the scheduled work to be conducted.

3. Conduct a safety meeting to go over procedures.

4. Post warning notices and isolate the working areas with caution tape.
5. Blow down the system for at least one hour with the blow down at the maximum rate that can be sustained by the make-up flow rate. Stop blow down process after one hour.
6. Add an appropriate disinfectant and maintain effective residual concentration and pH as specified by the water treatment chemical supplier. (For example: Add sodium hypochlorite (as commercial bleach containing approximately 10 to 15% available chlorine) to give a minimum free chlorine concentration of 5 to 10 parts per million (ppm) and pH of 7 to 8 in the water system as measured by the DPD No. 1 test reagent or its equivalent).
7. Add a suitable biodispersant to the cooling tower system to ensure a minimum product concentration as specified by the water treatment chemical supplier.
8. Run the water-recirculating pump. Open bypass line(s) as much as possible (up to 50% flow) without jeopardizing thermal load demand.
9. Measure disinfectant concentration and pH in the recirculating water immediately and thereafter every 15 minutes for the first 2 hours and every hour after that. Maintain disinfectant concentration and pH for time specified by chemical supplier. (For example: When using sodium hypochlorite,

maintain a minimum residual concentration of 5-ppm free chlorine and pH of 7 to 8 in circulation for at least 5 hours).
During routine chlorination of systems options exist for reducing the period of time for which the free chlorine is circulated by increasing the concentration of free chlorine, or for reducing the free chlorine concentration and increasing the time for which it is circulated. Examples would be 25 ppm of free chlorine for 1 hour or 2.5 ppm of free chlorine for 10 hours. It should be noted that increasing the free chlorine residual will significantly increase the corrosion rate of metals (particularly cuprous and zinc based metals) in the system. For a heavily fouled system or one with elevated Legionella concentrations the minimum free chlorine concentration should be 5 ppm.
10. After disinfection cycle return to normal operation and reopen the blow down valve. Additional metal corrosion inhibitor may be required until system returns to normal parameters.
11. Remove warning notices.
12. Complete log of work carried out (see attached for example).

E-2.0 POTABLE HOT WATER SYSTEMS

E-2.1 Thermal Disinfection (Pasteurization)

E-2.1.1 Introduction

This protocol details the procedure to be followed for the thermal disinfection (Pasteurization) of domestic (potable) hot water systems at NASA Ames Research Center at Moffett Field. This procedure should only be performed by qualified personnel after reviewing procedures with the equipment manufacturer.

E-2.1.2 Health and Safety

1. See Appendices C and H.
2. Caution is to be taken during this procedure due to high water temperatures (scalding) and pressurized systems.
3. Notify FSM of the scheduled work to be conducted.
4. Conduct a safety meeting to go over procedures.
5. Warning notices should be posted sufficient to keep non-authorized personnel out of the area.

E-2.1.3 Thermal Disinfection

1. Thermal disinfection of hot water systems is to be performed with the system on line. Notify employees when this process is being performed, for example post warning notices at all of the outlets indicating that very hot water is present and there is a risk of scalding.
2. Run water from the bottom drain valve of the vessel (tank) until the water runs clear.
3. Raise the temperature of the hot water vessel to at least 160^{o}F-170 ^{o}F (70^{o}C). Draw water from the bottom drain point to measure temperatures in the lower portion of the vessel.
4. Draw cold water through all of the outlets throughout the building for a minimum of 5 minutes before performing the same procedure to the hot water outlets.
5. Draw hot water through all of the outlets supplied by the vessel until the water at the distal point is at least 160^{o}F (71^{o}C) for a minimum of 5 minutes. Start with the outlet closest to the heater working away from the heater. Recirculation pumps should be operating at this time.

6. Reduce the temperature in the hot water vessel to normal operating temperature, 131°F (55° C) to 140°F (60°C).
7. Ensure normal operating temperature at all outlets before removing warning notices from the outlets. This should include resetting of any thermostatically controlled scald protection mixing valves.
8. Record actions as per Cleaning and Disinfection Log Sheet, Table E-1.

E-2.2 Chemical Disinfection of Potable Hot Water Systems

E-2.2.1 Introduction

Where temperatures cannot be raised to a sufficiently high level to perform thermal disinfection the following procedure may be followed. Note that Chemical Disinfection of domestic (potable) hot water systems will result in corrosion particularly of yellow metals (copper). This procedure should only be performed by qualified personnel after reviewing procedures with the equipment manufacturer. Inform security dispatch prior to starting the operation.

E-2.2.2 Health and Safety

See Appendices C and H.

E-2.2.3 Cleaning and Disinfection

1. Chemical disinfection of domestic (potable) hot water systems is to be performed with the system off line. Notify the FSM to schedule a day to disinfect the building. The building should be evacuated during the chlorination process. Post warning notices at all of the outlets indicating that chemically treated water is present and that outlets are not to be used.
2. Conduct a safety meeting to go over procedures.
3. Post warning notices and isolate the working areas by securing the building. Turn off heat source to hot water vessel. Ensure that exterior faucets are also locked and tagged.
4. Close the makeup valve to the hot water vessel and drain a portion of the water from the vessel. If a recirculation pump is present switch off the pump.
5. Introduce sufficient food grade (NSF Standard 60) sodium hypochlorite to raise the free chlorine residual to 50 ppm. Wait 10- minutes to allow chlorine to disperse through tank prior to testing from tank. Maintain 50-ppm free chlorine in the vessel and throughout the water system for a minimum of 16 hours.
6. Test the free chlorine again 4 hours after introduction. If chlorine levels are below 30 ppm then boost chlorine levels back up to 50 ppm and add 4 hours to the 16-hour hold time.
7. Prior to flushing the system verify a minimum of 10-ppm free chlorine was maintained in the distal points on the system. If the chlorine level is below 10 ppm at end of hold time boost chlorine levels back to 50 ppm and hold system for an additional 12 hours.
8. At the end of the soak period flush the entire system until the free chlorine residual at all of the outlets is less than 3 ppm. Prior and post flushing the free chlorine residual must be verified by Safety, Health, and Medical Services Division, Code QH. Monitor the flush points to ensure that water is freely flowing to drain through out the process.
9. Return the system to normal operation and check the supply temperature of the hot water.
10. Remove warning notices, notify NASA Ames security dispatch that work is complete.
11. Complete log of work carried out (see attached for example).

