CONSTRUCTION SPECIFICATION FOR CORROSION PROTECTION OF NEW AND EXISTING WATERMAINS

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442.01 SCOPE

This specification covers the requirements for providing corrosion protection to watermains and their metallic components, valves and fittings using galvanic anodes, or a microcrystalline wax and petrolatum tape coating system.

This specification also covers the requirements for corrosion monitoring for concrete pressure pipe.

442.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 441 Watermain Installation in Open Cut
OPSS 490 Site Preparation for Pipelines, Utilities, and Associated Structures
OPSS 492 Site Restoration Following Installation of Pipelines, Utilities, and Associated Structures

CSA Standards

C22.2 No. 197:M83 (R2023) PVC Insulating Tap

ASTM International

B418-16a(2021)	Cast and Wrought Galvanic Zinc Anodes
B843-18e1	Magnesium Alloy Anodes for Cathodic Protection
G97-18(2022)	Standard Test Method for Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications

American Water Works Association (AWWA)

C217 Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings

Underwriters Laboratories of Canada (ULC)

UL 467-22 Grounding and Bonding Equipment

Association for Materials Protection and Performance (AMPP)

SSPC-SP 1 - 2016 Surface Preparation - Solvent Cleaning

442.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Anode means the electrode of an electrochemical cell where corrosion occurs and metal ions enter solution. An anode refers to a packaged anode consisting of the casting, anode chemical packing material, lead wire, tube, and label.

Anode Chemical Packing means select materials used to surround an anode in its tube, in order to improve current efficiency, reduce local corrosion of the anode casting, help keep the anode moist, and increase the effective anode size and, for zinc, prevent the passivation of the anode.

Anode Type means both the material and the size of the anode as specified in Table 1, which is included in the A-WW-LL label on the outside of the anode. The A indicates the casting alloy material, Z for zinc and M for magnesium. The WW indicates the weight of the casting in pounds and the LL indicates the length of the casting in inches.

Associated Appurtenances means structures, devices, and appliances, other than pipe and conduit that are used in connection with a water distribution system, such as valves, hydrants, saddles, corporation and main stops, curb stops, services, and thrust restraints.

Backfill means material placed in a hole to fill the space around the anodes and other portions of the project.

Bonding means the joining of metallic components together to ensure complete electrical continuity throughout the piping system.

Cathodic Protection means a technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

Certified Cathodic Protection Specialist means a person that has received Cathodic Protection Specialist Certification by the Association for Materials Protection and Performance (AMPP).

Coating means a dielectric material applied to a structure to separate it from the environment.

Corrosion Protection means corrosion control of a metal surface either by coatings or cathodic protection or both.

Filler means a microcrystalline wax or petrolatum-based material used to fill voids or surface irregularities where the tape will not be in full contact with the steel surface. Also referred to as a mastic.

Fittings means as defined in OPSS 441.

Galvanic Anode means a metal that provides protection to metals that are more noble in the galvanic series when coupled in an electrolyte. This is in contrast to impressed current anode systems that use an external direct current power source between the cathode and anode bed.

Ground Clamp means a copper clamp device used to connect a wire to copper service tubing in order to create an electrical connection to earth.

Holiday means a discontinuity in the coating.

Metallic Components means metallic hydrants, valves, fittings and associated appurtenances designed to be used in connection with pipes.

Metallic Watermain or Pipe means a ductile iron, cast iron, or steel watermain pipe, excluding copper services.

Microcrystalline Wax means a refined mixture of solid, saturated aliphatic hydrocarbons produced by de-oiling petrolatum.

Native Material means the original in-situ material taken from the exact area being excavated.

Negative Lead means the wire running from the watermain or service pipe to the test station.

Petrolatum means a complex semisolid mixture of microcrystalline wax and white mineral oil distilled from petroleum wax.

Primer means a compound of microcrystalline wax or petrolatum and may contain suitable inhibitors.

Tape means a cold-applied saturant tape made from either microcrystalline wax or petrolatum and a non-cellulosic synthetic fiber fabric.

