CONSTRUCTION SPECIFICATION FOR FORCEMAIN INSTALLATION IN OPEN CUT

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412.01 SCOPE

This specification covers the requirements for the installation of Forcemains and associated appurtenances in open cut.

412.01.01 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 according to the Contract Documents.

412.01.02 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.

412.02 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 206	Grading
OPSS 401	Trenching, Backfilling, and Compacting
OPSS 404	Support Systems
OPSS 490	Site Preparation for Pipelines, Utilities, and Associated Structures
OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 492	Site Restoration Following Installation of Pipelines, Utilities, and Associated Structures
OPSS 517	Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 539	Temporary Protection Systems

Ontario Provincial Standard Specifications, Material

OPSS 1004	Aggregates - Miscellaneous
OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1350	Concrete - Materials and Production
OPSS 1842	Pressure Polyethylene Pipe Products

CSA Standards

B137.1-09	Polyethylene (PE) Pipe, Tubing, and Fittings for Cold Water Pressure Services [Part of B137 Series-09, Thermoplastic Pressure Piping Compendium]
B137.2-09	Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications [Part of B137 Series-09, Thermoplastic Pressure Piping Compendium]

B137.3-09 Rigid Polyvinylchloride (PVC) Pipe and Fittings for Pressure Applications [Part of B137 Series-09, Thermoplastic Pressure Piping Compendium]

ASTM International

A 153/A 153M-09	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A 276-15	Stainless Steel Bars and Shapes
A 307-14	Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
B 633-13	Electrodeposited Coatings of Zinc on Iron and Steel
B 766-86 (2015)	Electrodeposited Coatings of Cadmium
C 361-14a	Reinforced Concrete Low-Head Pressure Pipe (Metric)
D 3139 (2011)	Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

American Water Works Association (AWWA)

C104/A21.3-08	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
C110/A21.10-12	Ductile-Iron and Gray-Iron Fittings for Water
C111/A21.11-12	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
C151/A21.51-09	Ductile-Iron Pipe, Centrifugally Cast**,** for Water
C153/A21.53-11	Ductile-Iron Compact Fittings for Water Service
C200-12	Steel Water Pipe - 6 in. (150 mm) and Larger
C205-12	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger, Shop Applied
C206-11	Field Welding of Steel Water Pipe
C208-12	Dimensions for Fabricated Steel Water Pipe Fittings
C301-07	Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids
C302-11	Reinforced Concrete Pressure Pipe, Noncylinder Type
C303-11	Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
C504-10	Rubber-Seated Butterfly Valves
C509-09	Resilient-Seated Gate Valves for Water Supply Service

American Society of Mechanical Engineers (ASME)

B18.2.1-96 (R2010)	Square and Hex Bolts and Screws - Inch Series

412.03 DEFINITIONS

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

Associated Appurtenance means structures, devices, and appliances, other than pipe and conduit that are used in connection with a forcemain, such as valves and thrust restraints.

Backfilling means as defined in OPSS 401.

Excavation, Earth and Rock means the excavation classified as earth and rock according to OPSS 206.

Fitting means connections, appliances, and adjuncts designed to be used in connection with pipes (e.g., elbows and bends to alter the direction of a pipe; tees and crosses to connect a branch with a sewer main; plugs and caps to close a pipe end; and bushings, diminishers, or reducers to couple two pipes of different diameters).

Forcemain means an installation designed for the conveyance of sanitary or storm sewage under pressure, using pre-formed or pre-cast circular pipe sections that are laid end to end and joined using suitable methods.

412.05 MATERIALS

412.05.01 General

Pipe size, material, and class shall be according to the requirements specified in the Contract Documents.

Fittings shall be suitable for and compatible with the pipe size, material, and class with which they will be used.

412.05.02 Ductile Iron Pipe

Ductile iron pipe shall be according to AWWA C151/A21.51.

Fittings shall be gray iron according to AWWA C110/A21.10 or ductile iron according to AWWA C 110/A21.10 or AWWA C153/A21.53.

Ductile iron pipe and fittings shall be cement lined according to AWWA C104/A21.3.

Rubber gaskets for push-on or mechanical joints shall be according to AWWA C111/A21.11.