E-3.0 RECIRCULATING WATER AIR WASH HUMIDIFIERS AND EVAPORATIVE COOLERS

E-3.1 Introduction

This protocol details the procedure to be followed for the off-line disinfection of recirculating water air wash humidifiers and evaporative coolers. Qualified personnel should only perform this procedure.

E-3.2 Health and Safety

See Appendices C and H.

Water exceeding local discharge limits must not be allowed to run to surface drainage or sanitary sewer. Caution: disinfected water may harm ecosystem and disrupt local wastewater treatment systems.

E-3.3 Cleaning and Disinfection

This operation is designed to reduce levels of bacteria in an air wash humidifier with tank fed systems.

1. Notify FSM of the scheduled work to be conducted.
2. Conduct a safety meeting to go over procedures.
3. Post warning notices and isolate the working areas with caution tape.
4. Turn off supply air fans per ECPL guidelines to prevent disinfectant odor permeating work areas.
5. Drain system.
6. Refill system and add an appropriate disinfectant and maintain effective residual concentration and pH as specified by the water treatment chemical supplier. (For example: Add sodium hypochlorite (as commercial bleach containing 14 to 15% available chlorine) to give a minimum free chlorine concentration of 5 to 10 parts per million (ppm) and pH of 7-8 in the water system.
7. If needed based on visual assessment, add a suitable biodispersant to the humidifier system to ensure a minimum product concentration as specified by the water treatment chemical supplier.
8. Run the water-recirculating pump.
9. Maintain disinfectant concentration for time specified by chemical supplier. (For example: When using sodium hypochlorite, maintain a minimum residual concentration of 5 ppm free chlorine and pH of 7 to 8 in circulation for at least 30 minutes).
10. After disinfection cycle, drain and flush system.
11. Repeat flush process till there is no residual disinfectant. Following the disinfection, and with the system drained, evaluate tanks and sumps for scale and growths. If required, clean and disinfect (refer to Appendix E, Disinfection of Cooling Tower Manual Cleaning) as required.
12. After completing pre-clean disinfection, drain the sump or tank. Blank off all the outlets from the sump or tank.
13. Remove scaling and growth by cleaning the surfaces of the sump or tank working from top to bottom. Areas to be cleaned include all internal surfaces, distribution pan, support structure, cross braces, and sump. Assure proper personnel protective equipment is used (Appendix E). Cleaning methods may include hard brush with 1% hypochlorite solution, low-pressure jet washing or hosing. Minimize aerosol generation during cleaning.
14. Remove accumulated debris in the sump or tank and dispose of properly in accordance with local regulations.

15. Rinse and drain sump and tank. Remove blanks from outlets.

E-3.4 Post Cleaning Disinfection

1. Refill system and add an appropriate disinfectant and maintain effective residual concentration and pH as specified by the water treatment chemical supplier. (For example: Add sodium hypochlorite (as commercial bleach containing 14 to 15% available chlorine) to give a minimum free chlorine concentration of 5 to 10 parts per million (ppm) and pH of 7-8 in the water system.
2. If needed based on visual assessment, add a suitable biodispersant to the humidifier system to ensure a minimum product concentration as specified by the water treatment chemical supplier.
3. Run the water-recirculating pump.
4. Maintain disinfectant concentration for time specified by chemical supplier. (For example: When using sodium hypochlorite, maintain a minimum residual concentration of 5 ppm free chlorine and pH of 7 to 8 in circulation for at least 30 minutes).
5. After disinfection cycle, drain and flush system.
6. Repeat flush process till there is no residual disinfectant
7. Take water samples and submit to an accredited laboratory for independent analysis of microbial activity.
8. Return plant to normal operation including chemical dosing, reinstate system blow down, etc. Continue with routine monitoring in section 3.1.
9. Remove warning notices.
10. Complete log of work carried out (see attached for example).

APPENDIX F PROTECTIVE EQUIPMENT

The contractor will develop a health and safety plan in accordance with Appendix K, Sample Safety and Health Plan and Ames Health and Safety Manual APR 8715.1.
Please refer the safety checklist at the end of this section. This checklist must be used prior to chlorination.

F-1.0 ROUTINE INSPECTION OF COOLING TOWERS AND HUMIDIFIERS

HEPA-filtered, half-face negative pressure respirators must be used when there is potential for aerosolization of water.

F-2.0 CLEANING OF COOLING TOWERS

1. HEPA-filtered, half face negative pressure respirator.
2. Safety glasses.
3. Nitrile or neoprene gloves.
4. Tyvek or equivalent suit.
5. Fall protection where necessary.
6. Lockout Tagout procedures in place.

F-3.0 CLEANING OF HUMIDIFIERS

F-3.1 Low Counts

After obtaining a positive sample result during routine testing at or below process isolation/shutdown levels (less than 1,000 cfu/mL for cooling towers and evaporative condensers; less than 100 cfu/mL for domestic hot water; or less than 10 cfu/mL for water-based humidifiers and air washers), no personal protective equipment is required unless employees may be directly exposed to mist.

F-3.2 Mist Exposure

If mist exposure is possible, the following requirements apply to employees performing follow-up water sampling or disinfection activities. No personal protective equipment is required for production employees in the area.

1. Half mask respirator with P100 (HEPA) filters to protect against airborne mist that could contain Legionella bacteria. Acid gas cartridges are necessary if halogen (chlorine or bromine) exposures may be present.

2. Tyvek TM or similar impervious coveralls, if necessary, to protect against chemicals used in the disinfection process. Consult SDS's for guidance.

3. Eye protection (goggles or face shield) and skin protection (impervious gloves), if necessary, for procedure and products being used. Consult SDS's for guidance.

F-3.3 Elevated Counts

F-3.3.1 If Legionella counts are at or above process isolation/shutdown levels (greater than 1,000 cfu/mL for cooling towers or evaporative condensers; greater than 100 cfu/mL for domestic hot water; or greater than 10 cfu/mL for water-based humidifiers and air washers), equipment shutdown and off-line disinfection are required.

