**Modify Section 23 25 00 HVAC WATER TREATMENT per the following (deletions are shown struck through and additions are double underlined). Remainder of section is unchanged.**

# 23 25 00 HVAC WATER TREATMENT

**.01 ~~Water Treatment~~General Owner Requirements and Design Intent**

A. The Professional shall ~~follow the University's water treatment guidelines found in The Design and Construction Standards 23 25 00 for a more complete description of the requirements for water treatment.~~design each HVAC water treatment application with all the required equipment, materials and labor to achieve the functional intent of effective and safe operation, high reliability, and minimizing maintenance costs on those piping systems.

1. Construction documents shall include all drawings and specifications necessary to clearly define the scope of work for the contractor to furnish and install all the components and materials required to meet the functional intent above.
    a. Ensure details comply with manufacturer's installation instructions.
    b. Locate in safe and convenient area and provide convenient means for frequently inspecting and cleaning. Maintain manufacturer's recommended clearances.
    c. Coordinate requirements between Specifications and Drawings.

~~A.~~2. Guide Specifications are included at the end of this section.

B. At University Park Campus, ~~the University will~~ OPP's Water Treatment Contractor or authorized Mechanical Water Treatment representative shall be given adequate advance notification (minimum 4 weeks) in order to supervise the introduction of the chemical treatment into the system.

C. The Professional shall discuss provisions of the chemical treatment program at Commonwealth Campus projects with the University.

D. All closed systems (hot water and chilled water) shall be provided with chemical treatment.

E. All open recirculating systems (cooling towers) shall be provided with chemical treatment.

F. All steam boilers shall be provided with chemical treatment.

G. Guidelines for the use of ~~ethylene~~ glycol ~~will also be found in 23 25 00~~are also covered in this section.

~~G.~~H. Minimum requirements for flushing and cleaning of new and existing systems are covered in the Guide Specifications.

**.02 Closed Systems Water Treatment (Hot & Chilled Water)**

A. Equipment: All closed loops shall have a Bypass Feeder (Pot Feeder) piped into the circulation line, so that chemical treatment can be introduced into the system. ~~Pot feeder shall be constructed of 10 gauge steel, minimum. Cap shall be a minimum of 4 inch in size and made of cast iron with Buna N seat ring.~~ A flow indicator shall be installed to show indication of flow through the bypass feeder.

B. Equipment Installation: Bypass feeder shall be installed across the re-circulation pump to allow for a minimum 5 psi pressure drop. The discharge side of the pump shall be piped to the bottom of the feeder and the suction side piped to the top. This will allow an upward flow of material in the feeder. The shot feeder shall be located at least 12 inches off the floor, and manual ball valves shall be conveniently located near the bypass feeder to isolate and drain the bypass feeder. One ball valves shall include a memory stop set to keep a trickle flow through feeder to keep seals wetted.
C. Pre-operational Cleaner: All systems shall be flushed with water prior to chemical cleaning. Use water meter to fill, record, and tag (permanent tag) the system with the actual system volume. Chemical cleaner shall be added to remove grease, mill oil, organic soil, flux, iron oxide etc. All terminal control valves and valves at end of runs ("dead legs") shall be opened so that cleaner is circulated through the whole system. After cleaning, all strainers shall be flushed, and strainer screens cleaned or replaced. Once closed loop is chemically cleaned, system shall be dumped and flushed with water so that all cleaning chemical is removed from the system.
D. Chemical treatment: Shall be an alkaline, buffered, nitrite-based corrosion inhibitor, maintained at proper levels to prevent corrosion to the system.

**.03 Open Re-circulating Systems Water Treatment (Cooling Towers)**

A. Equipment:
    1. All towers (including Evaporative Condenser type Towers) shall be equipped with an automatic blowdown controller, LMI, model DC4000, or approved equivalent. Controller shall have flame retardant, molded TPFE housing and clear polycarbonate cover that can be secured with a padlock. Controller shall be capable of feeding chemicals 4 ways: Pulse, Percent of time, Limit timer, and Percent of bleed. Controller shall have LED indicators for all functions and shall have a 4 to 20 mA output. Controller shall be supplied with a flow assembly to include the conductivity probe as well as a flow switch. The flow switch shall be capable of preventing the controller from operating the blow down valve or feeding chemical if no flow is indicated. Flow assembly shall be able to be isolated by manual ball valves so that assembly can be repaired or replaced.
    2. The fresh water make-up line to the tower shall have an electrical contacting water meter, Carlon, model JSJ, or approved equivalent. This water meter must be capable of sending an electronic pulse to the controller to allow the controller to feed chemical based on the volume of fresh water to the tower. The water meter shall be installed with a by-pass that is capable of being valved off so that water can still feed the tower and meter can be taken out for repairs.
    3. Chemical feed pump shall be LMI, model P131-392SI, or approved equivalent capable of pumping 10 gal/day maximum. Pump shall be supplied with an integral anti-siphon/priming valve. All tubing shall be clear polyethylene. Pump shall be capable of modulating its stroke and speed. Pump shall have a liquid end construction of Polypropylene/Flourofilm/Polyprel.
    4. If the condenser water volume is greater than 800 gallons, a solid halogen feeder (brominator) shall be installed to provide a controlled distribution of tableted, approved bromine and chlorine donors. The brominator shall have an integrally mounted flow meter for accurate feeding and manual valve with the capacity to

adjust the flow from 0 to 5 gal/min. A pressure relief valve shall be used on those applications where the brominator is used on a pressure discharge or if the unit will be used in with conjunction with a solenoid and timer. For systems with less than 800 gallons, a simple water filter housing shall be provided for the feeding of the solid holagen.

B. Equipment Installation:

1. Blow down valve shall be installed so that the valve can be isolated by conveniently located ball valves so that blow down valve can be removed, repaired, and or replaced. A Strainer shall be installed up stream of the blow down valve to catch any dirt or debris that may prevent the blow down valve from functionally properly. Strainer shall be capable of easily being cleaned and replaced.
2. The chemical inhibitor shall be injected into an area of high flow and shall use an injection nozzle that has a check valve to prevent the flow of condenser water into the chemical injection line.
3. All new systems shall have a corrosion coupon rack installed, so that coupons can be used to help diagnose any potential corrosion problems. The rack shall be located so that coupons can be easily removed and installed.

