



Note: The PROV published in November 2017 replaces OPSS 603 COMMON, November 2015 with no technical content changes.

CONSTRUCTION SPECIFICATION FOR INSTALLATION OF DUCTS

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603.01 SCOPE

This specification covers the requirements for the installation of flexible ducts, rigid ducts concrete encased, rigid ducts direct buried, rigid ducts by subsurface installation, rigid ducts steel encased by subsurface installation, and surface mounted duct systems. This specification also covers the requirements for rock excavation for all electrical work.

603.02 REFERENCES

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 492	Site Restoration Following Installation of Pipelines, Utilities, and Associated Structures
OPSS 501	Compacting
OPSS 610	Removal of Electrical Equipment and Materials
OPSS 905	Steel Reinforcement for Concrete

Ontario Provincial Standard Specifications, Material

OPSS 1004	Aggregates - Miscellaneous
OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1350	Concrete - Materials and Production
OPSS 1359	Unshrinkable Backfill
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1802	Smooth Walled Steel Pipe

CSA Standards

B137.1-13	Polyethylene (PE) Pipe, Tubing, and Fittings for Cold-Water Pressure Services
C22.2 No. 45.1-07 (R2012)	Electrical Rigid Metal Conduit - Steel
C22.2 No. 211.1-06 (R2011)	Rigid Types EB1 and DB2/ES2 PVC Conduit
C22.2 No. 211.2-06 (R2011)	Rigid PVC (Unplasticized) Conduit
C22.2 No. 227.1-06 (R2011)	Electrical Nonmetallic Tubing
C22.2 No. 2515-09 (R2014)	Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

ASTM International

F 2160-10	Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)
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Underwriters Laboratories (UL)

UL 651A - 10/26/2011	Type EB and Rigid PVC Conduit and HDPE Conduit
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National Electrical Manufacturers Association (NEMA)

TC 7-2013	Smooth Wall Coilable Electrical Polyethylene Conduit
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Electrical Safety Authority (ESA)

Ontario Electrical Safety Code - 2012

603.03 DEFINITIONS

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

Electrical Junction Boxes means surface mounted or embedded boxes for use with electrical wirings or devices.

Horizontal Directional Drilling (HDD) means directional boring or guided horizontal boring.

Rock means as defined in OPSS 206.

603.05 MATERIALS

603.05.01 Concrete

Concrete shall be according to OPSS 1350 with a nominal 28-Day compressive strength of 20 MPa.

603.05.02 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

603.05.03 Sand Bedding

Sand bedding shall consist of sand conforming to the gradation requirements of mortar sand according to OPSS 1004.

603.05.04 Fish Line and Trace Wire

Fish line shall be nylon or polypropylene material with a minimum test strength of 400 N. Trace wire shall be minimum #12 AWG copper wire, green insulation.

603.05.05 Steel Liner

Steel liner shall be according to OPSS 1802.

603.05.06 Mortar

Mortar shall consist of a mixture of one part Portland cement according to OPSS 1301 and two parts mortar sand according to OPSS 1004, wetted with sufficient water to make the mixture plastic. Water shall be according to OPSS 1302. Air entrainment shall be 12%.

603.05.07 Unshrinkable Backfill

Unshrinkable backfill shall be according to OPSS 1359.

603.05.08 Ducts and Fittings

Ducts and fittings shall be according to the applicable standards shown in Table 1.

For surface mounted duct systems when runs of ducts exceed 50 m, rigid ducts and fittings shall be of regular wall thickness with watertight reinforced thermosetting resin conduit (RTRC) duct. Hanger support systems shall consist of galvanized steel supports and fibreglass tubular spacers with galvanized steel hardware. Support systems shall allow for multiple sizes of duct in each horizontal layer.

For surface mounted duct systems when runs of ducts are 50 m and under, they shall be rigid polyvinyl chloride (PVC) conduit or rigid galvanized steel conduit.

Ducts for HDD shall be solvent-free, mechanical spline connected with hydraulic seal, and rigid PVC ducts certified to CSA C22.2 No. 211.2.

603.05.09 Marker Tape

Marker tape shall be 75 mm wide polyethylene (PE) or copolymer material, colour red, with repeating black lettering "Caution - Buried Electric Line" or a similar message.

603.05.10 Concrete Anchors

Concrete anchors for surface mounted duct systems shall be of the epoxy resin system type when runs of ducts exceed 50 m. When runs are 50 m or less, the anchors shall be either of the epoxy resin type or metal expansion anchors. Each anchor shall have a minimum pullout strength of 60 kN for an embedment depth of 200 mm or less.