F-3.3.2 These conditions represent a high level of concern and the potential for an outbreak exists. In these situations or in case an outbreak has occurred, personal protective equipment requirements are the same as those listed above, except:

1. Respiratory protection required is a full-face piece powered air-purifying respirator with P100 (HEPA) filters when employees are performing a task where fine mist droplets are being generated (such as power washing or steam cleaning),
2. All personnel wearing respirators must comply with 29 CFR 1910.134. Handling and storage of cleaning chemicals must be in accordance with the supplier's recommendations and plant procedures and must be handled and treated accordingly.
3. In the unlikely event that equipment located on the plant floor cannot be shutdown in response to these Legionella counts, remove the employees from the area. Placard or tape around the area to prevent non-essential employees from entering the area until the disinfection process is completed. If roof-mounted equipment that generates a mist cannot be shutdown, close fresh air intakes within a minimum of 300 feet (100 meters) downwind of the unit.
4. Warning notices should be posted sufficient to keep non-authorized personnel out of the area. Water exceeding local discharge limits must not be allowed to run to surface drainage or sanitary sewer. Caution: Disinfected water may harm ecosystem and disrupt local wastewater treatment systems.

F-4.0 PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS DURING THERMAL DISINFECTION

During thermal disinfection (see Appendix E) of domestic hot water systems, personal protective equipment must be worn to prevent burns in case of contact with heated water. The choice of protective equipment depends on the equipment being pasteurized, but may include aprons, boots, and gloves made of heavy rubber or other similar materials that are waterproof and insulating. In addition, if splashing could occur, face shields must be worn to protect facial skin.

NASA Ames Pre-Chlorination Safety Checklist Table F-1

PPE Needed For Chlorination:	Complete	Initials	Comments
Proper PPE:			
Full face respirator			
Half face respirator w/safety glasses			
Appropriate cartridges (HEPA/ CL etc)			
Tyvex suit			
Booties			
Tape for Tyvex suit			
Nitrile Gloves			
Equipment:			
Adequate supply of low and high chlorine strips			
Thermometer			
Ensure spill response material is present			
Radio w/fully charged battery			
Ensure decon trailer is present			
Ensure eyewash is present at each tie in point			
Forms:			
Building closed signs			
Chlorine flush documentation papers			
Before Chlorination:			
Post Warning signs on all entrances to the building.			
Ensure everyone has appropriate PPE on.			
During Chlorination:			
Verify all water outlets are at the correct chlorine level. (Buildings 30ppm minimum, cooling towers 5-10 ppm minimum)			
Before flush verify chlorine levels at a representative number of locations.			
Verify temperature at the distal and proximal location to the hot water heater			

Verify that chlorination personnel are doing ok and there are no problems			
Respirator with cartridges			
Gloves			
Taped Tyvex			
After Flush:			
Verify that all water outlet locations are below 2 ppm and document on chlorination sheet.			
Do not need respirator ok to remove			
Wear gloves			

APPENDIX G PREPARATION OF DISINFECTING SOLUTION

50 mg/L Chlorine Solution

This is made up from ordinary commercial bleach with 5% available chlorine approved to NSF Standard 60, NOT chlorox/domestos, or other products with thickening or wetting agents, perfumes, etc.

To obtain a working strength solution, add 1 mL bleach to 1 liter of water.

Observe safety precautions (for example, gloves/goggles when using concentrated bleach). Ensure that concentrated bleach cannot mix with acid materials or chlorine gas will be given off.

APPENDIX H SHUTDOWN, STANDBY AND STARTUP PROCEDURES

Provide hazard protection for workers such as fall protection and lockout-tagout protection.

Equipment permanently out of service is to be identified as abandoned in place with the electrical power to the fan and or recirculation pumps disconnected and the city water make-up supply isolated from the main with a physical break in the pipe upstream of the equipment. Equipment abandoned in place is to be held dry.

Where a high-risk water system is not in use for a prolonged period (1 week or greater), the following actions are required to avoid stagnation and potential amplification of Legionella bacteria.

H-1.0 COOLING TOWERS AND EVAPORATIVE CONDENSERS

If a cooling tower or evaporative condenser is to be off line for more than one week, the system is to be dosed with biocide immediately prior to shutdown and all of the recirculation pumps operated with the fans off for one hour. The process is to be repeated at least once every week that the system is off line. Any three-way or control valves are to be set to 50 percent operation during this process and both duty and standby pumps operated to ensure that all parts of the system are on line. Prior to the system coming back on line, the system is to be dosed with biocide and all recirculation pumps operated for at least three hours prior to bringing fans on line.

If cooling towers are to be off line for greater than a month, the entire system, including holding tanks, heat exchangers and pipe work, is to be drained and held dry. When bringing the system back on line, the system is to be cleaned and chlorinated in accordance with the method set down in Appendix D. Chemical dosing and control equipment must be on line and operating before the cooling tower is brought back online.

H-2.0 POTABLE WATER AND DRINKING WATER SYSTEMS

Any potable water or drinking water outlet that is not used for a week is to be flushed at full flow for at least five minutes every seven days.

Where a site is not in use for a period of one month or longer, the potable water system is to be valved shut and drained. During the winter months, consideration is to be given to shutting down and draining the entire potable water or drinking water system at shutdown.

Short-term shutdown for a potable hot water system should require that the hot water vessel remains at the operating temperature as defined in this document. Where a potable hot water system is not used for more than one week, the temperature is to be raised to 140^0F (60^0C) for one hour prior to the system being put back in use. After the temperature has been raised to 140^0F (60^0C), hot water is to be drawn to each outlet for one minute; the hot water vessel is then to be returned to its normal operating temperature in accordance with Appendix D. Where potable cold water systems are off line for longer than one week, all outlets are to be flushed at full flow for five minutes prior to bringing the system back on line.

H-2.1 Shower Reactivation Procedure

When showers have been deactivated and capped for a period of time, they in essence become dead legs. Therefore prior to placing deactivated showers back into commission the following procedures should be followed.

