SECTION 232114 – UNDERGROUND HVAC PIPING

Latest Update: 05-02-2021 See Underlined Text for Edits.

(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specifications and adding any additional specifications that may be required by the project. Also turn off all "Underlines".)

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 and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for underground HVAC piping for campus chilled water system and specialties as follows: <Edit for Project>

1. Steel pipes and fittings.
2. Cathodic protection.
3. Cleaning and flushing.

1.3 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:

1. Chilled-Water Piping: 100 psig at 200°F.

B. Survey site and determine soil or water corrosivity (resistivity), current requirements, potential surveys, stray currents, and water chemistry/corrosivity (pH).

C. Select anodes and accessories relevant to level of protection. Design anodes for an estimated life of fifteen (15) years before replacement.

D. Cathodic protection systems shall provide protective potential that complies with referenced NACE standards. Insulators are required if needed to insulate protected metals from other structures.

1.4 ACTION SUBMITTALS

A. Product Data: For each specified product, include manufacturers cut sheets, dimensional data, performance data, installation instructions, specified options, and warranty information.

B. LEED Submittals: <Delete if not LEED project>

1. Product Data for Credit EQ 4.1: For adhesives, documentation including printed statement of VOC content and chemical components.

1.5 INFORMATIONAL SUBMITTALS

A. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than one (1) inch equals fifty (50) feet and at vertical scale of not less than one (1) inch equals five (5) feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing hydronic piping. <Edit for project>

B. Qualification Data: For qualified Installer.

C. Welding certificates.

D. Material Test Reports: For conduit cased piping.

E. Source quality control reports.

F. Field quality control reports.

1.6 CLOSEOUT SUBMITTAL

A. Operation and Maintenance Data: Include a copy of each approved submittal along with any applicable maintenance data in the project operation and maintenance manual.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31.9, "Building Services Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

C. Corrosion Engineer Qualifications: A qualified professional engineer who has education and experience in cathodic protection of buried and submerged metal structures and has NACE accreditation or certification as a Corrosion Specialist or Cathodic Protection Specialist.

1.8 CORRDINATION

A. Coordinate the installation of the underground chilled water service mains with all other trades that have work close to and/or in the same area of the project site.

1.9 FIELD CONDITIONS

A. Interruption of Existing Chilled Water Service: The existing chilled water service to facilities occupied by Owner or others shall not be interrupted by the contractor. When an interruption to the service is required the contractor shall notify the Construction Manager within thirty (30) days after the bid has been awarded. UMB will work with the CM to schedule the appropriate time for the interruption of the chilled water service.

1.10 WARRANTY/ GUARANTEE

A. See Division 23 Specification Section "Basic Mechanical Requirements – HVAC" for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Material Design and Selection: Underground HVAC pipe, fittings, and specialties shall be designed and selected, for the intended use, in accordance with the sizes on the drawings and the requirements of this specification.

B. Acceptable Manufacturers: Acceptable manufacturers shall be as follows:

1. Steel Piping Systems: All steel pipe and fittings shall be by one (1) manufacturer.

   a. Mueller Industries.
   b. Wheatland Tube Company.

2. Cased Piping System: All cased pipe and fittings shall be by one (1) manufacturer.

   a. Perma Pipe, Inc.
   b. Insul Tek Piping Systems, Inc.
   c. Thermal Pipe Systems.

3. Cathodic Protection:

   a. Magnesium Anodes, Type II: Corrpro Companies, Inc., Cott Manufacturing Company, CP Masters, Inc., or ELTECH Systems Corporation USA.
   b. Magnesium/Manganese Alloy Anodes: Corrpro Companies, Inc., Cott Manufacturing Company, CP Masters, Inc., or ELTECH Systems Corporation USA.
   c. Zinc Anodes: Corrpro Companies, Inc., Cott Manufacturing Company, CP Masters, Inc., or ELTECH Systems Corporation USA.
   d. Test Stations: Corrpro Companies, Inc., Cott Manufacturing Company, CP Masters, Inc., or ELTECH Systems Corporation USA.

e. Sealing, Potting and Dielectric Compounds: 3M, Chase Corporation – Specialty Coatings or Farwest Corrosion Company.

