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INSTALLATION & TESTING **OF UNDERGROUND PRIMARY AND SECONDARY** **POWER CABLES** **PRIOR TO ENERGIZATION**

REVISION SHEET

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0	Original document	2001-02-01	md/csm
1	Revise format and update document	2002-08-26	md/csm
2	Assign document number to form	2002-12-09	pl/csm
3	Added residential cable section Added primary cable check	2015-11-02	pl/csm
4	Increase days allowed for ESA and meggering, Increased required cable lengths	2021-12-02	mw/cm
5	Change "Manhole" to "Maintenance Hole"	2022	

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1.0 Introduction

Proper installation and testing of primary and/or secondary underground electrical power cables are vital to prevent a safety hazard and ensure the long term reliability of the electrical installation. Hydro Ottawa may add to the Ontario Electrical Safety Code (OESC) requirements for the specification, termination and testing of the underground cables. These requirements may differ depending on the type of service (primary vs. secondary, overhead vs. underground) and/or the proposed supply point (such as overhead lines, pad mounted transformer, vault type transformer etc.).

2.0 References

Hydro Ottawa – ESG0001 – Construction Verification Program (CVP)

Hydro Ottawa – ECS0012 – Conditions of Service

Hydro Ottawa – ECS0002 - Primary Voltage Service Specification

Hydro Ottawa – GCS0012 – Electrical Underground Distribution Plant Identification

IEEE – 400.1 – Guide for Field-Testing of Laminated Dielectric, Shielded Power Cable Systems Rated 5kV and Above with High Direct Current Voltage

Ontario Electrical Safety Code – current edition

Ontario Regulation 22/04 - Electrical Distribution Safety Regulation

3.0 Scope

This document covers the general requirements for the installation and testing of underground power cables to connect to the Hydro Ottawa power distribution system.

Although this procedure is intended for electrical contractors installing customer owned underground power cables, it also applies to contractors that install and terminate underground cables for Hydro Ottawa.

Hydro Ottawa reserves the right to refuse to connect and/or energize an underground power cable that does not satisfy these installation requirements.

Nothing contained in this specification shall prejudice or supersede any regulation and/or requirement(s) specified under the OESC for customer owned cables.

4.0 Installation and Testing of Secondary Service Cables at Pad-mounted Transformers

Listed below are the guidelines for the installation, termination, and acceptance testing of secondary cables at a pad-mounted transformer supplied and installed by Hydro Ottawa. The acceptance testing

shall be conducted after the cable installation is complete including cable terminations but before the service cables are terminated to the transformer LV spades and/or placed into service/energized.

- 4.1 All secondary service cables for general, residential and/or commercial installation shall be installed by an electrical Contractor in compliance with the OESC and applicable Hydro Ottawa requirements. Hydro Ottawa does not allow metallic shielded cable (e.g. TECK) in the base/maintenance hole. All metal shielded shall be stripped to the cable entrance into the base/maintenance hole. With customer owned cable, the Contractor is also responsible for procuring an authorization for connection from the Electrical Safety Authority (ESA) inspection department ten (10) business days prior to the proposed energization date. Contractors working for Hydro Ottawa shall comply with Ontario Regulation 22/04 and Hydro Ottawa's CVP quality assurance program (ESG0001).
- 4.2 Typically the secondary service cables are the first cables pulled within the equipment base so they do not interfere with the operation of the elbow connectors during switching operation. Cable tails must be provided within the equipment base to allow for proper cable training/racking: 10m minimum within a transformer base or 16m minimum within a Maintenance Hole. Confirm actual required cable lengths with Hydro Ottawa.
- 4.3 For secondary service cables larger than 250MCM or installation with multiple services, the cables shall be supported from within the transformer enclosure. The Contractor shall install a section of 41mm x 41mm [1-5/8" x 1-5/8"], 12 gauge galvanized, solid channel (such as unistrut or cantruss framing structure) across the opening of the transformer base pad. The support channel shall be fixed to the pad using removable screw type concrete anchors. The secondary cables must be secured to the cable support channel, using tie wraps, to relieve/minimize the downward stress from the secondary cables. The solid channel will be grounded at one end only to the 2/0 cable provided.
- 4.4 Customer owned secondary cables will be racked and tagged by Hydro Ottawa at the electrical ownership demarcation point to suit as per GCS0012.
- 4.5 Terminations of all secondary cables at the Hydro Ottawa transformer shall be the Contractor's responsibility. Terminations shall be compression single hole lugs for small cables and double hole lugs (2 x 1/2" holes with 1 3/4" hole spacing C/L to C/L) for cables ≥500 MCM with extended barrel for double crimp and superior pull-out resistance. The lugs must be CSA certified or equivalent.
- 4.6 Secondary cables shall be megger tested by the electrical Contractor a maximum of twenty (20) business days prior to energization. The testing shall be conducted after the cable installation is complete at the main service entrance disconnect/switchboard including phase markers (R/W/B), terminations and splices, but before the cable is terminated to the transformer LV spades. The megger test shall be applied as a diagnostic test (Type 2 - Non Destructive Field Test) to identify potential cross phasing connection. The megger test shall be performed by applying an elevated DC voltage to the conductor and measuring the current flow to a ground reference. It is understood that testing low voltage cables/unshielded cables may produce inherent results due to the lack of uniform ground plane over the dielectric of the cables.
- 4.7 Each lug must be wire brushed and have oxide inhibitor applied before bolting to a transformer LV spade.
- 4.8 The lugs must be secured to the transformer LV spades using 1/2" silicone bronze bolt(s) complete with nut(s) and 1/2" silicon bronze Belleville spring washers and silicon bronze split lock washers.