C. Pre-operational Cleaner: All condenser water systems shall be flushed with water prior to chemical cleaning. Use water meter to fill, record, and tag (permanent metal tag) the system with the actual system volume. Chemical cleaner shall be added to remove grease, mill oil, organic soil, flux, iron oxide etc. Once condenser water system is chemically cleaned, the system shall be dumped and flushed with water so that all cleaning chemical is removed from the system. After cleaning, all strainers shall be flushed, and strainer screens cleaned or replaced.

D. Chemical Treatment: Inhibitor shall be designed to control corrosion of all metals, as well as inhibit the formation of scale. The chemical inhibitor shall be a blend of organic inhibitors and dispersants that contain no molybate, zinc, or heavy metals. The use of the chemical inhibitor shall be in compliance with all local discharge regulations. The chemical treatment program shall maintain proper levels of chemical inhibitor to sustain a LSI of 2.5 to 3.0. PH of the condenser water shall not be below 8.0 and not exceed 9.5. Biocide program shall be limited to solid halogen feed chemicals. These chemicals shall be fed in a manor that prohibits the growth of bacteria, especially Legionella prevention.

**.04 Steam Boilers Water Treatment**

A. Equipment:

1. The fresh water make-up to the feed water tank shall be softened to remove calcium and magnesium particles from the water. The softeners shall be regenerated automatically based on a water meter. The unit shall be sized so that softener regenerates approximately twice per week.
2. The feed water tank shall be sized to allow for a minimum of 10-20 minutes residence time of the feed water to allow sufficient time for pre-warming of the feed water. The feed water tank shall be fitted with a stainless steel sparge line. The sparge shall be located on the bottom of the tank to allow for sufficient

contact with the feed water. Holes in the sparge line shall be positioned to the center of the tank away from the tank walls. The oxygen scavenger shall be fed directly into the feed water tank below the water line with a Stainless Steel injection nozzle. The feed water tank shall have a factory-installed coating to help prevent corrosion on the tank walls.

3. A conductivity controller, LMI, model DC-4000, or approved equivalent shall be used to maintain conductivity limits within the boiler. Controller shall have flame retardant, molded TPFE housing and clear polycarbonate cover, which can be secured with a padlock. Controller shall have LED indicators for all functions and shall have a 4 to 20 mA output. The controller will actuate a motorized ball valve when conductivity reaches above the set point. The controller shall then close the motorized ball valve when the conductivity goes below the deadband. The controller must be easily calibrated and come with a high-pressure conductivity probe. Controller shall be provided with a motorized ball valve and globe valve to prevent flashing.
4. Two mixing tanks shall be provided: one for the dispersant and phosphate liquid chemical, another mix tank for the oxygen scavenger. The mix tank pumps shall be relayed to the feed water pump so they are both activated when the feed water pumps are on. Each mix tank shall have a mixer to allow suitable mixing of chemicals. The water for the mix tanks shall be soft water, and if possible from either condensate or feed water tank. Chemical pumps shall be sized to overcome the boiler pressure as well as pressure in the feed water line. All connections from the chemical pump to the point of injection shall be hard piped, with check valves to prevent the feed/boiler water being pushed back into the chemical pump.
5. Stainless Steel Injection nozzles should be used to feed chemicals into the feed water line (or feed water tank for the oxygen scavenger). The injection nozzle for the inhibitor shall be in the feed water line, and after the feed water pumps but as far as possible from the boiler. Each injection nozzle shall be installed with an isolation valve in case any repairs are needed to chemical feed system. Provide check valves on all chemical feed lines to prevent the feed water from pushing back into the chemical injection line.

B. Pre-operational Cleaner: (Boil out) All steam boilers shall to be flushed with water prior to chemical cleaning. Specially formulated, liquid boil-out solution containing inorganic and organic surfactant materials, iron sequestrates, and corrosion inhibitors shall be used. The product shall be designed to remove oil, grease, and mill scale from new boiler surfaces and shall clean water-side surfaces that have become contaminated with oil or grease during service.
C. Chemical Treatment: The dispersant and inhibitor shall be liquid blend of polymeric dispersants, phosphate conditioning agents for control of deposit formation and improved iron and sludge dispersion. Product shall be suitable for FDA/USDA regulated facilities. The dispersant shall be mixed and maintained in a poly mix tank with mixer and high-pressure pump. This pump shall be activated whenever the feed water pumps are turned on. These chemicals shall be injected into the feed water line down stream from the feed water pumps and as close to the boiler as possible. Oxygen scavenger shall be a powdered sodium sulfite, used to protect the feed water tank, piping and boiler from dissolved oxygen attack. The oxygen scavenger shall be mixed and maintained in a poly

mix tank with mixer and pump. The pump shall be activated whenever the feed water pump is turned on. A check valve must prevent any back flow to the pump from the feed water tank.

**.05 ~~Ethylene~~ Glycol Solutions**

A. Equipment: Glycol systems shall be equipped with a mix and fill tank with manual fill capabilities, hose bibb from domestic water for tank filling, and tank level alarm interconnected with the BAS.
B. Equipment Installation:
    1. Do **not** direct-connect makeup lines to glycol systems.
    2. Glycol systems should be configured so that small sections of the system can be isolated with valves and drained to a local floor drain. Alternatively, a tank should be installed at the glycol system fill point that is large enough to capture the entire system's contents.
C. Pre-Operational Cleaning

    1. All systems that are to be filled with a glycol solution shall be cleaned as outlined under "Closed Systems Water Treatment (Hot & Chilled Water)" above.
D. Chemical Treatment

    1. Take reading of Glycol concentration in system. ~~(Should be 25% if system is off during winter months 30% if system runs in the winter ).~~ Required concentration may vary depending on the specific application. Refer to concentration and tolerances in the associated specification.
    2. Shutdown circulation pumps prior to adding additional glycol.
    3. Open air vents at top of system to allow air to escape as system fills.
    4. Use Glycol pump and add Glycol mixture (~~25% or 30%~~ ) until desired pressure is achieved. (If correct pressure level is unknown, use 5 lb. Per floor as rule of thumb).
    5. Turn on pumps and circulate system mixture.
    6. Continue to bleed air until system is free of air.
    7. Close valves to air vents once all air is out of system.
    8. Recheck Glycol concentration and system pressure. Add additional Glycol or water if needed to bring system to correct concentration level and correct pressure.
E. If you are not sure of proper fill procedures or how to determine correct concentration of mixture, please contact Mike Kelleher or one of the Environmental System technicians.