412.05.03 Concrete Pressure Pipe

Concrete cylinder pipe, including joints and fittings, shall be according to AWWA C301 or AWWA C303.

Non-cylinder pipe and joints shall be according to AWWA C302 or ASTM C 361. Fittings shall be according to AWWA C302.

412.05.04 Polyvinyl Chloride (PVC) Pressure Pipe

Polyvinyl chloride pressure pipe and fittings shall be according to CSA B137.3 and supplied from a plant approved by an organization accredited by the Standards Council of Canada (SCC).

Flexible elastomeric seals for bell and spigot joints shall be according to ASTM D 3139.

Fittings shall be either:

a) Gray iron according to AWWA C110/A21.10.

b) Ductile iron according to AWWA C110/A21.10 or AWWA C153/A21.53 and cement lined according to AWWA C104/21.4.

c) Injection moulded polyvinyl chloride plastic according to CSA B137.2.

d) Prefabricated polyvinyl chloride plastic for pipe diameters 200 mm and larger according to CSA B137.3.

412.05.05 Polyethylene (PE) Pressure Pipe

Polyethylene pressure pipe shall be according to OPSS 1842.

Fittings shall be either:

a) Flanged gray iron according to AWWA C110/A21.10.

b) Flanged ductile iron according to AWWA C110/A21.10 or AWWA C153/A21.53 and cement lined according to AWWA C104/A21.4.

c) Polyethylene according to OPSS 1842.

d) Heat fusion or insert or compression type fittings according to CSA B137.1.

412.05.06 Steel Pipe

Steel pipe shall be according to AWWA C200.

Fittings shall be according to AWWA C208.

Steel pipe shall have a cement-mortar protective lining and coating according to AWWA C205.

412.05.07 Valves

412.05.07.01 General

All valves shall open by operating in a counter clockwise direction, or as specified in the Contract Documents.

Valves shall be designed for a minimum cold water working pressure of 1,035 kPa.

Valve types shall be one of the following:

a) Valves less than 75 mm shall be brass or bronze gate valves.

b) Valves greater than or equal to 75 mm and less than or equal to 300 mm shall be cast iron or ductile iron gate valves.

c) Valves greater than 300 mm up to and including 500 mm shall be gate or butterfly valves.

d) Valves greater than 500 mm shall be butterfly valves.

e) Knife gate valves shall be installed when specified in the Contract Documents.

Fasteners shall be made from material meeting the strength requirements of ASTM A 307 with dimensions according to ASME B18.2.1. Bolts, studs, and nuts shall be cadmium plated according to ASTM B 766 or zinc coated according to ASTM A 153/A 153M or ASTM B 633. Fasteners for mechanical joints shall be ductile iron according to AWWA C111/A21.11.

412.05.07.02 Gate Valves

Gate valves shall be according to AWWA C509.

Stem sealing on non-rising stem valves shall use O-Ring type seals that do not require adjustment. The end configuration shall be as specified in the Contract Documents.

412.05.07.03 Butterfly Valves

Butterfly valves shall be according to AWWA C504.

Valves shall be short body flanged or mechanical-joint, class 150B.

Valve shafts shall be stainless steel, and when they project through the body, shall have seals that do not require adjustment.

A vertical operating nut shall be provided. Valves shall be provided with an external indicator showing valve position by means of a pointer operating through a 90° arc from open to close.

412.05.07.04 Knife Gate Valves

Valves shall be made of Type 304 or Type 316 stainless steel.

Valves shall have full port area and wafer face to face. The valves shall have face to face welded parts, including packing chest and packing stuffer and stem, complete with a resilient seat.

412.05.07.05 Air Release and Air/Vacuum Valves

Air release and air/vacuum valves shall be single acting type.

412.05.08 Concrete

Concrete for thrust blocks and fitting and appurtenance supports shall be according to OPSS 1350 with a nominal minimum 28-Day compressive strength of 20 MPa.

412.05.09 Mortar

Mortar for joints shall consist of one part Portland cement and three parts mortar sand, and wetted with sufficient water to the consistency of a thick cream. The mortar sand shall be according to OPSS 1004, the Portland cement shall be according to OPSS 1301, and the water shall be according to OPSS 1302.

