BOARD OF WATER SUPPLY

CITY AND COUNTY OF HONOLULU
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HONOLULU, HI 96843
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July 28, 2021

TO: WHOM IT MAY CONCERN

FROM: ERNEST Y. W. LAU, P.E., MANAGER AND CHIEF ENGINEER
BOARD OF WATER SUPPLY

SUBJECT: 2021 UPDATE OF THE WATER SYSTEM EXTERNAL CORROSION CONTROL STANDARDS

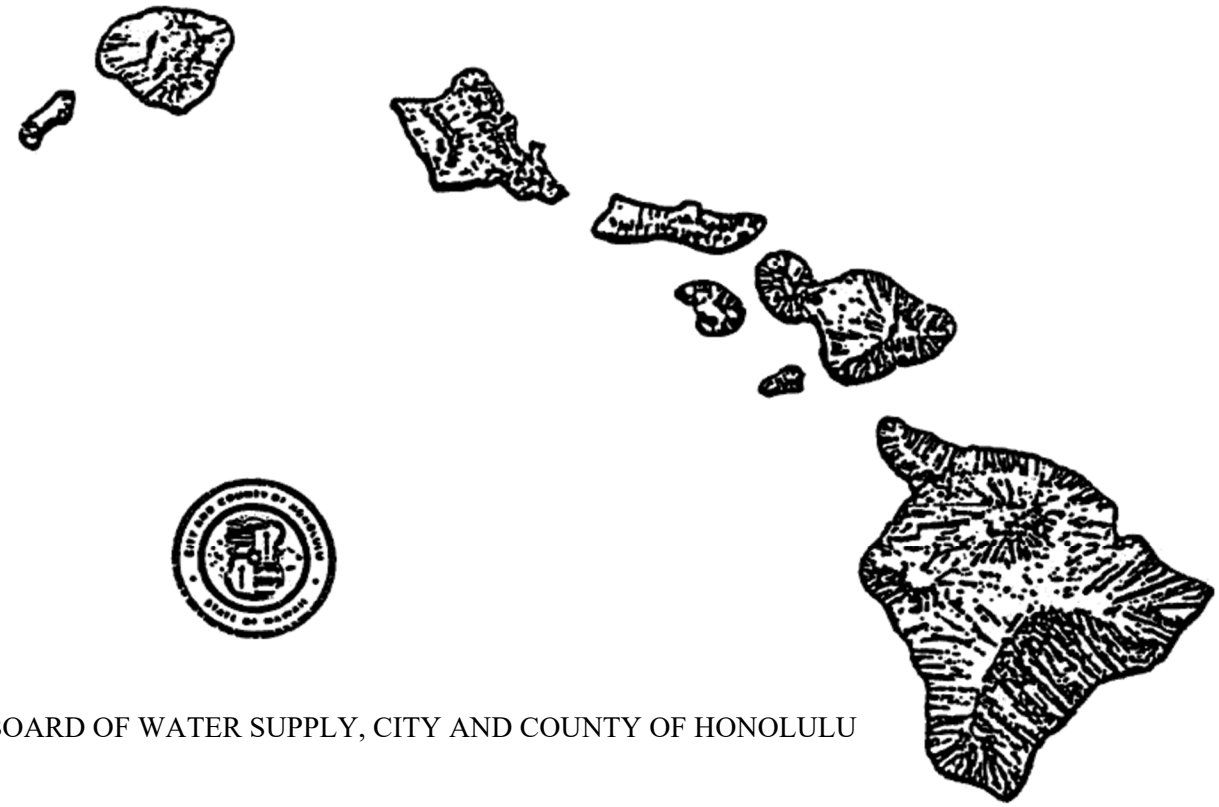
Effective immediately Oahu Only, the Water System External Corrosion Control Standards, dated 1991 shall be replaced with the update Water System External Corrosion Control Standards, dated 2021. All construction plans received by the Board of Water Supply shall comply with the updated Standards.

An electronic copy of the updated Standards is available on our website at boardofwatersupply.com/wss.

If you have any questions, please contact Michael Domion, Support Branch Head, Capital Projects Division, at (808) 748-5740 or mdomion@hbws.org.

cc: Hawaii, Kauai and Maui Water Departments

WATER SYSTEM EXTERNAL CORROSION CONTROL STANDARDS



BOARD OF WATER SUPPLY, CITY AND COUNTY OF HONOLULU

2021
VOLUME 3

WATER SYSTEM EXTERNAL CORROSION CONTROL STANDARDS

ERNEST Y. W. LAU, P.E.
MANAGER AND CHIEF ENGINEER
BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU

2021

FOREWARD

SCOPE

This publication shall govern the corrosion control design and construction for the water system facilities under the jurisdiction of the Board of Water Supply (BWS).

Any feature of design, materials to be installed, or construction methods to be used for any installation within the Water System External Corrosion Control Standards, but not specifically described herein, shall be of good quality, according to accepted practice, and shall meet with the approval of the Manager.

The Water System External Corrosion Control Standards is Volume 3 of the Water System Standards and subdivided as follows:

- Volume 3
    - Part 1 Soil Evaluation
    - Part 2 External Corrosion Control Requirements
    - Part 3 Pipe Coatings
    - Part 4 Bonded Dielectric Coating
    - Part 5 Cathodic Protection Design
    - Part 6 Galvanic Anode Cathodic Protection (GACP) System Specification
    - Part 7 Impressed Current Cathodic Protection (ICCP) System Specification
    - Part 8 Testing
    - Part 9 Payment
    - Part 10 Approved Material Supplier List
    - Part 11 Corrosion Control Details

The following types of pipe and fittings are currently permitted per BWS standards and are addressed in these corrosion control standards:

- Ductile iron pipe (DIP)
- Metallic fittings
- Copper pipe

DEFINITIONS

The following definitions are in addition to the ones in Volume 1 of the Water Systems Standards.

- Foreign owned: Any buried pipe or cable not specifically owned or operated by the BWS.
- Lead, lead wire, joint bond, pipe connection wire, cable: Insulated copper conductor; the same as wire.
- Electrically continuous pipeline: A pipeline that has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint, as specified in the testing section.
- Electrical isolation: The condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casing, etc.) and the environment as defined in NACE SP0169.

REFERENCE STANDARDS

When reference is made to known standard specifications, the most recently adopted and published edition of such specification on the date of the notice to bidders is contemplated, unless otherwise specified.

ABBREVIATIONS

The following abbreviation is in addition to the ones in Volume 1 of the Water System Standards:

- NACE – formerly the National Association of Corrosion Engineers
  NACE International
  15835 Park Ten Place
  Houston, TX 77084
  (281) 228-6200

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PART 1. SOIL EVALUATION

SECTION 1. REQUIREMENTS

1.1 General

To determine what external corrosion control measures are required for the various pipe alternatives, a soil investigation shall be performed before and/or during the pipeline design by a Corrosion Engineer. Testing shall be conducted by personnel experienced with testing per ASTM G57.

1.2 Investigation Requirements

The following table, Table 1, indicates the soil investigation that must be performed for each pipeline project.

Table 1. Soil Investigation Requirements

PIPE TYPE	SOIL INVESTIGATION
Ductile Iron Pipe (DIP) and Non-Metallic where Metallic Valves, Fittings, or Appurtenances shall be Installed	Soil resistivity at 300- to 1,000-foot increments along the alignment and at pin spacing approximating the pipe depth. At least three measurements shall be taken for each alignment. Soil analysis, including as-received and saturated resistivity, pH, and water-soluble chloride, sulfate, and bicarbonate ion concentrations. Samples shall be collected at 1,000-foot increments along the alignment at the approximate pipe depth where soil resistivity is less than 2,000 ohm-cm.

1.3 Soil Corrosion Category

The corrosion control methods used for the various pipe alternatives depend on the soil corrosion category. Table 2 provides criteria for determining the soil corrosion category. If any of the criteria fall within Corrosion Category A criteria, then the soil is considered Corrosion Category A. If all criteria fall within Corrosion Category B criteria, then the soil is considered Corrosion Category B.

Table 2. Soil Corrosivity Category

PARAMETER	CORROSION CATEGORY A (MODERATELY TO SEVERELY CORROSIVE)	CORROSION CATEGORY B (NEGLIGIBLY TO MILDLY CORROSIVE)
Resistivity	≤ 5,000 ohm-cm	> 5,000 ohm-cm
pH	≤ 6.5	> 6.5
Water-soluble chloride concentration	≥ 500 ppm	< 500 ppm
Water-soluble sulfate concentration	≥ 1,000 ppm	< 1,000 ppm
Ground Salt Water Table	Within Fluctuating Water Table	Always Below Water Table or Always Above Water Table

SECTION 2. SOIL RESISTIVITY

2.1 Definition

Resistivity is the electrical resistance of a unit volume of a material and is the reciprocal of conductivity. Resistivity measurements indicate the relative ability of a medium to carry electrical currents. When a metallic structure is immersed in a conductive medium, the ability of the medium to carry current will influence the magnitude of galvanic and cathodic protection currents.

2.2 Methods

The two basic methods of performing soil resistivity shall be either the Wenner 4-Pin Method or the Soil Box Method. Both tests shall be performed in accordance with ASTM G57.

2.3 Recording

The soil resistivity measurements and their location shall be tabulated and plotted on a graph (semi-log) for the Manager to review. Typical data sheets and typical graph setup are shown in Figure 1 through Figure 3.

SECTION 3. SOIL ANALYSES

3.1 Laboratory Evaluation

The soil samples shall be tested by a Hawaii Department of Health, State Laboratories Division approved soils testing laboratory for pH, chlorides, and sulfates using the water-soluble method. The measurements shall be in accordance with EPA SW9045 for pH measurements, EPA 300 for chloride and sulfate measurements, and EPA 310.1 for bicarbonate measurements.

3.2 Recording

The test results shall be tabulated for the Manager to review. A typical data sheet is shown in Figure 4.

Pipeline Location: _____ **Sheet** _____ **of** _____

Pipe Size: _____ **Date:** _____

Depth to Bottom of Pipe: _____ **By:** _____

SOIL RESISTIVITY - WENNER 4-PIN METHOD

Station No.	Location	Depth = Pin Spacing (x = ft)	Soil Resistance Meter Reading (R = ohm)	Calculated Soil Resistivity (ρ = ohm-cm)	Layer (ft)	Resistance of Soil Layer (ohm)	Resistivity of Soil Layer (ohm-cm)	Corrosion Category

Soil Resistivity Calculation: $\rho = 191.5(x)(R)$ where ρ = ohm-cm, x = ft, and R = ohms

Barnes Layer Resistance:

$$R_{A-B} = \frac{R_A R_B}{R_A - R_B}$$

R_{A-B} = resistance of soil layer between depth A and depth B (Ω)

R_A = soil resistance to depth A, value from meter (Ω)

R_B = soil resistance to depth B, value from meter (Ω)

Barnes Layer Resistivity:

$$\rho_{A-B} = 2\pi(B - A)R_{A-B}$$

ρ_{A-B} = average resistivity of soil layer from depth A to B (Ω-cm)

π = 3.14 (approximately)

A = distance from grade to Depth A (cm)

B = distance from grade to Depth B (cm)

R_{A-B} = resistance of soil layer between depth A and B (Ω)

Resistivity of the soil layer is used to determine corrosion category.

Figure 1. Soil Resistivity - Wenner 4-Pin Method

Pipeline Location: _____ **Sheet** _____ **of** _____

Pipe Size: _____ **Date:** _____

Depth to Bottom of Pipe: _____ **By:** _____

SOIL RESISTIVITY - SOIL BOX METHOD

Station No.	Location	Sample Depth (ft)	As-Received Resistivity (ohm-cm)	Minimum Resistivity (ohm-cm)	Corrosion Category

Minimum resistivity (ohm-cm) is used to determine corrosion category.

Figure 2. Soil Resistivity - Soil Box Method

Pipeline Location: _____ Sheet _____ of _____

Pipe Size: _____ Date: _____

Depth to Bottom of Pipe: _____ By: _____

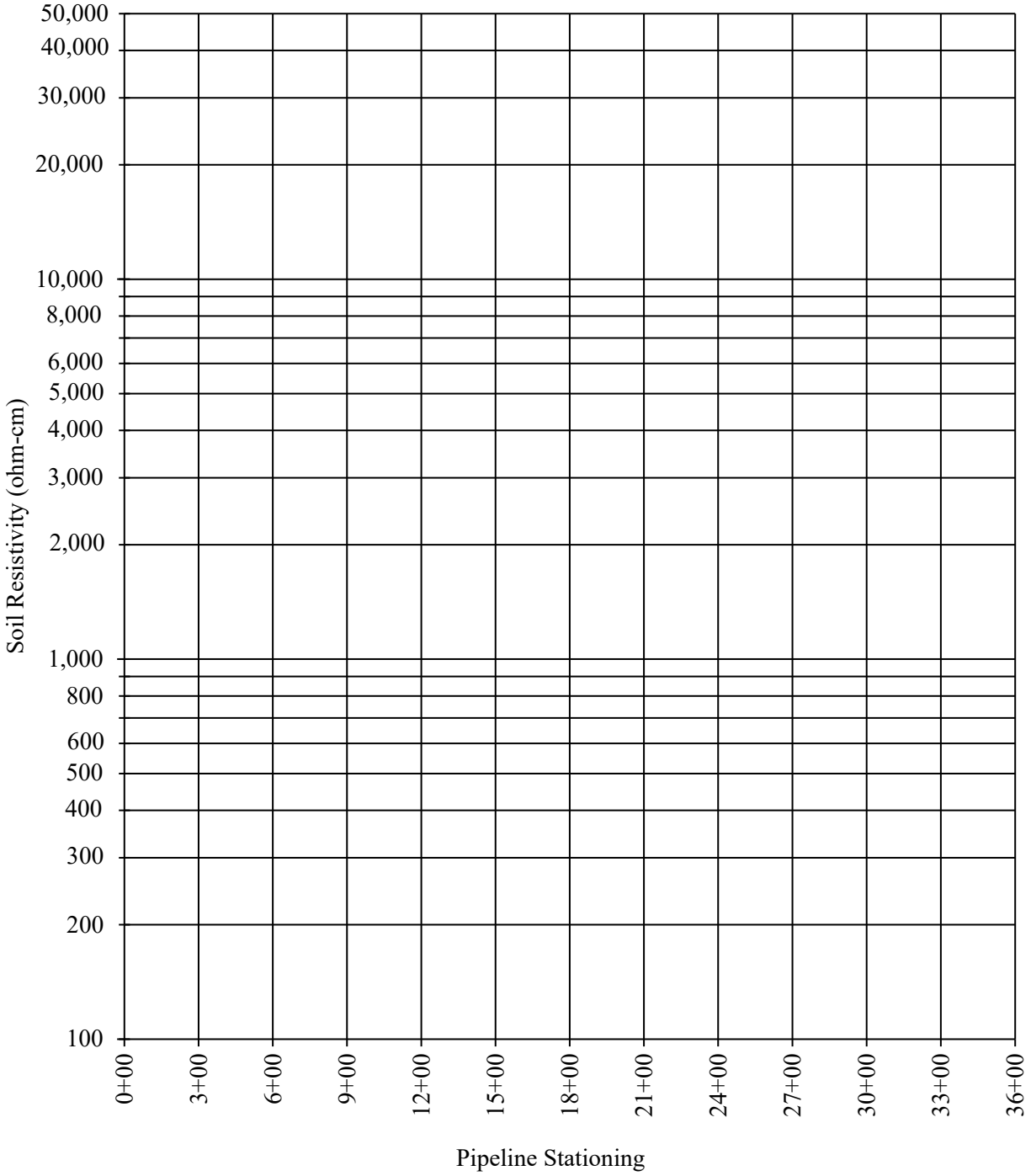


Figure 3. Soil Resistivity Graph

Pipeline Location: _____ **Sheet** _____ **of** _____

Pipe Size: _____ **Date:** _____

Depth to Bottom of Pipe: _____ **By:** _____

SOIL ANALYSES

Station No.	Sample Depth (ft)	Location	pH	Chlorides (ppm)	Sulfates (ppm)	Category A YES	NO

Figure 4. Soil Analyses

PART 2. EXTERNAL CORROSION CONTROL REQUIREMENTS

SECTION 1. REQUIREMENTS

1.1 General

External corrosion control is required for metallic pipe, valves, fittings, or other appurtenances used within the water system. The type of external corrosion control required depends on the material and corrosion category in which the material will be installed. The soil properties and corresponding soil corrosion category are shown in Part 1, 2, of this document.

1.2 Corrosion Control Requirements

The external corrosion control requirements as a function of material and corrosion category are shown in Table 3. The corrosion control products and execution are covered in Part 6 and Part 7 of this document. The connection between the various pipe materials and/or metallic casings can cause galvanic corrosion. Therefore, the requirements for electrical isolation are shown in Table 4.

Table 3. Corrosion Control Requirements

MATERIAL	CORROSION CATEGORY A (MODERATELY TO SEVERELY CORROSIVE)	CORROSION CATEGORY B (NEGLIGIBLY TO MILDLY CORROSIVE)
Ductile Iron Pipe (DIP)	1. Use Class 53 pipe 2. Bonded dielectric coating (100% solids polyurethane or epoxy) 3. Galvanic CP (GACP) or impressed current CP (ICCP) design by a Registered Professional Corrosion Engineer or NACE CP4 [a]	1. Use Class 53 pipe 2. Bonded dielectric coating (100% solids polyurethane or epoxy) 3. Galvanic CP
Metallic Valves and Fittings (when electrically continuous with Metallic Pipe)	1. Ductile iron with factory-applied coating 2. Petrolatum wax tape 3. Bonding wires to DIP that has CP system	1. Ductile iron with factory-applied coating 2. Petrolatum wax tape 3. Bonding wires to DIP that has CP system
Metallic Valves and Fittings (associated with Non-metallic Pipe)	1. Ductile iron with factory applied coating 2. Petrolatum wax tape 3. Galvanic CP	1. Ductile iron with factory-applied coating 2. Petrolatum wax tape
Tapping Saddles and Repair Clamps	1. 316 stainless steel or ductile iron with factory-applied coating 2. Wrap in petrolatum wax tape	1. 316 stainless steel or ductile iron with factory-applied coating 2. Wrap in petrolatum wax tape
Bolts, Nuts, and Washers	1. 316 stainless steel or coated steel 2. Wrap in petrolatum wax tape	1. 316 stainless steel or coated steel 2. Wrap in petrolatum wax tape
Copper Pipe	1. Insulate from dissimilar metals (such as ferrous pipe) 2. Type K copper 3. Galvanic CP only when soil resistivity is less than 500 ohm-cm	1. Insulate from dissimilar metals (such as ferrous pipe) 2. Type K copper

a – GACP is preferred over ICCP. ICCP systems may be used in cases that GACP cannot provide enough current to adequately protect the pipeline and must be approved by the Manager. ICCP systems must employ measures to mitigate DC stray current interference effects on nearby utilities and coordinate with nearby utilities to balance ICCP systems.

Table 4. Electrical Isolation Procedures for all Connections

	Ductile Iron	Grey Iron	Concrete Cylinder	Copper	Pump Station	Blow-off	Air Release Valves	Pipe within Casing
Ductile Iron	(a)	Insulate	Insulate	Insulate at Tap	Insulate	Insulate	Insulate	Insulate from casing
Copper	Insulate at Tap and After Meter	Insulate at Tap and After Meter	Insulate at Tap and After Meter	Do not Insulate	Insulate at Tap	N/A	N/A	Insulate from casing
PVC	Do not Insulate	Do not Insulate	Do not Insulate	Do not Insulate	Do not Insulate	Do not Insulate	Do not Insulate	Do not Insulate

a – Insulate existing pipe from newly installed pipe.
N/A – Not applicable

PART 3. PIPE COATINGS

SECTION 1. REQUIREMENTS

1.1 General

As part of the external corrosion protection of the buried pipe used in the water system, the ferrous pipe and appurtenances require external coatings. The external coating requirements for each type of pipe also depend on the corrosion category, as specified in Part 2. The coatings required in Part 2 are specified below.

1.2 Materials

1.2.1 Polyethylene encasement: Encase ductile iron pipes, valves, and fittings in one layer of 8 mil minimum thickness polyethylene material in accordance with ANSI A-21.5 and AWWA C105. Polyethylene encasement shall be installed in the field. The polyethylene shall be manufactured of virgin polyethylene and shall consist of three layers of co-extruded linear low density polyethylene (LLDPE), fused into a single thickness of not less than eight mils. The inside surface of the polyethylene wrap to be in contact with the pipe exterior shall be infused with a blend of an antimicrobial to mitigate microbiologically influenced corrosion and a volatile corrosion inhibitor to control galvanic corrosion. Polyethylene material shall have permanent markings per AWWA C105.

1.2.2 Bonded dielectric coating: Coat ductile iron pipe in accordance with Part 4.

1.2.3 Petrolatum wax tape: Metallic valves and fittings may be wrapped in petrolatum wax tape instead of polyethylene encasement. Petrolatum wax tape shall be applied in accordance with AWWA C217.

SECTION 2. INSPECTION/REPAIR

2.1 General

The various coatings shall be inspected and repaired by the manufacturer at the coating yard in accordance with the coating manufacturer's standard specifications.

2.2 Field Inspection and Repair

The Contractor shall provide manufacturer and supplier certification that coatings are in accordance with the specifications specified herein as well as the submittal requirements of the Contract. Any field repairs to damaged coating shall be done by the Contractor at no cost to BWS. The Contractor's Corrosion Technician or Engineer shall also provide a signed certification stating that the installation work as visually inspected conforms to the contract requirements and is submitted within one (1) day of the visual inspection.

2.3 Polyethylene Encasement

The coating shall be visually inspected by the Contractor's Corrosion Technician or Engineer after installation and before backfilling. All coating flaws shall be repaired in accordance with the coating manufacturer's recommendations. Extra care must be taken during backfilling operations to ensure that the coating is not damaged.

2.4 Bonded Dielectric Coating

Inspect the bonded dielectric coating in accordance with Part 4.

2.5 Petrolatum Wax Tape

The coating shall be visually inspected by the Contractor's Corrosion Technician or Engineer after installation and before backfilling. All coating flaws shall be repaired in accordance with the coating manufacturer's recommendations.

PART 4. BONDED DIELECTRIC COATING

SECTION 1. GENERAL

1.1 Overview

1.1.1 The Contractor shall furnish all tools, equipment, materials, and supplies and shall perform all labor required to complete the exterior 100% solids polyurethane or epoxy shop coating application on new ductile iron water transmission pipeline to be buried in soil. This specification also requires field touchups on damaged coatings. This work shall include all precleaning, surface preparation, coating application on ferrous surfaces, protection of surfaces not to be coated, cleanup, and appurtenant work, in accordance with the requirements of the Contract Documents.

1.1.2 The ductile iron pipe shall be provided to the coating applicator without an asphaltic coating.

1.1.3 All coatings, solvents, equipment, and procedures necessary to complete the work specified in the Contract Documents shall be suitable for potable water and soil exposure.

1.1.4 The coating system schedules summarize the surfaces to be coated, the required surface preparation, and the coating systems to be applied. Coating notes on the drawings are used to show exceptions to the schedules, to show or extend the limits of coating systems, or to clarify or show details for application of the coating systems.

1.2 Definitions

1.2.1 Contractor shall be defined as the coating applicator in the shop and the field applicator for touch ups.

1.2.2 Inspector shall be defined as a Quality Assurance/Quality Control person knowledgeable with SSPC and NACE standards and general coating industry standards. This person may be retained by BWS, shop applicator, or by the pipe installer.

1.2.3 Touchup shall be defined as a repair made by the shop applicator or field installer. The criteria for repairs are as defined in paragraphs 3.11 and 3.12.

1.3 Reference Specification, Codes, and Standards

ASTM International

D2240	Standard Test Method for Rubber Property – Durometer Hardness
D4414	Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gauges
D4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
D5402	Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs
D7393	Standard Practice for Indicating Oil in Abrasives

Code of Federal Regulations Title 40, Environmental Protection Agency
40CFR Part 59 Table 1 – VOC Content Limits for Industrial Coatings

National Association of Corrosion Engineers (NACE) International
SP0188 Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
SP0287 Field Measurements of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using Replica Tape

National Association of Pipe Fitters
500-03 Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings

SSPC - Steel Structures Painting Council, the Society for Protective Coatings
PA1 Shop, Field, and Maintenance Painting of Steel
PA2 Procedure for Determining Conformance to Dry Coating Thickness Requirements
SP1 Solvent Cleaning
SP2 Hand Tool Cleaning
SP3 Power Tool Cleaning
SP7 Brush Off Blast Cleaning
SP11 Power Tool Cleaning to Bare Metal
Vol. 1 Good Painting Practice

1.4 Contractor Submittals

1.4.1 Qualifications of the Shop Applicator

1.4.1.1 Letter identifying the person responsible for Quality Assurance/Quality Control (QA/QC) at the shop coating facility. This person shall have a minimum of 10 years of experience in the surface preparation of metals and application of the specified coatings. This person shall have a SSPC or NACE training certification and shall be familiar with the industry standards. This person will be responsible for submitting QA/QC documentation to the Owner.

1.4.1.2 A copy of a typical QA/QC inspection report containing inspection items listed in Paragraph 3.10 of this Specification.

1.4.1.3 Three references which verify that the shop painting facility has demonstrated successful application of the specified coating systems in the past 5 years. Provide the structure name and size (area of coating), time of completion, the owner's name, address, and telephone number for each installation referenced.

1.4.1.4 The manufacturer shall provide written certification that the shop painting facility's supervisor and each applicator performing Work on the project have been trained and approved by the manufacturer to apply the selected coating system.

1.4.1.5 A written certification from the shop painting facility stating that it is qualified and experienced in the application of the specified coating systems.

1.4.1.6 The Contractor shall provide a letter states the type of mixing, spraying, heating, and environmental control equipment for the specified coating products.

1.4.2 Complete data on each type and kind of paint, and materials shall be submitted for review. Acceptance shall be received from BWS before the paint is applied. This procedure must be followed whether or not the paint that the Contractor proposes to use is named in the Contract Documents. Submitted data shall show where and for what uses each paint product is proposed with cross-reference made to sections of these Specifications. Paint material submittals shall include the following:

1.4.2.1 Safety data sheets for all products used at the jobsite, including paints, thinners, solvents, and cleaners.

1.4.2.2 Product Data Sheets for all coating products with the following information:

1.4.2.2.1 Surface preparation requirements for immersion service or severe environments

1.4.2.2.2 Minimum and maximum wet and dry film thickness per coat

1.4.2.2.3 Minimum and maximum cure, induction, and pot lifetimes

1.4.2.2.4 Temperature and humidity requirements during and after application

1.4.2.2.5 Proper storage and shelf life at various temperatures

1.4.2.2.6 EPA Method 24 results to verify compliance with 40 CFR 59 for VOC's

1.4.2.2.7 Tensile, elongation, moisture vapor transmission rate, and abrasion testing results.

1.4.3 Manufacturer's product data sheet for each abrasive material to be used with the following:

1.4.3.1 Technical data sheet for each product used, including statements on the suitability of the material for the intended use.

1.4.3.2 State and country of origin.

1.4.3.3 Safety data sheet for each product, if applicable.

1.4.3.4 Size/mesh and percentage by weight of each component

1.4.4 Paint Manufacturer's Information: For each paint system to be used, the Contractor shall submit the following listed data at least 30 days prior to coating:

1.4.4.1 Paint manufacturer's technical application instructions for application, heating materials, mixing, spray tip sizes, and hose pressures.

1.4.4.2 The manufacturer shall provide written certification that the coating Contractor's supervisor and each applicator performing Work on the project have been trained and approved by the manufacturer to apply the selected coating system. The manufacturer shall state whether or not it has verified that the Contractor is going to use the proper mixing, coating application, heating, and environmental control equipment for the specified coating products.

1.4.4.3 Drawing details for field repairs or coating terminations at joints, fittings, or special pipe sections (where applicable).

1.5 Safety and Health Requirements

1.5.1 Head and face protection and respiratory devices shall include protective helmets conforming to the requirements of ANSI Z 89.1, which shall be worn by all persons at all times while in the vicinity of the work. In addition, workers engaged in or near the work during abrasive blasting shall wear eye and face protection devices meeting the requirements of ANSI Z 87.1 and a respirator with appropriate filter.

1.5.2 Where ventilation is used to control potential exposures to workers, as set forth in Section 1910.94 of the OSHA Regulations for Construction, ventilation shall be adequate to reduce the concentration of the air contaminant to the degree that a hazard to the worker does not exist. Methods of ventilation shall meet the requirements set forth in ANSI Z9.2.

SECTION 2. PRODUCTS

2.1 General

2.1.1 Definitions: The term "paint," "coatings," or "finishes," as used herein, shall include surface treatments, paints, and all other protective coatings, whether used as a pretreatment, primer, intermediate coat, or finish coat. The term "DFT" means minimum dry film thickness.

2.1.2 General: Coating materials shall be sealed in new containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer, all of which shall be plainly legible at the time of use.

2.1.3 The Contractor shall use coating materials suitable for the intended use and recommended by their manufacturer for buried and groundwater environments. Materials shall be delivered unopened to the applicator in their original containers bearing the manufacturer's label, completely identifying the contents, date of manufacture, volatile organic compounds (VOCs), and listing directions for their proper use. No products shall be allowed on site that do not conform with 40 CFR Part 59.

2.1.4 Compatibility: In any coating system, only compatible materials from a single manufacturer shall be used in the work. Particular attention shall be directed to compatibility of all applied coats.

2.1.5 Protective Coating Materials: Products shall be standard products produced by recognized manufacturers who are regularly engaged in production of such materials for essentially identical service conditions. Where requested, the Contractor shall provide BWS with the names of not less than 5 successful applications of the proposed manufacturer's products demonstrating compliance with this specification requirements.

2.1.6 Substitute or "Or-Equal" Submittals: Unless otherwise specified, materials are from the catalogs of the companies listed herein. Materials by other manufacturers are acceptable provided that they are established as being compatible with and of equal quality to the coatings of the companies listed. The Contractor shall provide satisfactory documentation from the firm manufacturing the proposed substitute or "or-equal" material that said material meets the specified requirements and is equivalent or better than the listed materials in the following properties:

2.1.6.1 Minimum and maximum cure times before immersion

2.1.6.2 Moisture vapor transmission rate per ASTM D1653 Method B at 40 mils minimum

2.1.6.3 Abrasion resistance per ASTM D4060 using a CS17 wheel

2.1.6.4 Minimum and maximum recoat times

2.1.6.5 Ability to recoat in future

2.1.6.6 Solids content by volume

2.1.6.7 Dry film thickness per coat

2.1.6.8 Compatibility with other coatings

2.1.6.9 Suitability for the intended service

2.1.6.10 Resistance to chemical attack

2.1.6.11 Temperature limitations in service and during application

2.1.6.12 Ease of application

2.1.6.13 Ease of repairing damaged areas

2.1.7 The cost of all testing and analysis of the proposed substitute materials that may be required by BWS shall be paid by the Contractor. If the proposed substitution requires changes in the contract work, the Contractor shall bear all such costs involved and the costs of allied trades affected by the substitution.

2.2 Industrial Coating System Substitute Materials

2.2.1 Material Sources: Each of the following manufacturers is capable of supplying many of the industrial coating materials specified herein. Where manufacturers and paint numbers are listed, it is to show the type and quality of coatings that are required. Proposed substitute materials must be shown to satisfy the material descriptions and to equal or exceed the properties of the listed materials as required in the paragraph entitled "Substitute or `Or-Equal' Submittals" herein.

2.2.1.1 Induron

2.2.1.2 International Protective Coatings

2.2.1.3 Raven Lining Systems

2.2.1.4 Sherwin Williams

2.2.1.5 Tnemec

2.3 Coating Systems

2.3.1 E100: A 100% solids epoxy to be used to coat the exterior surfaces of pipe exposed to corrosive soil conditions. The epoxy shall have a moisture vapor transmission rate less than 3 grams per square meter per 24 hours (g/m^2/24 hr) as measured per ASTM D1653 Method B at a thickness of 60 mils. Approved products include the following:

2.3.1.1 Finish Coat (DFT 40 mils): Carboline Plasite 4500, Induron Ceramawrap Epoxy, Tnemec Series FC22 Epoxoline, or approved equal.

2.3.1.2 Total System DFT: 40 mils.

2.3.2 P100: A 100% solids polyurethane to be used to coat the exterior surfaces of pipe exposed to corrosive soil conditions. The polyurethane shall have a moisture vapor transmission rate less than 6 grams per square meter per 24 hours (g/m^2/24 hr) as measured per ASTM D1653 Method B at a thickness of 40 mils. Abrasion resistance shall be less than 55 mg loss per ASTM D4060 using a CS17 1,000 g wheel. Approved products include the following:

2.3.2.1 Finish Coat (DFT 40 mils): Carboline Polyclad 777, Lifelast Durashield 210, or ITW Polyspec/Futura Coatings Protec II, Sherwin Williams Polycote 110, or approved equal.

2.3.2.2 Total System DFT: 40 mils.

SECTION 3. EXECUTION

3.1 Storage, Mixing, and Thinning of Materials

3.1.1 Plural Component Application Products: After each component of the coating system has been thoroughly heated, the Contractor shall perform a paint pump ratio test on the first day of spraying and at least once a week thereafter in the presence of the Inspector. The Contractor shall set up two see-through containers with preprinted volumetric marks on a flat surface. The hose valve for each component shall be opened simultaneously and each component flow rate shall be allowed to stabilize by pouring the discharging materials into separate disposable containers. After the flow is stabilized, the hoses shall be transferred to the pre-printed volumetric containers and the valves shall be shut off after one of the containers has been filled to 32 or 48 fluid ounces, depending on the mixing ratio recommended by the manufacturer. If the volumetric quantity of coating in the containers does not match the manufacturer's recommendation, the Contractor shall reduce or increase the pressure and temperature until it meets the specified mixing ratio. No spraying shall be performed until the ratio test result has been accepted by the Inspector.

3.1.2 Manufacturer's Recommendations: Unless otherwise specified herein, the coating manufacturer's printed recommendations and instructions for thinning, mixing, handling, applying, and protecting its coating materials, for preparation of surfaces for coating, and for all other procedures relative to coating shall be strictly observed. The Contractor shall supply BWS with copies of each manufacturer's instructions.

3.1.3 Thinning of paint shall be in accordance with the manufacturer's published instructions, especially as to the amount and kind of thinner used.

3.1.4 All protective coating materials shall be used within the manufacturer's recommended shelf life. Materials exceeding the storage life recommended by the manufacturer shall be removed from the jobsite.

3.1.5 Storage and Mixing: Coating materials shall be protected from exposure to temperatures greater than or less than the manufacturer's recommendations and shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Coatings of different manufacturers shall not be mixed together. Flammable materials shall be stored in accordance with state and local codes.

3.2 Preparation for Coating

3.2.1 All surfaces to receive protective coatings shall be cleaned as specified herein prior to application of said coatings. The Contractor shall examine all surfaces to be coated and shall correct all surface defects before application of any coating material. All slivers, sharp edges, gouges, sharp peaks, or burrs shall be grinded down.

3.2.2 Surface preparation shall be approved by the Inspector prior to application of coating.

3.2.3 The Contractor shall remove and dispose of all debris from abrasive blasting and other surface preparation prior to coating.

3.2.4 Protection of Surfaces Not to Be Coated: Surfaces that are not to receive protective coatings shall be protected during surface preparation, cleaning, and coating operations.

3.2.5 Care shall be exercised not to damage adjacent work during blast cleaning operations. Spray painting shall be conducted under carefully controlled conditions. The Contractor shall be fully responsible for and shall promptly repair any and all damage to adjacent work or adjoining property occurring from blast cleaning or coating operations.

3.2.6 Protection of Painted Surfaces: Cleaning and coating shall be so programmed that dust and other contaminants from the cleaning process will not fall on wet, newly-coated surfaces.

3.3 Environmental Requirements

3.3.1 No coating work shall be performed under the following conditions:

3.3.1.1 Surface or ambient temperatures exceed the manufacturer's recommended maximum or minimum allowable.

3.3.1.2 Dust or smoke laden atmosphere.

3.3.1.3 Damp or humid conditions, where the relative humidity is above the manufacturer's maximum allowable.

3.3.1.4 Substrate and ambient temperatures are less than 5°F above the dewpoint and are decreasing. Dewpoint shall be measured by use of an instrument such as a Sling Psychrometer in conjunction with U.S. Department of Commerce, Weather Bureau psychrometric tables. Elcometer 319 Dew Point meter or equal may also be used.

3.3.1.5 Ambient temperature that is expected to drop below 50°F or less than 5°F above the dewpoint within 8 hours after application of coating.

3.4 Specials, Fittings, and Connections

3.4.1 Coating and lining application for special sections, connections, and fittings for steel or ductile iron pipe shall conform to coating system and application requirements as specified in this section.

3.4.2 Specials, fittings, and connections shall be defined as any pipe section with turnouts for blow offs, interconnects, any valve or other appurtenances, tees, crosses, wyes, laterals, mitered angles or elbows, and pipes which require special fabrication that prevents mechanical production application of the specified system from end to end of pipe joint.

3.4.3 Hand-applied tape coatings applied at the shop will not be permitted on any specials, fittings, connections, and elbow fittings unless it has been previously approved by BWS.

3.4.4 Special, fittings, and connections shall be shop coated with the E100 or P100 coating system.

3.5 Metal Surface Preparation

3.5.1 The Shop Painting Facility shall remove all water, grease, dust, and other contaminants from the surfaces prior to centrifugal or manual abrasive blast cleaning. All oil, grease, and other surface contaminants shall be removed by solvent cleaning per SSPC SP1 prior to blast cleaning.

3.5.2 All sharp edges shall be rounded or chamfered, and all slivers and surface defects shall be ground smooth prior to blast cleaning. Rust, scale, welding slag, and spatter shall be removed, and the surface prepared by SSPC SP2, Hand Tool Cleaning, and SSPC SP3, Power Tool Cleaning.

