SECTION 15025 - CATHODIC PROTECTION

City of San Diego, CWP Guidelines

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NTS: This Section shall be reviewed and modified, as necessary, by the corrosion engineer hired by the DESIGN CONSULTANT. The corrosion engineer shall be a specialist in this field, who is a registered corrosion engineer in the State of California or a Certified Corrosion Specialist by the National Association of Corrosion Engineers and is regularly engaged in designing cathodic protection facilities. This Specification shall be customized to the needs of each individual project in the Clean Water Program.

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PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing a complete system as indicated including electrical connections, installation of anodes, and all accessories required for a complete operable system, including testing the system after installation.

B. The WORK also requires that one manufacturer accept responsibility for furnishing the WORK as indicated but without altering or modifying the CONTRACTOR'S responsibilities under the Contract Documents.

C. The WORK also includes coordination of design, assembly, and testing.

1.2 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 02620 Reinforced Concrete Pressure Pipe, Steel Cylinder Type
2. Section 02630 Ductile Iron Pipe
3. Section 02650 Steel Pipe, Mortar Lined and Mortar Coated
4. Section 02651 Steel Pipe, Mortar Lined and Tape or Enamel Coated
5. Section 02653 Steel Pipe and Specials
6. Section 09800 Protective Coating

1.3 STANDARD SPECIFICATIONS

A. Except as otherwise indicated in this Section of the Specifications, the CONTRACTOR shall comply with the Standard Specifications for Public Works Construction (SSPWC), as specified in Section 01090 - REFERENCE STANDARDS.

1.4 CODES

A. The WORK of this Section shall comply with the current editions of the following codes as adopted by the City of San Diego Municipal Code:

1. National Electrical Code

1.5 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

1.	NEMA	National Electrical Manufacturers Association
2.	ASTM	American Society for Testing and Materials
3.	IEEE	Institute of Electrical and Electronic Engineers
4.	ANSI	American National Standard Institute
5.	ICEA	Insulated Cable Engineers Association
6.	OSHA	Occupational Safety and Health Administration
7.	NACE	National Association of Corrosion Engineers
8.	UL	Underwriters' Laboratory

1.6 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Catalogue cuts, bulletins, brochures, and data sheets for all equipment.
2. Certification that the equipment and materials proposed meet the Specifications.
3. Catalogue cuts for all exothermic welds to be used.
4. Shop drawing of an anode centering device.

1.7 OWNERS MANUAL

A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:

1. Manufacturer's operation and maintenance instructions.
2. List of spare parts recommended for 2 years' successful operation.
3. Anode wire resistance test records.
4. Log of "Holiday" testing.
5. Factory test results for rectifiers.
6. Testing schedule and log form.
7. Diagram indicating locations of system tests.

1.8 PROJECT RECORD DRAWINGS

A. The following shall be included on the PROJECT RECORD DRAWINGS in compliance with Section 01300:

1. Accurate record of actual locations of cathodic protection equipment, devices, outlets, and appurtenances.

PART 2 -- PRODUCTS

2.1 GENERAL

A. All equipment and materials provided shall meet qualities of satisfactory service.

2.2 CONDUIT AND FITTINGS

A. The minimum conduit size shall be 3/4-inch unless otherwise indicated. Rigid steel conduit shall be galvanized conforming to UL 6. Rigid nonmetal conduit shall be PVC schedule 40 conduit approved for underground use.

Fittings for use with rigid steel conduit shall be galvanized cast ferrous metal, with gasketed covers. Rigid metallic conduit fittings shall be galvanized conforming to UL 514.

Fittings for use with either rigid nonmetallic conduit or duct shall be PVC and shall have solvent weld type conduit connections. If such are not available, then the Specification for rigid steel fittings shall apply except in corrosive locations where PVC coating shall be provided.

2.3 TEST STATION HOUSINGS (FOR ABOVE GRADE TEST STATIONS)

A. The test station housings shall be made from 4-inch diameter, schedule 80 galvanized steel pipe, 6 feet in length and complete with threaded steel end cap. The lower 2-1/2 feet of the pipe shall be tape-wrapped and the remainder of the pipe shall be coated with a bright orange exterior enamel paint. Black exterior enamel paint shall be used to inscribe "TEST STATION # _____", using 3-inch high letters, running vertically downward from the end cap.

2.4 TEST STATION HOUSINGS (FOR GROUND LEVEL TEST STATIONS)

A. The test station housings shall be round precast concrete traffic valve boxes with cast iron ring seats. Minimum throat diameters shall be 8 inches. [Each box shall have a 10-inch concrete extension.]