2.2 HVAC PIPE MATERIAL APPLICATION

A. General Application: All pipe, fittings and joint methods shall be as specified below:

B. HVAC Pipe Material Application Schedule:

Pipe System	Pipe Material	Fitting Material	Joint Material
Campus Chilled Water Loop Piping	Steel Pipe 2-1/2 inches to 12 inches: ASTM A53, Grade B, Schedule 40, black steel pipe covered with filament wound, polyester reinforcement composite directly applied to the pipe	2-1/2 inches to 12 inches; ASTM A234, butt welded, long radius ells, and weld o lets. Flanges: ANSI B 16.5, weld neck, raised faced with gaskets. All fittings shall be jacketed in a chopped spray up polyester resin/fiberglass reinforcement composite directly applied to the pipe. The minimum thickness shall be 0.085 inches	Welded: Latest revision of Section IX, ASME Boiler Pressure Vessel Code, Filler material per AWS D10.12.
Campus Chilled Water Loop Piping	Steel Pipe 14 inches and up: ASTM A53, Grade B, Standard Weight, black steel pipe covered with a filament wound ,polyester resin/fiberglass reinforcement composite directly applied to the pipe.	14 inches and up; ASTM A234, butt welded, long radius ells, and weld o lets. Flanges: ANSI B 16.5, weld neck, raised faced with gaskets. All fittings shall be jacketed in a chopped spray up polyester resin/fiberglass reinforcement composite directly applied to the pipe. The minimum thickness shall be 0.085 inches	Welded: Latest revision of Section IX, ASME Boiler Pressure Vessel Code, Filler material per AWS D10.12.

2.3 STEEL PIPES AND FITTINGS

A. Steel Welding Fittings: ASME B16.9 and ASTM A 234/A 234M, seamless or welded.

1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 JOINING MATERIALS

A. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 CATHODIC PROTECTION

A. Magnesium Anodes, Type II

1. Comply with ASTM B 843.
2. Chemical composition as percent of weight shall be as follows:

a. Aluminum: 0.010 maximum.
b. Manganese: 0.50 to 1.3.
c. Zinc: 0.05 maximum.
d. Silicon: 0.50 maximum.
e. Copper: 0.02 maximum.
f. Nickel: 0.001 maximum.
g. Iron: 0.03 maximum.
h. Other Impurities: 0.05 each; 0.3 maximum total.
i. Magnesium: Remainder.

3. Anode Core: Galvanized steel with anode wire silver-soldered to the core. Connection shall be recessed and epoxy insulated for 600-V rating. Connection shall be covered with heat-shrinkable tubing, and insulation shall be extended over connection.
4. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
5. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:

a. Hydrated Gypsum: 75%.

b. Bentonite Clay: 20%.
c. Anhydrous Sodium Sulfate: 5%.

B. Magnesium/Manganese Alloy Anodes

1. Chemical composition as percent of weight shall be as follows:

a. Aluminum: 0.01 maximum.
b. Manganese: 0.50 to 1.3.
c. Copper: 0.02 maximum.
d. Nickel: 0.001 maximum.
e. Iron: 0.03 maximum.
f. Other Impurities: 0.05 each; 0.3 maximum total.
g. Magnesium: Remainder.

2. Bare Anode Weight: 40 lb (18 kg), not including core, and a nominal length of sixty (60) inches (1520 mm).
3. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
4. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:

a. Hydrated Gypsum: 75%.
b. Bentonite Clay: 20%.
c. Anhydrous Sodium Sulfate: 5%.

