Call Henry, Inc.

FACILITIES OPERATION, REPAIR AND MAINTENANCE CONTRACT
NASA GLENN RESEARCH CENTER
Cleveland, Ohio

CHI-02-PLN-0006

Water Treatment / Operation Plan

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REVISION NO.	PARAGRAPH	DATE
Original	N/A	02/20/04
Revision A	Reviewed and Updated	05/15/09

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Approval Page

For
Revision No.: **Revision A**

CHI-02-PLN-0006, Water Treatment / Operations Plan, has been approved by the following personnel:

Title: Project Manager
Signature: Robert D. Carr
Date: 6-15-09

Title: Quality Management Representative
Signature: Raphael C. Clark
Date: 6/10/09

Title: Process Owner
(Document Maintenance Responsibility)
Signature: Billy Shemp Sr
Date: 6-17-09

Title: Accountable Person
(Implementation Responsibility)
Signature: Billy Shemp Sr
Date: 6-17-09

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Table of Contents

Section I. Objectives

The water treatment plan for CHI/NASA Glenn research center will provide the following:

- Products used successfully in applications of the same size and complexity as the NASA site.
- A cooling systems program for corrosion, scale, and microbio control within the operating parameters as established in the bid specification.
- A microbio control program that complies with the CDC, CTI, and ASHRAE guidelines for *Legionella* control.
- A boiler program that protects feedwater, steam generating, and condensate systems from corrosion and scale formation within the operating parameters as established in the bid specification.
- FDA compliant boiler products.
- Products and programs consistent with current applications, i.e. one drum approach for outlying boilers, chelant treatment with supplemental polymer for steam plant, etc.
- Performance documentation of the chemical program through on site visits, and laboratory and analytical field support. Primary and secondary representatives have technical and/or engineering degrees and a minimum of five years experience with similar systems. Service reports when completed are distributed as directed by CHI.
- Training on the proper and safe handling of chemicals supported by a safe delivery and on site chemical storage plan.
- ChemTreat operator training to ensure personnel is properly trained in the testing, handling, and implementation of the water treatment program. Special attention to environmental, as well as safety and handling.
- Log sheets, control charts, and testing parameters consistent with the specification.
- Continuous improvements in operating parameters, chemical technology, and cost reduction.
- Chemical deliveries in company owned tanker vehicles with proper safety protocols.
- An ISO 9001 certified manufacturing program to ensure product consistency.
- Material safety data sheets that comply with the latest standards and provide information regarding product formulations and components.
- A continuous bulk tank safety and audit process as part of standard operating procedures.
- Minimize product usage and on site storage. Optimum delivery quantities will be utilized.
- Corporate engineering staff support and at least one technical visit per year by corporate engineer.
- An emergency response phone number for chemical emergencies provide on material safety data sheets for each product, and posted on all chemical tank placards and in the water treatment laboratory.

This plan demonstrates the technical capabilities of ChemTreat and the excellent technical support and service currently provided to NASA Glenn, and the commitment to continue and improve the water treatment program. Experience in treating the complexities of this site are invaluable in achieving the results and performance requested in the specifications.

Section II. Cooling Water Program

Large Towers

There are three main tower systems at NASA Glenn. Two towers have an automated system for proper cycle management and chemical feed. Each of the tower systems is unique and requires special knowledge and attention.

Below is the treatment protocol for each system that allows the program to meet the requirements of the bid specification, and comments and information on the management of each tower system.

Most cooling towers using makeup water operate at 4–5 cycles of concentration. The orthophosphate levels in the makeup water do not allow for higher cycles. Systems that have operated at higher cycles have been plagued with calcium phosphate and calcium carbonate deposits. The Langelier Stability Index (LSI) determines the maximum cycles of concentration for the cooling systems based on conductivity, temperature, calcium hardness, alkalinity, and pH. Depending on the heat load, towers can run up to 2.2–2.5 LSI with proper inhibitors. In Cleveland, because of the orthophosphate, the cycles must be controlled below a 2.2–2.3 LSI. A sample calculation for LSI is included in this section.

Chemical Treatment Program

Scale and Corrosion Inhibition

ChemTreat CL-4892 is a scale and corrosion inhibitor specifically designed to provide protection in cooling systems with makeup waters like those in the Cleveland area. The Cleveland city water has low levels of orthophosphate. If systems are not properly treated and managed, there is potential for calcium phosphate and calcium carbonate scale. CL-4892 is a combination of new quadpolymers, HEDP, and tolyltriazole. The treatment range is 100–150 ppm as product, consistent with the specification. This product has effectively controlled scale and deposits in the main tower systems with corrosion coupon results consistently less that 1 mpy.