Traffic box covers for anode beds and test stations shall be cast iron with welded bead legend "CP TEST" as indicated.

2.5 JUNCTION BOXES

A. Anode junction boxes shall be NEMA Type [ ], fiberglass reinforced construction. Junction boxes shall have stainless steel or fiberglass hinges. Junction boxes shall be mounted and labeled as indicated.

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NTS: Select the products below which are applicable and delete the others. Delete each identifier in square brackets.

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2.6 ANODE JUNCTION BOXES [IMPRESSED CURRENT ALTERNATIVE]

A. Anode junction boxes shall be NEMA Type [ ], fiberglass construction. Boxes shall be sized as indicated. Hinges shall be built of stainless steel and a neoprene gasket shall be furnished with the box to ensure a water tight seal. Junction boxes shall have external mounting feet with drilled holes for anchor placement.

Boxes shall be labeled with a black plastic tag bolted to the front panel of the box. This tag shall be engraved in a contrasting color with the identification junction box. Minimum height of lettering shall be 3/4-inch.

2.7 PANEL BOARDS [IMPRESSED CURRENT ALTERNATIVE]

A. Panel boards for anode junction boxes shall be made of phenolic plastic 1/4-inch thick and sized as indicated. Double-nutted brass bolts, nuts and lockwashers shall be installed on the panel boards as indicated.

2.8 SHUNTS [GALVANIC ALTERNATIVE]

A. Shunts for the anode junction boxes shall be 0.01 ohm, 6 ampere, manganin wire type, as indicated.

2.9 SHUNTS [IMPRESSED CURRENT ALTERNATIVE]

A. Shunts for the impressed current anode systems shall be Type SS - 0.001 ohm and 25 ampere capacity.

2.10 WIRE

A. Conductors shall consist of solid or stranded copper of the gauge indicated. Wire sizes shall be based on American Wire Gage (AWG). Copper wire shall be in conformance with ASTM Designations B3 and B8.

All wires terminating in a junction box or test station shall have a wire identifier attached within 4 inches of end of wire at terminal board, prior to backfill, as indicated under paragraph 2.12.

2.11 ANODE WIRES

A. **Construction**: The wire attached to the anodes shall be AWG stranded, single conductor, copper, insulated for 600 volts. Wire size shall be minimum #8 AWG HMWPE (For impressed current anodes) and shall conform with the requirements of ASTM D1248m Type 1, Class C, Grade 5, and #10 AWG THW (for galvanic anodes) and conform with the requirements of ASTM D-2220 NEMA WC-5. Connection of wire to the anode shall have a pulling strength which shall exceed the tensile strength of the wire. Any damage to the wire insulation or anode shall require complete replacement of the wire and anode.

Anode wires shall be of one continuous length without splices from the anode connection to the respective Junction Box as indicated. Anode wires with the attached anode shall be shipped to the job site with the wire wound on a reel. The minimum core diameter of the reel shall be 5-1/2 inches. The anode wire insulation shall be free of nicks, abrasions and scratches throughout the entire length of the wire. Precaution shall be taken during fabrication, transportation and installation of the anodes to see that the wire is not kinked or sharply bent. Bends sharper than 2-1/2 inches in radius are not permissible.

B. **Resistance Testing**: The anode manufacturer shall conduct and report resistance tests performed on each anode wire connection to assure the finished connection does not exceed 0.004 ohms. These resistance tests shall be performed with a Kelvin bridge circuit or equal. Anode wire connections that have a resistance value of greater than 0.004 ohms shall not be acceptable. An accurate record of tests shall be submitted to the CONSTRUCTION MANAGER. The records shall include the following information, as a minimum:

1. Anode numbering system to identify anode under test
2. Anode wire length
3. Resistance value as indicated by test
4. Test equipment
5. Description of test method

The anode manufacturer shall mark the reel holding the anode wire for shipment to the job site with the same anode numbering system used on the test records and the total length of attached anode wire.

C. **"Holiday" Testing**: All wires used for cathodic protection systems shall be checked for breaks in the insulation at the jobsite before installation. The CONTRACTOR shall retain the services of a qualified "Holiday" testing firm to conduct such tests or may conduct the tests itself if it has employees with 5 or more years' experience with such tests. A test log including the date of the test, the wires tested, and who was present during the testing shall be submitted.

2.12 WIRE IDENTIFICATION

A. All wires shall be identified by 1-inch circular brass disks with stamped or engraved identifier. The letters and numbers shall be minimum 3/16-inch in size.