3.5.3 The pipe surfaces shall be abrasive blast cleaned per NAPF 500-03-04 with the following exceptions stated in this specification. The Contractor shall use 20/40 glass or 30/60 steel shot material to remove all rust staining, and to achieve a minimum of a 3-mil surface profile. The surface shall be free of all visible dust, loose annealing oxide, loose mold coating, or other foreign matter. The abrasive shall be tested in accordance with ASTM D7393 and shall not contain any oil or emulsion on the surface. The abrasive shall not be reused if oil is present in the jar test.

3.5.4 Cast ductile iron fittings shall be abrasive blast cleaned per NAPF 500-03-05 Blast Clean #1 with the following exceptions stated in this specification. The Contractor shall use 20/40 glass or 30/60 steel shot material to remove all rust staining, and to achieve a minimum of a 3-mil surface profile. The surface shall be free of all visible dust, loose annealing oxide, loose mold coating, or other foreign matter. The abrasive shall not be reused unless otherwise approved by the Inspector.

3.5.5 If the ductile iron pipe has an asphaltic coating, it shall be removed at no additional cost to BWS.

3.5.6 Blast cleaned metal surfaces shall be painted before any rusting or other contamination of the surface occurs.

3.5.7 During abrasive blasting, the surface profile shall be tested with the use of Press-o-Film as manufactured by Testex, or other NACE SP0287 approved equal, on 30% of the pipe sections. A minimum of three tests shall be conducted at the beginning, middle, and end of the work shift. The replica tape thickness shall be measured using a dial micrometer manufactured by Testex, or other ASTM D4417 Type C approved equal. For each test area, three replica tape tests shall be performed along the length of the pipe section. For each pipe section, the three replica tape thickness values shall be recorded and the average of the three tests must be within 10% of the coating manufacturer's recommended profile. If the average is below the recommended profile, additional abrasive blasting shall be performed to meet the recommended profile.

3.5.8 Compressed air for air blast cleaning shall be supplied at adequate pressure from well-maintained compressors equipped with oil/moisture separators that remove at least 95% of the contaminants. The Inspector shall conduct a blotter test to confirm the cleanliness of the air stream per ASTM D4285.

3.5.9 Surfaces shall be cleaned of all dust and residual particles from the cleaning operation by dry air blast cleaning, vacuuming, or another approved method prior to painting. The quantity and size of dust shall be tested in accordance with ISO 8502-3 and shall be Class 2 to Class 0 before proceeding.

3.5.10 Enclosed areas and other areas where dust settling is a problem shall be vacuum-cleaned and wiped with a tack cloth.

3.6 Workmanship

3.6.1 Each coat shall be subject to the inspection and approval of the Inspector before the next succeeding coat is applied. Defective work of any kind shall be deemed sufficient cause for completely stripping, preparing, and recoating the entire surface involved. Sufficient time shall be allowed between coats to assure proper drying for optimum bonding of the subsequent coats as recommended by the manufacturer for the existing ambient conditions. Excessive time beyond the manufacturer's recommended recoat window shall be avoided. When maximum recommended drying times are exceeded, surfaces shall be abraded for subsequent coats as recommended by the manufacturer.

3.6.2 All work shall be done in a professional manner with high quality workmanship leaving the finished surfaces free from runs, drops, ridges, waves, holidays, laps, brush marks, and variations in color, texture, and finish. No visual holes, bubbles, or blisters shall be allowed to be exposed to soil.

3.6.3 Skilled craftsmen and experienced supervision shall be used on all work.

3.6.4 Clean drop cloths shall be used to cover adjacent structures. All damage to surfaces resulting from the work hereunder shall be cleaned, repaired, and refinished to their original condition.

3.6.5 All coatings shall be applied under dry and dust-free conditions. Coating shall be done in a workmanlike manner so as to produce an even film of uniform thickness. Edges, corners, crevices, and joints shall receive special attention to ensure that they have been thoroughly cleaned and that they receive an adequate thickness of coating material.

3.7 Surfaces Not to be Coated

3.7.1 The following surfaces shall not be protective coated hereunder unless shown or specified herein or elsewhere in the Contract Documents. The following exterior surfaces shall be masked off by the Contractor prior to coating work being performed on adjacent surfaces requiring coating:

3.7.1.1 Push-on Joints, spigot end – Length of uncoated area shall vary with diameter of pipe. Do not coat surface covered by bell end of pipe or apply less than 10 mils DFT.

3.7.1.2 Push-on Joints, bell end – flush with bell end

3.7.1.3 Welded Flange Joint, spigot end – 3 inches minimum

3.7.1.4 Welded Flange Joint, bell end – 4 inches minimum

3.7.2 Valve gaskets or seals, mating surfaces of flanges, bolt holes, drains, or manhole seats, which are not to be painted, shall be masked off prior to coating work.

3.8 Application of Spray-applied Coatings

3.8.1 Materials and supplies provided shall be the standard products of the manufacturer. Materials within a coating system shall be the products of a single manufacturer.

3.8.2 The application of protective coatings to metal substrates shall be in accordance with SSPC PA1, Shop, Field, and Maintenance Painting of Steel.

3.8.3 The Contractor shall perform the pump ratio check prior to spraying any coating material on the pipes. Procedures are given in Paragraph 3.1.A of this specification.

3.8.4 Before the start of the coating application each day, the Contractor shall set up polyethylene sheet or cardboard on the ground for the purpose of performing a test patch. The Contractor, in the presence of the Inspector, shall spray on the polyethylene sheet or cardboard and shall not have any discoloration, bubbles, or pinholes in the coating and the spray gun shall not clog. The spray gun shall produce an even fan spray and the coating shall be of a consistent color. After these performance characteristics are achieved, the coating application may proceed.

3.8.5 No coating shall be applied under conditions which, in the opinion of the Inspector, could jeopardize the appearance or quality of the finish in any way. It is necessary for the Contractor to provide a working area which meets the manufacturer's recommended environmental conditions. It is the Contractor'S responsibility to maintain the proper ambient conditions required by the coating manufacturer.

3.8.6 Cleaned surfaces and all coats shall be inspected prior to each succeeding coat. The Contractor shall schedule such inspection with the Inspector in advance.

3.8.7 Blast cleaned ferrous metal surfaces shall be painted before any rusting or other deterioration of the surface occurs. Blast cleaning shall be limited to only those surfaces that can be coated in the same work week unless environmental controls are implemented.

3.8.8 Coatings shall be applied in accordance with the manufacturer's instructions and recommendations and this Section, whichever has the most stringent requirements.

3.8.9 The Contractor shall verify the wet film thickness with a notched gauge in conformance with ASTM D4414. A minimum of one wet film thickness reading shall be recorded on 30% of the pipe segments.

3.8.10 Special attention shall be given to edges, and other places where insufficient film thicknesses are likely to be present. Use stripe painting for these areas.

3.8.11 Special attention shall be given to materials which will be joined so closely that proper surface preparation and application are not possible. Such contact surfaces shall be coated prior to assembly or installation.

3.8.12 Finish coats, including touch-up and damage repair coats shall be overlapped 6 inches onto existing coatings and shall be applied in a manner that will present a uniform texture and color matched appearance.

3.8.13 The coating shall be smooth and free of sharp protrusions. It shall not exhibit any cracking, delamination, orange peeling, blisters, off-ratio discoloring, sticky areas, bubbles, craters, or pinholes. Sags and curtaining shall be less than 1% of total coated surface area for each pipe section. If any of the above defects exceed 1% of the total coated surface area of a pipe section, the pipe section shall be rejected.

3.8.14 Damaged shop coating that exposes the metal substrate greater than 1 inch in diameter or length shall be cleaned in accordance with SSPC SP11 using an MBX Bristleblaster, or equivalent, and in accordance with the manufacturer's recommendations.

3.9 Exterior Field Joint Coating

3.9.1 Pipe joints shall be field-coated after the pipe has been installed and before the surfaces have been contaminated with oil, grease, or soil.

3.9.2 All mechanical joint or push-on joint restraints, couplings, fittings, elbows, tees, crosses, interconnects, or valves with uncoated surfaces shall be protected with petrolatum tape as specified in the Cathodic Protection Specification.

3.10 Inspection and Testing During and After Application

3.10.1 The Inspector shall provide anchor profile measurements, ammeter reading indicating the electrical loading on the abrasive blasting wheel motor, type/percent mixture of the abrasive, and shall check the cleanliness of the abrasive blasting material.

3.10.2 The Inspector shall provide a written record of the quantity of coating material applied, the quantity of surface area covered, a pipe identification number, each coating product batch number, dew point temperature, surface temperature, ambient temperature, relative humidity, and names of applicators on a daily basis. The Inspector shall record the pressures and temperatures at which the coating material is being heated and delivered to the spray gun.

3.10.3 The Inspector shall provide wet film and dry film thickness readings, and results of the holiday testing, and shall note any discrepancies with the coating specifications.

3.10.4 Inspection Devices: The Contractor shall furnish, until final acceptance of such coatings, inspection devices in good working condition and calibrated for the detection of holidays and measurement of dry-film thicknesses of protective coatings. The Contractor shall provide the services of a trained operator of the holiday detection devices until the final acceptance of such coatings.

3.10.5 Holiday Testing: The Contractor shall holiday test all coated ferrous surfaces exposed to soil and severe service environments in the presence of the Inspector. After the specified coating has set hard to the touch, the Contractor shall test the coated surfaces for visual pinholes and sparking holidays using a high-voltage spark tester according to NACE SP0188. Areas which contain visual pinholes and sparking holidays shall be marked, repaired or recoated, and retested in accordance with the coating manufacturer's printed instructions. The electrode movement over the coating surface shall be continuous and shall proceed in a systematic manner, which ensures 100% coverage of the coated surfaces.

3.10.5.1 Coatings with DFT Exceeding 20 Mils: Pulse-type holiday detector, such as Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20, or equal, shall be used. Holiday testing shall be conducted with a new 12-inch or 18-inch wide wire brush electrode attached to the unit.

3.10.5.2 Induron Ceramawrap Coating: Low voltage-capable pulse type holiday detector such as Tinker & Rasor Model AP-W, Elcometer 236 DC, or equal, shall be used at a setting of 2,000 Volts. Holiday testing shall be conducted with a new or clean 12-inch or 18-inch wire brush electrode.

3.10.6 Film Thickness Testing: On ferrous metals, the dry film coating thickness shall be measured in accordance with the SSPC PA2, Determining Profile Compliance, using an electromagnetic-type Type 2 dry film thickness gauge. The instruments shall have the capability of measuring 50% over the specified coating thickness and shall produce an actual reading and shall not be estimated. No measurements shall be made until at least 8 hours after application of the coating. The following instruments are acceptable:

3.10.6.1 Ferrous and Non Ferrous Surfaces

3.10.6.1.1 Wet – Notched gauge per ASTM D4414 or approved equal.

3.10.6.1.2 Dry – Elcometer Model 456, PosiTector 6000, Fischer MMS DFT, or equal.

3.10.7 Surface Profile: 30% of the pipe sections shall have the surface profile tested. The surface profile shall be tested with the use of Press-o-Film as manufactured by Testex or other NACE SP0287 approved equal, at locations to be determined by the Inspector. The replica tape thickness shall be measured using a dial micrometer manufactured by Testex or other ASTM D4417 Type C approved equal. For each test area, three replica tape tests shall be performed within a single test area 12 inches in diameter. For each test area, the three replica tape thickness values shall be recorded and must be within 10% of the coating manufacturer's recommended profile.

3.11 Handling, Transportation, and Storage

3.11.1 Coated pipe shall not be shipped or installed until coating has developed full adhesion and cure.

3.11.2 During coating application, storage, loading, transportation, unloading, laying and installation, the handler shall take precaution to not damage the coating. Padding shall be installed on surfaces of forklift equipment that comes in contact with the pipe.

3.11.3 When transporting multiple stacks of pipe, padded bolsters between each layer of pipe and heavy duty padding under the load tie-downs shall be installed. Bolsters shall be curved to fit the outside of the pipe and 12 inches wide. All pipe contact locations shall be heavily padded with carpet, HDPE padding, or other durable material when shipping to the project location and from the shop coating application location to the job site.

3.11.4 Dragging or skidding of pipe on grade or in trench will not be permitted.

3.11.5 The pipe shall not be laid on asphalt without suitable padding at all contact points.

3.11.6 Metal chains, wire cables, clam shell bucket, or excavator bucket in contact with the exterior of the pipe or appurtenances without padding shall not be used to lift or move the pipe.

3.11.7 The coated pipe shall be inspected by the Contractor at the job site for damage prior to laying down the pipe in the trench. Damage to the coating as defined in Section 3.12, shall be repaired in accordance with the manufacturer's recommendations to the satisfaction of BWS. If the damage is widespread and is more than 5% of the total surface area of the pipe section, the lining shall be removed by abrasive blasting and recoated.

3.12 Shop and Field Repairs

3.12.1 If an area is found to have bubbles, blisters, insufficient film thickness, visual or sparking holidays, or other deficiencies; then the Contractor shall abrade, clean, and topcoat the coated surface per the manufacturer's mixing recommendations and these Specifications. The abraded area and repair coating shall overlap the surrounding coated area by 3 to 6 inches, depending on the size of the defect or field repair. Work shall be free of bubbles, blisters, visual or sparking holidays, and discoloration.

3.12.2 Damaged shop coating that exposes the metal substrate greater than 1 inch in diameter or length shall be cleaned in accordance with SSPC SP11 using an MBX Bristleblaster, or equivalent, and in accordance with the manufacturer's recommendations.

3.13 Curing of Coatings

3.13.1 If the coating exhibits delamination, blisters, or tackiness after the manufacturer's recommended cure time, the Inspector shall conduct a Solvent Rub Test in accordance with ASTM D5402. The test area shall be evaluated for appearance, hardness, or any color transfer to the cloth. If there is no change to the coating after the test, it will be considered cured. If there is color transfer to a cloth, the affected areas shall be removed and recoated at the Contractor's expense.

3.13.2 If the coating exhibits softness, blisters, or tackiness after the manufacturer's recommended cure time, the Inspector shall conduct Shore D Hardness Testing per ASTM D2240. In order to consider the coating cured and properly mixed, it must meet the manufacturer's recommended Shore D Durometer requirement for the specified product. If the hardness result does not meet the requirement, the affected areas shall be removed and recoated at the Contractor's expense.

3.13.3 The Contractor shall provide curing conditions in accordance with the conditions recommended by the coating material manufacturer or by this Section, whichever is the highest requirement, prior to placing the completed coating system into service.

3.13.4 In the case of enclosed areas, forced air ventilation, using heated air if necessary, may be required until the coatings have fully cured.

3.14 Coating System Schedules for Ductile Iron Pipe

3.14.1 One of the following 100% solids polyurethanes, 100% solids epoxy, or approved equal, shall be used to coat the exterior surfaces of pipe exposed to soil and groundwater.

3.14.2 Any deviations to the following schedule shall be submitted 10 business days in advance and shall be approved by BWS prior its application. Unapproved materials applied prior to approval by BWS shall be removed at the sole expense of the Contractor.

Substrate	Surface Preparation	Coating System No.
Ductile Iron Pipe Exterior	NAPF-500-03-04 with a 3 mil surface profile minimum	P100 or E100
Ductile Iron and Cast Iron Fittings, Elbows, Tees, Crosses, Wyes and other metal appurtenances	NAPF-500-03-05 Blast Clean #1 with a 3 mil surface profile minimum	P100 or E100

PART 5. CATHODIC PROTECTION DESIGN

SECTION 1. REQUIREMENTS

1.1 General

As part of the external corrosion protection of the buried pipe used in the water system, all metallic pipes, valves, and fittings require cathodic protection. The cathodic protection required for each type of pipe depends on the corrosion category.

SECTION 2. DESIGN

2.1 Design for Corrosion Category A

The design shall utilize a galvanic anode cathodic protection (GACP) system or an impressed current cathodic protection (ICCP) system designed by a Registered Professional Corrosion Engineer or NACE certified Cathodic Protection Specialist (CP4). The design shall be in accordance with accepted practice and NACE SP0169. The anodes and rectifier shall have a theoretical design life of at least 20 years, and the remainder of the cathodic protection system shall have a theoretical design life of 50 years. The design shall be approved by the Manager.

2.2 Design for Corrosion Category B

The design shall utilize a GACP system meeting NACE SP0169, except for paragraph 6.2.2.1 criteria for polarization for steel and cast iron pipe. The prescriptive requirements in this Standard shall apply.

For ductile iron pipe, two anodes shall be installed every 500 feet. The anodes shall be at least 5 feet from the pipe and at least 10 feet from one another. The anodes shall be 60-pound high-potential magnesium anodes, which are further described in Part 6.

For metallic fittings and valves associated with non-metallic pipe, install one anode per fitting or valve. The anode shall be at least 5 feet from the fitting or valve. The anode shall be 60-pound high-potential magnesium anodes, which are further described in Part 6.

Metallic fittings and valves associated with metallic pipe shall be bonded into the CP system for the metallic pipe and do not require independent CP systems on their own.

PART 6. GALVANIC ANODE CATHODIC PROTECTION (GACP) SYSTEM SPECIFICATION

SECTION 1. GENERAL

1.1 This Specification Includes

1.1.1 The WORK of this Specification includes providing a complete galvanic anode cathodic protection (GACP) system for metallic pipelines, valves, and fittings as outlined in this Specification and on the Drawings.

1.1.2 Electrical isolation of the structures from adjacent metallic structures, steel-reinforced concrete structures, casings, structures of dissimilar metal or dissimilar coatings, conduits, and all other metallic components that may impact the operation of the CP system.

1.1.3 Electrical bonding of all non-insulated, non-welded pipe joints and mechanical joints.

1.1.4 Installation of galvanic anodes, insulating joints, insulating corporation stops, test stations, other components associated with the CP system, and all other work described herein and on the Drawings.

1.1.5 Testing of CP system during installation.

1.1.6 Cleanup and restoration of work site.

1.1.7 Final System Checkout: Testing of CP system after installation and backfilling, including final testing and certification report.

1.2 Requirements

1.2.1 If the products installed as part of this Specification are found to be defective or damaged or if the WORK of this Specification is not in conformance with these Specifications, then the products and WORK shall be corrected at the Contractor’s expense.

1.2.2 Any retesting required due to inadequate installation or defective materials shall be paid for by the Contractor at no additional cost to the owner.

1.2.3 The WORK also requires that one Supplier or Subcontractor accept responsibility for the WORK, as indicated, but without altering or modifying the Contractor's responsibilities under the Contract Documents.

1.2.4 The WORK also requires coordination of assembly, installation, and testing between the pipeline contractor and any CP material supplier or subcontractor.

1.2.5 All electrical WORK shall be in accordance with NEC and local requirements.

1.3 Related Specifications

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

1.3.1.1 Site Safety and Regulatory Requirements

1.3.1.2 Excavation, Trenching, Backfilling, and Compacting

1.3.1.3 Piping

1.3.1.4 Cast-In-Place Concrete

1.3.1.5 Protective Coatings

1.4 Referenced Specifications, Codes, and Standards

1.4.1 The WORK of this Specification shall comply with the current editions of the following codes and standards:

AASHTO	American Association of State Highway and Transportation Officials
H20	Specification for Highway Bridges
ASTM	ASTM International
A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
B3	Standard Specification for Soft or Annealed Copper Wire
B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
B187	Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
B418	Standard Specification for Cast and Wrought Galvanic Zinc Anodes
B843	Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
C94	Standard Specification for Ready-Mixed Concrete
D1000	Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
G97	Standard Test Method for Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications
AWWA	American Water Works Association
C217	Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines
NSF	National Sanitation Foundation
NSF 61	Drinking Water System Components
NACE	NACE International, the Corrosion Society
SP0375	Field-Applied Underground Wax Coating Systems for Underground Metallic Pipelines: Application, Performance, and Quality Control
SP0169	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
SP0286	Electrical Insulation of Cathodically Protected Pipelines

TM0497	Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
NFPA	National Fire Protection Association
NFPA 70	National Electric Code (NEC)
NEMA	National Electrical Manufacturers Association
TC2	Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
SSPC	The Society for Protective Coatings
SP2	Hand Tool Cleaning
SP3	Power Tool Cleaning
SP11	Bare Metal Power Tool Cleaning
UL	Underwriters Laboratories
467	Grounding and Bonding Equipment

1.4.2 Whenever the Drawings or these Specifications require a higher degree of workmanship or better quality of material than indicated in the above codes and standards, these Drawings and Specifications shall prevail.

1.5 Permits and Job Access

1.5.1 Prior to the start of construction, the Contractor shall apply to the required authorities for permits required for the installation of the CP system.

1.5.2 The Contractor shall contact Hawaii One Call prior to commencing construction to locate existing utilities in the area of construction. Existing utilities include, but are not limited to, water lines, gas lines, telephone, streetlights, sewer and storm drains, and overhead and underground electric utilities.

1.5.3 If traffic control is necessary, it shall satisfy the requirements of the governing locality.

1.6 Quality Assurance

1.6.1 Installation of the CP equipment shall be performed by individuals having at least 5 years of experience in the installation of the CP equipment described herein.

1.6.2 All testing required to be performed by the Contractor's "Corrosion Technician" shall be performed by a NACE certified Corrosion Technician under the supervision of a Corrosion Engineer. A Corrosion Technician is a NACE CP1 (CP Tester), CP2 (CP Technician), CP3 (CP Technologist), or CP4 (CP Specialist). A Corrosion Engineer is a Registered Professional Corrosion Engineer or a NACE CP4 (CP Specialist).

1.7 Submittals

1.7.1 The following shall be submitted to the Manager prior to any equipment installation.

1.7.1.1 Catalog cuts, bulletins, brochures, or data sheets for all materials specified herein.

1.7.1.2 Statement that the equipment and materials proposed meet the Specifications and the intent of the Specifications.

1.7.1.3 Written certification of experience required, including NACE certificates or PE license.

1.7.1.4 Schedule, including the expected start date and planned completion date.

1.7.1.5 The data sheet to be used for the final system checkout that includes all of the data required in Section 3.16.

1.7.2 The following shall be submitted to the Manager after completion of the WORK.

1.7.2.1 Wire connection testing.

1.7.2.2 Insulating joint testing, before and after backfilling.

1.7.2.3 Casing insulator testing, before and after backfilling.

1.7.2.4 Joint bond testing, before and after backfilling.

1.7.2.5 Final System Checkout Report.

1.7.2.6 Record Drawings shall be submitted to and approved by the Manager before the WORK is considered complete.

1.8 Interference and Exact Locations

1.8.1 The locations of CP equipment, test stations, devices, outlets, and appurtenances, as indicated, are approximate only. Exact locations shall be determined by the Contractor in the field subject to the approval of the Manager.

1.8.2 The Contractor shall field verify all data and final locations of work done under other Specifications required for placing of the electrical work.

1.8.3 In case of interference with other work, foreign pipeline, or erroneous locations with respect to equipment or structures, the Contractor shall furnish all labor and materials necessary to complete the WORK in an acceptable manner.

SECTION 2. PRODUCTS

2.1 General

2.1.1 All materials installed must be new. All equipment and materials supplied shall be similar to that which has been in satisfactory service for at least 5 years.

2.2 Galvanic Anode

2.2.1 High-potential magnesium anodes: Cast magnesium anodes shall conform to ASTM B843 Type M1C. Anodes shall have an open circuit potential of −1.70 volts or more electronegative and a current efficiency of at least 48% when tested in accordance with ASTM G97. Anodes shall have the following size, form, and shape. Anodes shall be supplied by Farwest, Corrpro, Mesa, Matcor, or equivalent.

Ingot				Packaged		
Weight (lb)	Width (inch)	Height (inch)	Length (inch)	Weight (lb)	Diameter (inch)	Length (inch)
5	3 to 4	3 to 4	7 to 8	14 to 17	5 to 6	13 to 14
9	3 to 4	3 to 4	13 to 14	24 to 27	6	17
17	3 to 4	3 to 4	25 to 26	42 to 45	6 to 7	29 to 30
20	2 to 3	2 to 3	56 to 60	70	5 to 6	62.5 to 66
32	5 to 6	5 to 6	19 to 21	70	8	28 to 30
40	3 to 4	5 to 6	60	100	6 to 7	64 to 66
48	5 to 6	5 to 6	30 to 31	100 to 105	8	34 to 38
60	4 to 5	4	60	126 to 130	6 to 7	64

2.2.2 Standard-potential magnesium anodes: Cast magnesium anodes shall conform to ASTM B843 Type AZ63B (commonly known as H1A). Anodes shall have an open circuit potential of −1.53 to −1.55 volts and current efficiency of 45 to 55% when tested in accordance with ASTM G97. Anodes shall have the following size, form, and shape. Anodes shall be supplied by Farwest, Corrpro, Mesa, Matcor, or equivalent.

Ingot				Packaged		
Weight (lb)	Width (inch)	Height (inch)	Length (inch)	Weight (lb)	Diameter (inch)	Length (inch)
5	3 to 4	3 to 4	7 to 10	13 to 16	5 to 6	11 to 14
9	3 to 4	3 to 4	13 to 14	24 to 27	5 to 7	17 to 20
17	3 to 4	3 to 4	17 to 26	42 to 45	6 to 8	19 to 29
20	2 to 3	2 to 3	56 to 57	70	6 to 7	62
32	5 to 6	5 to 6	20 to 21	68 to 70	8 to 9	28 to 30
48	5 to 6	5 to 6	30 to 31	105	7 to 8	38
60	4 to 5	4 to 5	57 to 61	126	7 to 8	64

2.2.3 Zinc anodes: Cast and wrought galvanic zinc anodes shall conform to ASTM B418 Type II. Anodes shall have a ¼-inch galvanized mild steel or iron core. Anodes shall have the following size, form, and shape. Anodes shall be supplied by Farwest, Corrpro, Mesa, Matcor, Galvotec, or an approved equivalent.

Ingot				Packaged		
Weight (lb)	Width (inch)	Height (inch)	Length (inch)	Weight (lb)	Diameter (inch)	Length (inch)
5	1.4	1.4	9	16 to 24	4.5 to 5	12 to 15
15	2	2	15	36 to 50	6	21 to 24
18	1.4	1.4	36	55 to 70	5	42 to 43
30	2	2	30	67 to 70	5 to 6	36 to 38
30 to 33	1.4	1.4	60	86 to 100	5 to 6	65 to 66
45 to 48	2	2	45 to 48	100 to 110	5 to 6	51 to 58
60	2	2	60	120 to 130	5 to 6	65 to 66

2.2.4 Galvanic anodes shall be pre-packaged in a cloth bag containing backfill of the following composition: 75% gypsum, 20% bentonite, and 5% sodium sulfate. The anodes shall be of the size indicated on the Drawings and placed where indicated on the Drawings.

2.2.5 Anode lead wire:

2.2.5.1 The wire attached to the anodes shall be of the size and type indicated on the Drawings. The anode lead wire shall conform to the specifications given for "Wires" in this specification.

2.2.5.2 Connection of wire to the anode shall have a pulling strength that exceeds the wire's tensile strength.

2.2.5.3 Anode lead wires shall be of one continuous length, without splices, unless otherwise indicated on the Drawings, from the anode connection to the test station.

2.3 Flush-mounted Test Station

2.3.1 Flush-mounted test station boxes shall be traffic boxes rated to withstand AASHTO H20 traffic loading.

2.3.2 The traffic boxes shall be G05 Utility Boxes, as manufactured by Christy Concrete Products, Inc.; No. 3RT Utility Box, as manufactured by Brooks Products; or an approved equivalent.

2.3.3 Traffic box covers for test stations shall be cast iron with welded bead legend and labeled "CP TEST" or "ANODE," as required.

2.4 Ready-mixed Concrete

2.4.1 Ready-mixed concrete shall be in accordance with ASTM C94, permit requirements, and the Specification for cast-in-place concrete.

2.5 Reinforcing Steel

2.5.1 Reinforcing steel shall be in accordance with ASTM A615, permit requirements, and the Specification for reinforcing steel.

2.6 Panel Board

2.6.1 Panel boards shall be made of 1/4-inch thick phenolic plastic and sized as indicated on the Drawings.

2.6.2 Connection hardware shall be brass or bronze. All connections shall be double nutted bolts with serrated lock washers.

2.6.3 Copper bus bar shall be 1/8-inch thick and sized to fit. The copper bus bar shall be per ASTM B187 with 98% conductivity.

2.7 Mechanical Lug

2.7.1 Mechanical lugs shall be brass or copper with a brass, copper, or stainless steel set screw. Tin plating on the lugs is optional. Aluminum lugs shall not be permitted. Zinc-plated steel set screws shall not be permitted. The lug shall be listed per UL 467, suitable for direct burial, and appropriately sized for the incoming wires. The lug shall be ILSCO Type XT-6DB, Burndy GKA8C, or an approved equivalent.

2.8 Shunt

2.8.1 Shunts shall be selected by the size indicated on the Drawings.

2.8.2 0.01-ohm, 6-amp shunts shall be manganin wire type, as indicated. Shunts shall be Type RS, as manufactured by Holloway, or equivalent.

2.9 Conduit

2.9.1 The minimum conduit size shall be 2 inches unless otherwise indicated. Refer to NFPA 70 (NEC) for additional conduit size requirements.

2.9.2 The conduit placed below grade shall be Schedule 80 PVC in accordance with NEMA TC2.

2.10 Caution Tape

2.10.1 The caution tape shall be an inert plastic film designed for prolonged underground use. The caution tape shall be a minimum of 3 inches wide and a minimum of 4 mils thick.

2.10.2 The caution tape shall be continuously printed over the entire length with the wording "CAUTION: CATHODIC PROTECTION CABLE BURIED BELOW."

2.10.3 The wording shall be printed using bold black letters. The color of the tape shall be red.

2.11 Wire

2.11.1 Conductors shall consist of stranded copper of the gauge indicated on the Drawings. Wire sizes shall be based on American Wire Gauge (AWG). Copper wire shall be in conformance with ASTM B3 and ASTM B8.

2.11.2 Insulation Type and Colors: As shown on the Drawings.

2.11.2.1 High molecular weight polyethylene (HMWPE) wires shall be rated for 600 volts and shall conform to ASTM D1248, Type 1, Class C, Grade 5.

2.12 Wire Identification Tag

2.12.1 Wire identification tags shall be the wrap-around type with a high resistance to oils, solvents, and mild acids. Wrap-around markers shall fully encircle the wire with imprinted alpha-numeric characters for pipe identification. The letters and numbers height shall be 3/16 inch at minimum.

2.13 Exothermic Weld

2.13.1 Exothermic welds shall be in accordance with the manufacturer's recommendations. Exothermic welds shall be Cadweld manufactured by Erico, Thermoweld manufactured by Continental Industries, or an approved equivalent.

2.13.2 Prevent molten weld metal from leaking out of the mold, where necessary, by using Duxseal packing manufactured by Johns-Manville, Thermoweld packing material manufactured by Continental Industries, Cadweld T403 Mold Sealer manufactured by Erico, or an approved equivalent.

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

2.13.3.1 Pipe material

2.13.3.2 Pipe size

2.13.3.3 Wire size and requirement for sleeves

2.13.3.4 Number of wires to be welded

2.13.3.5 Orientation of weld (vertical or horizontal)

2.14 Exothermic Weld Coating Material

2.14.1 After exothermic welding, repair coatings and linings in accordance with the coating and lining manufacturer's recommendation.

2.14.2 Weld caps with an integrated primer shall be used to cover the exothermic weld connecting the wire to the pipe. The weld cap shall be a 10-mil thick durable plastic sheet that has a dome filled with a moldable compound to assure complete encapsulation of the exothermic weld and a layer of elastomeric adhesive with integrated primer. The adhesive and primer shall be compatible with the pipe material and pipe coating material. Adhesion to steel shall be at least 10 lb/in per ASTM D1000. Weld cap with integrated primer shall be Handy Cap IP manufactured by Royston or equivalent for wire size up to 8 AWG and Handy Cap XL IP manufactured by Royston or equivalent for wire size up to 2 AWG.

2.15 Pipe Clamp

2.15.1 Pipe clamp and screws shall be silicon bronze, bronze, or copper. Pipe clamp shall be designed for grounding. Pipe clamp shall be sized for the copper pipe and wire conductor size indicated on the Drawings.

2.16 Dielectric Insulating Flange Kit

2.16.1 Insulating flange kits shall include full-faced gaskets, insulating sleeves and washers, and 316 stainless steel bolts, nuts, and washers. The complete assembly shall have a pressure rating equal to or greater than the flanges between which it is installed. Sleeves, gaskets, and insulating washers shall have a minimum dielectric constant of 300 volts per mil. Stainless steel washers shall 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.

2.16.1.1 Insulating gasket shall be full-faced, Type E, and 1/8-inch thick. Acceptable gasket materials include nitrile faced phenolic, G-10, or material with equivalent or increased performance. Acceptable seal materials include EPDM, PTFE, or material with equivalent or increased performance. When used in potable water systems, gasket and seal shall be NSF 61 approved.

2.16.1.2 Insulating sleeves shall be 1/32-inch thick and equal the number of bolts on the flange. Acceptable materials include Mylar, G-10, or material with equivalent or increased performance.

2.16.1.3 Insulating washers shall be 1/8-inch thick and equal to twice the number of bolts on the flange. Acceptable materials include G-10 or material with equivalent or increased performance.

2.16.2 Dielectric insulating flange kits shall be manufactured by Advance Products & Systems Inc., GPT Industries, or an approved equivalent.

2.17 Insulating Corporation Stop

2.17.1 The insulating corporation stop shall be brass with nylon insulating material that effectively stops the flow of electrical current without compromising the strength of the service line. The seal shall be accomplished with an O-ring.

2.17.2 Insulating corporation stops shall be manufactured by Mueller Co. or an approved equivalent.

2.18 Casing End Seal

2.18.1 Casing end seal shall seal the annular space between the carrier pipe and casing. A casing end seal shall be installed on each end of the casing. The casing end seal shall be designed to last the life of the piping system.

2.18.2 Casing end seal shall be at least 1/8-inch thick neoprene, nitrile, or EPDM. The seal shall be secured with 316 stainless steel banding straps.

2.19 Petrolatum Wax Tape

2.19.1 Petrolatum wax tape shall meet or exceed the requirements of AWWA C217 and shall consist of three parts: Surface primer, wax tape, and outer covering. All three parts shall be the product of a single manufacturer.

2.19.2 The primer shall be a blend of petrolatums, plasticizers, and corrosion inhibitors having a paste-like consistency. Primer shall be Wax-Tape Primer manufactured by Trenton, Denso Paste manufactured by Denso, or approved equivalent.

2.19.3 The wax tape shall be synthetic-fiber felt, 45 to 90 mils thick, saturated with a blend of micro-crystalline wax, petrolatums, plasticizers, and corrosion inhibitors that are capable of easy conformability over irregular surfaces. Wax tape shall be #1 Wax-Tape manufactured by Trenton, Denso Tape manufactured by Denso, or approved equivalent.

2.19.4 The outer covering shall be a plastic wrap consisting of one 150-gauge sheet or three 50-gauge sheets wound together as a single sheet, clear polyvinylidene chloride, shrink wrap that is flexible enough to conform to irregular surfaces. Outer wrapping shall be Poly-Ply by Trenton, Poly-Wrap by Denso, or approved equivalent.

2.20 Permanent Reference Electrode

2.20.1 Reference electrodes shall be copper-copper sulfate and designed for continuous use in the soil for a minimum of 30 years, as manufactured by Borin Manufacturing or an approved equivalent. The reference electrode shall have a wire which will extend to the panel board, without splicing, as indicated on the Drawings.

2.20.2 Permanent reference electrodes shall be pre-packaged in a cloth bag containing backfill of the following composition: 75% gypsum, 20% bentonite, and 5% sodium sulfate.

2.21 Coupon

2.21.1 The coupon shall be the same material type as the pipeline and have an area of 10 cm^2.

2.21.2 The coupon shall have two #12 AWG stranded copper wire with HMWPE insulation (green). All wires shall be long enough to extend to the junction box or test station without splicing.

2.21.3 Coupons shall be manufactured by MC Miller or an approved equivalent.

2.22 Isolation Mat

2.22.1 Isolation mat shall be neoprene and of the dimensions shown on the Drawing.

SECTION 3. EXECUTION

3.1 Material and Equipment Storage

3.1.1 All materials and equipment to be used in construction shall be stored in such a manner to be protected from detrimental effects from the elements. If warehouse storage cannot be provided, materials and equipment shall be stacked well above ground level and protected from the elements with plastic sheeting or another method, as appropriate. All costs shall be considered incidental to the various contract items. No additional costs shall be borne by the BWS.

3.2 Surface Ground Bed for Galvanic Anode

3.2.1 Prepackaged anodes shall be installed at the locations indicated on the Drawings.

3.2.2 Plastic or paper wrapping shall be removed from the anode prior to lowering the anode into the hole. Anodes shall not be suspended by the lead wires. Damage to the canvas bag, anode-to-wire connection, copper wire, or wire insulation before or during installation will require replacement of the entire anode assembly. Anodes shall be inspected and approved prior to backfilling.

3.2.3 Anodes shall be backfilled with native 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. Upon completion of compaction of backfill to the top of the anode, and prior to filling the hole and compacting the backfill to the surface, a minimum of 10 gallons of fresh water shall be poured into the hole to saturate the prepackaged anode backfill and surrounding soil.

3.2.4 Anode lead wires shall be routed and terminated on the panel board, as shown in the Drawings.

3.2.5 For lateral conduit runs, install wires in PVC conduit set at the center of the trench. Maintain sufficient slack in wire to prevent the cable from being unduly stressed or broken during backfill operations.

3.3 Test Station

3.3.1 Test stations shall be installed at the approximate locations shown on the Drawings. Test stations shall be located within the pipeline easement. Test stations shall be located in areas not subject to vehicular traffic, such as sidewalks or behind the curb, unless otherwise approved by the Manager. Where possible, locate test station near fire hydrants and place lateral wire runs along the hydrant lateral for protection.

