



**CONSTRUCTION SPECIFICATION FOR
CORROSION PROTECTION OF NEW AND
EXISTING WATERMAINS**

TABLE OF CONTENTS

442.01	SCOPE
442.02	REFERENCES
442.03	DEFINITIONS
442.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
442.05	MATERIALS
442.06	EQUIPMENT - Not Used
442.07	CONSTRUCTION
442.08	QUALITY ASSURANCE
442.09	MEASUREMENT FOR PAYMENT
442.10	BASIS OF PAYMENT

APPENDICES

442-A	Commentary
--------------	-------------------

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.

442.01.01 Specification Significance and Use

This specification is written as a municipal-oriented specification. Municipal-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of many municipalities in Ontario.

Use of this specification or any other specification shall be as specified in the Contract Documents.

442.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

442.02 REFERENCES

When the Contract Documents indicate that municipal-oriented specifications are to be used and there is a municipal-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.MUNI, unless use of a provincial-oriented specification is specified in the Contract Documents. When there is not a corresponding municipal-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a provincial-oriented specification is specified in the Contract Documents.

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:M1983 (R2018) PVC Insulating Tape

ASTM International

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

American Water Works Association (AWWA)

C217-16	Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings
---------	--

Underwriters Laboratories of Canada (ULC)

UL 467-13	Grounding and Bonding Equipment
-----------	---------------------------------

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, 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 shown in Table 1, which is included in the A-WW-LL label on the outside of the anode. The A location 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 NACE International.

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.

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 noncellulosic 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.

442.05 MATERIALS

442.05.01 Zinc and Magnesium Anodes

442.05.01.01 Zinc Anode Castings

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

442.05.01.02 Magnesium Anode Castings

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

442.05.01.03 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.

442.05.02 Anode Packaging

The magnesium and zinc anode castings shall be supplied complete with an anode lead wire and shall be centred in and surrounded by chemical packing material. The anode casting and 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. However, 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 noted in Table 1.

442.05.02.01 Anode Chemical Packing Composition

The 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/cm³, and the following composition:

<u>Chemical Packing Component</u>	<u>% by Volume</u>
Gypsum	77 ± 2%
Bentonite	15 ± 1%
Sodium Sulphate	8 ± 1%

442.05.02.02 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:

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:

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.

442.05.03 Microcrystalline Wax and Petrolatum Tape Coating Systems

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

442.05.03.01 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.

442.05.04 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.

442.05.05 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 5 stainless steel terminals and one nickel plated copper bonding or shorting strap. All terminals shall have two stainless steel nuts for locking purposes.

- 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.

442.05.06 Thermite Welds

The thermite weld material shall be as follows:

Thermite Moulds or Welders:

- a) Shall be suitable for the wire, connection type, and orientation.
- b) Shall have a handle and lid.
- c) Shall be 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.
- d) Shall be from the same manufacturer as the weld metal.

Thermite Powder Cartridges:

- a) Shall be suitable for the pipe material.
- b) Weld metal shall contain vanadium, but not tin.
- c) 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.
- d) The batch control numbers shall be packaged with the product prior to shipment from the factory.

Starting Material:

- a) When used, shall consist of aluminum, copper, and iron oxide materials. It shall not contain phosphorous or any caustic, toxic, or explosive substances.
- b) 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.

Thermite Weld Protective Barrier Covers:

- a) Shall be moulded plastic domes filled with corrosion resistant compound on a base of thick elastomeric tape.
- b) Shall use an integrated primer in its adhesive.

Thermite Weld Protective Barrier Coatings:

- a) Shall bond firmly to surfaces without the use of primers and form a tough coating resistant to oxidizing, cracking, alligatoring, checking, loosening, or scaling.
- b) Shall be composed of heavy mastic with synthetic elastomeric additives in mixed solvent.

442.05.07 Miscellaneous Materials

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

Direct Bury Lugs:

- a) Shall 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) Shall be able to connect to header wire without cutting the header wire.
- c) Shall tighten with a screwdriver.
- d) Shall have high impact housing without sharp edges to prevent cuts or handling discomfort.
- e) Shall 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.