Microbiocides

ChemTreat CL-2150 is a 1.5 percent isothiazolin microbiocide. It is nonoxidizing and was chosen because it compliments the oxidizing microbiocide. The isothiazolin functions by inhibiting respiration and food transport through the cell wall. These products are compatible with CL-4891 and the chlorine bromine oxidizers. The isothiazolin is not as readily absorbed as other mechanical action biocides on suspended solids in the systems, thereby making them more effective. This product is currently fed with timers and application dosage changes are made based on ATP (bacteria) levels.

Bromine/Chlorine

ChemTreat C-2189T is a tablet form of oxidizing microbiocide. It is fed based on ATP levels and measurements of free chlorine. Application for all towers, except tower 1, is manual. This product was chosen for this application because the hypobromous acid is more effective than hypochlorous acid in the cooling systems' pH ranges of operation. C-2189T is 92.5 percent 1-bromo-3-chloro-5, 5-dimethylhydantoin. This is the primary oxidizing biocide that is part of the CHI/NASA *Legionella* control program.

Chlorine

Tower 1 utilizes liquid, 12.5 percent sodium hypochlorite as the primary oxidizing biocide. Treatment levels are maintained between 0.1–0.5 free chlorine. Liquid chlorine is less expensive than tablets, but its efficiency decreases as the pH increases. The cost advantages allow for the higher amounts required to provide effective microorganism control. Chlorine is fed continuously, and monitored using the free chlorine test and the ATP BioTrace/BioScan.

Testing and Log Sheets

All testing results are logged into electronic log sheets using ChemTrack®. When out-of-limit or target range results are detected, corrective actions are provided by the ChemTrack® program for the operators to follow.

Per the specification, ChemTreat tests these towers once per month. The CHI operating personnel test these systems three times per week.

Tower 1

This tower control is not automated. Cycles of concentration are adjusted by large amounts of blowdown when the conductivity is at or over the high end of the range. This causes serious changes to the water and chemical balances. Dumping 30 percent of the water volume reduces all the chemical levels by 30 percent. This is not cost effective and is not conducive to excellent

results or control. This method of operation does not allow the tower to cycle above the specifications (2.8–4.0 cycles)

Cell testing from this tower has potential for oil leakage that must be treated. There is a protocol to treat for this oil with surfactant and antifoam, and then eliminate it from the system. The concern is that the oil does not just remain in the basin, but coats the distribution piping from the entire system. This can impede heat transfer and create a food source for microorganisms. This will increase the chlorine demand and require additional chlorine to establish to proper free chlorine residuals. Off-contract purchases and application of ChemTreat CL-4059 will be required.

This system is treated with CL-4892, at 100–150 ppm as product levels. The chemical is stored and fed from a 1,000-gallon chemical tank with proper containment. Results have been excellent. Corrosion rates measured by corrosion coupons are consistently below 1 mpy.

This tower has an open sump that is exposed to sunlight creating potential for algae growth. We are treating this tower with combination oxidizing biocides (liquid sodium hypochlorite) and nonoxidizer CL-2150. The target RLU levels measured by BioTrace/BioScan are less than 100 when the program is monitored and applied properly. This is consistent with the *Legionella* compliance procedure.

A 550-gallon liquid chlorine tank provides positive suction on the chemical feed pump. The control of the chlorine feed is based on free chlorine residuals and adjusted based on the ATP testing.

CL-2150 has a 200-gallon storage tank with proper containment and flooded suction on the pump. It is fed via a pump timer combination that allows for consistent application. The product feed is also adjusted based on the ATP levels. The target range is less than 100 RLU.

Tower 3/6

This tower has been set up with automated control. The cycles of concentration were previously adjusted with large amounts of blowdown when the conductivity is at or over the high end of the range. This causes serious changes to the water and chemical balances. Dumping 30 percent of the water volume reduces chemical levels by 30 percent. This is not cost effective, and is not conducive to excellent results or control. This new automation should allow the system to stabilize and cycle up more efficiently. The target will be to get to the 4.0 to 4.67 cycles. We will monitor deposition and corrosion rates potential to ensure no problems.

This system is treated with CL-4892, at 100–150 ppm as product levels. The chemical is stored and fed from a 550-gallon chemical tank with proper containment. Results have been excellent. Corrosion rates measured by corrosion coupons are consistently below 1 mpy.

We are treating this tower with a combination of oxidizing biocides C-2189T (tablets of bromochloro hydantoin) and a non-oxidizer, CL-2150. The target RLU levels measured by BioTrace/BioScan are less than 100 when the program is monitored and applied properly.

The bromine/chlorine is fed by hand to the tower sump. Chlorine usage is determined by the ATP levels and monitored by free chlorine residuals.

CL-2150 has a 125-gallon storage tank with proper containment and flooded suction on the pump. It is fed with a pump timer combination that allows for consistent application. The product feed is also adjusted based on the ATP levels to achieve the targeted level of less than 100 RLU.

Tower 5

This system is treated with CL-4892, at 100–150 ppm as product levels. The chemical is stored and fed from a 125-gallon chemical tank with proper containment. Results have been excellent. Corrosion rates measured by corrosion coupons are consistently below 1 mpy.