3.3.2 For flush-mounted test stations, place the bottom of the test box on native soil. Do not place rock, gravel, sand, or debris in the box. Install 4,000 psi concrete collar with reinforcement after placement of the test box to finished grade. Provide sufficient sloping in the concrete pad or surrounding pavement to provide drainage away from the test box.

3.3.3 Connect wires to the terminal board as shown on the Drawings. Each wire shall be identified with a permanent wire identifier within 4 inches of the termination. After installation, all wire connections in the test station shall be tested by the Contractor to ensure they meet the requirements herein.

3.3.4 For foreign pipeline test stations, the Contractor shall notify the owner of foreign utility piping for which foreign pipeline crossing test stations are to be installed. Notification shall be provided at least 2 weeks in advance. Test leads to foreign pipelines shall be installed in the presence and to the satisfaction of a representative of the foreign pipeline owner.

3.3.5 The Contractor shall field verify the final location of the test stations. The Contractor shall provide the global positioning system (GPS) coordinates for each test station location with a minimum accuracy of 1 meter or 3 feet. The Contractor shall submit the GPS coordinates of the test stations to the Manager after installation.

3.4 Wire

3.4.1 Buried wires 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.

3.4.2 At least 12 inches of slack (coiled) shall be left for each wire at each flush-to-grade test station. Wire slack shall be sufficient to allow removal of wire extension for testing. Wire shall not be bent into a radius of less than 2 inches.

3.4.3 The wire conduits must be of sufficient diameter to accommodate the wires. This shall be determined by the number and size of wires in accordance with the applicable codes and standards.

3.4.4 Conduit shall be installed to a minimum depth of 36 inches below grade.

3.4.5 Install caution tape a minimum of 6 inches above buried wire and conduits. Every 3 feet, double over the tape for a distance of 8 inches to increase the apparent flexibility of the tape.

3.5 Wire Identification Tag

3.5.1 All wires shall be coded with wire identification tags within 4 inches of the wire end indicating diameter and type of pipe.

3.5.2 Wire identification tags shall be placed on all wires prior to backfilling and installation of test stations.

3.6 Exothermic Weld Connection

3.6.1 Exothermic weld connections shall be installed in the manner and at the locations indicated. Exothermic welds shall be spaced at least 6 inches apart from other exothermic welds, fittings, and circumferential welds.

3.6.2 Coating materials shall be removed from the surface over an area of sufficient size to make the connection and as indicated on the Drawings. The surface shall be cleaned to bare metal by grinding or filing per SSPC SP11 prior to welding the conductor. The use of resin impregnated grinding wheels will not be allowed.

3.6.3 Only enough insulation shall be removed such that the copper conductor can be placed in the welding mold. If the wire conductor diameter is not the same as the opening in the mold, then a copper adapter sleeve shall be fitted over the conductor.

3.6.4 The Contractor shall be responsible for testing all test lead and bond wire welds. The Manager, at his or her discretion, shall witness these tests.

3.6.5 After the weld has cooled, all slag shall be removed, and the metallurgical bond shall be tested for adherence by the Contractor. 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. All defective welds shall be removed and replaced in a new location at least 6 inches away from the original weld location.

3.6.6 A plastic weld cap with an integrated primer shall cover the exothermic weld and surrounding area. All surfaces must be clean, dry, and free of oil, dirt, loose particles, and all other foreign materials prior to the application of the weld cap.

3.6.7 The Contractor shall inspect both the interior and exterior of the pipe to confirm that all coatings and linings removed or damaged as a result of the welding have been repaired. The Contractor shall furnish all materials, clean surfaces, and repair protective coatings and linings damaged as a result of the welding. Repair of any coating or lining damaged during welding shall be performed in accordance with coating or lining manufacturer's recommendations.

3.6.8 All exposed surfaces of the copper and steel shall be covered with insulating materials. Coating repairs shall be performed in accordance with coating manufacturer's recommendations.

3.6.9 After backfilling pipe, all test lead pairs shall be tested for broken welds using a standard ohmmeter. The resistance shall not exceed 150% of the theoretical wire resistance, as determined from published wire data.

3.7 Joint Bond

3.7.1 Bond wires shall be provided across flexible couplings and all non-welded joints to ensure electrical continuity, except where insulating joints have been installed to provide electrical isolation. Joint bonds shall be of the size, length, and number shown on the Drawings and installed as indicated. The bond wires shall allow at least 2 inches of movement in the pipe joint. The wire shall be attached by exothermic welding. At least 2 bond wires shall be provided between all discontinuous joints.

3.7.2 For ductile iron pipe, the Contractor may, at his or her own expense, provide weld plates that are installed by the pipe manufacturer at the spigot end of the pipe. Provision of the weld plates does not relieve the Contractor from responsibility for repair of damage to the coating or lining as a result of exothermic welding of the pipe. Coating repairs shall be performed in accordance with coating manufacturer's recommendations.

3.8 Dielectric Insulating Flange Kit

3.8.1 All insulating components of the insulating flanged gasket set shall be cleaned of dirt, grease, oil, and other foreign materials immediately prior to assembly. If moisture, soil, or other foreign matter contacts any portion of these surfaces, disassemble the entire joint and clean with a suitable solvent. Dry the entire joint. Once completely dry, reassemble the joint.

3.8.2 Care shall be taken to prevent any excessive bending or flexing of the gasket. Creased or damaged gaskets shall be rejected and removed from the job site.

3.8.3 Bolt holes in mating flanges shall be properly aligned at the time bolts and insulating sleeves are inserted to prevent damage to the insulation. Follow the manufacturer's recommended bolt tightening sequence. Center the bolt insulating sleeves within the insulation washers so that the insulating sleeve is not compressed and damaged.

3.8.4 After flanged bolts have been tightened, each insulating washer shall be inspected for cracks or other damage. All damaged washers shall be replaced.

3.8.5 When the flange is determined to be properly functioning to the full satisfaction of the Manager, approval will be granted to proceed with the installation. Do not proceed with coating, lining, or backfilling the insulating joint prior to gaining approval to proceed. If the coating is applied prior to gaining approval to proceed, the coating shall be completely removed to the satisfaction of the Manager at the Contractor’s expense. If the insulating joint is backfilled prior to gaining approval from the Manager, the Contractor shall completely excavate the insulating joint at the Contractor’s expense.

3.8.6 After testing and acceptance by the Manager, coat the exterior insulating flange and pipe a minimum of 12 inches beyond the gasket with the wax tape system specified herein.

3.9 Insulating Corporation Stop

3.9.1 Insulating corporation stops shall be installed where copper laterals connect with the DIP mainline.

3.9.2 Care shall be taken to prevent any excessive bending or flexing of the insulating corporation stop.

3.9.3 Before and after installation, insulating corporation stops shall be inspected for damage. Damaged insulating corporation stops shall be rejected and removed from the job site.

3.9.4 When the insulating corporation stop is determined to be properly functioning to the full satisfaction of the Manager, approval will be granted to proceed with installation. Do not proceed with coating, lining, or backfilling the insulating corporation stop prior to gaining approval to proceed. If the coating is applied prior to gaining approval to proceed, the coating shall be completely removed to the satisfaction of the Manager at the Contractor’s expense. If the insulating corporation stop is backfilled prior to gaining approval from the Manager, the Contractor shall completely excavate the insulating corporation stop at the Contractor’s expense.

3.9.5 After testing and acceptance by the Manager, coat the exterior insulating corporation stop and pipe a minimum of 12 inches beyond the insulating corporation stop with the wax tape system specified herein.

3.10 Petrolatum Wax Tape

3.10.1 Petrolatum wax tape systems shall be applied on insulating joints, insulating corporation stops, and non-cathodically protected metallic appurtenances and fittings, regardless of whether they are bare or factory coated. Extend the petrolatum wax tape coating system over any adjacent pipe coating by a minimum of 12 inches. Petrolatum wax tape systems shall be applied in accordance with NACE RP0375, AWWA C217, these Specifications, and the Manufacturer's recommendations.

3.10.2 Surfaces shall be cleaned of all dirt, grease, oil, and other foreign materials immediately prior to coating. Loose rust, loose paint, and other foreign matter shall be removed in accordance with SSPC SP2 or SP3.

3.10.3 A prime coating shall be applied in a uniform coating over the entire surface to be wrapped. A liberal coating shall be applied to threads, cavities, shoulders, pits, and other irregularities.

3.10.4 Petrolatum wax tape shall be applied immediately after applying the primer using a 1-inch overlap. A spiral wrap shall be used, and slight tension shall be applied to ensure that there are no air pockets or voids. For bolts, nuts, and other irregular shapes, cut strips of wax tape and apply them by gloved hand so that there are no voids or spaces under the tape. Apply a sufficient amount of tape to completely encapsulate all exposed steel surfaces. After applying the tape, the applicator shall firmly press and smooth out all lap seams and crevice areas. The tape shall be in tight intimate contact with all surfaces. The minimum wax tape thickness shall be 70 mils over smooth surfaces and 140 mils over sharp and irregular surfaces, or more as required to fill all voids.

3.10.5 Apply two layers of outer covering over the wax tape coating by tightly wrapping it around the pipe such that it adheres and conforms to the wax tape. Secure the outer covering to the pipe with adhesive tape.

3.11 Coupon

3.11.1 Coupon shall be installed as shown on the Drawings.

3.12 Wire Connection

3.12.1 After installation, all wire connections shall be tested to ensure electrical continuity at the test station locations by the Contractor to ensure that they meet the requirements and intent of the Contract Documents.

3.13 Isolation Testing on Insulating Joints and Corporation Stops

3.13.1 Insulating joints and corporation stops shall be installed to effectively isolate metallic piping from foreign metallic structures. The Contractor shall test the performance of these insulating joints and corporation stops before and after backfilling in accordance with Part 8, Testing.

3.13.2 Before backfilling, the Contractor shall test the insulating joint and corporation stop using a Gas Electronics Model No. 601 Insulation Checker or an approved equivalent. If the testing results indicate less than 100% insulation, then the insulating joints and corporation stops shall be repaired and retested at the Contractor's expense.

3.13.3 After backfilling, testing shall be performed by measurement of native pipe-to-soil potentials at both sides of the insulating joints. If the difference in native pipe-to-soil potentials on both sides of the insulating joint is within ±100 mV, then additional testing shall be performed, as follows. Temporary CP current shall be circulated on one side of the insulating joint. "On" and "Instant Off" pipe-to-soil potentials shall be measured on the other side of the insulating joint. If the "Instant Off" potential is more negative than the native potential, the insulating joint shall be considered deficient and shall be repaired and retested at the Contractor's expense.

3.14 Isolation Testing on Casing Insulators

3.14.1 Casing insulators shall be installed as indicated in the Drawings to effectively isolate the pipeline from the casing. The Contractor shall test the performance of the casing insulators before and after backfilling in accordance with Part 8, Testing.

3.14.2 Before backfilling, the Contractor shall test the integrity of the insulators by using a Gas Electronics Model No. 601 Insulation Checker or an approved equivalent. If the testing results indicate less than 100% insulation, then the casing insulators shall be repaired and retested at the Contractor's expense.

3.14.3 After backfilling, testing shall be performed by measurement of native pipe-to-soil potentials on the pipeline and the casing at both ends of the casing. If the difference in native pipe-to-soil potentials is greater than 100 mV, then the casing shall be considered isolated from the pipeline. If the difference in native pipe-to-soil potentials between pipe and casing is less than 100 mV, then additional testing shall be performed, as follows. Temporary CP current shall be applied to the pipeline. "On" and "Instant Off" pipe-to-soil potentials shall be measured on the pipeline and the casing at both ends of the casing. If the "Instant Off" potential of the casing is more negative than the native potential of the casing, then the pipe is not isolated from the casing and shall be repaired and retested at the Contractor's expense.

3.15 Continuity Testing

3.15.1 Continuity testing of joint bonds shall be performed by the Contractor's qualified corrosion technician after backfilling and in accordance with Part 8, Testing. The electrical continuity test may additionally be performed before backfilling at the Contractor's option.

3.15.2 The pipe shall be tested for electrical continuity. Continuity shall be verified using the linear resistance method. The pipe should be tested in spans that are no less than 250 feet, unless the pipe is shorter than 250 feet, and no more than 1,000 feet, if test station locations are available. Each test span shall have two test leads connected to the pipe at each end. Existing test stations can be used. A direct current shall be applied through the pipe using two of four test leads. The potential across the test span shall be measured using the other two test leads. The current applied and voltage drop shall be recorded for a minimum of three different current levels.

3.15.3 The theoretical resistance of the pipe shall be calculated. It shall take into account the pipe wall thickness, material, and joint bonds.

3.15.4 The average measured resistance shall be compared to the theoretical resistance of the pipe and bond wires. If the measured resistance is greater than 125% of the theoretical resistance, then the joint bonds shall be considered deficient and shall be repaired and retested at the Contractor's expense. If the measured resistance is less than 100% of the theoretical resistance, then the test and/or calculated theoretical resistance shall be considered deficient and the test span shall be retested and/or recalculated at the Contractor's expense. If the piping forms a loop which allows current to flow both in and out of the test span, then consideration shall be made for current circulating through both the loop and the test span.

3.15.5 Alternative continuity testing methods can be submitted to the Manager for consideration and approval.

3.16 Final System Checkout

3.16.1 Upon completion of the installation, the Contractor shall provide testing of the completed system by a Corrosion Technician, and the data shall be reviewed by a Corrosion Engineer to ensure conformance with the Contract Documents, NACE SP0169, and NACE SP0286, except that Category B pipelines are not required to pass polarization voltage testing specified in NACE SP0169 paragraph 6.2.2.1.

3.16.2 The testing described herein shall be in addition to and not a substitution for any required testing of individual items at the manufacturer's plant and during installation.

3.16.3 Testing shall be performed at all test leads of all test stations, junction boxes, and locations of the exposed pipe as soon as possible after installation of the CP system.

3.16.4 Testing shall include the following and shall be conducted in accordance with NACE TM0497 and Part 8, Testing:

3.16.4.1 Measure and record native pipe-to-soil, casing-to-soil, and anode-to-soil potentials at all test locations BEFORE the cathodic protection system is energized.

3.16.4.2 Verify electrical isolation at all insulating joints, insulating corporation stops, and casing insulators per NACE SP0286.

3.16.4.3 Confirm electrical continuity of the cathodically protected pipeline in accordance with this Specification.

3.16.4.4 Measure and record the "On" and "Instant Off" pipeline-to-soil potentials at each location after the structure has been given adequate time to polarize.

3.16.4.5 Measure and record the current output of each anode when the CP system is initially turned on and again after it has been given adequate time to polarize.

3.16.5 Test results shall be analyzed to determine compliance with NACE SP0169, except that Category B pipelines are not required to pass polarization voltage testing specified in NACE SP0169 paragraph 6.2.2.1.

3.16.6 Test results shall be analyzed to determine if stray current interference is present. Stray current interference is defined as a ±50 mV shift in a pipeline's pipe-to-soil potential that is caused by a foreign current source. Stray current interference shall be tested on the project pipeline and foreign pipelines that have a reasonable chance of being affected by stray currents.

3.16.7 All test results shall be submitted to the Manager for review and approval before the corrosion control work is accepted. The Registered Professional Corrosion Control Engineer or the Corrosion Specialist (CP4) shall submit a summary report to include basic statements regards the operational performance of the cathodic protection system and the other corrosion control provisions. The Manager reserves the right to spot check any or all tests performed by the Contractor. All construction defects must be repaired and retested before the final acceptance is made. All unacceptable test must be reperformed by the Contractor at no additional cost to BWS. At the conclusion of the project, the Registered Professional Corrosion Engineer or the Corrosion Specialist (CP4) responsible for the field testing together with the Contractor, shall submit a cosigned Certification stating that the pipeline cathodic protection system has been installed according to the plans and specifications, and that the protection levels are within the most recent NACE SP0169 standards for the type of pipeline and appurtenances, except that Category B pipelines are not required to pass polarization voltage testing specified in NACE SP0169 paragraph 6.2.2.1.

PART 7. IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM SPECIFICATION

SECTION 1. GENERAL

1.1 This Specification Includes

1.1.1 The WORK of this Specification includes providing a complete impressed current cathodic protection (ICCP) system for metallic pipes, valves, and fittings as outlined in this Specification and on the Drawings. The Manager's approval is required to install an ICCP system.

1.1.2 Electrical isolation of the structures from adjacent metallic structures, steel-reinforced concrete structures, casings, structures of dissimilar metal or dissimilar coatings, conduits, and all other metallic components that may impact the operation of the CP system.

1.1.3 Electrical bonding of all non-insulated, non-welded pipe joints and mechanical joints.

1.1.4 Installation of rectifiers, anode beds, insulating joints, insulating corporation stops, test stations, other components associated with the CP system, and all other work described herein and on the Drawings.

1.1.5 Provision of electrical power for rectifiers, including any easements, permits, trenching, conduits, services meters, and other items as required. Not all required items are shown on the Drawings.

1.1.6 Testing of CP system during installation.

1.1.7 Cleanup and restoration of work site.

1.1.8 Final System Checkout: Testing of CP system after installation and backfilling, including final testing and certification report.

1.2 Requirements

1.2.1 If the products installed as part of this Specification are found to be defective or damaged or if the WORK is not in conformance with these Specifications, then the products and WORK shall be corrected at the Contractor's expense.

1.2.2 Any retesting required due to inadequate installation or defective materials shall be paid for by the Contractor at no additional cost to the owner.

1.2.3 The WORK also requires that one Supplier or Subcontractor accept responsibility for the WORK, as indicated, but without altering or modifying the Contractor's responsibilities under the Contract Documents.

1.2.4 The WORK also requires coordination of assembly, installation, and testing between the pipeline contractor and any CP material supplier or subcontractor.

1.2.5 All electrical WORK shall be in accordance with NEC and local requirements.

1.3 Related Specifications

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

1.3.1.1 Site Safety and Regulatory Requirements

1.3.1.2 Excavation, Trenching, Backfilling, and Compacting

1.3.1.3 Piping

1.3.1.4 Cast-In-Place Concrete

1.3.1.5 Protective Coatings

1.4 Referenced Specifications, Codes, and Standards

1.4.1 The WORK of this Specification shall comply with the current editions of the following codes and standards:

AASHTO	American Association of State Highway and Transportation Officials
H20	Specification for Highway Bridges
ASTM	ASTM International
A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A518	Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
B3	Standard Specification for Soft or Annealed Copper Wire
B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
B187	Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
C94	Standard Specification for Ready-Mixed Concrete
D1000	Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
D1785	Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
D2220	Standard Specification for Poly(Vinyl Chloride) Insulation for Wire and Cable, 75°C Operation
AWWA	American Water Works Association
C217	Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines
NSF	National Sanitation Foundation
NSF 61	Drinking Water System Components
NACE	NACE International, the Corrosion Society
SP0375	Field-Applied Underground Wax Coating Systems for Underground Metallic Pipelines: Application, Performance, and Quality Control

	SP0169	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
	SP0286	Electrical Insulation of Cathodically Protected Pipelines
	SP0572	Design, Installation, Operation and Maintenance of Impressed Current Deep Anode Beds
	TM0497	Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
NEMA		National Electrical Manufacturers Association
	250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
	TC2	Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
	TC3	PVC Fittings for Use with Rigid PVC Conduit and Tubing
NFPA		National Fire Protection Association
	NFPA 70	National Electric Code (NEC)
SSPC		The Society for Protective Coatings
	SP2	Hand Tool Cleaning
	SP3	Power Tool Cleaning
	SP11	Bare Metal Power Tool Cleaning
UL		Underwriters Laboratories
	6	Rigid Metal Conduits
	467	Grounding and Bonding Equipment
	506	Standard for Specialty Transformers
	514B	Fittings for Cable and Conduit

1.4.2 Whenever the Drawings or these Specifications require a higher degree of workmanship or better quality of material than indicated in the above codes and standards, these Drawings and Specifications shall prevail.

1.5 Permits and Job Access

1.5.1 Prior to the start of construction, the Contractor shall apply to the required authorities for permits required for the installation of the CP system.

1.5.2 The Contractor shall contact Hawaii One Call prior to commencing construction to locate existing utilities in the area of construction. Existing utilities include, but are not limited to, water lines, gas lines, telephone, street lights, sewer and storm drains, and overhead and underground electric utilities.

1.5.3 If traffic control is necessary, it shall satisfy the requirements of the governing locality.

1.5.4 The Contractor shall be responsible for reviewing the rectifier locations to determine whether there are any conflicts with obtaining power at the indicated locations. The Contractor shall report any conflicts to the Manager prior to proceeding with the Work.

1.5.5 The Contractor shall submit an application to the local power company for AC power to the new rectifiers. The Contractor shall be responsible for all fees and expenses (including easements) associated with providing power to the rectifiers.

1.6 Quality Assurance

1.6.1 Installation of the CP equipment shall be performed by individuals having at least 5 years of experience in the installation of the CP equipment described herein.

1.6.2 All testing required to be performed by a "Corrosion Technician" shall be performed by a NACE certified Corrosion Technician under the supervision of a Corrosion Engineer. A Corrosion Technician is a NACE CP1 (CP Tester), CP2 (CP Technician), CP3 (CP Technologist), or CP4 (CP Specialist). A Corrosion Engineer is a Registered Professional Corrosion Engineer or a NACE CP4 (CP Specialist).

1.6.3 All well drilling shall be performed by a Hawaii licensed (C-57) Well Drilling Contractor.

1.6.4 All deep well installations shall be installed in accordance with Hawaii Well Construction Standards and the applicable sections on wells from local regulations.

1.7 Submittals

1.7.1 The following shall be submitted to the Manager prior to any equipment installation.

1.7.1.1 Catalog cuts, bulletins, brochures, or data sheets for all materials specified herein.

1.7.1.2 Certification that the equipment and materials proposed meet the Specifications and the intent of the Specifications.

1.7.1.3 Written certification of experience required.

1.7.1.4 Schedule, including the expected start date and planned completion date.

1.7.1.5 Copy of well drilling or surface disturbance permits, if a permit(s) is required by local jurisdiction.

1.7.1.6 Description of power system to be provided for rectifiers, including cut sheets, meter sizing, power company requirements, and copy of permits.

1.7.1.7 The data sheet to be used for the final system checkout that includes all of the data required in Section 3.20.

1.7.2 The following shall be submitted to the Manager after completion of the WORK.

1.7.2.1 Wire connection testing.

1.7.2.2 Insulating joint testing, before and after backfilling.

1.7.2.3 Casing insulator testing, before and after backfilling.

1.7.2.4 Joint bond testing, before and after backfilling.

1.7.2.5 Well completion report.

1.7.2.6 Electrical log with anode-to-earth resistances.

1.7.2.7 Final System Checkout Report.

1.7.2.8 Record Drawings shall be submitted to and approved by the Manager before the WORK is considered complete.

1.7.3 The following shall be included in the Owner's Manual:

1.7.3.1 Operations and maintenance (O&M) manual with instructions for CP system and components. O&M manual may include rectifier operations and instructions for adjustments, CP measurements at recommended frequencies, and testing documentation guidelines.

1.7.3.2 List of spare parts recommended for two years of successful operation.

1.8 Interference and Exact Locations

1.8.1 The locations of CP equipment, test stations, devices, outlets, and appurtenances, as indicated, are approximate only. Exact locations shall be determined by the Contractor in the field subject to the approval of the Manager.

1.8.2 The Contractor shall field verify all data and final locations of work done under other Sections of the Specifications required for placing of the electrical work.

1.8.3 In case of interference with other work, foreign pipeline, or erroneous locations with respect to equipment or structures, the Contractor shall furnish all labor and materials necessary to complete the WORK in an acceptable manner.

SECTION 2. PRODUCTS

2.1 General

2.1.1 All materials installed must be new. All equipment and materials supplied shall be similar to that which has been in satisfactory service for at least 5 years.

2.2 Rectifier

2.2.1 Rectifiers shall be air-cooled, single-phase, and 115/230 V_{AC} input. The output voltage (V_{DC}) and output current (A_{DC}) shall be selected on a project-by-project basis and defined on the project Drawings. Rectifiers shall be manufactured by Universal Rectifiers, Corrpro, JA Electronics, or an approved equivalent.

2.2.2 Rectifiers shall be designed to operate continuously at an ambient temperature of 50°C without damage to the rectifier components.

2.2.3 Transformer: Two-winding, insulating type that meets the requirements of NEMA and UL 506.

2.2.4 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 25 equal steps from approximately 4% of rated voltage to the full rated output voltage. This adjustment shall be accomplished with silver-plated or stainless steel connectors and adjustment link bars.

2.2.5 Rectifying element shall be a full-wave bridge, silicon diode stack with efficiency filter, metal oxide thyristors, and current-limiting devices for overvoltage and overcurrent protection of stack. Silicon stacks shall be equipped with silicon diodes rated at a minimum of 1,000 peak inverse volts.

2.2.6 All rectifiers shall have overload and lightning protection for both AC and DC circuits.

2.2.7 A digital voltmeter and ammeter shall be provided. Voltmeter and ammeter shall be calibrated and adjusted at the factory.

2.2.8 Electrical tests shall be performed by the manufacturer 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

2.2.9 The following shall be provided for each rectifier. Each item shall be provided in a waterproof bag or container.

2.2.9.1 Operations and Maintenance Manual

2.2.9.2 Circuit Diagram

2.2.9.3 Electrical Test Report

2.3 Rectifier Cabinet

2.3.1 Rectifier cabinets shall be NEMA 250 Type 3R and sized as shown on the Drawings.

2.3.2 Rectifier cabinets shall be made of steel that is either shop coated with a baked enamel finish, galvanized per ASTM A123, or pre-galvanized sheet finished with a powder coat.

2.3.3 Rectifier cabinets shall have a single door with a full-length hinge and a lockable latch. Hinge, latch, and other miscellaneous metallic components on the cabinet shall be 304 or 316 stainless steel.

2.3.4 Rectifier cabinets shall have sufficient venting provided for air cooled rectifiers.

2.3.5 Rectifiers shall be equipped with permanent identification tags affixed to the outside front door. The identification tag shall have white engraving for identification of the rectifier. Minimum height of lettering shall be 3/4 inch. The tags shall have the following legend:

BOARD OF WATER SUPPLY, CITY AND COUNTY OF HONOLULU

PROJECT NAME AND STATION NUMBER

CATHODIC PROTECTION RECTIFIER

2.4 Anode Junction Box

2.4.1 Junction boxes shall be NEMA 250 Type 3R or 4X enclosure and sized as shown on the Drawings.

2.4.2 Junction boxes shall be made of 316 stainless steel.

2.4.3 Junction boxes shall have a single door with a full-length hinge and a lockable latch. Hinge, latch, and other miscellaneous metallic components on the cabinet shall be 316 stainless steel.

2.4.4 Junction boxes shall be equipped with permanent identification tags affixed to the outside front door. The identification tag shall have white engraving for identification of the junction box. Minimum height of lettering shall be 3/4 inch. The tags shall have the following legend:

BOARD OF WATER SUPPLY, CITY AND COUNTY OF HONOLULU

PROJECT NAME AND STATION NUMBER

ANODE JUNCTION BOX

2.5 High-Silicone Cast Iron (HSCI) Anode

2.5.1 HSCI anodes shall meet the requirements of ASTM A518 Grade 3. Anodes shall be manufactured by Anotec or equivalent.

2.5.2 HSCI anodes shall be tubular type anodes with centered wire connection. Anodes shall be the type indicated on the Project Drawings and shall have the following size, form, and shape.

Anode Type	Length (inch)	Diameter (inch)	Weight (lb)	Surface Area (ft^2)
2260Z or TACD	60	2 to 2.2	32 to 36	2.8 to 2.9
2284Z or TA2	84	2 to 2.2	46 to 50	4.0
2660Z or TAD	60	2 to 2.7	45 to 50	3.5
2684Z or TA3	84	2 to 2.7	63 to 70	4.9
3860Z	60	2.9	62	3.8
3884Z	84	2.9	90	5.3

2.5.3 Anode lead wire:

2.5.3.1 The wire attached to the anodes shall be of the size and type indicated on the Drawings. The anode lead wire shall conform to the specifications given for "Wires" in this specification.

2.5.3.2 The wire shall be connected to the interior of the anode and sealed by the manufacturer. The anode wire connection shall have a pulling strength exceeding the wire's tensile strength. Any damage to the wire insulation or anode shall require complete replacement of the wire and anode.

2.5.3.3 Anode lead wires shall be of one continuous length, without splices, unless otherwise indicated on the Drawings, from the anode connection to the anode terminal board. Anode wires with the attached anodes 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 surface damage such as nicks, abrasions, scratches, etc., in all respects throughout the entire length of the wire. Precautions 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.

2.5.4 The resistance of each anode wire connection shall not exceed 0.004 ohms. Each anode wire connection should be tested by the manufacturer for conformance with these Specifications. A record of tests shall be submitted to the Manager. The records shall include a minimum of three copies of the following information:

2.5.4.1 Anode numbering system to identify anode under test

2.5.4.2 Anode wire length

2.5.4.3 Resistance value, as indicated by the test

2.5.4.4 Test equipment

2.5.4.5 Test method

2.5.5 Anodes shall be individually labeled with the length of lead wire and anode number. Anodes shall be consecutively numbered with the deepest anode being Number 1.

2.6 Calcined Coke Breeze

2.6.1 Backfill material for impressed current anodes shall be calcined coke breeze.

2.6.2 Calcined coke breeze shall have a resistivity of 25 ohm-cm or less when tested with an applied pressure of 2 psi and a bulk density of 64 to 74 pounds per cubic foot. The particle size shall be between 200 mesh and 18 mesh and shall be dust free. The minimum calcination temperature of base materials shall be 1250 °C.

2.6.3 Calcined coke breeze shall have the following chemical properties:

2.6.3.1 Fixed carbon 98% minimum

2.6.3.2 Ash 0.6% maximum

2.6.3.3 Volatile matter 1.0% maximum

2.6.3.4 Moisture 1.0% maximum

2.6.4 Calcined coke breeze shall be Loresco SC-3, Asbury 251, or approved equivalent when installed by pumping down the hole. If installed via the freefall method, calcined coke breeze shall be Loresco RS-3, Ashbury 218-L, or equivalent.

2.7 Anode Vent Piping

2.7.1 Anode vent piping for the impressed current anode vent piping shall be 2-inch diameter PVC, Schedule 80, conforming to ASTM D1785 Type 1 Grade 1.

2.7.2 Slots and perforations shall be provided in the immediate vicinity of the anodes and throughout the coke breeze and sized such that coke breeze does not enter vent pipe. The vent pipe shall be capped at both ends during the backfilling operation to mitigate infiltration of backfill material or mud.

2.7.3 Above ground portions of anode vent piping shall be rated for sunlight resistance.

2.7.4 Above ground outlet for vent piping shall have a vent screen with an orientation preventing rainfall accumulation and bug intrusion.

2.8 Anode Centralizer

2.8.1 Centering devices shall be designed and fabricated by the Contractor or Supplier and shall be submitted to the Manager for acceptance prior to use. The device shall be constructed of metal.

2.9 Flush-mounted Test Station

2.9.1 Flush-mounted test station boxes shall be traffic boxes rated to withstand AASHTO H20 traffic loading.

2.9.2 The traffic boxes shall be G05 Utility Boxes, as manufactured by Christy Concrete Products, Inc.; No. 3RT Utility Box, as manufactured by Brooks Products; or an approved equivalent.

2.9.3 Traffic box covers for test stations shall be cast iron with welded bead legend and labeled “CP TEST” or “ANODE,” as required.

2.10 Ready-mixed Concrete

2.10.1 Ready-mixed concrete shall be in accordance with ASTM C94, permit requirements, and the Specification for cast-in-place concrete.

2.11 Reinforcing Steel

2.11.1 Reinforcing steel shall be in accordance with ASTM A615, permit requirements, and the Specification for reinforcing steel.

2.12 Panel Board

2.12.1 Panel boards shall be made of 1/4-inch thick phenolic plastic and sized as indicated on the Drawings.

2.12.2 Connection hardware shall be brass or bronze. All connections shall be double nutted bolts with serrated lock washers.

2.12.3 Copper bus bar shall be 1/8-inch thick and sized to fit. The copper bus bar shall be per ASTM B187 with 98% conductivity.

2.13 Mechanical Lug

2.13.1 Mechanical lugs shall be brass or copper with a brass, copper, or stainless steel set screw. Tin plating on the lugs is optional. Aluminum lugs shall not be permitted. Zinc-plated steel set screws shall not be permitted. The lug shall be listed per UL 467, suitable for direct burial, and appropriately sized for the incoming wires. The lug shall be ILSCO Type XT-6DB, Burndy GKA8C, or an approved equivalent.

2.14 Shunt

2.14.1 Shunts shall be selected by the size indicated on the Drawings.

2.14.2 0.001-ohm, 25-amp shunts shall be Type SS, as manufactured by Holloway, or equivalent.

2.15 Conduit and Fitting

2.15.1 The minimum conduit size shall be 2 inches unless otherwise indicated. Refer to NFPA 70 (NEC) for additional conduit size requirements.

2.15.2 Conduit and fittings placed below grade shall be Schedule 80 PVC in accordance with NEMA TC2 and NEMA TC3.

2.15.3 Conduit and fittings placed above grade shall be rigid steel. Rigid Steel conduit shall be galvanized and conform to UL 6.

2.15.4 Conduit clamps shall be galvanized steel, 304 stainless steel, or 316 stainless steel.

2.15.5 Fittings for use with rigid steel conduit shall be galvanized cast ferrous metal, with gasketed covers, Crouse Hinds Condulets, Appleton Unilets, or equivalent. Rigid metallic conduit fittings shall be galvanized, conform to NEMA FB 1, and listed to UL 514B.

2.15.6 Union couplings for conduit shall be Erickson or Appleton Type EC, 0-Z Gedney 3-piece Series 4, or equivalent.

2.16 Caution Tape

2.16.1 The caution tape shall be an inert plastic film designed for prolonged underground use. The caution tape shall be a minimum of 3 inches wide and a minimum of 4 mils thick.

2.16.2 The caution tape shall be continuously printed over the entire length with the wording "CAUTION: CATHODIC PROTECTION CABLE BURIED BELOW."

2.16.3 The wording shall be printed using bold black letters. The color of the tape shall be red.

2.17 Wire

2.17.1 Conductors shall consist of stranded copper of the gauge indicated on the Drawings. Wire sizes shall be based on American Wire Gauge (AWG). Copper wire shall be in conformance with ASTM B3 and ASTM B8.

2.17.2 Insulation Type and Colors: As shown on the Drawings.

2.17.2.1 High molecular weight polyethylene (HMWPE) wires shall be rated for 600 volts and shall conform to ASTM D1248, Type 1, Class C, Grade 5.

2.17.2.2 Halar/HMWPE wires (CP wire) shall be rated for 600 volts and have dual insulation. The primary layer of insulation shall be a homogeneous 20-mil wall of ECTFE fluoropolymer (Halar), and the jacket shall be a 65-mil wall of HMWPE conforming to ASTM D1248, Type 1, Class C, Grade 5. Halar/HMWPE wire shall be UL listed as Cathodic Protection Wire.

2.17.2.3 RHW wires shall be UL listed and marked as RHW or RHW-2 and rated for 600 volts. RHW wires shall have crosslinked polyethylene (XLPE) insulation that conforms with ASTM D1248.

2.17.2.4 THWN wires shall be UL listed and marked as THWN or THWN-2 and rated for 600 volts. THWN wires shall have polyvinyl chloride (PVC) insulation that conforms with ASTM D2220 and an outer jacket of nylon.

2.18 Wire Identification Tag

2.18.1 Wire identification tags shall be the wrap-around type with a high resistance to oils, solvents, and mild acids. Wrap-around markers shall fully encircle the wire with imprinted alpha-numeric characters for pipe identification. The letters and numbers height shall be 3/16 inch at minimum.

2.19 Exothermic Weld

2.19.1 Exothermic welds shall be in accordance with the manufacturer’s recommendations. Exothermic welds shall be Cadweld manufactured by Erico, Thermoweld manufactured by Continental Industries, or an approved equivalent.

2.19.2 Prevent molten weld metal from leaking out of the mold, where necessary, by using Duxseal packing manufactured by Johns-Manville, Thermoweld packing material manufactured by Continental Industries, Cadweld T403 Mold Sealer manufactured by Erico, or an approved equivalent.

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

2.19.3.1 Pipe material

2.19.3.2 Pipe size

2.19.3.3 Wire size and requirement for sleeves

2.19.3.4 Number of wires to be welded

2.19.3.5 Orientation of weld (vertical or horizontal)

2.20 Exothermic Weld Coating Material

2.20.1 After exothermic welding, repair coatings and linings in accordance with the coating and lining manufacturer's recommendation.

2.20.2 Weld caps with an integrated primer shall be used to cover the exothermic weld connecting the wire to the pipe. The weld cap shall be a 10-mil thick durable plastic sheet that has a dome filled with a moldable compound to assure complete encapsulation of the exothermic weld and a layer of elastomeric adhesive with integrated primer. The adhesive and primer shall be compatible with the pipe material and pipe coating material. Adhesion to steel shall be at least 10 lb/in per ASTM D1000. Weld cap with integrated primer shall be Handy Cap IP manufactured by Royston or equivalent for wire size up to 8 AWG and Handy Cap XL IP manufactured by Royston or equivalent for wire size up to 2 AWG.

2.21 Pipe Clamp

2.21.1 Pipe clamp and screws shall be silicon bronze, bronze, or copper. Pipe clamp shall be designed for grounding. Pipe clamp shall be sized for the copper pipe at the reduced pressure backflow preventer and wire conductor size indicated on the Drawings.

