Engineering Instruction EI-4

Design and Interconnection Requirements for Customer-Owned Electric Power Substations.

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Overview

This Engineering Instruction is intended to guide London Hydro's customers and their agents in the preparation of servicing plans and proposals for customer-owned electric power substations, installed on private property, and providing electric service to commercial, industrial, institutional, and apartment buildings.

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Revision Index

Changes from previous editions of this Engineering Instruction are listed below. Relocations of paragraphs or editorial changes are not shown.

Revision Number	Issue Date	Section	Description of Revision
R3	August 31, 2000		This Engineering Instruction was originally entitled *Cable Measurements on Riser Poles*. The original issue simply encompassed the interconnection of privately owned primary cables at a fused riser pole. This edition has been expanded to encompass the submission, design, and revenue metering requirements for the most commonly encountered customer-owned substation projects.
R4	September, 2009	1.4	Eligible added to projects and defined.
R5	July, 2013	3.4; 4.4; 5.1	Air-insulated padmounted sectionalizing switchgear replaced with deadfront padmounted sectionalizing switchgear. Cable termination requirements and coordination with London Hydro's system protection changed accordingly.
		6.2	Three-phase oil-filled primary metering unit replaced with dry type metering unit.
R6	April, 2016	1.5	Removed reference to EI-8, *Standard Arrangements for Providing Revenue Metering Pulse Signals to Customer-Owned Energy Management Systems*, as this is not available for new installations. Changed EI-22 document title to *Guidelines for Supplying Interval –Style Revenue Metering Systems*
		6.6	Changed section content and title to Meter Communication Circuit
		6.8	Removed section Optional Data Interfaces To The Revenue Meter. Pulse output no longer supported.
R7	March, 2017	4.2.2	Added request for installation of Dual-Winding Transformers, when qualified

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A Drawings

- London Hydro drawing E.CS-150, *Cable Measurement, PUC Pole Reference.*
- London Hydro drawing E.CS-415 Sht.2, Primary and Secondary Cable Riser Details.

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1 INTRODUCTION

1.1 Purpose and Intent

This Engineering Instruction identifies the division of responsibilities and installation requirements for customer-owned electric power substations, installed on private property, and providing electric service to commercial, industrial, institutional, and apartment buildings.

The intent of this Engineering Instruction is to guide London Hydro customers and their agents in the preparation of servicing plans and proposals for customer-owned electric power substations. Nothing contained in this Engineering Instruction shall prejudice or affect various the other codes or any regulations published in the current edition of the Ontario Electrical Safety Code.

1.2 Exclusions

This Engineering Instruction is not intended to encompass the unique requirements for electric power substations used to interconnect private co-generation facilities with the London Hydro's medium-voltage electrical distribution system.

1.3 Document Revisions and Distribution

This Engineering Instruction is distributed within London Hydro as controlled distributions document (i.e. all registered holders of Engineering Instruction manuals automatically receive updates as they are generated).

London Hydro customers and their agents will automatically receive the current release of this Engineering Instruction in response to a formal application request, but no updates thereafter.

If there is an extended time period between an initial inquiry and carrying out of the work, the customer (or their agent) shall be responsible for ensuring that they have the most updated version of this Engineering Instruction before proceeding.

1.4 Governing Policy

The electric servicing of most commercial, industrial, institutional, and apartment buildings is via transformation supplied, owned, operated and maintained by London Hydro.

However, a customer-owned electric power substation shall service projects that meet one or more of the following criteria:

- Projects that require transformation in excess of London Hydro's limitations (e.g. 500 kVA for supply from a pole-mounted transformer bank; 750 kVA at 120/208Y V for supply from a three-phase pad-mounted distribution transformer, 1500 kVA at 347/600Y V for supply from a three-phase distribution transformer (multiple units can be installed to provide 3000 or 4500 kVA transformation and the services are to be grouped in one common electrical room) , and 2000 kVA per transformer room at 347/600Y V for supply from an indoor transformer vault);
- Projects whereby the customer requires a utilisation voltage other than London Hydro's standard offerings of 120/208Y V, 347/600Y V or 2400/4160Y V;
- Projects whereby the customer's internal distribution scheme is incompatible with the types and ratings of over-current devices typically used by London Hydro on the high-voltage winding of distribution transformers.

  Note: London Hydro generally uses full-range current-limiting fuses with a nominal line-to-ground rating on the high-voltage winding of distribution transformers. Some internal distribution schemes, such as resistance- or reactance-grounded systems, can result in recovery voltage in excess of the fuse's capability when called upon to operate.

- Projects involving supply to customer processes that generate harmonics in excess of the design limitations of London Hydro's distribution transformers — refer to Section 4.1.5, *Load Current*, of IEEE Standard C57.12.00, *IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*.
- Projects for which London Hydro would not have unrestricted access to the distribution equipment using available equipment (e.g. London Hydro will not provide transformers for installation in enclosed courtyards, on an upper level of an office tower, etc.).

For "eligible projects" serviced via a customer-owned substation, the customer's bill shall be reduced by an allowance as approved by the Ontario Energy Board. Refer to London Hydro's tariff schedule (*Allowance for Customer-Owned Step-down Facilities*) for information on the prevailing allowance. "Eligible projects" is defined as those projects that will result in the customer being classified within the London Hydro OEB approved General Service 50 kW and over.

1.5 Reference Publications

Where reference is made to the following publications, such references shall be considered to refer to the latest edition and revisions thereto, unless stated otherwise. This Engineering Instruction refers to the following such publications and the year dates shown indicate the latest edition available at the time of printing:

- Ontario Electrical Safety Code, 25th Edition, 2016.
- CAN/CSA-C802.1-00(R2011), *Minimum Efficiency Values for Liquid-Filled Distribution Transformers*.
- CAN/CSA-C802.3-15 (R2011), *Maximum Efficiency Values for Power Transformers*.
- CAN/CSA Standard C22.3 No. 1-15, *Overhead Systems*.
- CSA Standard C22.3 No. 7-15, *Underground Systems*.
- CAN/CSA Standard C22.2 No. 31-10, *Switchgear Assemblies*.
- CAN/CSA Standard C22.2 No. 94-M91 (R2011), *Special Purpose Enclosures*.
- IEEE Standard C57.12.00 (R2012), *IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*.
- IEEE Standard 400.2-2013, *IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)(less than 1 Hz)*.
- IEEE Standard 48-2009, *IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV Through 765 kV*.
- IEEE Standard 386-2006, *IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V*.
- London Hydro Engineering Instruction EI-7 (latest revision), *Customer Charges for Electric Servicing*.
- London Hydro Engineering Instruction EI-22 (latest revision), *Guidelines for Supplying Interval-Style Revenue Metering Systems*.

