

OWNER

Cathodic Protection Installation and Testing



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ISSUE SUMMARY AND APPROVAL

This page records each issue of SPC-SPC-015. The preparer, reviewer and approver sign for each revision.

Rev.	Date	Issue purpose	Description
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Contributors

Rev.	Discipline	Prepared by	Reviewed by	Approved by
A	Specifications			

SECTION PC-SPC-015

CATHODIC PROTECTION INSTALLATION AND TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes the installation, energizing, testing and documentation of the cathodic protection (CP) system designed in CP-CAL-001 and shown on CP-DWG-001 and CP-DWG-002. The protected structure is the buried metallic piping between the insulating joints IJ-101 (inlet) and IJ-102 (outlet), and the outlet lateral:

1. Buried station piping between IJ-101 and IJ-102, including the buried drains 2"-L-1060 and 2"-L-1061 and any buried metallic vent piping.
2. The buried outlet lateral 12"-G-1042-A6 (NPS 12, 0.500 in wall) from IJ-102 at (220, 152.5) to the tap valve flange at (220, 257), about 96 ft buried plus the riser (final length by survey, HOLD H-04). The lateral is protected by the station system and isolated from the trunkline of (the receiving pipeline operator), unless the receiving pipeline operator directs otherwise. The electrical boundary at the tap valve, an insulating flange kit or an agreed bond, depends on its requirements (HOLD H-01 and H-04).
3. The impressed current deep anode bed DW-101 and its rectifier, header and lead cables, junction boxes, test stations, reference electrodes and coupons, exothermic connections to pipe, insulating joint testing, and the AC mitigation of CP-CAL-001 Section 11.
4. The native potential survey, energizing and adjustment, commissioning survey, and interference testing with the trunkline and any foreign structure.
5. Electrical isolation of above-grade piping from its supports by dielectric pads, coordinated with SPC-SPC-004 and SPC-SPC-006.

B. Related sections:

1. SPC-SPC-004, Structural Steel, Canopy and Pipe Supports; SPC-SPC-006, Piping Fabrication and Installation.
2. SPC-SPC-009, External Coating of Buried Pipe and Field Joints (coating and repair materials).
3. SPC-SPC-012, Tie-in, Hot Tap Coordination and Purging.
4. SPC-SPC-013, Electrical Installation in Hazardous Locations (rectifier AC supply and station grounding).
5. SPC-SPC-018, Pre-commissioning, Commissioning and Startup; SPC-SPC-020, Construction Records and Turnover.

C. Work by others:

1. CP of the Owner's upstream 12 in lateral, upstream of IJ-101 (separate Owner project).
2. CP of the trunkline and hot tap fitting (receiving pipeline operator).



3. The AC circuit to the rectifier disconnect (SPC-SPC-013).
4. Pipe coating and holiday testing (SPC-SPC-009). Coating repair at CP connections is included in this section, with the SPC-SPC-009 repair materials.
5. Station grounding (SPC-SPC-013). Decoupling devices between the grounding and CP systems are included in this section where CP-CAL-001 requires them.

1.02 REFERENCES

A. Codes and standards:

1. 49 CFR 192 Subpart I, Requirements for Corrosion Control, including 192.455 (protection within one year of construction), 192.463 and Appendix D (criteria), 192.465 (monitoring), 192.467 (electrical isolation), 192.469 and 192.471 (test stations and leads), 192.473 (interference) and 192.491 (records).
2. 165:20, pipeline safety rules.
3. AMPP SP0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems (current edition).
4. AMPP SP0177, Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems.
5. AMPP SP21424, Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring; ISO 18086, Corrosion of Metals and Alloys, Determination of AC Corrosion.
6. AMPP TM0497, Measurement Techniques Related to Criteria for Cathodic Protection.
7. AMPP SP0286, Electrical Isolation of Cathodically Protected Pipelines.
8. AMPP SP0572, Design, Installation, Operation, and Maintenance of Impressed Current Deep Anode Beds.
9. AMPP SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
10. ASTM G57 and IEEE 81 (soil resistivity by the Wenner four-pin method).
11. Water Resources Board rules, 785 (well construction, driller licensing and registration), as they apply to a deep anode well (HOLD H-19).
12. NFPA 70-2023 (rectifier wiring).

B. Project documents:

1. CP-CAL-001, Cathodic Protection Design (including Section 11, AC interference screening); CP-LST-001, CP Test Station Schedule.
2. CP-DWG-001, Cathodic Protection Layout Plan; CP-DWG-002, Cathodic Protection Details.
3. ELE-CAL-005, Station Grounding and Bonding Design; ELE-DWG-004, Grounding and Lightning Protection Plan; ELE-RPT-001, Hazardous Area Classification.