2.22 Dielectric Insulating Flange Kit

2.22.1 Insulating flange kits shall include full-faced gaskets, insulating sleeves and washers, and 316 stainless steel bolts, nuts, and washers. The complete assembly shall have a pressure rating equal to or greater than the flanges between which it is installed. Sleeves, gaskets, and insulating washers shall have a minimum dielectric constant of 300 volts per mil. Stainless steel washers shall 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.

2.22.1.1 Insulating gasket shall be full-faced, Type E, and 1/8-inch thick. Acceptable gasket materials include nitrile faced phenolic, G-10, or material with equivalent or increased performance. Acceptable seal materials include EPDM, PTFE, or material with equivalent or increased performance. When used in potable water systems, gasket and seal shall be NSF 61 approved.

2.22.1.2 Insulating sleeves shall be 1/32-inch thick and equal the number of bolts on the flange. Acceptable materials include Mylar, G-10, or material with equivalent or increased performance.

2.22.1.3 Insulating washers shall be 1/8-inch thick and equal to twice the number of bolts on the flange. Acceptable materials include G-10 or material with equivalent or increased performance.

2.22.2 Dielectric insulating flange kits shall be manufactured by Advance Products & Systems Inc., GPT Industries, or an approved equivalent.

2.23 Insulating Corporation Stop

2.23.1 The insulating corporation stop shall be brass with nylon insulating material that effectively stops the flow of electrical current without compromising the strength of the service line. The seal shall be accomplished with an O-ring.

2.23.2 Insulating corporation stops shall be manufactured by Mueller Co. or an approved equivalent.

2.24 Casing End Seal

2.24.1 Casing end seal shall seal the annular space between the carrier pipe and casing. A casing end seal shall be installed on each end of the casing. The casing end seal shall be designed to last the life of the piping system.

2.24.2 Casing end seal shall be at least 1/8-inch thick neoprene, nitrile, or EPDM. The seal shall be secured with 316 stainless steel banding straps.

2.25 Petrolatum Wax Tape

2.25.1 Petrolatum wax tape shall meet or exceed the requirements of AWWA C217 and shall consist of three parts: Surface primer, wax tape, and outer covering. All three parts shall be the product of a single manufacturer.

2.25.2 The primer shall be a blend of petrolatums, plasticizers, and corrosion inhibitors having a paste-like consistency. Primer shall be Wax-Tape Primer manufactured by Trenton, Denso Paste manufactured by Denso, or approved equivalent.

2.25.3 The wax tape shall be synthetic-fiber felt, 45 to 90 mils thick, saturated with a blend of micro-crystalline wax, petrolatums, plasticizers, and corrosion inhibitors that are capable of easy conformability over irregular surfaces. Wax tape shall be #1 Wax-Tape manufactured by Trenton, Denso Tape manufactured by Denso, or approved equivalent.

2.25.4 The outer covering shall be a plastic wrap consisting of one 150-gauge sheet or three 50-gauge sheets wound together as a single sheet, clear polyvinylidene chloride, shrink wrap that is flexible enough to conform to irregular surfaces. Outer wrapping shall be Poly-Ply by Trenton, Poly-Wrap by Denso, or approved equivalent.

2.26 Permanent Reference Electrode

2.26.1 Reference electrodes shall be copper-copper sulfate and designed for continuous use in the soil for a minimum of 30 years, as manufactured by Borin Manufacturing or an approved equivalent. The reference electrode shall have a wire which will extend to the panel board, without splicing, as indicated on the Drawings.

2.26.2 Permanent reference electrodes shall be pre-packaged in a cloth bag containing backfill of the following composition: 75% gypsum, 20% bentonite, and 5% sodium sulfate.

2.27 Coupon

2.27.1 The coupon shall be the same material type as the pipeline and have an area of 10 cm^2.

2.27.2 The coupon shall have two #12 AWG stranded copper wire with HMWPE insulation (green). All wires shall be long enough to extend to the junction box or test station without splicing.

2.27.3 Coupons shall be manufactured by MC Miller or an approved equivalent.

2.28 Isolation Mat

2.28.1 Isolation mat shall be neoprene and of the dimensions shown on the Drawing.

SECTION 3. EXECUTION

3.1 Material and Equipment Storage

3.1.1 All materials and equipment to be used in construction shall be stored in such a manner to be protected from detrimental effects from the elements. If warehouse storage cannot be provided, materials and equipment shall be stacked well above ground level and protected from the elements with plastic sheeting or another method, as appropriate.

3.2 Excavation and Backfill

3.2.1 Buried wires shall have a minimum cover of 36 inches.

3.2.2 Caution tape shall be installed above buried wire. Caution tape shall be installed a minimum of 6 inches above underground wires and conduits.

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

3.3 Rectifier

3.3.1 Approximate rectifier locations are shown on the Drawings. The Contractor may propose an alternative rectifier location to the MANAGER for review and approval.

3.3.2 Rectifier installation includes provision of AC power to the rectifier by the Contractor. Contractor shall furnish and install all required wiring, conduits, wires, meters, splice boxes, and equipment necessary for operation of the rectifier and as required by the local power agency.

3.3.3 The reinforced concrete pad shall be constructed such that water will not collect against the rectifier cabinet. The concrete pad shall extend a minimum of 2 inches above grade and should be higher than the 100-year flood plain. The finished grade shall be sloped away from the concrete pad to direct drainage water away from the rectifier cabinet. The vent pipe riser and conduits into the enclosure shall be cast into the concrete pad. After the concrete is set, the enclosure shall be securely anchored to the pad with expanding anchor bolts.

3.4 Deep Anode Well

3.4.1 Impressed current anode beds shall be installed in accordance with NACE SP0572, local well standards, and these Specifications.

3.4.2 Well Drilling

3.4.2.1 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.

3.4.2.2 The Contractor shall protect the well bore from the intrusion of contaminants into the hole at all times. The Contractor is responsible for the cost of all cleanup associated with contamination of the well and/or job site resulting from the Contractor's WORK.

3.4.2.3 Fresh water shall be circulated from the bottom of the hole to clear the well of drilling mud and cuttings after the well is drilled.

3.4.2.4 The well shall be covered with a steel trench plate or another heavy device that blocks access and cannot be removed by hand whenever the well is left unattended.

3.4.3 Well Casing

3.4.3.1 The Contractor may elect to install the well with or without a casing. In the event that the well collapses for any reason, including the elimination of the casing, the well shall be relocated, re-drilled, and the original hole abandoned at the Contractor's expense. Only a metallic casing may be used in the coke breeze column.

3.4.4 Vent Pipe

3.4.4.1 The bottom of the vent pipe shall be securely capped with a PVC cap solvent-welded to the vent pipe.

3.4.4.2 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 steel clamp. The vent pipe shall not be attached to the anode itself. Obtain the Manager's acceptance of the attachment before the vent pipe is lowered into the hole. Sections of vent pipe shall be joined to one another as the first anode, with the vent pipe attached, is lowered into the hole. Joints shall be solvent-welded.

3.4.4.3 The top of the vent pipe shall be temporarily sealed during the coke breeze loading process. Any foreign material entering the vent pipe shall be removed.

3.4.5 Anodes

3.4.5.1 Loading of anodes and other equipment in the well shall be done in the presence of the Engineer. A minimum of 48 hours' notice shall be given prior to loading anodes. Loading of the anodes into the well shall begin early enough in the day to ensure completion of all loading, including backfilling, during regular working hours. Loading shall not be commenced later than 1:00 p.m. unless the Contractor has obtained prior written acceptance from the Manager.

3.4.5.2 The Engineer shall visually inspect the insulation on the anode lead wire for abrasion or other damage to the insulation and wire before and as the anode is lowered into place. Anodes with damaged insulation or wire are not acceptable and shall not be installed. Splices are not allowed on the anode wire.

3.4.5.3 Attach the centering devices to the anodes before lowering them in the well. All sharp edges on the centering device assembly shall be taped with vinyl electrical tape to preclude damaging any wires while lowering anodes into place.

3.4.5.4 The terminal end of the anode wires shall be identified with permanent wire markers.

3.4.5.5 Anode No. 1 shall be lowered into the well supported by the attached lead wire. The Contractor shall fabricate an apparatus that allows the anodes to be lowered by the lead wire but does not bend the wire into a radius less than 2.5 inches. The vent pipe shall be secured to the centering device on Anode No. 1, not the anode itself, and lowered alongside Anode No. 1. A soil resistance meter, furnished and operated by the ENGINEER, shall be connected between the anode lead wire for Anode No. 1 and the pipeline drain wire. The drain wire should be installed and be accessible to the ENGINEER during the time of testing. The Contractor shall stop lowering the anode at 10-foot intervals to tape the anode lead wire to the vent pipe and to allow the ENGINEER to measure the resistance profile of the anode well. This shall continue to the bottom of the hole and the vent pipe shall be secured in place.

3.4.5.6 Continuing with Anode No. 2, the anodes shall be lowered into the well by the attached lead wires. The vent pipe shall not be attached to the centralizers or lead wires for Anodes No. 2 to the last anode lowered. The Engineer may adjust the depths of the individual anodes to avoid high resistance soil layers. When an anode has been placed at the final depth, it shall be securely fixed in that position prior to coke breeze backfilling.

3.4.5.7 Anodes shall not be backfilled until the Engineer has inspected the placement of the anodes and given permission to backfill.

3.4.6 Coke Breeze Backfill

3.4.6.1 Coke breeze shall be placed using a slurry pump that pumps the coke into the bottom of the hole using a tremie pipe, allowing the hole to be filled from the bottom up. Coke breeze shall not be pumped through the vent pipe.

3.4.6.2 Coke breeze shall be mixed with water when introduced into the hole to prevent bridging or the creation of voids. Minimize the risk of bridging by ensuring the hole has sufficient water and the backfilling rate is controlled. In the event that voids or bridging does occur, the Contractor shall correct the deficiency to the satisfaction of the Engineer.

3.4.6.3 If coke breeze cannot be pumped from the bottom up due to space constraints onsite, then coke breeze may be installed using the top load method. If the top load method is used, coke breeze shall be placed in the hole at a steady rate to ensure the coke breeze does not bridge or block the hole. The hole shall be kept completely full of water during placement of backfill.

3.4.6.4 Backfill settling and anode coverage will be determined by measuring the anode-to-earth resistance from the digital resistance meter. During coke breeze backfilling, the Engineer will measure the resistance between the lowermost uncovered anode and the protected structure. Coverage of the anode will be indicated by a rapid decrease in resistance, normally by at least 50%. As soon as coverage of a lower anode is indicated, the circuit shall be attached to the next highest anode in the hole. Testing will continue until coverage of all anodes has been verified. The Engineer shall record the resistance of each backfilled anode. At least 20 feet of coke breeze shall be added above the top anode. The Contractor shall sound the anode hole with a weighted tape measure and determine the final height of the coke breeze column.

3.4.6.5 Coke shall be allowed 24 hours to settle. After 24 hours, the coke column shall be topped off, as required, to achieve the specified coke column length.

3.4.6.6 Incomplete coverage of each anode with coke breeze shall be cause for rejection of the anode well.

3.4.6.7 The Contractor shall record the total weight of coke breeze placed in each anode well.

3.4.7 Well Seal

3.4.7.1 Backfilling operations above the coke breeze column shall begin no sooner than 24 hours after installation of the coke breeze to allow for settling. Backfilling shall be done continuously and without interruption until the hole is sealed.

3.4.7.2 Collapse of the hole prior to the introduction of the seal material shall be cause for abandonment of the well at the Contractor’s expense.

3.4.7.3 Sealing materials shall not be allowed to drop from the top of the hole. All materials shall be pumped into the hole from the top of the coke breeze column to the top of the hole.

3.4.7.4 If well casing materials are used in the construction of the well, then the annular space between the well bore and the casing shall also be sealed with a conductive grout.

3.4.7.5 Sealing material shall not enter the vent pipe.

3.4.7.6 The Contractor shall record the volume of sealing material installed in the hole.

3.4.8 Well Head

3.4.8.1 The well head shall be a concrete traffic box set at the top of the anode hole and shall contain slack for the anode lead wires, as indicated on the Drawings.

3.4.8.2 The concrete traffic box lid shall be cast iron and marked "ANODE."

3.4.9 Storage and Disposal of Drilling Fluids, Cuttings, and Mud

3.4.9.1 During the drilling and loading process, drilling fluids, cuttings, and mud shall be stored onsite in uncontaminated, watertight, lockable debris boxes. Alternative storage methods may be used only with prior approval of the Manager.

3.4.9.2 Drilling mud and cuttings shall be disposed of by the Contractor at a suitable disposal site.

3.5 Test Station

3.5.1 Test stations shall be installed at the approximate locations shown on the Drawings. Test stations shall be located within the pipeline easement. Test stations shall be located in areas not subject to vehicular traffic, such as sidewalks or behind the curb, unless otherwise approved by the Manager. Where possible, locate test station near fire hydrants and place lateral wire runs along the hydrant lateral for protection.

3.5.2 For flush-mounted test stations, place the bottom of the test box on native soil. Do not place rock, gravel, sand, or debris in the box. Install 4,000 psi concrete collar with reinforcement after placement of the test box to finished grade. Provide sufficient sloping in the concrete pad or surrounding pavement to provide drainage away from the test box.

3.5.3 Connect wires to the terminal board as shown on the Drawings. Each wire shall be identified with a permanent wire identifier within 4 inches of the termination. After installation, all wire connections in the test station shall be tested by the Contractor to ensure they meet the requirements herein.

3.5.4 For foreign pipeline test stations, the Contractor shall notify the owner of foreign utility piping for which foreign pipeline crossing test stations are to be installed. Notification shall be provided at least 2 weeks in advance. Test leads to foreign pipelines shall be installed in the presence and to the satisfaction of a representative of the foreign pipeline owner.

3.5.5 The Contractor shall field verify the final location of the test stations. The Contractor shall provide the global positioning system (GPS) coordinates for each test station location with a minimum accuracy of 1 meter or 3 feet. The Contractor shall submit the GPS coordinates of the test stations to the Manager after installation.

3.6 Anode Junction Box

3.6.1 Junction boxes shall be installed at the locations indicated on the Drawings. The Contractor shall field verify all final locations. Attachment of wire identification tags, wire terminals, and shunts shall be made as indicated on the Drawings. Junction boxes and subsequent connections shall be in conformance with all applicable codes and regulations.

3.6.2 Connect wires to the terminal board as shown on the Drawings. Each wire shall be identified with a permanent wire identifier within 4 inches of the termination. After installation, all wire connections in the junction box shall be tested by the Contractor to ensure they meet the requirements herein.

3.6.3 The Contractor shall provide the global positioning system (GPS) coordinates for each junction box location with a minimum accuracy of 1 meter or 3 feet. The Contractor shall submit the GPS coordinates of the test stations to the MANAGER after installation.

3.7 Wire

3.7.1 Buried wires 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.

3.7.2 At least 12 inches of slack (coiled) shall be left for each wire at each flush-to-grade test station. Wire slack shall be sufficient to allow removal of wire extension for testing. Wire shall not be bent into a radius of less than 2 inches.

3.7.3 The wire conduits must be of sufficient diameter to accommodate the wires. This shall be determined by the number and size of wires in accordance with the applicable codes and standards.

3.7.4 Conduit shall be installed to a minimum depth of 36 inches below grade.

3.7.5 Install caution tape a minimum of 6 inches above buried wire and conduits. Every 3 feet, double over the tape for a distance of 8 inches to increase the apparent flexibility of the tape.

3.8 Wire Identification Tag

3.8.1 All wires shall be coded with wire identification tags within 4 inches of the wire end indicating diameter and type of pipe.

3.8.2 Wire identification tags shall be placed on all wires prior to backfill and installation of test stations.

3.9 Exothermic Weld Connection

3.9.1 Exothermic weld connections shall be installed in the manner and at the locations indicated. Exothermic welds shall be spaced at least 6 inches apart from other exothermic welds, fittings, and circumferential welds.

3.9.2 Coating materials shall be removed from the surface over an area of sufficient size to make the connection and as indicated on the Drawings. The surface shall be cleaned to bare metal by grinding or filing per SSPC SP11 prior to welding the conductor. The use of resin impregnated grinding wheels will not be allowed.

3.9.3 Only enough insulation shall be removed such that the copper conductor can be placed in the welding mold. If the wire conductor diameter is not the same as the opening in the mold, then a copper adapter sleeve shall be fitted over the conductor.

3.9.4 The Contractor shall be responsible for testing all test lead and bond wire welds. The Engineer, at his or her discretion, shall witness these tests.

3.9.5 After the weld has cooled, all slag shall be removed, and the metallurgical bond shall be tested for adherence by the Contractor. 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. All defective welds shall be removed and replaced in a new location at least 6 inches away from the original weld location.

3.9.6 A plastic weld cap with an integrated primer shall cover the exothermic weld and surrounding area. All surfaces must be clean, dry, and free of oil, dirt, loose particles, and all other foreign materials prior to the application of the weld cap.

3.9.7 The Contractor shall inspect both the interior and exterior of the pipe to confirm that all coatings and linings removed or damaged as a result of the welding have been repaired. The Contractor shall furnish all materials, clean surfaces, and repair protective coatings and linings damaged as a result of the welding. Repair of any coating or lining damaged during welding shall be performed in accordance with coating or lining manufacturer's recommendations.

3.9.8 All exposed surfaces of the copper and steel shall be covered with insulating materials. Coating repairs shall be performed in accordance with coating manufacturer's recommendations.

3.9.9 After backfilling pipe, all test lead pairs shall be tested for broken welds using a standard ohmmeter. The resistance shall not exceed 150% of the theoretical wire resistance, as determined from published wire data.

3.10 Joint Bond

3.10.1 Bond wires shall be provided across flexible couplings and all non-welded joints to ensure electrical continuity, except where insulating joints have been installed to provide electrical isolation. Joint bonds shall be of the size, length, and number shown on the Drawings and installed as indicated. The bond wires shall allow at least 2 inches of movement in the pipe joint. The wire shall be attached by exothermic welding. At least 2 bond wires shall be provided between all discontinuous joints.

3.10.2 For ductile iron pipe, the Contractor may, at his or her own expense, provide weld plates that are installed by the pipe manufacturer at the spigot end of the pipe. Provision of the weld plates does not relieve the Contractor from responsibility for repair of damage to the coating or lining as a result of exothermic welding of the pipe. Coating repairs shall be performed in accordance with coating manufacturer's recommendations.

3.11 Dielectric Insulating Flange Kit

3.11.1 All insulating components of the insulating flanged gasket set shall be cleaned of dirt, grease, oil, and other foreign materials immediately prior to assembly. If moisture, soil, or other foreign matter contacts any portion of these surfaces, disassemble the entire joint and clean with a suitable solvent. Dry the entire joint. Once completely dry, reassemble the joint.

3.11.2 Care shall be taken to prevent any excessive bending or flexing of the gasket. Creased or damaged gaskets shall be rejected and removed from the job site.

3.11.3 Bolt holes in mating flanges shall be properly aligned at the time bolts and insulating sleeves are inserted to prevent damage to the insulation. Follow the manufacturer's recommended bolt tightening sequence. Center the bolt insulating sleeves within the insulation washers so that the insulating sleeve is not compressed and damaged.

3.11.4 After flanged bolts have been tightened, each insulating washer shall be inspected for cracks or other damage. All damaged washers shall be replaced.

3.11.5 When the flange is determined to be properly functioning to the full satisfaction of the Manager, approval will be granted to proceed with the installation. Do not proceed with coating, lining, or backfilling the insulating joint prior to gaining approval to proceed. If the coating is applied prior to gaining approval to proceed, the coating shall be completely removed to the satisfaction of the Manager at the Contractor’s expense. If the insulating joint is backfilled prior to gaining approval from the Manager, the Contractor shall completely excavate the insulating joint at the Contractor’s expense.

3.11.6 After testing and acceptance by the Manager, coat the exterior insulating flange and pipe a minimum of 12 inches beyond the gasket with the wax tape system specified herein.

3.12 Insulating Corporation Stop

3.12.1 Insulating corporation stop shall be installed where copper laterals connect with the DIP mainline.

3.12.2 Care shall be taken to prevent any excessive bending or flexing of the insulating corporation stop.

3.12.3 Before and after installation, insulating corporation stops shall be inspected for damage. Damaged insulating corporation stops shall be rejected and removed from the job site.

3.12.4 When the insulating corporation stop is determined to be properly functioning to the full satisfaction of the Manager, approval will be granted to proceed with installation. Do not proceed with coating, lining, or backfilling the insulating joint prior to gaining approval to proceed. If the coating is applied prior to gaining approval to proceed, the coating shall be completely removed to the satisfaction of the Manager at the Contractor’s expense. If the insulating joint is backfilled prior to gaining approval from the Manager, the Contractor shall completely excavate the insulating joint at the Contractor’s expense.

3.12.5 After testing and acceptance by the Manager, coat the exterior insulating corporation stop and pipe a minimum of 12 inches beyond the insulating corporation stop with the wax tape system specified herein.

3.13 Petrolatum Wax Tape

3.13.1 Petrolatum wax tape systems shall be applied on insulating joints, insulating corporation stops, and non-cathodically protected metallic appurtenances and fittings, regardless of whether they are bare or factory coated. Extend the petrolatum wax tape coating system over any adjacent pipe coating by a minimum of 12 inches. Petrolatum wax tape systems shall be applied in accordance with NACE RP0375, AWWA C217, these Specifications, and the Manufacturer's recommendations.

3.13.2 Surfaces shall be cleaned of all dirt, grease, oil, and other foreign materials immediately prior to coating. Loose rust, loose paint, and other foreign matter shall be removed in accordance with SSPC SP2 or SP3.

3.13.3 A prime coating shall be applied in a uniform coating over the entire surface to be wrapped. A liberal coating shall be applied to threads, cavities, shoulders, pits, and other irregularities.

3.13.4 Petrolatum wax tape shall be applied immediately after applying the primer using a 1-inch overlap. A spiral wrap shall be used, and slight tension shall be applied to ensure that there are no air pockets or voids. For bolts, nuts, and other irregular shapes, cut strips of wax tape and apply them by gloved hand so that there are no voids or spaces under the tape. Apply a sufficient amount of tape to completely encapsulate all exposed steel surfaces. After applying the tape, the applicator shall firmly press and smooth out all lap seams and crevice areas. The tape shall be in tight intimate contact with all surfaces. The minimum wax tape thickness shall be 70 mils over smooth surfaces and 140 mils over sharp and irregular surfaces, or more as required to fill all voids.

3.13.5 Apply two layers of outer covering over the wax tape coating by tightly wrapping it around the pipe such that it adheres and conforms to the wax tape. Secure the outer covering to the pipe with adhesive tape.

3.14 Reference Electrode

3.14.1 Reference electrodes shall be installed as shown on the Drawings.

3.14.2 Reference electrode lead wire shall be terminated on the panel board as shown on the Drawings.

3.15 Coupon

3.15.1 Coupon shall be installed as shown on the Drawings.

3.16 Wire Connection

3.16.1 After installation, all wire connections shall be tested to ensure electrical continuity at the test station locations by the Contractor to ensure that they meet the requirements and intent of the Contract Documents.

3.17 Isolation Testing on Insulating Joints and Corporation Stops

3.17.1 Insulating joints and corporation stops shall be installed to effectively isolate metallic piping from foreign metallic structures. The Contractor shall test the performance of these insulating joints and corporation stops before and after backfilling in accordance with Part 8, Testing.

3.17.2 Before backfilling, the Contractor shall test the insulating joint and corporation stop using a Gas Electronics Model No. 601 Insulation Checker or an approved equivalent. If the testing results indicate less than 100% insulation, then the insulating joints and corporation stops shall be repaired and retested at the Contractor's expense.

3.17.3 After backfilling, testing shall be performed by measurement of native pipe-to-soil potentials at both sides of the insulating joints. If the difference in native pipe-to-soil potentials on both sides of the insulating joint is within ±100 mV, then additional testing shall be performed, as follows. Temporary CP current shall be circulated on one side of the insulating joint. "On" and "Instant Off" pipe-to-soil potentials shall be measured on the other side of the insulating joint. If the "Instant Off" potential is more negative than the native potential, the insulating joint shall be considered deficient and shall be repaired and retested at the Contractor's expense.

3.18 Isolation Testing on Casing Insulators

3.18.1 Casing insulators shall be installed as indicated in the Drawings to effectively isolate the pipeline from the casing. The Contractor shall test the performance of the casing insulators before and after backfilling in accordance with Part 8, Testing.

3.18.2 Before backfilling, the Contractor shall test the integrity of the insulators by using a Gas Electronics Model No. 601 Insulation Checker or an approved equivalent. If the testing results indicate less than 100% insulation, then the casing insulators shall be repaired and retested at the Contractor's expense.

3.18.3 After backfilling, testing shall be performed by measurement of native pipe-to-soil potentials on the pipeline and the casing at both ends of the casing. If the difference in native pipe-to-soil potentials is greater than 100 mV, then the casing shall be considered isolated from the pipeline. If the difference in native pipe-to-soil potentials between pipe and casing is less than 100 mV, then additional testing shall be performed, as follows. Temporary CP current shall be applied to the pipeline. "On" and "Instant Off" pipe-to-soil potentials shall be measured on the pipeline and the casing at both ends of the casing. If the "Instant Off" potential of the casing is more negative than the native potential of the casing, then the pipe is not isolated from the casing and shall be repaired and retested at the Contractor's expense.

3.19 Continuity Testing

3.19.1 Continuity testing of joint bonds shall be performed by the Contractor's qualified corrosion technician after backfilling and in accordance with Part 8, Testing. The electrical continuity test may additionally be performed before backfilling at the Contractor's option.

3.19.2 The pipe shall be tested for electrical continuity. Continuity shall be verified using the linear resistance method. The pipe should be tested in spans that are no less than 250 feet, unless the pipe is shorter than 250 feet, and no more than 1,000 feet, if test station locations are available. Each test span shall have two test leads connected to the pipe at each end. Existing test stations can be used. A direct current shall be applied through the pipe using two of four test leads. The potential across the test span shall be measured using the other two test leads. The current applied and voltage drop shall be recorded for a minimum of three different current levels.

3.19.3 The theoretical resistance of the pipe shall be calculated. It shall take into account the pipe wall thickness, material, and joint bonds.

3.19.4 The average measured resistance shall be compared to the theoretical resistance of the pipe and bond wires. If the measured resistance is greater than 125% of the theoretical resistance, then the joint bonds shall be considered deficient and shall be repaired and retested at the Contractor's expense. If the measured resistance is less than 100% of the theoretical resistance, then the test and/or calculated theoretical resistance shall be considered deficient and the test span shall be retested and/or recalculated at the Contractor's expense. If the piping forms a loop which allows current to flow both in and out of the test span, then consideration shall be made for current circulating through both the loop and the test span.

3.19.5 Alternative continuity testing methods can be submitted to the Manager for consideration and approval.

3.20 Final System Checkout

3.20.1 Upon completion of the installation, the Contractor shall provide testing of the completed system by a Corrosion Technician, and the data shall be reviewed by a Corrosion Engineer to ensure conformance with the Contract Documents, NACE SP0169, and NACE SP0286.

3.20.2 The testing described herein shall be in addition to and not a substitution for any required testing of individual items at the manufacturer's plant and during installation.

3.20.3 Testing shall be performed at all test leads of all test stations, junction boxes, and locations of the exposed pipe as soon as possible after installation of the CP system.

3.20.4 Testing shall include the following and shall be conducted in accordance with NACE TM0497 and Part 8, Testing:

3.20.4.1 Measure and record native pipe-to-soil, casing-to-soil, and anode-to-soil potentials at all test locations BEFORE the cathodic protection system is energized.

3.20.4.2 Verify electrical isolation at all insulating joints, insulating corporation stops, and casing insulators per NACE SP0286.

3.20.4.3 Confirm electrical continuity of the cathodically protected pipeline in accordance with this Specification.

3.20.4.4 Measure and record the “On” and “Instant Off” pipeline-to-soil potentials at each location after the structure has been given adequate time to polarize.

3.20.4.5 Measure and record the current output of each anode when the CP system is initially turned on and again after it has been given adequate time to polarize.

3.20.5 Test results shall be analyzed to determine compliance with NACE SP0169.

3.20.6 Test results shall be analyzed to determine if stray current interference is present. Stray current interference is defined as a ±50 mV shift in a pipeline’s pipe-to-soil potential that is caused by a foreign current source. Stray current interference shall be tested on the project pipeline and foreign pipelines that have a reasonable chance of being affected by stray currents.

3.20.7 All test results shall be submitted to the Manager for review and approval before the corrosion control work is accepted. The Registered Professional Corrosion Control Engineer or the Corrosion Specialist (CP4) shall submit a summary report to include basic statements regards the operational performance of the cathodic protection system and the other corrosion control provisions. The Manager reserves the right to spot check any or all tests performed by the Contractor. All construction defects must be repaired and retested before the final acceptance is made. All unacceptable test must be reperformed by the Contractor at no additional cost to BWS. At the conclusion of the project, the Registered Professional Corrosion Engineer or the Corrosion Specialist (CP4) responsible for the field testing together with the Contractor, shall submit a cosigned Certification stating that the pipeline cathodic protection system has been installed according to the plans and specifications, and that the protection levels are within the most recent NACE SP0169 standards for the type of pipeline and appurtenances.

PART 8. ADDITIONAL TESTING REQUIREMENTS

SECTION 1. EQUIPMENT

1.1 General

Equipment used to test the cathodic protection system shall be kept in good working condition and calibrated.

1.2 Required Equipment

The following equipment is required to test the cathodic protection system:

1.2.1 Multimeter with test leads

1.2.1.1 Current: Up to at least 10 A

1.2.1.2 Volts: Up to at least 1,000 V

1.2.1.3 Resistance: Up to at least 50 MΩ

1.2.1.4 Capacitance: Up to at least 1 mF

1.2.2 Copper-copper sulfate reference electrode

1.2.3 Gas Electronics Model No. 601 Insulation Checker

1.2.4 DC power supply with a steady capacity of 25 A at minimum

1.2.5 Knife switch, safety switch, or time-controlled relay suitable for test current

1.2.6 Insulated wire suitable rated for the test current, length as required

SECTION 2. REQUIRED TEST & RECORD KEEPING

2.1 General

Galvanic anode cathodic protection (GACP) systems shall be tested in accordance with Part 6. Impressed current cathodic protection (ICCP) systems shall be tested in accordance with Part 7. The following typical test set ups and data sheets are provided for reference:

SECTION 3. TRAINING

3.1 General

The Contractor shall be responsible for instructing BWS personnel (5 or 6 people) on the proper operation, testing, and maintenance of all corrosion control items used on the project.

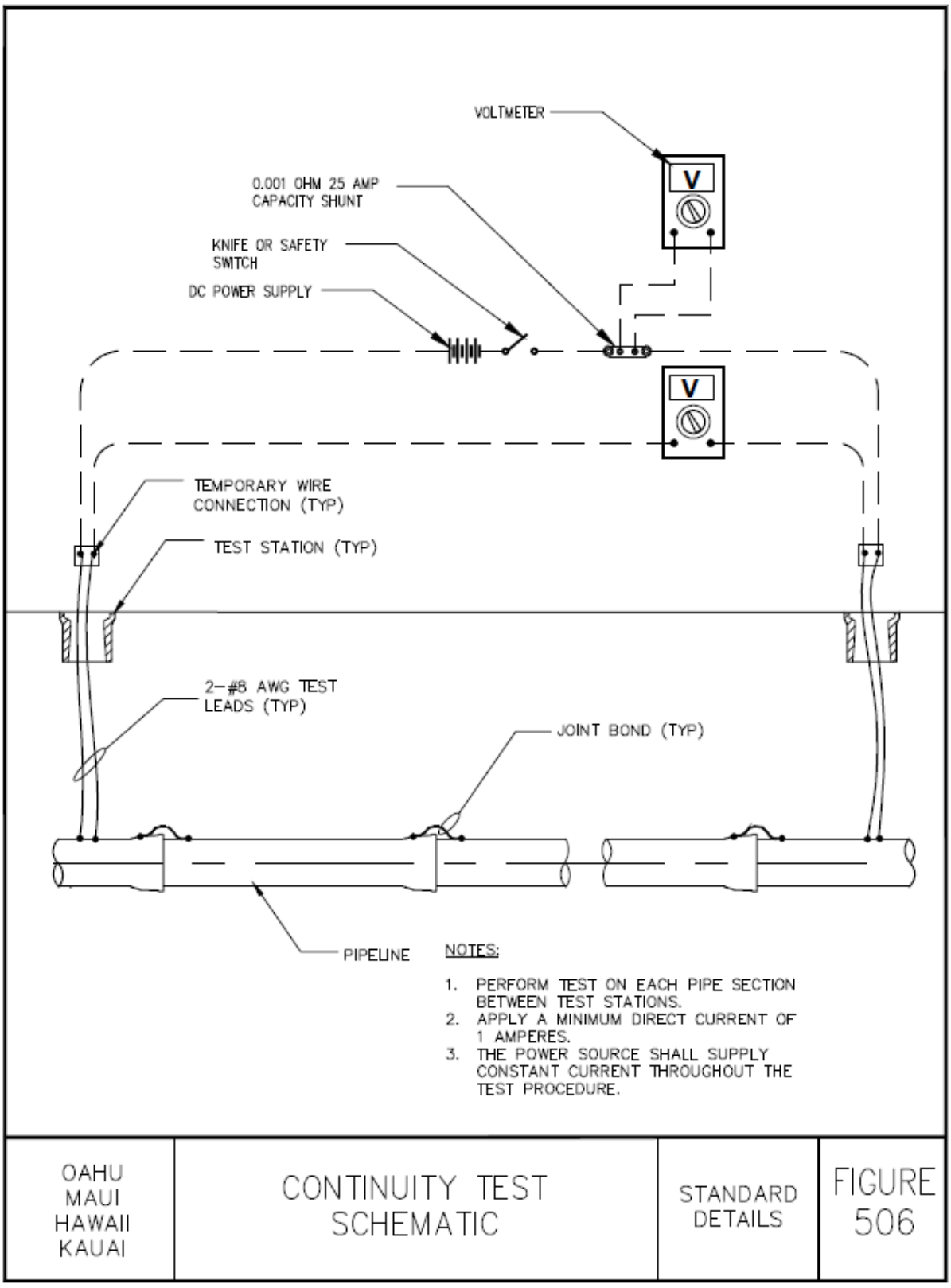


Figure 5. Continuity Test Schematic

Pipeline Location: _____ **Sheet** _____ **of** _____

Pipe Size: _____ **Date:** _____

By: _____

LONGITUDINAL PIPE RESISTANCE ELECTRICAL CONTINUITY TEST

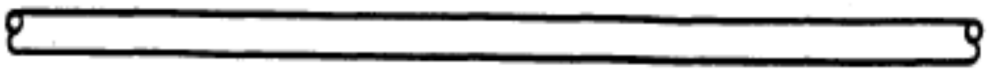
Pipeline: _____

Test Span: _____ Test No. _____ Dwg No. _____

Test Span Location: _____ Sta. No. _____ To Sta. No. _____

Street: _____ Total Distance _____ FT

Pipe Size: _____ Type _____ K = Calculated Resistance/FT= _____ mΩ



Sketch (Include Test Connections. Distances, Stationing)

Test Points	-	-	-	-	-
Voltage Off (Before Test)	FT	FT	FT	FT	FT
Voltage Off (At Test)	mV	mV	mV	mV	mV
Voltage On	mV	mV	mV	mV	mV
Δ Voltage (Off-On)	mV	mV	mV	mV	mV
Current through Shunt X Factor (If Req'd)	mV	mV	mV	mV	mV
Current (I)	A	A	A	A	A
Measured Resistance (ΔV/i) R_m	mΩ	mΩ	mΩ	mΩ	mΩ
Calculated (D x K Factor) Resistance (+ Extra) mΩ Total R_c	+ _____ mΩ	+ _____ mΩ	+ _____ mΩ	+ _____ mΩ	+ _____ mΩ
% (Meas. R/Cal R x 100)	%	%	%	%	%
Notes:					

Figure 6. Longitudinal Pipe Resistance Electrical Continuity Test

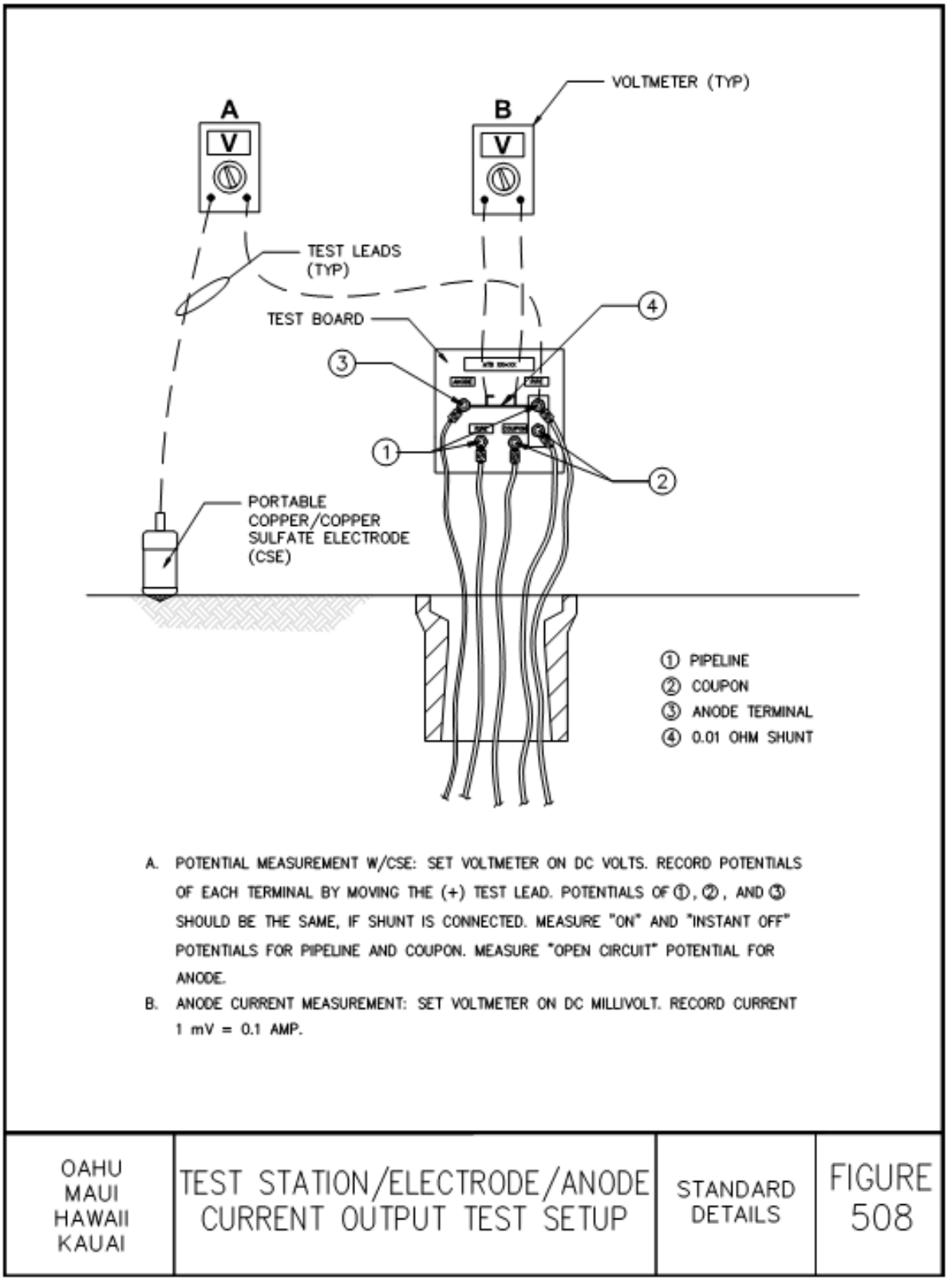


Figure 7. Test Station/Electrode/Anode Current Output Test Setup

Pipeline Location: _____ **Sheet** _____ **of** _____

Pipe Size: _____ **Date:** _____

By: _____

POTENTIAL MEASUREMENTS

Test No.	Location	Pipe-to-Soil Potential, ON (mV_{CSE})	Pipe-to-Soil Potential, INSTANT OFF (mV_{CSE})	Anode-to-Soil Potential, OFF (mV_{CSE})	Anode Output (mA)

Figure 8. Potential Measurements

PART 9. PAYMENT

SECTION 1. REQUIREMENTS

1.1 General

Unless otherwise specified, payment for the furnishing and application or installation of the external corrosion control system will be made at the unit price bid, or lump sum bid, whichever is specified, for the item of which the external corrosion control is a part. The unit price bid or lump sum bid shall be full compensation for all labor, materials, tools, and equipment for all handling, application, installation, and other incidental materials and work necessary to place the external corrosion control system in place to complete.