1.6 Installation Responsibilities

1.6.1 London Hydro

For customer-owned electric power substations, London Hydro's responsibilities are generally limited to:

- framing a primary cable riser pole or installing switchgear at the designated point of primary supply;

- connecting the customer's terminated underground primary cables to the riser or switchgear, or attaching the customer's aerial conductors to suspension / dead-end insulators at the tap pole; and
- supply of instrument transformers for the revenue metering system, outfitting the back panel of the remote metering compartment, and installing the interconnecting control wiring.

1.6.2 Owner

For customer-owned electric power substations, the Owner's responsibilities include:

- engineering design, procurement, installation and testing of the substation facilities; and
- engineering design, procurement, installation and testing of the aerial primary circuit, or alternatively the underground primary power cable and duct system, that interconnects the substation with London Hydro's primary distribution circuitry.

Note: Some insurance listing agencies (e.g. Factory Mutual) may have specific supplementary requirements that pertain to customer-owned electric power substations. The onus is on the Owner to familiarize himself with such requirements.

The Owner's responsibilities also includes:

- preparation of clearly defined procedures for isolating and grounding of equipment and circuits as needed for Owner and / or contractor maintenance functions; and
- staff training for the Owner's operations and maintenance personnel.

1.7 Project Scheduling

London Hydro strives to provide electric service with minimum delay or inconvenience. Owners will obtain prompt and satisfactory electric service provided they consider the following items when preparing their plans:

- The long lead times for the purchase and delivery of medium-voltage switchgear (where required) and instrument transformers, often on the order of 16 to 20 weeks, makes it essential that London Hydro's Engineering Department receive comparable advance notification of proposals to take electric supply. So that appropriately rated instrument current transformers may be selected for the project, it is essential that preliminary electric demand calculations accompany the advance notification.

  If primary voltage distribution circuit extensions are required, special equipment is required, or equipment delivery problems occur, then significantly longer lead times may be required. The Owner will be notified of any extended lead times.

- The Engineering Department will not release designs and work instructions to the Operations Department for construction until:
  - all technical submissions identified within Section 2 below have been received, reviewed, and approved where appropriate; and
  - payment of the electric servicing charges applicable to the project have been received.

  On average, two weeks from receipt of the above items should be allowed to prepare the designs and work instructions.

- Assuming all required materials are in stock, the job will be scheduled by the Operations Department on receipt of the engineering designs and work instructions. The projected start date averages two weeks after receipt, but this is dependent on the number and scope of other projects already included in the work schedule.

  Request for information relating to the job start date, progress, completion, etc. may be obtained directly from London Hydro's Project Scheduler & Materials Supervisor (☎ 661-5800 Ext. 5554).

1.8 Continuing Ownership Responsibilities

The Owner is responsible for carrying out normal life-of-plant maintenance and operation functions (refer to Rule 2-300, *General Requirements for Maintenance and Operation*, of the Ontario Electrical Safety Code) within the boundaries of the customer-owned substation. Although the Owner is responsible for contributing towards the costs of switching and protective equipment at the point of primary supply (e.g. fuse primary cable riser, fused aerial junction, etc.), London Hydro maintains exclusive operating control of these devices.

Owners of customer-owned substations are reminded that if in future the City of London should:

- undertake a road widening project; or
- pass an ordinance calling for the replacement of overhead electric facilities with underground electric facilities along certain public streets and roads,

the Owner shall bear a portion of the costs (in accordance with the prevailing cost sharing formula for joint-use facilities) of relocating or adjusting the facilities forming the point of primary supply.

2 SUBMISSION REQUIREMENTS

Electrical Inspection Bulletin 36-1-23, *Plan Submissions for High Potential Installations*, indicates the minimum content requirement for plans submitted to the provincial Electrical Safety Authority. One additional copy of the plans and specifications shall be submitted to London Hydro.

Prior to energizing the substation, London Hydro requires the following document submissions:

- One (1) set of as-built nameplate and outline drawings for the substation transformer and any medium-voltage switchgear;
- One (1) co-ordination study which demonstrates co-ordinated protection between London Hydro's over-current protection installed at the point of primary supply (where applicable), the substation's high-voltage over-current protection, and the substation's low-voltage over-current protection.
- One (1) set of certified test results for the substation transformer, showing as a minimum the tested no-load losses, the load losses (corrected to 85°C), and the impedance voltage.

3 INTERCONNECTION ARRANGEMENTS

3.1 Overview

In general, the point of primary supply (i.e. the delineation point between London Hydro's medium-voltage distribution system and the customer-owned medium-voltage facilities) will be at a designated riser pole, junction pole, or padmounted switchgear installed at standard location within the public road allowance.

All aerial or underground medium-voltage circuits between the point of primary supply and the customer-owned substation shall be designed in accordance with:

- CAN/CSA Standard C22.3 No. 1, *Overhead Systems*; or
- CSA Standard C22.3 No. 7, *Underground Systems*.

The following subsections illustrate the most common interconnection arrangements, and describe the usual division of installation responsibilities.

3.2 Aerial Supply Via a Primary Service Tap

For projects where the customer-owned substation is to be connected via private aerial conductors to London Hydro's aerial distribution system, London Hydro will frame the designated primary service tap pole with a steel cross-arm, suspension / dead-end insulators, straight dead-end conductor clamps, and (either inline or cross-arm mounted) drop-out style power fuses. See Figure 3-1 below for a typical primary service tap pole framing.

Note: The straight dead-end clamps stocked by London Hydro are of aluminum alloy construction and can accommodate conductor sizes ranging from #2 AWG ASC to 556.5 kcmil ASC. Owners planning to install *copper* conductors shall be responsible for providing to the site suitably sized straight dead-end clamps constructed of *malleable iron*.

Figure 3-1, Typical Fused Tap Framing

Figure 3-2, Typical Fused Riser Framing

The Owner shall leave a coil of conductor of sufficient length for London Hydro to make attachment to the primary service tap pole.