Wire identifiers for anodes shall be the wrap around type with a high resistance to oils, solvents and mild acids. Marker shall fully encircle wire with imprinted alpha-numeric characters for pipe identification.

The following colors shall be used:

1. Test Leads	White
2. Drain Cable	Blue
3. Anode Leads	Black
4. Insulating Joint Test Leads Protected Side	White
5. Insulating Joint Test Leads Unprotected Side	Red

2.13 EXOTHERMIC WELDS

A. Exothermic welds shall be provided for connecting cables to structures in strict accordance with the manufacturer's recommendations. Connections shall be made at locations indicated. Packing shall be used where necessary to prevent leakage of molten weld metal.

The shape and charge of the exothermic weld shall be chosen based on the following parameters:

1. Pipe material
2. Pipe size
3. Wire material
4. Number of strands to be welded
5. Orientation of weld (vertical or horizontal)

Types of exothermic weld to be used shall be submitted to the CONSTRUCTION MANAGER for approval.

2.14 BITUMASTIC COATING

A. Bitumastic coatings shall be cold-applied, black, thixotropic material containing plasticized coal tar pitch, solvents and special fillers.

2.15 WELD CAPS

A. Weld caps shall consist of igloo shaped domes with a tunnel shaped opening over a small square of plastic. Specially compounded elastomeric material shall be placed in the tunnel shaped opening.

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NTS: Zinc anodes are intended for use where soil resistivity is less than 1500 ohm-centimeters. Magnesium anodes should be used where soil resistivity is greater than 1500 ohm-centimeters. The high silica cast iron anodes are for impressed current systems.

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2.16 ZINC ANODES

A. Zinc anodes shall be 99.99 % zinc bars, conforming to ASTM B-418, Type 1, prepackaged in a cloth bag containing backfill of the following composition; 50% Gypsum and 50% Bentonite. The zinc anodes shall be of the size indicated and placed where indicated. Cable for the anodes shall be Black, No. 10 AWG THW, stranded, and of sufficient length to extend to the junction box without splicing.

Anodes shall be cast with a galvanized steel core strap. One end of the anode shall be recessed to provide access to the rod for connection of the lead wire. The lead wire shall be silver brazed to the rod, making a mechanically secure connection. The connection shall be insulated to a 600 volt rating by filling the recess with asphalt. The asphalt material shall be extended over the lead wire insulation by not less than 1/2-inch. The CONTRACTOR shall repair all damaged lead wire insulation as directed by the CONSTRUCTION MANAGER and at no additional cost to the OWNER.

2.17 MAGNESIUM ANODES

A. Magnesium anodes shall be "High Potential" magnesium anodes of the following composition, percent by weight:

Aluminum	0.01% max
Manganese	0.50 - 1.30%
Copper	0.02% max
Nickel	0.001% max
Iron	0.03% max
Other	0.05% each or 0.30% max total

The anodes shall be prepackaged in a cloth bag containing backfill of the following composition; 75% gypsum, 20% bentonite and 5% sodium sulfate. The magnesium anodes shall be of the size indicated and placed where indicated. Cable for the anodes shall be black, No. 10 AWG THW, stranded, and of sufficient length to extend to the junction box without splicing.

2.17 HIGH SILICON CAST IRON ANODES

A. High silicon cast iron anodes shall be tubular type anodes with a minimum wall thickness of [ ] inch, length of [ ] inches, and shall be furnished with a minimum (black) 8 AWG HMWPE cable attached to the interior of the anode and sealed using the manufacturer's standard connection.

The anodes to be installed in the deep well anode shall be [ ] inch outside diameter with a minimum weight of [ ] pounds and minimum surface area of [ ] square feet.

Composition of the anodes shall conform to the following requirements:

Element	Minimum Percent	Maximum Percent
Silicon	14.2	14.75
Carbon	0.8	1.1
Manganese	0.75	1.5
Chromium	3.0	6.0
Iron	Remaining	Remaining

2.19 INSULATING FLANGE KITS

A. Insulating flange gaskets shall include full faced gaskets, insulating sleeves and washers and steel washers. The complete assembly shall have a pressure rating equal to that of the flanges between which it is installed. Gasket shall be neoprene faced phenolic, 1/8-inch thick having a high dielectric constant. Insulating sleeves shall be fabric reinforced resin, 1/32-inch thick. Insulating washers shall be two sets of 1/8-inch thick neoprene faced phenolic, having a high dielectric constant.