C. Zinc Anodes For Buried Service, Type Z-1

1. B 418, Type II.
2. Chemical composition as percent of weight shall be as follows:

a. Aluminum: 0.005 maximum.
b. Cadmium: 0.003 maximum.
c. Iron: 0.0014 maximum.
d. Zinc: Remainder.

3. Bare Anode Ingot Weight: 30 lb (13.6 kg), 2 inches (50 mm) square and 30 inches (760 mm) long. Packaged weight of anode bag shall be 70 lb (32 kg).
4. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to

ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.

5. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:

    a. Hydrated Gypsum: 75%.
    b. Bentonite Clay: 20%.
    c. Anhydrous Sodium Sulfate: 5%.

D. Permanent Reference Electrodes:

1. Copper/copper sulfate (Cu/CuSO4), suitable for direct burial. Electrode shall be guaranteed by supplier for fifteen (15) years' service in the installed environment.

E. Wire And Cable:

1. Anode Header Cable: Single-conductor, Type HMWPE, insulated cable specifically designed for direct-buried dc service in cathodic protection installations.

    a. Conductor: Stranded, annealed, uncoated copper, not less than No. 8 AWG, complying with ASTM B 3 and ASTM B 8.
    b. Insulation: High-molecular-weight polyethylene, complying with NEMA WC 70/ICEA S-95-658.
    c. Minimum Average Thickness of Insulation: 110 mils for Nos. 8 through 2 AWG, and 125 mils for Nos. 1 through 4/0 AWG; rated at 600 V.
    d. Connectors: Copper-compression type or exothermic welds.

2. Conductors and Cables: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

    a. Bonding Conductors for Joint and Continuity Bonds: Not less than No. 8 AWG, stranded, Type THWN copper conductors.
    b. Flexible Pipe Coupling Bonds: Flexible copper straps with electrical resistance equal to No. 1/0 AWG stranded copper wire and with five holes for five exothermic welds to pipe.
    c. Test Wires: No. 12 AWG, Type THWN copper conductors.
    d. Resistance Wires: No. 16 or No. 22 AWG nickel-chromium wire.
    e. Cables for Installation in Conduit: Type THWN copper conductors.

F. Test Stations:

1. Plastic Test Stations: Flush-mounted type, manufactured of high-impact-resistant PVC or polycarbonate with watertight conduit connections and cover and removable terminal board having at least five terminals.
2. Test Station Mounting Enclosures:

    a. Non-Traffic-Area Boxes: Comply with requirements in Division 26 Specification Section "Raceways and Boxes for Electrical Systems."
    b. Traffic-Area Boxes: Comply with requirements in Division 26 Specification Section "Underground Ducts and Raceways for Electrical Systems." Boxes shall have cast-iron covers with a welded bead legend "CP TEST."

G. Sealing, Potting, And Dielectric Compounds:

1. Sealing and Dielectric Insulating Compound: Comply with NACE RP0188. Black, rubber based, soft, permanently pliable, tacky, moldable, and unbacked; 0.125 inch thick.
2. Potting Compound: Comply with NACE RP0188. Cast-epoxy, two-package type; fabricated for this purpose and covered with heat-shrinkable tape.
3. Pressure-Sensitive, Vinyl-Plastic Electrical Tape: Comply with UL 510.

H. Exothermic Welding Materials

1. Exothermic Weld Kits: Specifically designed by manufacturer for welding materials and shapes required.
2. Exothermic Weld Caps: Dome of high-density polyethylene, 10-mil (0.254-mm) minimum thickness, filled with mastic and containing a tunnel portion to separate lead wire from exothermic weld.

I. Coating Repair Materials

1. Touchup Coating Materials: Comply with requirements in Architectural Specification Section "High-Performance Coatings" for coating systems for touchup of factory-applied coatings.
2. Adhesive-Applied Coating Materials: Coating materials shall be compatible with factory-applied coating system.

    a. Nominal thickness of coating materials shall be not less than 8 mils, plus or minus 5%.
    b. Coating materials shall be one of the following supplied by factory-applied coating system manufacturer:

        1) Polyvinyl-chloride, pressure-sensitive, adhesive tape.
        2) High-density polyethylene/bituminous rubber compound tape.
        3) Butyl rubber tape.
        4) Coal-tar epoxy.