H-2.1.1 Flushing: Once shower pipes have been uncapped, the line should be flushed.
(a) Flow cold water until it reaches stable temperature. Once stable temperature is reached, flush cold water for a minimum of five minutes.
(b) Flow hot water until it reaches 160-170^{0}F (see also ASHRAE Guideline-12). Once 160-170^{0}F is reached, continue to flow for a minimum of 5 minutes. For each building, document the hot water supply temperature, the stable temperature at each outlet flushed and duration of flush. At the completion of the flush, a copy of the documentation should be sent to a Safety, Health, and Medical Services Division, Code QH representative for historical archiving.
(c) The number of outlets flushed simultaneously will depend on the capacity of the hot water heater and flow capacity of the system. If due to the operating capacity of the hot water tanks it is not possible to reach 160-170^{0}F, the system should be raised to the highest temperature possible and flushed at the highest stable temperature possible. The time for flushing should be increased 5 minutes for every 10 degrees F below 160^{0}F.

H-2.1.2 Disinfection: Install new showerheads or disinfect old heads prior to re-installation by soaking in a 5% solution of hypochlorite overnight. After disinfection and before installation, the showerheads should be thoroughly flushed in clean water to remove traces of hypochlorite.
H-2.1.3 Injury prevention and PPE during flushing
(a) A full or ½ face respirator should be worn with HEPA filters.
(b) Follow appropriate safety procedures to prevent scalding. It is recommended that this work be performed after hours or on weekends to prevent scalding of the occupants. Wear appropriate gloves (e.g. Nitrile, leather, flock lined gloves, etc) to prevent scalding during flush.

H-3.0 HUMIDIFIERS

All humidifier systems are to be drained on shutdown and the entire system, including holding tank, is to be held dry. Prior to bringing the system back on line, the humidifiers should be cleaned and chlorinated in accordance with Appendix D, then refilled with fresh city water.

H-4.0 EVAPORATIVE COOLING SYSTEMS

On shutdown, all evaporative cooling systems are to be drained and held dry. On restart, the system is to be cleaned and chlorinated in accordance with Appendix D, then refilled with fresh make-up water.

APPENDIX I RANGES OF REPORTED DOSAGES OF DISINFECTANTS AGAINST LEGIONELLA BACTERIA

Table I-1

Disinfectants		Typical Dosage (mg/L)	Contact Time	Application Targets[a]	Remark
Metals	Cu^{++} and Ag^{+}	0.1 - 1 for Cu^{++} 0.01 - 0.1 for Ag^{+}	hrs to days	PW	effective for PW but not on CW and MWFs, discharge limits
	Cu^{++}	0.1 - 1	hrs to days	PW	little info on CW and MWFs
Oxidizing Disinfectants	**Halogen Containing Compounds**				
	Chlorine	0.1 - 10	min to hrs	PW/CW	Effective
	Bromine	0.1 - 10	min to hrs	CW	not as effective as chlorine, not for PW
	Chlorine Dioxide	1 - 10	min to hrs	PW	effective, little info on CW
	Monochloramine	1 - 10	hours to days?	PW	possibly more effective than chlorine for PW (for *Legionella* only)
	BCDMH[b]	1 - 10	min to hrs	CW	equivalent to adding chlorine/bromine
	Chloroisocyanurate				little info
	Others				
	Ozone	0.1 - 1	min to hrs	PW/CW	more effective than chlorine but no residual effect and low solubility
	Potassium Permanganate				Ineffective
	Hydrogen Peroxide				little info impossible to test residual
Non-oxidizing Disinfectants	**Heterocyclic Ketones (isothiazolones)**				
	Kathon[c]	1 - 100	hrs to days	CW/MWFs	not as effective as chlorine or glutaraldehyde
	BIT[d]	1 - 100	hrs to days	CW/MWFs	not as effective as Kathon
	Guanidines				
	PHMB[e]	1 - 100	hrs to days	CW/MWFs (?)	possibly more effective than glutaraldehyde and Kathon
	Halogenated Amides				
	DBNPA[f]	1 - 100	hrs to days	CW/MWFs	effective, more effective than Kathon
	Halogenated Glycols				
	Bronopol[g]	10 - 500	hrs to days	CW/MWFs	produces formaldehyde, comparable to PHMB in one study, less effective than Kathon in another study
	Amines				
	Quaternary Amines	10 - 500	hrs to days	CW	Ineffective.
	Aldehydes				
	Glutaraldehyde	10 - 500	hrs to days	CW	effective, more effective than Kathon but less effective than DBNPA
	Others				
	Thiocarbamates				Ineffective
	Thiocyanates				Ineffective
	Organo-Tin Compounds				possibly effective, use is banned in California due to discharge limitations
	Dowicil 75[h]			MWFs	little info
	Grotan[i]			MWFs	produces formaldehyde, little info

a. PW (potable water, hot and cold); CW (cooling water); and MWFs (metalworking fluids)
b. BCDMH (1-bromo-3-chloro-5,5-dimethylhydantoin), a halogenated hydantoin.
c. Kathon contains 5-chloro-N-methylisothiazolone and N-methylisothiazolone.
d. BIT (benzisothiazolone).
e. PHMB (polyhexamethylene biguanide).
f. DBNPA (2,2 dibromo-3-nitorpropionamide).

g. Bronopol contains 2-bromo-2-nitro-1,3-propanediol).
h. Dowicil 75 contains 1-(3-chloroallyl)-3,5,7-triaza-1-azoniaadamantane chloride.
i. Grotan contains hexahydro-1,3,5-tris(2-hydroxyethyl)-S-triazine.

APPENDIX J MEDICAL SERVICES

The NASA Ames Safety, Health, and Medical Services Division (Code QH) will provide a program of medical surveillance for recognized waterborne disease outbreaks of Legionella in areas serviced by NASA ARC. Where there is concern regarding a possible outbreak of Legionella, the NASA ARC Health Unit will interface with the NASA Ames Safety, Health, and Medical Services Division Chief to determine an appropriate course of action. Medical monitoring is only required following confirmation of a case of pneumonia or in the event of a suspected outbreak of Pontiac Fever. Initial testing for active Legionella infection should be a urinary antigen test. If a positive test result is obtained, the Health Unit will report the case to Santa Clara County.