442.07 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 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 backfill so that the anode shall reside 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 approved wire splicing methods.

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 cathodically 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.
- 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.
- 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.

Refer to the latest version of AWWA C217 for further details.

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 - 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 an approved splice connection method.

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.

442.07.07.01 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 according to the Test Station Installation - General subsection.

442.07.07.02 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 according to the Test Station Installation - General subsection.

442.07.07.03 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 mm² 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

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.

442.07.10.01 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.

442.07.10.02 Direct Bury Lug Splices

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

442.07.10.03 Soldered Splices

Soldered connections shall be performed according to industry practices.

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

In all cases, the anode shall be placed in native soil, not in granular bedding material. The Contract Administrator shall inspect the anode installation prior to backfilling. Backfill shall be packed uniformly around the anode container to eliminate voids adjacent to the anode.

442.07.14 Testing and Evaluation

For applications using test stations, the following procedures shall be performed 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 an Engineer or a Certified Cathodic Protection Specialist, and shall be submitted to the Contract Administrator.

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 according to the Contract Documents.

442.08 QUALITY ASSURANCE

442.08.01 Anodes

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

The Owner may randomly select samples of supplied anodes for testing by an independent laboratory.

Any batch of anodes found not to be according to 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 be according to the required specifications shall be replaced.

442.08.02 Tape Coating Systems

Ensure that the complete tape coating system supplied is according to this specification.

Prior to installing any tape coating system, confirm to the Owner that the tape coating system supplied complies with the requirements of this specification.

Any installed tape coating system found not to be according to this specification shall be removed and replaced.

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.

442.09.02 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 Systems

Payment for the supply and installation of a tape coating system shall be according to requirements of the Construction Contract.

Replacement of any tape coating system that does not meet the requirements of this specification shall be the Contractor's responsibility 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 *		Approximate Dimensions Range *	
			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

* Call manufacturer for exact weights and dimensions

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

Appendix 442-A, November 2020 FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

The designer should specify the following in the Contract Documents:

- The test station to be flush-mounted or post-mounted. (442.05.05)
- Length of post-mounted test stations (442.05.05)
- Type of C Taps. (442.05.07)
- General methods of corrosion protection. (442.07.01)
- Methods of corrosion protection for metallic components. (442.07.04.06)
- Locations of concrete pressure pipe corrosion monitoring stations. (442.07.05)
- Splice connection method. (442.07.10)

Type and spacing of anodes are dependent on the soil conditions. Soil conditions should be verified before specifying the anode type and spacing. Assumptions used for anode spacings provided for new metallic watermains are as follows:

- i. Soil resistivity of 2,000 ohm-cm.
- ii. Bitumen coatings on pipe or other components are of no value (i.e., essentially bare).
- iii. 150 mm main with copper services should require about 2 mA of cathodic protection current per lineal foot and so in 2,000 ohm-cm soil 50 mA from a 24 lb zinc anode should cover 8.0 m of pipe.
- iv. 6.0 m spacing would allow for one anode per joint so discontinuities should not be a problem.
- v. A 24 pound zinc anode has a capacity of about 1,000 ma years so the anodes should have a life of about 20 years.

The anode items are titled "*type*" Individual Anode-Item and "*type*" Anode Bank-Item. The reference to "*type*" is to indicate that the complete item title for tender should include the type of anode (i.e., zinc or magnesium) required. (442.10.01)

The test station item is titled "*type*" Test Station-Item. The reference to *type* is to indicate that the complete item title for tender should include the type of test station (i.e., flush-mounted or post-mounted) required. (442.10.01)

The designer should ensure that the General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

Related Ontario Provincial Standard Drawings

OPSD 1109.010	Cathodic Protection for Metallic Watermain Systems
OPSD 1109.011	Cathodic Protection for PVC Watermain Systems
OPSD 1109.012	Cathodic Protection of Existing Metallic Watermains, Exposed Service or Pipe Method

OPSD 1109.013 Anode Installation Over Pipe Method for Existing Metallic Watermains
OPSD 1109.014 Vertical Anode Bank at Service
OPSD 1109.015 Horizontal Anode Bank at Service
OPSD 1109.025 Waterproofing of Splices