UPDATE LOG FOR TECHNICAL PROVISIONS – DIVISION 19		
Date	Item(s) Changed	Page #
1/1/09	**TECHNICAL PROVISIONS** **DIVISION 19 – CATHODIC PROTECTION** **19.2 Materials** 19.2.7 Reference Electrode Reference electrode shall be the copper-copper sulfate ~~silver-silver chloride~~ type, suitable for direct burial and designed to remain stable for at least 20 years. 1. The reference electrode shall have a minimum sensing surface area of 8 square inches. It shall be capable of maintaining a stable potential within plus or minus 10 millivolts to that of a freshly made reference electrode while a 3-microampere electrical current is applied to it. 2. Reference electrode shall contain a barrier to inhibit migration of chloride ions from the soil into the reference electrode. 3. Reference electrode lead wire shall be #14 AWG, stranded copper, with RHH-RHW yellow ~~blue~~-colored insulation and shall be silver-soldered to the copper core of the reference electrode with the connection epoxy sealed by the manufacturer. If wires need to be extended for direct-bury anodes, extend with #8 AWG. 4. Use ~~Stelth 2 Model SRE-00-SUB by Borin Manufacturing or~~ Staperm Model CU-1-UG ~~AG-4-UGPC~~ by GMC Corrosion, or equal.	19-8
	19.2.8 Wire and Cable 4. Joint Bond Cables: The joint bond cables shall be of the rod-cable-rod type. The rod shall be ¼-inch diameter general purpose 1018 carbon steel conforming to ASTM A108. The cable shall be No. 6 ~~8~~ AWG stranded copper wire with 7/64 inch thick HMWPE insulation specifically designed for cathodic protection service and suitable for direct burial in corrosive soil, conforming to ASTM D1248, Type I, Grade J3, Class C, Category 5 (HMWPE Type CP). Install bond wires at a minimum length.	19-8 and 19-9

Change Legend:
Added
~~Strike-out~~

Date	Item(s) Changed	Page #
	TECHNICAL PROVISIONS **DIVISION 19 – CATHODIC PROTECTION** 19.2.10 Anode Junction Box The enclosure shall be UL listed NEMA 4X fiberglass box having dimensional and electrical stability over the environmental range it will be exposed. Junction boxes shall not rust, corrode, shatter, peel or absorb water. Cabinet shall have a stainless steel, hinged, rain-tight cover with stainless steel lockable quick release latch. Test stations shall have dimensional and electrical stability from minus 20-degrees F to plus 175-degrees F and be stable under ultraviolet exposure. Junction boxes shall be the Stahlin fiberglass J1614HPL series or approved equal. The junction box shall include a cross-laminated phenolic terminal board with a minimum thickness of 0.25-inch. The terminal board shall contain individual lugs for each wire entering the junction box. The shunts shall be Agra J.B. type shunts or approved equal with a calibrated resistance of 0.01 ohm, rated to 8 amperes, and accurate to plus or minus 1%. Cable connection lugs shall be constructed from high conductivity, high strength copper alloy such as Ilsco Type SLU, Ilsco Type CP, or approved equal. Cable connection lugs shall not have any aluminum or steel subcomponents. All current carrying bolts and hardware shall be copper alloy. A durable wire identification tag shall be attached to each cable. Acceptable tags are 1½-inch diameter by 1/16-inch thick die stamped brass or stainless steel tags. Secure the tags to each cable with two heavy duty nylon wire ties, twisted bare No. 12 copper wires, or approved equal fastener as shown on the drawings. Die stamp the tags per the job specific identification legend on Standard Drawing RW-48 ~~on the plans~~.	19-9 and 19-10

Change Legend:
Added
~~Strike-out~~

Date	Item(s) Changed	Page #
	TECHNICAL PROVISIONS **DIVISION 19 – CATHODIC PROTECTION** **19.3 Execution** 19.3.7 Corrosion Test Station Refurbish existing and provide new test facilities for measuring the effectiveness of the cathodic protection system. Designated test station installations shall include a concrete test box and pad to allow measurement of structure-to-soil potentials. Existing lead wires shall be placed inside a new concrete test box. New CTS locations will require the installation of new structure lead wires; the new lead wires should be attached to the pipeline at the nearest joint. Underground insulating pipe flanges shall contain a test station to verify and monitor the resistance and effectiveness of these joints. Install the CTS boxes in areas away from traffic hazards, such as in medians or behind curbs. In areas not yet developed, route the lead wires and place the test box at the edge of the District's right-of-way or the future public road right-of-way, which ever is greater. Install the cables with sufficient slack so that the cable insulation and conductors will not be damaged during the pipe backfilling process. Connect test lead wires to the structure via alumino-thermic welding. Route all wires to their terminus points via 2-inch Schedule 80 PVC conduit. Provide a minimum of 18-inches of slack in all test wires to enable them to be removed from the test box during periodic CP system testing. Provide and install a single ~~4-inch diameter~~ steel pipe marker post to denote the location of each test station per Standard Drawing RW-1 and RW-1A. ~~Bury the marker post 2 feet below ground and encase the buried portion in concrete. Extend the marker post four feet above ground. Fill and cap the marker post with concrete. Paint the marker post with APWA purple, PMS 353, in high gloss enamel and apply an identification label.~~	19-16

Change Legend:
Added
~~Strike-out~~

UPDATE LOG FOR TECHNICAL PROVISIONS – DIVISION 19		
Date	Item(s) Changed	Page #
	TECHNICAL PROVISIONS **DIVISION 19 – CATHODIC PROTECTION** 19.3.9 Installation of Wires Cover the bottom of the wire trench with a 3-inch layer of sand or stone free earth. Place all wires in Schedule 80 PVC electrical conduit. Center the conduit on the backfill layer. Place backfill over the conduit in layers not exceeding six inches deep, compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter or refuse in the backfill. Plastic warning tape shall be placed 24 ~~12~~ inches above conduit. 19.3.14 Installation of Permanent Reference Electrodes Measure the accuracy of each copper-copper sulfate ~~silver/silver chloride~~ reference electrode before installation by measuring the direct current voltage (VDC) difference between it and one or more reference electrodes of known accuracy. The measurements shall be less than plus or minus 0.010 VDC for all reference electrodes. Perform these measurements after totally submerging the reference electrodes in a 5-gallon bucket of potable water for a minimum period of 15 minutes. Brackish water or saltwater will not be allowed. Install the copper-copper sulfate ~~silver/silver chloride~~ reference electrodes as shown on the plans. Provide a minimum of 24-inches of slack wire around the reference electrode to allow for movement during backfill and soil compaction. Exercise care so as not to damage or pierce the insulation of the reference electrode lead wire. Cover the reference electrode with 6-inches of native rock free soil and saturate it with a minimum of 5-gallons of potable drinking water. Backfill as shown in the plans. Exercise care so as not to damage or pierce the insulation of the reference electrode lead wire. Route the lead wire back to its terminus via electrical conduit.	 19-17 19-19