APPENDIX K SAMPLE SAFETY AND HEALTH PLAN

The offeror shall submit a detailed safety and health plan, as part of its proposal, showing how the contractor intends to protect the life, health, and well-being of NASA and contractor employees as well as property and equipment. The plan must include a detailed discussion of the policies, procedures, and techniques that will be used to ensure the safety and health of contractor employees and to ensure the safety of all working conditions throughout the performance of the contract. The plan must similarly address safety and health for subcontractor employees for any proposed subcontract whose value is expected to exceed $500,000 including commercial services and services provided in support of a commercial item. Also, when applicable, the plan must address the policies, procedures, and techniques that will be used to ensure the safety and health of NASA employees and the public. This plan, as approved by the contracting officer, will be included in any resulting contract. In addition, the contractor will ensure the protection of personnel, property, equipment, and the environment in the production of contractor products and or the pursuit of any of its activities. In order for NASA to understand the contractor's method for compliance with pertinent NASA policies and requirements and Federal, State, and local regulations for safety, health, environmental protection, and fire protection, the contractor shall develop and subsequently implement a safety and health program in accordance with a safety and health plan generated by the contractor and approved by NASA. The plan will also assure the proper integration of the on-site contractor as a full participant in the Center's Safety and Health Program. This plan shall contain the information requested in the outline of contractor safety and health plan as follows:

Contents of the Contractor Safety and Health Plan

K-1.0 MANAGEMENT LEADERSHIP AND EMPLOYEE PARTICIPATION.

K-1.1 Policy. Provide the contractor's corporate safety policy statement with the plan. Compare the contractor's policy statement with those of NASA and OSHA and discuss any differences.

K-1.2 Goals and Objectives. Describe specific goals and objectives to be met. Discuss status of safety program using the Performance Evaluation Profile (PEP) as safety performance criteria. Describe the contractor's approach (including milestone schedule) to achieve and maintain level 5 of the PEP in all areas (see contents of PEP).

K-1.3 Management Leadership. Describe management's procedures for implementing its commitment to safety and health through visible management activities and initiatives including a commitment to the exercise of management control to ensure workplace safety and health. Describe processes and procedures for making this visible in all contract and subcontract activities and products. Include a statement from the project manager or designated safety official indicating

that the plan will be implemented as approved and that the project manager will take personal responsibility for its implementation.

K-1.4 Employee Involvement. Describe procedures to promote and implement employee (e.g., non-supervisory) involvement in safety and health program development, implementation, and decision-making. Describe the scope and breadth of employee participation to be achieved so that approximate safety and health risk areas of the contract are equitably represented.

K-1.5 Assignment of Responsibility. Describe line and staff responsibilities for safety and health program implementation. Identify any other personnel or organization that provides safety services or exercises any form of control or assurance in these areas. State the means of communication and interface concerning related issues used by line, staff, and others (such as documentation, concurrence requirements, committee structure, sharing of the work site with NASA and other contractors, or other special responsibilities and support). As a minimum, the contractor will identify the following:

a. Safety Representative. Identify by title the individual who will be responsible for the contractor's adherence to Center-wide safety, health, environmental, and fire protection concerns and goals, and who will participate in meetings and other activities related to the Center's Safety and Health program.

b. Company Physician. Provide the identification of a company physician to facilitate communication of medical data to the head of the NASA clinic. The contractor shall identify a point of contact (such as the company physician) by name, address, and telephone number to the NASA-Ames Medical Clinic, Building N-215, Mail Stop 215-8. Any changes that occur in the identity of the point of contact will be promptly conveyed to the NASA Clinic.

c. Building Fire Wardens. Each building occupied by the contractor shall assign an individual to facilitate the Center's fire safety program including coordination of related issues with NASA facility managers and emergency planning and response officials and their representatives.

d. Designated Safety Official. Identify by title the official(s) responsible for implementation of this plan and all formal contacts with regulatory agencies and with NASA.

K-1.6 Provision of Authority. Describe consistency of the plan with applicable NASA requirements and contractual direction as well as applicable Federal, State, and local regulations and how this will be maintained throughout the life of the contract.

K-1.7 Accountability**.** Describe procedures for ensuring that management and employees will be held accountable for implementing their tasks in a safe and healthful manner. The use of traditional and/or innovative personnel management methods (including discipline, motivational techniques, or

any other technique that ensures accountability) will be referenced as a minimum and described as appropriate.

K-1.8 Program Evaluation. Describe the method for internal program evaluation. The program evaluation may consist of either (1) participation in a PEP survey at the request of the Government or (2) a written report which documents the contractor's procedures for determining the existence and criticality of the contractor's hazardous operations in a manner that proper risk management techniques can be applied and notable safety risk documented. The report will also include but is not limited to the following: identification of the contractor's hazardous operations and products; ranking the risk in a severity classification; approach to identifying and implementing specific risk evaluation tasks, managing the risks, and documenting the results; and responsibilities and methods for internal audits and evaluations of the overall safety and health program including personnel who conduct the audit and evaluation, to whom the report is made, and the frequency (at least annually) with which it is performed. These evaluations shall include subcontracted tasks. Correlation of the program evaluation to the applicable criteria of the PEP will be clearly described.

When a written program evaluation is requested, it will be delivered to the Government no later than 30 days after the end of each contract year or at the end of the contract, whichever is applicable. Distribution of these program evaluations will be the same as that for the safety and health plan. The PEP survey will be scheduled and administered at the discretion of the Government.

K-1.9 The contractor will describe its approach to document its safety and health program performance to provide the Government with the necessary visibility and insight. This includes the identification, acquisition, and processing of safety and health data; development of procedures; recordkeeping; statistical analyses including metrics; and the furnishing of data and reports to the Government. Electronic access by the Government to this data is preferred as long as Privacy Act requirements are met and Government safety and health professionals and their representatives have full and unimpeded access for review and audit purposes. For contractor activities conducted on NASA property, the contractor will identify what records it will make available to the Government in accordance with the Voluntary Protection Program criteria of OSHA as implemented in Ames Health and Safety Manual, APR 8715.1, as revised. This document is available at http://dq.arc.nasa.gov/safetymanual/ or in the safety office, Building N-218, second floor. For the purpose of this plan, safety and health documentation includes but is not limited to logs, records, minutes, procedures, checklists, statistics, reports, analyses, notes, or other written or electronic document which contains in whole or in part any subject matter pertinent to safety, health, environmental protection, or emergency preparedness. The contractor will acknowledge the following as standing requests of the Government to be handled as described below.

a. Roster of Terminated Employees. NASA will expect that terminated employees be reported to the Center occupational health program office. Identify personnel terminated by contractor. Send the report to the Occupational Health Officer no later than 30 days after the end of each contract year or

at the end of the contract, whichever is applicable. At the contractor's discretion, the report may be submitted for personnel changes during the previous year or cumulated for all years.