Tape Coating System means the complete finished corrosion protection product consisting of the primer, filler, if applicable, and tape.

Test Station means a pole or flush mounted terminal that is used to conveniently monitor electrical currents and potentials associated with galvanic cathodic protection systems.

Thermite Weld means a permanent low resistance electrical connection made by a powder welding process using an exothermic copper-depositing mixture ignited in a graphite mould.

Valves means as defined in OPSS 441.

Watermains means as defined in OPSS 441.

442.04 DESIGN AND SUBMISSION REQUIREMENTS

442.04.02 Submission Requirements

442.04.02.01 Corrosion Protection of New and Existing Watermains

The manufacturer's instructions shall be submitted to the Contract Administrator 7 Days prior to any work being carried out and shall include the following:

a) Handling, transportation, and storage for all components of the tape coating system.

b) Application of tape around straight line pipe.

c) Application of tape on valve bodies, flanges, and couplings.

d) Procedures on how to thermite weld all wire connections to metallic surfaces.

e) Installation of coating and cover.

f) Application of splicing kits designed for cathodic protection systems when used.

g) Splicing using direct bury lugs.

h) Performing soldered connections.

i) Attaching ground clamps to copper services.

442.05 MATERIALS

442.05.01 Anode Packaging

442.05.01.01 General

The magnesium and zinc anode castings shall be supplied complete with an anode lead wire and shall be centred in and surrounded by anode chemical packing material. The anode casting and anode chemical packing shall be contained within a biodegradable, water permeable cardboard tube of sufficient durability to permit normal handling without appreciable damage. Anode castings and overall weight requirements shall meet the requirements specified in Table 1.

442.05.01.02 Anode Chemical Packing Composition

The anode chemical packing material shall have an electrical resistivity of less than 45 ohm-cm when saturated with distilled water, a compacted density of 1.5 g/cm^3, and the following composition:

Anode Chemical Packing Component	% by Volume
Gypsum	77 ± 2%
Bentonite	15 ± 1%
Sodium Sulphate	8 ± 1%

442.05.01.03 Labelling

All anodes shall be labelled on the outside of the cardboard tube indicating the type and the specification designation OPSS 442, as follows:

a) For each zinc anode, each tube shall be labelled as follows:

   i. A-WW-LL Anode According to OPSS 442 (e.g., Z-6-12 Anode According to OPSS 442)

b) For each magnesium anode, each tube shall be labelled as follows:

   i. A-WW-LL Anode According to OPSS 442 (e.g., M-17-20 Anode According to OPSS 442)

The letters shall be a minimum of 25 mm in height.

442.05.02 Microcrystalline Wax and Petrolatum Tape Coating Systems

442.04.02.01 General

Microcrystalline wax and petrolatum tape coating system components shall meet the material and testing requirements of AWWA C217.

442.05.02.02 Labeling

All components of a tape coating system including the primer, mastic and petrolatum or petroleum wax tape shall be properly labeled on the outside of the package as to the contents and name of the manufacturer.

442.05.03 Miscellaneous Materials

Ground clamps for copper water services shall be according to UL 467 listed for direct burial, high strength, high conductivity, and a minimum of 80% copper alloy.

Direct bury lugs shall:

a) Be one piece, high impact housing, pre-filled with silicone providing waterproof and corrosion proof protection and be designed for long term direct bury applications.

b) Be able to connect to header wire without cutting the header wire.

c) Tighten with a screwdriver.

d) Have high impact housing without sharp edges to prevent cuts or handling discomfort.

e) Be designed for use with wires from #14 to #10 AWG or larger and under 50 volts.

Wire splicing kits for cathodic protection systems shall be waterproof and suitable for direct bury applications.

C Taps shall be as specified in the Contract Documents.

The solder shall be 60% tin and 40% lead mix, resin core type.

Moisture proofing shall be fast drying sealant and bonding compound specifically designed for coating electrical connections.

Insulating putty shall be dielectric, easy to handle and apply, have excellent adhesion to surfaces, and be suitable for filling voids and irregular surfaces.