1.2 Replacement Provisions

Unless otherwise specified, payment for the furnishing and delivering of all additional external corrosion control items to BWS shall not be made directly but shall be part of the unit price bid, or lump sum bid, whichever is specified, for the items of which the external corrosion control is a part.

PART 10. APPROVED MATERIAL SUPPLIER LIST

SECTION 1. MATERIAL SUPPLIER

1.1 General

The following is an approved supplier list.

- Farwest Corrosion Control, Downey, CA (www.farwestcorrosion.com)
- Corrpro (a subsidiary of Aegion Corporation), Houston, Texas (www.corrpro.com)
- Mesa, Tulsa, Oklahoma (www.mesaproducts.com)
- Matcor, Chalfont, Pennsylvania (www.matcor.com)

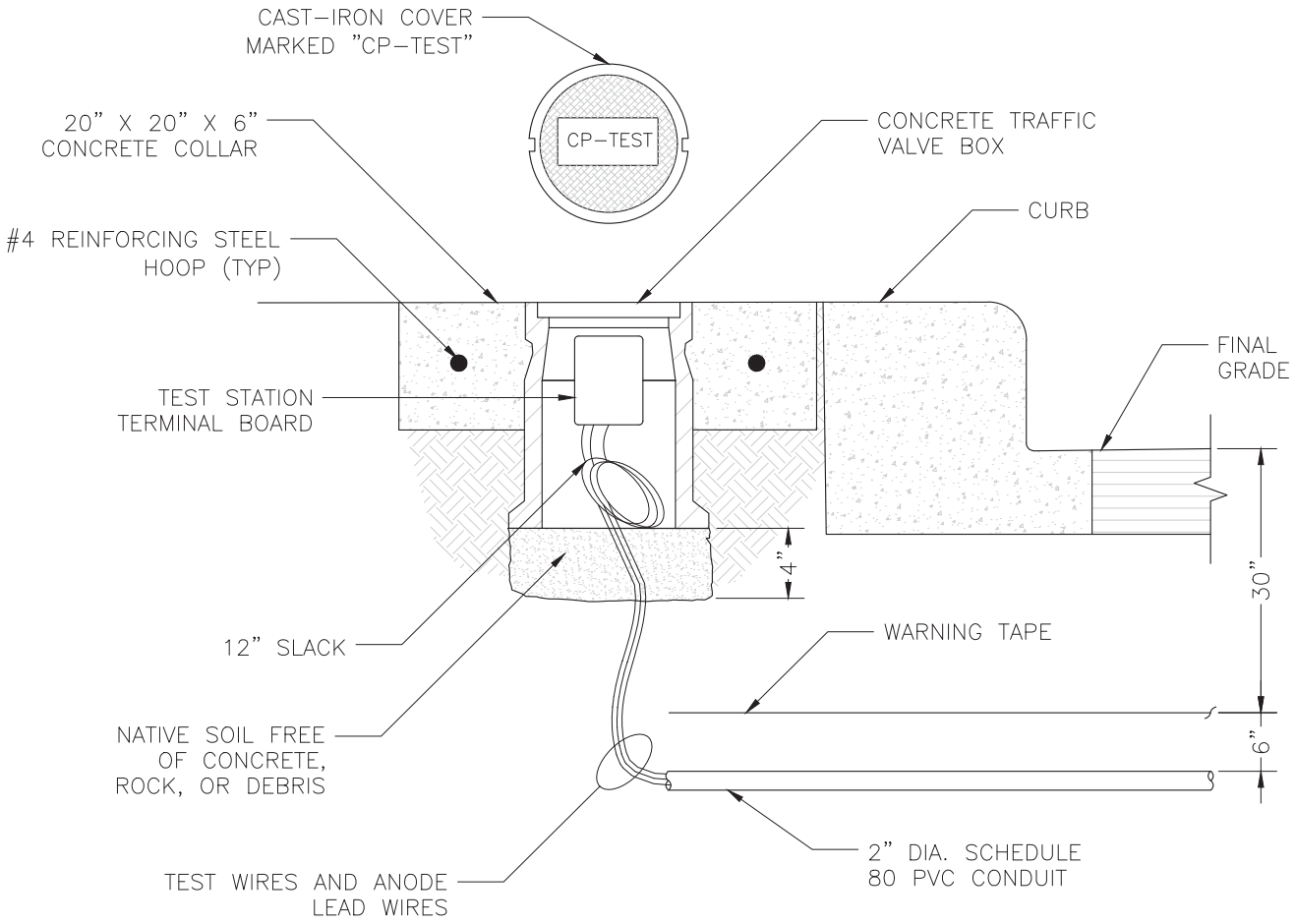
PART 11. CORROSION CONTROL DETAILS

SECTION 1. DETAILS

1.1 General

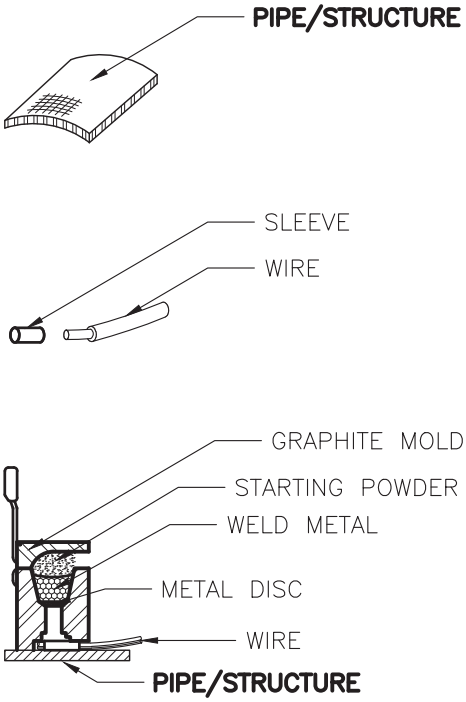
This section includes standard details for external corrosion control for buried pipelines. The details include:

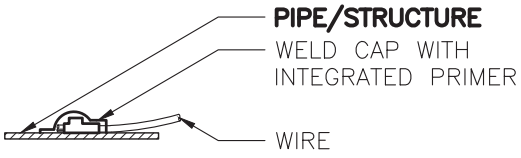
CP01 Flush Mounted Test Station Detail
CP02 Exothermic Weld for Ductile Iron and Steel Detail
CP03 Pipe Joint Bonding for Non-Insulated Joints Detail
CP04 Pipe Joint Bonding for Non-Insulated Joints Detail
CP05 Wire Identifier Detail
CP06 Dielectric Insulating Flange Kit Detail
CP07 Coupon Detail
CP08 Anode Test Station (ATS) for Four Anodes Plan View
CP09 Anode Test Station (ATS) for Four Anodes Section View
CP10 Anode Test Station (ATS) for Four Anodes Terminal Board Detail
CP11 Anode Test Station (ATS) for Two Anodes Plan View
CP12 Anode Test Station (ATS) for Two Anodes Section View
CP13 Anode Test Station (ATS) for Two Anodes Terminal Board Detail
CP14 Anode Test Station (ATS) for Fitting/Valve/Tee Plan View
CP15 Anode Test Station (ATS) for Fitting/Valve/Tee Section View
CP16 Anode Test Station (ATS) for Fitting/Valve/Tee Terminal Board Detail
CP17 Anode Test Station (ATS) for Multiple Fittings Plan View
CP18 Anode Test Station (ATS) for Multiple Fittings Section View
CP19 Anode Test Station (ATS) for Multiple Fittings Terminal Board Detail
CP20 Flexible Coupling Joint Bond Detail
CP21 Insulating Joint Test Station (IJTS) for Coupling Plan View
CP22 Insulating Joint Test Station (IJTS) for Coupling Section View
CP23 Insulating Joint Test Station (IJTS) for Bolted Flanges Plan View
CP24 Insulating Joint Test Station (IJTS) for Bolted Flanges Section View
CP25 Insulating Joint Test Station (IJTS) Terminal Board Detail
CP26 Insulating Joint Anode Test Station (IJATS) Plan View
CP27 Insulating Joint Anode Test Station (IJATS) Section View
CP28 Insulating Joint Anode Test Station (IJATS) Terminal Board Detail
CP29 Foreign Pipeline Test Station (FPTS) Section View
CP30 Foreign Pipeline Test Station (FPTS) Terminal Board Detail
CP31 Casing Test Station (CTS) Plan View
CP32 Casing Test Station (CTS) Section View
CP33 Casing Test Station (CTS) Terminal Board Detail
CP34 Potential Test Station (PTS) Plan View
CP35 Potential Test Station (PTS) Section View
CP36 Potential Test Station (PTS) Terminal Board Detail
CP37 Anode Test Station (ATS) for Repaired Section Plan View
CP38 Anode Test Station (ATS) for Repaired Section Section View
CP39 Anode Test Station (ATS) for Repaired Section Terminal Board Detail



	2021
	REVISION

OAHU	FLUSH MOUNTED TEST STATION DETAIL	STANDARD DETAILS	CP01

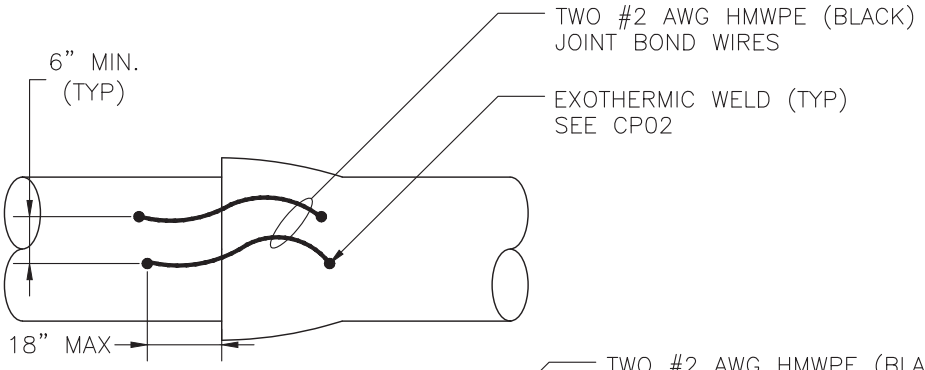


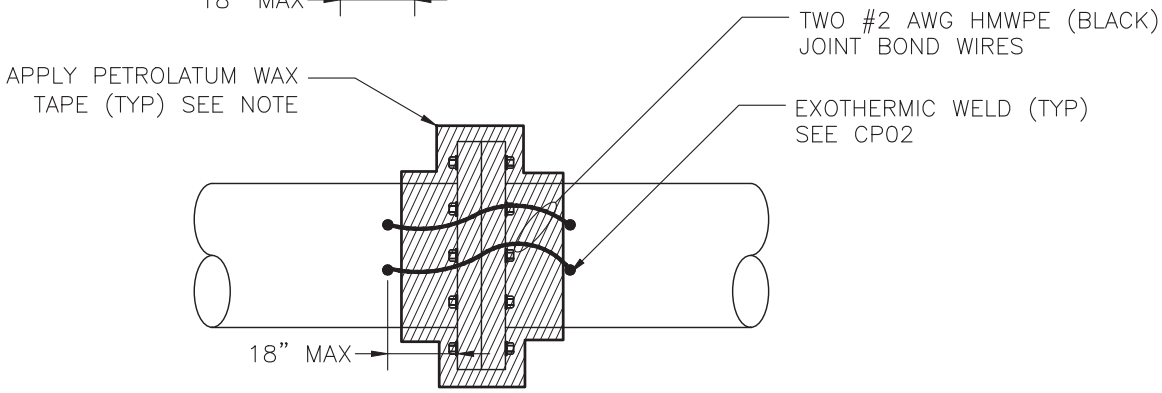


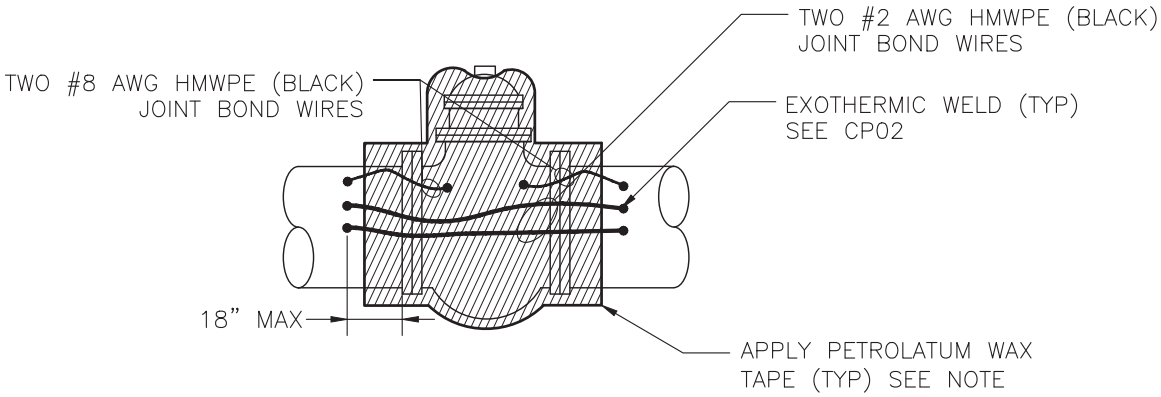
1. ALL WELDS SHALL BE 6" APART AT MINIMUM.
2. GRIND **PIPE/STRUCTURE** TO BARE METAL AND CLEAN SURFACE. GROUND AREA SHALL BE LARGE ENOUGH FOR EXOTHERMIC WELD AND SMALL ENOUGH TO BE COMPLETELY COVERED BY WELD CAP.
3. STRIP INSULATION FROM WIRE AND ATTACH SLEEVE.
4. HOLD MOLD FIRMLY WITH OPENING AWAY FROM OPERATOR. IGNITE WITH FLINT GUN. REMOVE SLAG FROM CONNECTION WITH CHIPPING HAMMER. TEST WELD WITH 22 OZ HAMMER.
5. COVER CONNECTION WITH WELD CAP WITH INTEGRATED PRIMER. REPAIR ALL DAMAGE TO COATING AND LINING IN ACCORDANCE WITH COATING AND LINING MFG RECOMMENDATIONS.

2021	
REVISION	

OAHU	EXOTHERMIC WELD FOR DUCTILE IRON AND STEEL DETAIL	STANDARD DETAILS	CP02







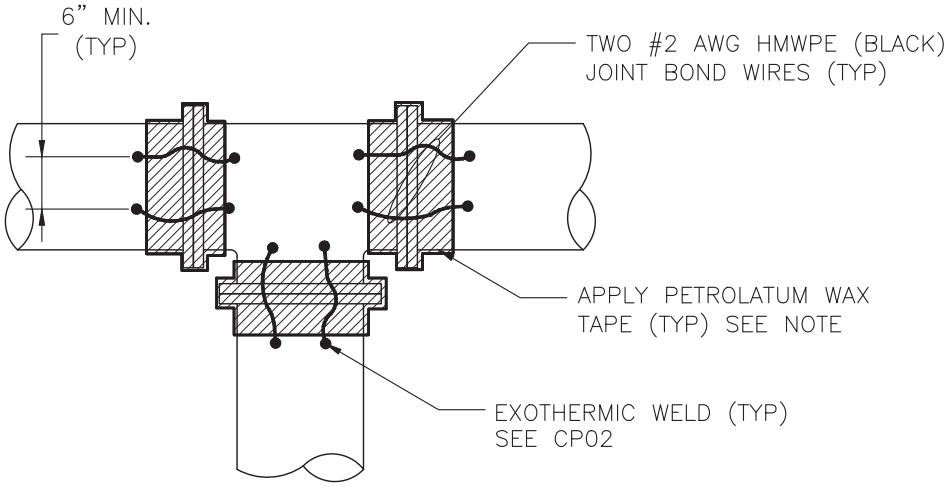
NOTES:

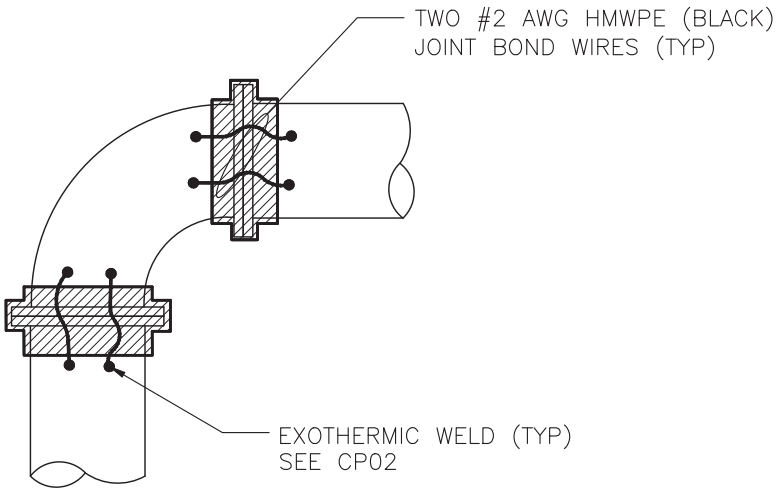
1. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".

2. PROVIDE A MINIMUM OF 2" SLACK TO ACCOMMODATE PIPE SETTLEMENT.

2021	
REVISION	

OAHU	PIPE JOINT BONDING FOR NON-INSULATING JOINTS DETAIL	STANDARD DETAILS	CP03





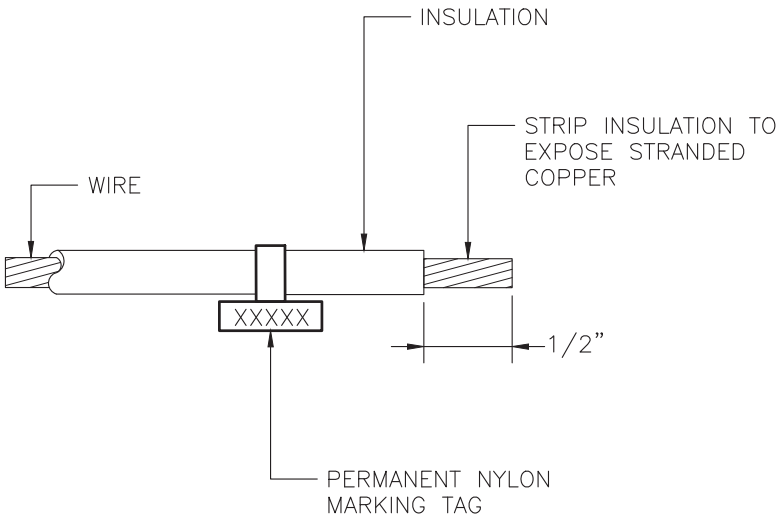
NOTES:

1. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".
2. PROVIDE A MINIMUM OF 2" SLACK TO ACCOMMODATE PIPE SETTLEMENT.

2021
REVISION

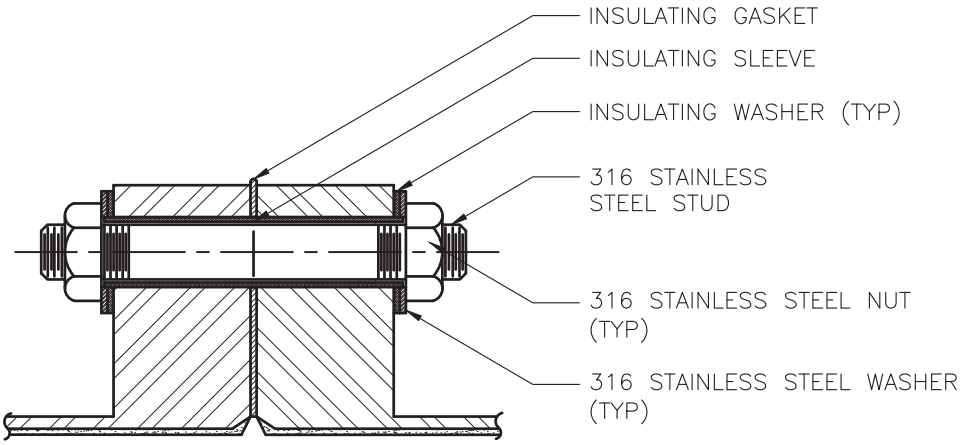
OAHU	PIPE JOINT BONDING FOR NON-INSULATING JOINTS DETAIL	STANDARD DETAILS	CP04

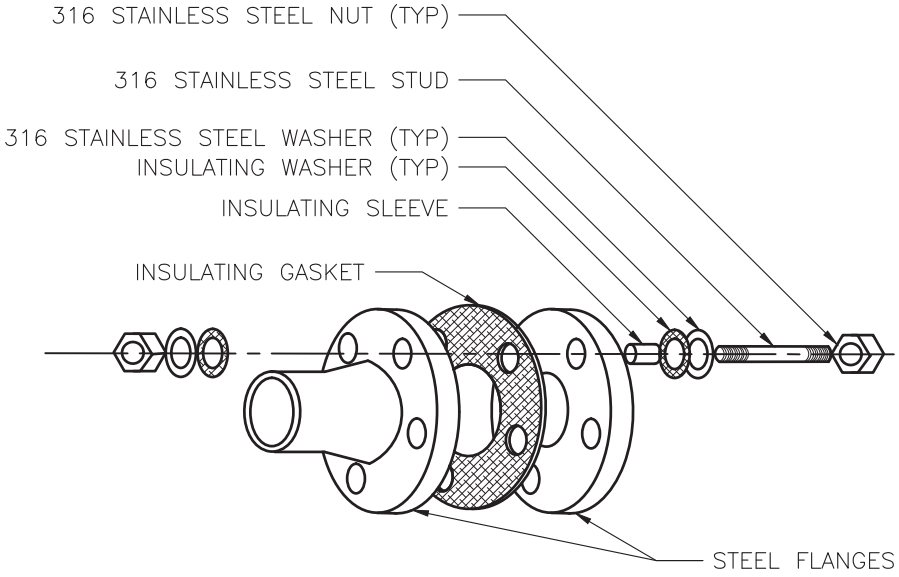
WIRE IDENTIFIER SCHEDULE
ANODE
COUPON
PIPE



2021	
REVISION	

OAHU	WIRE IDENTIFIER DETAIL	STANDARD DETAILS	CP05



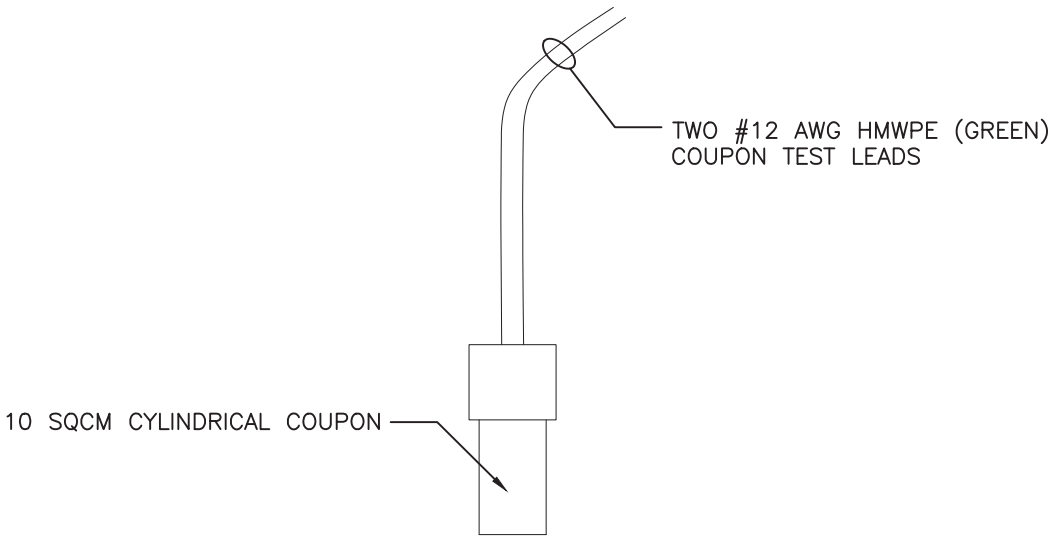


NOTE:

PETROLATUM WAX TAPE NOT SHOWN

	2021
	REVISION

OAHU	DIELECTRIC INSULATING FLANGE KIT DETAIL	STANDARD DETAILS	CP06

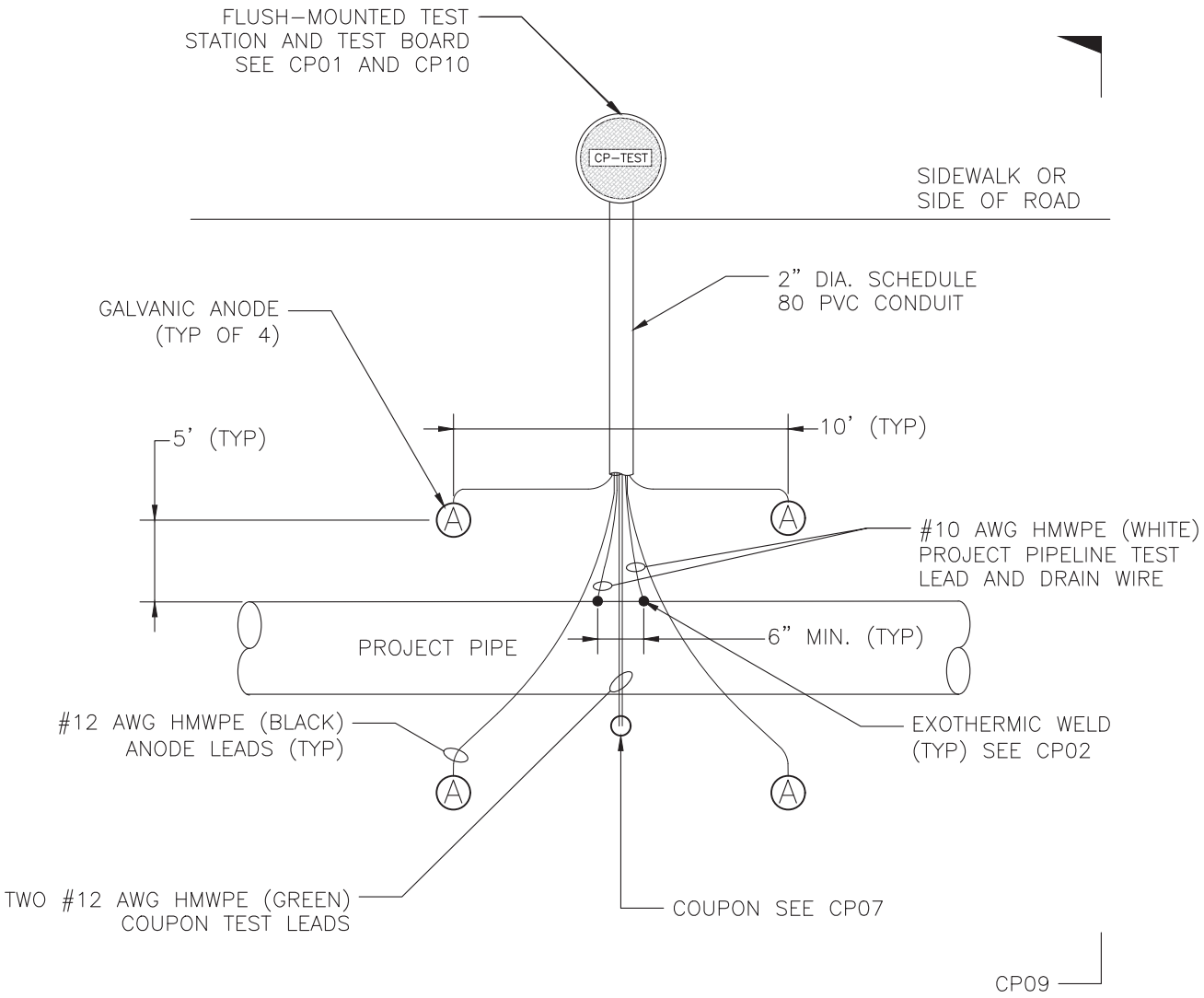


NOTE:

COUPON MATERIAL SHALL BE THE SAME AS THE PIPELINE.

	2021
	REVISION

OAHU	COUPON DETAIL	STANDARD DETAILS	CP07

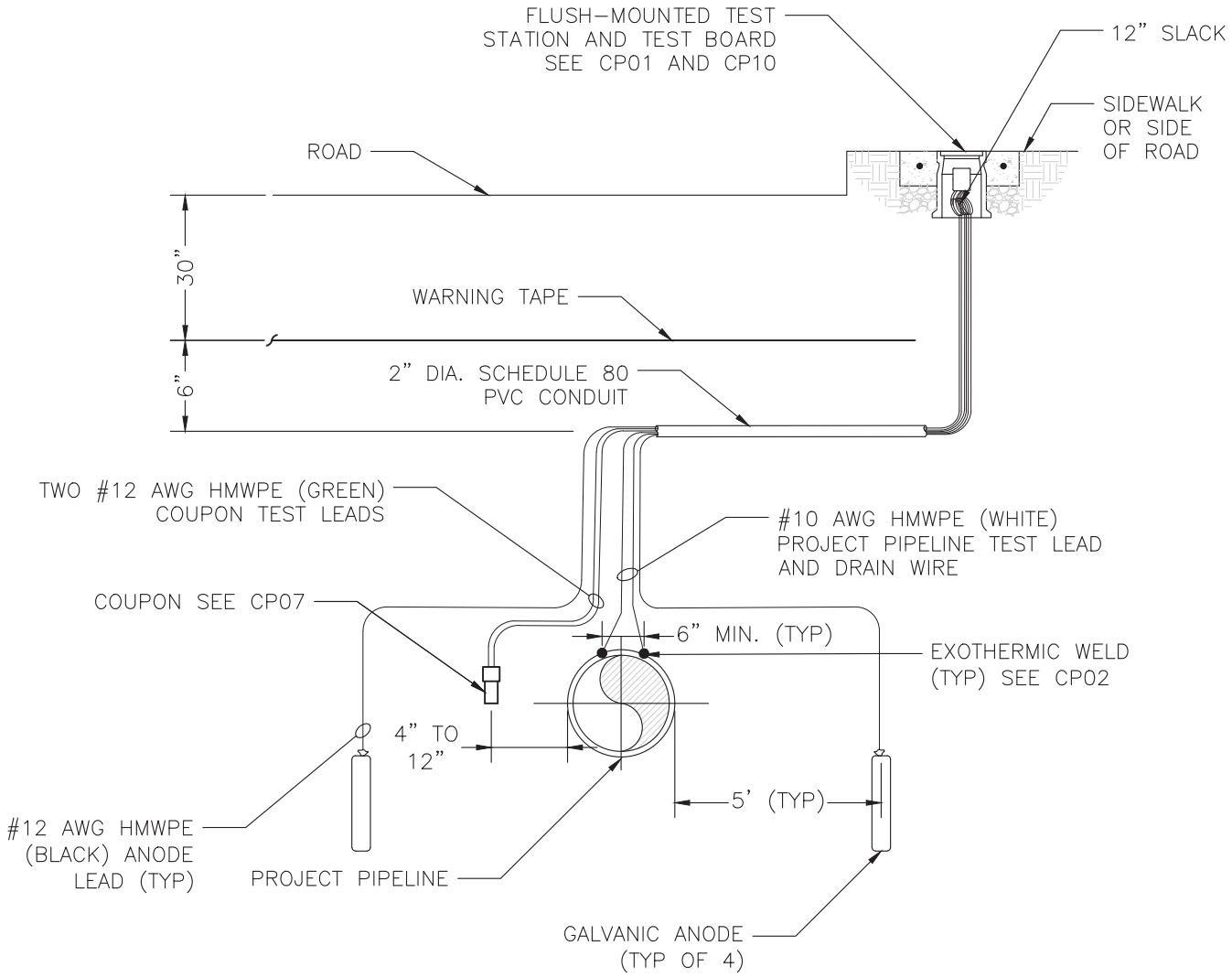


NOTE:

TEST STATIONS SHALL BE LOCATED NEXT TO FIRE HYDRANTS, WHERE FEASIBLE, SO THAT LATERAL WIRE RUNS PARALLEL FIRE HYDRANT LATERALS.

2021	
REVISION	

OAHU	ANODE TEST STATION (ATS) FOR FOUR ANODES PLAN VIEW	STANDARD DETAILS	CP08

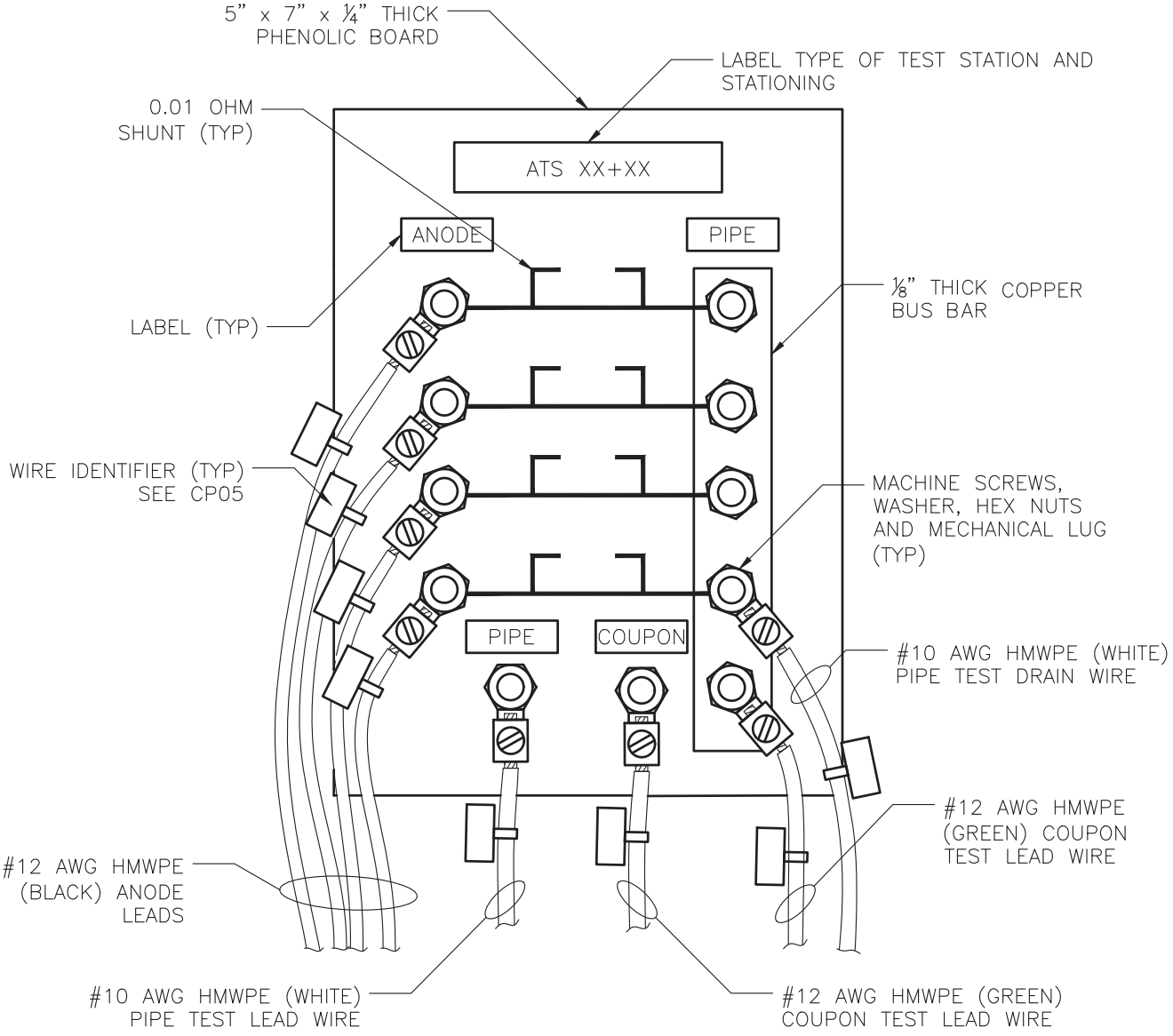


NOTE:

TOP OF ANODE SHALL BE ALIGNED WITH THE BOTTOM OF THE PROJECT PIPELINE.