Change Legend:
Added
~~Strike-out~~

UPDATE LOG FOR TECHNICAL PROVISIONS – DIVISION 19		
Date	Item(s) Changed	Page #
	TECHNICAL PROVISIONS **DIVISION 19 – CATHODIC PROTECTION** 19.3.17 Cathodic Protection System Activation The Contractor's cathodic protection technician or corrosion engineer shall conduct the tests. The District will witness the system activation tests at its discretion. Provide a minimum of five days advance notice to the Engineer before the cathodic protection activation will be performed to allow for coordination and observance of these tests. Before beginning each day of testing, calibrate portable copper sulfate reference electrodes with respect to a master reference copper sulfate reference electrode. Measure CP Native Potentials (i.e. baseline pipe-to-soil potentials) at all Cathodic Test Stations prior to activating the cathodic protection system. Measure CP Native Potentials on both sides of all insulating flanges and at all CTS wires. Where two wires are attached to the same pipeline, measure and record the CP Native Potentials for both wires. If the potential measurements for the same pipeline differ by more than 2 mV, investigate the cause. At CTSs constructed with buried copper-copper sulfate ~~silver/silver chloride~~ reference electrodes (i.e. "stationary reference electrode"), measure CP Native Potentials of the pipeline using both the stationary reference electrode and a portable copper sulfate reference electrode before the CP system is activated. Activate the cathodic protection system by energizing the rectifier(s) and setting their output(s) to the estimated output required. Measure CP "On and Off Potentials" at the same locations where CP "Native Potentials" were previously measured. Measure all anode currents at anode junction boxes by measuring the voltage drop across the calibrated shunts provided. Calculate the corresponding amount of direct current flow using the shunt rating. Explicitly state the shunt rating on each data sheet. Measure all cathode currents at cathode junction boxes by measuring the voltage drop across the calibrated shunts provided. Calculate the corresponding amount of direct current flow using the shunt rating. Explicitly state the shunt rating on each data sheet. Remeasure CP "On and Off Potentials" at all CTS at least two weeks after the initial energization of the cathodic protection system to allow for the development of the cathodic polarization process.	19-20 and 19-21

Change Legend:
Added
~~Strike-out~~

UPDATE LOG FOR TECHNICAL PROVISIONS – DIVISION 19		
Date	Item(s) Changed	Page #
	TECHNICAL PROVISIONS **DIVISION 19 – CATHODIC PROTECTION** 19.3.17 Cathodic Protection System Activation (Cont'd) Furnish all test results including all CP potential readings, anode and cathode current readings, insulating flange test data, dates, and times. Reference all data to pipeline station numbers. Submit all data along with a letter report to the District for review before final acceptance. The letter report shall include a description of the test methods, analysis of all project data including, but not limited to, electrical continuity and electrical isolation testing, and conclusions about the CP system's effectiveness. Submit the final report after the District's review in both electronic and hardcopy formats. The electronic copy of the report shall be submitted in either Microsoft Word or PDF file formats. All data shall be submitted in spreadsheet format compatible with Microsoft Excel.	

DIVISION 19

CATHODIC PROTECTION

19.1 General

19.1.1 General Description

This section includes the procurement, installation, and testing of a cathodic protection system utilizing galvanic anodes.

19.1.2 Related Work Specified Elsewhere:

A. DIVISION 1 Earthwork

B. DIVISION 2 Concrete

C. DIVISION 3 Pipeline

D. DIVISION 6 Electrical

19.1.3 Reference Specifications, Codes, and Standards

American Association of State Highway and Transportation Officials (AASHTO)

American Society for Testing and Materials (ASTM)

A108 Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished

C94 Standard Specification for Ready Mix Concrete

C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars

C596 Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement

D1248 Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

F480 Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

American Water Works Association (AWWA)

C217 Application and Handling of Wax-Type Protective Coatings and Wrapper Systems for Underground Pipelines

National Association of Corrosion Engineers (NACE)

RP0169	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
RP0286	Electrical Insulation of Cathodically Protected Pipelines
RP0572	Design, Installation, Operation, and Maintenance of Impressed Current Deep Groundbeds

National Electrical Manufacturers Association (NEMA)

250	Enclosures for Electrical Equipment (1000 Volts Maximum)
MR20	Cathodic Protection Units
ST 1	Specialty Transformers (Except General Purpose Type)

National Fire Protection Association (NFPA)

70	National Electric Code (NEC)

Underwriters Laboratories, Inc. (UL)

44	Thermoset-Insulated Wires and Cables
83	Thermoplastic-Insulated Wires and Cables
489	Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
854	Service-Entrance Cables

19.1.4 General Requirements

The plans indicate the general arrangement of the cathodic protection facilities to be constructed. Where no dimensions are indicated on the plans, the locations of anodes, corrosion test stations (CTS), rectifiers, and conduits may be changed up to five feet without the approval of the Engineer to avoid interference with other utilities and unforeseen obstacles. Where specific dimensions are shown on the plans, or where proposed changes are greater than five feet, written approval by the Engineer is required. In all cases, the rectifier and all CTSs shall be located within Rancho California Water District's right-of-way outside of traffic areas; all monitoring equipment shall be placed behind existing and future curbs. Where applicable, materials and equipment shall bear evidence of UL approval and conform to the requirements of all applicable federal, state and local laws, codes, and regulations.

19.1.5 Submittals

Qualifications of the Contractor’s corrosion engineer and technician meeting the experience requirements specified herein who will be performing the work and providing reports.

Qualifications of the Contractor’s cathodic protection well driller meeting the experience requirements specified herein, including contact information for project references.

Proposed alternate anode installation methods, proposed alternate testing methods, proposed alternate cathodic protection system startup procedure.

Welding procedures and qualification certifications for the individuals performing joint bond welding shall be submitted in accordance with American Welding Society (AWS) D1.1.

Manufacturer's information for each item listed below. Include sufficient information to show that the materials meet the requirements provided herein, including references to specific sections and details shown on the plans.

1. Rectifier
2. Mixed Metal Oxide Anodes
3. Anode Centralizers
4. Coke Backfill
5. Anode Vent Pipe
6. Anode Well Sealing Materials
7. Reference Electrode
8. Wire And Cable
9. Concrete Box
10. Anode Junction Box
11. Cathode Junction Box
12. Wire Connectors and Splicing Materials
13. Plastic Warning Tape
14. Alumino-Thermic Weld Kits
15. Weld Coating
16. Pipe Flange Insulating Kits
17. Coating for Above-Grade Insulated Pipe Flanges
18. Coating For Buried Insulated Pipe Flanges And Uncoated Pipe Special Connectors

Deep anode well drilling permits and completion report.

A list of the anode well logging equipment and testing procedures that is to be used to generate the anode well resistance log.

A typed anode well resistance log for each deep well.

Submit record drawings showing the exact locations of all rectifiers, anodes, buried wires, and CP test boxes, using dimensional ties to existing structures or survey monuments. Record all changes by using a red pen or red pencil on full size drawings. The record drawing shall be maintained throughout the installation of the equipment.

Submit all intermediate cathodic protection related test results for review prior to issuing the final acceptance report. This includes, but is not limited to, insulating flange tests, pipeline continuity testing, anode groundbed resistance logs, native potential survey, and an ON/OFF potential survey.

All reports, both intermediate and final, shall be submitted in hard copy and electronic copy formats. The electronic copies shall be in Microsoft Word or PDF file formats for the report and in Microsoft Excel file format for the data.

A final acceptance report issued by the Contractor's corrosion engineer certifying that the criteria in these specifications are met. At a minimum, the report shall include native structure-to-electrolyte potentials, insulating joint test results, measured pipeline electrical continuity versus theoretical continuity calculations for spans containing inline mechanical joints, specials, valves, etc. that required joint bonding, structure-to-electrolyte potentials with the CP system activated and adjusted to an acceptable operating level, and instant off structure-to-electrolyte potentials (i.e., interruption of all sources of CP current).