603.07 CONSTRUCTION

603.07.01 General

General requirements for electrical work shall be as specified in the Contract Documents.

Ducts shall be installed as specified in the Contract Documents.

Ducts for communication cables shall be installed in trenches with varying depth so that drainage is provided. A minimum depth of cover of 450 mm may be used in flat terrain in order to ensure that the ducts slope towards a maintenance hole. When the terrain allows natural drainage due to its slope, the depth of cover shall be 550 mm.

Non-metallic ducts installed and used when exposed to direct rays of the sun shall be specifically approved for the purpose and be marked (e.g., "SR," "Outdoor," "RTRC Type AG") according to the Ontario Electrical Safety Code.

Wobble joint fittings with expanded polystyrene bedding shall be installed when direct buried rigid ducts terminate at concrete structures such as electrical maintenance holes, footings, bridge structures, retaining walls, and duct banks.

603.07.02 Protection During Construction

When ducts are installed prior to placing roadbed granular materials, the ducts shall be protected with a minimum cover of 300 mm of compacted backfill material.

603.07.03 Removals

Removals shall be according to OPSS 610.

603.07.04 Locating Existing Ducts

The Contractor shall locate all existing ducts requiring modification or usage.

603.07.05 Excavation

603.07.05.01 General

Trenches shall be excavated to the widths, depths, and alignment as specified in the Contract Documents. Such dimensions may be adjusted to obtain proper clearances with Utilities or other works.

The trench bottom shall be free of sharp rock fragments or debris and uniformly graded to support the ducts.

603.07.05.02 Earth Excavation

When unsuitable earth material is encountered in the trench bottom, it shall be removed and replaced with suitable material, as directed by the Contract Administrator.

The trench bottom shall be undisturbed earth or suitable imported material compacted according to OPSS 501.

When trenches are to be constructed prior to the completion of final grades, the Contractor may excavate trenches to give a minimum temporary cover of 300 mm for the ducts.

603.07.05.03 Rock Excavation for Electrical Installations

Rock excavation for the installation of ducts shall be according to OPSS 206.

603.07.06 Flexible Ducts

Flexible ducts shall be laid loosely in the trench to allow for expansion and contraction. Ducts shall be installed free of kinks or flattening and without sharp objects in the trench.

Couplings used for flexible ducts made of PE shall be PVC serrated couplings or shall consist of a 450 mm piece of the duct, one size larger than the flexible duct, slotted, and centred over the butted joint and securely fastened using stainless steel strapping. When PE pipe is used, pulling points for cable shall be similarly constructed.

For the PE flexible ducts for communication fibre-optic cable, installation of runs between maintenance holes up to 120 m in length shall be done with a single run of non-spliced duct. For runs up to 240 m in length, one splice is allowed. For runs exceeding 240 m, one splice per 120 m maximum is allowed. Such duct splices shall be fully waterproofed using silicon sealant and plasticized waterproofing sealant and shall be inspected by the Contract Administrator prior to backfilling.

Couplings used for flexible ducts made of electrical non-metallic tubing (ENT) shall be according to manufacturer's drawings or instructions. When ENTs are used, pulling points for cable shall be at the electrical chambers.

High density polyethylene (HDPE) couplings shall be used for HDPE duct and shall be according to manufacturer's drawings or instructions. When HDPE ducts are used, pulling points for cable shall be at the electrical chambers.

Flexible ducts shall be installed so that stacking or crossovers within the trench are not required, except for the purpose of entering concrete encased rigid ducts or electrical chamber sleeves.

Flexible ducts shall be installed within all underpavement crossings not having an electrical chamber on each end.

At direct buried poles, flexible ducts shall be inserted into the wiring aperture and turned up to within 450 mm of the pole handhole.

At concrete footings for base mounted poles, flexible ducts shall be inserted through the sleeves to at least 750 mm above the foundation.

At entries to pad mounted substations and to pad mounted traffic signal controllers, flexible ducts shall be installed within the sleeves and cut off flush with the top of the sleeves. The void between the duct and the sleeve shall be sealed with an electrical sealant for pad mounted controllers.

When it is required to join flexible ducts with rigid ducts, serrated adapter couplings shall be installed.

When flexible ducts are brought into electrical chambers, the ducts shall remain free in the entry holes of handholes and grouted into entry holes of maintenance holes.