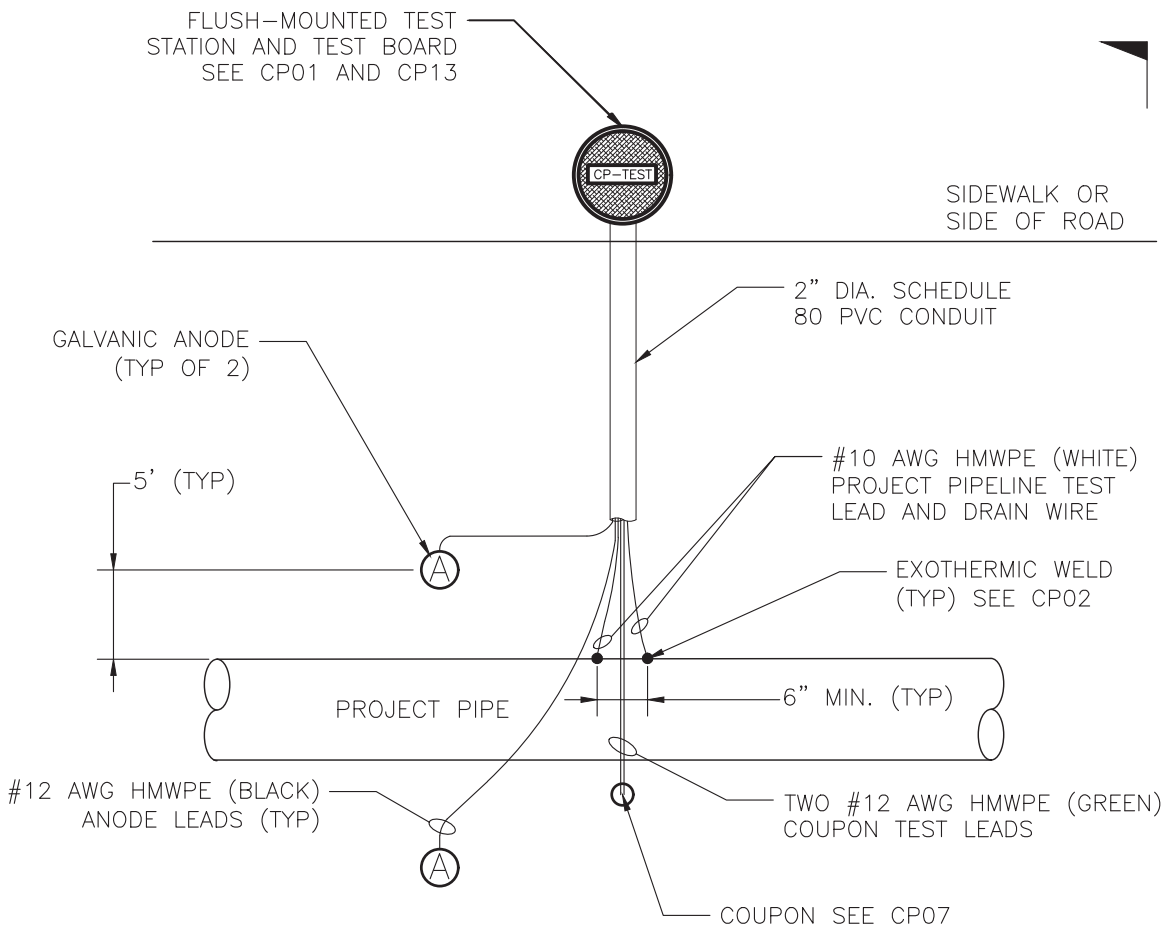
2021
REVISION

OAHU	ANODE TEST STATION (ATS) FOR FOUR ANODES SECTION VIEW	STANDARD DETAILS	CP09



2021	
REVISION	

OAHU	ANODE TEST STATION (ATS) FOR FOUR ANODES TERMINAL BOARD DETAIL	STANDARD DETAILS	CP10



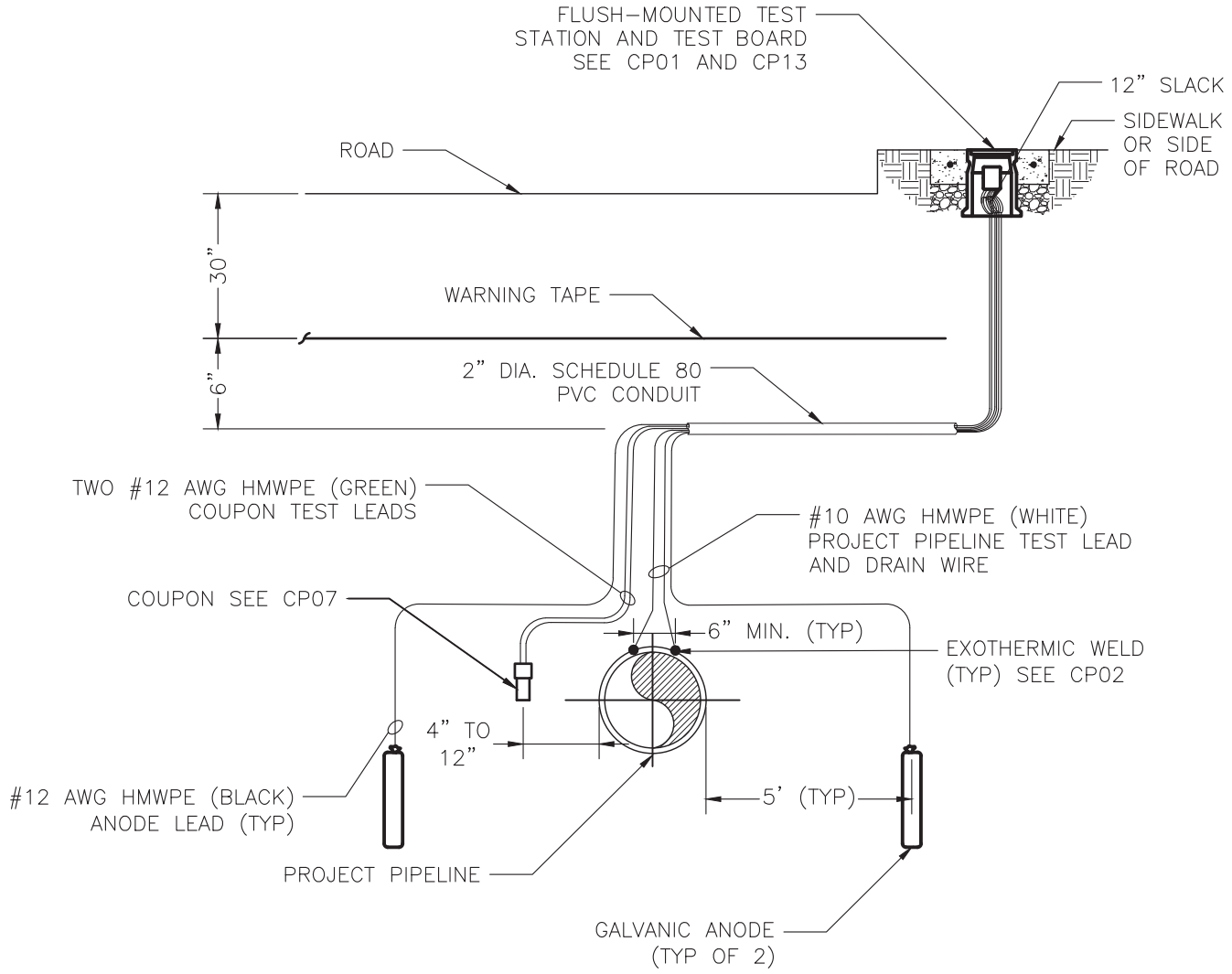
CP12

NOTE:

TEST STATIONS SHALL BE LOCATED NEXT TO FIRE HYDRANTS, WHERE FEASIBLE, SO THAT LATERAL WIRE RUNS PARALLEL FIRE HYDRANT LATERALS.

	2021
	REVISION

OAHU	ANODE TEST STATION (ATS) FOR TWO ANODES PLAN VIEW	STANDARD DETAILS	CP11

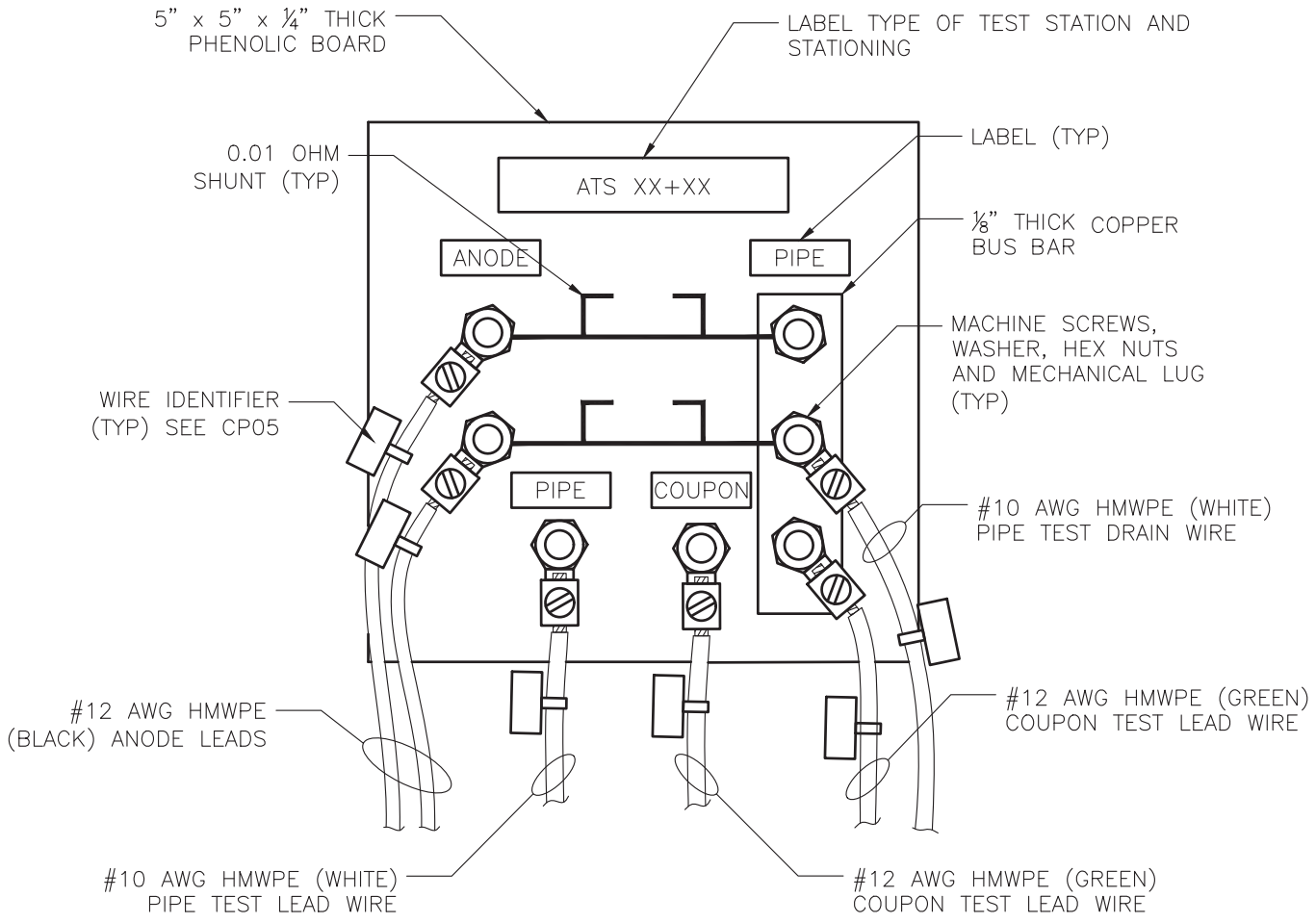


NOTE:

TOP OF ANODE SHALL BE ALIGNED WITH THE BOTTOM OF THE PROJECT PIPELINE.

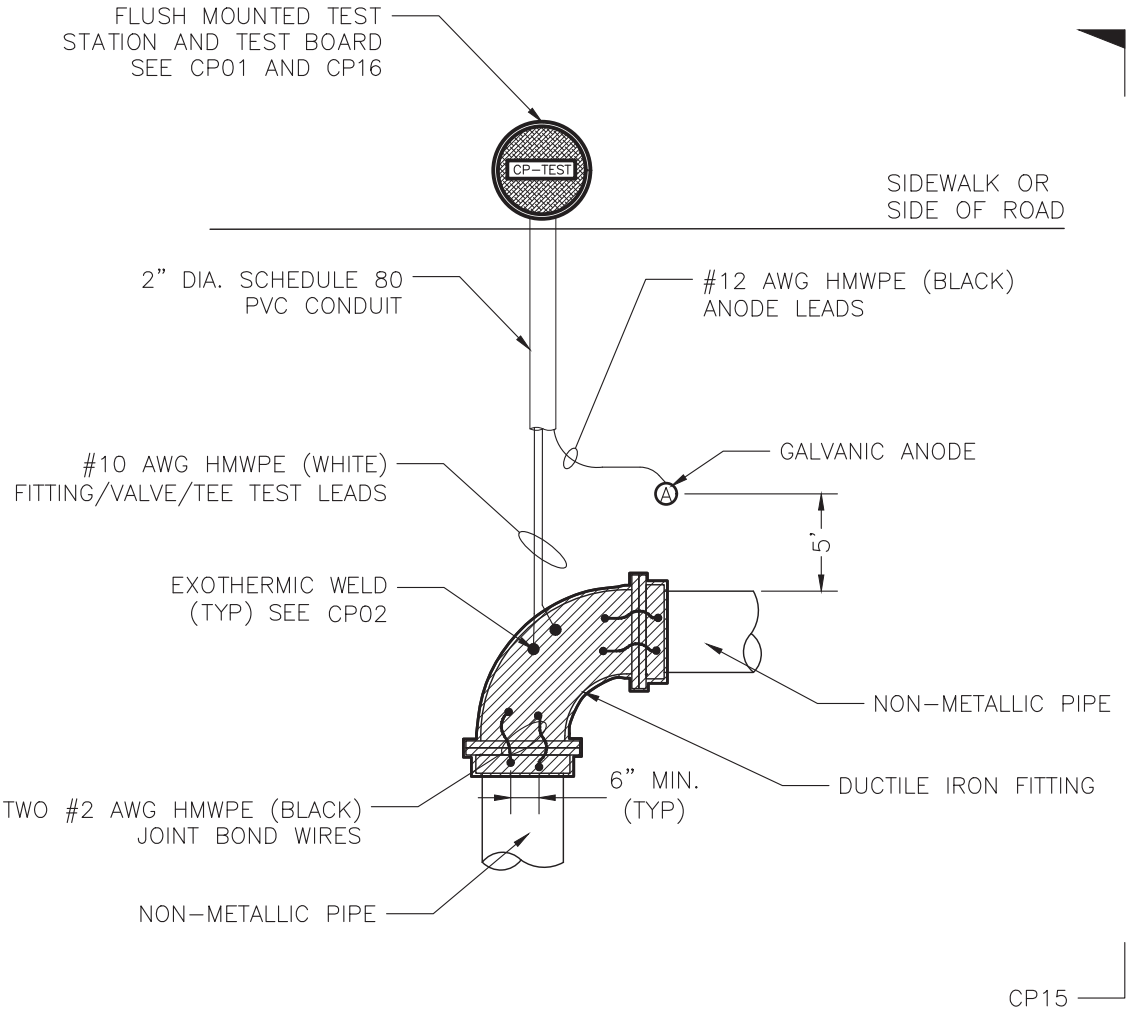
2021
REVISION

OAHU	ANODE TEST STATION (ATS) FOR TWO ANODES SECTION VIEW	STANDARD DETAILS	CP12



	2021
	REVISION

OAHU	ANODE TEST STATION (ATS) FOR TWO ANODES TERMINAL BOARD DETAIL	STANDARD DETAILS	CP13



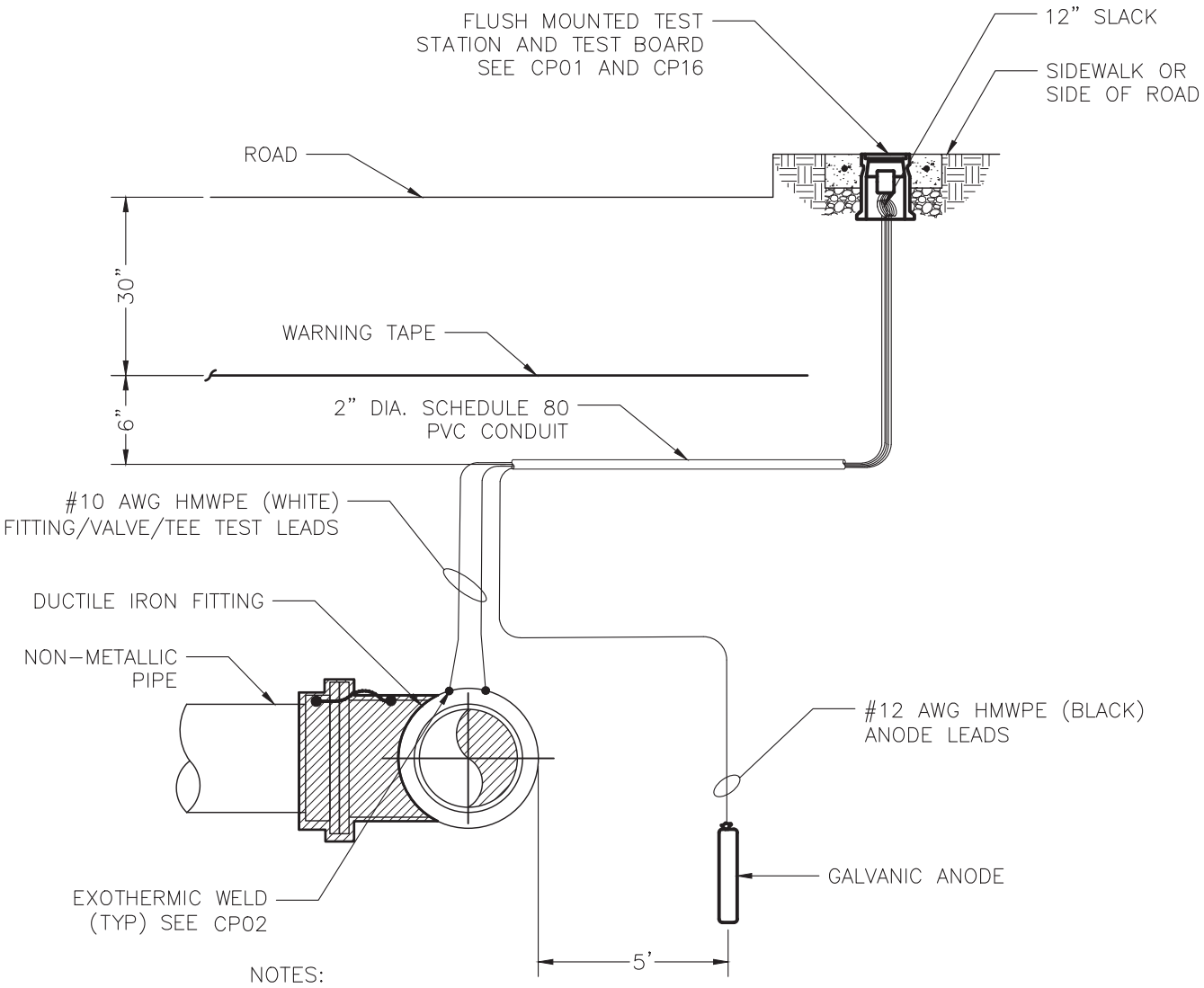
CP15

NOTES:

1. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".
2. PROVIDE A MINIMUM OF 2" SLACK TO BOND WIRES TO ACCOMMODATE PIPE SETTLEMENT.

2021	
REVISION	

OAHU	ANODE TEST STATION (ATS) FOR FITTING/VALVE/TEE PLAN VIEW	STANDARD DETAILS	CP14

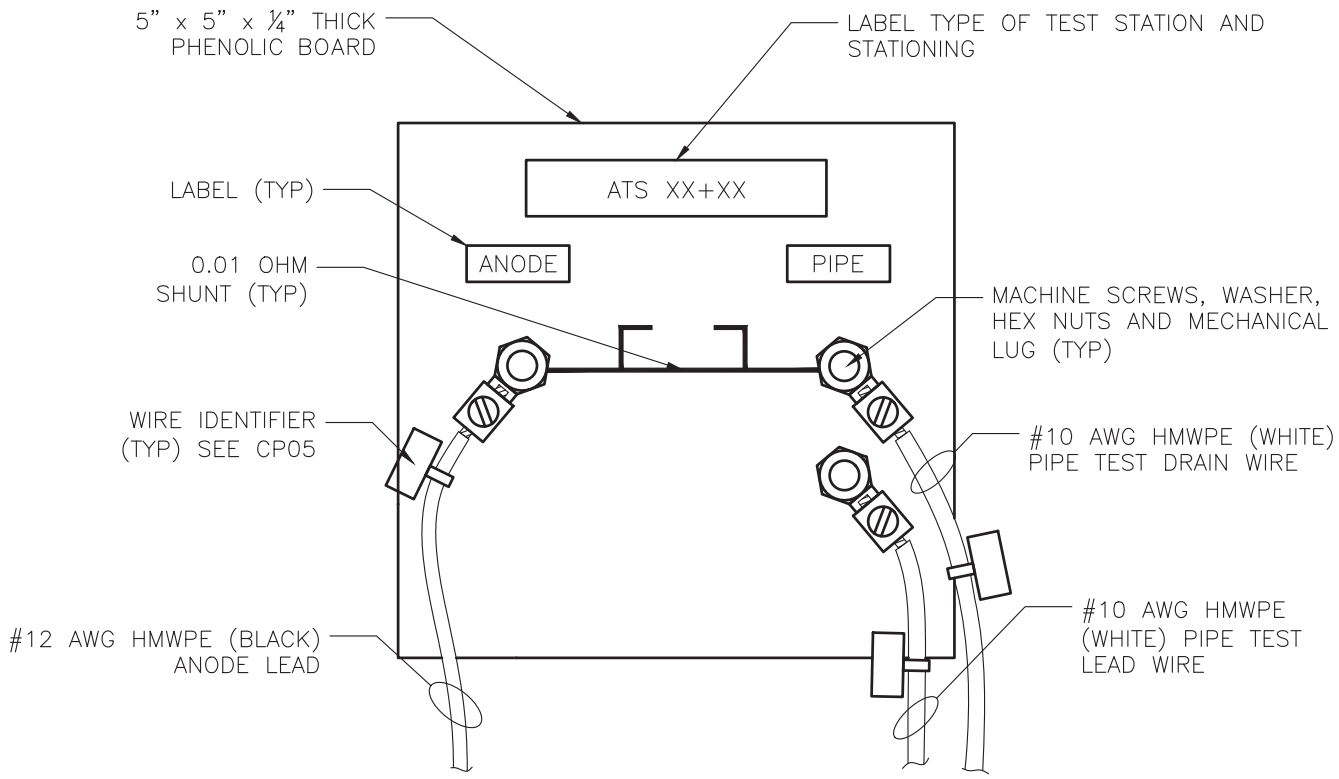


NOTES:

1. TOP OF ANODE SHALL BE ALIGNED WITH THE BOTTOM OF THE PROJECT PIPELINE.
2. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".
3. PROVIDE A MINIMUM OF 2" SLACK TO BOND WIRES TO ACCOMMODATE PIPE SETTLEMENT.

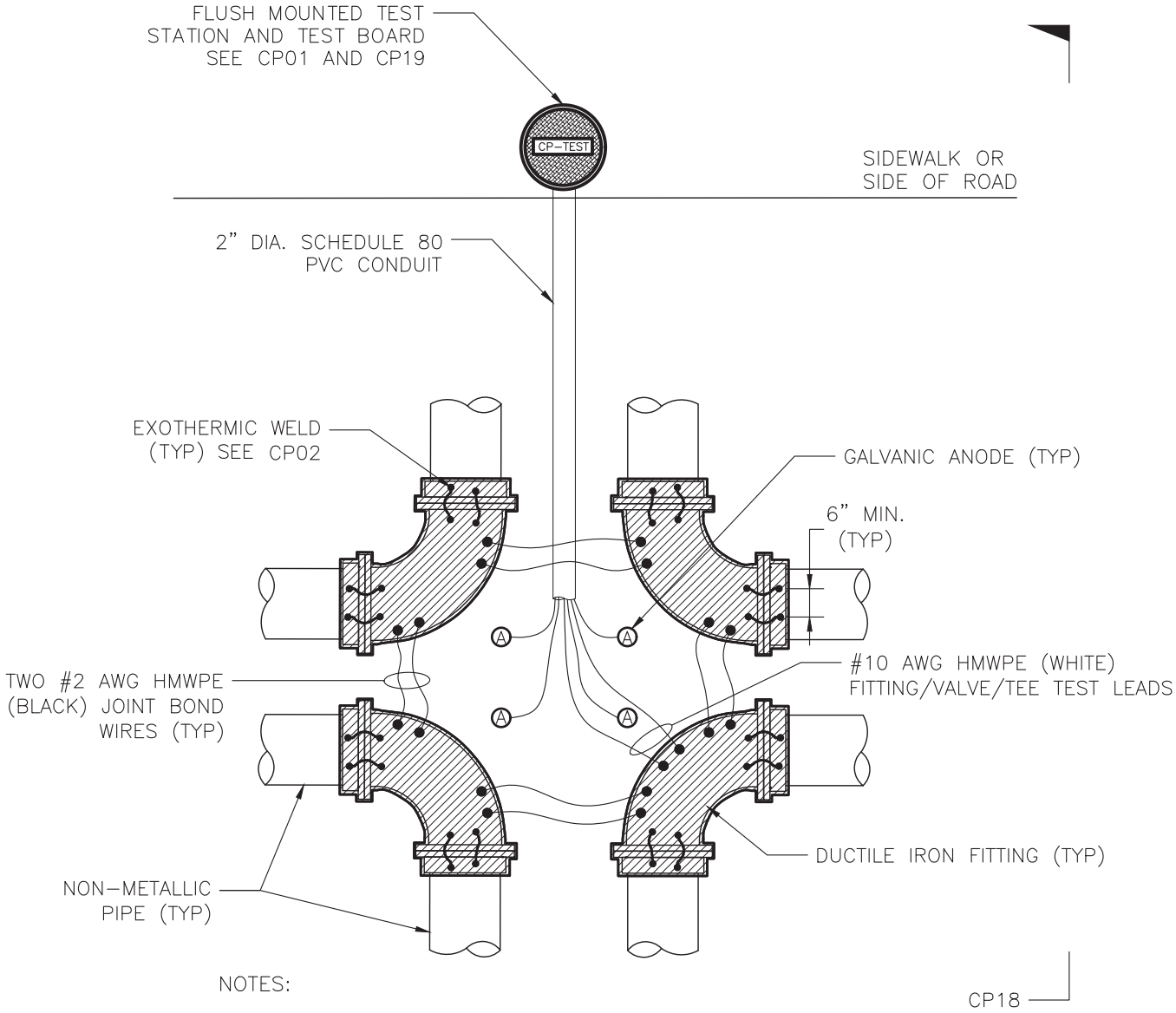
2021	
REVISION	

OAHU	ANODE TEST STATION (ATS) FOR FITTING/VALVE/TEE SECTION VIEW	STANDARD DETAILS	CP15



	2021
	REVISION

OAHU	ANODE TEST STATION (ATS) FOR FITTING/VALVE/TEE TERMINAL BOARD DETAIL	STANDARD DETAILS	CP16



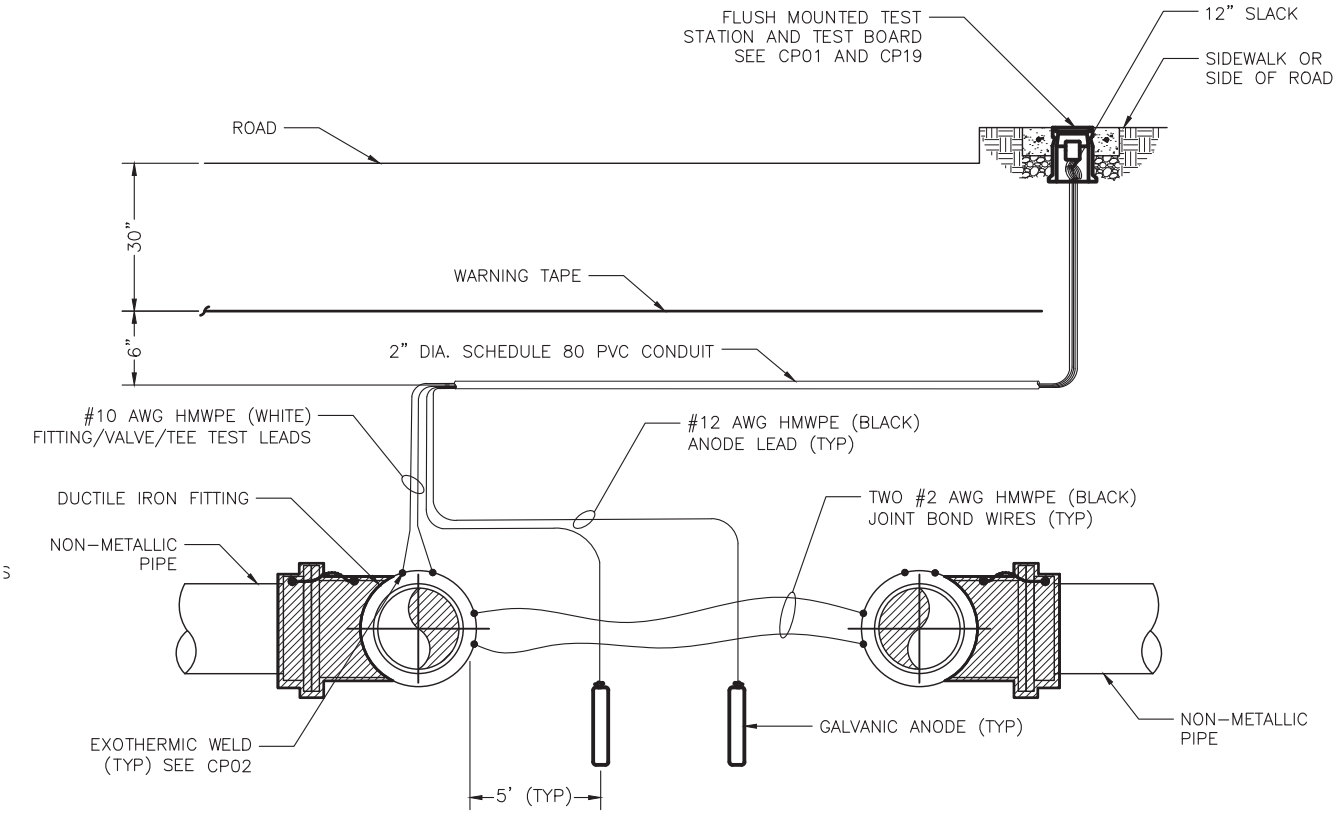
NOTES:

1. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".
2. PROVIDE A MINIMUM OF 2" SLACK TO BOND WIRES TO ACCOMMODATE PIPE SETTLEMENT.

CP18

	2021
	REVISION

OAHU	ANODE TEST STATION (ATS) FOR MULTIPLE FITTINGS PLAN VIEW	STANDARD DETAILS	CP17

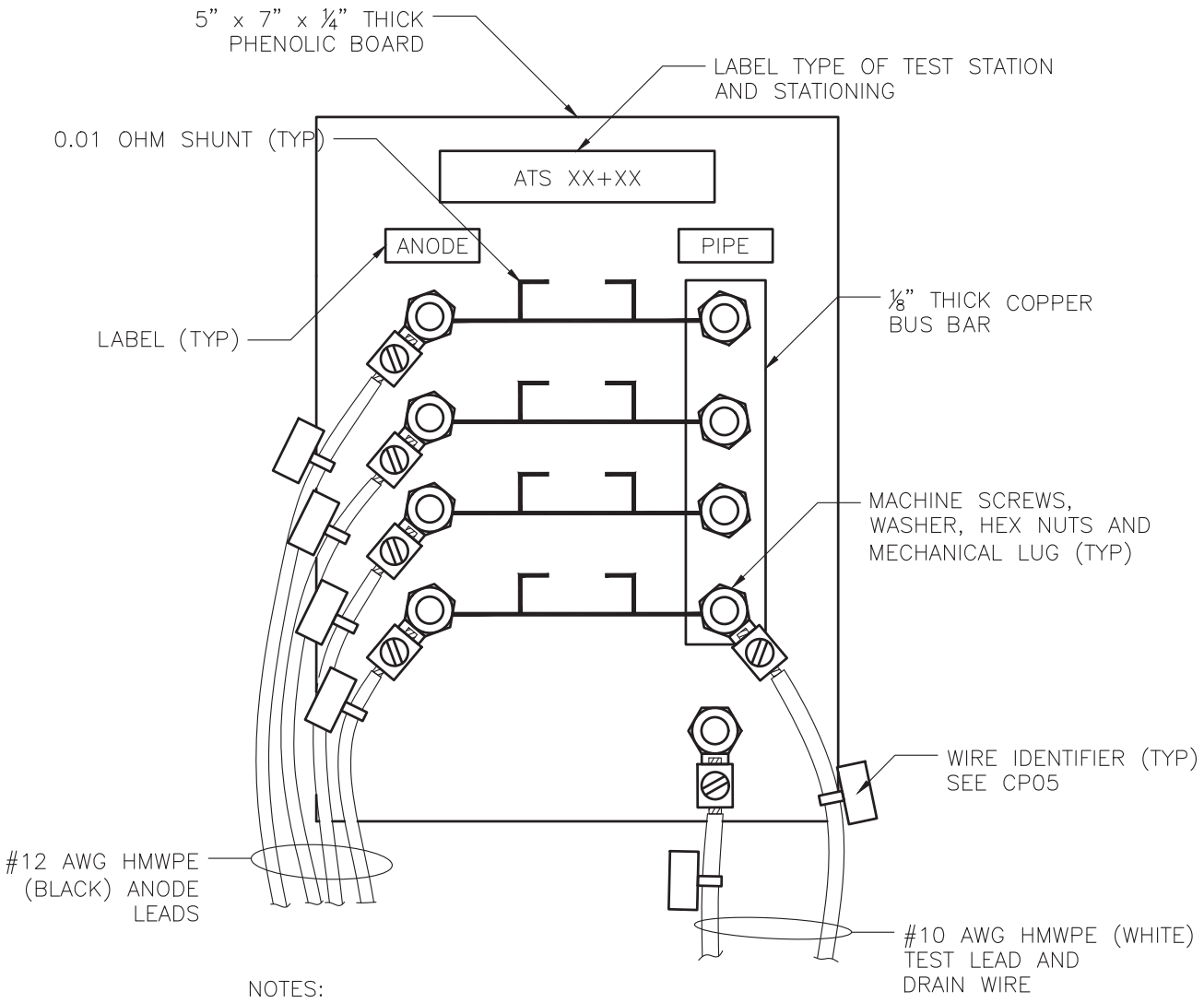


NOTES:

1. TOP OF ANODE SHALL BE ALIGNED WITH THE BOTTOM OF THE PROJECT PIPELINE.
2. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".
3. PROVIDE A MINIMUM OF 2" SLACK TO BOND WIRES TO ACCOMMODATE PIPE SETTLEMENT.

2021	
REVISION	

OAHU	ANODE TEST STATION (ATS) FOR MULTIPLE FITTINGS SECTION VIEW	STANDARD DETAILS	CP18

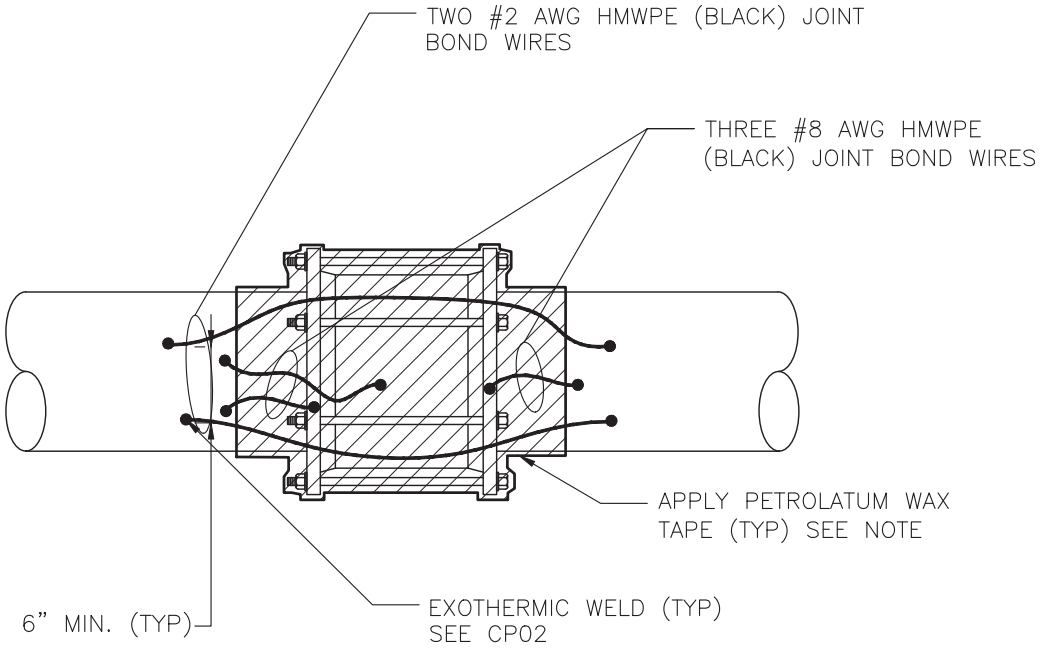


NOTES:

1. MAXIMUM OF 4 FITTINGS MAY BE BONDED TOGETHER IF THEY ARE WITHIN 25' OF EACH OTHER.
2. ONE GALVANIC ANODE IS TO BE PLACED NEXT TO EACH FITTING.
3. TEST LEAD AND DRAIN WIRE ARE TO BE ATTACHED TO ONE OF THE BONDED FITTINGS AND ATTACHED TO THE TEST BOARD.