19.1.6 Quality Assurance

Furnish proof of welding experience to the District for verification in the form of a list of welders proposed for use on the project. Submittals are to include certifications in accordance with AWS D1.1 General Welding; *Name Of Welder, Years Of Experience, Names Of Recent Projects, Description Of Work Performed, Duration Of Work*, and *Contacts* with updated contact numbers. The District shall have the option of requiring the welder to validate his/her qualifications with additional testing.

Provide all materials, equipment, labor, and supervision necessary for the completion of all installations and testing.

The installation of the cathodic protection system's electrical components shall conform to the latest revisions of National Electrical Code, applicable local codes, and the Recommended Practices of NACE Standards RP0169, RP0286, and RP0572.

Employ or retain the services of a corrosion engineer to inspect, activate, adjust, and evaluate the effectiveness of the cathodic protection system. The corrosion engineer is herein defined as a registered Professional Engineer with certification or licensing that includes education and experience in cathodic protection of buried or submerged metal structures, or a person accredited or certified by NACE International at the level of corrosion specialist or cathodic protection specialist (i.e. NACE International CP Level 4). Such a person shall have not less than five years experience inspecting pipeline cathodic protection systems.

Cathodic protection well drillers must have completed the installation of a minimum of five successful cathodic protection deep well anode projects greater than 100-feet deep and must possess a valid California C-57 Well Driller's License.

All deficiencies identified by the District shall be corrected and retested by the Contractor's corrosion engineer in the presence of the District at the Contractor's expense.

The District's corrosion engineer will test selected components of each system installed to confirm the accuracy of the Contractor's testing before being accepted by the District.

19.1.7 Warranty

All workmanship, materials, and equipment provided and installed by the Contractor shall be guaranteed for a period of one year from the date of acceptance.

19.2 Materials

Provide cathodic protection system materials and equipment that are new, undamaged, and in the original packaging marked with the manufacturer's name or trademark. The materials and equipment shall be of the manufacturer's latest standard design and shall be fully compatible to provide a complete and functional cathodic protection system.

19.2.1 Rectifier

General: Rectifier shall be capable of supplying its full rated DC output continuously at an ambient temperature of 112 degrees F in full sunlight with an expected minimum life of 10 years. Rectifier shall be a product of a firm that regularly produces cathodic protection rectifiers.

DC Output: The maximum DC output rating shall be 25 volts and 20 amps.

Transformer and output adjustments: DC output shall be adjusted manually by transformer tap bars. Provide six coarse and six fine transformer tap settings for a total of 36 equal output increments. The transformer shall conform to NEMA ST1 (specialty transformers).

Double AC Input Ratings: The rectifier's transformer shall be rated for operation with either 120 or 240 Volt AC, single phase, 60 Hz input voltages. The rectifier shall be designed with manually changeable buss bars to enable changing the input voltage between 120 and 240 volts while maintaining the nominal DC output voltage and amperage ratings.

Cooling: The rectifier shall be air-cooled.

Diodes: Silicon diodes connected in such a manner to provide full wave rectification.

Overall efficiency: Minimum 65 percent when operated at full output. Provide bench test quality control checklist of efficiency testing.

Meters: Provide separate voltmeter and ammeter, minimum two-inch round faceplate, two-percent, full-scale accuracy. Provide an on-off toggle switch for each meter.

Main Circuit Breaker: The rectifier shall have a molded case magnetic circuit breaker conforming to UL 489. The breaker shall be sized for 120 percent to 200 percent of the normal operating current at full rated output.

Surge protection: Protect silicon diodes by use of AC and DC lightning arrestors or metal oxide varistors against overvoltage surges and by current-limiting devices against overcurrent surges.

Fuses: Provide easily accessible, replaceable fuses or magnetic circuit breaker switches in the AC secondary, DC positive and DC negative circuits.

Spare parts: Provide two spare units for all DC and AC fuses (or circuit breakers); all lighting arrestors or MOV's, and one extra set of transformer tap bars and hardware. Place spare parts in a heavy duty plastic box and label it, "SPARE PARTS."

Final Assembly: Rack mount all components on four vertical supports so as to be free standing when mounted on a flat horizontal surface. The final assembly shall be mounted in an ornamental enclosure. In order to fit inside the ornamental enclosure, the maximum dimensions of the rectifier unit shall not exceed 19.75-inches high, by 21.5-inches wide, by 10.5-inches deep.

Ornamental Enclosure: The ornamental enclosure shall be constructed of 0.125” 5052-H32 aluminum with stainless steel hardware; be rainproof NEMA Type 3R; meet EUSERC 308 requirements; be UL listed; capable of accepting 120V/240V, 1 phase, 3 wire AC power from the power company; have a two-pole main disconnect circuit breaker meeting the requirements of the power company that energizes the rectifier; have a separate one-pole 20A circuit breaker to energize a 20A GFI duplex receptacle; accept a 4 jaw, 100 amps meter socket with test blocks; have a weather stripped door covering the rectifier equipped with padlockable T-handle latching mechanism; and be coated with TGIC polyester powder coat in ASA-70 gray (*Maybe APWA purple, PMS 253)* with anti-graffiti clear coat. The enclosure shall be a Myers Power Products MEUG26-CC or approved equal.

Operating manual: Provide three copies of the rectifier operating manual complete with a laminated spare parts list and a laminated wiring diagram.

19.2.2 Mixed Metal Oxide Anodes

Mixed metal oxide anodes shall be tubular anodes with center connections. The anode substrate shall be high purity titanium meeting the requirements of ASTM B338 Grades 1 or 2. The titanium substrate shall be coated by thermal decomposition of mixed metal oxide salts of the platinum group of metals to produce a crystalline, anhydrous, acid resistant coating that is highly conductive to anodic current flow. The thickness of the mixed metal oxide coating shall be designed by the manufacturer using empirical accelerated life testing to be capable of sustaining a 100 ampere per square meter anodic current density in an oxygen-generating electrolyte at 150 degrees F for a period of not less than 20 years. A copy of an independent testing laboratory’s report to certify the conformance of the anodes to the preceding requirement shall be furnished, upon request, to the Engineer at no extra cost. Use ELTECH Tubular Lida Anodes, TELPRO Tubular MMO Anodes, or approved equal.

The anode lead wire shall be No. 8 AWG stranded copper, single conductor cable with a dual layer of insulation. Wire insulation shall be black color. The inner insulation shall be a minimum 20-mil thick chlorine gas resistant ethylene-chlorotrifluoroethylene (Halar) extruded insulation. The outer insulation layer shall be 65-mil thick high molecular weight polyethylene extruded insulation conforming to ASTM D1248, Type 1, Class A, Category 5, Grades E4 and E5.

19.2.3 Anode Centralizers

A centralizing device shall be attached to both ends of all impressed current anodes installed in coke backfill. The centralizer shall be designed to hold the anode away from the vent pipe and sides of the drilled hole so that there is a minimum one-inch thick layer of coke backfill surrounding all surfaces of the anode and shall not block the hole or impair installation of the anode, anode wire, or coke breeze. The centralizer shall be constructed of carbon steel or stainless steel as shown in the plans.