Steel washers shall be cadmium plated and fit well within the bolt facing on the flange. Insulating washers shall fit within the bolt facing the flange over the outside diameter of the sleeve.

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NTS: Delete Paragraph below if not applicable.

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2.20 COPPER COPPER/SULFATE REFERENCE ELECTRODE

A. Reference electrodes shall be permanent, prepackaged, copper copper/sulfate reference electrodes specifically manufactured for underground use. The cell shall be a minimum 1-1/4-inch diameter by 10-inch long, plastic tube with an ion trap to minimize contamination of the cell. The cell shall be prepackaged with a backfill material as recommended by the manufacturer. Each cell shall have a No 12. AWG THW cable, of sufficient length to extend to the test station without splicing.

2.21 CALCINED COKE BREEZE

A. Backfill material for impressed current system anodes shall be calcined coke breeze with a resistivity of 25 ohm-cm or less when tested with an applied pressure of two pounds per square inch. The material shall conform to the following gradation requirements:

Sieve Size	Percent Passing
3/8	100 minimum
1/8	5 maximum

The impressed current system anode backfill shall have the following chemical properties:

Fixed carbon	98.0% minimum
Ash	0.5% maximum
Sulfur	5.0% maximum
Volatile matter	1.0% maximum
Moisture	1.0% maximum

2.22 ANODE VENT PIPING

A. Plastic conduit for the impressed current system anode vent piping shall be polyvinyl chloride (PVC) type EPC-80-PVC conforming to NEMA TC2 (conduit) and TC3 (fittings). The vent piping shall have 3/16-inch diameter holes located 6 inches apart and at 90-degrees around the vent pipe along the length of vent tube which is in the coke breeze backfill.

2.23 ANODE CENTERING DEVICES

A. Centering devices for the non-canistered anodes in the augured holes shall be designed and fabricated by the CONTRACTOR or the manufacturer and shall be submitted to the CONSTRUCTION MANAGER for acceptance prior to use. The device shall be constructed of carbon steel and shall be designed to provide easy adjustment in the field.

2.24 PEDESTAL MOUNTED AIR COOLED RECTIFIER

A. **Construction**: Rectifiers shall be pedestal mounted with slide out racks for transformers and stacks. Cases shall be heavy duty steel with swing open doors, coated with white baked enamel finish, supported by standard 10-inch legs.

B. **Electrical Characteristics**:

1. Rectifier shall have a [ ] Volt [ ]-phase AC input and have a rated DC output of [ ] volts-[ ] amperes, satisfying the requirements of NEMA publication MR-20. Rectifiers shall be capable of operating continuously at the rated output current at any voltage from zero to 100% without damaging any rectifier components. Full rated DC output voltage shall be adjustable by not less than 20 equal steps from approximately 5 percent of rated voltage to full rated output. This adjustment may be accomplished with studs and link-bars or tap switches. If tap switches are used, they shall not carry over 50% of the nominal current rating assigned by the manufacturer.

2. Rectifiers shall be designed to operate continuously at rated maximum voltage and current in ambient temperature of 45 degrees C without damage to the rectifier components. Cooling shall be accomplished by natural convection. Fan cooling is not acceptable for unattended equipment.

3. Silicon stacks shall be equipped with silicon diodes rated a minimum of 800 peak inverse volts. Heat sinks shall be sized to keep diode junction and case temperatures for exceeding 100 degrees C under 45 degrees C ambient temperature conditions.

C. **Transformers**: Transformers shall be isolation type with a grounded electrostatic shield between the primary and secondary windings. Dielectric strength of all insulting materials shall not be less than 2,000 volts RMS as tested for one minute than applied between windings and the transformer core. Magnet wire insulation and layer insulation shall be rated no less than 155 degrees C. Magnetic wire insulation shall not show signs of softening or crazing after 24 hours immersion in any of the following chemicals: Naptha, Toluene, Ethyl Alcohol, Trichloro-Ethylene, Stryene Polyester, Butyl Acetate, Mild Acids, or Acetone. Impregnating varnish used shall meet the standards for 155 degrees C when tested according to AIEE test procedures. The transformer shall be preheated before dipping and baked after dipping. The transformer temperature rise, as measured by thermocouples within the transformer, shall not exceed 85 degrees C. The transformer efficiency shall not be less than 85 percent. The transformer voltage regulation shall not exceed 3% from full rated load to 1/4 of rated load when measured in accordance with the procedure described in MR-20-1958. Chokes and reactors shall meet the requirements listed for transformers.