Information required:

(1) Date of report, contractor identity, and contract number.

(2) For each person listed, provide name, social security number, assigned Center badge number, and date of termination.

(3) Name, address, and telephone number of contractor representative to be contacted for questions or other information.

b. Material Safety Data. Describe the procedure by which the contractor shall prepare and/or deliver to NASA, Material Safety Data for hazardous materials brought onto Government property or included in products delivered to the Government. These data are required by the Occupational Safety and Health Administration (OSHA) regulation, 29 CFR 1910.1200, "Hazard Communication," and Federal Standard 313 (or FED-STD-313), "Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities," as revised. A single copy of each Safety Data Sheet (SDS) will be sent upon receipt of the material for use on NASA property to the Ames Construction Manager, Facility Engineering Branch, Code JCE, Mail Stop 213-8, along with information on new or changed locations and/or quantities normally stored or used. If the SDS arrives with the material and is needed for immediate use, the SDS shall be delivered to the Construction Manager by close of business of the next working day after it enters the site.

c. Hazardous Materials Inventory. The contractor shall compile an annual inventory report of all hazardous materials it has located on Government property and which is within the scope of 29 CFR 1910.1200, "Hazard Communication," and Federal Standard 313 (or FED-STD-313), "Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities," as revised.

K-1.10 Government Access to Safety and Health Program Documentation. The contractor shall recognize in its plan that it will be expected to make all safety and health documentation (including relevant personnel records) available for inspection or audit at the Government's request.

K-1.11 The contractor may be requested to participate in the review and modification of safety requirements that are to be implemented by the Government including any referenced documents therein. This review activity will be implemented at the direction of the NASA Contracting Officer's Technical Representative in accordance with established NASA directives and procedures.

K-1.12 Procurement. Identify procedures used to assure that the contractor's procurements are reviewed for safety considerations and that specifications contain appropriate safety criteria and

instructions. Set forth authority and responsibility to assure that safety tasks are clearly stated in subcontracts.

K-2.0 WORKPLACE ANALYSIS.

Describe the method by which hazards within the contractor's workplace shall be systematically identified during the duration of the contract. The identified method should explain the information collection process for assembling, through a combination of surveys, analyses, and inspections of the workplace, investigations of mishaps and close calls, and the collection and trend analysis of safety and health data such as: records of occupational injuries and illnesses; findings and observations from preventive maintenance activities; reports of spills and inadvertent releases to the environment; facilities related incidents related to partial or full loss of systems functions; employee reports of hazard; etc. Every hazard identified by any of the techniques identified below shall be ranked and processed in accordance with Center procedure. All hazards on NASA property, which are immediately dangerous to life or health, shall be reported immediately to the NASA safety office. All safety engineering products, which address operations, equipment, etc., on NASA property will be subject to the review and concurrence of the NASA Safety Office unless otherwise specified in the approved safety and health plan. The contractor is expected to have processes to address similar instances in contractor facilities utilizing contractor resources to manage such instances.

K-2.1 Hazard Identification. Describe the procedures and techniques to be used to compile an inventory of hazards associated with the work to be performed on this contract. This inventory of hazards shall address the work specified in this contract as well as operations and work environments that are performed in the vicinity or in close proximity to contract operations. The results will be reported to the Government in a manner suitable for inclusion in facilities baseline documentation as a permanent record of the facility. Specific techniques to be considered include:

a. Comprehensive Survey. A "wall to wall" engineering assessment of the work site including facilities, equipment, processes, and materials (including waste).

b. Change Analysis. Typically addresses modifications in facilities, equipment, processes, and materials (including waste); and related procedures for operations and maintenance. Change analyses periodically will be driven by new or modified regulatory and NASA requirements.

c. Hazard Analysis. May address facilities, systems/subsystems, operations, processes, materials (including waste), and specific tasks or jobs.

K-2.2 Inspections. This paragraph includes requirements for assignments, procedures, and frequency for regular inspection and evaluation of work areas for hazards and accountability for implementation of corrective measures. The contractor will describe administrative requirements and procedures for control of and regularly scheduled inspections for fire and explosion hazards. The contractor has the option, in lieu of this detail, to identify policies and procedures with the

stipulation that the results (including findings) of inspections conducted on NASA property or involving Government furnished property will be documented in safety program evaluations or the monthly Accident/Incident Summary reports. Inspections will identify the following:

a. Discrepancies between observed conditions and current requirements.

b. New (not previously identified) or modified hazards.

K-2.3 Employee Reports of Hazards. Identification of methods to encourage employee reports of hazardous conditions (e.g., close calls) and analyze/abate hazards. The contractor will describe steps it will take to create reprisal-free employee reporting with emphasis on management support for employees and describe methods to be used to incorporate employee insights into hazard abatement and motivation/awareness activities.

K-3.0 MISHAP INVESTIGATION AND RECORD ANALYSIS.

K-3.1 Mishap Investigation. Identification of methods to assure the reporting and investigation of mishaps including corrective actions implemented to prevent recurrence. The contractor will describe the methods to be used to report and investigate mishaps on NASA property and on contractor or third party property. The contractor shall describe its procedures for implementing use of NASA mishap reporting and investigation forms and alternate forms used by the contractor with emphasis on timely notification of NASA; investigation procedures; exercise of jurisdiction over a mishap investigation involving NASA and other contractor personnel; follow up of corrective actions; communication of lessons learned to NASA; and solutions to minimize duplications in reporting and documentation including use of alternate forms, etc. The contractor will discuss its procedures for immediate notification requirements for fires, hazardous materials releases, and other emergencies. The contractor will include appropriate details to address the use of the NASA Mishap Information System (NMIS), https://q.arc.nasa.gov/content/nasa-mishap-information-system-nmis to submit a "Mishap Report" (or equivalent), including 24-hour and ten-day mishap reports to the Occupational Safety Office, Mail Stop 237-14.