When flexible ducts are specified in the Contract Documents, the Contractor shall have the option of using rigid ducts of the same inside diameter.

603.07.07 Rigid Ducts, Concrete Encased

Plastic spacers, suitable to the size and type of ducts and the duct separation specified in the Contract Documents, shall be installed along the trench bottom at 1.5 m maximum intervals. When transitions in grade are required, the trench bottom shall be adjusted to allow the spacers to seat firmly and hold any required duct bends.

Steel reinforcement shall be installed according to OPSS 905. Rods shall overlap by at least 60 mm and shall be tied to the plastic spacers. Lengths of duct shall be connected using couplings suitable to the size and type of duct. Couplings shall be staggered to obtain a minimum of 50 mm clearance between ducts or couplings. Ducts shall be tied to the spacers. The assembly shall be anchored securely to prevent shifting during placing of concrete.

Concrete may be poured directly into the trench or form work installed along the sides of the duct bank. The method of transporting, placing, and consolidating the concrete shall be such as to prevent segregation. Concrete placing and transporting devices shall not be supported by the steel reinforcement. Concrete shall be deposited within 1.5 m of its final position. Chutes shall have sufficient slope to deliver concrete of the approved consistency and shall have a maximum length of 15 m. When concrete is to be dropped more than 1.5 m, fully enclosed vertical drop chutes extending to the point of deposit shall be used. Concrete shall be placed at a steady rate such that a monolithic concrete is obtained without the formation of cold joints. The finish shall be raked or trimmed to produce a flat surface.

Rigid ducts shall be installed with a minimum slope of 400H:1V. Where deviations in vertical grade are required to avoid Utilities or other works, ducts shall be installed so that water cannot accumulate in the ducts.

Except where connections to electrical maintenance holes are required, rigid ducts and casing crossing paved areas shall extend 1.0 m beyond the back face of the curb or to the back edge of the shoulder.

When it is required to install transition sections between different types of rigid duct installations, the Contractor shall use deflection couplings or bend the ducts as required over a maximum of two standard duct lengths to obtain the required configuration.

603.07.08 Rigid Ducts, Direct Buried

The trench bottom shall be shaped and uniformly graded to support the entire duct. Lengths of duct shall be connected using couplings suitable to the size and type of duct supplied.

603.07.09 Flexible and Rigid Ducts by Subsurface Installation

Pits required for subsurface installation operations shall be set back a minimum distance from the edge of pavement or back of curb so that excavation is not done within a 1H:1V slope from the edge of pavement or back of curb to the bottom of the pit.

Bore holes shall only be 50 mm larger in diameter than the rigid duct being installed. When rigid ducts are being installed using the push-pull method, the steel rod shall be accurately aligned and pushed through the target pit. The push cap shall be replaced by a suitably sized expander unit and pulled back to the operating pit.

Lengths of duct shall be connected using couplings suitable to the size and type of duct supplied.

All temporary piling or supports used for boring or jacking equipment shall be removed or cut off to a minimum of 1.0 m below finished grade. All excavations or holes shall be backfilled and all temporary fill shall be removed.

When steel encasements are being installed using the boring and jacking method, the steel encasement shall be advanced so that the bore hole wall is supported by the steel encasement to within 300 mm of the head of the auger.

For HDD method, no drilling pit is required. Installation shall be according to the HDD machinery and duct manufacturers' guidelines and recommendations.

603.07.10 Surface Mounted Duct Systems

The Contractor shall not drill through bridge reinforcing steel. The Contractor shall locate reinforcing steel with a cover meter and position anchors accordingly.

For surface mounted duct systems, when the runs exceed 50 m horizontally:

- a) The installation of the support systems and ducts shall be carried out according to the duct manufacturer's installation procedures.
- b) Rigid ducts shall be installed parallel to the structural surfaces, either horizontally or vertically, using offset bends or fittings where changes in alignment are necessary.

For surface mounted duct systems, when runs are 50 m or less horizontally:

- a) Conduit fittings and junction boxes shall be installed in neat straight lines in the locations specified in the Contract Documents
- b) Rigid conduits shall be installed parallel to the structural surfaces, either horizontally or vertically, using offset bends or fittings where changes in alignment are necessary.

Appropriate fittings and deflection couplings shall be used for the installation. PVC boxes shall be mounted to provide the least interference with at least two stainless steel bolts and expansion anchors. Duct connection shall be cemented to the PVC box adapters.

Conduits shall be secured at intervals using conduit straps according to the Ontario Electrical Safety Code.