**.06 Side Stream Filters**

A. Closed Systems (Heating and Cooling)
    1. All new closed circulating systems shall have a side stream filter. This shall include all heating hot water, chilled water, dual temperature, and glycol solution piping distribution systems.
    ~~0. Equipment: All closed circulating systems shall have a side stream filter piped into the circulation line, so that suspended solids can be removed from the~~

~~system. All filters shall be bag filter type so that bags can be either taken out and cleaned and reused or replaced. All bags shall be 25 micron size. Filters shall be sized to handle a minimum of 10% of the system flow (gallons per minute) that the circulating pumps are capable of producing.~~

~~0. Filter Vessel: Material of construction shall be 304 Stainless Steel, with removable cap and swing-out bolts with eyenuts. Units shall be capable of 150 psi working pressure. Pressure gauges shall be mounted so that pressure can be read on both sides of the filter. Gauges shall be capable of showing pressures from 0-100 psi, unless a higher operating system pressure is required.~~

~~0. Filter Bags: Construction shall be polyester fiber, felt material. Bags shall be capable of operating temperatures between 275 – 325 ?F. Bags shall be a standard size to fit into the filter vessel.~~

~~0. Equipment Installation: Filter shall be installed across the circulation pump to allow for a minimum of a 5 psig pressure drop across the filter unit. Manual valves shall be conveniently located near the filter to isolate, balance, and drain the filter. A ball valve shall be installed in the inlet pipe to the filter. A combination shut-off/balancing valve shall be installed in the discharge pipe from the filter, and set for 10% system flow at all times. The drain line shall be piped to the sanitary sewer.~~

~~F.~~B. Open Re-circulating Systems (Cooling Towers)

1. All new open circulating condenser water systems shall have a side stream filter.
2. Equipment: All open circulating systems shall have a side stream filter piped into the circulation line, so that suspended solids can be removed from the system. All filters shall be bag filter type so that bags can be either taken out and cleaned and reused or replaced. All bags shall be 100 micron size. Filters shall be sized to handle a minimum of 10% of the system flow (gallons per minute) that the circulating pumps are capable of producing.
3. Filter Vessel: Material of construction shall be 304 Stainless Steel, with removable cap and swing-out bolts with eyenuts. Units shall be capable of 150 psi working pressure. Pressure gauges shall be mounted so that pressure can be read on both sides of the filter. Gauges shall be capable of showing pressures from 0-100 psi.
4. Filter Bags: Construction shall be polyester fiber, felt material. Bags shall be capable of operating temperatures between 275 – 325 ?F. Bags shall be a standard size to fit into the filter vessel.
5. Equipment Installation: Filter shall be installed across the circulation pump to allow for a minimum of a 5 psig pressure drop across the filter unit. Manual valves shall be conveniently located near the filter to isolate, balance, and drain the filter. A ball valve shall be installed in the inlet pipe to the filter. A combination shut-off/balancing valve shall be installed in the discharge pipe from the filter, and set for 10% system flow at all times. The drain line shall be piped to the sanitary sewer.

~~G.~~C. Manufacturer (open Loop only, refer to specification for closed loop)

1. Filter Vessels: Filter Specialists, Inc.

a. BFN 11:
    i. 2” inlet and 2” outlet
    ii. Uses one #1 bag
    iii. Maximum 100 GPM water flow
b. BFN 12:

    i. 2” inlet and 2” outlet
    ii. Uses one #2 bag
    iii. Minimum 4.4 square ft bag surface area
    iv. Maximum 220 GPM water flow
c. BFN 13:

    i. 1” inlet and 1” outlet
    ii. Uses one #3 bag
    iii. Minimum 0.5 square ft bag surface area
    iv. Maximum 25 GPM water flow
d. BFN 14:

    i. 1” inlet and 1” outlet
    ii. Uses one #4 bag
    iii. Minimum 1.0 square ft bag surface area
    iv. Maximum 45 GPM water flow

2. Filter Bags: Filter Specialists, Inc.

    a. Bag Size #1:

        i. Minimum 2.0 square ft bag surface area
        ii. Minimum 2.1 gallon bag volume
        iii. 7” diameter x 16.5” long bag
    b. Bag Size #2:

        i. Minimum 4.4 square ft bag surface area
        ii. Minimum 4.6 gallon bag volume
        iii. 7” diameter x 32” long bag
    c. Bag Size #3:

        i. Minimum 0.5 square ft bag surface area
        ii. Minimum 0.37 gallon bag volume
        iii. 4” diameter x 8.25” long bag
    d. Bag Size #4:

        i. Minimum 1.0 square ft bag surface area
        ii. Minimum 0.67 gallon bag volume
        iii. 4” diameter x 14” long bag

**.07 Water Analysis and Testing for Closed Loop Systems**

A. The purpose of this procedure is to outline the steps used to test any closed re-circulating loops on campus, (chilled water, hot water, glycol, etc.). This procedure also outlines many implications of what might happen if a closed loop system is not properly chemically treated.
B. The following tests will be run on each closed loop:
    1. Visual Inspection:
        a. After taking a sample of the water, the water analyst will visually inspect the water and see how clear the water is. If the water is relatively clear the water analyst may continue with the remaining tests.
        b. If the water appears cloudy and dark brown in color, the analyst will check to see if any filtration system is on the closed loop. If so, the filter may need to be changed or backwashed.
        c. The analyst may choose to take a water sample and let it set for a couple of hours.
            i. After the water sample had time to sit for a couple of hours, if the water starts to clear up and a deposit forms on the bottom of the container – this indicates the water contains high levels of suspended solids.
            ii. If a filter is not already on the system the analyst may choose to recommend installation of some type of filter to help clear up the water.
            iii. Suspended solid loading in a closed water circulating loop can lead to problems, the solids can settle out in low flow areas. The resulting deposit can cause corrosion and provide conditions that promote bacteria growth. Some bacteria can absorb the chemical inhibitors used to prevent corrosion, which will still leave the system untreated, even though chemical has been added. Deposits can act as an insulator preventing good heat transfer. Not maintaining good heat transfer will increase energy costs to any system.
    2. The analyst may choose to run an iron test using the Hach colorimeter based on the degree of water discoloration.