2.6 UNDERGROUND PIPE – DETECTABLE WARNING TAPE

A. Detectable Warning Tape: Acid and alkali resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of six (6) inches wide and four (4) mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to thirty (30) inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EARTHWORK

A. See Division 31 Specification Section "Earth Moving" and Division 33 Section Specification Section "Common Work Results for Utilities" for excavating, trenching, and backfilling requirements.

3.2 EXAMINATION

A. Examine roughing in's for HVAC piping system to verify actual locations of piping connections to the existing campus underground HVAC piping and the building before installing the new piping.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Remove standing water in the bottom of trench.

C. Do not backfill piping trench until field quality control testing has been completed and results approved.

D. Install piping free of sags and bends.

E. Install fittings for changes in direction and branch connections.

F. See Division 23 Specification Section "Sleeves, Sleeve Seals and Escutcheons for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.

G. Secure anchors with concrete thrust blocks. Concrete is specified in Architectural Specification Section "Cast in Place Concrete."

3.4 OUTDOOR PIPING INSTALLATION

A. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

B. Install fittings for changes in direction and branch connections.

3.5 VALVE INSTALLATION

A. Install underground valves with valve boxes.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.7 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Specification Section "Identification for HVAC Systems and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, twelve (12) inches below finished grade, except six (6) inches below subgrade under pavements and slabs.

3.8 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than four (4) inches larger in both directions than supported unit.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on eighteen (18) inch centers around the full perimeter of the base.
3. Install epoxy coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Use three thousand (3,000) psig, twenty eight (28) day, compressive strength concrete and reinforcement as specified in Architectural Specification Section "Miscellaneous Cast in Place Concrete."

3.9 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

D. Pressure Sealed Joints: Use manufacturer recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.10 GENERAL INSTALLATION REQUIREMENTS

A. Comply with ANSI/IEEE C2 and NFPA 70.

B. Make connections to ferrous pipe using exothermic welding.

C. Coat welds with the coating repair material and apply an exothermic weld cap.

3.11 MAGNESIUM ANODE INSTALLATION

A. Install magnesium anodes at locations that clear obstructions. Install at least thirty six (36) inches (900 mm) and no more than ten (10) feet from pipe to be protected. Install in augered holes with top of anode twenty four (24) inches below pipe invert elevation. In soils that will collapse into augered holes, use casing of galvanized sheet steel.

B. Install anodes in a dry condition after plastic or waterproof protective covering has been completely removed from water-permeable permanent container that houses anode metal. Do not use anode-connecting wire for lowering anode into hole. Backfill annular space around anode with fine earth in six (6) inch (150-mm) layers; compact each layer using

hand tools. Do not strike anode or connecting wire during backfilling and compacting. After backfilling and compacting to within six (6) inches (150 mm) of finished grade, pour approximately five (5) gallons (20 L) of water into each filled hole. After water has been absorbed by earth, complete backfilling to finished level.

C. If rock strata are encountered before achieving specified augured hole depth, install anodes horizontally at depth at least as deep as bottom of pipe to be protected.

D. Install anodes spaced as indicated, [directly connected] [connected through a test station] to the pipeline, allowing slack in connecting wire to compensate for movement during backfill operation.

E. Do not use resistance wires to reduce current output of individual or group anodes.

3.12 ZINC ANODE INSTALLATION

A. Install zinc anode horizontally in a hole at least three (3) inches (76 mm) larger than anode. Install anode under new copper water tubing, including service lines, blowoffs, and air releases. Separate piping and anode by at least twenty four (24) inches (600 mm), but not more than sixty (60) inches (1520 mm).