Conduit straps and junction boxes shall be fastened to concrete surfaces by drilling and inserting concrete anchors and securing the equipment with stainless steel bolts.

Conduit straps and junction boxes shall be fastened to steel structural members using stainless steel hardware.

603.07.11 Utility Clearance

When Utilities interfere with the specified elevation of any ducts, the Contractor shall notify the Contract Administrator to arrange inspection of the crossing point. The Contractor shall adjust the location of the ducts to obtain the clearance required and shall construct any concrete saddle or alternative protection approved by the Utility company.

603.07.12 Breaking Into Concrete Structures

When specified in the Contract Documents, the Contractor shall break into existing electrical chambers and existing substation or controller pads for installing ducts.

The space between the duct and the opening shall be filled with mortar.

603.07.13 Extension of Existing Duct Bank

Extension of existing duct banks shall be as specified in the Contract Documents.

603.07.14 Cable and Duct Protection and Marking

The Contractor shall install cable bricks or concrete protection at locations specified in the Contract Documents. Marker tape shall be installed along the centreline of the trench approximately 250 mm below finished grade or asphalt or concrete surfaces.

Cable brick shall be seated on uniformly graded and compacted material and butted end to end. Multiple rows of bricks shall be installed in trenches with direct buried high-voltage cables and when the width of the trench exceeds 300 mm.

Concrete protection shall be poured on uniformly graded and compacted material occupying the full width of the excavated trench to a minimum depth of 50 mm.

603.07.15 Termination

All ducts shall be temporarily plugged or sealed until wiring is installed. All ducts with wiring installed that terminate in traffic signal control cabinets, Advanced Traffic Management Systems (ATMS) control cabinets, or distribution assemblies shall be sealed.

When ducts are specified in the Contract Documents as spare or intended for future use, the duct ends shall be plugged with plastic plugs.

603.07.16 Backfilling

Except when unshrinkable backfill is used, backfilling shall be according to OPSS 401. Backfill material containing rock fragments and stone larger than 50 mm in diameter shall not be placed within 300 mm of the duct.

Sand bedding shall be placed in trenches for flexible duct when the trench bottom contains sharp rock fragments and when crossover of flexible ducts is required.

Backfill for concrete encased rigid ducts shall be placed at least 24 hours after pouring concrete.

Unshrinkable or granular backfill in trench for rigid ducts crossing paved areas shall extend to the wall of maintenance hole when maintenance holes are required; otherwise, 1.0 m beyond the back face of curb or, when there is no curb, to the back edge of shoulder.

603.07.17 End Marking

The location of the ends of all ducts not terminating in electrical chambers or pole foundations shall be marked by a concrete marker that is flush with the finished grade and located 300 mm beyond the shoulder edge or by a 50 x 50 mm cut cross on curbs, sidewalks, or barriers. The marker shall have an impressed arrow indicating the position of the ducts.

Concrete 400 x 300 x 50 mm markers shall be installed over runs of ducts for communication cables deviating from a straight line. A marker shall be installed wherever a tangent section meets a circular section. When the circular section is more than 20 m in length, an intermediate marker shall be installed.

Concrete markers shall be installed within 72 hours of backfilling of the trench.

603.07.18 Fish Line and Trace Wire

Fish line and trace wire shall be installed in all ducts specified in the Contract Documents as being spare or intended for future use. A 1.5 m length of fish line and trace wire shall extend out of each end of the duct beside the plastic plug, remain coiled, and tied in an accessible location.

603.07.19 Quality Control

603.07.19.01 Pre-Installation Testing and Inspection

All ducts shall be inspected to ensure that they are as specified in the Contract Documents.

All ducts shall be inspected to ensure they are stamped with the appropriate CSA designation, strength, and type. During installation, all ducts shall be inspected to ensure they are properly bedded, have sufficient depth of cover, and are coupled or connected to electrical chambers, poles, or other devices as specified in the Contract Documents.

603.07.19.02 Proof of Performance Testing and Inspection

All ducts shall be inspected and tested to ensure that they are as specified in the Contract Documents. All ducts shall be tested to ensure that they are free of debris, water, breakage, or distortion.

603.07.20 Temporary Electrical Work

The work for temporary electrical installations shall be the same as for permanent installations of the same type of work, except that the work shall include the removal of the installations when they are no longer required.

603.07.21 Site Restoration

Site restoration shall be according to OPSS 492.

