

SECTION 26 42 01
PIPE BONDING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
2. American National Standards Institute (ANSI).
3. American Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
4. American Water Works Association (AWWA):
 - a. C110, Ductile-Iron and Gray-Iron Fittings for Water.
 - b. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger - Shop Applied.
 - c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
 - d. C216, Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
 - e. C217, Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines.
5. American Wood Preservers' Association (AWPA):
 - a. C2, Lumber, Timber, Bridge Ties, and Mine Ties-Preservative Treatment by Pressure Processes.
 - b. P9, Standards for Solvents and Formulations for Organic Preservative Systems.
6. ASTM International (ASTM):
 - a. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
 - b. A615/A615M, Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
 - c. B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes.
 - d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
 - e. C150, Standard Specification for Portland Cement.
 - f. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
 - g. F436, Standard Specification for Hardened Steel Washers.
7. Association for Materials Protection and Performance (AMPP) [formerly NACE International (NACE)]: SP0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

8. Concrete Reinforcing Steel Institute (CRSI).
9. National Electrical Manufacturers Association (NEMA):
 - a. C80.1, Electrical Rigid Steel Conduit (ERSC).
 - b. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
 - c. WC 70, Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
10. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
11. NSF International (NSF).
12. The Society for Protective Coatings (SSPC):
 - a. SP 1, Solvent Cleaning.
 - b. SP 10, Near-White Blast Cleaning.

1.02 DEFINITIONS

- A. Electrical Isolation: Condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casings) and the environment as defined in NACE RP0169.
- B. Electrically Continuous Pipeline: 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 this section.
- C. Ferrous Metal Pipe: Pipe made of steel or iron, or pipe containing steel or iron as a principal structural material, except reinforced concrete pipe.
- D. Foreign Owned: Buried pipe or cable not specifically owned or operated by Government.
- E. Lead, Lead Wire, Joint Bonds, Pipe Connecting Wires, Cable: Insulated copper conductor; the same as wire.

1.03 SUBMITTALS

- A. Action Submittals: Catalog cuts and information for products proposed for use.
- B. Informational Submittals: Field Test Reports, including results of insulator testing.

1.04 QUALITY ASSURANCE

- A. Obtain services of qualified Cathodic Protection Specialist to inspect, adjust, and evaluate effectiveness of cathodic protection system. Cathodic Protection Specialist shall be person accredited or certified by AMPP/NACE International at level of Corrosion Specialist or Cathodic Protection Specialist (such as, NACE International CP Level 4). Cathodic Protection Specialist

shall have not less than 5 years' experience inspecting pipeline cathodic protection systems.

1. Cathodic Protection Technician shall be person accredited or certified by AMPP/NACE International at level of Cathodic Protection Technician (such as, NACE International CP Level 2). Cathodic Protection Technician shall have not less than 5 years' experience testing cathodic protection systems and be under direct supervision of Cathodic Protection Specialist.

1.05 SCHEDULING

- A. Specified weld-in fittings may have long delivery times. Contact manufacturers and obtain commitments for delivery before scheduling installation.

PART 2 PRODUCTS

2.01 WIRES

- A. Physical Characteristics:

1. Joint Bond:
 - a. General: Single-conductor, stranded copper wire with 600-volt HMWPE insulation. Supply joint bonds complete with formed copper sleeve on each end of wire.
 - b. Push-On, Mechanical, or Flanged Joints: 2 AWG wires, 18 inches long.
 - c. Flexible Coupling Joints: 2 AWG wires, 24 inches long, with two 12-inch-long HMWPE insulated 12 AWG wire pigtails.
 - d. Flanged Joints (Non-Insulated): Two, 2 AWG wire, 18 inches long.

- B. Functional Characteristics: None.

- C. Performance Characteristics: Conform to applicable requirements of NEMA WC 70.

2.02 THERMITE WELD MATERIALS

- A. General:

1. Thermite weld materials consist of wire sleeves, welders, and weld cartridges according to weld manufacturer's recommendations for each wire size and pipe or fitting size and material.

2. Welding materials and equipment shall be product of a single manufacturer. Interchanging materials of different manufacturers is not acceptable.