- 4.9 The final connection shall be torqued to the manufacturer specification and/or to the OESC Table D7 specification.
- 4.10 Hydro Ottawa's report for "Installation and Testing of Secondary Cables at Pad-mounted Transformer", refer to attached report Schedule 1, must be completed by the electrical Contractor within twenty (20) business days before the proposed energization date. The installation report must be received and accepted by the Hydro Ottawa Project Manager before the service is scheduled for energization.

5.0 Installation and Testing of Secondary Cables at Vault Type Transformers

The proposed vault equipment layout and the proposed routing/training of secondary cables must be submitted to the Hydro Ottawa Project Manager for comment prior to finalizing the vault design.

Listed below are the guidelines for the installation, termination and acceptance testing of secondary cables at vault type transformers supplied and installed by Hydro Ottawa.

The acceptance testing shall be conducted after the cable installation is complete including cable terminations but before the cables are terminated to the transformer LV spades and/or placed into service/energized.

- 5.1 All secondary service cables within a building electrical vault shall be installed by an electrical Contractor in compliance with the OESC and applicable Hydro Ottawa requirements. With customer owned cable, the Contractor is also responsible for procuring an authorization for connection from the Electrical Safety Authority inspection department ten (10) business days prior to the proposed energization date. Contractors working for Hydro Ottawa shall comply with Ontario Regulation 22/04 and Hydro Ottawa's CVP quality assurance program (ESG0001).
- 5.2 Secondary cables installed within a building electrical vault shall be racked by the electrical Contractor as directed by Hydro Ottawa. The secondary cables must be trained and supported to relieve/minimize the cable stress transfer to the transformer LV spades.
- 5.3 The secondary cables shall not interfere with the removal of adjacent transformers and shall not either be located above or behind the transformers.
- 5.4 All secondary cable terminations at the vault transformers shall be visible from the operating area of the vault.
- 5.5 Terminations of all secondary cables at the transformer LV spades shall be the Contractor's responsibility. Terminations shall be compression single hole lugs for small cables and double hole lugs (2 x ½" holes with 1 ¾" hole spacing C/L to C/L) for cables ≥ 250 MCM with extended barrel for double crimp and superior pull-out resistance. The lugs must be CSA certified or equivalent.
- 5.6 Secondary cables shall be megger tested by the electrical Contractor a maximum of twenty (20) business days prior to energization. The testing shall be conducted after the cable installation is complete at the main service entrance disconnect/switchboard including phase markers (R/W/B), terminations and splices, but before the cable is terminated to the transformer LV spades. The megger test shall be applied as a diagnostic test (Type 2 - Non Destructive Field Test) to identify potential cross phasing connection. The megger test is performed by applying an elevated DC

voltage to the conductor and measuring the current flow to a ground reference. It is understood that testing low voltage cables/unshielded cables may produce inherent results due to the lack of uniform ground plane over the dielectric of the cables.

- 5.7 The lugs must be secured to the transformer LV spades using ½" silicone bronze bolt(s) complete with nut(s) and ½" silicon bronze Belleville spring washers and silicon bronze split lock washers.
- 5.8 Each lug must be wire brushed and have oxide inhibitor applied before bolting to a transformer LV spade.
- 5.9 The final connection shall be torqued to the manufacturer specification and/or to the OESC Table D7 specification.
- 5.10 The transformer secondary cable neutral bus shall be grounded in one location inside the transformer vault in compliance with Hydro Ottawa engineering specification GCS0002. In order to reduce circulating current, the ground conductor shall connect with the service neutral conductor(s) at the same transformer LV spade.
- 5.11 Hydro Ottawa's report for "Installation and Testing for Secondary Cables at Vault transformers", refer to attached report Schedule 2, must be completed by the electrical Contractor within twenty (20) business days before the proposed energization date. The installation report must be received and accepted by the Hydro Ottawa Project Manager before the service is scheduled for energization.