B. Install anode midway between both ends of piping. Install anode wire in piping trench and connect to piping at an accessible location. Install anode wire in PVC conduit where rising out of the ground to the aboveground connection.

3.13 INSTALLATION OF REFERENCE ELECTRODES

A. Install directly beneath the buried metallic component being protected.

3.14 CABLE AND WIRE INSTALLATION

A. Install conductors, except anode wires, in PVC conduit with waterproof PVC junction boxes. Comply with requirements in Division 26 Specification Section "Raceways and Boxes for Electrical Systems" for conduit and its installation.

B. Anode Wire Installation: Cover trench bottom for the anode wire with three (3) inch (76-mm) layer of sand or stone-free earth. Center wire on backfill layer and do not stretch or kink the conductor. Place backfill over wire in layers not exceeding six (6) inches (150 mm) deep, and compact each layer. Use clean fill, free from roots, vegetable matter, and refuse. Place cable underground-line warning tape within eighteen (18) inches (460 mm) of finished grade, above cable and conduit.

C. Bonding Conductors: Install conductors on metallic pipe and tanks, to and across buried flexible couplings, mechanical joints, and flanged joints except at places where insulating joints are specified. Welded and threaded joints are considered electrically continuous and do not require bonding.

1. Install at least two bonds between parts requiring bonding.
2. Bonding conductors must contain sufficient slack for anticipated movement between structures. Bonding conductors across pipe joints shall have not less than a four (4) inch (100-mm) slack for pipe expansion, contraction, and soil stress.
3. Connect bonding conductors to pipe, coupling follower rings and coupling middle ring or sleeve. Connect bonding conductors with exothermic welds.

D. For wire splicing, use compression connectors or exothermic welds.

3.15 TEST STATIONS

A. Install test stations as follows:

1. At one thousand (1,000) foot intervals.
2. At insulating joints.
3. At both ends of casings when casing material is included in the cathodic protection system.
4. Where pipe crosses other metal pipes.
5. Where pipe connects to existing piping system.
6. Where pipe connects to dissimilar metal pipe.
7. At each tank component.

B. Install test stations on backfill complying with requirements for trench bottom fill for anode wires unless otherwise indicated.

C. Terminate test conductors on terminal boards and install a spare set of test leads at each testing location.

3.16 IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic piping. Locate tapes six (6) to eight (8) inches below finished grade, directly over piping.

3.17 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:

   a. Leave joints, including welds, uninsulated and exposed for examination during test.
   b. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
   c. Use vents installed at high points to release trapped air while filling system.

2. Test hydronic piping as follows:

   a. Subject hydronic piping to hydrostatic test pressure that is not less than one and one half (1.5) times the design pressure.
   b. After hydrostatic test pressure has been applied for ten (10) minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.

3. Test conduit as follows:

   a. Seal vents and drains and subject conduit to 15 psig for four (4) hours with no loss of pressure. Repair leaks and retest as required.

E. Cathodic Protection

1. Comply with NACE RP0169 and NACE RP0285.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installation, including connections.
3. Perform tests and inspections.

   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

4. Tests and Inspections:

   a. Static Pull Test: Choose, at random, one completed anode of each type for this destructive test. Demonstrate that anode wire connections have enough strength to withstand a minimum tensile load of 300 lb (136 kg). If test fails, replace all anodes and repeat test at another randomly selected anode.
   b. Insulation Testing: Before anode system is connected to pipe, test insulation at each insulating joint and fitting. Demonstrate that no metallic contact, or short circuit, exists between the two (2) insulated sections of pipe. Replace defective joints or fittings.