3.3 Underground Supply From a Primary Cable Riser

For projects where the customer-owned substation is to be connected via underground power cable to London Hydro's aerial distribution system, London Hydro will frame the designated riser pole with a

cluster bracket, power fuse mounts C/W power fuses, distribution class surge arresters, and a pole grounding system. The Owner is responsible for the supply and installation of primary power cable, cable terminations (including pin-style compression terminal connectors with a tin-plated copper rod design) and attachment devices for attaching the terminator to the termination cluster mount. Refer to Figure 3-2 above for an example of a typical fused riser pole framing.

The acceptable interface arrangements between the Owner's underground duct structure and the designated primary cable riser pole are illustrated in London Hydro drawing E.CS-415 Sht.2 *Primary & Secondary Cable Riser Details*. Specifically note that the concrete encasement of the duct bank does not extend to the riser pole.

The Owner is further responsible for the supply of U-cable guard and straps to the site. The U-cable guard and straps shall comply with CSA Item Standard C83.53, *U-Cable Guard (Plain),* Item Standard C83.54, *U-Cable Guard (Flared),* and Item Standard C83.55, *U-Cable Guard Strap*, all for aluminum alloy product.

The cable measuring practice used by London Hydro is illustrated in London Hydro drawing E.CS-150, *Cable Measurement* (a copy has been included in Appendix A for convenience of reference). When a request for a measurement is received, the Line Department will give the measurement referenced from a painted staple installed at the base of the pole to the bottom bolt of the cable termination bracket.

London Hydro will attach the private power cables to the pole and the power fuse mount once the Owner has carried out an *acceptance test* in accordance with IEEE Standard 400.2 *IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) (less than 1 Hz).*

Note: As a reference convenience, Clause 5.1.1 *VLF AC Withstand Voltage Test Parameters* and Table 3, VLF *Withstand Test Voltages for Sinusoidal and Cosine-Rectangular Waveforms,* within this standard indicate the appropriate acceptance test voltage for 28 kV cable system rating as being 36 kV $_{rms}$ (conductor to ground) for a 60 minute duration at 0.1 Hz.

3.4 Underground Supply from a Padmounted Switchgear

For projects where the customer-owned substation is to be connected via underground power cable to London Hydro's underground distribution system, London Hydro will install a three-phase, deadfront, padmounted, sectionalizing switchgear generally as illustrated in Figure 3-3 below. The Owner is responsible for the supply and installation of the underground duct and manhole system (from the switchgear to the substation), primary power cable, and cable terminations (load break elbow connectors).

Figure 3-3, Typical Padmounted Deadfront Sectionalizing Switchgear

For most projects, London Hydro will require an easement for the padmounted switchgear. The easement dimensions will depend upon the switchgear orientation as illustrated in Figure 3-4 below.

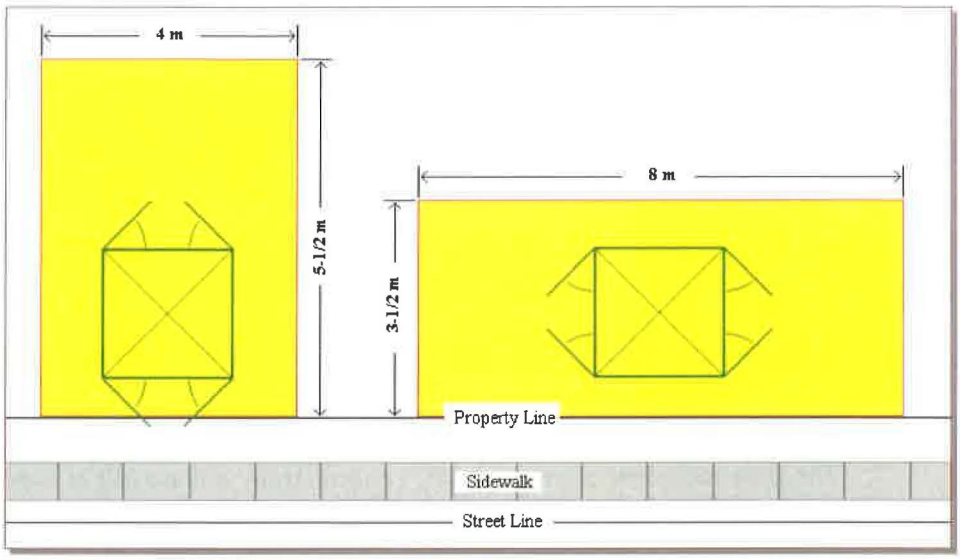


Figure 3-4, Minimum Easement Dimensions for Padmounted Switching Enclosure

Co-ordination of the installation will depend upon the status of the switchgear. If the switchgear happens to be de-energized, London Hydro will grant the Owner access to the interrupter switch compartment that forms the point of primary supply. If the switchgear is energized, then London Hydro's forces will be responsible for directing the final lengths of ducts into the switchgear foundation, direct the installation of power cables, stand by for the termination and acceptance testing of the power cables, and finally attach the power cables to the switchgear.

Figure 3-5, View of Switchgear Interrupter Switch Compartments

London Hydro will attach the private power cables to the pole and the power fuse mount once the Owner has carried out an *acceptance test* in accordance with IEEE Standard 400.2 *IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) (less than 1 Hz).*

Note: As a reference convenience, Clause 5.1.1 *VLF AC Withstand Voltage Test Parameters* and Table 3, VLF *Withstand Test Voltages for Sinusoidal and Cosine-Rectangular Waveforms,* within this standard indicate the appropriate acceptance test voltage for 28 kV cable system rating as being 36 kV_{rms} (conductor to ground) for a 60 minute duration at 0.1 Hz.

3.5 Underground Supply from an Indoor Switching Vault

For projects where the customer-owned substation is to be connected via power cable to an adjacent indoor switching vault, London Hydro will install a wall-mounted metal-enclosed fuse generally as illustrated in

Figure 3-6 below. The Owner is responsible for the supply and installation of the duct bank (from the fuse to the substation), primary power cable, and elbow-type separable connectors.