6.0 Installation and Testing of Primary Cables

The proposed primary design must be submitted to the Hydro Ottawa Project Manager for comment prior to finalizing the HV design. Hydro Ottawa's requirements for specification, installation and termination of primary cables/lines shall depend on the type of installation (overhead vs. underground), the service configuration (radial vs. loop), the primary voltage, and the electrical ownership demarcation point with Hydro Ottawa.

Listed below are the guidelines for the installation, termination and acceptance testing of primary cables at pad-mounted and/or vault type switching equipment supplied and installed by Hydro Ottawa. The acceptance testing shall be conducted after the cable installation is complete including cable terminations but before the primary cables are terminated to the Hydro Ottawa switching equipment and/or placed into service/energized.

- 6.1 All primary service cables shall be installed by a High Voltage electrical Contractor in compliance with the OESC and applicable Hydro Ottawa requirements. With customer owned cable, the HV Contractor is also responsible for procuring an authorization for HV connection from the Electrical Safety Authority inspection department ten (10) business days prior to the proposed energization date. Contractors working for Hydro Ottawa shall comply with Ontario Regulation 22/04 and Hydro Ottawa's CVP quality assurance program (ESG0001).
- 6.2 The termination of the primary cables ready for connection shall be the HV contractor responsibility.
- 6.3 Primary cables part of an underground power distribution system, will be racked and tagged (as per GCS0012) by Hydro Ottawa where both the utility and customer owned cables share the same underground structures.

- 6.4 Primary cables installed within a building electrical vault or switching room shall be racked and tagged by the HV Contractor as directed by Hydro Ottawa. The cables must be trained and supported to relieve/minimize the cable stress transfer to the switching equipment. For primary cables installed in a pad mounted equipment base or maintenance hole, cable tails must be provided within the equipment base to allow for proper cable training/racking: 10m minimum within a transformer base or 16m minimum within a Maintenance Hole. Confirm actual required cable lengths with Hydro Ottawa.
- 6.5 The final connection of the customer owned primary cables/lines at the Hydro Ottawa distribution system shall be Hydro Ottawa's responsibility.
- 6.6 A visual inspection shall be performed before the final acceptance testing to evaluate the condition of the cables. The visual inspection shall include but not be limited to the condition of the cables, the conditions of the terminations and splices, the arc proofing of cable (if required), the bending radius not to exceed the manufacturer recommendations, the shield and/or concentric neutral terminations.

As a minimum acceptance testing, the primary cables shall be checked for continuity and phase meggered by the HV electrical Contractor a maximum of twenty (20) business days prior to energization.

6.7 DC hi-pot acceptance testing is conducted after the primary cable system installation, including all terminations and joints (splices), but before the cable system is placed into normal service. The test is intended to detect installation damage and to show any gross defects or errors in installation of other system components/accessories.

DC hi-pot leakage current test technique shall be preformed for the primary cable voltage rating as follows:

Table 1: Hi-pot Test Limits for Underground Primary Power Cables

Maximum Insulation Test Voltages	
Cable Rating	DC HI-Pot
5 kV	10 kV
15 kV	30 kV
28 kV	50 kV
46 kV	85 kV

For testing, bring DC voltage up to prescribed test level in five equal steps. Raise the voltage at an even rate, so as to reach the required level in not less than 10 seconds. Hold the voltage at each step for 60 seconds.

Hold the full test voltage for not less than 10 minutes or more than 15 minutes. Read and record the leakage current. After the initial cable charging period, leakage current greater than 15mA is considered a test failure and the cable system should be reviewed for damage and corrected as required before retesting.

6.8 _____ Hydro's report for "Installation and Testing of Primary Cables", refer to attached report Schedule 3, must be completed by the electrical Contractor twenty (20) business days before the proposed energization date. The completed report must be received and accepted by the Hydro Ottawa Project Manager before the service is scheduled for energization.