4. PIP-DWG-001 to PIP-DWG-003, Piping General Arrangement; PIP-DWG-004, Tie-in and Outlet Lateral 1042 Plan and Profile.
5. GEN-DB-001, Basis of Design (soil resistivity 1,500 ohm-cm assumed, HOLD H-08).

1.03 DEFINITIONS

- A. CSE: copper/copper-sulfate reference electrode.
- B. On potential: the structure-to-electrolyte potential with CP current applied, including IR drop.
- C. Instant-off potential: the potential measured 0.2 to 1 s after synchronous interruption of all current sources, taken as the polarized potential.
- D. Native potential: the potential before any CP current is applied. Polarization shift: the difference between the native (or depolarized) and instant-off potentials.
- E. Coupon: a bare steel sample of known area connected to the pipe through a test station, used for IR-free potential and AC current density measurements.

1.04 SUBMITTALS

- A. The Contractor shall submit the items in Table 1-1.

Table 1-1: Submittal Schedule

No.	Submittal	Timing	Action
15-01	Installer qualifications: supervisor certified AMPP CP Technician (CP2) or higher; commissioning survey by an AMPP CP Technologist (CP3) or CP Specialist (CP4); operator qualification for the covered tasks	30 days before start	Owner approval
15-02	Material data: anodes, rectifier datasheet and factory test report, cable, test stations, reference electrodes, coupons, decouplers, thermite molds and cartridges, repair coating	30 days before purchase	EOR approval
15-03	Installation procedure, including the thermite weld procedure, charge sizes and the method of verifying pipe wall thickness	14 days before installation	EOR approval
15-04	Soil resistivity and native potential survey results (if not already done under HOLD H-08)	Before anode installation	EOR review
15-05	Insulating joint test reports: factory certificates and field tests on receipt, after installation and after hydrotest	Within 3 days of each test	EOR and Owner review
15-06	Energizing and commissioning survey report: native, on and instant-off potentials at every test point, rectifier settings and output, anode current, coupon data, AC data, interference results, and conclusion against the criteria	Within 14 days of the survey	EOR and Owner approval
15-07	Interference test agreement and results with the receiving pipeline operator and any foreign operator, signed by both parties	Before and after energizing	Owner review

No.	Submittal	Timing	Action
15-08	CP as-builts: surveyed locations of the anode well, cables, test stations, coupons and insulating joints (± 0.2 ft)	At turnover	EOR and Owner review
15-09	Water Resources Board registration of DW-101, or the Owner's written determination that none is required, and the driller's license	Before drilling	Owner approval

1.05 QUALITY ASSURANCE

- A. Only persons qualified under the Owner's operator qualification program for the task shall make exothermic connections to pipe or take CP readings.
- B. Reference electrodes shall be checked against a master electrode before each survey and shall agree within 5 mV.
- C. Hold and witness points shall be as listed in 3.10 and in SPC-SPC-019.

1.06 MEASUREMENT AND PAYMENT

- A. Pay item 15.01, Cathodic protection installation: lump sum, including all Contractor-furnished CP materials (anode well, rectifier, cable, test stations, coupons, reference electrodes, decouplers, and dielectric pads not supplied with the supports), soil resistivity and AC surveys if not previously done, installation, thermite connections with coating, insulating joint tests, dielectric isolation of supports and as-builts. It excludes the rectifier AC circuit (pay item 13.01) and the insulating joints, which are Owner-furnished.
- B. Pay item 15.02, CP energizing and commissioning survey: lump sum, including the native survey, energizing, the preliminary (24 hour) and final (30 day) surveys, interrupters, interference testing with the receiving pipeline operator and foreign operators, and the report. The receiving pipeline operator's own costs are excluded.

PART 2 PRODUCTS

2.01 GENERAL

- A. CP materials are Contractor-furnished and shall be furnished exactly as specified in CP-CAL-001. The minimum requirements in this part apply where the design is silent.

2.02 ANODES, RECTIFIER AND CABLE

- A. Deep anode bed: mixed metal oxide tubular anodes or high-silicon chromium cast iron anodes in calcined petroleum coke breeze, with a vent pipe, as designed in CP-CAL-001.
- B. Rectifier: air-or oil-cooled, with the output voltage and current of the design, a silicon diode bridge, tap or constant-current control, a remote monitoring output to the remote terminal unit (4 to 20 mA or Modbus where specified), a current interrupter capable of GPS-synchronized cycling,

surge protection on the AC and DC sides, and a lockable NEMA 3R or 4X enclosure. It shall be located outside the classified areas or listed for the location.