19.2.4 Coke Backfill

Fine Spherical Grained Coke Backfill: Use fine spherical grained coke for mixed metal oxide anodes. The bulk density shall be between 62 and 66 pounds per cubic foot. The grains shall be spherical to prevent bridging problems associated with installations into deep anode groundbeds. The grain size shall be such that 90 percent will pass through a No. 4 screen and greater than 80 percent shall be retained on a 20 mesh screen. The electrical resistivity shall be less than or equal to 0.03 ohm cm when compressed at 150 pounds per square inch. The carbon content as measured by the “loss of ignition method” shall be minimum 99.9 percent. The coke backfill shall be Asbury Graphite of California product No. 4518, or equal.

19.2.5 Anode Vent Pipe

Anode vent pipe shall be two-inch diameter SCH 40 PVC pipe with slots cut in the transverse direction per the plans. The slots shall be 0.062-inch wide by 1.30-inches long as measured on the inside diameter of the pipe. The slots shall be regularly spaced on the pipe in three columns with one-inch of solid pipe between each open slot (measured along the axis of the pipe) to provide a minimum open area of 0.8-square inches per foot of vent pipe. The vent pipe shall have flush threaded joints per ASTM F480. Solvent weld slip fit joints: *reinforcement screws are not allowed*. Seal the bottom end of the vent pipe with a solvent welded end cap. Temporarily seal the top end of the vent pipe with duct tape during the anode well installation work to prevent contamination of the inside of the vent pipe.

19.2.6 Anode Well Sealing Materials

Concrete sealing materials shall be lean concrete with a 28-day compressive strength of 2000 psi and minimum cement content of 376 lb/cubic yard.

Bentonite sealing materials shall be naturally occurring Wyoming sodium bentonite clay mined from specially selected ore bodies, which exhibit a high swelling capability. It shall be specifically manufactured to create a stable, permanent, below-grade seal in monitoring wells and water wells.

1. The bentonite particles shall have a minimum bulk density of 68 lb/cf and be size graded so that 100 percent of the particles pass through a 3/8-inch screen and all the particles are retained on a 1/4-inch screen.

2. The bentonite product shall be certified by the National Sanitation Foundation for use in the construction of potable water wells.

3. The bentonite well sealing material shall be Falcon GDP Inc.'s "HOLEPLUG - SIZE 3/8 INCH CHIPS," Falcon "BARIOD BENTONITE PELLETS - SIZE 3/8 INCH," or equal.

19.2.7 Reference Electrode

Reference electrode shall be the copper-copper sulfate type, suitable for direct burial and designed to remain stable for at least 20 years.

1. The reference electrode shall have a minimum sensing surface area of 8 square inches. It shall be capable of maintaining a stable potential within plus or minus 10 millivolts to that of a freshly made reference electrode while a 3-microampere electrical current is applied to it.

2. Reference electrode shall contain a barrier to inhibit migration of chloride ions from the soil into the reference electrode.

3. Reference electrode lead wire shall be #14 AWG, stranded copper, with RHH-RHW yellow-colored insulation and shall be silver-soldered to the copper core of the reference electrode with the connection epoxy sealed by the manufacturer. If wires need to be extended for direct-bury anodes, extend with #8 AWG.

4. Use Staperm Model CU-1-UG by GMC Corrosion, or equal.

19.2.8 Wire and Cable

Use stranded copper wire with insulation rated at 600 volts. Wires with cut or damaged insulation are not acceptable and replacement of the entire lead would be required. Wires shall be sufficient length to extend from the point of installation on the pipeline to the appropriate corrosion monitoring test box without splices.

1. Pipe Test Lead Wires: The pipe test lead wires shall be No. 8 AWG stranded copper wire with RHH/RHW-2 or USE-2 insulation conforming to UL 44 and UL 854 as specified on the drawings. Test stations with only two pipe lead connections shall have black insulation. Test stations associated with buried insulating flanges (IF) shall have black insulation on the south or east sides of the

IF and white insulation on the north or west sides of the IF. White insulation shall be used for voltage drop test leads. In all cases, a minimum of 18 inches of slack wire shall be left at each test station.

2. Anode Header Cable: The anode header cable shall be No. 6 AWG stranded copper wire with red RHH/RHW-2 or USE-2 insulation conforming to UL 44 and UL 854 or as specified on the drawings.

3. Cathode cable: The cathode header cable shall be No. 6 AWG stranded copper wire with black RHH/RHW-2 or USE-2 insulation conforming to UL 44 and UL 854 or as specified on the drawings.

4. Joint Bond Cables: The joint bond cables shall be of the rod-cable-rod type. The rod shall be ¼-inch diameter general purpose 1018 carbon steel conforming to ASTM A108. The cable shall be No. 6 AWG stranded copper wire with 7/64 inch thick HMWPE insulation specifically designed for cathodic protection service and suitable for direct burial in corrosive soil, conforming to ASTM D1248, Type I, Grade J3, Class C, Category 5 (HMWPE Type CP). Install bond wires at a minimum length.

19.2.9 Concrete Boxes

CTS boxes shall be at-grade concrete valve boxes designed to withstand AASHTO H-20 traffic loads. Test boxes shall be 10 inches I.D. and 12 inches deep, with a cast iron cover. The cover shall have the words "RCWD CP TEST" and the pipeline station number cast or welded thereon in neat raised letters. The letters shall be a minimum of ¾-inch tall with a ¼-inch relief from the surrounding surface. Use Christy Concrete Products Model G5 or approved equal.

Anode well vault boxes shall be an at-grade concrete valve box designed to withstand AASHTO H-20 traffic loads. The vault box shall be 14.5 inches I.D. and 12 inches deep, with a cast iron cover marked “ANODE.” Use Christy Concrete Products Model G12 or approved equal.

19.2.10 Anode Junction Box

The enclosure shall be UL listed NEMA 4X fiberglass box having dimensional and electrical stability over the environmental range it will be exposed. Junction boxes shall not rust, corrode, shatter, peel or absorb water. Cabinet shall have a stainless steel, hinged, rain-tight cover with stainless steel lockable quick release latch. Test stations shall have dimensional and electrical stability from minus 20-degrees F to plus 175-degrees F and be stable under ultraviolet exposure. Junction boxes shall be the Stahlin fiberglass J1614HPL series or approved equal.

The junction box shall include a cross-laminated phenolic terminal board with a minimum thickness of 0.25-inch. The terminal board shall contain individual lugs for each wire entering the junction box.

The shunts shall be Agra J.B. type shunts or approved equal with a calibrated resistance of 0.01 ohm, rated to 8 amperes, and accurate to plus or minus 1%.

Cable connection lugs shall be constructed from high conductivity, high strength copper alloy such as Ilsco Type SLU, Ilsco Type CP, or approved equal. Cable connection lugs shall not have any aluminum or steel subcomponents. All current carrying bolts and hardware shall be copper alloy.

A durable wire identification tag shall be attached to each cable. Acceptable tags are 1½-inch diameter by 1/16-inch thick die stamped brass or stainless steel tags. Secure the tags to each cable with two heavy duty nylon wire ties, twisted bare No. 12 copper wires, or approved equal fastener as shown on the drawings. Die stamp the tags per the job specific identification legend on Standard Drawing RW-48.