c. Bonding Tests: Test for electrical continuity across all bonded joints. Repair or add additional bonds until electrical continuity is achieved.
d. Baseline Potentials: After backfilling of pipe and anodes is completed, but before anodes are connected to pipe, measure the static potential of pipe to soil. Record initial measurements.
e. Anode Output: Measure electrical current as anodes or groups of anodes are connected to pipe. Use a low-resistance ammeter. Record current, date, time, and location of each measurement.
f. Pipe-to-Reference Electrode Potential Measurements: On completion of installation of entire cathodic protection system, make electrode potential measurements according to NACE RP0169, using a copper/copper-sulfate reference electrode and a potentiometer-voltmeter, or a dc voltmeter with an internal resistance (sensitivity) of not less than 100,000 ohms per volt and a full scale of 1 or 2 V. Make measurements at same locations as those used for baseline potentials. Record voltage, date, time, and location of each measurement, using one of the following two (2) methods:

1) 0.85 V Negative Voltage: With cathodic system in operation, measure a negative voltage of at least minus 0.85 V between pipe and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe.
2) 100-mV Polarization Voltage: Determine polarization voltage shift by interrupting protective current and measuring polarization decay. An immediate voltage shift will occur if protective current is interrupted. Use voltage reading, after immediate shift, as base reading from which to measure polarization decay. Measure at least a minimum polarization voltage shift of 100 mV between pipe and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe.

5. Location of Measurements for Piping: For coated piping or conduit, measure from reference electrode in contact with the earth directly over pipe. Measure at intervals not exceeding four hundred (400) feet (120 m). Make additional measurements at each distribution service riser, with reference electrode placed directly over service line.
6. Location of Measurements for Tanks: For underground tanks, measure from reference electrode located as follows:

a. Directly over center of tank.
b. At a point directly over tank and midway between each pair of anodes.
c. At each end of tank.

7. Interference Testing: Test interference with cathodic protection from any foreign pipes tanks in cooperation with Owner of foreign pipes. Report results and recommendations.

8. Stray Current Measurements: Perform at each test station. Mitigate stray currents due to lightning or overhead ac power transmission lines as provided for in NACE standards.
9. Inspect coatings; comply with NACE RP0188. Repair imperfections of factory-applied coatings as specified in "Coatings" Article.

    a. Use electronic holiday detectors to detect coating imperfections.
    b. All damage to the protective coating during transit and handling shall be repaired before installation.
    c. Repair factory-applied coatings to have equal or better corrosion resistance than the factory-applied coating system. Field-repair material shall be of the type approved by, and shall be applied as recommended by, manufacturer of the coating material.

F. Prepare test and inspection reports.

3.18 CLEANING AND FLUSHING

A. General Requirement: The contractor shall secure the services of the water treatment company that is under service contract to UMB, to clean, flush and add chemical treatment to new piping systems that are required to be connected to existing piping systems serving the building or campus. The cost for labor and material for this work must be included in the contractors bid price. The contractor shall be responsible for the scope of work for the UMB water treatment company.

B. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris; repair damaged finishes, including chips, scratches, and abrasions.

C. Flushing portions of the system:

1. After a piping loop has been completed and prior to the installation of strainer baskets, flush that portion of the system. Connections shall be same size as piping being flushed, or one size smaller.
2. Flushing shall remove sediment, scale, rust and other foreign substances.
3. After flushing pressure test system and make it tight.

D. Flushing building system: After the various portions of the piping system have been tested and flushed and system is substantially completed, fill the system completely with water, venting all trapped air, and operating the pump.

1. Open a drain at the low point of the system while replacing the water through the make-up at the same rate.
2. Continue flushing until clean water shows at the drain, but for not less than two (2) hours.

E. Chemical cleaning: Fill system with sufficient detergent and dispersant to remove dirt, oil, and grease.

1. Circulate for at least forty eight (48) hours.
2. Open a drain valve at the lowest point and bleed while the system continues to circulate. Assure that the automatic make-up valve is operating.
3. Continue until water runs clear and all chemicals are removed. Sample and test the water until pH is the same as pH of makeup water.
4. After chemical cleaning, remove strainers, clean and reinstall them.

F. Submit certificate and test results to the UMB Project Manager.

END OF SECTION 232114