2021	
REVISION	

OAHU	ANODE TEST STATION (ATS) FOR MULTIPLE FITTINGS TERMINAL BOARD DETAIL	STANDARD DETAILS	CP19

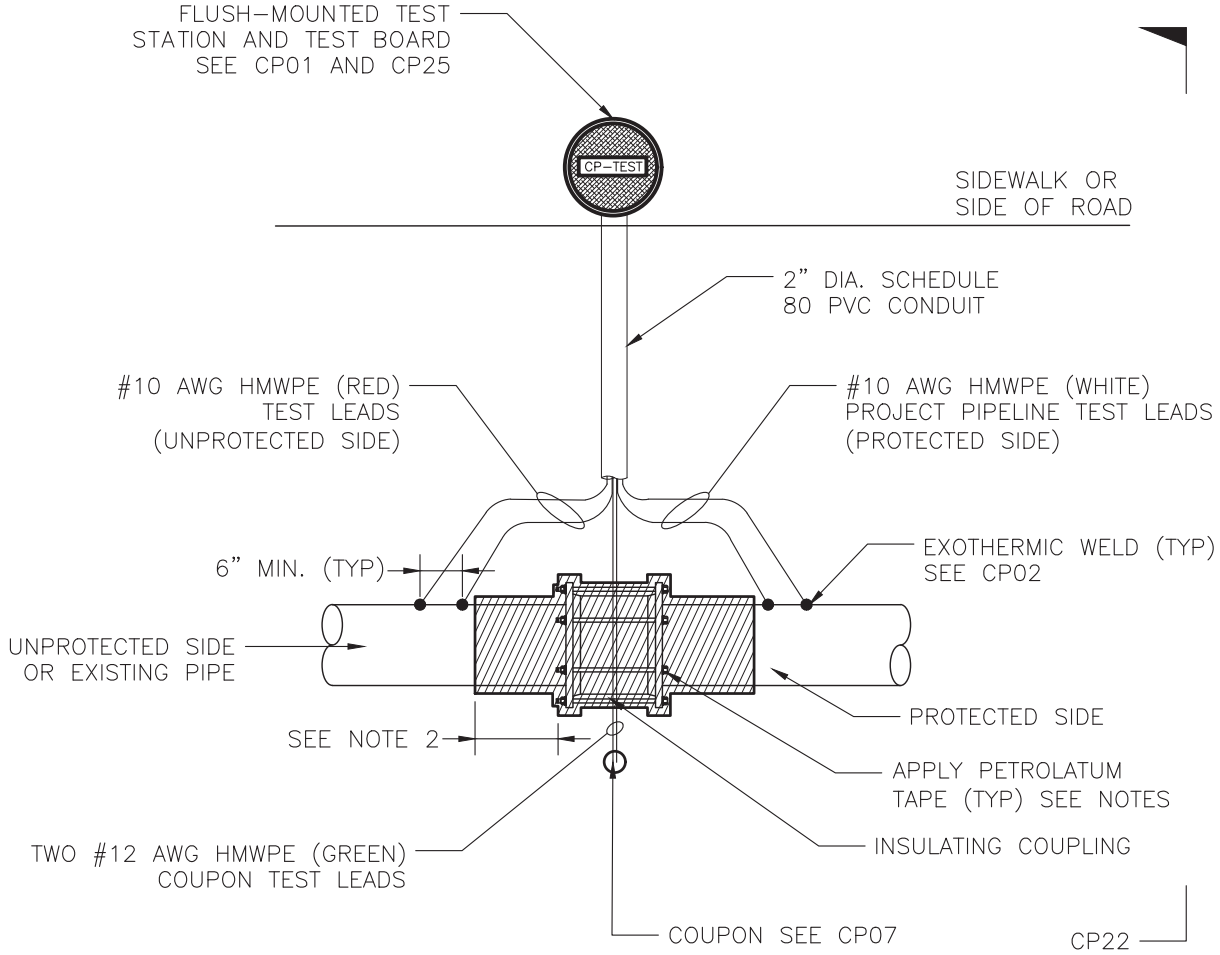


NOTES:

1. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".
2. PROVIDE A MINIMUM OF 2" SLACK TO ACCOMMODATE PIPE SETTLEMENT.

	2021
	REVISION

OAHU	FLEXIBLE COUPLING JOINT BOND DETAIL	STANDARD DETAILS	CP20

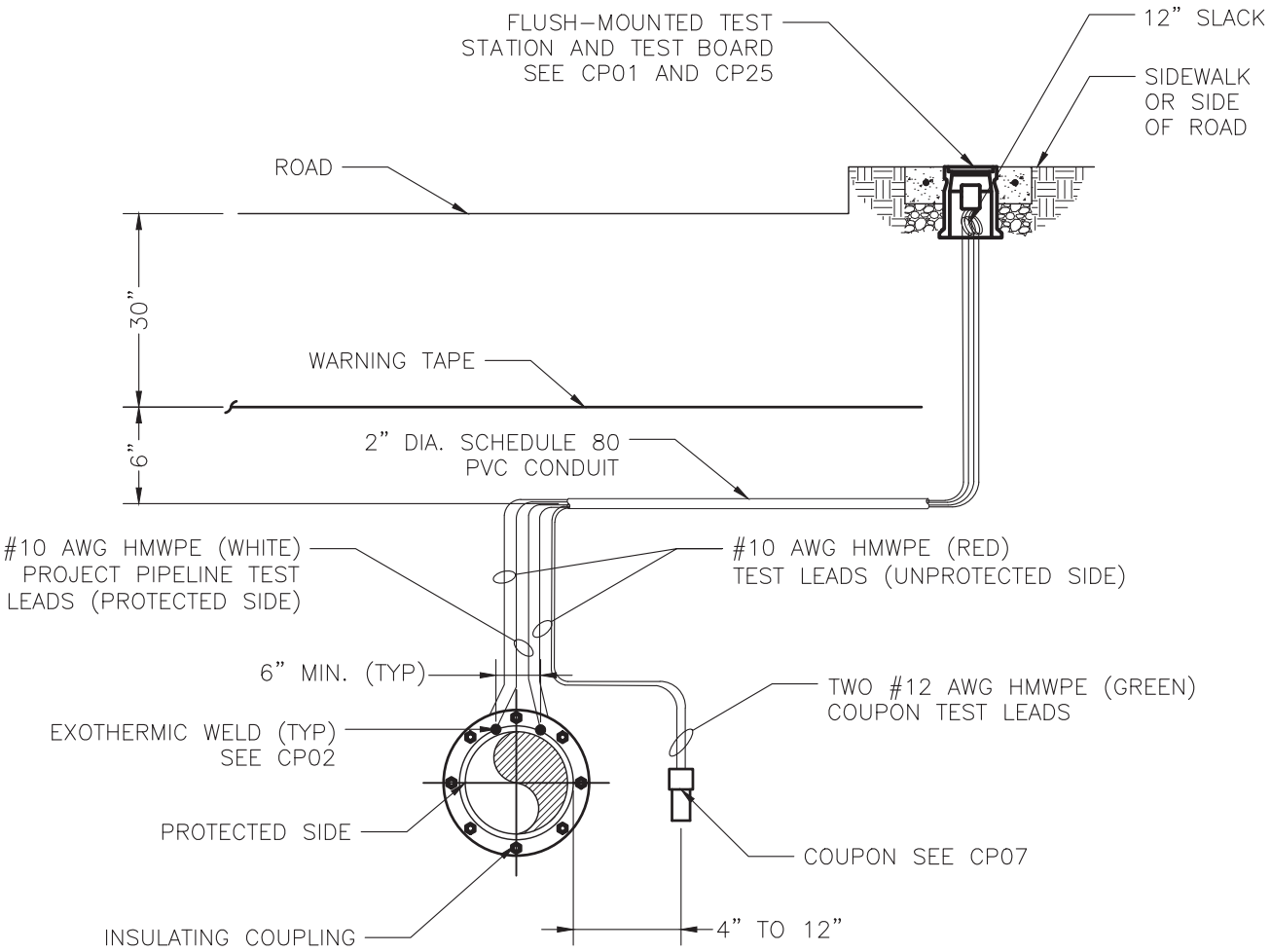


NOTES:

1. DO NOT APPLY PETROLATUM TAPE IF COUPLING IS LOCATED ABOVE GRADE OR IN A VAULT.
2. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".

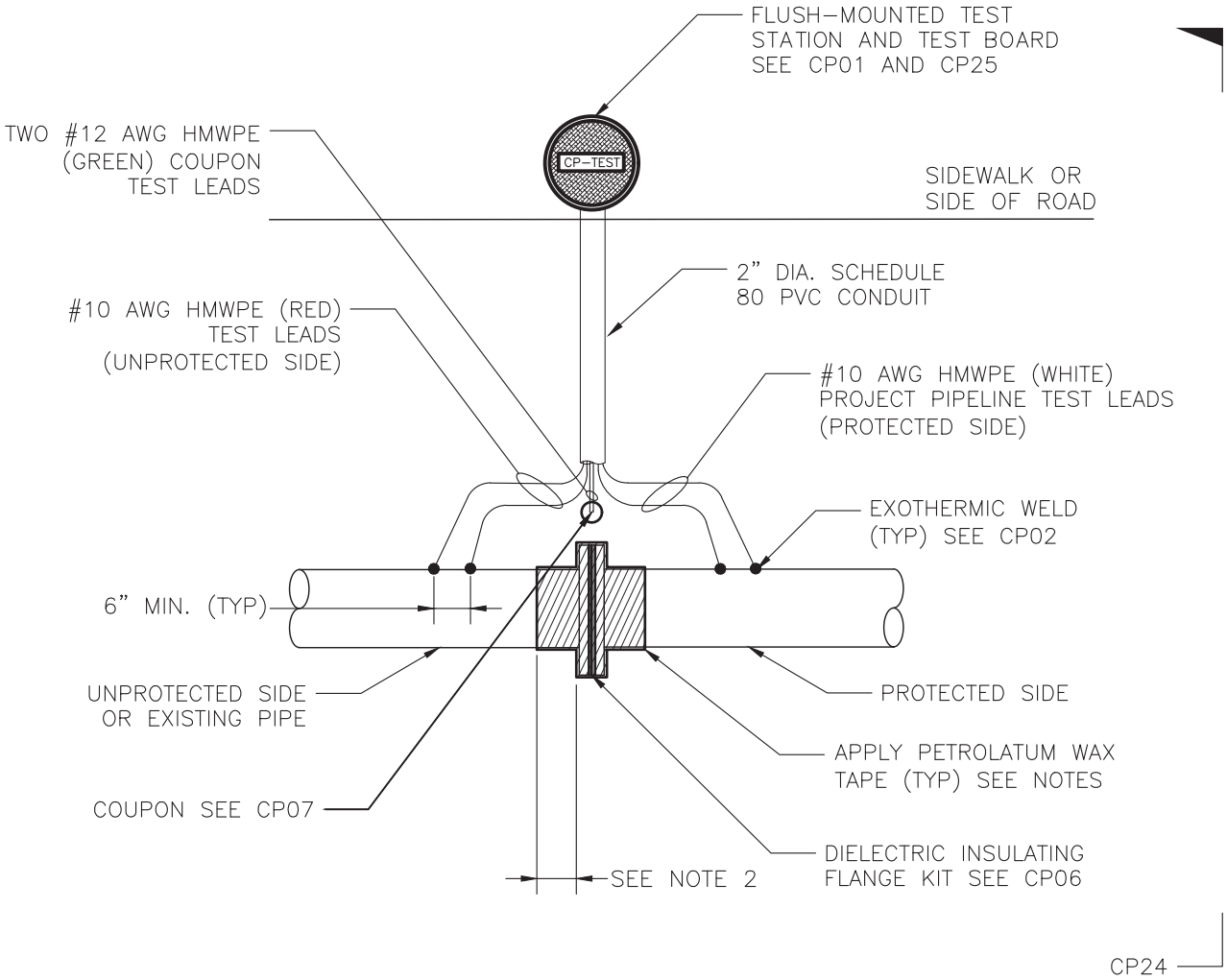
	2021
	REVISION

OAHU	INSULATING JOINT TEST STATION (IJTS) FOR COUPLING PLAN VIEW	STANDARD DETAILS	CP21



2021
REVISION

OAHU	INSULATING JOINT TEST STATION (IJTS) FOR COUPLING SECTION VIEW	STANDARD DETAILS	CP22



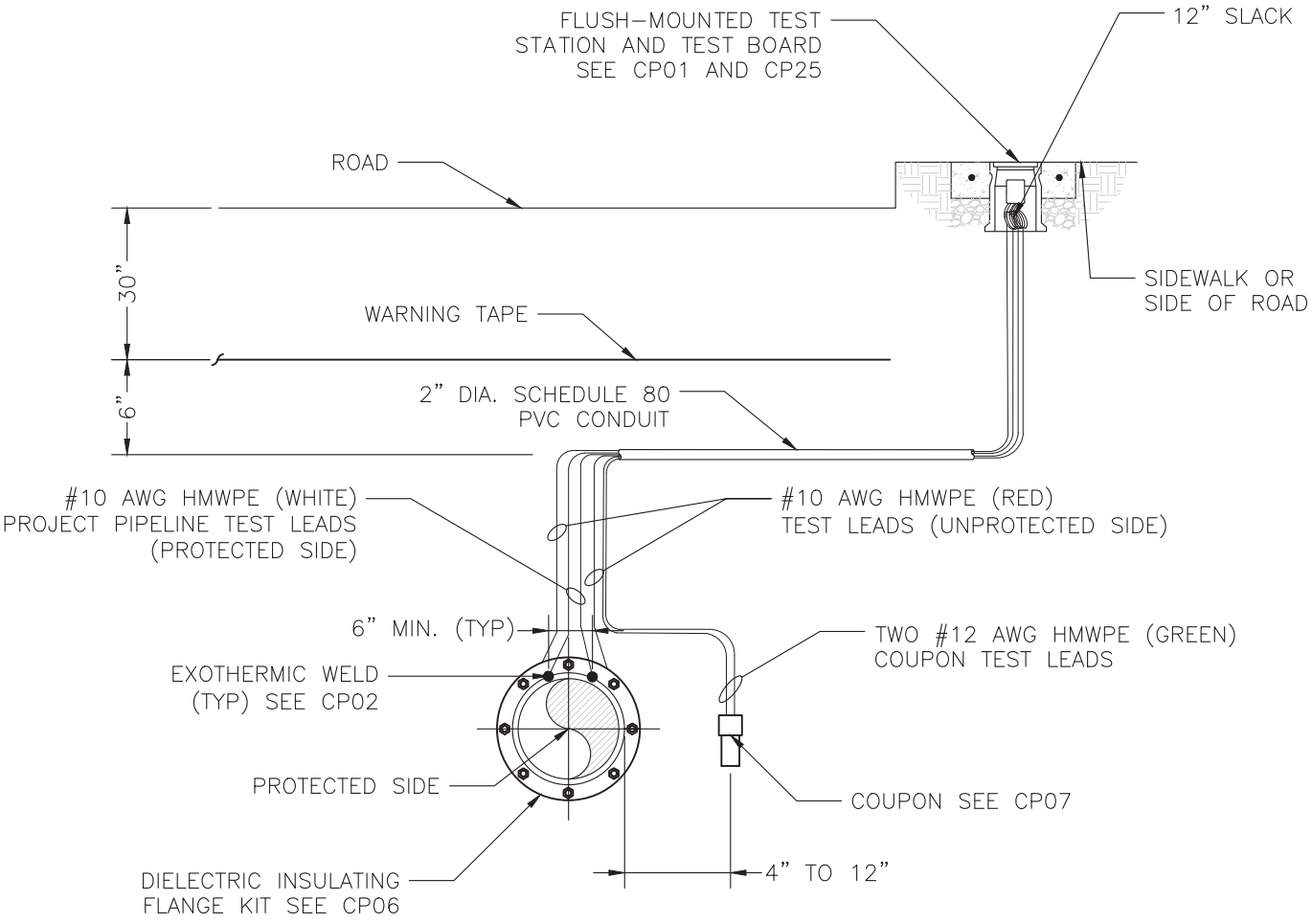
CP24

NOTES:

1. DO NOT APPLY PETROLATUM WAX TAPE IF INSULATING JOINT IS LOCATED ABOVE GRADE OR IN A VAULT.
2. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".

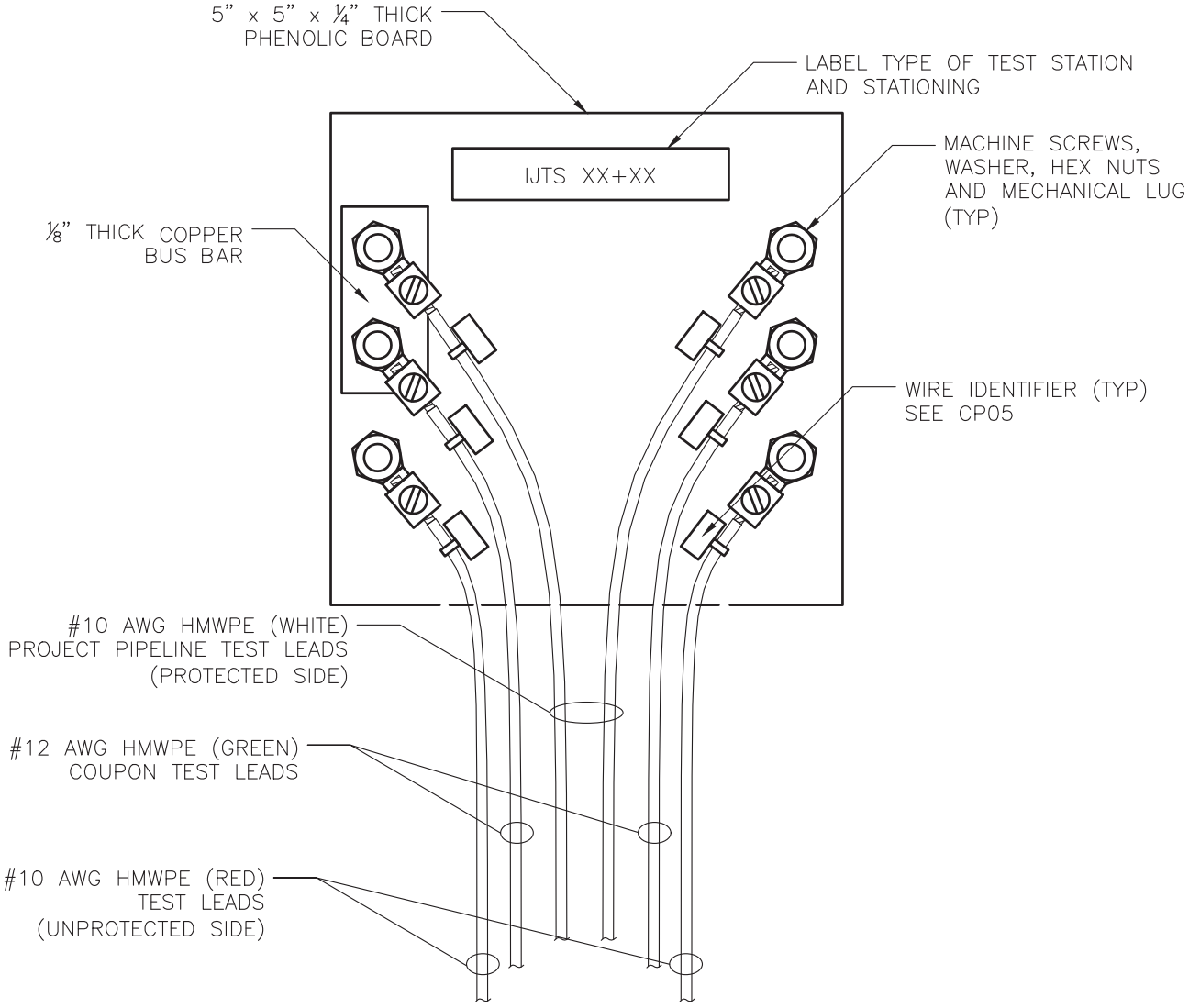
2021	
REVISION	

OAHU	INSULATING JOINT TEST STATION (IJTS) FOR BOLTED FLANGES PLAN VIEW	STANDARD DETAILS	CP23



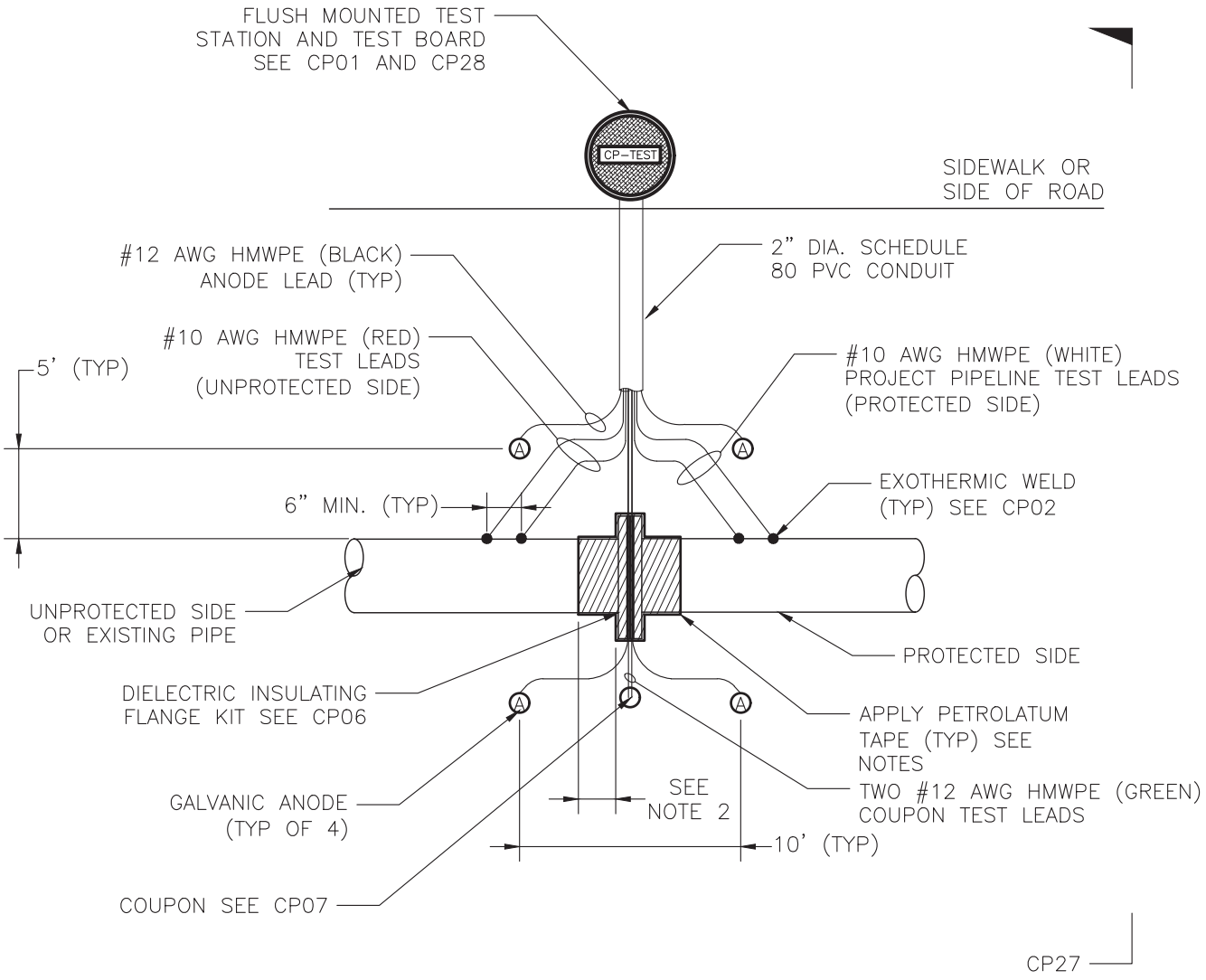
2021
REVISION

OAHU	INSULATING JOINT TEST STATION (IJTS) FOR BOLTED FLANGES SECTION VIEW	STANDARD DETAILS	CP24



2021	
REVISION	

OAHU	INSULATING JOINT TEST STATION (IJTS) TERMINAL BOARD DETAIL	STANDARD DETAILS	CP25



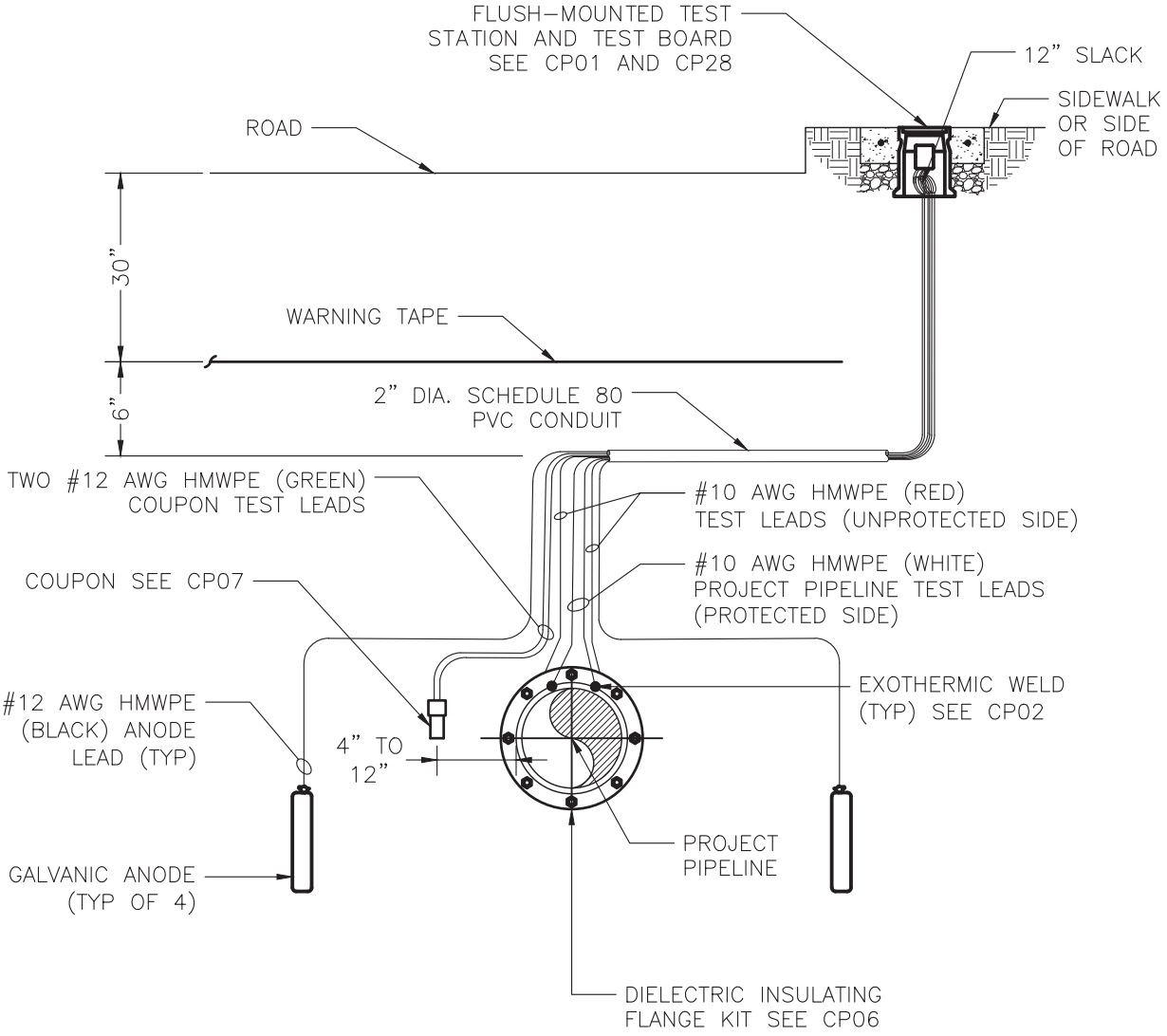
NOTES:

1. DO NOT APPLY PETROLATUM WAX TAPE IF INSULATING JOINT IS LOCATED ABOVE GRADE OR IN A VAULT.

2. WRAP FITTING IN PETROLATUM WAX TAPE AND OVERLAP PIPE BY 12".

	2021
	REVISION

OAHU	INSULATING JOINT ANODE TEST STATION (IJATS) PLAN VIEW	STANDARD DETAILS	CP26

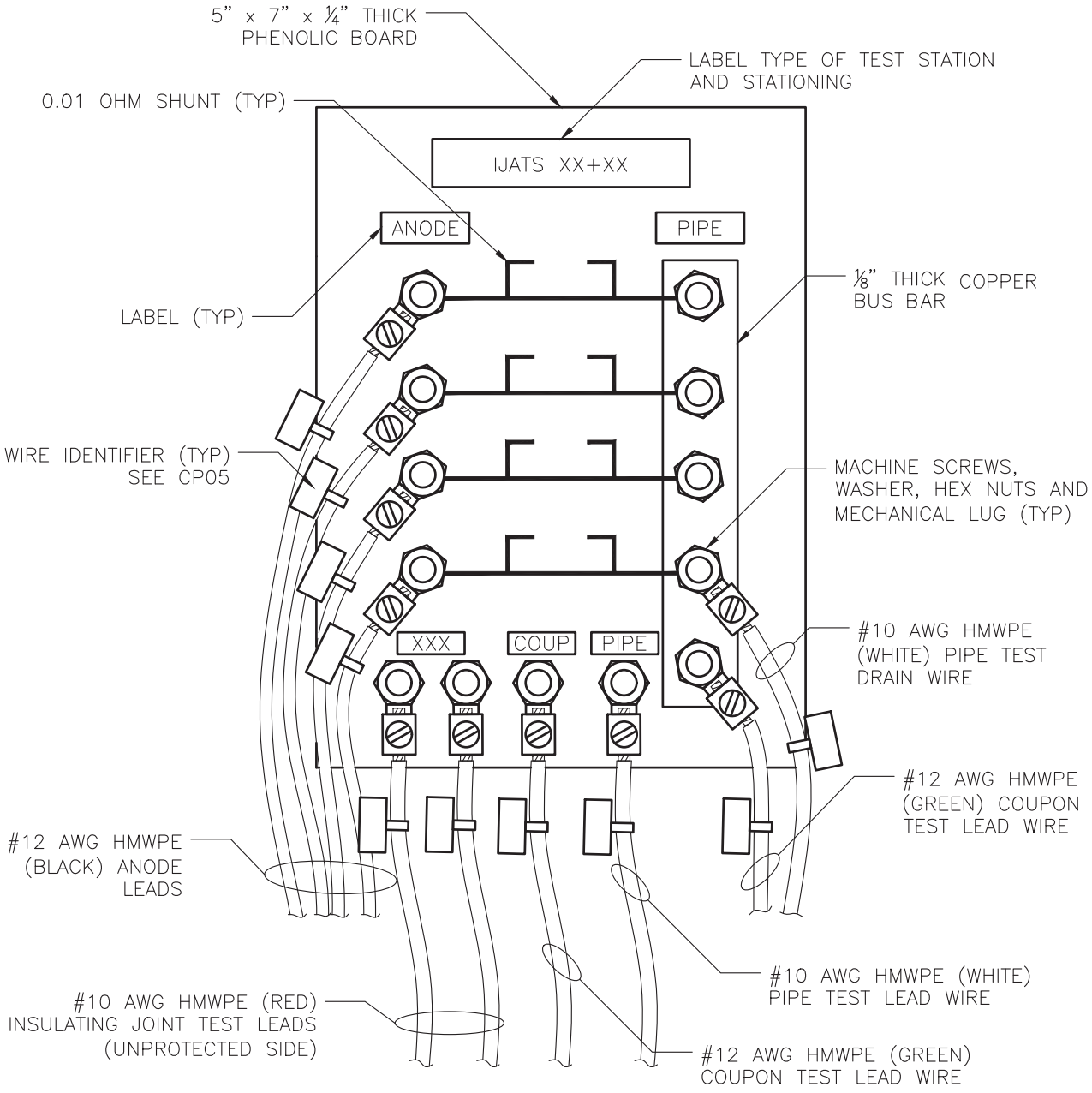


NOTE:

TOP OF ANODE SHALL BE ALIGNED WITH THE BOTTOM OF THE PROJECT PIPELINE.

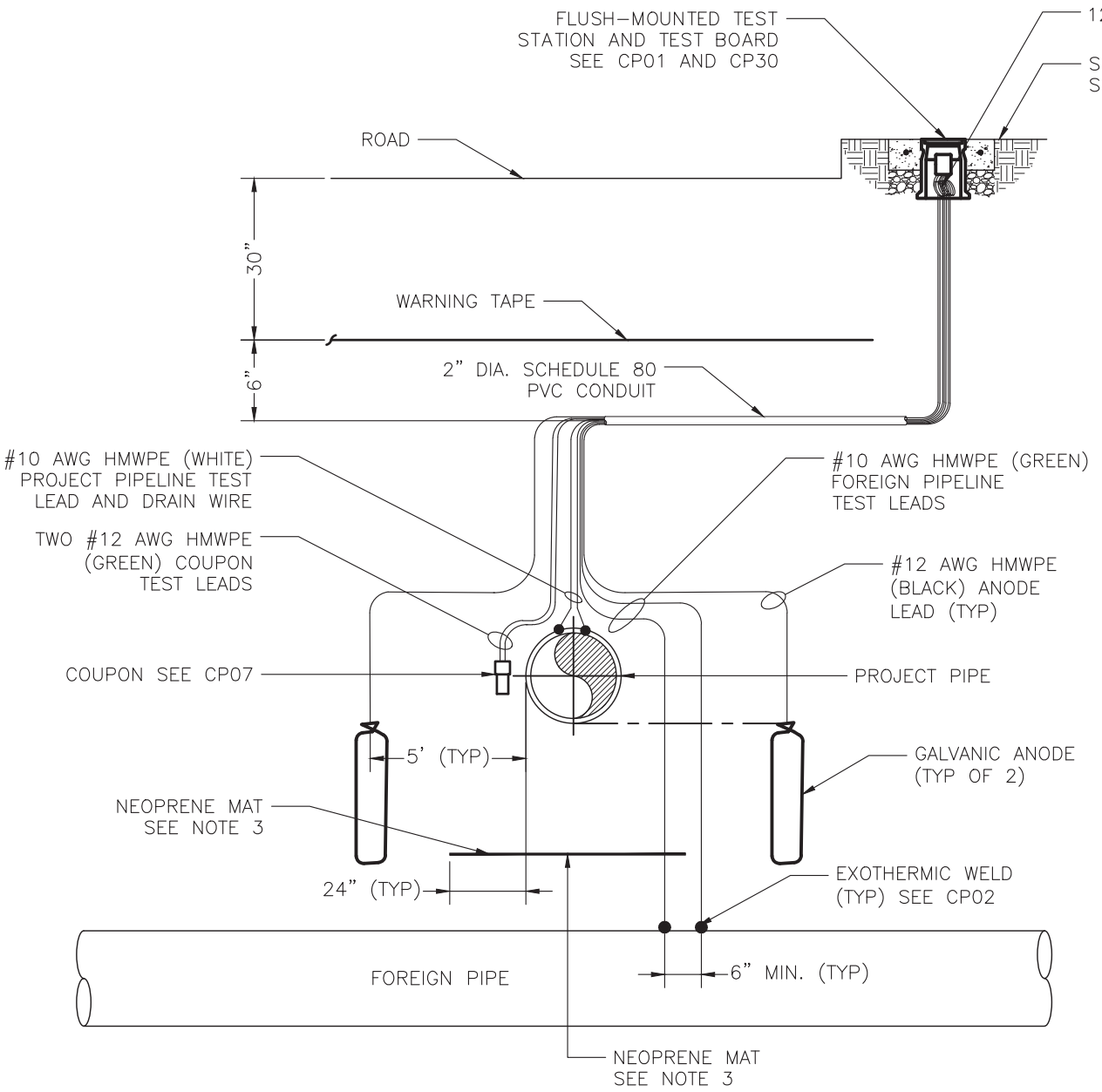
2021	
REVISION	

OAHU	INSULATING JOINT ANODE TEST STATION (IJATS) SECTION VIEW	STANDARD DETAILS	CP27



2021	
REVISION	

OAHU	INSULATING JOINT ANODE TEST STATION (IJATS) TERMINAL BOARD DETAIL	STANDARD DETAILS	CP28

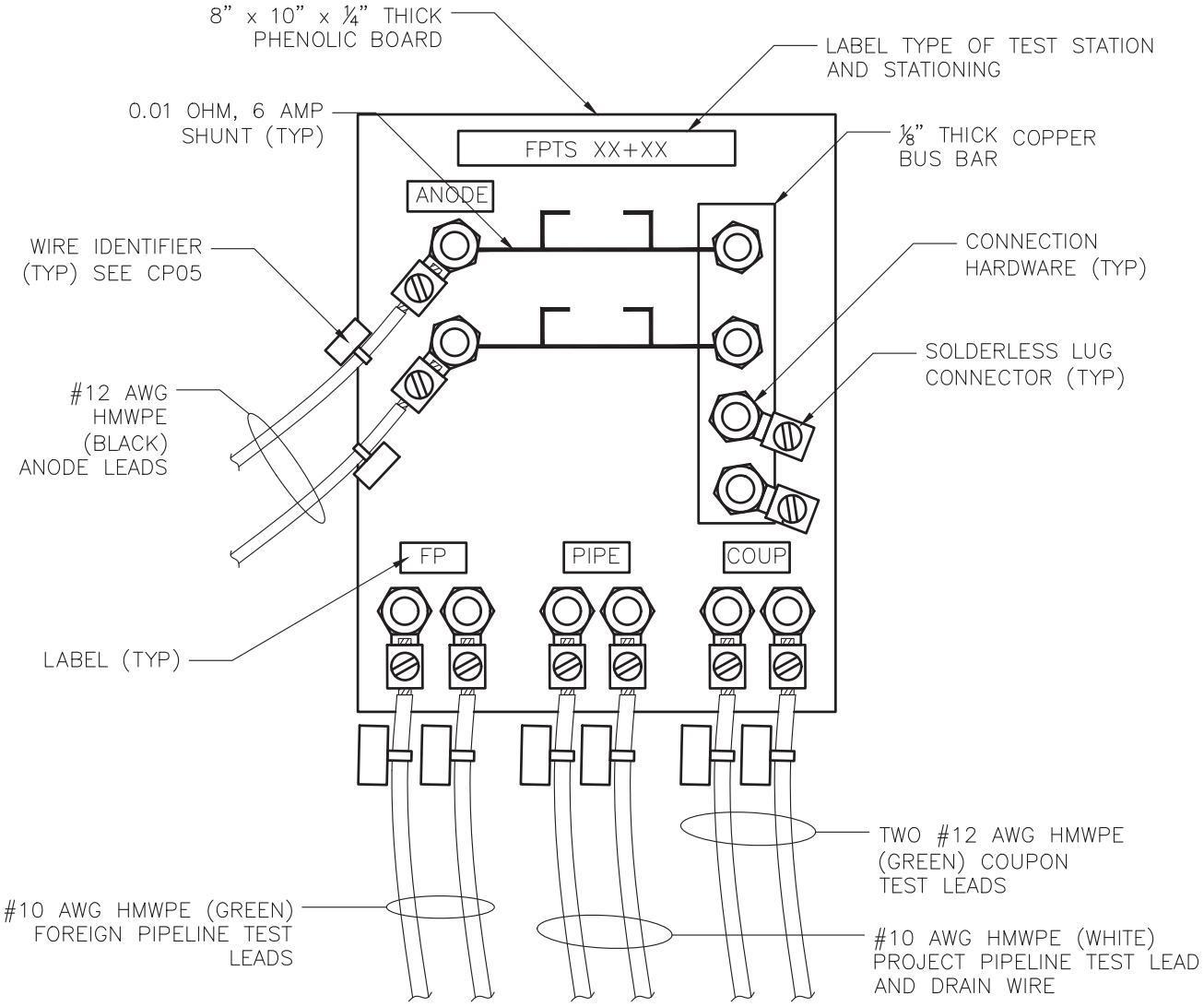


NOTES:

1. CONNECTIONS TO FOREIGN PIPELINES SHALL BE MADE BY THE OWNER'S REPRESENTATIVE.
2. TOP OF ANODE SHALL BE ALIGNED WITH THE BOTTOM OF THE PROJECT PIPELINE.
3. NEOPRENE MAT SHALL EXTEND 24" (MIN.) BEYOND PROJECT PIPE EDGE ON EACH SIDE.
4. COUPON SHALL BE INSTALLED 4" TO 12" FROM PROJECT PIPELINE.