19.2.11 Cathode Junction Box

The cathode junction box shall be an air cooled enclosure normally used to house rectifier components. The enclosure shall accommodate the cooling capacity of 1200W having nominal interior dimensions of 14 inches wide x 20 inches high x 12 inches deep. The rectifier case shall be NEMA 3R, completely weatherproof for outdoor use. The case shall be constructed of not less than 11 gauge steel. All fabrication welds shall be clean and smooth. The entire case shall be hot dip galvanized per ASTM-123. The cabinet is to be equipped with a suitable pole mounting channel welded to the case prior to galvanizing. Screens in the ventilation openings at the top and bottom of the case shall be double zinc plated. The front door shall be hinged on one side and have a positive locking device capable of taking a lock with a 3/8" diameter shank. In addition to the front door, the left side panel of the case shall be hinged and easily removable. The enclosure shall have a slide-out rack assembly for accessibility.

The shunts shall have a calibrated resistance such that a 25-amp current causes a voltage drop of 25-millivolts (i.e. 0.001 ohms). Shunts shall be the Holloway Type SS constantan shunt or approved equal.

The phenolic panel shall be cross-laminated phenolic boards with a minimum thickness of 0.25 inches and be NEMA LE grade. The panels shall be engraved as shown on the drawings and shall contain individual lugs for each wire entering the junction box.

A heat shield shall be installed between the phenolic board the rheostat.

The rheostats shall be rated for 100 watts having a variable resistance of 0.5-50K ohms. The rheostat shall be Ohmite Model RKS-R50 with finger grip without pointer or approved equal.

19.2.12 Wire Connector and Splicing Materials

Splices can only be made to existing wires: no splices are allowed where new lead wires are to be installed.

Splices are to be a mechanical high compression type butt splice such as Burndy Hylink Series or approved equal. Size the butt splice according to wire conductor size.

The splice will be covered with a waterproof, adhesive lined heat-shrink sleeve sized appropriately for the splice. Use DGA Canusa type CFTV or approved equal. A 100% butyl filler shall be used at all sharp edges and voids such as at the edge of the butt splice to prevent the heat-shrinkable sleeves from experiencing abrupt and large changes in surface elevations so that upon the completion of the installation, no voids exist between the heat-shrinkable sleeves and the substrate interface.

Exothermic weld material shall be a mixture of copper oxide and aluminum, packaged by size in plastic tubes. The materials shall be non-explosive and not subject to spontaneous ignition.

19.2.13 Plastic Warning Tape

Plastic warning tape for horizontal runs of buried leads in cable trenches shall be a minimum of 4-mils thick and 6-inches wide, inert yellow plastic film designed for prolonged use underground. The tape shall have the words, "CAUTION CATHODIC PROTECTION CABLE BELOW," or similar, clearly visible in repeating patterns along its entire length.

19.2.14 Alumino-Thermic Weld Kits

Exothermic weld material shall be a mixture of copper oxide and aluminum, packaged by size in plastic tubes as shown in the plans. The materials shall be non-explosive and not subject to spontaneous ignition.

Exothermic weld material and accessories shall be Erico Products, Inc., ThermOweld® or approved equal. Materials from different manufacturers shall not be mixed.

Use the correct mold for the correct position (i.e., vertical, horizontal, etc.).

19.2.15 Weld Coating

All exothermic welds and joint bond welds shall be coated with a high build, 0 VOC, 100% solids surface tolerant epoxy coating. The epoxy shall have a maximum curing time of 2 hours at 708 F capable of providing a minimum coating thickness of 20 mils. The surface shall be prepped and the coating applied with time to cure before backfilling according to the manufacturer’s instructions. The epoxy coating shall be Tape Coat’s TC 7010 or approved equal.

19.2.16 Pipe Flange Insulating Kits

Pipe flange insulating kit materials shall be of the type designated by the manufacturer as suitable for appropriate operating temperatures and pressures of the pipeline.

Flange insulating kits shall consist of a one-piece, full-face, insulating gasket, one insulating sleeve for each bolt, two insulating washers, and two steel washers.

1. Insulating Gasket: Insulating gasket retainers shall be full face, Type E, NEMA G-10 epoxy glass retainers with a nitrile (Buna-N) rectangular cross section O-ring seal. Minimum total gasket thickness shall not be less than 1/8-inch. The gasket shall have the same outside diameter as the pipe flange. The gasket’s inside diameter shall be one inch greater than the nominal pipe diameter. Dielectric strength shall be not less

than 550 volts per mil, and compressive strength shall be not less than 50,000 psi. Use PSI Linebacker insulating gasket, or equal.

2. Insulating Sleeves: Provide full length, one piece, insulating flange bolt sleeves for the appropriate bolt size. Insulating sleeves shall be NEMA G-10 epoxy glass. Dielectric strength shall be not less than 400 volts per mil. The length of the insulating sleeves shall be sized to for the thickness of both flanges, plus the thickness of the insulating gasket, plus the two inner steel washers (pipe diameters over 36 inches), plus two insulating washers, plus one of the two outer steel washers. This leaves a clearance equal to the thickness of one steel washer. The insulating sleeve length is a critical requirement. The air gap between the end of the insulating sleeves and inside surface of the stud bolt nuts shall be 1/32-inch minimum and 1/8-inch maximum.

3. Insulating Washers: Insulating washers shall be NEMA G-10 epoxy glass with a minimum thickness of 1/8-inch. Dielectric strength shall not be less than 550 volts per mil, and compressive strength shall not be less than 50,000 psi. The insulating washer's inside diameter shall be sized to fit over the insulating sleeve's outside diameter.

4. Provide steel washers for placement over the insulating washers with a minimum thickness of 1/8-inch. The inside diameter and outside diameter of the steel washers shall match those of the insulating washers. The steel washers must be able to freely rotate around the insulating sleeve. Attention must be paid to the fit between the steel washers and the insulating sleeve in order to avoid the washers twisting the sleeves when the flange bolts are torqued.

Provide four extra insulating sleeves and eight extra insulating washers for each insulating flange. Provide unused sleeves and washers to the Engineer upon successful inspection of the insulating flange.

19.2.17 Coating for Above-Ground Insulated Pipe Flanges

The tape coating for above-ground insulated pipe flanges shall be a minimum 14 mils thick general utility pipeline tape such as Polyken No. 900-12 or equal.

19.2.18 Coating for Buried Insulated Pipe Flanges

The wax-tape coating shall conform to the requirements of AWWA C217, and shall consist of three parts: surface primer, wax-tape, and outer covering.

1. The primer shall be a blend of petrolatum, plasticizer, and corrosion inhibitors having a paste like consistency such as Trenton Wax-Tape Primer, or approved equal.

2. The wax-tape shall be a plastic-fiber felt tape, 50 to 70 mils thick, and saturated with a blend of petrolatum, plasticizer, and corrosion inhibitors that is easily formed over irregular surfaces such as Trenton #1 wax-tape, or approved equal.

3. The outer covering shall be a plastic wrapper consisting of three (3), each 50 gauge, clear polyvinylidene chloride, high cling membranes wound together as a single sheet such as Trenton Poly-Ply, or approved equal.

19.3 Execution

19.3.1.1 Installation of Rectifiers

Order and install rectifier without the manufacturer's standard outer electrical enclosure. Assemble the rectifier inside a larger electrical enclosure as shown in the plans. Make wiring connections as indicated on the plans.

Handle wire to prevent stretching or kinking of the conductors or damage to the insulation. Use lubricants when pulling wires into conduits.