K-3.2 Trend Analysis. Describe approach to performing trend analysis of data (occupational injuries and illnesses; facilities, systems, and equipment performance; maintenance findings; etc.) Discuss methods to identify and abate common causes indicated by trend analysis. In support of site-wide trend analysis to be performed by the Government, the contractor will discuss method of providing data as follows:

a. Accident/Incident Summary Report. The contractor shall describe how it shall prepare and deliver Accident/Incident Summary Reports as specified on [specify locally used format]. All new and open mishaps, including vehicle accidents, incidents, injuries, fires, and any close calls shall be described in summary form along with current status. Negative reports are to be required monthly. Report

frequency is monthly; date due is the 10th day of the month following each month reported. Report to be delivered to the Ames Safety Office, Mail Stop 237-14.

b. Log of Occupational Injuries and Illnesses. For each establishment on and off NASA property that performs work on this contract, the contractor shall deliver to the Government (under separate contractor's cover letter), a copy of its annual summary of occupational injuries and illnesses (or equivalent) as described in Title 29, Code of Federal Regulations, Subpart 1904.5. If contractor is exempt by regulation from maintaining and publishing such logs, equivalent data in contractor's format is acceptable (such as loss runs from insurance carrier) which contains the data required. Data shall be compiled and reported by calendar year and provided to the Government within 45 days after the end of the year to be reported (e.g., not later than February 15 of the year following).

K-4.0 HAZARD PREVENTION AND CONTROL.

Identified hazards must be eliminated or controlled. In the multiple employer environment of the Center, it is required that hazards including discrepancies and corrective actions be collected, for risk management purposes. Describe your approach to implementing this requirement.

K-4.1 Appropriate Controls**.** Discuss approach to consideration and selection of controls. Discuss use of hazard reduction precedence sequence. Discuss approach to identifying and accepting any residual risk. Discuss implementation of controls including verifying effectiveness. Discuss scope of coverage (hazardous chemicals, equipment, discharges, waste, energies, etc.). Discuss need for coordination with safety, health, environmental services, and emergency authorities at NASA.

K-4.1.1 Hazardous Operations. Establish methods for notification of personnel when hazardous operations are to be performed in their facilities or when hazardous conditions are found to exist during the course of this contract. NASA policy will serve as a guide for defining, classifying, and prioritizing hazardous operations. Develop and maintain a list of hazardous operations to be performed during the life of this contract. The list of hazardous operations will be provided to the contracting officer as part of the safety plan for review and approval. The contracting officer (CO) and the contractor will decide jointly which operations are to be considered hazardous, with the CO as the final authority. Before hazardous operations commence, the contractor will develop a schedule to develop written hazardous operations procedures with particular emphasis on identifying the job safety steps required. The contractor may implement this requirement as follows:

a. Identify contractor policies and procedures for management and implementation of hazardous operations procedures together with a statement that NASA will have access on request to any contractor data necessary to verify implementation; or

b. In lieu of contractor management and development of such procedures, identify the method whereby the contractor will identify and submit such procedures to the NASA Occupational Safety Office for review and approval.

K-4.1.2 Written Procedures. Identification of methods to assure that the relevant hazardous situations and proper controls are identified in documentation such as inspection procedures, test procedures, etc., and other related information. Describe methods to assure that written procedures are developed for all hazardous operations, including testing, maintenance, repairs, and handling of hazardous materials and hazardous waste. Procedures will be developed in a format suitable for use as safety documentation (such as a safety manual) and be readily available to personnel as required to correctly perform their duties.

K-4.1.3 Protective Equipment. Set forth procedures for obtaining, inspecting, and maintaining protective equipment, as required, or reference written procedure pertaining to this subject. Set forth methods for keeping records of such inspections and maintenance programs.

K-4.1.4 Hazardous Operations Permits. Identify facilities, operations, and/or tasks where hazardous operations permits will be required as specified in the Center's local requirement. Set forth guidance to adhere to established NASA Center procedures. Clearly state the role of the safety group or function to control such permits.

a. Operations Involving Potential Asbestos Exposures. Set forth method by which compliance is assured with the Center's Asbestos Control Program as established in Ames Health and Safety Manual, APR 8715.1.

b. Operations Involving Exposures to Toxic or Unhealthful Materials. Such operations must be evaluated by the NASA Occupational Health Office and must be properly controlled as advised by same. The NASA Occupational Health Office must be notified prior to initiation of any new or modified operation potentially hazardous to health.

c. Operations Involving Hazardous Waste. Identify procedures used to manage hazardous waste from point of generation through disposal. Clearly identify divisions of responsibility between contractor and NASA for hazardous waste generated throughout the life of the contract. Operations that occur on site must also be evaluated by the Center environmental services office and must be properly controlled as advised by same. The Center environmental services office must be notified prior to initiation of any new or modified hazardous waste operation on site.

d. Operations Involving New or Modified Emissions/Discharges to the Environment. Set forth methods for identifying new or modified emissions/discharges and coordinating results with the Center environmental services office. Set forth procedures to minimize or eliminate environmental pollution. Address management of hazardous materials; substitution of non-hazardous or less hazardous materials for hazardous materials; proper segregation of hazardous wastes from non-hazardous wastes; and other methods described by NASA. Emphasis shall be placed on providing for sufficient lead-time for processing permits through the appropriate State agency and/or the Environmental Protection Agency.

K-4.2 Discuss your responsibilities for maintaining facilities baseline documentation in accordance with Center requirements. The contractor will implement any facilities baseline documentation tasks (including safety engineering) as provided in the contractor's safety and health plan approved by NASA or as required by Government direction.

K-4.3 Preventive Maintenance. Discuss approach to preventive maintenance. Describe scope, frequency, and supporting rationale for your preventive maintenance program including facilities and/or equipment to be emphasized or de-emphasized. Discuss methods to promote awareness in the NASA community (such as alerts, safety flashes, etc.) when preventive maintenance reveals design or operational concerns in facilities and equipment (and related processes where applicable).

K-4.4 Medical Program. Discuss your medical surveillance program to evaluate personnel and workplace conditions to identify specific health issues and prevent degradation of personnel health as a result of occupational exposures. Discuss approach to cardiopulmonary resuscitation (CPR), first aid, and emergency response.

K-5.0 EMERGENCY RESPONSE.