        a. The water analyst should record the readings so comparisons can be made to previous readings to help diagnose the system in the future.
        b. If the dissolved levels of iron are greater than 30 ppm, the analyst will recommend to have the system flushed and chemically cleaned.
        c. High levels of dissolved iron left in the system can lead to more corrosion problems, leaks, poor heat transfer efficiency, as well as bacteria problems.
    3. Conductivity: Every system will have the conductivity measured.

        a. After reading the conductivity with the conductivity meter the analyst will record the current reading and review past readings. A conductivity reading higher or lower than the previous reading generally indicates a number of situations.

i. If the conductivity reading is higher than previous readings, this indicates that something has been added to the system, for example the water analyst may have added chemical to the system during the last service. If chemical was not added and the conductivity has increased dramatically, the water analyst may need to check for potential areas of contamination. If conductivity is above 5000 mmhos, it may be recommended that the system be drained and refilled with treated water.

ii. Extreme levels of high conductivity can lead to some types of corrosion problems.

iii. If the conductivity reading is lower than previously recorded, this indicates that some water was lost from the system. (Most likely the chemical inhibitor levels will be low as well). The water analyst may need to check with area maintenance to see if any work was done on the system to explain the water loss. If the closed system inhibitor (NT403) has been added and conductivity levels have not risen from the last visit, this may indicate the system has a continuous leak. If the conductivity levels remain low (approximately the same conductivity as the raw water), the analyst will need to check for leaks and report the problem to area maintenance.

iv. Running at low conductivity may cause a number of problems. First, it is a huge waste of water, chemicals and energy. Secondly, it may damage equipment. Fresh water makeup brought into a leaking hot water boiler loop will deposit certain types of deposition on the boiler tubes. If the leak is not caught in time the tubes could fail and the boiler may need to be re-tubed. Leaks in a chilled water system can lead to scale build up in heat exchangers and chillers, lowering the equipment efficiencies and raising the Universities energy costs. It may also promote corrosion and may increase the chance of piping failures.

4. Nitrite Test: Each treated closed loop will be tested for Nitrite levels.

   a. The water analyst will check past history of the nitrite levels for each system being tested. If nitrite levels are lower than what is required, the water analyst will add the appropriate amount of closed system inhibitor (GE Betz NT403) to the system. The water analyst should record the approximate amount of closed system inhibitor added to the system. Not maintaining the proper nitrite levels will lead to corrosion problems, which may require the system to be repaired or re-piped. It may also lead to iron oxide deposition in piping causing low flows and reduced heat transfer efficiencies.
   b. If the nitrite levels remain low after adding the closed system inhibitor and conductivity has remained the same. The analyst may choose to run a bacteria test on the system in question by using the GE Betz BioScan.

i. If the readings for the closed system is above 25 RLU's the water analyst may request that the system be flushed.
ii. If the water analyst discovers that the system does have a bacteria growth problem, he may choose to recommend the closed loop system be drained, refilled and treated with a closed system biocide as well as a bio-dispersant. After the system has circulated for a couple of days the system should be dumped and refilled with fresh water retreated with closed system inhibitor (GE Betz NT403).
iii. Within 2 weeks of retreating, the water analyst should retest the closed loop system for bacteria levels again, to verify the bacteria growth problem is gone. Some bacteria can feed off the nitrite in the closed system inhibitor and will in turn promote corrosion was well as increase the chance of slimes and biomasses growing within the system. These bacteria could reduce the efficiencies of the equipment and could cause health and safety issues for employees and the general public.

c. If the nitrite levels are high, it is not recommended to drain the system. Rather, leave the system as is and record nitrite levels. Additional chemical will not hurt the system.
d. The analyst may choose to run a sulfate reducing bacteria test and may need to contact the GE Betz water treatment representative to do so.

5. PH Measurement: Every closed loop will have the pH tested and recorded.

a. The water analyst will review the previous pH reading s and see if any big pH swing is evident.

i. The pH of the closed loop should always be higher than the make up water pH.
ii. The pH of a closed loop should never be below 7.0. If this ever arises, the closed loop should immediately be drained and retreated. Any pH below 7.0 is considered to be a corrosive environment.
iii. It is important to have a properly calibrated pH meter. If the meter is not functioning properly the results may not be helpful in any system diagnosis.

b. If the pH reading has dropped dramatically from the previous service visit, it would indicate that there might be a bacteria growth problem. Refer to the Nitrite Testing section of this procedure for testing and dealing with the potential of bacteria growth.
c. If the pH reading is high (above a pH of 11) the system should be drained, refilled and retreated with closed system inhibitor. Certain types of corrosion can occur at high pH levels.

6. Glycol: Each glycol system should have the glycol measured using a refractometer.

a. This reading will indicate the level of freeze protection the closed loop is treated for.
b. If lower than what is required for the system, the water analyst will contact Central Services for glycol addition.

**.08 Water Treatment Test Control Limits**

A. Condenser Water
    1. 6 to 9 ppm of Phosphonate
    2. 0.5 to 1.0 ppm of Chlorine Residual
    3. 2.5 cycles of concentration
B. Closed Loop Chilled Water System

    1. 300 to 600 ppm of Nitrite
C. Closed Loop Hot Water System

    1. 600 to 900 ppm of Nitrite
D. Glycol Systems

    1. ~~Systems operating in the winter: 30% solution by volume, (3? F freeze protection)~~Refer to concentration and tolerances in the guide specification.
    ~~0. Systems not operating in the winter: 25% solution by volume, (10? F freeze protection)~~

~~F.~~E. Hot Water Boilers

    1. 600 to 900 ppm of Nitrite

~~G.~~F. Steam Boilers

    1. 30-60 ppm of Sulfite
    2. 30-60 ppm of phosphate
    3. 3000-4000 mmhos of neutralized conductivity

## .09 Guide Specifications:

A. Design Professional shall carefully review and edit the guideline specifications below, adapting them as needed to achieve application-specific, fully developed specifications for each project.