- C. Anode lead and header cable: dual-insulated chlorine-resistant cable (Halar over high-molecular-weight polyethylene) for anode leads, and header cable sized per the design (typically 2 to 8 AWG). Chlorine-resistant insulation is required because the anode reactions in a deep bed generate chlorine that degrades ordinary insulation.
- D. Test leads: stranded copper with THWN or high-molecular-weight polyethylene insulation, 10 AWG for current and drain leads and 12 AWG for potential leads, color coded per 3.04 B.

2.03 TEST STATIONS, COUPONS AND REFERENCES

- A. Test stations shall be flush-mounted with traffic-rated lids in roads and yard areas, or post-mounted outside traffic areas, with labeled terminal boards and shunts.
- B. Coupons shall be steel with 1 cm² or 10 cm² exposed area as designed, with an integral permanent CSE reference or a separate coupon with a portable reference, each with its own test station.
- C. Permanent reference electrodes shall be long-life copper/copper-sulfate or zinc, at IJ-102 and at the most remote buried point, as designed.
- D. Decoupling devices shall be solid-state, rated for the fault and AC currents of CP-CAL-001 Section 11 and ELE-CAL-005, and listed for Class I, Division 2 where located in a classified area.

2.04 CONNECTION AND ISOLATION MATERIALS

- A. Exothermic connections to pipe shall use copper-oxide thermite in cartridges of no more than 15 g (3.03), with molds sized for the cable and the pipe diameter.
- B. Connection coating repair shall be an epoxy mastic or a prefabricated thermite-weld cap compatible with fusion-bonded epoxy, per SPC-SPC-009.
- C. Dielectric pads shall be fiberglass-reinforced plastic or high-density polymer, at least 1/4 in thick, extending at least 1 in beyond the support contact on each side, at every above-grade pipe support.
- D. IJ-101 and IJ-102 are Owner-furnished monolithic insulating joints, factory tested per 3.08.

PART 3 EXECUTION

3.01 SEQUENCE

- A. The work shall follow this sequence:
 - 1. Soil resistivity survey by the Wenner four-pin method at the anode well and along the piping, and an AC interference survey of nearby power lines, if not already complete (HOLD H-08). Results shall go to the CP designer for confirmation before the anode well is drilled.

2. Review of insulating joint factory certificates and test on receipt.
3. Test leads attached to the pipe during installation, before lowering-in where possible, and coated.
4. Anode well, header cable and test stations installed during backfill of the piping trenches, before final grading.
5. Insulating joint tests after installation and after hydrotest.
6. Native potential survey after backfill and before energizing, at least 7 days after backfill so that potentials have stabilized.
7. Energizing within the one year that 49 CFR 192.455 allows, and in any case before gas-in, so that the station is protected at startup (Owner requirement).
8. A preliminary survey 24 hours after energizing and the final commissioning survey at least 30 days after energizing, when the pipe has polarized.
9. Interference testing with the receiving pipeline operator and any foreign operator.

3.02 DEEP ANODE BED AND RECTIFIER

- A. The impressed current deep anode well DW-101 shall be installed per CP-CAL-001 and AMPP SP0572: a 10 in hole to 175 ft total depth at plot (285, -45) in the southeast corner of the lease tract, with 20 ft of 12 in PVC surface casing and an active coke column from 100 to 160 ft, and with a drilling log, anode spacing, breeze column and vent. Drilling within 50 ft of any pipe requires Owner approval.
- B. Registration with the Water Resources Board may be required before drilling (HOLD H-19). Drilling shall not start until the Owner releases this hold in writing (hold point HP-15-05). The driller shall hold the license the Board requires for the well type, shall grout the surface casing annulus so that the well cannot connect aquifers, and shall submit the well log or completion report within the period the Board requires. Groundwater encountered shall be recorded on the drilling log, and drilling shall stop and the Owner be notified if artesian flow or a hydrocarbon odor is encountered.
- C. Header cable splices shall use listed epoxy-encapsulated splice kits and shall be tested. Any nick in the insulation of positive (anode) cable shall be cause for replacing that cable section, because a break in positive cable insulation in soil corrodes through quickly.
- D. The rectifier shall be mounted on a galvanized post stand or on the exterior wall of B-102 as designed, outside the classified areas (or listed for the location), with a lockable disconnect. The positive terminal shall go to the anode bed and the negative to the structure through two separate negative drain connections to the pipe.

