

**Construction Specification for
Cathodic Protection of
Existing Iron Watermains**

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TS 7.20.01 SCOPE

This specification covers the requirements for the cathodic protection of existing iron watermains.

TS 7.20.02 REFERENCES

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

City of Toronto Standard Drawings

T-1106.02 Thermite Welding of Metallic Watermains
T-1106.07 Test Station for Cathodic Protection of Ductile Iron Watermains

American Society of Testing and Materials

B843 Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
G97 Standard Test Method for Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications

National Association of Corrosion Engineers

Cathodic Protection Survey Procedure, 3rd Edition

TS 7.20.03 DEFINITIONS

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

AWG means American Wire Gauge

GPS means Global Positional System

NACE means National Association of Corrosion Engineers

TS 7.20.04 DESIGN AND SUBMISSION REQUIREMENTS

TS 7.20.04.01 Cathodic Protection Survey – Over the Line Potential

The cathodic protection survey shall consist of the following:

TS 7.20.04.01.01 *Pipe to Soil Potentials*

Pipe-to-soil potential readings shall be taken directly over the watermain at a maximum of one metre interval in accordance with NACE Cathodic Protection Survey Procedures using a high resistance voltmeter and a portable Copper: Copper Sulphate (Cu:CuSO₄) half-cell reference electrode CSE. The potential readings are to be taken at the same locations and in the same sequence for both the pre and post installation surveys. The negative connection shall be made to the pipe through the same connection point for the pre-installation potential survey which will mostly be at residential services or hydrants, or in special circumstances at test stations as the case may be.

TS 7.20.04.01.02 *Close Interval Survey*

The cathodic protection surveys shall be according to NACE Cathodic Protection Survey Procedures and shall provide close interval survey readings when crossing hard surfaces such as sidewalks, driveways, or intersections when possible. This will eliminate gaps in the potential measurement graphs. This is carried out at openings or cracks in the asphalt. At intersections, there are typically cracks in the asphalt that can be used for readings. More accurate readings can be achieved when grounds are wet.

TS 7.20.04.01.03 *Unavailable Residential Surveys*

In the event that residential services are unavailable or electrically connected to the watermain, the negative connection shall be made to the pipe at the test stations.

TS 7.20.04.01.04 *Continuous Electrical Flow of Watermain*

In the event that pipe-to-soil potentials are undertaken as specified above, the surveyor shall take into consideration that the watermain may not be electrically continuous.

TS 7.20.04.01.05 *Relevant Information*

The survey shall include the date of the survey, the location of all hydrants, valves, and valve chambers, and once installed, the GPS coordinates of the test stations, if applicable.

TS 7.20.04.02 *Final Report Submission*

The Contractor shall submit a comprehensive final written report which shall include the results of all the data collected through the surveys. Included in the report shall be an analysis and evaluation of the anode and test station installations—if present—with comments on each street concerning the degree of cathodic protection, identifying areas of concern for each street. All deficiencies are to be noted on the graphs and within the report.

The report shall provide direction as to remedial action required to rectify any noted deficiencies. The Contractor shall then take action to rectify the noted deficiencies. The remedial work shall be coordinated with the Contract Administrator for inspection.

The pre and post installation potential measurements for each street shall be presented in graph format with both the pre and post surveys shown on the same graph. The length of watermain shown on each graph shall be limited to 250 m.

The graphs shall be created in Microsoft Excel format. The location of each test station shall be identified with its closest municipal address and its GPS coordinate accurate within one metre. The coordinates shall be referenced to the NAD83 (CSRS) / MTM Zone 10 datum.

The format of all reports shall be approved by the Contract Administrator prior to initial submission. The final report must be indexed by District and street name in alphabetical order. The Contractor shall provide the Contract Administrator with two hard copies of the final survey data, graphs, and report documents on letter size paper in a 3-ring binder. In addition to the hard copies, the Contractor shall submit two electronic copies of the survey data, graphs, and report documents on a USB drive or approved digital medium.