B. These shall be edited using the process described in the instructions contained at the beginning of the document. Proposed modifications shall be reviewed with OPP staff.

C. Finalized version shall be included in the project contract documents. Use of other specifications is not acceptable.

| Document | Version Date | Description |
| --- | --- | --- |
| 232500 HVAC WATER TREATMENT - CLOSED SYSTEMS - GUIDE SPECIFICATION | September 19, 2014 | OPP minimum specification requirements for HVAC Water Treatment for Closed Systems |

**END of revision**

**Update Commentary:**

Section was updated primarily for the following reasons:

1) *To add the guide specifications for closed systems*
2) *To revise the portions of the standard associated with closed system to conform to the guide specifications.*

SECTION 232500 – HVAC WATER TREATMENT – CLOSED SYSTEMS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

*General Notes:*

1. *This guide specification is intended to provide the Design Professional with a basic guideline of minimum OPP requirements.*

2. *The guide specification shall be carefully reviewed and edited with respect to application-specific project requirements. Proposed modifications shall be reviewed with OPP Staff.*

3. *Finalized version shall be included in the project contract documents.*

*Editing Notes*

1. *This OPP Guide specification must only be altered by notation (i.e. deleted text with strikethrough and additional text with double underline). This shall be accomplished by using Tools /Track Changes / Highlight Changes, and select "Track changes while editing" in MS Word or equivalent.*

2. *The Review Submittal Specification section shall be provided in electronic form for OPP Review.*

3. *Leave the following Note ("For Construction Document Review, Design Submittal") as part of the Review Submittal, to aid any Reviewer to understand WHY there are strikeouts and underlines. Also, leave any "DESIGNER NOTE" placed in this Guide Spec.*

4. *AFTER comments are received from PSU and incorporated, the strikeouts and underlines shall be removed, and the REVIEWER NOTEs deleted, before the spec is issued for Bidding.*

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. All sections of the project manual are directly applicable to this specification section. Should a conflict arise between specification sections or between specifications and drawings and/or code requirements, the contractor shall notify the Architect/Engineer of the conflict in writing. If

direction is not provided prior to the submission of the bid, the contractor shall price the more extensive system.

1.2 SUMMARY

A. This Section defines:
   1. The coordinated scope of work required of:
      a. The Mechanical Contractor (MC)
      b. The Water Treatment Contractor (WTC)
      c. The Owner (PSU)
      d. The Controls Contractor (BAS)
   2. The hydronic systems that will be cleaned and treated under this contract.
   3. The equipment required and procedures that must be followed in performing the work.
   4. The definition of final piping system condition and system water quality required at project completion.
   5. Submittals

B. Scope of Work
   1. Systems:
      a. System #1 (i.e. building chilled water hydronic system) [**To be edited by designer**]
      b. System #2 (i.e. building process chilled water hydronic system) [**To be edited by designer**]
      c. System #3 (i.e. building hot water hydronic system) [**To be edited by designer**]

C. Project Coordination
   1. General:
      a. The Mechanical Contractor (MC) shall subcontract the WTC to provide direction and supervision for the execution of the system cleanup.
      b. Hydronic system material and labor for the system cleanup shall be provided by the MC, and directed by the WTC. PSU will supply specific components for installation to maintain consistency in maintenance items. All items not specifically addressed as “provided by owner” will be provided and installed by the MC.
      c. All chemicals used for cleanup and system startup shall be provided by the WTC.
      d. The owner (PSU) shall be the sole judge of system quality based on testing and sampling reports provided by the WTC.
      e. PSU technicians shall not be involved in the cleaning, operation or acceptance of the systems prior to the formal project acceptance, unless directed by the owner.

D. Contact Information
   1. Water Treatment Contractor
      a. Brian Merrill
         Account Manager
         GE Power and Water
         Water & Process Technologies
         (p) 800-786-8599, ext. 1218
         (c) 315-569-7227

2. Owner
   a. Stephen Oskin
      Continuous Commissioning Engineer
      139B Office of Physical Plant
      University Park, PA 16802
      seo110@psu.edu
      814-867-4715

1.3 PERFORMANCE REQUIREMENTS

A. Closed piping loops, including heating, cooling, heat recovery or drycooler (glycol or water) shall have the following water qualities:

B. Water Test Results:
   1. pH: maintain a value from 8 to 10.3.
   2. Conductivity: Less than 3,000mmhos
      a. System must be capable of operating for a minimum of (4) weeks on a 10 micron filter bag.
   3. Nitrite (steel protection): maintain a level of 300 to 600 PPM (1000 PPM if system is off-line).
   4. Azole (copper protection): 3-6 PPM Total (greater than 3 PPM free and available). 6 PPM if system is offline.
   5. Iron: Less than 0.5 PPM
   6. Copper: Less than 0.2 PPM
   7. Bacteriological testing (i.e. bioscan, dipslide): Less than or equal to 1,000 Cells/ml. A bioscan of ATP at 50 RLU or lower.
   8. Mild steel corrosion coupons: Less than 0.5 mils per year (MPY) corrosion rate. (1 mil = 0.001")
   9. Copper corrosion coupons: Less than 0.1 mils per year (MPY) corrosion rate.
   10. Glycol percentage and type must be listed on test results.

The University standard for freeze protection utilizes Propylene Glycol (PG) in new facilities and in systems that have been fully flushed and cleaned, provided the mechanical system has capacity for the increased viscosity and reduced heat transfer characteristics.

Certain new systems and the majority of the existing systems are currently filled with Ethylene Glycol (EG). While EG has superior freeze protection, viscosity and heat transfer characteristics, the environmental impact and safety concerns of this product warrant phase-out. Contact PSU for direction on existing system freeze protection.

Design Professional shall determine and edit the appropriate concentration below to assure adequate freeze protection, minimum pump energy penalty, and avoiding biological growth for each application.

Applications may require higher concentrations for maintaining full circulation of fluid such as snow-melting, glycol runaround heat recovery, hydronic systems subjected to 100% outside air, process cooling applications requiring circulating fluid near or below 32°F.

