

SECTION 232516 - WATER TREATMENT FOR OPEN-LOOP HYDRONIC SYSTEMS

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on Masterworks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on Masterworks/Supporting Information.

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.

1.2 SUMMARY

- A. Section includes the following HVAC water-treatment systems:
 - 1. Manual chemical-feed equipment.
 - 2. Automatic chemical-feed equipment.
 - 3. Ozone-generator biocide equipment.
 - 4. Stainless-steel pipes and fittings.
 - 5. UV biocide equipment.
 - 6. Chemical treatment test equipment.
 - 7. Chemicals.
- B. Related Requirements:
 - 1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water softeners, RO equipment, and filtration equipment.

1.3 DEFINITIONS

- A. EEPROM: Electrically erasable, programmable read-only memory.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- C. RO: Reverse osmosis.
- D. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
1. Bypass feeders.
 2. Water meters.
 3. Inhibitor injection timers.
 4. pH controllers.
 5. TSS controllers.
 6. Biocide feeder timers.
 7. Chemical solution tanks.
 8. Injection pumps.
 9. Ozone generators.
 10. UV-irradiation units.
 11. Chemical test equipment.
 12. Chemical material safety data sheets.
- B. Shop Drawings: Pretreatment and chemical[, and **ozone-generator biocide**][, and UV] treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems.
1. Include plans, elevations, sections, and attachment details.
 2. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Other Informational Submittals:
1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
 2. Water Analysis: Illustrate water quality available at Project site.
 3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2.2 PERFORMANCE REQUIREMENTS

- A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Open HVAC systems, including [condenser] [fluid-cooler spray] water, shall have the following water qualities:
 - 1. pH: Maintain a value within [8.0 to 9.1] <Insert range>.
 - 2. "P" Alkalinity: Maintain a maximum value of [100] <Insert number> ppm.
 - 3. Chemical Oxygen Demand: Maintain a maximum value of [100] <Insert number> ppm.
 - 4. Soluble Copper: Maintain a maximum value of [0.20] <Insert number> ppm.
 - 5. TSS: Maintain a maximum value of [10] <Insert number> ppm.
 - 6. Ammonia: Maintain a maximum value of [20] <Insert number> ppm.
 - 7. Free "OH" Alkalinity: Maintain a maximum value of [zero] <Insert number> ppm.
 - 8. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of [10,000] <Insert number> organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of [1000] <Insert number> organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of [100] <Insert number> organisms/mL.
 - d. Sulfate Reducers: Maintain a maximum value of [zero] <Insert number> organisms/mL.

- e. Iron Bacteria: Maintain a maximum value of [zero] <Insert number> organisms/mL.
 - 9. Polymer Testable: Maintain a minimum value within [10 to 40] <Insert range>.
 - 10. <Insert other requirements if necessary>.
- D. Passivation for Galvanized Steel: For the first 60 days of operation.
- 1. pH: Maintain a value within [7 to 8] <Insert range>.
 - 2. Calcium Carbonate Hardness: Maintain a value within [100 to 300] <Insert range> ppm.
 - 3. Calcium Carbonate Alkalinity: Maintain a value within [100 to 300] <Insert range> ppm.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
- 1. Capacity: [2 gal. (7.6 L)] [5 gal. (19 L)] <Insert value>.
 - 2. Minimum Working Pressure: [125 psig (860 kPa)] [175 psig (1210 kPa)] <Insert value>.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

- A. Water Meter:
- 1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
 - 2. Body: Bronze.
 - 3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
 - 4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 - 5. Registration: Gallons (Liters) or cubic feet (cubic meters).
 - 6. End Connections: Threaded.
 - 7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac, and that will close at adjustable increments of total flow.
 - 8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Water Meter:
- 1. AWWA C701, turbine-type, totalization meter.
 - 2. Body: Bronze.
 - 3. Minimum Working-Pressure Rating: 100 psig (690 kPa).
 - 4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 - 5. Registration: Gallons (Liters) or cubic feet (cubic meters).
 - 6. End Connections: Threaded.
 - 7. Control: Low-voltage signal capable of transmitting 1000 feet (305 m).