D. **Output Monitoring**: Separate voltmeter and ammeter shall be provided for monitoring rectifier output. Minimum meter width shall be 3.5 inches round or rectangular with minimum scale length of 2-7/8 inches. Meter movement shall be jewel and pivot D'Arsonval type. Taut band meters are not acceptable because of a tendency to break when jolted during shipment. Meter accuracy shall be a minimum of plus or minus 2 percent of full scale at 80 degrees F and shall be temperature compensated to vary no more than 1 percent per 10 degrees F temperature variation. Scale faces shall be metal or plastic. Ammeter shunt shall be block type mounted on the from panel for easy access. Current and millivolt ratings shall be clearly stamped on the shunt. Shunt accuracy shall be at least plus or minus one percent.

E. **Overload Protection**: All rectifiers shall have overload protection. Protection from overload on the input shall be accomplished by molded case fully magnetic circuit breakers on the incoming power lines. These circuit breakers shall hold at 100 percent of load and may trip between 101 percent and 125 percent of rated load. They shall trip at 125 percent of rated load. The trip point shall be unaffected by changes in ambient temperature. Trip handles of individual pole breakers shall be mechanically linked to open all lines when an overload occurs. Units shall be equipped with silicon stacks, overload protection shall be provided by a quick opening fuse in the transformer secondary.

F. **Surge Protection**: Voltage surge protection for units equipped with silicon stacks shall be supplied by AC and DC lightning arresters and metal oxides varistors across all secondary lines to the stack and across the DC output of the rectifier. The metal oxide varistors must fire before the voltage surge reaches the peak inverse voltage rating of the diodes used in the stack.

G. **Testing**: Electrical tests shall be performed at the factory and recorded as listed below:

- AC Volts Input
- DC Amperes Input
- Apparent Watts Input
- True Watts Input
- Power Factor
- DC Volts Output
- DC Amperes Output
- DC Watts Output
- Conversion Efficiency
- Dielectric Strength
- Transformer Primary to Ground
- Transformer Secondary to Ground

- Transformer Primary to Secondary
- Stack AC to Ground
- Stack DC to Ground
- Ripple Voltage at Full Output

Results of the tests shall be furnished to the CONSTRUCTION MANAGER in the OWNER'S MANUAL.

2.25 MANUFACTURERS

A. Products of the type indicated shall be manufacturer by the following (or equal):

1. Conduit Fittings

   Crouse Hinds Condulets
   Appleton Unilets
   Erickson Type EC
   Appleton Type EC
   O-Z Gedney 3-Piece Series 4

2. Traffic Valve Boxes

   Christy G5 Utility Box
   Brooks Products No. 1RT Utility

3. Shunts

   Holloway

4. Exothermic Welds

   Erico Products, Inc., Cadweld
   Continental Industries, Inc., Thermoweld
   Johns-Manville Duxseal Packing

5. Bitumastic Coating

   Tapecoat Company, TC Mastic
   Kopcoat, Inc. Bitumastic 505

6. Weld Caps

   Royston Laboratories, Inc., Royston Handy Cap
   Phillips Petroleum Co., Thermite Weld Cap

7. Rectifiers

   Goodall Electric, Inc.

PART 3 -- EXECUTION

3.1 GENERAL

A. **Field Control of Location and Arrangement**:

1. The locations of cathodic protection equipment, devices, outlets, and appurtenances indicated are approximate only. Locations shown on the drawings should be adhered to as closely as possible, but in the case of interference with other WORK or equipment or structures, exact locations shall be determined by the CONTRACTOR subject to the approval of the CONSTRUCTION MANAGER.

B. Upon completion of installation of each component as indicated, testing shall be performed to demonstrate that the installation has been completed and the component is in working order. The test data shall be submitted to the CONSTRUCTION MANAGER for acceptance to demonstrate that the system is in proper working order. The cost of the testing shall be borne by the CONTRACTOR, including any additional expenses which may result from retesting due to equipment or installation which is not in conformance with the Contract Documents.

3.2 EXCAVATION AND BACKFILL

A. Buried wires shall have a minimum cover of 24 inches. The bottom of the trenches shall be covered with 1-inch of mortar sand prior to placing wires, insulation, anodes, coatings or other underground appurtenances.

Initial backfill to 12 inches above the wire, insulation, anode or appurtenances shall be mortar sand. Mortar sand shall be per SSPWC Subsection 200-1.5 with a minimum sand equivalency of 50.

Anode wire identification tags shall be placed on the wires prior to placing wire in conduit or backfilling.