Other applications can also include adequate burst protection in non-circulating, isolated parts or zones of a hydronic system where intermittent or seasonal operation increase the danger of freezing (for example – exterior piping and evaporator of air cooled chillers systems).

The concentration must also be kept above approximately 25% to avoid glycol becoming food source for bacteria and thus promoting biological growth which can lead to the formation of glycolic acid. Review with University's HVAC Water Treatment Representative. That minimum can be higher than the minimum calculated for minimum freeze/burst protection.

**Remove the non-applicable glycol below:**

C. Glycol Systems
   a. [**Propylene Glycol**] (Preferred)
      1) Minimum Concentration: [**30%**] (by volume)
         a) Tolerance: 0 to +5%
      2) Pre-inhibited glycol is not acceptable, i.e.: Phosphate Inhibited Blends or premixes. If a system is filled with inhibited glycol without written acceptance from PSU, the system will be drained, cleaned, flushed and refilled with the appropriate solution at the contractor's expense.
      3) Inhibitor: Uninhibited
   b. [**Ethylene Glycol**]
      1) Minimum Concentration: [**30%**] (by volume)
         a) Tolerance: 0 to +5%
      2) Pre-inhibited glycol is not acceptable, i.e.: Phosphate Inhibited Blends or premixes. If a system is filled with inhibited glycol without written acceptance from PSU, the system will be drained, cleaned, flushed and refilled with the appropriate solution at the contractor's expense.
      3) Inhibitor: Uninhibited

1.4 ACTION SUBMITTALS

A. MC shall submit product data for each type of product indicated. These must clearly indicate the model number along with all options that are being provided. Include dimensional data and pipe connection size.

B. Design engineer shall submit to WTC an estimated hydronic system volume for each system included in the project scope. Volume estimate shall be based on piping and component sizing and amount. This estimate must be provided prior to MC contacting WTC for quote as chemical quantities are directly related to system volume.

C. WTC shall submit post flush/clean/treatment test report.

PART 2 - PRODUCTS

2.1 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass chemical pot feeder. Manufacturer: Neptune. Model#: DBF-2HP. Furnished by owner, installed by MC.

2.2 CHEMICAL TREATMENT TEST EQUIPMENT

A. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material (304SS), complete with piping, valves, flow control device, and (4) coupon holders. Pipe Size: 1" NPT. Manufacturer: GE. Model#: 2032806. Furnished by owner, installed by MC.

2.3 SIDE STREAM BAG FILTER HOUSING

A. Stainless steel vessel. Gaskets rated for 230°F minimum. 1 ½ " NPT side inlet and bottom outlet. Manufacturer: Filter Specialist Inc. Model# CBFP11 or CBFP12. Furnished by owner, installed by MC. Filtration Media (Filter Bag) for inside the housing provided by WTC.

Bag filters are selected based on the integrity of the system. New systems should be provided with a 10 micron bag, existing or renovated systems with good water quality should be provided with a 10 or 25 micron bag, systems with poor water quality or piping integrity should be supplied with 50 micron bags.

2.4 CHEMICALS

A. Excluded from MC scope. Provided by WTC, Chemicals shall be as recommended by WTC that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements".

2.5 MAKE-UP WATER METER

A. Direct read water meter with remote capability. Manufacturer: Neptune. Model#: T-10 Size: 5/8", Tricon 4-20mA encoder option. Furnished and installed by MC, connection to local control system by BAS contractor.

B. Controls contractor to provide and install SCADA meter interface unit (SMIU) Ether Meter Model EM-100 required for interface to BAS system.

2.6 GLYCOL FEED SYSTEMS

A. Single System Connection
   1. Neptune Model G-50-1
      a. Tank: 50 Gallon Polyethylene
      b. Pump: Bronze Rotary Gear, 1.5 gpm @ 100 psi

c. Controls:
   1) Hand – Off – Auto control.
   2) Low level and operational pilot lights
   3) Dry contact for low-level alarm connected to DDC control system
d. Power: Plug, 115/1/60
e. Solution: Pre-mixed, uninhibited glycol (PG or EG, 30%)

B. Dual System Connection
1. Neptune Model G-50-2
   a. Tank: 50 Gallon Polyethylene
   b. Pump: Bronze Rotary Gear, 1.5 gpm @ 100 psi
   c. Controls:
      1) Hand – Off – Auto control.
      2) Low level and operational pilot lights
      3) Dry contact for low-level alarm connected to DDC control system
   d. Power: Plug, 115/1/60
   e. Solution: Pre-mixed uninhibited glycol (PG or EG, 30%)

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. MC shall install bypass chemical pot feeder(s), glycol feed systems, and side stream filter(s) on concrete bases, level and plumb. Anchor floor-mounted equipment to substrate. Maintain manufacturer's recommended clearances and arrange such that all equipment that will require service is accessible.

B. MC shall install coupon station(s) on wall near water chemical application equipment. Alternatively strut materials may also be used to construct a freestanding bracket for mounting.

C. MC shall install makeup water meters in all closed loop, non-glycol hydronic systems.

D. Install bypass piping or hoses at the supply and return piping connections at heat exchangers, chillers, cooing towers, pumps and cooling coils, etc, to prevent debris from being caught or causing damage to equipment which will be connected to the piping system

E. MC shall insulate all systems in compliance with the mechanical insulation specifications. Direct connections between pipe hangers and piping are prohibited.

F. MC is responsible for installation of all hardware items in the construction drawings and specifications.

Remove this section if project is for an entirely new system.

G. MC shall perform all of the hydronic piping system modifications indicated on the design drawings. Unless noted otherwise, the MC shall furnish and install all piping, equipment, and appurtenances indicated.

H. The Controls Contractor (BAS) shall implement a control strategy to provide **[daily] [weekly]** circulation of the of the entire hydronic system to prevent stagnation of the system. The control strategy shall be fully automated for this purpose. The WTC shall work with the design engineer, controls contractor and the MC to develop a circulation plan that will ensure flow throughout the facility. In variable volume systems, the pumping system is not designed to operate the entire system at design flow. A coordinated isolation plan is required to circulate the system in sections.

I. The Controls Contractor (BAS) shall implement a control strategy to provide single action (one BAS command) circulation of the of the entire hydronic system to allow circulation of the system during treatment.