Self-amalgamating tape shall be made using modified silicone rubber compound that forms a moisture-proof abrasion-resistant bond. Tape shall have high dielectric strength, adhering to itself creating an immediate permanent bond even when wet.

Rubber splicing tape shall be 25 mm wide waterproof neoprene.

Electrical tape shall be 25 mm wide PVC electrical tape, rated for 600 V with a working temperature of -10 to 90 °C, and according to CSA C22.2 No. 197.

442.05.04 Test Stations

Each test station shall consist of a non-conductive housing and lid and shall be either flush-mounted or post-mounted as specified in the Contract Documents. The lid shall be supplied with a stainless steel locking bolt and an Allen key head and shall be blue in colour. The terminal board shall include five stainless steel terminals and one nickel plated copper bonding or shorting strap. All terminals shall have two stainless steel nuts for locking purposes.

Mounting of test stations shall meet the following requirements:

a) Flush-mounted test stations shall be mounted on a 300 mm length of 150 mm diameter UV stabilized polyethylene or polycarbonate pipe.

b) Post-mounted test stations shall be mounted on a 1,500 mm length of 32 mm diameter PVC or UV stabilized polyethylene pipe and fastened securely to a suitable support.

442.05.05 Thermite Welds

The thermite weld material shall be as follows and meet the requirements listed:

a) Thermite Moulds or Welders:

i. Suitable for the wire, connection type, and orientation.
ii. Have a handle and lid.
iii. Made of graphite or synthetic graphite, be able to withstand high temperatures, and be designed to provide an average life of not less than 50 separate exothermic welds.
iv. Be from the same manufacturer as the weld metal.

b) Thermite Powder Cartridges:

i. Suitable for the pipe material.
ii. Weld metal shall contain vanadium, but not tin.
iii. Weld metal shall be sealed in a suitable capsule and be identified with the part number and size and type of metals to be connected, such as copper to steel or copper to ductile iron.
iv. The batch control numbers shall be packaged with the product prior to shipment from the factory.

c) Starting Material:

i. When used, shall consist of aluminum, copper, and iron oxide materials. It shall not contain phosphorous or any caustic, toxic, or explosive substances.
ii. When used, shall be electrical igniters that have a lead length of 1.83 m or greater and use an electric ignition system that does not use spark ignition material.

d) Thermite Weld Protective Barrier Covers:

i. Be moulded plastic domes filled with corrosion resistant compound on a base of thick elastomeric tape.
ii. Use an integrated primer in its adhesive.

e) Thermite Weld Protective Barrier Coatings:

i. Bond firmly to surfaces without the use of primers and form a tough coating resistant to oxidizing, cracking, alligatoring, checking, loosening, or scaling.
ii. Be composed of heavy mastic with synthetic elastomeric additives in mixed solvent.

442.05.06 Wires

Bond wires shall be 450 mm in length with TWU or RWU-90 black insulation with AWG #4/7 strand copper wire or, when specified, AWG #1/0 - 19 strand copper wire.

Anode wires shall be 3.0 m in length of AWG #10/7 strand copper wire having RWU-90 insulation, blue for magnesium anodes, and white for zinc anodes, and shall be silver soldered to the steel core of the anode casting.

Anode header wires for anode banks shall be AWG #10/7 strand wire with red RWU-90 insulation.

Negative wires from test stations to ground clamps or pipe shall be AWG #10/7 strand wire with RWU-90 black insulation.

Wire for corrosion monitoring probes for concrete pressure pipe shall be AWG #10/7 strand wire with RWU-90 black insulation.

Wire for connecting the watermain negative wires from the pipe joint bonding wire of concrete pressure pipe to the test station shall be AWG #4/7 strand wire with RWU-90 black insulation.

442.05.07 Zinc and Magnesium Anodes

442.05.07.01 Magnesium Anode Castings

Magnesium anode castings shall have a composition according to ASTM B843, Type M1-C, have a minimum current efficiency of 50% and shall be according to ASTM G97.