TS 7.20.04.03 As-built Data Collection

The Contractor shall provide all as-built data for each anode and test station—if any—installed on the prescribed form included in the attachments to this Contract. As-built data shall include the following:

- Municipal address adjacent to each installation
- Type of installation – anode / test station (if applicable)
- GPS coordinates for test stations—only if they are installed
- Location of installation, for example, under sod or asphalt
- The chainage from the watermain valve which coincides with the over the line potential pre-installation survey for that given street.

TS 7.20.05 MATERIALS**TS 7.20.05.01 Handling and Storage of Materials**

Material shall be stored so as to prevent injury to persons and to prevent the delay of work by others.

Sacrificial anodes and other materials which can be damaged by exposure to the environment shall be stored in a clean, dry enclosure.

Sacrificial anodes shall not be stored on site.

Sacrificial anodes shall not be handled by their lead wires

TS 7.20.05.02 Manufacture of Sacrificial Anodes

Lead wire silver-soldered to steel core.

Soldered connection encapsulated in heat shrinkable tubing.

Magnesium casting centered in anode package and surrounded by a minimum of 25 mm of special backfill.

TS 7.20.05.03 Magnesium Anodes

Packaged magnesium anodes shall have a 14.5 kg magnesium casting having a length of 560 mm +20 mm and a high potential alloy composition according to ASTM B843, Type M1C specification or equal.

The magnesium casting shall be contained in a rugged moisture-absorbent cardboard container of the following dimensions: 200 mm diameter x 700 mm long. The core shall be a 3 mm diameter steel core extending a minimum of 75 per cent of the length of the casting.

The magnesium anode shall be no less than 45 per cent efficient for each sample tested according to ASTM G97.

The magnesium casting within the container shall be supplied surrounded with a special backfill material having an electrical resistivity of less than 45 ohm-cm when saturated with distilled water and the following composition by volume:

-
- Gypsum 77% $\pm 2\%$
 - Bentonite 15% $\pm 1\%$
 - Anhydrous Sodium Sulphate 8% $\pm 1\%$

Packaged magnesium anode shall be supplied with 3000 mm of AWG No 10/7 strand copper with RWU90 blue insulation.

TS 7.20.05.04 Test Stations

Test stations shall be Street Fink manufactured by Cott Industries Ltd. or equivalent with:

- Colour: Blue
- Terminals: 6
- Support Post: 150 mm \varnothing x 600 mm long
- Bonding Straps: 2

TS 7.20.05.05 Conductors

Watermain lead wires shall be AWG N^o 10/7 strand copper conductor having RWU90 black insulation.

TS 7.20.05.06 Electrical Connectors

Electrical connectors shall be manufactured by Thomas & Betts Inc. or equivalent.

Test lead terminals:

- Anode headers and pipe lead wires, Sta-Kon Cat. N^o D8-14
- Monitoring probe lead wires, Sta-Kon Cat. N^o RA18-14

TS 7.20.05.07 Crimp Connectors

The crimp connectors inside of the test stations shall be Burndy YA8CL 1 One-hole Barrel Lug with AWG N^o 8 red with ¼" bolt size or equivalent.

TS 7.20.05.08 Coal Tar Coating Mastic

Brush applied coal tar coating mastic shall be Roskote A51 mastic for below grade applications.

TS 7.20.06 EQUIPMENT

The Contractor shall use the necessary specialized equipment required for the excavation of the watermain such as augering or vacuum excavation, the connection of lead wires to the watermain by electrical resistance welding or thermite welding, and the compaction of the backfilled excavations.

The City shall inspect and approve the suitability of the Contractor's equipment.

TS 7.20.07 CONSTRUCTION

TS 7.20.07.01 Preliminary Site Work

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 prior to installation.

Test station locations:

- Within 10 m of each end of the watermain.
- At minimum intervals of 150 m along the watermain.
- At locations where they shall not interfere with, or present a hazard to pedestrian or vehicular traffic.
- At the nearest property line, whenever possible.

Anode locations:

Within 3 m of each end of the watermain and at the following intervals along the watermain, according to watermain diameter according to Table 1.

Table 1: Anode spacing interval

Watermain diameter (mm)	Spacing (m)
100	22.0
150	15.0
200	11.5
300	8.0
400	6.0
600	4.5

Anode locations may be shifted a maximum of 3 m to avoid driveways and other paved areas.