3.03 CONNECTIONS TO PIPE

- A. The pipe wall thickness at each connection point shall be measured with an ultrasonic thickness gauge before welding. Connections shall not be made to pipe thinner than 0.188 in without an EOR-approved procedure.

- B. Coating shall be removed to bare metal over no more than 2 x 2 in, cleaned to near-white metal by file or grinder, free of sulfur-bearing or oily contamination.
- C. Thermite cartridges shall not exceed 15 g on pressure piping, the conventional limit used by pipeline operators to restrict heat input to the pipe wall. Cable at the weld shall not exceed 6 AWG; larger cable shall connect through a 6 AWG pigtail, or by pin brazing with EOR approval.
- D. Connections to pressurized gas piping after gas-in require Owner approval, a hot work permit and compliance with the in-service welding restrictions of SPC-SPC-007. Thermite welding on the trunkline or the hot tap fitting is prohibited.
- E. Each connection shall be struck with a 2 lb hammer after cooling (it shall not detach) and inspected for slag and porosity, then coated with the specified cap or epoxy mastic overlapping sound coating by at least 2 in, and holiday tested at the SPC-SPC-009 voltage.
- F. Each connection location shall have two leads (one current, one potential) attached at least 6 in apart, with 18 in of slack at the pipe and 24 in in the test station.

3.04 TEST STATIONS

- A. Test stations shall be located per CP-DWG-001 and CP-LST-001 and at least: on both sides of IJ-101 and IJ-102 (two leads on each side); at the tap valve, with the receiving pipeline operator's consent, for bond or isolation leads (HOLD H-04); at each foreign line crossing, with the foreign operator's consent; at each coupon; at the anode header junction box; and at the design spacing along the outlet lateral.
- B. Leads shall be color coded: white for protected pipe current, black for protected pipe potential, red for anode, yellow for foreign line, green for coupon and blue for reference electrode, unless the Owner's standard differs.
- C. Terminal boards shall carry engraved tags, with 0.01 ohm shunts where anodes connect, as designed.

3.05 ELECTRICAL ISOLATION

- A. Buried station piping shall have no metallic contact with the ground grid, fence, reinforcing steel, conduit or foreign structures, and shall clear foreign pipes and ground conductors by at least 12 in at crossings. Where that is not achievable, a dielectric shield shall be installed per the CP design.
- B. Every above-grade pipe support shall have a dielectric pad, with sleeved or coated U-bolts, and its isolation shall be verified unless the grounding design bonds that piping intentionally.
- C. Any casing shall be isolated from the carrier pipe by insulators and end seals, with test leads on both.
- D. IJ-101 and IJ-102 shall not be bridged by conduit, tubing, grounding conductor, support steel or tools during construction or operation. Surge protection across each joint (spark gap or decoupler) shall be installed where the design specifies it, rated for the fault and lightning currents of CP-CAL-001 Section 11.

3.06 AC MITIGATION

- A. AC mitigation (gradient control wire, zinc ribbon, decouplers, and grounding mats at test stations and valves) shall be installed exactly as designed in CP-CAL-001 Section 11, subject to the AC interference survey (HOLD H-08), and shall achieve the AC criteria in Table 3-2.

3.07 ENERGIZING AND SURVEYS

- A. Before continuous operation, polarity shall be verified by energizing the rectifier momentarily at low output and confirming a negative shift of the structure potential. Reversed polarity makes the pipe the anode and shall be excluded before the rectifier is left on.
- B. The rectifier shall be started at its lowest tap and raised to the design output, recording volts, amps and taps.
- C. GPS-synchronized current interrupters shall be installed in the rectifier and, by arrangement, at every other influencing source, typically cycling 3 s on and 1 s off.
- D. The native survey shall measure structure-to-soil potential with a calibrated CSE at every test station, above each buried valve and riser, and at 10 ft intervals over the buried outlet lateral where accessible.
- E. The commissioning survey shall measure on and instant-off potentials at the same points, coupon on and instant-off potentials, coupon AC current density, AC pipe-to-soil voltage, rectifier data and insulating joint isolation.
- F. The -850 mV criterion shall be applied to the instant-off potential or a coupon instant-off potential, not to the on potential, because 49 CFR 192 Appendix D and AMPP SP0169 require IR drop to be considered.
- G. For interference testing with the receiving pipeline operator (HOLD H-04), the trunkline potential shall be measured at its nearest test point and at the tap with the station rectifier interrupted, and the station piping measured with the trunkline rectifiers interrupted by arrangement. The shift shall be reported both ways. Interference shall be resolved by mutual agreement (a resistance bond or relocation of anodes) under 49 CFR 192.473. Foreign line crossings shall be tested the same way with the foreign operator.