603.07.22 Management of Excess Material

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

603.08 QUALITY ASSURANCE

The Owner may perform field tests required for concrete according to OPSS 1350.

The Owner may perform tests for compaction according to OPSS 501.

603.09 MEASUREMENT FOR PAYMENT

603.09.01 Actual Measurement

- 603.09.01.01 Flexible Ducts**
- Rigid Ducts, Concrete Encased**
- Rigid Ducts, Direct Buried**
- Rigid Ducts by Subsurface Installation**
- Rigid Ducts, Steel Encased by Subsurface Installation**
- Flexible Ducts by Subsurface Installation**

Measurement of ducts shall be by length in metres horizontally along the longitudinal axis of the duct or trench; from centre to centre of poles, pole footings, electrical chambers, junction boxes, sign footings, and traffic signal controller cabinet pads; and to the face of bridge structures, retaining walls, and substation pads.

603.09.01.02 Rock Excavation for Electrical Installations

Measurement of rock excavation shall be by volume in cubic metres based on the quantity of rock below the upper limit and within the theoretical lines specified in the Contract Documents. The upper limit is the existing rock surface as measured after removal of overburden, but prior to rock excavation or the lowest elevation of all other excavation specified in the Contract Document, whichever is lower.

The volume of boulders in an excavation shall be based on 3 maximum rectilinear dimensions. When boulders classified as rock are measured for payment, only the amount removed shall be considered for payment. The total volume of rock considered for payment shall not exceed the volume of excavation within the theoretical lines.

603.09.01.03 Surface Mounted Duct Systems

Measurement of surface mounted duct systems shall be by length in metres horizontally along the duct, without deductions for junction boxes, from one point of attachment to other points of attachment.

603.09.02 Plan Quantity Measurement

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

603.10 BASIS OF PAYMENT

- 603.10.01 Flexible Ducts - Item**
- Rigid Ducts, Concrete Encased - Item**
- Rigid Ducts, Direct Buried - Item**
- Rigid Ducts by Subsurface Installation - Item**
- Rigid Ducts, Steel Encased by Subsurface Installation - Item**
- Rock Excavation for Electrical Installation - Item**
- Surface Mounted Duct Systems - Item**
- Flexible Ducts by Subsurface Installation - 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.

If the Contractor chooses to substitute flexible ducts with rigid ducts, payment for those rigid ducts shall be at the unit price bid for the tender item Flexible Ducts.

When drilling and blasting are required as a part of the work, progress payment shall be made according to OPSS 206.

The work of providing clearance for required Utility crossing shall be administered as Change in the Work.

- 603.10.02 Flexible Ducts, Temporary - Item**
- Rigid Ducts, Concrete Encased, Temporary - Item**
- Rigid Ducts, Direct Buried, Temporary - Item**
- Rigid Ducts by Subsurface Installation, Temporary - Item**
- Rigid Ducts, Steel Encased by Subsurface Installation, Temporary - Item**
- Surface Mounted Duct Systems, Temporary - Item**

Flexible Ducts by Subsurface Installation, Temporary - Item

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

Progress payment for temporary installation of the above tender items shall be based on the following percentages of the Contract price:

80% for supply and installation

20% for removal

**TABLE 1
Ducts and Fittings**

Duct and Fitting Description	Type	Direct Buried	Concrete Encased	Subsurface Installation		Embedded Work	Surface Mounted	Standard
				In Ground	In Liner			
PE	Flexible	X	-	-	-	-	-	CSA B137.1 Series 75
ENT	Flexible	X	X	X	X	X	-	CAN/CSA C22.2 No. 227.1
HDPE	Flexible	X	-	X (Note 1)	-	-	-	UL 651A; ASTM F 2160, Schedule 40; and NEMA TC 7 for type EPEC
PVC	Rigid	X	X	X	X	X	X	CSA C22.2 No. 211.2
Polymeric PVC	Rigid	-	X Type DB2	-	-	X Type DB2	-	CSA C22.2 No. 211.1
RTRC	Rigid	X standard or heavy wall (Note 2)	X standard or heavy wall	X standard or heavy wall (Note 2)	X standard or heavy wall	X standard or heavy wall	X standard or heavy wall	CSA C22.2 No. 2515
Galvanized Steel	Rigid	X	-	X	X	-	X	CSA C22.2 No. 45.1

Notes:

1. HDPE duct may be used for subsurface installation for extra low-voltage cables only when ducts are 50 mm diameter or smaller.
2. Heavy wall shall be used when ducts are 100 mm diameter or greater.