Obtain clearances from buried and overhead facilities as follows:

- Clearances to excavate shall be obtained from all other parties having buried and overhead facilities in the immediate vicinity of the watermain being cathodically protected.
- The locations of all water service piping in the vicinity of the watermain being protected shall be determined.
- The locations of all anodes shall be adjusted such that no anodes are located within 1000 mm of buried facilities specified above.

TS 7.20.07.02 Pre-installation Survey

Prior to installing or connecting the anode the Contractor shall undertake a pre-installation survey of the existing over the line potential, according to TS 7.20.04.01, using preferably the end of street hose bibb or end of street hydrant if no hose bibb are available. The Contractor shall note on the survey the connection point as the same connection point must be used for the pre and post installation potential surveys.

The survey shall be conducted in presence of the Contractor Administrator.

The Contractor shall submit the pre-installation survey to the Contract Administrator for review prior to the installation of any anodes.

A GPS datalogger shall be used to perform the survey and the raw data files shall be provided along with all other survey data to the Contract Administrator.

The surveys shall include separate potential measurements to be recorded at all test stations, if present, not used as connection points for the surveys and at all hydrants. This will involve making a temporary connection to these stations and hydrants in addition to the recording of their GPS coordinates. This data will assist in establishing the level of electrical continuity of the watermains for a better interpretation of the survey's data.

TS 7.20.07.03 Anode Installation

The excavation at each anode site shall be performed using a vacuum excavator so as to expose the pipe wall and accommodate the anode to be installed. The anodes are only to be installed underneath soft surfaces such as grassed boulevards and landscaped areas as required by the Contract Documents,

- The Contractor shall increase the number of anodes installed at either side of the road or driveway crossings as required to provide adequate protection to the watermain. For the anode spacing interval, see Table 1.
- If the watermain is located under a sidewalk, the Contractor shall not core through the sidewalk. Anodes may be installed on a watermain located under a sidewalk only if the watermain can be assessed safely without disturbing or cutting the sidewalk.

The size of the excavation at each anode location shall be kept to an absolute minimum.

The pipe surface shall be cleaned to facilitate welding.

The anode lead shall be welded to the pipe surface either by a thermite welding process, for example Cadweld as specified on T-1106.02 or an electrical resistance welding process, for example Nelson Stud Welder or equivalent.

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

The cleaned watermain surface, the weld, and the exposed copper wire shall be coated with mastic.

The excavation shall be backfilled with 300 mm of native backfill prior to placement of the anode.

The anode shall be placed in the excavation, no closer than 300 mm to the watermain.

Should the watermain pipe be less than 1.70 m in depth, the anode shall not be placed vertically but diagonally so that the top of the anode is no closer than 300 mm from the bottom of the road subgrade.

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

If the excavation is not underneath the pavement, it shall be filled to within 150 mm of the natural grade with excavated natural material, manually compacted and thoroughly watered. Place 150 mm of topsoil and restore sodded area to as good as or better than original condition and watered.

If the excavation is underneath the pavement or any hard surface, it shall be backfilled with compacted Granular B material to the top of the anode. The remaining cut shall be filled to within 100 mm of the surface with unshrinkable fill and then filled to grade with temporary asphalt.

TS 7.20.07.04 Test Station Installation

Test stations shall not be installed unless specified in the Contract Documents. Test stations are for special circumstances, such as a street with all non-metallic residential services and having no hydrant which can be used as an alternate connection point for the pipe potential surveys.

Install test stations:

- As shown on T-1106.07.
- Within 10 m of each end of the watermain.
- At minimum intervals of 150 m along the watermain.
- At locations which where they will not interfere with, or present a hazard to, pedestrian or vehicular traffic.
- At the nearest property line, whenever possible.
- Flush with the pavement or boulevard.

Install test stations and connect lead wires according to T-1106.07.

Install test stations flush with the pavement or boulevard.

At each test station location, connect two lead wires to the watermain.

Install the lead wire from the nearest anode into the test station rather than connecting it directly to the watermain.