412.05.10 Stainless Steel Straps, Tie-Rods, Angles, Nuts, and Bolts

Stainless steel straps, tie-rods, angles, nuts, and bolts used with concrete thrust blocks shall be according to ASTM A 276, Type 316 stainless steel.

412.07 CONSTRUCTION

412.07.01 Site Preparation

Site preparation shall be according to OPSS 490.

412.07.02 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

412.07.03 Protection Against Floatation

Damage to the pipeline due to floatation shall be prevented during construction and until completion of the work.

412.07.04 Cold Weather Work

All work shall be protected from freezing. Pipes and bedding material shall not be installed on frozen ground.

412.07.05 Transporting, Unloading, Storing, and Handling Pipe

Manufacturer's recommendations for transporting, unloading, storing, and handling of pipe shall be followed.

All pipes, fittings, and gaskets that are unsound or damaged shall be rejected.

412.07.06 Excavation

Excavation for placing forcemains shall be according to OPSS 401.

412.07.07 Support Systems

Support systems shall be according to OPSS 404.

412.07.08 Dewatering

Dewatering shall be according to OPSS 517.

412.07.09 Temporary Protection Systems

The construction of all temporary protection systems shall be according to OPSS 539. When the stability, safety, or function of an existing roadway, railway, other works, or proposed works may be impaired due to the method of construction, such protection as may be required shall be provided. Protection may include sheathing, shoring, and the driving of piles, where necessary, to prevent damage to such works or proposed works.

412.07.10 Backfilling and Compacting

Backfilling and compacting shall be according to OPSS 401.

412.07.11 Installation of Pipe

Pipe shall be laid in a dry trench.

Ends of pipe shall be kept clean.

Pipe shall be laid within the alignment and grade tolerances specified in the Contract Documents. The barrel of each pipe shall be in contact with the shaped bed throughout its full length.

Pipe shall be kept clean as work progresses. Water shall not be allowed to flow through the pipe during construction. A removable watertight bulkhead shall be installed at the open end of the last pipe laid whenever work is suspended.

Pipe shall not be laid until the preceding pipe joint has been completed and the pipe carefully embedded and secured in place.

412.07.12 Jointing

412.07.12.01 General

Joint surfaces shall be clean. Pipe ends shall be lubricated with material recommended by the pipe manufacturer.

Manufacturer's instructions for jointing pipes shall be followed.

Joints and all connections shall be made watertight.

All bolts, nuts, couplings, rubber rings, and connecting pieces shall be cleaned thoroughly prior to installation.

Pipes shall be aligned on centreline to previously laid pipe.

Pipe shall be pulled or pushed into the previously laid pipe by hand or by a hand operated winch. A backhoe or other equipment shall not be used to push the pipe.

Joints shall be prevented from opening after the pipe has been laid.

412.07.12.02 Ductile Iron Pipe

412.07.12.02.01 Mechanical Joints

The gland shall be positioned on the pipe with the lip extension toward the joint. The gasket shall be slipped on the pipe with the thick edge towards the gland. The spigot end shall be pushed to its seat in the bell. The gasket shall be pressed to seat it evenly around the joint.

The gland shall be positioned for bolting and the bolts shall be inserted. All nuts shall be hand tightened.

The nuts shall be tightened half a turn at a time with a calibrated torque wrench. All nuts shall be tightened uniformly to the torque specified in AWWA C111/A21.11.

412.07.12.02.02 Bell and Spigot Joints

The gasket shall be lubricated and placed in the groove of the bell making certain it is properly seated.

Pipes to be joined shall be aligned and the spigot shall be carefully entered into the bell until the spigot end just makes contact with the gasket.

The entry of the spigot into the bell shall continue until the second reference mark is flush with the face of the bell.

412.07.12.03 Concrete Pressure Pipe

412.07.12.03.01 Bell and Spigot Joints

A cotton or burlap diaper shall be placed around the bell end of the pipe already in place.

A rubber gasket shall be placed on the spigot end of the pipe to be laid ensuring that the stretch and volume of the gasket is equalized around the entire circumference of the pipe. The gasket and spigot shall be lubricated prior to the spigot end being inserted home into the bell end.