3.3 JUNCTION BOXES

A. Junction boxes shall be installed at the indicated locations. Attachment of wire identification tags, split bolts and shunts shall be made as indicated.

3.4 TEST STATIONS

A. Test stations shall be placed at the locations indicated. The CONTRACTOR shall field verify final location of the test stations. Wire identifiers shall be placed on all wire prior to backfill and installation of test stations.

3.5 WIRES

A. Wires buried in the ground shall be laid straight, without kinks. Each wire run shall be continuous in length and free of joints or splices, unless otherwise indicated. Care shall be taken during installation to avoid punctures, cuts or other damage to the wire insulation. Damage to insulation shall require replacement of the entire length of wire at the CONTRACTOR'S expense.

At least 18 inches of coiled slack shall be left for each conductor at each test station housing. Slack in the wire shall be sufficient to allow removal of wire extension for testing. Wire shall not be bent into a radius of less than 8 times the diameter of the wire. Copper split bolts or other appropriate connection hardware shall be used for all test station connections.

Where buried cable is to be placed in existing conduit, the conduit diameter must be of sufficient diameter to accommodate the additional cable. This shall be determined by the number and size of both existing and new cable in accordance with all applicable codes and standards. This shall also apply where new cable is to be installed in new PVC conduit. PVC conduit shall be installed to a minimum depth of 24 inches below grade.

Red "Caution" tape 3 inches in width shall be installed above buried wire and conduits at a maximum depth of 18 inches below grade.

3.6 WIRE IDENTIFICATION

A. Brass wire identifiers or wrap around cable markers shall be placed on the wires prior to backfill.

3.7 EXOTHERMIC WELD CONNECTIONS

A. Exothermic weld connections shall be installed in the manner and at the locations indicated. Coating materials shall be removed from the surface over an area of sufficient size to make the connection. The steel surface shall be cleaned to white metal by grinding or filing prior to welding the conductor. The use of resin impregnated grinding wheels will not be allowed. The conductor shall be welded to the pipe by the exothermic welding process with a copper sleeve fitted over the conductor. Only enough insulation shall be removed such that the copper conductor can be placed in the welding mold. After the weld has cooled, all slag shall be removed and the metallurgical bond shall be tested for adherence to the pipe or casing. All defective welds shall be removed and replaced. All exposed surfaces of the copper and steel shall be covered with insulating materials as indicated. Weld caps shall be sealed with [a spiral wrapping of] bitumastic tape. No connections to the piping shall be covered or buried prior to inspection and approval of the CONSTRUCTION MANAGER.

3.8 COATING OF WELDS

A. The CONTRACTOR shall furnish all materials, clean surfaces and repair any damage to protective coatings and linings damaged as a result of the welding.

A coating shall be applied to all exothermic weld locations. The coating for ductile iron or dielectrically coated steel shall be a bitumastic coating. The coating shall be covered with a plastic weld cap and bitumastic tape. All surfaces must be clean and dry and free of oil, dirt, loose particles and all other foreign materials prior to application of the coating. For cement mortar lined and coated pipe, the coating shall match the exterior mortar.

3.9 JOINT BONDS

A. Bond cables shall be provided across flexible couplings and all nonwelded joints on steel pipe, on cement mortar coated steel cylinder pipe joints and ductile iron pipe joints as necessary to ensure electrical continuity. Joint bonds shall be installed as indicated.

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NTS: The following three paragraphs on anode installation are applicable to 3 different types of protection systems. Select the one which applies and delete the other two. Delete the identifier in square brackets.

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3.10 ANODE INSTALLATION [GALVANIC CATHODIC PROTECTION SYSTEMS]

A. Prepackaged anodes shall be installed at the locations indicated. Plastic or paper wrap shall be removed from the anode prior to lowering the anode into the hole. Anodes shall not be suspended by the lead wires. When compacted soil is required and has been placed to the top of the anode and prior to the filling of the hole with soil, a minimum of ten gallons of water shall be poured into the hole to saturate the anode backfill and surrounding soil.

Backfilling with native soil shall proceed in 6 inch lifts, compacting the soil around the anode during each lift until the backfill has reached grade. Damage to the canvas bag, anode to wire connection, copper wire or wire insulation shall require replacement of entire assembly.

Anodes shall not be backfilled prior to inspection and approval of the CONSTRUCTION MANAGER.

3.11 ANODE INSTALLATION [IMPRESSED CURRENT, DEEP WELL]

A. **General**: The CONTRACTOR shall obtain and pay for all fees and permits required for well drilling. CONTRACTOR shall log the well in accordance with local and State agency requirements.