We are treating this tower with a combination of oxidizing biocides (tablets of bromochloro hydantoin) and non-oxidizer, CL-2150. The target RLU levels measured by BioTrace/BioScan are less than 100 when the program is monitored and applied properly.

The bromine chlorine is fed by hand to the tower sump. The chlorine usage is determined by the ATP levels and monitored by free chlorine residuals. To reduce cost and handling, a liquid chlorine product can be used.

CL-2150 has a 125-gallon storage tank with proper containment and flooded suction on the pump. It is fed with a pump timer combination that allows for consistent application. The product feed is also adjusted based on the ATP levels that target achievement of levels less than 100 RLU.

Small Towers

Tower 142

This tower has automated control. The system provides for automatic monitoring of conductivity and adjusts blowdown according to the set point. The controller allows for 3–4 cycles of concentration, effectively managing the water and the chemical inhibitor level to provide for excellent protection and manage the clean up program.

This system is treated with CL-4892 at 100–150 ppm as product levels. The chemical is stored and fed from a 120-gallon chemical tank with proper containment. Results have been excellent. Corrosion rates measured by corrosion coupons are consistently below 1 mpy.

We are treating this tower with combination oxidizing biocides (tablets of bromochloro hydantoin) and non-oxidizer, CL-2150. The target RLU levels measured by BioTrace/BioScan are less than 100 when the program is monitored and applied properly.

The bromine chlorine is fed by hand to the tower sump. The chlorine usage is determined by the ATP levels, and monitored by free chlorine residuals.

The CL-2150 has an 80-gallon storage tank with proper containment and flooded suction on the pump. It is fed with a pump that allows for consistent application. The product feed is also adjusted based on the ATP levels.

Towers 333/301/302/500

These towers all have automated control. The system provides for automatic monitoring of conductivity, and adjusts blowdown according to the set point. The controller allows for 4.0–6.0 cycles of concentration, effectively managing the water and the chemical inhibitor level to provide for excellent protection. In towers 301 and 333, it is possible to push to six cycles, though ChemTreat prefers five cycles of operation maximum based on LSI. We can ensure there is minimal or no deposition on the tower or chillers. There are no other issues with this tower.

Systems are treated with CL-4892, at 100–150 ppm as product levels. The chemical is stored and fed from a chemical tanks with proper containment. Results have been excellent. Corrosion rates measured by corrosion coupons are consistently below 1 mpy.

We are treating these towers with a combination of oxidizing biocides (tablets of bromochloro hydantoin) and non-oxidizer, CL-2150. The target RLU levels measured by BioTrace/BioScan are less than 150 when the program is monitored and applied properly.

The bromine chlorine is fed by hand to the tower sumps. The chlorine usage is determined by the ATP levels, and monitored by free chlorine residuals.

CL-2150 is in chemical storage tanks with proper containment and flooded suction on the pump. They are fed with pumps and/or pump timer combinations that allow for consistent application. The product feed is also adjusted based on the ATP levels.

Chilled and Hot Loops

All[1] chilled and hot water loops (with the exception of Building 9 and Building 94 chilled loops) are treated with a molybdenum-based product. The chilled loops are controlled at 75–100 ppm Mo+6 and the hot loops at 100–150 ppm Mo+6. Proper control is important since there is corrosion potential in closed loops. Proper servicing includes testing for inhibitor and pH to ensure proper protection.

Treatment levels of Mo+6 will be maintained using ChemTreat CL-2875, a combination of molybdenum, polymer, and TTA (yellow metal inhibitor).

Most systems have limited makeup water needs; therefore, once they are charged with chemical, they should need minimal additions. Additions are made through shot feeders or directly into the circulating lines. Testing is conducted monthly and laboratory samples are sent four times per year.

Building 9 Chilled

This system has had leaks and on occasion, leaks into the cooling tower (tower 1). This affects both systems, but only to a minor extent. Since molybdenum is very expensive, we use the CL-1432 ortho phosphate corrosion inhibitor in this system due to the large volume contained within this system. Corrosion rates in this system are excellent.

The CL-1432 is stored and fed from an 80-gallon chemical tank with proper containment.

Building 94 Chilled

This system has had leaks on occasion. Since molybdenum is very expensive, we use the CL-1432 ortho phosphate corrosion inhibitor in this system due to the large volume contained within this system. Corrosion rates in this system are excellent.

The CL-1432 is stored and fed from an 80-gallon chemical tank with proper containment.

Section III. Boiler Programs

Steam Plant Building 12

The main steam plant at NASA Glenn provides steam for the east side of the complex. There are five boilers in Building 12.

Historically, these boilers have been operating at conductivity levels exceeding 2,500–3,000 and were scaled and had impeded heat transfer caused excess fuel usage causing significant annual costs for turbining the boilers to remove the deposits. The chemical and service program in place has produced very positive performance measured by internal boiler inspections and water analysis. Cleaning of the boilers has not been necessary in recent years. Attempts to increase the boiler conductivities could result in deposit problems, requiring clean up at an additional cost. There would also be added fuel cost because of the reduced heat transfer on the tube surfaces.