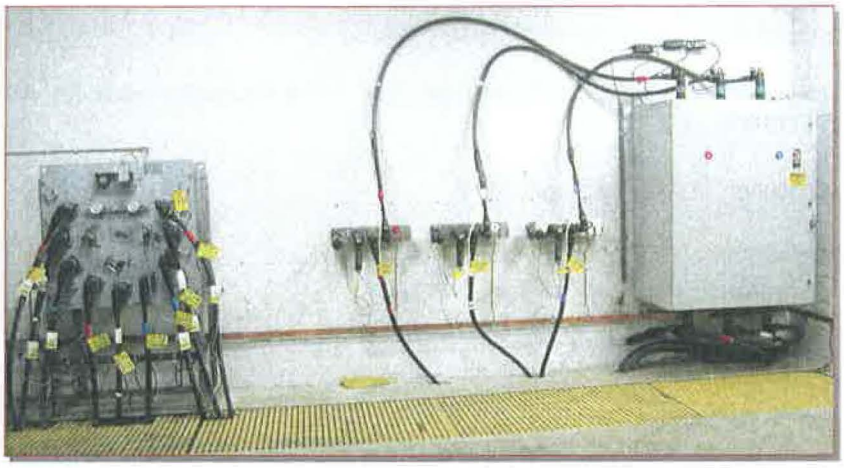


Figure 3-6, Indoor Switching Vault

London Hydro will attach the private power cables to the pole and the power fuse mount once the Owner has carried out an *acceptance test* in accordance with IEEE Standard 400.2 *IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) (less than 1 Hz).*

Note: As a reference convenience, Clause 5.1.1 *VLF AC Withstand Voltage Test Parameters* and Table 3, VLF *Withstand Test Voltages for Sinusoidal and Cosine-Rectangular Waveforms,* within this standard indicate the appropriate acceptance test voltage for 28 kV cable system rating as being 36 kV_{rms} (conductor to ground) for a 60 minute duration at 0.1 Hz.

4 SUBSTATION EQUIPMENT RATINGS

4.1 Basic Impulse Insulation Level (BIL)

All customer-owned equipment shall be rated 150 kV BIL or greater for operation on the 16/27.6Y kV distribution system.

4.2 Transformer Winding Connections

4.2.1 Delta-Connected Primary Winding

Except in instances where the high-voltage over-current protection is via a three-pole circuit breaker, transformation with a delta-connected primary winding is not permitted for operation on the 16/27.6Y kV distribution system.

Note: For reasons set forth in ANSI/IEEE Standard C57.105, *IEEE Guide for Application of Transformer Connections in Three-Phase Distribution Systems*, it is recommended that transformers with a three-legged core design be avoided.

Certain applications that are outside the *usual service conditions* for distribution or power transformers (e.g. loads with high harmonic content, arc furnace loads, etc.) will require the customer to procure a custom designed transformer. The transformer's internal winding connection for these applications shall be subject to investigation by London Hydro's Planning & Standards Engineer for compatibility with the distribution system.

4.2.2 Dual-Winding Transformers

Where the Customer's transformer is proposed to be located in an area where the 16/27.6Y kV distribution system is currently not available, the transformer shall be equipped with dual voltage windings suitable for connection to the 16/27.6Y kV distribution system.

4.3 Available Short-Circuit Levels

The fault levels given following are for demonstrating compliance with Rule 14-012, *Ratings of Protective and Control Devices*, of the Ontario Electrical Safety Code:

- 17,000 amperes r.m.s. symmetrical, for a bolted three-phase fault; and
- 12,000 amperes r.m.s. symmetrical, for a line-to-ground fault.

Note that these are maximum values at the point of supply. For a 16/27.6Y kV system, an asymmetry factor of 1.6 is commonly used.

4.4 Cable Terminations

For projects where underground power cable is installed, the cable terminators shall meet the requirements of IEEE Standard 48, *IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV Through 765 kV*, for an outdoor, Class 1 termination with a *minimum* 28 kV insulation class rating.

For installation on a primary cable riser pole, the cable terminator design shall be for a *Level III* environment with parameters as follows:

- minimum leakage distance: ..... 720 mm
- minimum arcing distance: ..... 320 mm

For installation within a padmounted sectionalizing switchgear and in cases (generally within the core area of the city) where the private primary power cables are to be connected to London Hydro's wall-mounted

metal-enclosed fuses within an indoor switching vault, the power cables shall be terminated with elbow-style load-break separable connectors. Such connectors shall meet the requirements of ANSI/IEEE Standard 386, *IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V*, for devices with a 200 A, 16.2/28 kV class rating. For these projects, London Hydro will provide specific guidance on the selection of an appropriate elbow-style terminator.

5 OTHER DESIGN REQUIREMENTS

5.1 Co-ordination with London Hydro's Service Tap Fusing

For the primary service tap, London Hydro will install the service tap fusing/relaying identified following:

Table 5-1, Service Tap Fusing

Point of Primary Supply	Fuse Mounting	Largest Fuse Available [1) 2) 3)]
Aerial Tap	S&C Electric's type SMD-20 Drop-Out In-Line Fuse Mount	S&C Electric's *type SMU-20* power fuse rated 23 kV and 200K.
Primary Cable Riser	S&C Electric's SMD-20 Drop-Out Fuse Mount	S&C Electric's *type SMU-20* power fuse rated 23 kV and 200K.
Padmounted Switchgear	N/A	Molded Vacuum Interrupter (MVI) programmed as K Type fuse rated 200K
Indoor Switching Vault	S&C Electric's SML-20 Fuse Mounting	Hi-Tech current limiting fuse rated 17.2 kV and 50A.

Notes:

1) In cases whereby the current rating of the fuse is restricted (to obtain co-ordinated operation with upstream overcurrent devices), the Owner will be so notified following submission of plans (refer to Section 2).

2) Faster operating times will be achieved if the current rating of the fuse is as small as can be selected and yet still coordinate with the downstream substation protection. The current and speed ratings of type *SMU-20* power fuses available are 25K, 40K, 50K, 80K, 100K, 140K and 200K.

3) Hi-Tech current limiting fuses available at 20A, 30A, 40A and 50A continuous current rating.

The substation protection should co-ordinate with the service tap fusing in addition to meeting the requirements of Rule 26-252, *Overcurrent Protection for Power and Distribution Transformers Rated Over 750 V*, of the Ontario Electrical Safety Code.