The pipe shall be aligned and the spigot end shall be inserted into the bell of the pipe already in place. Steel inserts shall be placed in the joints to prevent the spigot from entering the full depth of the bell. The location of the rubber gasket shall be checked around the entire circumference of the joint. The steel insert shall be removed and the pipe pushed until the spigot enters the full depth of the socket and is retained in position.

The diaper shall be carefully placed around the joint recess. Cement mortar shall be poured around the assembled joint.

412.07.12.04 Polyvinyl Chloride (PVC) Pressure Pipe

Joints shall be bell and spigot with rubber gaskets. If gaskets are supplied separately, they shall be inserted in the groove of the bell end of the pipe.

The spigot shall be lubricated. The spigot end shall be inserted and pushed into the bell until the second reference mark is flush with the face of the bell.

412.07.12.05 Polyethylene (PE) Pressure Pipe

Polyethylene pressure pipe 100 mm diameter and larger shall be joined by the thermal butt fusion process. Procedures recommended by the pipe manufacturer shall be followed.

Polyethylene pressure pipe that is smaller than 100 mm shall be joined with heat fusion or insert or compression type fittings that are recommended by the pipe manufacturer and that prevent pull out and resist creep deformation at full test pressure.

Connections to non-polyethylene fittings and appurtenances that are 50 mm diameter and larger shall be made with flanged joints according to manufacturer's recommendations. Bolts shall be tightened to the torque specified by the manufacturer for the particular size and type of stub end.

412.07.12.06 Steel Pipe

Steel pipe shall be jointed according to AWWA C200. Field welding for joints shall be according to AWWA C206.

412.07.13 Cutting of Pipe

Whenever cutting of pipe is required, the pipe shall be cut according to the recommendations of the pipe manufacturer.

412.07.14 Change in Line and Grade

412.07.14.01 Ductile Iron Pipe

Fabricated bends shall be provided for changes in line and grade of 11.25° or more.

Deflections of less than 11.25° may be made using a series of pipe joint deflections. The manufacturer's recommendation in deflecting any single pipe joint shall not be exceeded.

412.07.14.02 Concrete Pressure Pipe

Fabricated bends, bevel adapters, or elbows shall be used for changes in line or grade greater than 5°. Changes in line or grade less than 5° shall be made using a manufactured joint or bevel connection or may be made over several joints, but at no time shall the manufacturer's joint deflection recommendations be exceeded.

412.07.14.03 Polyvinyl Chloride (PVC) Pressure Pipe

Polyvinyl chloride pressure pipe joints may be deflected, but shall not exceed manufacturer's recommendations. Otherwise, fabricated bends shall be used.

412.07.14.04 Polyethylene (PE) Pressure Pipe

Use of pipe flexibility may be allowed, but shall not exceed manufacturer's recommendations.

412.07.14.05 Steel Pipe

Fabricated bends shall be used at all changes in line or grade, unless the change can be accomplished by deflections at pipe joints without exceeding the manufacturer's recommendations for deflection at pipe joints.

412.07.15 Installation of Valves

412.07.15.01 General

The work of installing valves shall include the valves and couplings, and when specified in the Contract Documents, valve boxes. Valves shall be installed in locations and of the type specified in the Contract Documents. Valves and connecting pipes shall be aligned accurately and supported as specified in the Contract Documents.

412.07.15.02 Air Release and Air/Vacuum Valves

Air release and air/vacuum valves shall be installed at locations specified in the Contract Documents.

Each air release and air/vacuum valve shall be provided with an isolating valve.

412.07.16 Thrust Restraints

All connections, caps, and bends shall be restrained by concrete blocking or restrained joints as specified in the Contract Documents. Concrete for thrust blocks shall be placed against undisturbed ground. Joints and couplings shall remain free from concrete.

412.07.17 Hydrostatic Testing

412.07.17.01 General

Hydrostatic testing shall be conducted under the supervision of the Contract Administrator.

A test section shall be either a section between valves or the completed forcemain. The forcemain that is to be tested shall be backfilled before testing commences.

Test pressure shall be as specified in the Contract Documents.

The test section shall be filled slowly with water and all air shall be removed from the pipeline. A 24-hour absorption period may be allowed before starting the test. The test section shall be subjected to the specified continuous test pressure for two hours.