All chemicals, except for the sulfite and resin cleaner, are added to a chemical mix tank, and then fed to the boiler. Surface blowdown is controlled by conductivity controllers.

The boiler treatment program is designed to:

- Provide clean heat transfer surfaces in the boiler
- Provide corrosion protection to the steam and condensate lines
- Protect the feedwater water system from corrosion
- Improve softener performance through clean resin

Chemical Treatment Program

Deposit Control

The deposit control program utilizes a combination of chemicals. A program of chelant/phosphate and polymer was found to work effectively to keep the boilers clean. The ChemTreat program will utilize the chemicals that are working well presently. These products are all FDA approved.

The main internal treatment is ChemTreat BL-1173, a liquid chelant phosphate containing polymer dispersants. It is stored in an 80-gallon chemical feed tank, with containment. The handling of the liquid is much easier than the previous dry chemical, and is added into solution in the mix tank more readily. BL-1173 treatment range is 20–40 ppm controlled using the phosphate test. This will provide proper orthophosphate in the boilers and provide added polymer. At this treatment level, proper chelant levels will also promote boiler cleanup.

In addition to BL-1173, a combination polymer phosphonate product, ChemTreat BL-4350 is used. This polymer is base fed to the system to provide added dispersion for the solids. This product is stored in a 200-gallon tank and fed to the mix tanks.

Condensate Treatment

ChemTreat BL-1544 is used in the steam line condensate treatment. This product is a 50 percent active solution of two amines: DEAE and cyclohexylamine. These products have distribution ratios that provide excellent corrosion protection for condensate systems by neutralizing carbonic acid and maintaining a pH of 8.2–9.0. Condensate corrosion problems were serious in the past, causing replacement of the condensate system. Application of this technology will continue to provide excellent protection for the systems.

Deaerator Oxygen Control

Presently a dry sulfite is used to eliminate the oxygen entering the feedwater system. The product is provided in 200-pound fiber containers, fed to a mix tank and then to the storage section of the deaerator. Sulfite residuals are maintained at 30–50 ppm.

Dry sulfite is 100 percent active, and relatively inexpensive.

Resin Cleaner

ChemTreat CL-16 is fed to the regeneration cycle of the water softeners to improve the performance on the resin. CL-16 is a combination citric acid and phosphonate that removes iron on the resin, extends the life of the resin, and improves performance on the softeners.

Outlying Boilers (Steam)

There are steam boilers in buildings 333, 301, 302, and 500. There is also a small steam boiler in building 142. Historically, these boilers have been operating at conductivity levels of 4,000-4,500. This is a proper range for these systems.

Most of these boilers are manually blown down. The boilers on building 500 and 333 have blowdown controllers to assist in maintaining proper conductivity levels in the boilers.

There are no deaerators on any of these systems; therefore, sulfite feed is critical. Many of the systems operate feedwater at 160–190°, with inadequate oxygen removal. The chemical treatment levels on many of the outlying boilers were low and the recent operator training significantly improved the results.

There is a log sheet for boilers 301, 302, and 333 and a separate log sheet for the complexities of building 500. Boiler 142 data is managed through ChemTrack®.

There are specific control charts in the operations manual, which provide information on actions to take. All operators have been trained in testing and chemical handling.

The boiler treatment program is designed to:

- Provide clean heat transfer surfaces in the boiler
- Provide corrosion protection to the steam and condensate lines
- Protect the feedwater water system from corrosion
- Improve softener performance through clean resin

Chemical Treatment Program

Deposit Control

The deposit control program utilizes a combination of chemicals. A program of chelant/phosphate and polymer was found to work effectively to keep the boilers clean. The ChemTreat program will utilize the chemicals that are working well. These products are all FDA compliant.

To aid in treatment of these small systems, a simplified all-in-one program utilizing ChemTreat BL-8703 has been implemented. This program, approved by NASA, monitors and tracks with PO_4. Treatment levels are tested with PO_4 tests at 40–60 ppm. The BL-8703 includes phosphate, polymer, amine treatment, and sulfite.

When the correct level of PO_4 is maintained, the proper levels of polymer are in the system to prevent deposits and provide sufficient amine (DEAE) a to achieve the condensate target range for pH of 8.2–9.0. Because of the feedwater temperatures and high potential for oxygen attack, supplemental sulfite is fed to ensure protection, range is 30-50 ppm. As a result of the higher potential for oxygen attack, the boilers in building 500 have a target of 75-100 ppm sulfite. Concerning Building 500, since so much condensate is returned to this system, alkalinity levels were always low in the steam boiler, thus causing corrosion to occur. To rectify this problem, the addition of the BL-1301 alkalinity builder was added to the program at Building 500 to establish a minimum 400 ppm of P-Alkalinity within the steam boilers.