442.05.07.02 Steel Core of Anode Castings

The steel core of the anode castings shall be electro-galvanized and extend a minimum 75% of the anode length.

442.05.07.03 Zinc Anode Castings

Zinc anode castings shall have a high potential alloy composition according to ASTM B418, Type II.

442.07 CONSTRUCTION

442.07.01 General

The methods for corrosion protection shall be as specified in the Contract Documents.

Anodes shall be installed complete with their cardboard tube container and enclosed anode chemical packing.

The anode shall be wetted prior to backfill, to enhance performance.

442.07.02 Site Preparation

Site preparation shall be according to OPSS 490.

442.07.03 Transporting, Unloading, Storage, and Handling Materials

Anodes and other materials that can be damaged by exposure to the elements shall be stored in a clean dry secured enclosure until installation.

Anodes shall not be carried or lowered by their lead wires.

All components of a tape coating system shall be transported, stored and handled according to manufacturer's recommendations.

442.07.04 Anode Installation

442.07.04.01 Existing Metallic Watermains - Over Pipe Method

Prior to installation, the location for each anode and test station shall be marked with a white stake or white paint on paved areas and shall be approved by the Contract Administrator.

Anodes shall be of the type and spacing specified in Table 2. The first anode at each end of the watermain shall be within 3.0 m of the end of the watermain.

Anode locations may be shifted a maximum of 3.0 m to avoid driveways and other paved areas.

Each anode site shall be excavated to expose the top of the pipe and accommodate the anode to be installed.

The anode wire shall be thermite welded to the metallic pipe and the connection protected.

The excavation shall be partially backfilled with native material so that the anode resides 300 mm above the watermain.

The excavation shall be backfilled with material matching the existing subgrade that shall be manually compacted and thoroughly watered. Granular subbase and base profiles shall be reinstated above the subgrade.

442.07.04.02 Existing Metallic Watermains - Anode Bank Method

The anode bank method applies to both vertical and horizontal anode banks for the purpose of retrofitting existing metallic watermains with cathodic protection.

Anodes and anode banks shall be of the type and spacing specified in Table 3.

Anode banks shall be installed on the side of the street opposite to the watermain. Anodes shall be installed so the centre of the anode is at the same depth as the service to which they are being attached or a minimum of 2.0 m below the finished grade, whichever is greater.

Each anode site shall be excavated to expose the top of the pipe and accommodate the anode to be installed.

The anode leads shall be spliced to the header wires using one of the methods specified in the Anode and Header Wire Splicing and Waterproofing subsection.

442.07.04.03 Existing Metallic Watermains - Exposed Pipe or Service Method

The exposed pipe or service method applies when an existing watermain is not catholically protected, and when the existing watermain or water services are exposed during the course of other work (e.g., another Utility installation or watermain break repair).

Anodes to be used for this application shall be magnesium type M-32-22.

Anodes shall be installed at least 1.5 m horizontally away from the watermain pipe and as deep as the bottom of the excavation. Anodes shall be spaced as far apart in the trench as the wires and trench permit.

The anode lead shall be electrically connected to the water piping by connecting to either:

a) A copper or lead service pipe using a ground clamp; or

b) The watermain using the thermite weld procedure.

442.07.04.04 New Metallic Watermains and Copper Services

Anodes shall be of the type and spacing specified in Table 4.

Anodes shall also be installed as follows:

a) On the lateral piping of each hydrant; and

b) At each metallic component.

Anodes shall be installed at least 1.0 m horizontally away from the watermain or service pipes and as deep as the bottom of the pipes. The minimum distance between anodes shall be 1.0 m.

442.07.04.05 New Polyvinyl Chloride Watermains with Metallic Components

Anodes shall be of the type and spacing specified in Table 5.

Anodes shall be installed at least 1.0 m horizontally away from the metallic component and as deep as the bottom of the metallic component. The minimum distance between anodes shall be 1.0 m.

442.07.04.06 New Watermains with Metallic Components

All metallic components specified in the Contract Documents shall be protected using corrosion protection methods as specified in the Contract Documents.