5.2 Padlocking (for Unit Substations)

For projects where a unitized substation is being constructed, London Hydro has supplementary requirements to the interlock requirements set forth in CSA Standard C22.2 No. 31, *Switchgear Assemblies*, and the padlocking requirements of the provincial Electrical Safety Authority. These requirements are listed below:

- The access doors to the primary cable termination compartment and the primary switch compartment shall be designed to accommodate London Hydro's standard padlock.
- The installation of London Hydro's padlocks on the access doors (to the primary cable termination compartment and the primary switch compartment) shall not in any way impede the customer's ability to operate the primary switch for the purposes of isolation, to replace the primary fuses, to adjust the setting of the off-circuit tap changer, or to perform preventive or corrective maintenance activities within the secondary cable termination compartment.
- In cases where the customer prefers joint control of the high-voltage switch, the external operating handle shall be equipped with a dual-locking yoke, constructed in accordance with the sketch below.

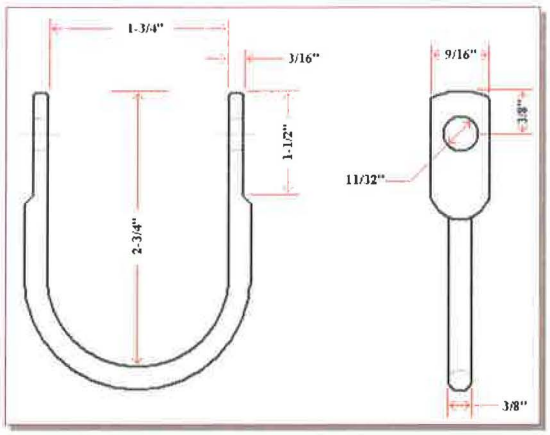


Figure 5-1, Typical Dual-Locking Yoke

Manufacturers of suitable yoke design include Almat Metal Limited's #K52-10 (with a 2¼ inch length) or #K52-20 (with a 3¼ inch length) products.

In general, the submitted nameplate and outline drawings for unit substations do not include sufficient detail for London Hydro to verify that the above requirements have been fulfilled. As such, London Hydro's approval of substation drawings does not imply acceptance of non-conforming padlocking arrangements.

5.3 Potential Indicator and Viewing Window

For substation designs with both metal-enclosed or metal-clad medium-voltage switchgear and primary metering, there is no requirement to provide a Kirk key interlock system between the access door for the primary metering unit and the main disconnect device. Instead, the metering compartment shall be outfitted as follows:

- The access doors shall accommodate installation of London Hydro's standard padlock;
- The compartment shall be outfitted with a Groupe Sicame *type IPL75-B13* potential indicator mounted on the centre phase bus bar. One such unit (with different bus bar clamping hardware) is depicted below:

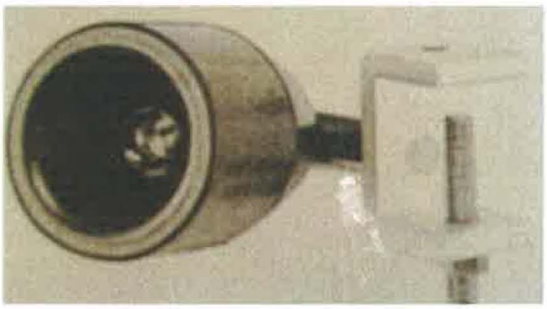


Figure 5-2, Potential Indicator

Note: The local distributor for these indicators is:

Thies Electrical Distributing Co.
43 Hilltop Drive
Cambridge, Ontario
N1R 1T2

☎ 519-621-2524

- The access door for the compartment shall be outfitted with a viewing window dimensioned and positioned for ready viewing of the potential indicator. One can assume that the user is standing 60 cm from the access door, and that the standing eye height of the typical user may range from 151.1 cm to 173.3 cm, (Source: Table XIII, *Standing Body Dimensions*, of MIL Standard 1472C, *Human Engineering Design Criteria for Military Systems, Equipment and Facilities*).

5.4 Underground Plant Locates

Under Section 228 (1)(a) of the provincial *Occupational Health and Safety Act*, it is the Owner's responsibility to obtain all utility clearances (including hydro) before any excavation takes place. Arrangements may be made through the central *Locates — Call Before You Dig* service. The telephone number may be found under the telephone book listings for any of the major utilities (e.g. London Hydro, Bell Canada, Union Gas, etc.).

6 REVENUE METERING REQUIREMENTS

6.1 General

The following guidelines determine whether revenue metering will be performed on the primary or secondary side of the substation transformer:

- In cases where the secondary voltage is non-standard (i.e. other than 120/208Y or 347/600Y volts), primary metering shall be installed.
- Except as noted in the Totalizing Circuitry section, London Hydro will not provide totalized revenue metering. In cases where the electric power substation is comprised of two or more substation transformers, primary metering shall be installed.
- The largest secondary current transformer provided by London Hydro is rated 3,000-5 amperes. For low-voltage service entrance equipment with a rating greater than 3,000 amperes, primary metering shall be installed. London Hydro will provide the metering unit or high-voltage instrument transformers, but the Owner is responsible for providing the high-voltage metering compartment or mounting provisions on a pole.
- London Hydro will only provide secondary metering to projects where the substation transformer is designed to meet the requirements of CAN/CSA-C802.1, *Minimum Efficiency Values for Liquid-Filled Distribution Transformers*, or CAN/CSA-C802.3, *Maximum Losses for Power Transformers*, and compliance is conclusively demonstrated via the submission of test results from the transformer manufacturer. Such test results shall bear the seal of a Registered Professional Engineer.

Where primary metering is installed, the revenue metering system will be configured to deduct the transformer losses from the measured demand and energy readings. The maximum no-load and load loss values given in CAN/CSA Standard C802.1 or CAN/CSA Standard C802.3 (as applicable) are used to determine the deduction.

6.2 Primary Metering for Outdoor Substations

For outdoor primary metering installations, London Hydro will supply and install pole-mounted medium-voltage metering unit that consists of:

- three (3) - Sadtem *type OCF24-2 - 34.5 kV voltage class* outdoor current transformers (see Figure 6-2 below); and
- three (3) – Sadtem *type YE7 - 34.5 kV voltage class* (unfused) outdoor potential transformers (see Figure 6-3 below)
- aluminum cluster mount bracket

One such unit is illustrated below.