## 3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. MC shall install piping adjacent to equipment to provide manufacturer or engineer required and recommended service and maintenance clearances.

C. MC shall make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified elsewhere in these contract specifications.

D. MC shall install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section "General-Duty Valves for HVAC Piping." [**To be edited by designer**]

E. All components shall be installed with unions, flanges, isolation valves, and bypasses where required to maintain system operation during routine maintenance and repair. Under no circumstances should a hydronic system require shutdown to service water treatment equipment.

F. Refer to Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems. [To be edited by designer]

## 3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. PSU shall inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.

3. MC shall test for leaks and defects per the Hydronic Piping specification section.

Designer is to select one or both sections below to direct system cleaning. It is up to the discretion of the designer to modify the sequence based on project scope. The Owner must accept the modified scope prior to issuing documents for bid.

## 3.4 FLUSHING AND CLEANING (New Systems)

A. The system must be pressure tested and accepted as leak free per the "Hydronic Piping" specification by the owner prior to flushing and cleaning.

B. Control systems that operate automatic isolation valves, temperature control valves, or other automated hydronic devices must be in place and operational prior to cleaning. Manual operation of automated valves is not acceptable.

C. On completely new piping system installations, the contractor shall use temporary strainers to flush and clean the piping systems. Do not use Owner's permanent strainers to trap debris during pipe flushing operations. Fit the temporary construction strainers with a line size blowoff valve.

D. The MC/WTC shall submit a cleaning and chemical treatment plan to the owner for approval prior to execution.

E. For new systems that will connect to existing systems utilize section 3.5 Flushing and Cleaning (Existing / Expanded / Modified systems)

F. The MC shall:
1. Fill the system with fresh water. Meter the fill level to ascertain the system volume.
2. Open/close automated valves as required to achieve flow in all areas.
    a. The WTC shall work with the design engineer, controls contractor and the MC to develop a circulation plan that will ensure flow throughout the facility. In variable volume systems, the pumping system is not designed to operate the entire system at design flow. A coordinated isolation plan is required to circulate the system in sections.
    b. The system should be operated as close to 10 ft/sec as possible during the cleaning and flushing operations.
    c. Install all piping main bypasses as required to facilitate cleaning.
3. Enable the pumps, and circulate the system for a length of time to be determined by the WTC. The circulation cycle time will vary greatly depending on flow, system size and isolation strategy.
4. Flush the system with fresh water for time period as directed by the WTC.
5. Disable the pumps.
6. The WTC will test and verify flush water quality before proceeding.
7. Drain the system.
8. Remove all startup strainers from the system, and clean. This includes strainers at pumps, terminal devices, fill points, etc.
9. Purge the dirt separator (if not connected directly to side stream filter), and replace the side stream filter bag.

10. Fill the system and chemically clean the system as directed by the WTC.
11. Perform additional strainer cleanings in the defined systems as requested by the WTC.
12. Repeat the cleaning process until the WTC deems the system acceptable.
13. Perform final flush as directed by WTC.
14. The WTC will test and verify the final flush water condition before proceeding.
15. Remove all startup strainers from the system, and replace with the specified operational strainer. This includes strainers at pumps, terminal devices, fill points, etc.
16. Refill system to operating pressure, WTC shall treat the system for normal operation.
17. The WTC will provide test reports of system water quality to the owner for verification.

G. The WTC shall:
   1. Develop an approved cleaning and treatment plan in coordination with the MC and the BAS contractor.
   2. Utilizing labor provided by the MC as needed, flush and chemically clean the defined hydronic systems as required to obtain completely clean and scale free internal piping surfaces.
      a. Criteria for system acceptance:
         1) Acceptable water test results within defined ranges from the main pump location.
         2) Acceptable water test results within defined ranges from remote areas in quantities and locations defined by the WTC and PSU.
   3. After system cleaning is complete, provide water treatment as needed to allow the loop water quality parameters to fall within the ranges specified under section 1.2 “Performance Requirements”.
   4. Maintain hydronic water system testing and treatment throughout the warranty period of (1) year after project acceptance.
   5. Provide a project closeout report and ongoing maintenance plan to the owner
      a. Domestic water test results
      b. Initial startup water test results
      c. Monthly water test results during warranty operation
      d. System maintenance schedule
      e. Final water test results, at conclusion of warranty period.
   6. At [**four**] week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that chemical treatment program is maintaining water quality within performance requirements specified in this Section. WTC shall schedule the monthly testing with PSU to involve owner representatives. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

## 3.5 FLUSHING AND CLEANING (Existing / Expanded / Modified Systems)

A. Existing systems shall be cleaned and flushed prior to the installation of new work. Existing systems typically have large amounts of debris and contaminants that can cause damage to new components, and once removed, may cause excessive leakage. Every effort shall be made to remove this debris prior to installation and operation of new equipment.

B. Control systems that operate automatic isolation valves, temperature control valves, or other automated hydronic devices must be in place and operational prior to cleaning. Manual operation of automated valves is not acceptable.

Remove either paragraph C or D based on project scope. Large scale renovations or cleanup projects should use C. Smaller projects should use paragraph D. Request direction from the Owner for clarification.

C. New equipment (or otherwise in very good condition) shall not be used for the circulation of chemical cleaning solutions intended to remove built-up scale and corrosion in existing piping systems at any point, before or after system modification. Options may include the following:

1. If the existing pump system are already in poor condition and/or would not be appropriate for meeting final operating conditions and are not economical to salvage and thus to be entirely replaced anyway, the contractor may use the existing pump for the circulation of cleaner/dirty fluid prior to replacement.

2. If the existing pump system is otherwise in good condition and planned to be reused after chemical cleaning operations, then:
   a. Include all materials and labor for inspection and cleaning of all wetted parts and replacing of worn items, at a minimum the definite replacement of the seals, after all chemical cleaning and flushing is completed and before system is refilled with final clean fluid.