Schedule 1: Installation and Testing of Secondary Cables at Pad-mounted Transformer

Business Name: _____ Phone Number: _____

Contractor's Address: _____ E-mail: _____

Proposed energization date: _____

Hydro project number: _____

Civic Address of Installation: _____

Please complete the following installation report:

1. Secondary cable size: _____ Number of cables per phase: _____
2. Confirm installation of the cable support channel at the transformer pad opening:
Yes / No
3. Confirm cable tails to be 10 m in transformer base or 16 m into the Maintenance Hole, customer to confirm actual lengths required with Hydro Ottawa: Yes / No
4. Confirm the cable lugs are double crimp for cable $\geq 500\text{MCM}$: Yes / No
5. Meggering results of cables Phase to Ground: (grounded neutral at the main service entrance)
@ 1000V DC **A-N_{GND}** _____ Ω , **B-N_{GND}** _____ Ω , **C-N_{GND}** _____ Ω
6. Meggering Results of cables Phase to Phase:
@ 1000V DC **A-B** _____ Ω , **A-C** _____ Ω , **B-C** _____ Ω
7. Confirm secondary spades and lugs were wire brushed and oxide inhibitor applied: Yes / No
8. Confirm use of $\frac{1}{2}$ " silicon bronze bolt c/w Belleville spring washer and split lock silicone bronze washers: Yes / No
9. Specify torque strength at transformer LV spades (as per OESC or bolt manufacturer): _____
ft·lbs / N·m

Hydro Ottawa shall accept no responsibility, direct or indirect, for personnel injury or equipment damage due to faulty installation or improper testing of customer owned secondary cables. Please be aware that Hydro may not continue with the energization of a faulty installation for safety reasons.

Contractor Signature: _____ Date Signed: _____

Contractor Name (Print): _____



Schedule 2: Installation and Testing of Secondary Cables at Vault Type Transformer

Business Name: _____ Phone Number: _____

Contractor's Address: _____ E-mail: _____

Proposed energization date: _____

Hydro project number: _____

Civic Address of Installation: _____

Please complete the following installation report:

1. Transformer rating: _____ kVA
2. Transformer LV spades and tank ground lugs visible from operating area: Yes / No
3. Secondary cable size: _____ Number of cables per phase: _____
4. Type of cable lugs/connectors (2 crimp lug \geq 250 MCM): _____
5. Meggering results of cables Phase to Ground:
@ 1000V DC **A-N_{GND}** _____ Ω , **B-N_{GND}** _____ Ω , **C-N_{GND}** _____ Ω
6. Meggering results of cables Phase to Phase:
@ 1000V DC **A-B** _____ Ω , **B-C** _____ Ω , **A-C** _____ Ω
7. Secondary spades and lugs wire brushed and oxide inhibitor applied : Yes / No
8. Installed 1/2" silicon bronze bolt c/w Belleville or split lock silicone bronze washer: Yes / No
9. Specify torque strength at secondary spade (as per OESC or bolt manufacturer): _____ ft-lbs / N·m
10. Transformer ground conductor size (ref. to GCS0002) : _____
11. Transformer tank bond conductors size (ref. to GCS0002): _____

Hydro Ottawa shall accept no responsibility, direct or indirect, for personnel injury or equipment damage due to faulty installation or improper testing of customer owned secondary cables. Please be aware that Hydro may not continue with the energization of a faulty installation for safety reasons.

Contractor Signature: _____ Date Signed: _____

Contractor Name (Print): _____



Schedule 3: Installation and Testing of Primary Cables

Business Name: _____ Phone Number: _____

Contractor's Address: _____ E-mail: _____

Proposed energization date: _____

Hydro project number: _____

Civic Address of Installation: _____

Please complete the following installation report:

1. Primary cable field data:

Manufacturer: _____ Rated voltage: _____

Insulation type: _____ Rated insulation level: _____

Conductor size: _____ Conductor material: _____

MFG year: _____ Temp rating: _____

Note: Parallel cable runs are not acceptable if the cables are to terminate to Hydro owned equipment.

2. Termination field data:

Manufacturer: _____ Termination type: _____

3. Cable tails to be 10 m in transformer base or 16 m into the Maintenance Hole, customer to confirm actual lengths required with Hydro Ottawa: Yes / No

4. Perform a visual inspection of the cable to be tested for physical cable condition, terminations, shield grounding, bending radius and concentric neutral. Report any problems/recommendations:

5. Meggering of cables between isolated neutral and grounded phase conductor:

@ 5kV DC A-N _____ Ω , B-N _____ Ω , C-N _____ Ω

6. Hi-pot Test: A-N _____ mA, B-N _____ mA, C-N _____ mA

Hydro Ottawa shall accept no responsibility, direct or indirect, for personnel injury or equipment damage due to faulty installation or improper testing of customer owned secondary cables. Please be aware that Hydro may not continue with the energization of a faulty installation for safety reasons.

Contractor Signature: _____ Date Signed: _____

Contractor Name (Print): _____