442.07.05 Corrosion Monitoring for Concrete Pressure Pipe

The locations for corrosion monitoring test stations shall be as specified in the Contract Documents.

All concrete watermains shall include bonding wires connected by thermite weld to provide electrical continuity. Galvanic zinc anodes are recommended.

All concrete pressure pipe sections, including pipe within jacking and boring encasement pipe and all bevel and bend fittings shall have two electrical bonding connections on each side, located 45° off the vertical.

Corrosion test monitoring stations for concrete pressure pipe shall include three probes or pipe coupons at each station. The probes shall be connected to the test monitoring station with approved wire.

442.07.06 Tape Coating System Installation

442.07.06.01 General Surface Preparation Requirements

Remove mud, loose mill scale, lacquer, wax, paint, coal tar, asphalt, oil, grease, excessive surface moisture and other foreign matter from the bare metallic surface. Surfaces shall be inspected and, if required, precleaned according to SSPC-SP 1.

Remove weld slag, spatter and scale, sharp points, burrs and edges.

Bare metal surfaces to be coated shall be cleaned immediately before applying the tape coating system.

High pressure water blasting may be used to prepare the surface of an existing metallic pipe, valve or fitting. An Engineer shall determine the appropriate pressure to provide adequate cleaning of the surface to apply the product, and any necessary precautions that must be taken during the water blasting process.

Ensure that any new metal valves, fittings and fasteners are clean and free from any mud, grease and oil, or other foreign matter prior to installation of a tape coating system.

Petrolatum and petroleum wax tape coating systems shall be applied according to the procedures described in AWWA C217.

442.07.06.02 Watermains, Valves and Fittings

Apply specified primer by brush, hand, glove, or roller. Apply a uniform and continuous film over the entire surface to be wrapped. Apply a liberal coating to threads, cavities, shoulders, pits, etc.

To protect irregular surfaces and sharp edges such as valve bodies, flanges, couplings, fasteners, etc., apply

the filler (profiling mastic) by filling spaces and packing into or around irregular surfaces to achieve a uniform contour to which tape can be applied without bridging or voids.
Refer to the manufacturer's specification for application of tape around straight line pipe.

Refer to the manufacturer's specification for application of tape on valve bodies, flanges, and couplings.

442.07.07 Test Station Installation

442.07.07.01 General

Test stations shall be installed at locations as follows:

a) Where they do not interfere with or present a hazard to pedestrian or vehicular traffic and at the nearest property line, whenever possible.

b) For new metallic watermains, over pipe method, and concrete pressure pipe, at each hydrant and, if there are no hydrants, start within 20 m of the project limit and locate at 150 m intervals along the watermain.

c) At each anode bank.

Flush-mounted test stations shall be installed flush with the ground, sidewalk, or pavement surface. Post-mounted test stations shall be mounted so that the top of the cover is 600 mm above the surface.

The anode lead may be extended using an additional length of the same type of wire spliced with one of the approved splice connection methods specified in the Anode and Header Wire Splicing and Waterproofing subsection.

Except for corrosion monitoring applications, test station connections shall be as follows:

a) The two negative leads shall be brought into the test station and connected to terminals 2 and 3.

b) Terminal 1 shall be connected to terminal with a bonding strap.

c) No bonding strap shall be connected to terminal 3 or 4.

Sufficient wire slack of 0.5 m in the housing below the panel shall be left in the wires to prevent any stress on either during backfilling and subsequent soil settlement and for withdrawing the terminal panel, if necessary during test work.

442.07.07.02 Test Station Connections for New Metallic Watermains

The lead wire of the anode nearest to the test station shall not be welded directly to the pipe, but instead shall be brought into the test station and connected to terminal 1.

Two watermain negative wires shall be thermite welded to the crown of the watermain pipe 150 mm apart and the other ends of the wires shall be connected as specified in the Test Station Installation - General clause.

442.07.07.03 Test Station Connections for Anode Banks

The header wires shall be brought into the test station and connected to terminal 1.