8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: **[Bronze] [Epoxy-coated cast iron]**.
3. Minimum Working-Pressure Rating: **150 psig (1035 kPa)**.
4. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa)**.
5. Registration: **Gallons (Liters) or cubic feet (cubic meters)**.
6. End Connections: Flanged.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac, and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High- or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. TSS Controller:
1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door.[**Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
 2. Digital display and touch pad for input.
 3. Sensor probe adaptable to sample stream manifold.
 4. High, low, and normal conductance indication.
 5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
 6. Hand-off-auto switch for solenoid bleed-off valve.
 7. Bleed-off valve activated indication.
 8. Internal adjustable hysteresis or deadband.
 9. Bleed Valves:
 - a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
 - b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.
- G. Biocide Feeder Timer:
1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door.[**Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."**]
 2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
 3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
 4. Solid-state alternator to enable use of two different formulations.
 5. 24-hour display of time of day.
 6. 14-day display of day of week.
 7. Battery backup so clock is not disturbed by power outages.
 8. Hand-off-auto switches for biocide pumps.
 9. Biocide A and Biocide B pump running indication.
- H. Chemical Solution Tanks:
1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
 2. Molded cover with recess for mounting pump.
 3. Capacity: [30 gal. (114 L)] [50 gal. (189 L)] [120 gal. (454 L)] <Insert value>.
- I. Chemical Solution Injection Pumps:
1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.

2. Adjustable flow rate.
 3. Metal and thermoplastic construction.
 4. Built-in relief valve.
 5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
 6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- J. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.
- K. Injection Assembly:
1. Quill: Minimum **NPS 1/2 (DN 15)** with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
 2. Ball Valve: **[Three] [Two]**-piece stainless steel as described in "Stainless-Steel Pipes and Fittings" Article; selected to fit quill.
 3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
 4. Assembly Pressure/Temperature Rating: Minimum **600 psig (4137 kPa)** at **200 deg F (93 deg C)**.

2.5 OZONE-GENERATOR BIOCIDE EQUIPMENT

- A. Corona discharge generator with stainless-steel generating cells, and transformer housed in a NEMA 250, Type 4 enclosure. Assembly shall be suitable for continuous duty. Include factory-mounted site glasses to verify proper operation of generator.
- B. Generator vessels shall be constructed according to ASME Boiler and Pressure Vessel Code, bear an ASME label, and be equipped with pressure relief valve.
- C. External air compressor or induced airflow through a cleanable prefilter shall supply concentrated oxygen through a molecular sieve with **minus 62 deg F (minus 52 deg C)** dew point to avoid the formation of nitric acid.
- D. Controls: Microprocessor based with software in EEPROM, surge protection, high-temperature cutout, and operational status lights. **[Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."]**
- E. Ozone Contactors:
1. Bubble diffusers.
 2. Induction injection nozzle.
 3. Injectors with static mixers.
- F. Ozone Detector and Alarm Devices:
1. Detector:

- a. Sensor: Metal dioxide semiconductor.
 - b. Concentration Range: **[0.01 to 0.14]** <Insert range> ppm.
 - c. Accuracy: Plus or minus 20 percent of range.
 - d. Sensitivity: 0.01 ppm.
 - e. Response Time: Maximum 10 seconds.
 - f. Operating Temperature: **50 to 100 deg F** (10 to 38 deg C).
 - g. Relative Humidity: 20 to 95 percent, noncondensing over the operating temperature range.
2. Horns:
- a. Electric-vibrating-polarized type.
 - b. 24-V dc, with provision for housing the operating mechanism behind a grille.
 - c. Horns shall produce a sound-pressure level of 90 dBA, measured **10 feet (3 m)** from the horn.
 - d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Visible Alarm Devices:
- a. Xenon strobe lights listed in UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate.
 - b. Rated Light Output: **[75] [110]** <Insert number> candela.
 - c. Strobe Leads: Factory connected to screw terminals.
 - d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Self-Contained Breathing Apparatus: Open-circuit, pressure-demand, compressed air includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.
- 1. Face Piece: EPDM or silicone rubber construction material, one-size-fits-all with double-sealing edge, stainless-steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in mask, close-fitting nose piece to ensure no CO₂ buildup, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.
 - 2. Backplate: Orthopedically designed of **[chemical and impact-resistant, glass-fiber composite] [aluminum]**.
 - 3. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulder straps. Modular in design, detachable components, and easy to clean and maintain. Shoulder straps padded with flame-resistant material, reinforced with stainless-steel cable, and attached with T-nuts, washers, and screws.
 - 4. Air Cylinder: **[30] [45] [60]**-minute, low-pressure, air-supply-loaded **[fiberglass] [aluminum] [steel]** cylinders fitted with quick-fill assembly for refilling and air transfer.
 - 5. Wall-Mounting Cabinet: Leakproof, corrosion-resistant, clear, plastic case.
 - 6. Tested and Certified: By the National Institute for Occupational Safety and Health and by the Mine Safety and Health Administration, according to 42 CFR 84, Subpart H.