Condensate Treatment

BL-8703 includes an amine: DEAE. This product has a distribution ratio that provides excellent corrosion protection for condensate systems by neutralizing carbonic acid and maintaining a pH of 8.2–9.0.

Oxygen Control

A dry sulfite is currently used to eliminate the oxygen entering the feedwater system. The product, ChemTreat B-120, is provided in 200-pound fiber containers and is fed to a mix tank and then to the storage section of the deaerator. Sulfite residuals are maintained at 30–50 ppm. Dry sulfite is used in all buildings except for building 500. In building 500, an 80-gallon chemical storage tank is used for ChemTreat BL-1254 liquid sulfite, a 45 percent sulfite blend.

Dry sulfite is 100 percent active, and relatively inexpensive.

Section IV: Representative Team

The services of a qualified chemist or engineer are essential to ensure that all the benefits of our chemical treatment program are achieved. This service is key to the success of any chemical treatment program. Your ChemTreat representatives have the following qualifications:

Corporate Account Manager:	**Fred Klemencic**
Degree and College:	B.S. Chemical Engineering Case Western Reserve University
Water Treatment Experience:	35 years
Residence:	Avon, Ohio
Territory Serviced:	Cleveland
Previous Experience:	Betz Mogul Monsanto
Primary Representative:	**Joseph E. Royle**
Degree and College:	B.S. Mechanical Engineering University of Akron
Water Treatment Experience:	19 years
Residence:	Avon Lake, Ohio
Territory Serviced:	North Eastern Ohio

Service Technician:	**Willis Williams**
Degree and College:	Bachelors of Science Muskingum College
Water Treatment Experience:	21 years
Residence:	Oberlin, Ohio
Territory Serviced:	Cleveland and Northwest Ohio
Backup Representative:	**Robert M. Rabe**
Degree and College:	B.S. Petroleum Engineering New Mexico Institute of Mining and Technology
Water Treatment Experience:	22 years
Residence:	Sagamore Hills, Ohio
Territory Serviced:	Northeast Ohio

Education, training, and experience are needed to make sound technical recommendations in all phases of industrial water treatment.

Emergency Response

Fred Klemencic

Mobile:	1-216-408-2179
Voicemail:	1-800-442-8292, Extension 647

Joe Royle

Mobile:	1-216-401-1843
Voicemail	1-800-442-8292, Extension 695

Willis Williams

Mobile	1-440-315-8456
Voicemail:	1-800-442-8292, Extension 631

Bob Rabe

Mobile:	1-330-283-4943
Voicemail:	1-800-442-8292, Extension 478

ChemTreat also utilizes the ChemTrec national response service involving chemical spills or accidents in our 24-hour-per-day coverage.

ChemTrec: 1-800-424-9300

Section V: Service Schedule

In addition to routine evaluation of chemical applications and feed equipment, our program will include, at no additional charge, specific services designed to improve the applications. Routine services will occur. The following is an initial commitment based on present needs. Expansion of these services is available as future directions are discussed.

Boiler Water System

Service	As Needed	Monthly	Quarterly	Semi-Annually	Annually
Feedwater Dissolved Oxygen Studies	✓				
Calculate Percentage Condensate Returns		✓			
System Iron Profiles	✓				
Condensate pH Profiles	✓				
Steam Purity Testing	✓				
Visual Inspections of Boiler					✓
Condensate Corrosion Coupon Studies					✓
Makeup Analyses					✓
Energy Savings Calculations	✓				
System Sampling and Laboratory Analyses			✓		
Track and Monitor all Steam plant data.			✓		
Provide Log Sheets, control charts, and testing reagents for all boiler systems	✓				
Deposit Analyses	✓				
Metallurgical Analyses	✓				
Testing of Off-Line, Wet-Stored Boilers	✓				

Cooling Water System

Service	As Needed	Monthly	Quarterly	Semi-Annually	Annually
Microbiological Studies		✓			
Makeup Analyses	✓				
Complete and update cooling water usage for all metered tower systems					✓
Conduct troubleshooting of cooling and loop systems based on field, lab water analysis and usage rates.	✓				
Corrosion Coupon Studies					✓
System Pretreatment	✓				
System Sampling and Laboratory Analyses			✓		
Iron and Copper Profiles	✓				
Toxicant Evaluations for Biocide Selection	✓				
Deposit Analyses	✓				
Metallurgical Analyses	✓				
Equipment Inspections	✓				
Tower Wood Studies	✓				
Biofilm Monitoring	✓				

External Treatment

Service	As Needed	Monthly	Quarterly	Semi-Annually	Annually
Pretreatment Analyses	✓				
Regenerant Elution Studies	✓				
Resin Analyses	✓				
Exchange Capacity Studies	✓				
Out-of-Service Resin Cleaning	✓				
Deposit Analyses	✓				

General Services

Service	As Needed	Monthly	Quarterly	Semi-Annually	Annually
Reviews of Plant Testing		✓			
Operator Training	✓				
Chemical Cost Summaries	✓				
Formal Management Reviews	✓				
Chemical Inventory Reviews		✓			
Laboratory analysis must be performed by company owned laboratory.	✓				
Equipment review and recommendations					✓
Provide Delivery in Company owned trucks with proper safety protocols.	✓				
Review ChemTrack programs and data fields, statistical and graphical information to evaluate trends and problems.	✓				

ChemTreat, Inc.