Two watermain negative wires shall be attached to the metallic service line, each with their own ground clamp and the other ends of the wires shall be connected as specified in the Test Station Installation - General clause.

442.07.07.04 Test Station Connections for Corrosion Monitoring

Two watermain negative wires shall be connected to the concrete pressure pipe joint bonding wires with an approved splice connection method. The other ends of the wires shall be connected to terminals 1 and 2 of the

test station. The three probe or pipe coupon wires shall be brought into the test station and connected to terminals 3, 4, and 5.

442.07.08 Thermite Weld Connections

All wire connections to metallic surfaces shall be made by means of a thermite weld method according to the following procedure:

a) Remove all coating, and clean bright and thoroughly dry a 75 mm^2 metal welding surface.

b) Select the proper mould for the application.

c) Insert bared end of wire into mould. A reinforcing sleeve may be required, depending on flexibility of wire. Manufacturer's instructions shall be followed.

d) Thermite weld the anode lead to the metallic surface shall be according to the manufacturer's instructions.

e) Remove all slag from the weld-on wire connection and file smooth all sharp edges.

f) The integrity of each weld shall be tested by giving a sharp pull on the lead wire.

Sufficient slack shall be left in the wires to prevent any stress on either the anode or the wire-to-pipe connection during backfilling and subsequent soil settlement.

For new watermains, and where practical for existing watermains, the anode lead wire shall be wrapped around the pipe and secured with a knot. The free end of the wire shall then be thermite welded to the watermain, metallic component, or valve.

442.07.09 Thermite Weld Protection

The cleaned metallic surfaces, thermite weld, and the exposed copper wire surfaces shall all be protected with an approved thermite weld protective barrier coating or cover. Both shall overlap existing coating and insulation on wire to prevent holidays in the protection.

Coating and cover shall be installed according to the manufacturer's instructions.

442.07.10 Anode and Header Wire Splicing and Waterproofing

442.07.10.01 General

Wire splicing to the header wire shall be accomplished without cutting the header wire.

Wire-to-wire splicing shall be accomplished by one of the following methods as specified in the Contract Documents:

a) Approved C taps.

b) Approved direct bury lugs with built-in waterproof protection.

c) Soldered splices.

d) Wire-to-wire thermite weld.

Splicing products shall be suitable for the size of wire being spliced.

Prior to backfilling, all splices and connections without built-in waterproof protection shall be rendered waterproof by either careful application of the waterproof tape method or by use of a wire splicing kit designed for cathodic protection.

Waterproof tape method shall be performed as follows:

a) Apply moisture proofing over connector and exposed wire.

b) Apply insulating putty to break sharp corners at the connection.

c) Apply tape according to one of the following methods:

   i. Two half-lapped layers of approved self-amalgamating tape overlapping the wire insulation.
   ii. Four half-lapped layers of approved rubber splicing tape overlapping the wire insulation and apply four half-lapped layers of approved self-adhesive electrical tape.

When using splicing kits designed for cathodic protection systems, the kits shall be applied according to the manufacturer's instructions.

442.07.10.02 C Tap Splices

Prior to cutting the wire for splicing, the wire shall be loose to avoid stretching.

The wire shall be stripped about the length of the electrical connector using an appropriate stripping tool. The exposed copper wire shall be free of nicks or scores.

An approved C Tap shall then be placed over the exposed area of the wire. The connecting wire shall be carefully inserted into the C Tap up to the insulation and tightened using an approved compression tool specifically designed for C Taps. Vice-grips, pliers, battering with a hammer, etc. shall not be permitted.

The splice shall be inspected for exposed copper and snugness. Splices that fail inspection shall be cut and redone using a new C Tap.

442.07.10.03 Direct Bury Lug Splices

Splices using direct bury lugs shall be performed according to the manufacturer's instructions.

442.07.10.04 Soldered Splices

Soldered connections shall be performed according to the manufacturer's instructions.