Connect all lead wires to the appropriate test station terminals using test lead terminal connectors.

Horizontal, underground wiring runs shall be at least 500 mm deep.

Sufficient slack shall be left in the watermain test leads and the anode wires to prevent any stress on either the anode or pipe connections during backfilling and subsequent soil settlement.

Measure and record the GPS coordinates of each test station to within ± 250 mm and submit all data to the City.

TS 7.20.07.05 Post-installation Survey

No sooner than 60 Days after the installation of the anodes, the Contractor shall conduct an over the line potential survey according to TS 7.20.04.01 of the newly installed cathodic protection system. The post-installation surveys shall use the same connection points as used for the pre-installation surveys in order to facilitate data review of the anticipated potential shifts subsequent to anode installation.

The survey shall be conducted in presence of the Contract Administrator.

A GPS datalogger shall be used to perform the survey and the raw data files shall be provided along with all other survey data to the Contract Administrator.

The post-installation survey shall also include separate potential measurements to be recorded at all test stations – if present – not used as connection points for the surveys and at all hydrants in addition to the recording of their GPS coordinated. These extra measurements will be used to assess whether or not the watermain is electrically continuous and helps confirm that anodes are providing cathodic protection to the hydrant and watermain piping sections.

TS 7.20.07.06 Surface Restoration and Final Clean-Up

The excavated surface shall be restored as specified in the Contract Documents.

The Contractor shall be responsible for removal and disposal of all surplus material.

Surplus materials shall be removed and disposed by the Contractor at the end of each Working Day. No surplus materials are allowed to be left on site for any reason unless authorized by the Contract Administrator.

In no event shall open holes be left on the street unless suitably fenced.

The Contractor shall be responsible for replacing any surrounding pavement or concrete removed or damaged during the installation of the anode.

Surface restoration and final clean-up shall be to the satisfaction of the Contract Administrator.

TS 7.20.07.07 Watermain Breaks

The Contractor shall immediately notify the City if a watermain break occurs.

Watermain breaks caused by the Contractor in the process of anode installation shall be the responsibility of the Contractor.

The City shall repair breaks for the Contractor and charge the Contractor for the cost of the repair.

Breaks occurring during the wire welding process, due to decreased pipe structural strength, shall be the responsibility of the City.

The Contractor shall be responsible for all damages to other utilities.

TS 7.20.07.08 System Deficiencies

Any system deficiencies as identified by the City's corrosion consultant, shall be corrected at the Contractor's expense. Such deficiencies shall include:

- missing anodes
- broken lead wire connections
- use of improper materials
- inadequate restoration and clean-up

Deficiencies shall be corrected within 90 Days of notification by the City.

TS 7.20.08 QUALITY ASSURANCE

TS 7.20.08.01 Quality Assurance

Contractor shall ensure that the anodes supplied conform to this specification.

The Contractor or anode supplier shall forward a copy of the *Certificate of Compliance* acquired from the anode manufacturer to the City for each anode shipment, prior to either their installation or delivery acceptance.

The City may randomly select samples of anodes supplied by the Contractor for testing in accordance with ASTM G97, by an independent laboratory, with testing costs to be borne by the City.

Any batch of anodes found not to conform to the specification shall be replaced immediately by the Contractor at no extra cost to the City. No additional work shall take place until such time that the anodes are approved and accepted by the Contract Administrator.

Any installed anodes found not to conform to the required specifications shall be replaced by the Contractor at no extra cost to the City.

TS 7.20.09 MEASUREMENT FOR PAYMENT

TS 7.20.09.01 Anode Installation

For measurement purposes, a count shall be made of the number of anodes installed.

TS 7.20.09.02 Test Station Installation

For measurement purposes, a count shall be made of the number of test stations installed.

TS 7.20.09.03 Cathodic Protection Survey

Measurement of pre and post installation surveys shall be in metres (m) of watermain cathodically protected. The costs are inclusive of submission of the final report and as-built data collection.

TS 7.20.10 BASIS OF PAYMENT

- TS 7.20.10.01 Anode Installation – Item**
Test Station Installation – Item
Cathodic Protection Survey – Item

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