3.08 INSULATING JOINT TESTING

- A. The insulating joints shall be tested at the stages in Table 3-1. A shorted or leaking joint shall be reported at once; the joints are Owner-furnished and their replacement is at the Owner's direction.

Table 3-1: Insulating Joint Tests

Stage	Test	Criterion
Factory	Insulation resistance at 1,000 VDC, dry	25 megohm or more (typical, confirm with vendor data, HOLD H-15)

Stage	Test	Criterion
Factory	Dielectric strength at the vendor's rated AC voltage (typically 5 kV AC for 1 min)	No breakdown
On receipt	Insulation resistance at 1,000 VDC, joint dry and clean	25 megohm or more
After welding in, before backfill and hydrotest	Radio-frequency insulation checker	Isolated
After hydrotest, joint dried	Radio-frequency insulation checker and potential difference	Isolated
After energizing	Potential across the joint with the rectifier cycling	Unprotected side shifts less than 10 % of the protected side's shift

3.09 ACCEPTANCE

A. The CP system is accepted when the commissioning survey meets every criterion in Table 3-2 and the EOR has accepted the survey report.

Table 3-2: Acceptance Criteria

Parameter	Criterion	Method
Protection, primary criterion	Polarized (instant-off) potential of -850 mV CSE or more negative at every test point and coupon (49 CFR 192 Appendix D; AMPP SP0169)	Synchronized interruption, CSE
Protection, alternate criterion	At least 100 mV of cathodic polarization (instant-off against native or depolarized) at any test point where -850 mV instant-off is not reached	Polarization formation or decay
Overprotection	Instant-off not more negative than -1,200 mV CSE; an Owner limit, consistent with AMPP SP0169 guidance, to avoid disbonding the fusion-bonded epoxy coating	Instant-off
AC touch voltage	15 VAC or less open circuit, pipe to soil, at test stations and above-grade appurtenances (AMPP SP0177)	AC voltmeter
AC corrosion	Coupon AC current density below 30 A/m ² ; where above 30 A/m ² , DC current density below 1 A/m ² (ISO 18086; AMPP SP21424)	Coupon measurement
Interference	No positive (anodic) shift of more than 20 mV on the trunkline or any foreign line caused by the station system, or as agreed in writing with the operator	Interrupted surveys
Insulating joints	Per Table 3-1	Checker, potential difference
Support isolation	Each support isolated, more than 1 kohm by two-wire test, unless intentionally bonded	Ohmmeter
Thermite connections	Pass the hammer test, coated, holiday free	Visual, hammer, holiday detector

Parameter	Criterion	Method
Rectifier output	Within ± 10 % of the design operating point at the commissioning survey; interrupter working	Meter, shunt
Records	Every reading with location, date, time, weather and reference electrode check (within 5 mV of the master), as 49 CFR 192.491 requires	Review

3.10 FIELD QUALITY CONTROL

A. Records shall use forms QF-15-01 (thermite connection log), QF-15-02 (insulating joint test), QF-15-03 (anode and test station installation), QF-15-04 (native potential survey), QF-15-05 (rectifier energizing) and QF-15-06 (interference test).

B. The hold and witness points in Table 3-3 apply. Party codes: C Contractor, O Owner, E EOR, W receiving pipeline operator; H hold, W witness, R review, S surveillance, P perform.

Table 3-3: Hold and Witness Points

ID	Activity	C	O	E	W	Record
HP-15-05	Water Resources Board registration of DW-101 obtained, or confirmed not required, before drilling (HOLD H-19)	P	H	R	-	Registration or Owner release letter
HP-15-01	CP materials, installer qualifications and thermite procedure approved	P	R	H	-	Submittals 15-01 to 15-03
WP-15-01	Thermite connections to pipe (first three per welder, then 10 %), including hammer test and coating	P	W	-	-	QF-15-01
WP-15-02	IJ-101 and IJ-102 insulation tests on receipt and after installation	P	W	-	W	QF-15-02
WP-15-03	Anode, header cable and test station installation before backfill	P	W	-	-	QF-15-03
HP-15-02	Native potential survey complete and accepted before energizing	P	R	H	-	QF-15-04
HP-15-03	Polarity verification at energizing	P	H	-	-	QF-15-05
WP-15-04	Interference test at the tap valve and trunkline	P	W	S	W	QF-15-06, submittal 15-07
HP-15-04	Commissioning survey accepted by the EOR against the criteria before turnover	P	R	H	R	Submittal 15-06

END OF SECTION