442.07.11 Electrical Bonding of Joints

442.07.11.01 New Metallic Pipe

All new metallic pipe joints, valves, and components shall be connected together with a bond wire to ensure complete electrical continuity throughout the metallic piping system. Bond wires shall be connected to the metallic surfaces using a thermite weld.

Bare copper bond straps, conductivity screws, and conductivity wedges shall not be used to provide electrical continuity. If bare copper bond straps are supplied with the piping, they shall be removed.

442.07.11.02 Existing Metallic Pipe

Bond wires shall be installed by thermite welding between all metallic components and across all joints that are exposed within the excavation.

Where a repair clamp is installed across a break, a bond wire shall be installed across the break after repair clamp installation.

Where a cut-out is required, a bond wire shall be installed.

442.07.12 Wire Connections to Copper Services

The anode lead shall be connected to copper services using a ground clamp. Ground clamps shall be attached to copper services according to the manufacturer's instructions. Wires shall be connected to the ground clamps according to the manufacturer's instructions.

442.07.13 Anode Backfilling

Prior to backfilling, the entire cathodic protection system shall be inspected by a certified cathodic protection specialist in the presence of the Contract Administrator to ensure that it meets the requirements specified in the Contract Documents.

In all cases, the anode shall be placed in native material and not in granular bedding material. Backfill shall be packed uniformly around the anode container to eliminate voids adjacent to the anode. Backfilling shall be according to OPSS 441.

442.07.14 Material Sampling and Testing

442.07.14.01 Testing and Evaluation

For applications using test stations, the following procedures shall be performed by a certified cathodic protection specialist and recorded between 90 and 120 Days after the installation:

a) Pipe potentials shall be measured with respect to a copper sulfate electrode at maximum intervals of 30 m throughout the route of the piping. The voltmeter employed to measure these potentials shall have an input impedance not less than 10 mega Ohms.

b) Potential measurement connection locations shall be made at the nearest test station to the electrode. The reference electrode and pipe connection locations employed for the potential measurements shall be identical for both the pre-construction and post-construction testing procedures. The electrical continuity of the piping shall be verified by comparison of pipe potential.

c) During post construction testing, the following measurements shall be made at the test stations:

    i. Anode output current.
    ii. Pipe potential with anode connected.
    iii. Pipe potential with anode disconnected.

All testing data and associated recommendations pertinent to the continued effectiveness of the cathodic protection system shall be included in a comprehensive written report. This report shall be prepared by a certified cathodic protection specialist and shall be submitted to the Contract Administrator within 14 Days after completion of the testing.

442.07.15 Site Restoration

Site restoration shall be according to OPSS 492.

442.07.16 Management of Excess Material

Management of excess material shall be as specified in the Contract Documents.

442.08 QUALITY ASSURANCE

442.08.01 Anodes

Prior to installing each shipment of anodes, a copy of a certificate from the anode manufacturer indicating that the shipment of anodes complies with the requirements of this specification shall be forwarded to the Contract Administrator.

The Contract Administrator may randomly select samples of supplied anodes for testing by an independent laboratory. Any batch of anodes found not to meet the requirements of this specification shall be replaced immediately. No additional work shall take place until such time that the anodes are approved and accepted by the Owner.

Any installed anodes found not to meet the requirements specified in this specification shall be removed and replaced at no additional cost to the Owner.

442.08.02 Tape Coating Systems

Tape coating system supplied shall meet the requirements specified in this specification.

Any installed tape coating system found not meeting the requirements specified in this specification shall be removed and replaced at no additional cost to the Owner.

442.09 MEASUREMENT FOR PAYMENT

442.09.01 Actual Measurement

442.09.01.01 Individual Anodes

For measurement purposes, a count shall be made of the number of each anode type installed, other than in an anode bank, and of the number of anodes supplied for testing.

442.09.01.02 Anode Banks

For measurement purposes, a count shall be made of the number of each anode bank type installed.

442.09.01.03 Test Stations

For measurement purposes, a count shall be made of the number of each test station type installed.