412.07.17.02 Polyethylene (PE) Pressure Pipe

The test procedure shall consist of initial expansion and test phases.
During the initial expansion phase, the test section shall be pressurized to the test pressure, and sufficient make-up water shall be added each hour for 3 hours to return to the test pressure. After the initial expansion phase, the test phase begins.

The test phase shall be 2 hours after which a measured amount of make-up water is added to return the test pressure. If the amount of make-up water added does not exceed the value in Table 1, leakage is not indicated. If the amount of make-up water exceeds the Table 1 value, all leaks shall be located and repaired and the test section shall be retested until a satisfactory result is obtained.

The test procedure duration should not exceed 8 hours. If the pressure test is not completed, the test section shall be de-pressurized and allowed to relax for at least 8 hours prior to bringing the test section up to pressure again.

412.07.17.03 Other Pipe

The test section shall be subject to the specified continuous test pressure for 2 hours.

The leakage shall be the amount of water added to the test section to maintain the specified test pressure for the test duration. The measured leakage shall be compared with the allowable leakage as calculated for the test section. The allowable leakage shall be 0.082 litres per millimetre of pipe diameter per kilometre of pipe for the 2 hour test period.

If the measured leakage exceeds the allowable leakage, all leaks shall be located and repaired and the test section shall be retested until a satisfactory result is obtained.

412.07.18 Cleaning and Flushing Forcemains

All forcemains shall be cleaned and flushed.

412.07.19 Site Restoration

Site restoration shall be according to OPSS 492.

412.07.20 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

412.09 MEASUREMENT FOR PAYMENT

412.09.01 Actual Measurement

412.09.01.01 Forcemains

Measurement of forcemains shall be by length in metres horizontally along the centreline of the pipe from the existing point of connection to a point vertically above the end of the new forcemain.

412.09.01.02 Valves

For measurement purposes, a count shall be made of the number of valves installed regardless of the type or size.

412.09.02 Plan Quantity Measurement

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

412.10 BASIS OF PAYMENT

412.10.01 Forcemains - Item
Valves - 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 the Owner raises or lowers the invert of a forcemain by up to 150 mm, it will not constitute a Change in the Work and no adjustment shall be made to the payment. When the invert of a forcemain is raised or lowered by 150 mm or more, this shall then constitute a Change in the Work for the full extent of the change from the original grade.

TABLE 1
Test Phase Make-Up Amount for Pressure Polyethylene Pressure Pipe

Pipe Diameter Mm	Make-Up Water litre/km
30	12.38
40	12.38
50	13.62
75	18.60
100	31.00
150	74.50
200	124.20
250	161.40
275	248.30
300	285.60
350	335.20
400	409.70
450	533.90
500	682.90
550	869.10
600	1,105.00
700	1,378.20
800	1,775.50
900	2,234.90
1,000	2,731.60
1,050	3,104.00
1,200	3,973.20
1,350	5,152.70
1,600	7,449.70

Appendix 412-A, November 2018
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 may consider including soil boring data, a geotechnical report, a subsurface report, or a soils report in the Tender Documents.

The designer should specify the following in the Contract Documents:

- Pipe size, material, and class. (412.05.01)

- Valve opening instruction if needed (412.05.07.01)

- Gate valve end configuration. (412.05.07.02)

- Alignment and grade tolerances for the pipe installation. (412.07.11)

- Valve type, location, and support. (412.07.15.01)

- Location of air release and air/vacuum valves. (412.07.15.02)

- Type of thrust restraints. (412.07.16)

- Test pressure for hydrostatic testing. (412.07.17.01)

The requirement for valve boxes should be determined. If they are required, they should be specified in the Contract Documents. (412.07.15.01)

Corrosion protection system provisions should be specified, if appropriate.

Tracer wire and marker tape should be specified if appropriate. Designer may wish to add identifier codes or markings to identify the use of the pipe (e.g., sanitary or storm vs. watermain or gas).

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 1103.010	Concrete Thrust Blocks for Tees, Plugs, and Horizontal Bends
OPSD 1103.020	Concrete Thrust Blocks for Vertical Bends