Anodes shall be installed in the deep anode well at the locations indicated. All drilling shall be done in strict conformance with California State Bulletin Number 74 regulating the classification, construction and sealing of wells. The CONTRACTOR shall provide a grout seal for a minimum of 50 feet.

B. **Drilling**:

1. The impressed current system anode holes shall be drilled by means of a rotary drill rig using circulating water base drilling mud. Holes shall be drilled to obtain a nominal 10 inch diameter anode well. The well shall be drilled to the minimum depth indicated and shall be essentially straight and plumb. Drilling mud may be circulated through a portable sump or through a sump dug in the ground at the drill site. If a "dug sump" is used, it shall be emptied and backfilled upon completion. Backfilling shall be such that the sump is safe for vehicle traffic without settling. Drilling mud and cuttings shall be disposed by the CONTRACTOR at a suitable disposal site at no additional cost to the OWNER.

2. When the hole has been drilled to specified depth, fresh water shall be circulated from the bottom of the hole to clear the hole of drilling mud and cuttings. The hole shall be flushed until fluid is thinned as much as possible without danger of cave-in. The degree to which the hole is flushed shall be determined by the CONSTRUCTION MANAGER. The hole shall be maintained full to the top with fresh water throughout the entire loading operations.

C. **Loading**:

1. Preparation of the impressed current system anode hole and loading of anodes and other equipment in the hole shall be done in the presence of the CONSTRUCTION MANAGER. A minimum of 24 hours notice prior to anode loading shall be given by the CONTRACTOR to the CONSTRUCTION MANAGER. Loading of the anode hole shall be begun early enough in the day to insure completion of all loading, including backfilling, during regular working hours. Loading shall not be commenced later that 1:00 p.m. unless prior approval has been obtained by the CONTRACTOR from the CONSTRUCTION MANAGER.

2. Anode assemblies with centralizers attached shall be lowered into the hole supported by the attached lead wires. Anode vent pipes, shall be lowered to the depth indicated. The CONSTRUCTION MANAGER shall visually inspect the insulation on the anode lead wire for abrasion or other damage to the insulation and wire as the anode is lowered into place. The CONSTRUCTION MANAGER will reject all anodes with damaged insulation or wire, and they shall not be installed. Splices and/or any form of wire repair shall not be allowed on the anode lead wire from the point of connection at the anode to the top of the deep well anode bed hole. In the event that an anode must be retrieved after it has been lowered into the hole, the entire length of the anode lead wire shall be inspected by the CONSTRUCTION MANAGER for abrasion or other forms of damage to the insulation and wire. Anodes with damaged wires shall be rejected by the CONSTRUCTION MANAGER and shall not be reinstalled.

3. When an anode has been placed at specified depth, it shall be securely fixed in that position by tying the anode lead wire to a rack, sawhorse, etc., placed over or adjacent to the anode hole. That portion of the device to which the anode wire is tied shall be smooth and round and shall have a diameter of not less than 5-1/2 inches so as to prevent kinking or sharply bending the wire.

4. All anodes shall be loaded prior to coke breeze backfill. No anodes shall be buried until the CONSTRUCTION MANAGER has inspected the placement of the anodes and given permission to backfill.

5. The vent pipe shall be installed along with the first anode placed in the hole by attaching it to one of the centralizer straps with a stainless clamp. The vent pipe shall not be attached to the anode proper. The CONSTRUCTION MANAGER will approve the attachment before the vent pipe is lowered into the hole. Joints shall be made up as the anode assembly, with the vent pipe attached, is lowered into the hole.

D. **Coke Breeze**:

1. Coke breeze shall be placed in the hole by pouring directly from the bag into the anode hole. Pouring shall be at a steady rate and shall be slow enough to insure that the coke breeze does not bridge or block in the hole. The hole shall be kept completely full of water during placement of backfill. The top of the hole shall be kept free of floating coke breeze particles.

2. Settling of the backfill and coverage of the anodes shall be determined by the CONSTRUCTION MANAGER by observing the CONTRACTOR'S measurement of anode current output through a 12V DC power source circuit. During backfill placement, continuous monitoring of the current output of the lowermost uncovered anode shall be made. Coverage of the anode will be indicated by a rapid increase in current output, normally by at lease 50%. As soon as coverage of a lower anode is indicated, the circuit shall be attached to the next higher anode in the hole and so on until coverage of all anodes has been verified. The CONTRACTOR shall record the anode current output of each backfilled anode on the same form used for recording the initial current output of the anode. After coverage of the top anode has been verified, sufficient coke breeze shall be placed in the hole to insure backfilling a minimum of 5 feet above the uppermost anode.