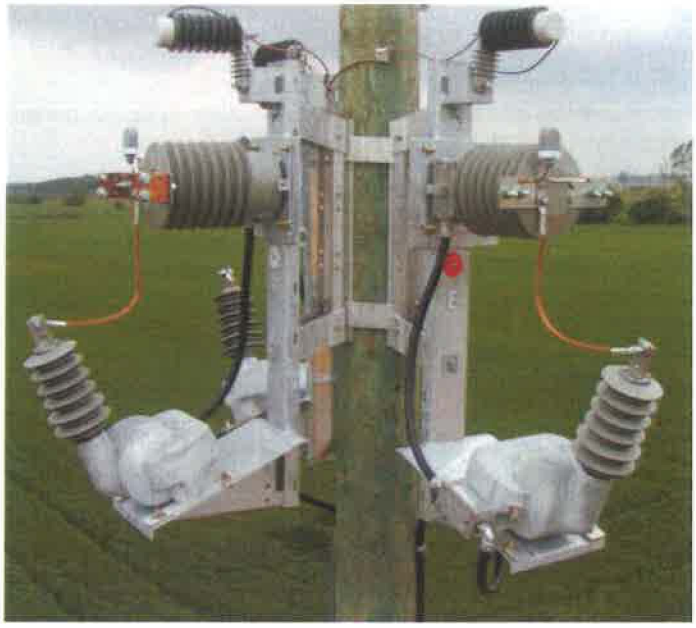


Figure 6-1, Typical Primary Metering Unit

For primary metering installations in outdoor switchgear, London Hydro will supply the following instrument transformers to the medium-voltage switchgear manufacturer for factory-installation:

- three (3) - Sadtem *type OCF24-2 - 34.5 kV voltage class* outdoor current transformers (see Figure 6-2 below); and
- three (3) – Sadtem *type YE7 - 34.5 kV voltage class* (unfused) outdoor potential transformers (see Figure 6-3 below),

for arrangement in a 3-element revenue metering scheme.

Figure 6-2, Typical Outdoor CT

Figure 6-3, Typical Outdoor VT

London Hydro will provide outline drawings to medium-voltage switchgear manufacturers who may be unfamiliar with these types of instrument transformers.

6.3 Primary Metering for Indoor Substations

For primary metering installations in indoor substation switchgear, London Hydro will supply the following instrument transformers to the medium-voltage switchgear manufacturer for factory-installation:

- three (3) - Sadtem *type SW54 - 34.5 kV voltage class* indoor current transformers (see Figure 6-4 below); and
- three (3) – Sadtem *type RY6A - 34.5 kV voltage class* (unfused) indoor potential transformers (see Figure 6-5 below),

for arrangement in a 3-element revenue metering scheme. These units are illustrated below.

Figure 6-4, Typical Indoor CT

Figure 6-5, Typical Indoor VT

London Hydro will provide outline drawings to medium-voltage switchgear manufacturers who may be unfamiliar with this type of instrument transformer.

6.4 Secondary Metering

For secondary metering installations, London Hydro will supply the following instrument transformers to the low-voltage service-entrance switchgear manufacturer for factory-installation:

- three (3) – ABB *type CMF*, Schlumberger *type R6MC,* GE *type JAK-0* (or similar) dual-ratio window-style current transformers; and
- three (3) – ABB *type PT.7*, Schlumberger *type ME-7,* GE *type PTM-0,* Hammond *type VM6* (or similar) indoor potential transformers, rated 360:120 V.

for arrangement in a 3-element revenue metering scheme. These units are illustrated below.

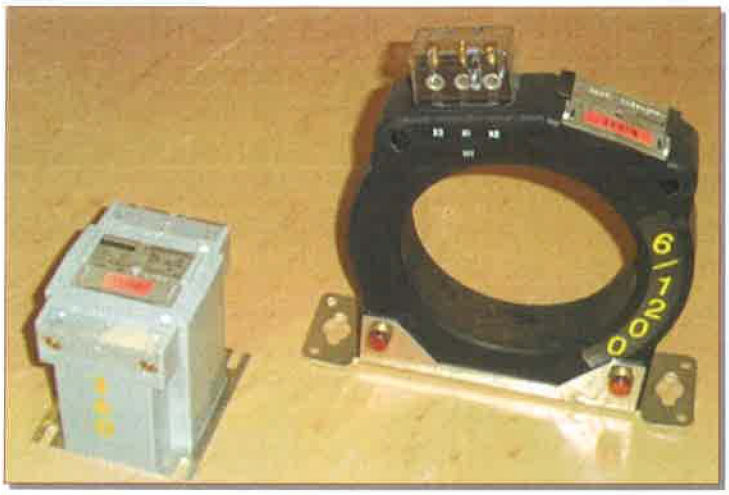


Figure 6-6, Low-Voltage Instrument Transformers

London Hydro will provide outline drawings to low-voltage switchgear manufacturers who may be unfamiliar with this type of instrument transformer.

6.5 Remote Metering Cabinet

6.5.1 General Arrangement

The customer is responsible for supplying and installing:

- a remote metering cabinet, with dimensions as specified in subsection 6.5.2 or 6.5.3 below, and located no greater than fifty feet (50') from the metering unit / instrument transformers.
- a 1-¼ inch diameter conduit interconnecting the revenue metering compartment or metering unit with the remote metering cabinet.
- a ½ inch diameter conduit interconnecting the remote metering cabinet with telecommunications circuit.

London Hydro will supply and install the interconnecting control wiring.

6.5.2 Outdoor Metering Cabinet Specification

For outdoor installations, the remote metering cabinet shall conform to CAN/CSA Standard C22.2 No. 94, *Special Purpose Enclosures*, for a metallic *Type 4X* enclosure (i.e. outdoor, water-tight, corrosion-resistant). The cabinet shall have nominal external dimensions no less than 48" H x 36" W x 12" D.

The enclosure shall have the design features / accessories listed following:

- finish colour: grey (ASA #61) or natural if aluminum or stainless steel construction;
- single-door design, with piano-hinge and a 135° door stop;
- removable inner panel;
- a three-point latching assembly with a handle designed to accept a standard Hydro padlock;
- drip shield, to protect door and hardware from falling dust and water; and
- four (4) external mounting tabs for affixing the enclosure to a wall, substation fence, or wood pole (with adapters).

All conduit entries shall enter into the bottom of the enclosure.

Note: The products indicated below have been used successfully on other projects:

- Hammond Manufacturing Co. Ltd..... #1418-N4-SSS12 enclosure c/w doorstop, drip shield, and latch assembly.
- Ralston Metal Products Ltd. ..... #V-GP-483612 (custom) enclosure c/w #V-4836 inner panel, and vault-type padlocking handle & 3-point hardware.