B. Physical Characteristics:

1. Molds: Graphite; ceramic “One-Shot” molds not acceptable.
2. Adapter Sleeves:
 - a. For 12 AWG wires.
 - b. Prefabricated factory sleeve joint bonds or bond wires with formed sleeves made in field are acceptable. Attach field-formed joint bond sleeves with appropriate size and type of hammer die furnished by thermite weld manufacturer.
 - c. Extend wire conductor 1/4 inch beyond end of sleeve.
3. Cartridges:
 - a. Cast-iron thermite weld cartridges for cast and ductile iron pipe and fittings.
 - b. Maximum Cartridge Size: 25 grams for steel and 32 grams for cast and ductile iron materials, respectively.
4. Welders and Cartridges:
 - a. For attaching copper wire to pipe material:

Pipe Material	Weld Type	Cartridge Size, Max.
4 AWG Wire and Smaller:		
Steel	HA, VS, HC	25 gm
Ductile Iron	HB, VH, HE	32 gm
Cast Iron	HB, VH, HE	32 gm
2 AWG Joint Bonds:		
Steel	FS	25 gm
Ductile or Cast Iron	FC	32 gm
Concrete Cylinder Pipe	HA, GR	32 gm

5. Thermite Weld Coating:
 - a. Thermite Weld Caps: Prefabricated weld cap with coating and suitable primer.
 - b. Insulating Resin: 100 percent solids epoxy that can cure in submerged or buried conditions. At Contractor’s option, bitumastic coating may be used if it is allowed to dry completely before covering
 - c. Use products recommended by pipe or fitting coating manufacturer to repair spot damage at thermite weld connections

not covered by standard pipeline coating repair procedure or thermite weld cap.

C. Functional Characteristics: None.

D. Performance Characteristics: None.

E. Welding Materials Manufacturer:

1. Erico Products Inc. (Cadweld), Cleveland, OH.
2. Or equal.

2.03 INSULATING JOINTS

A. As specified in Section 40 27 00, Process Piping—General.

2.04 FUNCTIONAL TEST EQUIPMENT

A. Test Equipment:

1. Before construction begins, obtain test equipment necessary for electrical continuity testing and the following equipment:
 - a. Item 1200, Aboveground Insulation Checker.
 - b. Buried Insulation Checker.
 - c. High impedance (1 MOhm minimum), Digital Multimeter, with case and test leads.
 - d. Two copper-copper sulfate reference electrodes.
 - e. One quart of copper sulfate antifreeze solution.
 - f. One-half pound of copper sulfate crystals.

B. Store test equipment at Site and maintain in accurately calibrated, working condition. Test equipment shall be available to Contracting Officer for testing purposes. Upon completion of Project, test equipment listed above shall be turned over to Contracting Officer in clean, accurate, and fully functional condition, along with operating manuals, test wires, and cases supplied with equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Construct system of pipe connecting wires and pipe joint bonds to form an electrically continuous piping network.

3.02 PIPE JOINT BONDING

- A. Electrically bond joints of buried steel and iron pipe, including vault and manhole piping and fittings, and including restrained joints, except joints specified to be threaded, welded, or insulated.
- B. Install two joint bond wire assemblies at each joint that requires bonding.
- C. Use thermite weld process for electrical connection of wires to pipe and fittings.
- D. Test each bonded joint for continuity prior to backfilling.
- E. Joint bonds for cast-iron soil pipe and fittings and high silicon cast-iron pipe and fittings shall be in accordance with manufacturer's recommendations. Bronze wedges are not an acceptable method of achieving electrical continuity.

3.03 CONDUITS

- A. Install insulated bushings and insulated throat connectors on ends of rigid metallic conduit.
- B. Use watertight couplings and connectors. Install and equip boxes and fitting to prevent water from entering conduit or box. Seal unused openings.

3.04 WIRE CONNECTIONS

- A. Thermite Weld:
 - 1. Use thermite weld method for electrical connection of copper wire to steel, ductile, and cast-iron surfaces. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation recommended by welder manufacturer. Ensure that pipe or fitting wall thickness is of sufficient thickness that thermite weld process will not damage integrity of pipe or fitting wall or protective lining.
 - 2. After weld connection has cooled, remove slag, visually inspect, and physically test wire connection by tapping with a hammer; remove and replace defective connections.
 - 3. On pipe and fittings with dielectric linings, make weld connection on shop tab provided or on a thick metal section to minimize damage to lining and coating. After weld is made, coat weld with coating repair material.
 - 4. Install prefabricated thermite weld cap over each completed connection. Repair exposed metal surfaces not covered by thermite weld cap in accordance with coating manufacturer's recommendations.

3.05 WIRE INSULATION REPAIR

- A. Handle wires with care. Splices for damage to wire insulation shall be required by spirally wrapping (50 percent overlap, minimum) with two coats of high-voltage rubber splicing tap and two layers of vinyl electrical tape. Optional use of two-part epoxy resin splice kit. Make wire splices with suitable sized compression connectors or mechanically secure and solder with rosin cored 50/50 solder. Splices shall be approved by Contracting Officer.