E. **Backfill**:

1. Backfill of the hole above the coke breeze column shall be sealed with 5 feet of sand. Following placement of the sand, the hole shall be sealed within 3 feet of the top with

premixed grout as specified in California State Bulletin Number 74. Backfill of the uppermost 3-foot portion of the anode hole shall consist of round drain rock as indicated. Round drain rock used for backfill shall be 3/4-inch to 1/2-inch diameter thoroughly washed to insure removal of sand and fines.

2. Backfilling operations above the coke breeze column shall begin no sooner than 30 minutes, nor later than 24 hours, after the anode current measurements, indicating that the uppermost anode had been covered with coke breeze. Once backfilling has begun, it shall continue until the hole is filled with grout. The backfill for the uppermost 3-foot portion of the anode hole shall be done after the grout has set. The CONSTRUCTION MANAGER will visually inspect the entire backfill operations.

F. **Traffic Box**: Concrete traffic box shall be set at the top of the anode hole as indicated. From the top of the anode hole, the anode leads shall be run to the junction box locations. The anode vent pipe shall be terminated in the traffic box as indicated. Individual anode leads shall terminate in the anode junction box and be permanently marked with cable identifiers to their respective position in the anode hole as indicated.

3.12 ANODE INSTALLATION [IMPRESSED CURRENT, SURFACE BED]

A. Preparation of the impressed current system anode holes and loading of anodes and other equipment in the hole shall be done in the presence of the CONSTRUCTION MANAGER. A minimum of 24-hours notice prior to placement of the anodes shall be given by the CONTRACTOR to the CONSTRUCTION MANAGER.

Anode assemblies shall be lowered into the hole or trench supported by the attached lead wires. Vertical anodes shall be installed with anode centering devices and anode vent pipe, as required. Horizontal anode installation will not require anode centering devices or vent pipe. Anodes shall be placed at the depth indicated.

The CONSTRUCTION MANAGER shall visually inspect the insulation on the anode lead wires for abrasion or other damage to the insulation and cable as the anode is lowered into place. Anodes with damaged cable or insulation shall be rejected. No splices or repair of cable or insulation will be allowed from the point of connection to the anode to the anode (*splice or junction*) box. In the event that an anode must be retrieved after it has been lowered into the hole, the entire length of cable shall be inspected by the CONSTRUCTION MANAGER for abrasion or other forms of damage.

Wire identification is to be placed on the anode wires prior to placement of the wires in conduit or backfilling.

3.13 WIRE CONNECTIONS

A. After installation, all wire connections shall be tested at the test station and junction box locations, by the CONTRACTOR.

3.14 EXOTHERMIC WELDS

A. Exothermic welds shall be tested by the CONTRACTOR for adherence to the pipe or casing and for electrical continuity between the pipe or casing and wires. A 22-ounce hammer shall be used for adherence testing by striking a blow to the weld. Care shall be taken to avoid hitting the wires.

3.15 INSULATING JOINT TESTING

A. Insulating flange kits shall be installed to effectively isolate metallic piping from foreign metallic structures. The CONTRACTOR shall test the performance of these insulating flange kits prior to backfill. Testing shall be performed using a Gas Electronics Model No. 601 Insulation Checker or approved equal. Any insulating flanges which do not meet requirements shall be considered deficient and shall be repaired and retested at the CONTRACTOR'S expense.

3.16 JOINT BOND TESTING

A. After installation, all joint bonds shall be tested for effectiveness. The testing shall be performed prior to backfill of the pipe and shall be verified upon completion of backfilling operations. Prior to backfilling, current shall be circulated through the pipe and the measured resistance shall be compared to the theoretical resistance of the pipe and bond cables. The resistance measured shall not exceed 150 percent of the theoretical resistance.

3.17 SYSTEM CHECK-OUT

A. Upon completion of the installation, the CONTRACTOR shall furnish testing of the system by a qualified corrosion engineer. The testing shall be conducted in the presence of the CONSTRUCTION MANAGER. The testing shall include measurement of all anode currents and potentials, potentials of metallic pipelines and casings with anodes connected. Measurements shall be made at all test stations and anode junction box locations. All system checkout test results shall be recorded as the "Acceptance Test Results" in the test log form furnished under paragraph 1.7. Any deficiencies of systems tested shall be reported to the CONSTRUCTION MANAGER and repairs to the systems and retesting of systems shall be at no additional cost to the OWNER.

** END OF SECTION **