This information is offered only to assist Owners, and not to preclude the installation of competing enclosures with equal or better designs.

As an alternative, in cases where the substation includes metal-enclosed or metal-clad switchgear, the provisions for revenue meters, test switches, etc. can be designed as a sub-compartment (with separate access provisions) to the primary metering compartment

6.5.3 Indoor Metering Cabinet Specification

For indoor installations, the remote metering cabinet shall conform to CAN/CSA Standard C22.2 No. 94, *Special Purpose Enclosures*, for a metallic *Type 12* enclosure (i.e. indoor, dust-proof, drip-proof). The cabinet shall have nominal external dimensions no less than 36" H x 36" W x 12" D.

The enclosure shall have the design features / accessories listed following:

- finish colour:grey (ASA #61) or natural if aluminum or stainless steel construction;
- double-door design, with piano-hinge and 135° door stops;
- removable inner panel; and
- a three-point latching assembly with a handle designed to accept a standard Hydro padlock.

All conduit entries shall enter into the bottom of the enclosure.

As an alternative, in cases where the substation includes switchgear, the provisions for revenue meters, test switches, etc. can be designed as a sub-compartment (with separate access provisions) to the primary metering compartment.

6.6 Meter Communication Circuit

Pursuant to the Ontario Energy Board's *Distribution System Code*, the Owner shall provide a communication option to the remote metering cabinet in accordance with the requirements set forth in London Hydro's Engineering Instruction EI-22, *Guidelines for Supplying Interval-Style Revenue Metering Systems*.

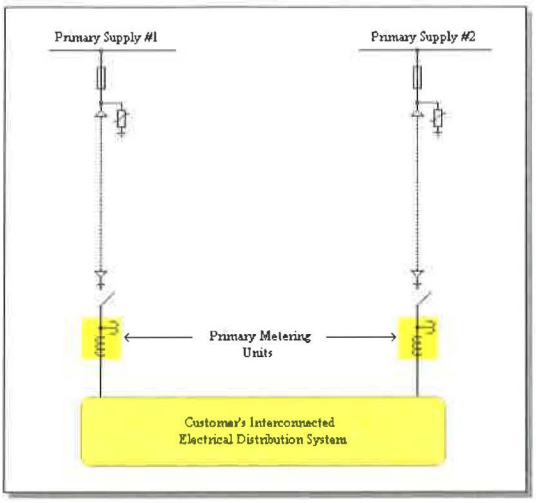
6.7 Totalizing Circuitry

London Hydro will provide totalizing circuitry in the following instances:

[1] Limitations in London Hydro's electric distribution system capacity or revenue metering equipment do not allow a customer to be supplied via a single point of supply. In this case, London Hydro will supply the necessary instrument transformers and totalizing equipment at no cost.

Example #1: A customer-owned substation to be supplied from London Hydro's 16/27.6Y kV primary distribution system has a predicted electric demand in excess of 10 MW. This demand exceeds the capability of the 200/100-5 A current rating of the largest current transformer used by London Hydro.

The customer will be required to take two or more points of primary supply with a service and revenue metering arrangement as illustrated following:

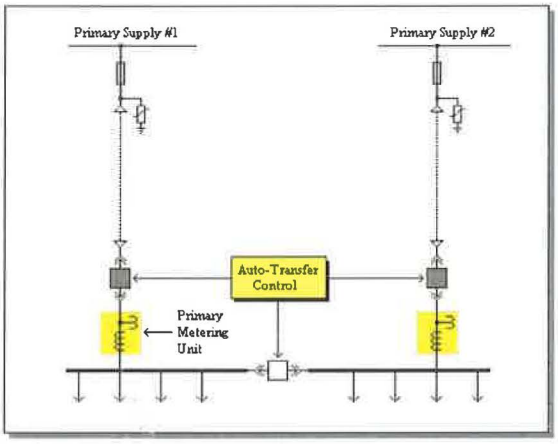


London Hydro will determine whether totalizing is performed locally at the customer's premises or remotely at London Hydro's premises based on cost and mutual convenience considerations.

Example #2: A customer-owned substation to be supplied from London Hydro's 16/27.6Y kV primary distribution system has a predicted electric demand in excess of 20 MW. This demand exceeds the preferred normal load rating of the distribution circuit.

The customer will again be required to take two or more points of primary supply with a service and revenue metering arrangement as illustrated in Example #1.

[2] The customer has installed an internal auto-transfer system and is contracting for standby power. In this case, the customer is responsible for the second (and subsequent) set of instrument transformer as well as the cost of totalizing equipment.



As a final note, some customers have sites distributed throughout the service area. One example is the City of London's pollution control plants. While any given site may be eligible for totalized revenue metering if one or more of the above stated criteria are fulfilled, a totalized billing would not be provided for the collection of data.

Note: Totalized billing should not be confused with summary billing, a service that is presently offered by London Hydro.

6.8 Allowance for Customer-Owned Step-Down Facilities for Multi-Metered Projects

Where a bulk revenue meter is provided in a multi-tenant residential building (e.g. apartment building) or multi-tenant commercial building, the allowance for customer-owned transformation (refer to Section 1.4 on page 1) will be calculated based on the peak monthly demand recorded by the bulk revenue meter. Where individual tenant metering is provided, the allowance will be calculated based on the maximum

monthly peak demand of the *house* meter unless provisions are made in the customer's service entrance switchgear for additional metering for allowance calculation purposes. Contact London Hydro for additional details.

7 INSPECTION RESPONSIBILITIES

The provincial Electrical Safety Authority is responsible for inspecting the customer-owned substation. Upon receipt of connection authorization (refer to Rule 2-012, *Connection Authorization*, of the Ontario Electrical Safety Code) from the Inspector, London Hydro will install London Hydro's padlocks (as required), install fuses at the point of primary supply, and then close the main switch to energize the substation.

8 PRICE SCHEDULES

London Hydro's contributed capital requirements for the utility portion of the work at the point of interconnection (e.g. framing a primary cable riser pole, installing a padmounted switchgear, etc.) vary from year to year and are outlined in the latest edition of Engineering Instruction EI-7, *Customer Charges for Electric Servicing*.