Building 12
Steam Plant Control Tests

Product	Test	Control Range
BL-1173	Orthophosphate	20–40 ppm
BL-4350	Base feed	1–2 quart/shift
B-120	Sulfite	30–50 ppm
	'P'-Alkalinity	700–900 ppm
BL-1544	Condensate pH	8.2–9.0
Continuous Blowdown	N-Conductivity	2,500–3,000 mhos
Manual Blowdown		Daily

Orthophosphate: If **below** 20 ppm, adjust BL-1173 in mix tank and add in pint increments to get into proper range.
If **above** 40 ppm, reduce BL-1173 in mix tank.

Sulfite: If **below** 30 ppm, add additional B-120 to the chemical mix tank. Suggest additions in pint increments until in proper range.
If **above** 50 ppm, reduce the amount of B-120 in the mix tank.

Condensate pH: If **below** 8.2, add additional BL-1544 to the mix tank. Add in pint increments and check pH to get into range.
If **above** 9.0, decrease the amount of BL-1544 in the chemical mix tank.

'N'-Conductivity: If **below** 2,500, reduce blowdown.
If **above** 3,000, increase blowdown.

'P'-Alkalinity: If **below** 700, allow boiler to cycle and reduce blowdown.
If **above** 900, increase blowdown.

Chemical levels can also be adjusted through changes in feed pumps stroke/speed.

ChemTreat, Inc.

Boiler 301

Please test twice per week

Softener Hardness: **<1 ppm**	If softener tests **greater than** one, please regenerate.
Feedwater Conductivity:	Record. If **over** 150, indicates problem with condensate or boiler carryover.
Boiler Water Tests:	
Sulfite: ***30–50 ppm***	If **above** 50, reduce the speed on the chemical pump for the B-120 day tank (LMI). If **below** 30, increase the speed on the chemical pump for the B-120 day tank (LMI).
Neutralized Conductivity: ***4,000–4,500***	If **above** 4,500, blowdown the boiler. If **below** 4,000, allow boiler to cycle up before another blowdown.
Phosphate: ***40–60 ppm***	If **above** 60, reduce the speed on the chemical pump for the BL-8703 tank (LMI). If **below** 40, increase the speed on the chemical pump for the BL-8703 tank (LMI).
Condensate Tests:	
pH ***8.2-9.0***	If **above** 9.0, reduce the chemical, BL-8703, feed. Adjust the pump speed. If **below** 8.2, increase the chemical, BL-8703, feed. Adjust through the pump speed/stroke.
Conductivity ***0-100***	Record. If there is any conductivity in the condensate, system should be checked for leaks, or high boiler conductivity for possible carryover. Sulfite overfeed could also contribute to high boiler conductivity, and require blowdown.

ChemTreat, Inc.

Boiler 302

Please test twice per week

Softener Hardness: **<1 ppm**	If softener tests **greater than** one, please regenerate.
Feedwater Conductivity:	Record. If **over** 150, indicates problem with condensate or boiler carryover.
Boiler Water Tests:	
Sulfite: ***30–50 ppm***	If **above** 50, reduce the speed on the chemical pump for the B-120 day tank (LMI). If **below** 30, increase the speed on the chemical pump for the B-120 day tank (LMI).
Neutralized Conductivity: ***4,000–4,500***	If **above** 4,500, blowdown the boiler. If **below** 4,000, allow boiler to cycle up before another blowdown.
Phosphate: ***40–60 ppm***	If **above** 60, reduce the speed on the chemical pump for the BL-8703 tank (LMI). If **below** 40, increase the speed on the chemical pump for the BL-8703 tank (LMI).
Condensate Tests:	
pH ***8.2-9.0***	If **above** 9.0, reduce the chemical, BL-8703, feed. Adjust the pump speed. If **below** 8.2, increase the chemical, BL-8703, feed. Adjust through the pump speed/stroke.
Conductivity ***0-100***	Record. If there is any conductivity in the condensate, system should be checked for leaks, or high boiler conductivity for possible carryover. Sulfite overfeed could also contribute to high boiler conductivity, and require blowdown.

ChemTreat, Inc.