Pumps that have been running in closed systems with contaminated, dirty water are at much higher risk of premature mechanical seal failures. Furthermore, existing pumps that are run during restorative chemical pipe cleaning and flushing processes will assuredly have their seals compromised or damaged to the point of imminent or immediate failure thereafter due to the high concentration of dissolved and suspended solids removed from the internal pipe surfaces. Projects that are intended to include major pipe cleanup using aggressive chemical cleaners shall include option b. Coordinate below with list of Allowances, Unit Prices or Alternate Bids in Division 1, whatever is most appropriate for the project scope. Request direction from the Owner for clarification if unsure.

   b. [**For each existing pipe system to be restored via chemical cleaning, provide cost to furnish and install a temporary pump with performance characteristics to achieve the purposes of restorative chemical pipe cleaning and handling the associated aggressive and abrasive circulating fluid for the duration of the process. Upon system acceptance, the cleaning circulator is to be removed and replaced with the specified operational pump. Additional cleaning is not to be required once the new pump is in place.**]

D. When constructing minor piping modifications or additions verify with Owner if the Owner's pumps and strainers can be used for flushing and chemical cleaning operations. When the flushing and cleaning operations are complete, the contractor shall insure the strainer baskets and screens installed in the piping systems permanent strainers replaced with clean elements. Keep temporary strainers in service until the equipment has been tested, then replace straining element with a new strainer and deliver the old straining elements to Owner. Fit the Owners strainers with a line size blowoff valve.

E. The MC shall:
1. Install bypasses to facilitate system flush as directed by the Engineer or Owner.
   a. Bypasses are typically located where steel connects to copper, where main piping terminates, or at terminal equipment.
2. Starting with an existing system where the system is filled and operational.
3. Remove all strainers from the system, and clean or replace as necessary. This includes strainers at pumps, terminal devices, fill points, etc.
4. Open/close automated valves as required to achieve flow in all areas.
   a. The WTC shall work with the design engineer, controls contractor and the MC to develop a circulation plan that will ensure flow throughout the facility. In variable volume systems, the pumping system is not designed to operate the entire system at design flow. A coordinated isolation plan is required to circulate the system in sections.
   b. The system should be operated as close to 10 ft/sec as possible during the cleaning and flushing operations.
   c. Install all piping main bypasses as required to facilitate cleaning.
5. Enable the pumps, and circulate the system for a length of time to be determined by the WTC. The circulation cycle time will vary greatly depending on flow, system size and isolation strategy.
6. Flush the system with fresh water for a time period as directed by the WTC.
7. Purge the dirt separator (if not connected directly to side stream filter), and replace the side stream filter bag (if present).
8. Remove all strainers from the system, clean and replace. This includes strainers at pumps, terminal devices, fill points, etc.
9. Refill system to normal operating pressure and chemically clean the system as directed by the WTC.
10. Perform additional strainer cleanings in the defined systems as requested by the WTC. Compensation for this work will be based upon unit prices to clean single strainers 3/4 inch through 8 inch. MC shall fill out and submit at bid time the unit price sheet included at the end of this specification section. The initial bid should include three (3) strainer cleanings and removal of the new startup strainers.
11. Repeat the cleaning process until the WTC deems the system acceptable.
12. Modify the systems per the construction documents/job scope.
13. Fill the system with fresh water. Meter the fill level to ascertain the new system volume.
14. Open/close automated valves as required to achieve flow in all areas.
   a. The WTC shall work with the design engineer, controls contractor and the MC to develop a circulation plan that will ensure flow throughout the facility. In variable volume systems, the pumping system is not designed to operate the entire system at design flow. A coordinated isolation plan is required to circulate the system in sections.
   b. The system should be operated as close to 10 ft/sec as possible during the cleaning and flushing operations.
   c. Install all piping main bypasses as required to facilitate cleaning.
15. Enable the pumps, and circulate the system for a length of time to be determined by the WTC. The circulation cycle time will vary greatly depending on flow, system size and isolation strategy.
16. Flush the system with fresh water for time period as directed by WTC.
17. Remove all startup and existing strainers from the system, clean, and reinstall. This includes strainers at pumps, terminal devices, fill points, etc.

18. Purge the dirt separator (if not connected directly to side stream filter), and replace the side stream filter bag.
19. Fill the system to new operating pressure as defined by Design Engineer and chemically clean the system as directed by the WTC.
20. Perform additional strainer cleanings in the defined systems as requested by the WTC.
21. Repeat the cleaning process until the WTC deems the system acceptable.
22. Remove all startup strainers from the system, and replace with the specified operational strainer. This includes strainers at pumps, terminal devices, fill points, etc.
23. Refill system to operating pressure, WTC shall treat the system for normal operation.
24. Provide test reports of system water quality to the owner for verification.

F. The WTC shall:
1. Develop an approved cleaning and treatment plan in coordination with the MC and the BAS contractor.
2. Utilizing labor provided by the MC as needed, flush and chemically clean the defined hydronic systems as required to obtain completely clean and scale free internal piping surfaces.
   a. Criteria for system acceptance:
      1) Acceptable water test results within defined ranges from the main pump location.
      2) Acceptable water test results within defined ranges from remote areas in quantities and locations defined by the WTC and PSU.
3. After system cleaning is complete, provide water treatment as needed to allow the loop water quality parameters to fall within the ranges specified under section 1.2 “Performance Requirements”.
4. Maintain hydronic water system testing and treatment throughout the warranty period of (1) year after project acceptance.
5. Provide a project closeout report and ongoing maintenance plan to the owner
   a. Domestic water test results
   b. Initial startup water test results
   c. Monthly water test results during warranty operation
   d. System maintenance schedule
   e. Final water test results at end of warranty period
6. At [**four**] week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that chemical treatment program is maintaining water quality within performance requirements specified in this Section. WTC shall schedule the monthly testing with PSU to involve owner representatives. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

## 3.6 WARRANTY

A. Hydronic system acceptance will not occur until after receipt of an approved water quality test report from WTC.

B. The MC shall warrant the installation of the Hydronic System in compliance with the project contract requirements.

C. The WTC shall warrant the individual components, work products and chemical treatment of the system for one (1) year from project acceptance. **<Not applicable for existing systems>**

D. The Owner reserves the right to independently test water systems to ensure compliance with the established criteria. If a discrepancy should arise between the WTC results and the Owner's results, an independent testing agency will be contracted to verify the testing results. In the event that the independent results verify that the system is not within compliance, the WTC shall clean and treat the system at no cost to the owner, with system acceptance verified by the independent testing agency.

END OF SECTION 232500