3.06 INSULATED JOINTS

- A. Install insulated joints to electrically isolate pipeline from other structures. Insulating joints shall be installed above grade at pipe termination point
- B. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations.
- C. Do not use fastener lubricants that contain graphite or metallic compounds that will interfere with the insulating capability of the completed joint.
- D. Test the completed insulating joint as specified herein.
- E. Insulating Flange Lining and Coating:
 - 1. After assembly of insulated flanges, repair coatings and linings as shown on the Drawings and as specified herein.
 - a. Interior Lining: For cement mortar linings, prepare cement-mortar surface in accordance with paint manufacturer's instructions and apply a 20-mil minimum thickness of NSF potable water approved, 100 percent solids water or air curing epoxy coating to interior of pipeline. Apply coating for minimum of two pipe diameter lengths from insulating flange in both directions. Apply and cure coating in accordance with manufacturer's recommendations. Do not apply coating where it will interfere with operation of pipeline valves or other pipeline assemblies.
 - b. Exterior Coating: For buried insulating flanges, coat completed joint with petroleum wax tape in accordance with AWWA C217. heat shrink sleeve in accordance with AWWA C216.

3.07 FIELD QUALITY CONTROL

- A. Electrical Continuity Testing:
 - 1. Provide necessary equipment and materials and make electrical connections to pipe as required to test continuity of bonded joints.

2. Conduct continuity test on buried joints that are required to be bonded. Test electrical continuity of joint bonds after bonds are installed but before backfilling of pipe.
3. Qualified personnel will monitor tests of bonded joints.
4. Test electrical continuity of completed joint bonds using either a digital low resistance ohmmeter or by Calculated Resistance Method, at Contractor's option.
 - a. Digital Low Resistance Ohmmeter Method:
 - 1) Provide the following equipment and materials:
 - a) One digital low resistance ohmmeter.
 - b) One set of 10-amp duplex heavy-duty fixed-point current and potential hand spikes, cable length as required or one set of duplex helical current and potential hand spikes, cable length as required.
 - c) One calibration shunt rated at 0.001 ohm, 100 amperes.
 - 2) Test Procedure:
 - a) Measure resistance of joint bonds with low resistance ohmmeter in accordance with manufacturer's written instructions.
 - b) Use helical hand spikes to contact pipe on each side of joint, without touching thermite weld or bond.
 - c) Clean contact area to bright metal by filing or grinding and without surface rusting or oxidation.
 - d) Record measured joint bond resistance on test form described herein.
 - e) Repair damaged pipe coating.
 - b. Calculated Resistance Method:
 - 1) Provide the following equipment and materials:
 - a) One dc ammeter (meter or clamp-on) with full scale reading of 100 amperes and a minimum resolution of 1 ampere or a 100-ampere shunt with a voltmeter as specified herein.
 - b) One high resistance electronic voltmeter with a dc low range of 200 millivolts full scale to a dc high range of 20 volts full scale and capable of a minimum resolution of 1 millivolt (2 voltmeters are required if a shunt is used).
 - c) One knife switch, safety switch, or time-controlled relay suitable for test current.
 - d) Two electrical probes for the voltmeter.
 - e) Insulated wire suitable for carrying the test current, length as required.
 - f) One dc power supply with a steady capacity of 50 amperes minimum; storage batteries are not an acceptable power supply.

- g) Test Procedure: Either tightly clamp or thermite weld current wire connections to the pipe. Determine wire size for the test current, and do not exceed 1,000 feet in length.
- c. Apply a minimum direct current of 50 amperes.
- d. Measure voltage drop across each joint with voltmeter by contacting pipe on each side of joint. Voltmeter connections to bond wire or thermite welds will not be acceptable.
- e. Measure current applied to test span and voltage drop across joint simultaneously.
- f. Record measured voltage drop and current for each joint of test form described herein and calculate bond resistance in accordance with the following formula:

$$R = \frac{E}{I}$$

Where:

- R = Resistance of the joint bond.
- E = Measured voltage drop across the joint, in volts.
- I = Test current applied to the pipe test span, in amperes.

- 5. Joint Bond Acceptance:
 - a. Joint Bond Resistance: Less than or equal to the maximum allowable bond resistance values in Table 1.