Install an electrical grounding system, which conforms to the most recent NEC. In addition to the applicable NEC requirements, the electrical resistance of the rectifier's electrical enclosure, measured with respect to remote soil, shall be less than or equal to 5 ohms. At all locations direct bury a minimum or 20 feet of bare soft drawn No. 2 AWG stranded copper cable at a minimum burial depth of 3-feet. If necessary, construct additional direct buried ground cable and/or provide a six 6-inch layer of slurried powdered bentonite in the ground cable trench to sufficiently reduce the soil contact resistance. Bond the No. 2 AWG cable directly to the enclosure.

19.3.2 Deep Anode Well Drilling

Obtain a cathodic protection well drilling permit from the County of Riveside, Department of Environmental Health, and pay all applicable permit fees. A copy of the permit shall be submitted to the District a minimum of 30 days before drilling commences.

The contractor is responsible to ensure that the deep well anode installation is constructed in accordance with the State of California, Department of Water Resources Bulletin 74-90 - Cathodic Protection Well Standards.

Drill the deep anode well where shown and to the depth indicated on the plans. Unless otherwise shown on the plans, the standard anode hole shall be 10 5/8-inch diameter. The anode hole shall be drilled sufficiently straight and true to allow the anodes to be installed without binding or straining the anode cables. If using rotary tricone drilling bit equipment, select the type and consistency of drilling fluids to be consistent with the soil characteristics.

The term "hard rock" is defined in this specification (for the purpose of deep well anode hole drilling only) as a condition where a drilling rig in good working condition experiences an average drilling rate of less than or equal to one 1-foot in 12 minutes for a minimum continuous period of one hour (i.e. less than five 5-feet in 60 continuous minutes) while operating with a minimum down hole drill bit pressure of 50 percent of the equipment's full rating. If hard rock drilling conditions are encountered before drilling to the depth on the plans, notify the Engineer immediately.

Surface Casing: Install a permanent PVC pipe casing from grade to active anode well column plus 3". Use only PVC pipe with ASTM F480 flush threaded joints in order to maintain the required 2-inch annular space between the pipe's outside diameter and the drilled hole. Do not use screws to reinforce the well casing pipe joints. Do not introduce anything into the anode well that has a sharp or abrasive surface that could damage the anode wires. Ten-foot or 20-foot lengths of pipe may be used.

Optional Steel Well Casings: The use of temporary steel well casings other than the PVC well casing shown in the plans may be necessary to hold the hole open depending on the soil characteristics and the type of drilling equipment used. If steel casings are used, no portion of the steel casing may be left in the top "Non-Active Zone" of the anode well upon completion.

19.3.3 Deep Anode Well Anode Installation

Before lowering the anodes into the hole, carefully examine the wire insulation on each anode. Damaged anodes or anode cables with cracks, entrapped air bubbles, inclusions or other defects shall not be used. Defective anodes shall be removed from the work site no later than the conclusion of the workday. Label the anode wires with colored tape or paint to mark the intended final depth.

The final installed depth of the anodes shall be as shown in the plans. Variances with the depths as shown on the plans may be made with the Engineer's approval based on the electrical resistivity log of the hole. Anodes shall not be closer together than 3 feet (end to end) nor shall they be located with the inactive column as shown on the Plans. Contractor shall record the final installed depth of each anode and submit it to the District.

Supply anodes with sufficient wire lengths to run continuous from the installed anode depth to the anode junction box without any splices. Exercise extreme care not to damage the anode wire insulation during the entire installation procedure. No splices are allowed in the anode wires.

Attach the first anode to a centralizer using a stainless steel hose type clamp. Next, attach the first section of slotted 2-inch diameter SCH 40 Anode Vent Pipe to the same centralizer.

Lower the anode vent pipe/anode/centralizer assembly into the hole the appropriate distance until the next anode and centralizer distance is reached. Secure the downhole assembly by wrapping the anode lead wires around a smooth pipe no smaller than 4 inches in diameter. Do not kink or tightly bend the anode wires around anything smaller than a 4-inch diameter smooth rigid surface. Do not tie knots with the anode lead wires.

Assemble the next anode and centralizer to the downhole column and lower into hole. Assemble the next section of anode vent pipe by threading it onto the downhole section.

As the anodes are lowered into the hole, label each wire. Label the first anode in the hole as Anode No. 1 and so on. Preserve the wire identities until all the anode wires are secured to the numbered shunts inside the rectifier enclosure.

19.3.4 Coke Breeze Installation

After all anodes and vent pipe are in place in the deep anode hole, but before any coke backfill is added, measure the resistance to remote soil of each anode.

Bottom Loading: This method is recommended but not mandatory. Install the coke in slurry form with a tremie pipe by pumping it into the well from the bottom up. Do not extend coke higher than 15 feet above the top of the top anode.

Top Loading: If this method is used, careful attention must be paid towards avoidance of coke plugs which could bridge the hole and prevent the complete encapsulation of the anodes by the coke. Install the coke by pouring it into the hole from the top. Thoroughly wet the coke as it is added to aid in the settling process. Do not extend the coke column higher than 15 feet above the top of the top anode.

During the installation of the coke slurry, monitor the electrical resistance to earth of the bottom anode until the value decreases a minimum of 25 percent. The abrupt decrease in resistance indicates proper settling of the highly conductive coke around it. Monitor the resistance of the other anodes until it is evident that the coke has reached the top anode. If there is any evidence of bridging, remedial measures shall be taken to ensure proper settling. The volume of coke added to the well shall be compared with well volume to ensure that bridging, blockage, or collapse of the hole has not occurred.

24-Hour Mandatory Waiting Period: A full 24-hour waiting period must be allowed after the completion of the coke loading process to allow for coke settlement and its natural compaction process. If more coke is needed to bring it up to the depth indicated, pour a calculated amount of coke into hole again. If more than 20 feet of coke is required to be added, an additional 24-hour waiting period must be allowed and the preceding process repeated.

Unused coke and excess drilling mud and excavated earth shall be hauled away and/or disposed by the Contractor in a manner conforming to state and local regulations.

19.3.5 Deep Anode Well Sealing

Bentonite: Pour a calculated amount of bentonite pellets into the annular space between the drilled hole and the PVC well casing to produce a minimum 5-foot long water seal at the bottom of the solid PVC well casing.

Cement or Grout Seal: Once the bentonite has settled, pump neat cement or grout into the annular space between the drilled hole and the solid PVC well casing. Use a 1- to 1-1/2 inch diameter tremie pipe to prevent free falling of the sealing material more than 30 feet in the annular space. Do not top load the sealing material.

19.3.6 Deep Anode Well Head

PVC Wellhead Fittings: Use sandpaper to smooth the outside diameter of the top 6-inch pipe nipple and the inside of the top 6-inch end cap to allow a smooth fit so that it can be removed by hand. Do not use PVC cement on the end cap. Do not drill any holes into the end cap for venting purposes. The anode well is to be vented solely by the anode vent pipe as shown in the plans.

Wellhead Finishing: Prepare concrete formwork, reinforcing steel, vent pipe, electrical conduit, and concrete electrical pull box for finishing the top of the anode well as shown in the plans.

Anode Wire Trench: Trench the anode wire conduit and anode vent pipe as shown in the plans. Maintain a smooth minimum slope in the run of the anode vent pipe of 1:75 away from the deep anode hole.

19.3.7 Corrosion Test Station

Refurbish existing and provide new test facilities for measuring the effectiveness of the cathodic protection system.