2.6 STAINLESS-STEEL PIPES AND FITTINGS

- A. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.
- B. Stainless-Steel Fittings: Comply with ASTM A 815/A 815M, Type 316, Grade WP-S.
- C. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351/A 351M, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and **250-psig (1725-kPa)** steam working-pressure rating and **600-psig (4140-kPa)** cold working-pressure rating.

2.7 UV BIOCIDES EQUIPMENT

- A. Target Irradiation: Minimum 30,000 microwatts x s/sq. cm.
- B. Light Source Vessels:
 - 1. ASTM A 666, Type 304 stainless steel.
 - 2. Construct for minimum **[150 psig (1035 kPa)]** <Insert value> at **[150 deg F (65 deg C)]** <Insert value> according to ASME Boiler and Pressure Vessel Code, and equipped with pressure relief valve.
 - 3. Light Source Sleeve: Quartz, with EPDM O-ring seals.
 - 4. Light Source: Replaceable UV lamp producing a minimum target irradiation of 254-nm wavelength light.
- C. Controls: Interlock with pumps to operate when water is circulating.

2.8 CHEMICAL TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TSS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
- B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 - 1. **[Four]** <Insert number>-station rack for open systems.

2.9 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water testing equipment on wall near water chemical application equipment.
- D. Install interconnecting control wiring for chemical treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Install automatic chemical-feed equipment for [condenser] [fluid-cooler spray] water and include the following:
 - 1. Install makeup-water softener.
 - 2. Install water meter in makeup-water supply.
 - 3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
 - a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
 - 4. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 5. Install TSS controller with sensor and bleed valves.
 - a. Bleed valves shall cycle to maintain maximum TSS concentration.
 - 6. Install pH sensor and controller with injection pumps and solution tanks.
 - a. Injector pumps shall operate to maintain required pH.
 - 7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
 - a. Injection pumps shall operate to feed biocide on an alternating basis.
 - 8. Install ozone generator with diffusers in condenser-water piping.

- a. Ozone generator shall operate continuously with condenser-water flow.
- 9. Install UV-irradiation lamps in condenser-water piping.
 - a. UV lights shall operate continuously with condenser-water flow.

3.3 OZONE-GENERATOR INSTALLATION

- A. Install ozone generator and equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Pipe ozone from ozone generator to condenser water with stainless-steel pipe and fittings with welded joints.
- D. Install [**two**] [**three**]-piece, stainless-steel ball valve in ozone supply to condenser water.
- E. Pipe cooling water to ozone generator and to air-gap drain fitting with stainless-steel pipe and fittings with welded joints where enclosed in ozone-generator room.
- F. Install [**two**] [**three**]-piece, stainless-steel ball valve in cooling water supply to ozone generator.
- G. Mounting supports for ozone generator shall be ASTM A 666, Type 316 stainless steel.
- H. Mount breathing apparatus outside ozone-generator room.
- I. Mount and install ozone detector, warning lights, and audible alarm inside ozone-generator room. Mount another set of warning lights and audible alarm just outside the main entrance to ozone-generator room.

3.4 UV-IRRADIATION UNIT INSTALLATION

- A. Install UV-irradiation units on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install seismic restraints for UV-irradiation units and floor-mounting accessories and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

3.5 CONNECTIONS

- A. Where installing piping adjacent to equipment, allow space for service and maintenance.

- B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for dielectric fittings.
- C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."
- D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
- E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.

- D. Prepare test and inspection reports.
- E. At **[four]** **[six]** **[eight]** **<Insert number>**-week intervals following Substantial Completion, perform separate water analyses on HVAC systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.
- F. Comply with ASTM D 3370 and with the following standards:
 - 1. Silica: ASTM D 859.
 - 2. Acidity and Alkalinity: ASTM D 1067.
 - 3. Iron: ASTM D 1068.
 - 4. Water Hardness: ASTM D 1126.

3.7 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for **[condenser-water piping]** and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
 - 1. Initial water analysis and hydronic water-treatment recommendations.
 - 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 - 3. Periodic field service and consultation.
 - 4. Customer report charts and log sheets.
 - 5. Laboratory technical analysis.
 - 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train]** **[Train]** Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232516