Boiler 333

Please test twice per week

Softener Hardness: **<1 ppm**	If softener tests **greater than** one, please regenerate.
Feedwater Conductivity:	Record. If **over** 150, indicates problem with condensate or boiler carryover.
Boiler Water Tests:	
Sulfite: ***30–50 ppm***	If **above** 50, reduce the speed on the chemical pump for the B-120 day tank (LMI). If **below** 30, increase the speed on the chemical pump for the B-120 day tank (LMI).
Neutralized Conductivity: ***4,000–4,500***	If **above** 4,500, blowdown the boiler. If **below** 4,000, allow boiler to cycle up before another blowdown.
Phosphate: ***40–60 ppm***	If **above** 60, reduce the speed on the chemical pump for the BL-8703 tank (LMI). If **below** 40, increase the speed on the chemical pump for the BL-8703 tank (LMI).
Condensate Tests:	
pH ***8.2-9.0***	If **above** 9.0, reduce the chemical, BL-8703, feed. Adjust the pump speed. If **below** 8.2, increase the chemical, BL-8703, feed. Adjust through the pump speed/stroke.
Conductivity ***0-100***	Record. If there is any conductivity in the condensate, system should be checked for leaks, or high boiler conductivity for possible carryover. Sulfite overfeed could also contribute to high boiler conductivity, and require blowdown.

ChemTreat, Inc.

Boiler 500
Please test twice per week

Softener Hardness: **<1 ppm**	If softener tests **greater than** one, please regenerate.
Feedwater Conductivity: ***Sulfite:*** ***4–7 ppm***	If **low**, increase pump speed for BL-1254. If **high**, decrease pump settings. Record any change in pump settings.
Conductivity:	Record. If **over** 150, indicates problem with condensate or boiler carryover.
Boiler Water Tests: ***Sulfite:*** ***75–100 ppm***	**Operating Boilers** If **above** 100, reduce the speed on the chemical pump for the BL-1254. If **below** 75, increase the speed on the chemical pump for the BL-1254. **Note:** Maintain standby boilers at 100–200 ppm.
Neutralized Conductivity: ***4,000–4,500***	If **above** 4,500, blowdown the boiler. If **below** 4,000, allow boiler to cycle up before another blowdown.
Phosphate: ***40–60 ppm***	If **above** 60, reduce the speed on the chemical pump for the BL-8703. If **below** 40, increase the speed on the chemical pump for the BL-8703.
P-Alkalinity: **400-800 ppm**	If **above** 800, reduce BL-1301 alkalinity builder product usage. If **below** 400, increase BL-1301 alkalinity builder product usage.
Condensate Tests: ***pH*** ***8.2-9.0***	If **above** 9.0, reduce the chemical, BL-8703, feed. Adjust the pump speed. If **below** 8.2, increase the chemical, BL-8703, feed. Adjust through the pump speed/stroke.
Conductivity ***0-100***	Record. If there is any conductivity in the condensate, system should be checked for leaks, or high boiler conductivity for possible carryover. Sulfite overfeed could also contribute to high boiler conductivity, and require blowdown.

C15-33 (New)

Cooling Towers Operating Perameters - Large Towers

System	Operating Cycles	Treatment Control Range	Conductivity	pH	Free Chlorine	RLU		Corrosion Coupons Mild Steel	Copper
Towers 1 and 4	2.8 - 4.0	0.5-1.0 MO+6	<1200	8.5 - 9.0	0.1-0.5ppm	<100		<1.5	<0.1
Tower 2	4.0 -4.67	0.5-1.0 MO+6	<1400	8.5 - 9.0	0.1-0.5ppm	<100		<1.5	<0.1
Towers 3 and 6	2.8 - 4.0	0.5-1.0 MO+6	<1200	8.5 - 9.0	0.1-0.5ppm	<100		<1.5	<0.1
Tower 5	4.0 - 4.67	0.5-1.0 MO+6	<1400	8.5 - 9.0	0.1-0.5ppm	<100		<1.5	<0.1

Cooling Towers Operating Perameters - Small Towers

System	Operating Cycles	Treatment Control Range	Conductivity	pH	Free Chlorine	RLU	Added Products	Corrosion Coupons Mild Steel	Copper
Building 142	3.0 - 4.0	1.0 - 1.5 ppm Mo+6	<1450	8.5 - 9.0	0.1-0.5ppm	<100	Polymer for cleanup	<1.5	<0.1
Building 301/Old	4.0-4.67	0.5-1.0 MO+6	<1450	8.5 - 9.0	0.1-0.5ppm	<100	Polymer for cleanup	<1.5	<0.1
Building 301/New	4.8 - 6.0	0.8 - 1.2 ppm Mo+6		8.5 - 9.0	0.1-0.5ppm	<100	Polymer for cleanup	<1.5	<0.1
Building 302	4.0-4.67	0.5-1.0 MO+6	<1450	8.5 - 9.0	0.1-0.5ppm	<100	Polymer for cleanup	<1.5	<0.1
Building 333	4.0-4.67	0.5-1.0 MO+6	<1450	8.5 - 9.0	0.1-0.5ppm	<100	Polymer for cleanup	<1.5	<0.1
Building 500	4.0-4.67	0.5-1.0 MO+6	<1450	8.5 - 9.0	0.1-0.5ppm	<100	Polymer for cleanup	<1.5	<0.1

Closed Water Sytems Operating Parameters

System	Type	Treatment Control Range	Conductivity	pH	Free Chlorine	RLU		Corrosion Coupons Mild Steel	Copper
Building 4	Hot	100-150 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 5	Hot	100-150 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 9	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 21/X	Hot	100 - 150 ppm Mo+6		>8.2		<25		<1.5	<0.1

Building 60	Hot	100 - 150 ppm Mo+6		>8.2		<25		<1.5	<0.1

Closed Water Sytems Operating Parameters (cont.)