Table 1		
Joint Type	Max. Allowable Resistance	
	1 Bond/Joint	2 Bonds/Joint
Push-On, Mechanical, or Flanged	0.000325 ohm	0.000162 ohm
Flexible Coupling	0.000425 ohm	0.000212 ohm
Concrete Cylinder	0.000200 ohm	0.000100 ohm

- b. Replace joint bonds that exceed the allowable resistance. Retest replacement joint bonds for compliance with bond resistance.
 - c. Repair defective joint bonds discovered during energizing and testing.
- 6. Record Tests of Each Bonded Pipeline:
 - a. Description and location of pipeline tested.
 - b. Starting location and direction of test.
 - c. Date of test.
 - d. Joint type.

- e. Test current and voltage drop across each joint and calculated bond resistance (Calculated Resistance Method only).
- f. Measured joint bond resistance (Digital Low Resistance Ohmmeter method only).
- g. Record test information on a form that includes information listed above.

B. Insulated Joint Testing:

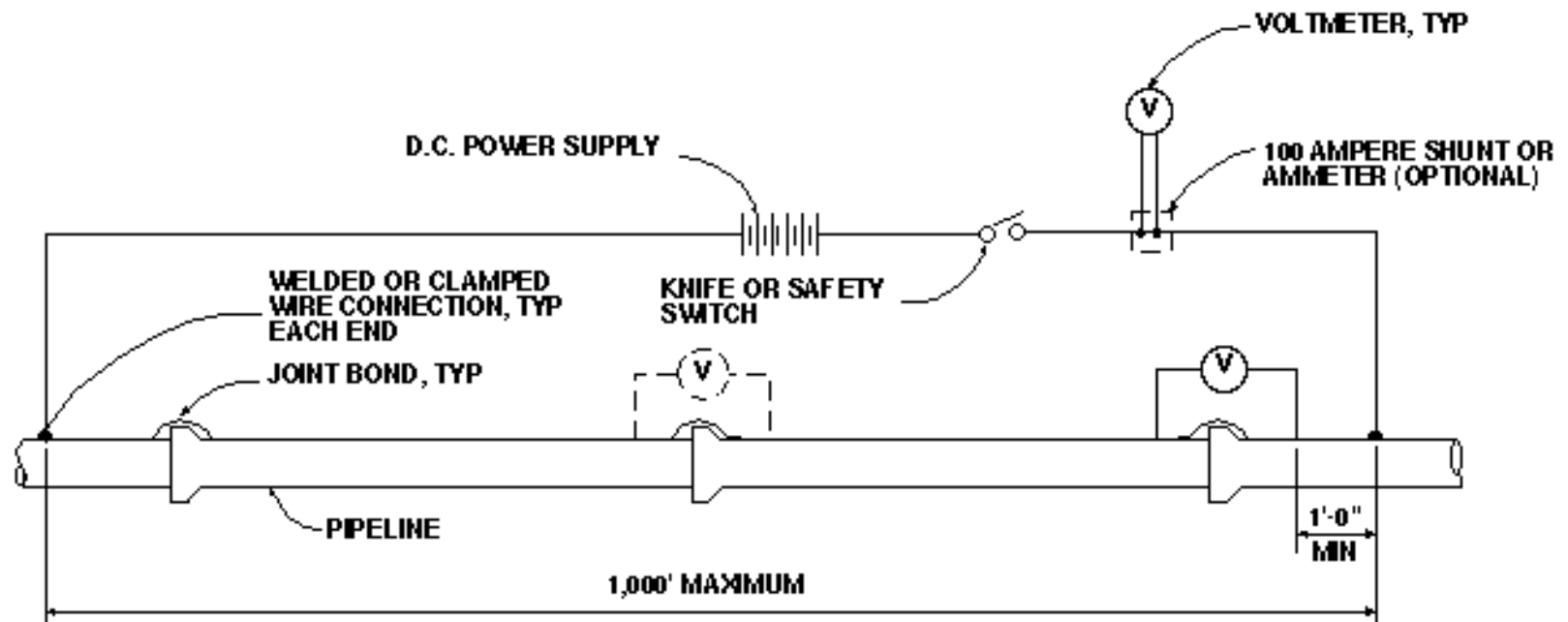
- 1. Provide Contracting Officer with 3 days' advance notice before beginning tests.
- 2. Test each joint after assembly with insulator tester in accordance with manufacturer's written instructions.
- 3. For insulating flanges, test and record insulating values of each bolt in addition to the completed flange.
- 4. Replace damaged or defective insulation parts.
- 5. Correct defects identified during testing.

3.08 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

- 1. Joint Bond Continuity Test Schematic.

END OF SECTION



JOINT BOND CONTINUITY TEST SCHEMATIC

JTE 195 SP 104-17-95.mdb