Designated test station installations shall include a concrete test box and pad to allow measurement of structure-to-soil potentials. Existing lead wires shall be placed inside a new concrete test box. New CTS locations will require the installation of new structure lead wires; the new lead wires should be attached to the pipeline at the nearest joint.

Underground insulating pipe flanges shall contain a test station to verify and monitor the resistance and effectiveness of these joints.

Install the CTS boxes in areas away from traffic hazards, such as in medians or behind curbs. In areas not yet developed, route the lead wires and place the test box at the edge of the District’s right-of-way or the future public road right-of-way, which ever is greater.

Install the cables with sufficient slack so that the cable insulation and conductors will not be damaged during the pipe backfilling process.

Connect test lead wires to the structure via alumino-thermic welding.

Route all wires to their terminus points via 2-inch Schedule 80 PVC conduit.

Provide a minimum of 18-inches of slack in all test wires to enable them to be removed from the test box during periodic CP system testing.

Provide and install a single steel pipe marker post to denote the location of each test station per Standard Drawing RW-1 and RW-1A.

19.3.8 Test Wire Connections

Exothermically weld the CP test wires to the pipeline at the nearest pipe joint to minimize coating damage.

Make connections to the structure with the alumino-thermic weld process ("Cadweld" or equal) per manufacturer’s recommendations. This process shall consist of a mixture of granulated copper oxide and aluminum together with a powdered magnesium starting charge, the whole being manufactured so that the charge, when poured into a suitable carbon mold, may be ignited by a spark gun to initiate a chemical reaction that will deposit molten copper welding metal at the point of the connection. Make exothermic welds in accordance with the manufacturer's procedures.

Install the cables with sufficient slack so that the cable insulation and conductors will not be damaged during the pipe backfilling process. Protect the cables by running them in schedule 40 PVC electrical conduit. Begin the PVC conduit within 3 feet of the welded connection to the pipe. Ream the PVC conduit were lead wires at ingress and egress points.

Prepare the pipe surface by removing a 4-inch square "window" from the coating. File, wire brush, sand blast, or mechanically grind the pipe surface until a bright metal finish is obtained.

Where two or more wires are welded to the metallic structure, the minimum spacing between exothermic welds shall be 6 inches.

After the weld is performed, test the bond by striking the weld nugget with a 2-lb hammer. If the weld comes loose, or is not completely connected, remove the wire and reweld the wire to the structure. The new weld location shall be moved a minimum of 3 inches away from the failed location.

Coat the alumino-thermic weld nuggets with the specified weld coating. Allow the weld coating to cure. Apply a concrete bonding agent per manufacturer’s recommendations before repairing cement-mortar pipe coating.

After the weld coating cures, cover the exothermic weld nugget and all disturbed areas of the pipeline coating with a quick cure, non-shrink, cementitious, patching compound. Before applying the patching material, clean all debris from the area to be patched and coat with a cement bonding agent. Apply the patching compound to a minimum thickness of 1-inch or match the surrounding pipe coating thickness, whichever is greater. The patching compound shall have a set time of 20 minutes, a maximum shrinkage of 0.087 percent after seven days (ASTM C596 test method), achieve a minimum compressive strength of 3,570-PSI in one day, and a minimum compressive strength of 8000-PSI in 28 days (ASTM C109). Use “Jet Set Complete Repair” as manufactured by Jet Set Cement Corporation or approved equal.

19.3.9 Installation of Wires

Cover the bottom of the wire trench with a 3-inch layer of sand or stone free earth. Place all wires in Schedule 80 PVC electrical conduit. Center the conduit on the backfill layer. Place backfill over the conduit in layers not exceeding six inches deep, compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter or refuse in the backfill. Plastic warning tape shall be placed 24 inches above conduit.

19.3.10 Joint Bonding

Excavate and bond each non-circumferentially welded pipe joint using 2 rod-cable-rod joint bond assemblies described herein. Non-welded joints include rubber-gasket joint, dresser couplings, in-line valves, tees, crosses, bolted flanged joints, and other non-conductive fittings. *DO NOT BOND ACROSS INSULATED PIPE FLANGES.*

Completely coat the welded rod and half of the steel substrate with a 0 VOC, 100% solid epoxy coating. Work coating into all crevices to provide a full encapsulation of the rod.

After the weld coating cures, cover the entire steel rod and ¼-inch of the steel substrate with a quick cure, non-shrink, cementitious, patching compound. Before applying the patching material, clean all debris from the area to be patched and coat with a cement bonding agent. Apply the patching compound to a minimum thickness of 1-inch or match the surrounding pipe coating thickness, whichever is greater. The patching compound shall have a set time of 20 minutes, a maximum shrinkage of 0.087 percent after seven days (ASTM C596 test method), achieve a minimum compressive strength of 3,570-PSI in one day, and a minimum compressive strength of 8000-PSI in 28 days (ASTM C109). Use “Jet Set Complete Repair” as manufactured by Jet Set Cement Corporation or approved equal.

19.3.11 Excavation and Backfilling

Excavation and backfill shall conform to DIVISION 1 - EARTHWORK, and the following.

Trenches for anode lead wires or header cables shall be a minimum of 36 inches deep or as shown otherwise on drawings.

Backfill the trenches with native, rock-free excavated material.

Do not use large rocks, stones, boulders or other foreign materials as, or in, backfill material.

Place the backfill in 6 inch layers and thoroughly and carefully tamp until the wires and conduit have a depth of cover not less than 18 inches. Compacting the backfill with water will not be permitted.

19.3.12 Installation of Flange Insulating Kit Materials

Install pipe flange insulating materials at the locations shown on the plans and in accordance with the manufacturer's recommendations and NACE recommended practice RP0286, "Electrical Isolation of Cathodically Protected Pipelines." Particular attention shall be paid to properly aligning the flanges prior to inserting the insulating sleeves around flange bolts. Prevent moisture, soil, or other foreign matter from contacting any portion of the insulating joint prior to or during installation. If moisture, soil, or other foreign matter contacts any portion of the insulating joint, disassemble the entire joint, clean with a suitable solvent, and dry prior to reassembling. Follow the manufacturer's recommendations regarding the torquing pattern of the bolts and the amount of torque to be used when installing the insulating flange kit. As required, use only non-conductive lubricants such as Huskey 2000 Lubricating Paste & Anti-Seize compound, 3M Super 77 Spray Adhesive, and Triflow aerosol lubricant with Teflon additive, on the flange bolts or other flange components.

19.3.13 Coating of Buried Insulated Pipe Flanges

Coat buried insulated pipe flanges with an external wax-tape coating in accordance with AWWA C217 and as modified herein. Do not apply the wax-tape coating until the insulated pipe flanges have been tested and approved by the District. The wax-tape coating shall consist of a surface primer, wax-tape, and an outer covering.

1. Surface Primer: Clean the surface of dirt, dust and loose rust by wire bush and by wiping with a clean cloth until dry. Apply primer by hand or bush. Work a thin coating of primer into all crevices, i.e., around all bolts and in threads, and completely cover all exposed metal surfaces. Extend the primer a minimum of 2 pipe diameter onto the adjacent surfaces of the pipe or valve.