Discuss approach to emergency preparedness and contingency planning which addresses fire, explosion, inclement weather, environmental releases, etc. Discuss compliance with 29 CFR 1910.120 (HAZWOPER) and the role the contractor will play in the local Incident Command System. Discuss methods to be used for notification of Center emergency forces including emergency dispatcher, safety hotline, director's safety hotline, etc. Discuss establishment of pre-planning strategies through procedures, training, drills, etc. Discuss methods to verify emergency readiness.

K-6.0 SAFETY AND HEALTH TRAINING.

Describe the contractor's training program including identification of responsibility for training employees to assure understanding of safe work practices, hazard recognition, and appropriate responses including protective and/or emergency countermeasures. Address management techniques used to identify and utilize any Center training resources (such as asbestos worker training/certification, hazard communication, confined space entry, lockout/tagout, etc.) as appropriate with particular emphasis on programs designed for the multiple employer work environment on NASA property. Describe approach to training personnel in the proper use and care of protective equipment. Discuss tailoring of training towards specific audiences (management, supervisors, and employees) and topics (safety orientation for new hires, specific training for certain tasks or operations). Discuss approach to ensure that training is retained and practiced. Discuss personnel certification programs. Certifications should include documentation that training requirements have been satisfied and learning validated by one or more of the following: physical examination, testing, on-the-job performance, etc. All training materials and training records will be provided for NASA review on request.

APPENDIX L SAMPLING PROTOCOL

This sampling protocol will be used to obtain information about the presence of Legionella bacteria in the water systems of all NASA buildings operated by Ames Research Center.

L-1.0 OBJECTIVE

The purpose of water sampling in this plan is to locate and evaluate Legionella amplification sources and relative concentrations, to design control remedies or otherwise take preventative actions.

L-1.1 Schedule

Sampling will be conducted only for the following:

1. When required by ASHRAE Guideline 12-2000.

2. When required by project specifications to validate engineered plumbing system changes.

3. Following disease outbreak suspected by the Ames Health Unit to be associated with legionella in any of NASA's systems.

4. When determined by the Chief, Safety, Health, and Medical Services Division, Code QH, to be beneficial to the Center.
5. When advised by Appendix D-3.3 for cooling towers and humidifers.

L-2.0 GENERAL APPROACH

1. The general approach is to sample water at the incoming to the building for a baseline; and a representative number of samples collected from: showers, restroom sinks, janitor's sinks, drinking fountains, lab sinks, and any other specialty equipment located in the building.

2. Samples will be sent to a Laboratory approved by Safety, Health, and Medical Services Division, Code QH for cell-culture analysis. Analysis results should be returned directly to Safety, Health, and Medical Services Division, Code QH at Ames Research Center.

3. A detection limit of 1 cfu/ml is required. If more than one laboratory is used, agreement will be reached on a single set of definitions for reporting low concentrations (such as "not detected", "below minimum level of quantification", "<1 cfu/ml" or other similar designations). Laboratories must be accredited by the American Industrial Hygiene Association as part of its Environmental Microbiology Laboratory Accreditation Program (EMLAP) for labs identifying microorganisms commonly detected in air, fluids, and bulk samples during indoor air quality studies. Sample analysis

must be performed according to "Procedures for the Recovery of Legionella from the Environment," Centers for Disease Control and Prevention or "Water Quality-Enumeration of Legionella," International Standards Organization ISO 11731, or other method approved in writing by NASA.

4. Record temperatures for each sample using thermometers. Temperature data may indicate locations of tepid water that can be corrected through maintenance.

5. It is important not to overlook any potential water sources in the building. Water from ice machines, hand spray bottles, decorative fountains, and for plastic injection molding equipment have been implicated in past outbreaks or have been found to be significantly contaminated.

L-2.1 Water Sampling Procedure

1. Wear appropriate respiratory protection such as a half-face respirator equipped with a P-100 (HEPA) filter or a similar type of filter media capable of effectively collecting particles in the one micron size range if a significant potential exists for exposure to aerosols.

2. When measuring temperature from faucets, showers, water fountains, etc., record the initial water temperature, and then allow the fixture to discharge until the temperature stabilizes. Record the initial and final temperatures, and the time needed to stabilize and collect a stable temperature flow sample. It is preferable to accomplish this by measuring the water stream flowing from the water source and not by placing the thermometer in the sample container.

3. Take water culture samples as follows:

Domestic Water Heaters.

- Take a sample of water from the closest downstream sink.

Faucets and Showers.

- Collect a "before-flush" (initial flow) sample of water.
- Collect an "after-flush" sample of water when the maximum temperature has been reached.

The initial (before-flush) sample is intended to indicate the level of contamination at the sample point or fitting, and the final sample should reveal the quality of the water being supplied to the fitting.

Cooling Towers.

The following locations should be sampled in order:

- Cooling tower sump (basin) dip sample as far from the make up water inlet as is practicable. The sample is to be collected prior to any biocide additions.
- Cooling tower return line immediately prior to entering the distribution trough. .
- Using a gloved hand disturb deposits on the bottom of the sump. This will suspend material in the water of the sump. Collect a sample from the sump that contains a portion of the suspended deposits.
- Collect a sample from the outlet side of the heat exchanger at the nearest available valve. Be sure to sample the condenser water not the chilled water.

Humidifiers, Swamp Coolers, and Spas.

- Take a sample from the water reservoirs. Sample the incoming water supply if it is accessible.
- For cooling towers, humidifiers, swamp coolers, and building water services, collect samples of sludge, slimes, or sediments, particularly where accumulations occur.

L-2.2 Sample Transportation

Prepare samples for shipment carefully, as follows:

- Wrap vinyl tape clockwise around the neck of each bottle to hold its screw cap firmly in place and seal the interface between the cap and the bottle.
- Wrap absorbent paper around bottles, and place the bottles in a sealable (zip-lock) plastic bag.
- Place the sealed plastic bag in an insulated container (styrofoam chest or box).

L-2.3 Report Format

The desired format for reporting results is a narrative report stating the methods used for sampling, methods used in the laboratory analysis, any deviations from this protocol, and tabulation of reported results in an Excel spreadsheet, and graphic presentation of results on a map showing sample locations and reported water Legionella concentrations, free residual chlorine concentration, and temperature.