2021	
REVISION	

OAHU	FOREIGN PIPELINE TEST STATION (FPTS) SECTION VIEW	STANDARD DETAILS	CP29

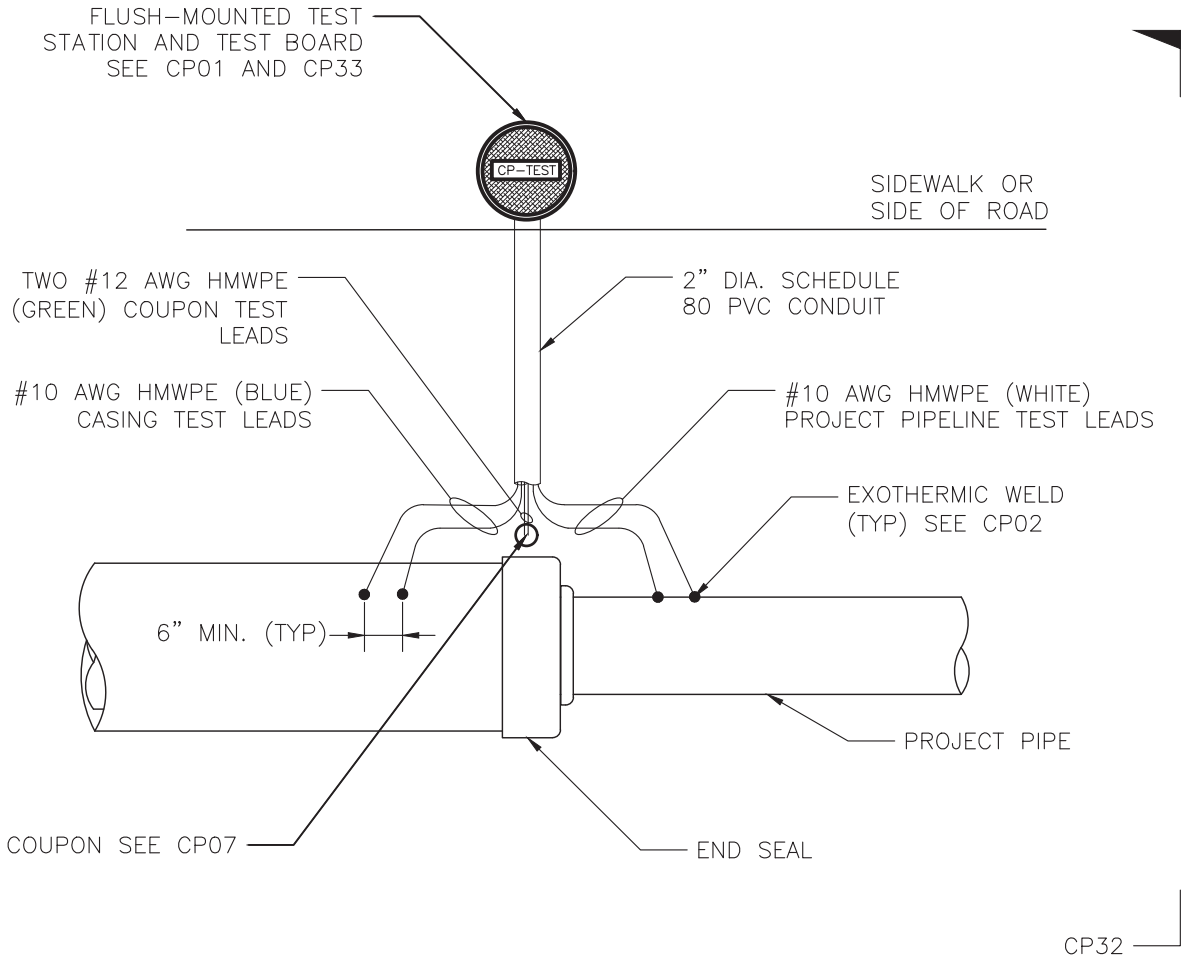


NOTE:

TERMINATE PIPELINE DRAIN WIRE AND COUPON DRAIN WIRE ON BUS BAR IF STRAY CURRENT IS A CONCERN.

2021	
REVISION	

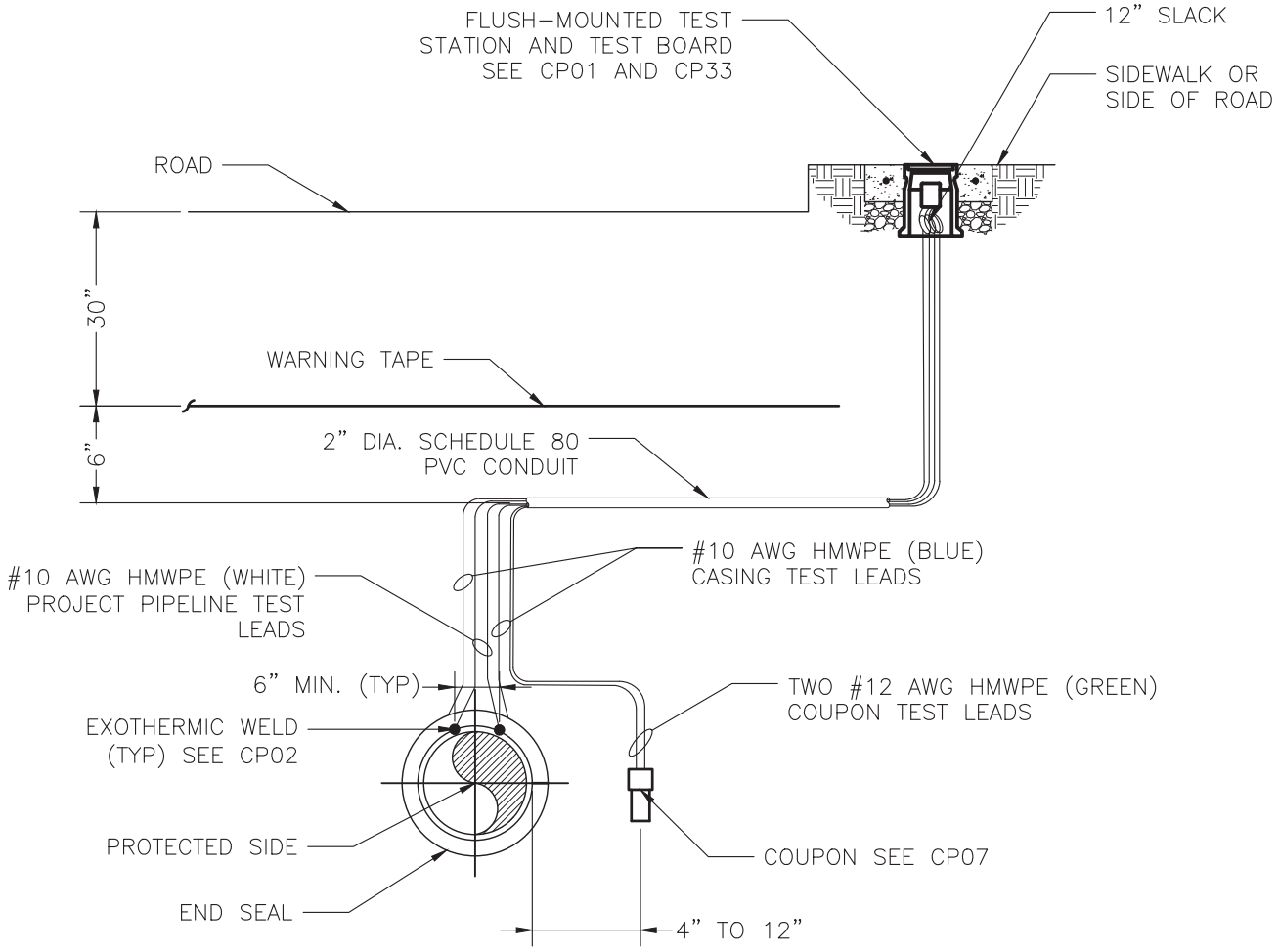
OAHU	FOREIGN PIPELINE TEST STATION (FPTS) TERMINAL BOARD DETAIL	STANDARD DETAILS	CP30



CP32

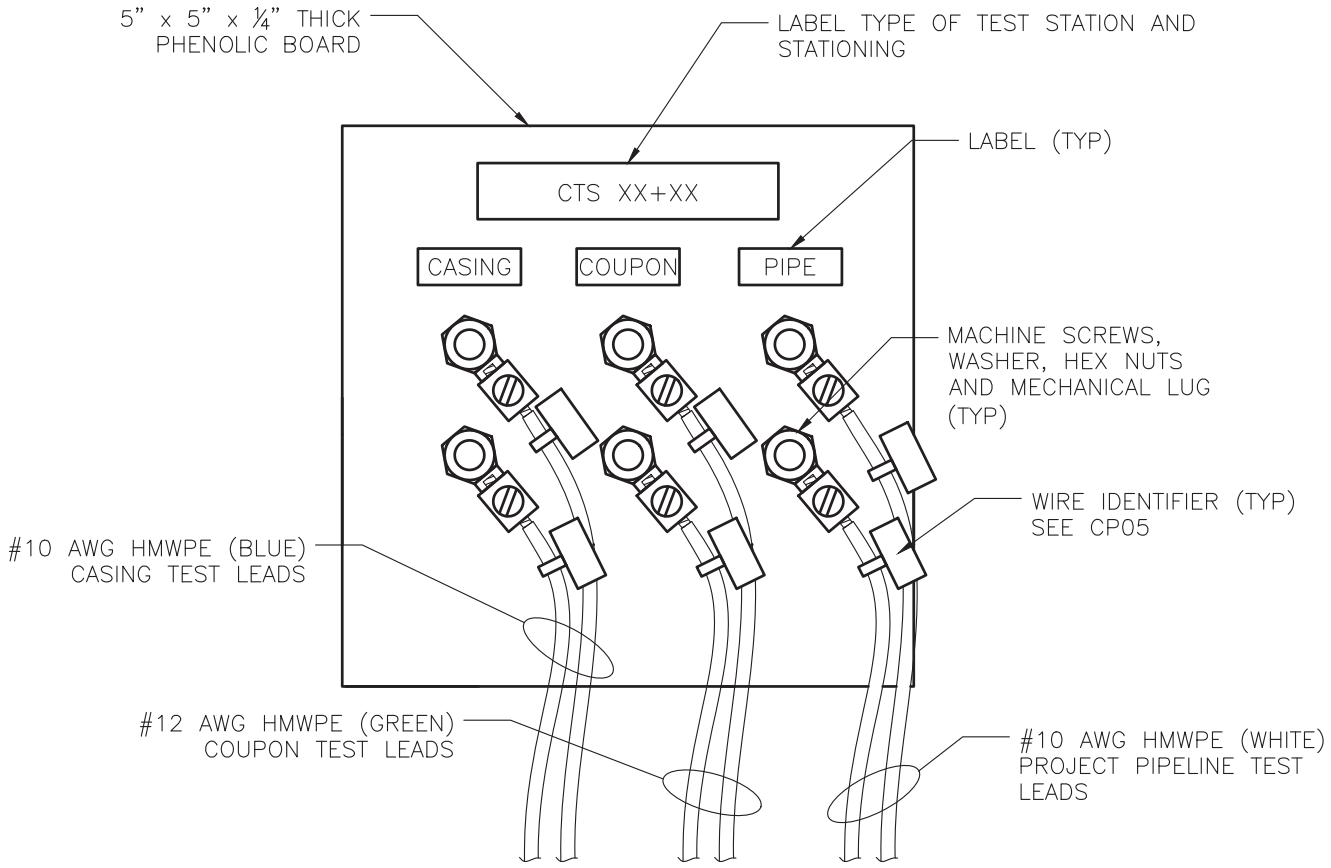
	2021
	REVISION

OAHU	CASING TEST STATION (CTS) PLAN VIEW	STANDARD DETAILS	CP31



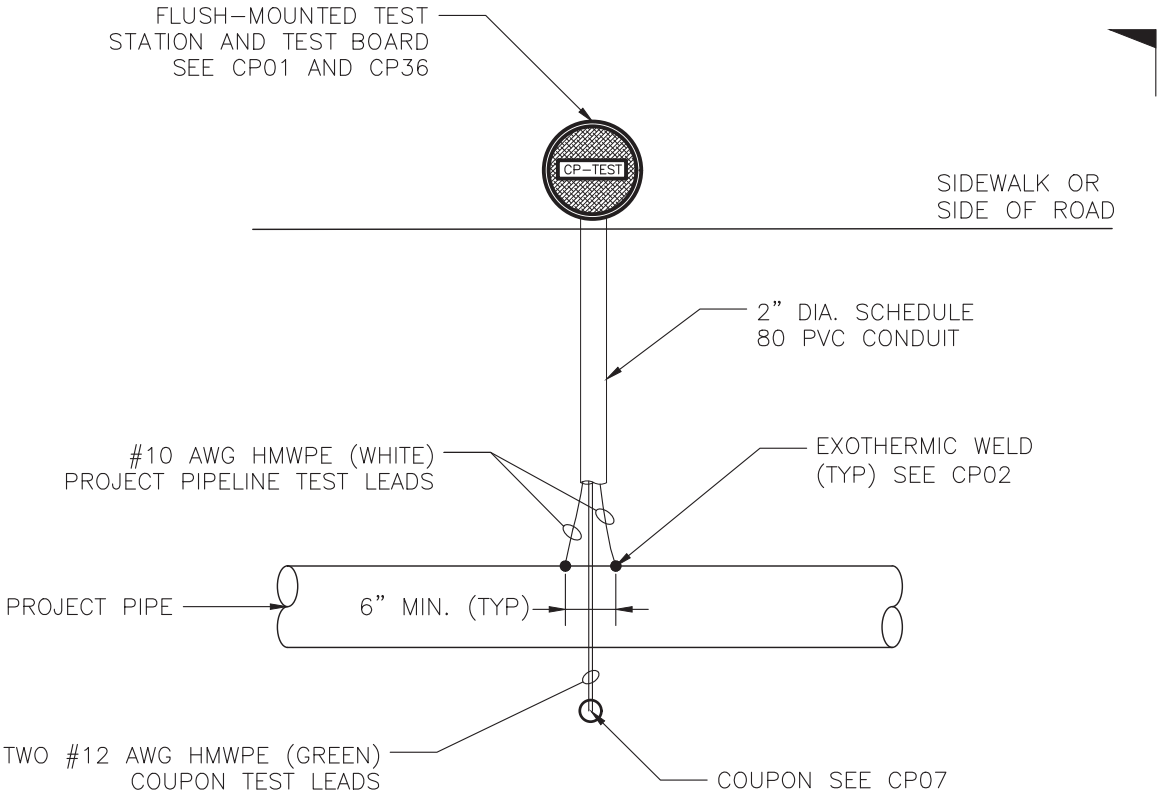
	2021
	REVISION

OAHU	CASING TEST STATION (CTS) SECTION VIEW	STANDARD DETAILS	CP32



2021	
REVISION	

OAHU	CASING TEST STATION (CTS) TERMINAL BOARD DETAIL	STANDARD DETAILS	CP33



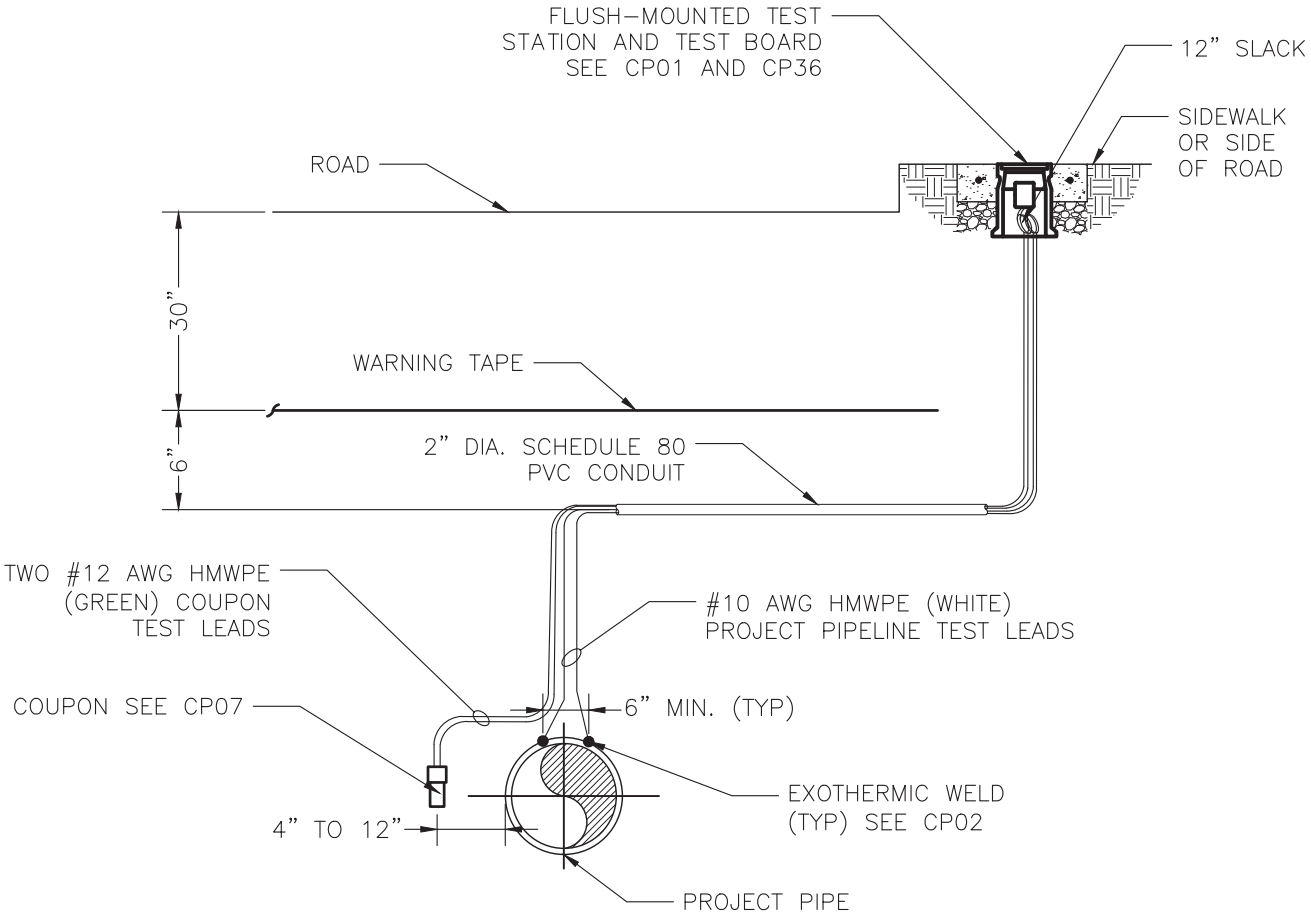
CP35

NOTE:

TEST STATIONS SHALL BE LOCATED NEXT TO FIRE HYDRANTS, WHERE FEASIBLE, SO THAT LATERAL WIRE RUNS PARALLEL FIRE HYDRANT LATERALS.

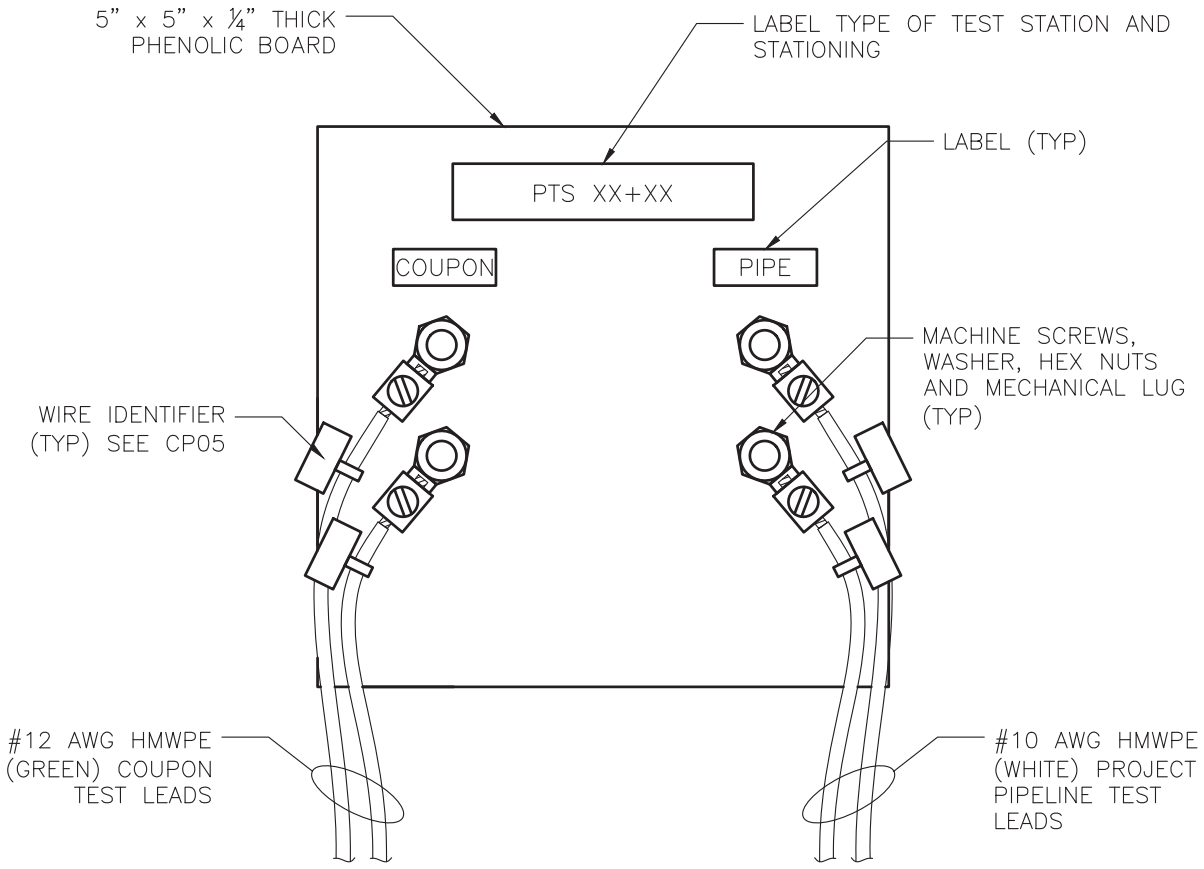
2021	
REVISION	

OAHU	POTENTIAL TEST STATION (PTS) PLAN VIEW	STANDARD DETAILS	CP34



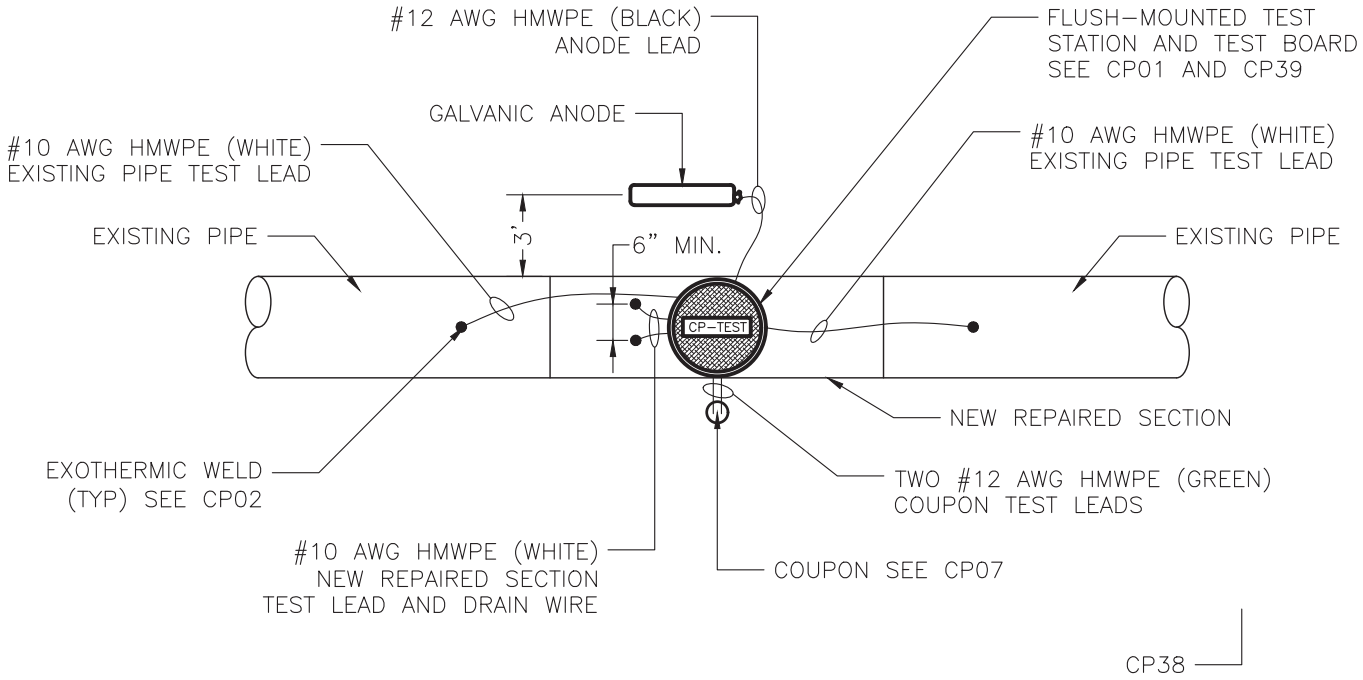
2021	
REVISION	

OAHU	POTENTIAL TEST STATION (PTS) SECTION VIEW	STANDARD DETAILS	CP35



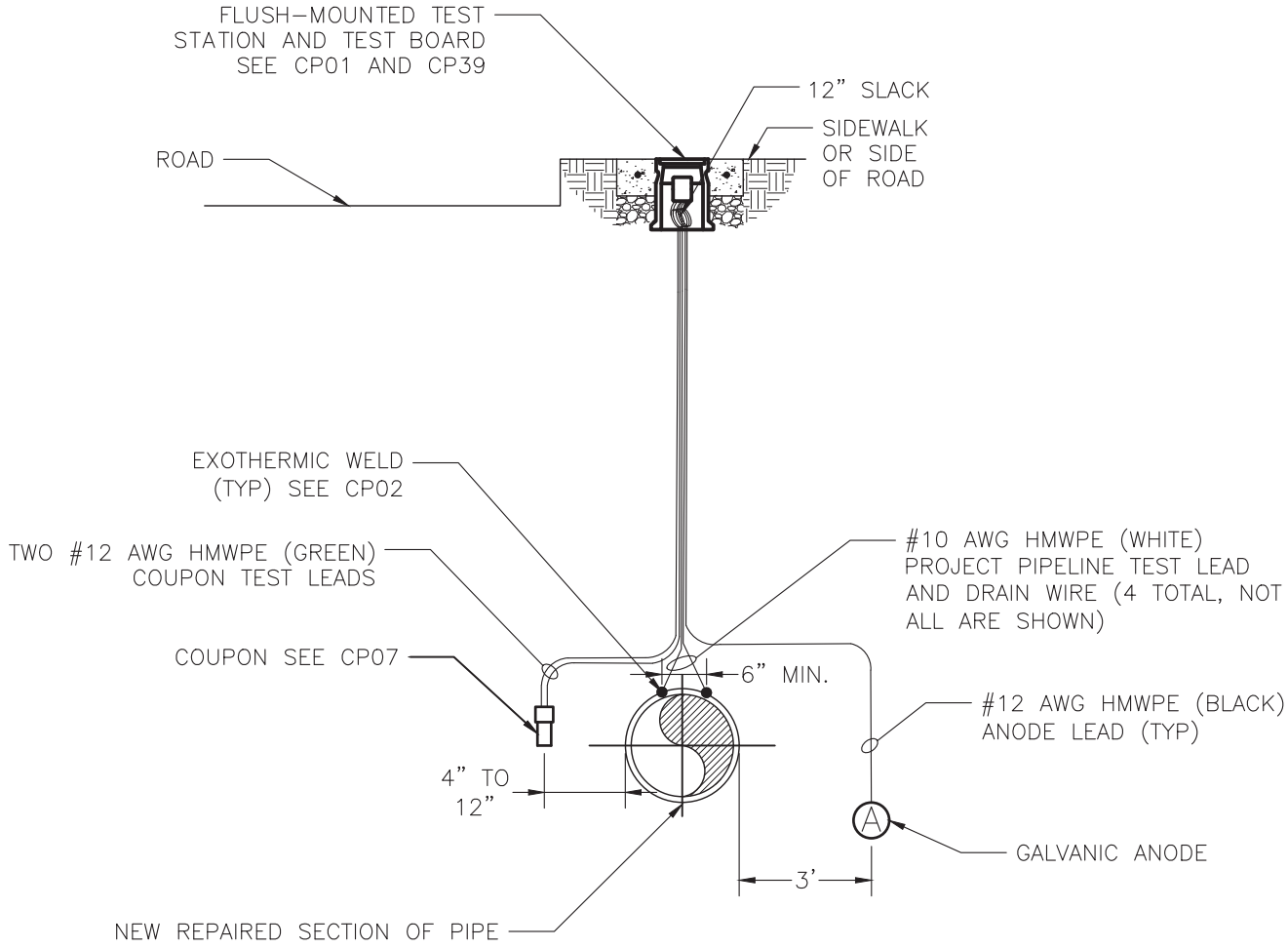
	2021
	REVISION

OAHU	POTENTIAL TEST STATION (PTS) TERMINAL BOARD DETAIL	STANDARD DETAILS	CP36



	2021
	REVISION

OAHU	ANODE TEST STATION (ATS) FOR REPAIRED SECTION PLAN VIEW	STANDARD DETAILS	CP37

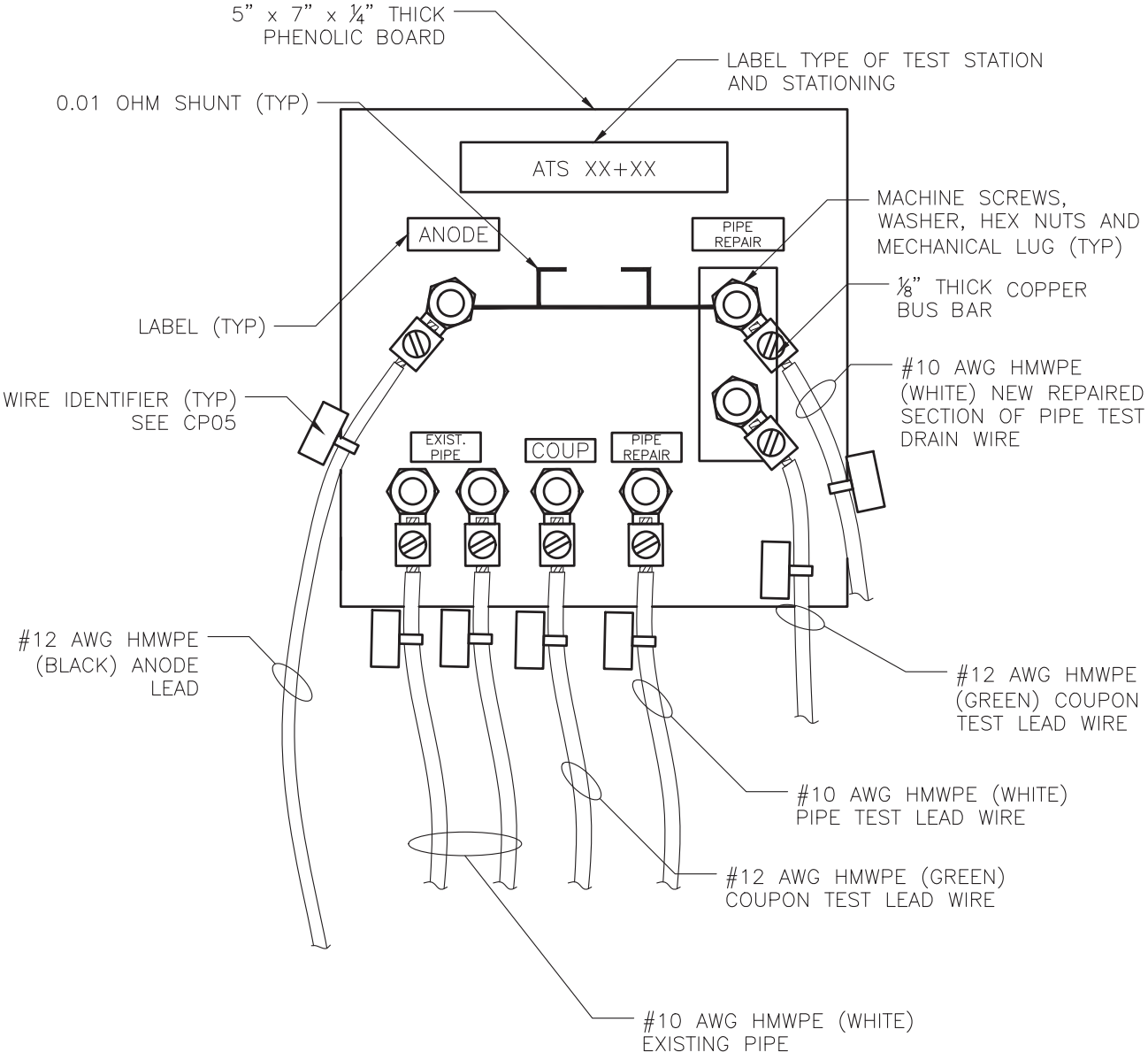


NOTE:

ANODE SHALL BE PLACED IN THE CORNER OF THE EXCAVATION TRENCH.

	2021
	REVISION

OAHU	ANODE TEST STATION (ATS) FOR REPAIRED SECTION SECTION VIEW	STANDARD DETAILS	CP38



2021	
REVISION	

OAHU	ANODE TEST STATION (ATS) FOR REPAIRED SECTION TERMINAL BOARD DETAIL	STANDARD DETAILS	CP39