2. Wax-Tape Application: Apply the wax tape immediately after the primer application. Cut short lengths of tape and place completely around each bolt head and nut. Work the tape into the crevices around the bolts and nuts. Wrap the wax tape spirally around the pipe and across the flanges to adjacent pipe or valve. Use a minimum overlap of 55 percent of tape width. Work the tape into the crevices and contours of the irregularly shaped surfaces and smooth out so that there is a continuous protective layer with no voids or spaces under the tape. When complete, all surfaces and edges coated with wax-tape shall have a minimum thickness of 100 mils.

3. Outer Covering: Over-wrap the completed wax tape installation with two layers of polyvinylidene chloride, high cling membrane sheet such that the material conforms and adheres to the wax-tape surface. Secure plastic wrap to pipe with adhesive tape.

19.3.14 Installation of Permanent Reference Electrodes

Measure the accuracy of each copper-copper sulfate reference electrode before installation by measuring the direct current voltage (VDC) difference between it and one or more reference electrodes of known accuracy. The measurements shall be less than plus or minus 0.010 VDC for all reference electrodes. Perform these measurements after totally submerging the reference electrodes in a 5-gallon bucket of potable water for a minimum period of 15 minutes. Brackish water or saltwater will not be allowed.

Install the copper-copper sulfate reference electrodes as shown on the plans. Provide a minimum of 24-inches of slack wire around the reference electrode to allow for movement during backfill and soil compaction. Exercise care so as not to damage or pierce the insulation of the reference electrode lead wire. Cover the reference electrode with 6-inches of native rock free soil and saturate it with a minimum of 5-gallons of potable drinking water. Backfill as shown in the plans.

Exercise care so as not to damage or pierce the insulation of the reference electrode lead wire.

Route the lead wire back to its terminus via electrical conduit.

19.3.15 Testing Insulated Pipe Flanges

The Contractor’s corrosion engineer or corrosion technician shall test the electrical isolation effectiveness of each insulated pipe flange. The Contractor shall provide written notice of this testing to the District a minimum of three days in advance. If the insulated pipe flange will be buried, it shall be tested for electrical isolation by the Contractor before the wax tape coating is applied. At the District’s option, the District’s corrosion engineer may repeat this testing during or immediately after the installation of the insulating flange. Replace or repair any insulated pipe flange that is determined not to be electrically effective. Testing shall be performed in accordance with NACE RP0286.

After each insulating flange kit is tested, all tests results shall be submitted to the District for review within 5 working days for review.

Replace or repair any insulated pipe flange that is determined not to be electrically effective.

19.3.16 Electrical Continuity Testing

Conduct electrical continuity testing to demonstrate that all buried pipe joints (except insulated flanges) are either welded joints or have been electrically bonded across with two rod-cable-rod joint bond assemblies. The Contractor’s cathodic protection technician or corrosion engineer shall conduct the tests. The District will witness the electrical continuity tests at its discretion. The Contractor shall demonstrate to the District’s satisfaction that full electrical continuity has been achieved and shall make all required rod-cable-rod connections in the event that electrical continuity of the pipe is not achieved.

Perform electrical continuity tests between adjacent test stations by circulating a known DC current through the pipe span and measuring the resulting voltage (IR) drop. Use two pairs of test wires, one for current flow, one for IR measurement. Calculate the electrical resistance of the pipeline section in ohms using Ohm's Law. The pipe span is said to be electrically continuous when the measured resistance is 110% of the calculated theoretical resistance. The theoretical resistance shall include the resistance of the pipe span, the resistance of the rod-cable-rod joint bond assemblies, and the pipelines fringing resistance.

If other electrical continuity test methods are proposed, the Contractor shall prepare a written test procedure specifying the alternate method and equipment that will be used. A standard handheld digital multi-test meter's ohmmeter circuit (e.g. Fluke 87 or Beckman HD110) is not suitable for properly making these measurements. Submit in writing the alternate proposed test method to the Engineer for approval a minimum of 30 days before the pipe laying begins.

After each pipe span is tested, all tests results shall be submitted to the District for review within five working days for review.

19.3.17 Cathodic Protection System Activation

The Contractor’s cathodic protection technician or corrosion engineer shall conduct the tests. The District will witness the system activation tests at its discretion.

Provide a minimum of five days advance notice to the Engineer before the cathodic protection activation will be performed to allow for coordination and observance of these tests.

Before beginning each day of testing, calibrate portable copper sulfate reference electrodes with respect to a master reference copper sulfate reference electrode.

Measure CP Native Potentials (i.e. baseline pipe-to-soil potentials) at all Cathodic Test Stations prior to activating the cathodic protection system. Measure CP Native Potentials on both sides of all insulating flanges and at all CTS wires. Where two wires are attached to the same pipeline, measure and record the CP Native Potentials for both wires. If the potential measurements for the same pipeline differ by more than 2 mV, investigate the cause.

At CTSs constructed with buried copper-copper sulfate reference electrodes (i.e. “stationary reference electrode”), measure CP Native Potentials of the pipeline using both the stationary reference electrode and a portable copper sulfate reference electrode before the CP system is activated.

Activate the cathodic protection system by energizing the rectifier(s) and setting their output(s) to the estimated output required.

Measure CP “On and Off Potentials” at the same locations where CP “Native Potentials” were previously measured.

Measure all anode currents at anode junction boxes by measuring the voltage drop across the calibrated shunts provided. Calculate the corresponding amount of direct current flow using the shunt rating. Explicitly state the shunt rating on each data sheet.

Measure all cathode currents at cathode junction boxes by measuring the voltage drop across the calibrated shunts provided. Calculate the corresponding amount of direct current flow using the shunt rating. Explicitly state the shunt rating on each data sheet.

Remeasure CP “On and Off Potentials” at all CTS at least two weeks after the initial energization of the cathodic protection system to allow for the development of the cathodic polarization process.

Furnish all test results including all CP potential readings, anode and cathode current readings, insulating flange test data, dates, and times. Reference all data to pipeline station numbers. Submit all data along with a letter report to the District for review before final acceptance. The letter report shall include a description of the test methods, analysis of all project data including, but not limited to, electrical continuity and electrical isolation testing, and conclusions about the CP system’s effectiveness.

Submit the final report after the District’s review in both electronic and hardcopy formats. The electronic copy of the report shall be submitted in either Microsoft Word or PDF file formats. All data shall be submitted in spreadsheet format compatible with Microsoft Excel.

19.3.18 Acceptance Criteria for Steel Pipe with Cement-Mortar Coating

The operation of the cathodic protection system shall be tested to ensure that all portions of the pipeline are provided a full level of corrosion protection. The standards used to evaluate the CP potential measurements shall be in accordance with either of the three following NACE RP0169 criteria:

1. A negative voltage of at least 0.85 volt as measured between the pipeline and a copper sulfate reference electrode contacting the soil immediately over or adjacent to the pipeline. Determination of this voltage is to be made with the cathodic protection current applied. *Voltage drops must be considered for valid interpretation of this voltage measurement.*

2. A negative polarized, instant off, potential of at least 850 mV relative to a saturated copper/copper sulfate reference electrode.

3. 100 mV CP POLARIZATION SHIFT - A minimum polarization shift of 100 millivolts measured between the pipeline being protected from corrosion and a copper sulfate reference electrode contacting the soil immediately over or next to the pipeline. This minimum polarization shift shall be determined by interrupting all cathodic protection currents and measuring the polarization formation or decay. At the instant the cathodic protection current is interrupted ("instant off"), an immediate voltage shift will occur. The voltage reading just after the immediate shift shall be used as the base reading from which to calculate the polarization formation or decay.