System	Type	Treatment Control Range	Conductivity	pH	Free Chlorine	RLU		Corrosion Coupons Mild Steel	Copper
Building 64/1	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 64/2	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 94	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 105/SPA	Hot	100 - 150 ppm Mo+6		>8.2		<25		<1.5	<0.1
Building 105/PER	Hot	100 - 150 ppm Mo+6		>8.2		<25		<1.5	<0.1
Building 142/OLD	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 142/NEW	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 301	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 301/MIR	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 301	Hot	100-150 ppm MO+6		>8.2		<25		<1.5	<.01
Building 302	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 333	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1
Building 500	Chilled	75-100 ppm MO+6		>8.2		<25		<1.5	<0.1

COMMENTS: No Morpholine and Nitrite

Micro Biological Operating Parameters

All Cooling Towers Less Than 100 Biomass (RLU)

All Closed Loops Less Than 25 Biomass (RLU)

Legionella Control

The CTI guidelines for effective cooling tower *Legionella* control are application of an oxidizing biocide and maintaining a free chlorine residual of 0.1–0.5 ppm. Additional best practice to minimize risk of *Legionella* is keeping the towers clean and good maintenance.

The program for compliance with these guidelines at NASA Glenn Research Center is:

- Application of liquid sodium hypochlorite (12.1 percent solution) and/or 1-bromo-3-chloro-5, 5-dimethylhydantoin (96 percent). Oxidizer application is continuously fed in tower 1 with chlorine residual testing weekly to ensure free chlorine is in proper range. Adjustments are made through the speed/stroke of the sodium hypochlorite chemical feed pump.

- The hydantoin (C-2189T) is the oxidizer for all other cooling towers. Chlorine residual testing is completed weekly and manual adjustments to chlorine addition are made manually.

- ATP tests are run weekly on all cooling towers. ATP determines the total bacteria levels in the water, which includes *Legionella*. Targets for living ATP is less than 100 RLU. This test combined with the chlorine residual test also determines adjustments to the pump or manual feed.

- The nonoxidizing biocide is fed to compliment the oxidizers. CL-2150 is 1.5 percent isothiazolin. This provides additional bacteria control and supports the general tower cleanliness factor.

- Cleanliness or general maintenance with scale and corrosion inhibitors is critical. There is a program of inhibitor/polymer application and required chemical ranges. These are tested two-three times per week and adjustments made to ensure system control and cleanliness.

Call Henry/NASA Glenn Research Center

CTI strongly recommends that all cooling tower systems in operation are treated with high levels of a halogen-based biocide including chlorine and/or bromine. The ChemTreat water treatment program, which will be implemented at Call Henry/NASA Glenn Research Center meets the Cooling Technology Institute of America's guidelines. When the cooling towers are in operation, we will feed sufficient levels of a halogen-based biocide, sodium hypochlorite. The sodium hypochlorite liquid is fed continuously into the cooling tower #1 and a free chlorine residual of 0.10–0.50 ppm is maintained to combat all types of bacteria including *Legionella*. The other cooling towers will be treated with a bromine/chlorine tablet and a target residual of 0.1–0.5 ppm

will be maintained. This free chlorine residual will be tested by ChemTreat and Call Henry personnel to verify adequate levels are being maintained. Furthermore, bacteria studies are performed weekly and monthly ensure bacteria levels are under control.

A nonoxidizing biocide, CL-2150, will be utilized as described in the CTI guidelines.

ChemTreat utilizes BioTrace to monitor bacteria in cooling tower systems. ChemTreat is one of the only water treatment companies with this technology and yields on site test results within two minutes. BioTrace measures ATP, a protein level in the tower water that is found in all living organisms including aerobic bacteria, molds, yeasts, *Legionella*, nitrifiers, sulfate reducers, iron bacteria, etc. A regular dipslide culture can only measure aerobic bacteria, molds and yeasts. BioTrace measures all living organisms in the tower water, thus; if the living ATP levels with a given cooling tower system are zero or extremely low, the risks for *Legionella* formation have been severely minimized.

Annual water samples of the cooling systems will be sent to a certified laboratory for *Legionella* evaluation.

If *Legionella* cleanup is required, ChemTreat will contract a local expert company certified to provide this service.