442.09.01.04 Tape Coating Systems

Measurement of tape coating system shall be by length in metres along the horizontal centreline of the watermain pipe from the point of connection to a point vertically above the end of the watermain.

442.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clauses under Actual Measurement.

442.10 BASIS OF PAYMENT

442.10.01 *"type"* Individual Anode - Item
***"type"* Anode Bank - Item**
***"type"* Test Station - Item**

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

When an existing unprotected watermain or service is exposed during the construction of other work, payment for the labour, Equipment, and Material for such work shall be full compensation for the excavation, backfill, and compaction required to install anodes on the exposed watermain or service.

Replacement of anodes that do not meet the requirements of this specification shall be at no extra cost to the Owner.

442.10.02 Tape Coating System

Payment for supply and installation of a tape coating system shall be at the Contract price for the tender item "Watermain" according to OPSS 441.

Replacement of any tape coating system that does not meet the requirements of this specification shall be at no extra cost to the Owner.

TABLE 1
Casting Weights and Approximate Finished Product Package Weights and Dimensions

Anode Type	Casting				Finished Product Overall Package			
	Nominal Weight		Approximate Length Range *		Approximate Weight Range (Note 1)		Approximate Dimensions Range (Note 1)	
			From	to			Diameter	Length
	Lbs	Kg	mm	mm	Lbs	Kg	mm	mm
Zinc								
Z-5	5	2.3	175	250	14-17	6.4 - 7.7	100 - 130	400 - 510
Z-6	6	2.7	275	375	14-17	6.4 - 7.7	100 - 130	400 - 510
Z-12	12	5.4	575	625	26-28	11.8 - 12.7	100 - 130	675 - 760
Z-24	24	10.9	550	1220	50-55	22.7 - 25	100 - 130	1000 - 1520
Magnesium								
M-5	5	2.3	175	200	12-17	5.5 - 7.7	127 - 160	250 - 430
M-9	6	4.0	325	550	20-30	9.1 - 13.6	127 - 160	425-600
M-17	17	7.7	575	650	35-50	15.9-22.7	127 - 160	750 - 800
M-32	32	14.5	475	600	80-90	36.4 - 40.9	200 - 225	725-775

Notes:

1. * Contact manufacturer for exact weights and dimensions
2. The length dimensions and overall package requirements may be used as a guide to account for the fact that each manufacturer's products may vary slightly from the values specified in this table.

TABLE 2
Anode Spacing for Over Pipe Method

Pipe Diameter mm	Anode Type	Spacing m
100	M-32-22	22.0
150	M-32-22	15.0
200	M-32-22	11.5
250	M-32-22	10.0
300	M-32-22	8.0
400	M-32-22	6.0
600	M-32-22	4.5

TABLE 3
Anodes Per Location for the Horizontal and Vertical Anode Bank Method

Pipe Diameter mm	Anode Type	Number of Anodes Per Location	Spacing m
150	M-32-22	8	70 ± 5
200	M-32-22	10	70 ± 5
250	M-32-22	12	70 ± 5
300	M-32-22	14	70 ± 5

TABLE 4
Anode Spacing for Metallic Pipe and Copper Services

Diameter mm	Anode Size	Maximum Spacing m
Less than 50 mm Copper Service	Z-12-24	20.0
50 mm Copper Service	Z-12-24	16.0
100	Z-24-48	12.0
150	Z-24-48	8.0
200	Z-24-48	6.0
250	Z-24-48	5.0
300	Z-24-48	4.0
400	Z-24-48	3.0

TABLE 5
Anode Locations and Spacing for New PVC Pipe with Metallic Components

Location	Anode Type	Maximum Spacing and Quantity
Less than 50 mm Copper Service	Z-12-24	20.0 m
50 mm Copper Service	Z-12-24	16.0 m
100 - 300 mm Metallic Fittings and Valves	Z-12-24	1 per fitting and valve
400 mm Metallic Fittings and Valves	Z-24-48	1 per fitting and valve
Hydrant Bases	Z-24-48	1 per hydrant
Tracer Wire	Z-12-24	1 per every 1,000 m of tracer wire