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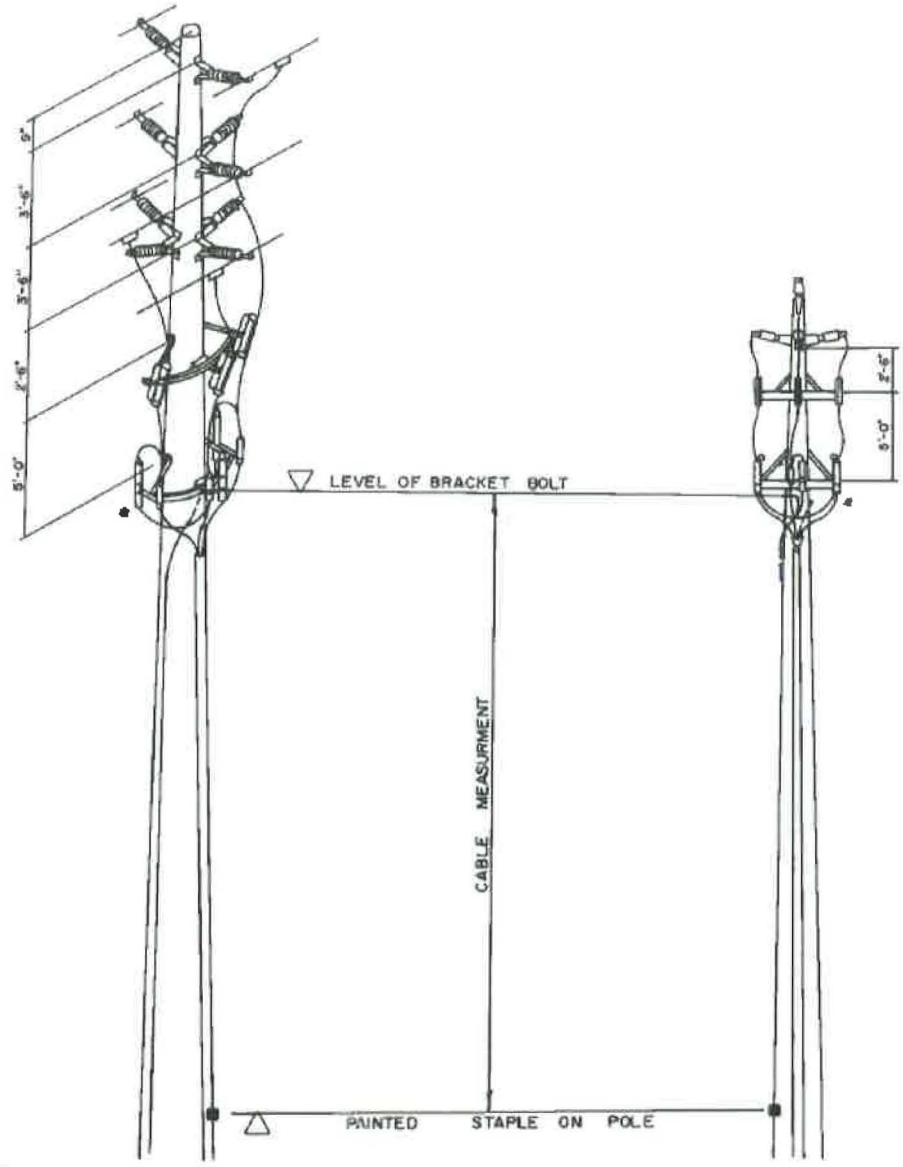
APPENDIX A – DRAWINGS

E-CS-150



* CONTRACTOR TO MAKE ALLOWANCE FOR OUTER CABLES, RADIUS-AND-TERMINATOR LENGTH AND SUPPORT.

REVIEWED BY:
LONDON HYDRO
ENGINEERING
DATE Feb 11/13

REV.	DATE	ORDER	DESCRIPTION	BY	CHK'D	APP'D

THE PUBLIC UTILITIES COMMISSION
CITY OF LONDON

CABLE MEASURMENT
PUC POLE REFERENCE

DESIGN	DRAWN	DATE	ORDER	SCALE
	RJT	NOV. 1989		NTS

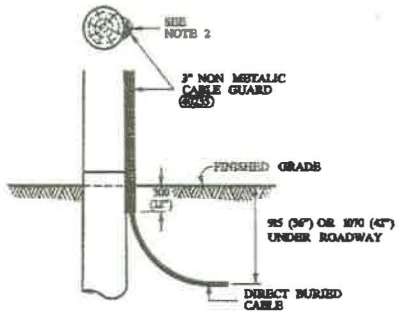
CHECKED | APPROVED | DWG. E-CS-150 EI-4-R1

APPENDIX A – DRAWINGS (Continued)

LONDON HYDRO

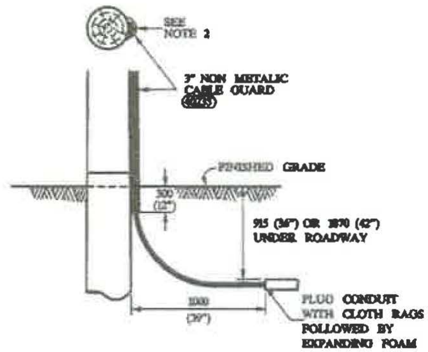
M LINEAR DIMENSIONS SHOWN IN MILLIMETRES

ECS-415
SHT. 2
APR 2005



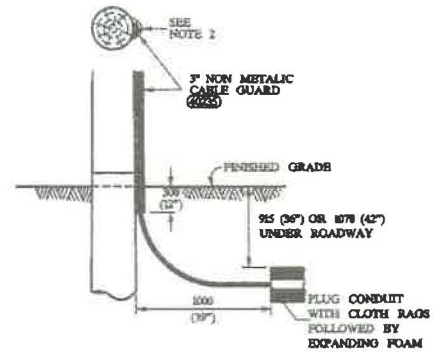
CABLE RISER DIRECT BURIED

(FIG. #1)



CABLE RISER IN DIRECT BURIED CONDUIT

(FIG. #2)



CABLE RISER IN CONCRETE ENCASED CONDUIT

(FIG. #3)

NUMBER OF PRIMARY CABLES PER CABLE GUARD

SIZE AND VOLTAGE RATING OF CABLE	CABLES IN 76mm (3") CABLE GUARD
1000 kcmil 28 kV XLPE CN PVCJ CABLE	1
#1/0 Al 28 kV XLPE CN PVCJ CABLE	3
#3/0 Cu 28 kV XLPE CN PVCJ CABLE	3

NOTES:

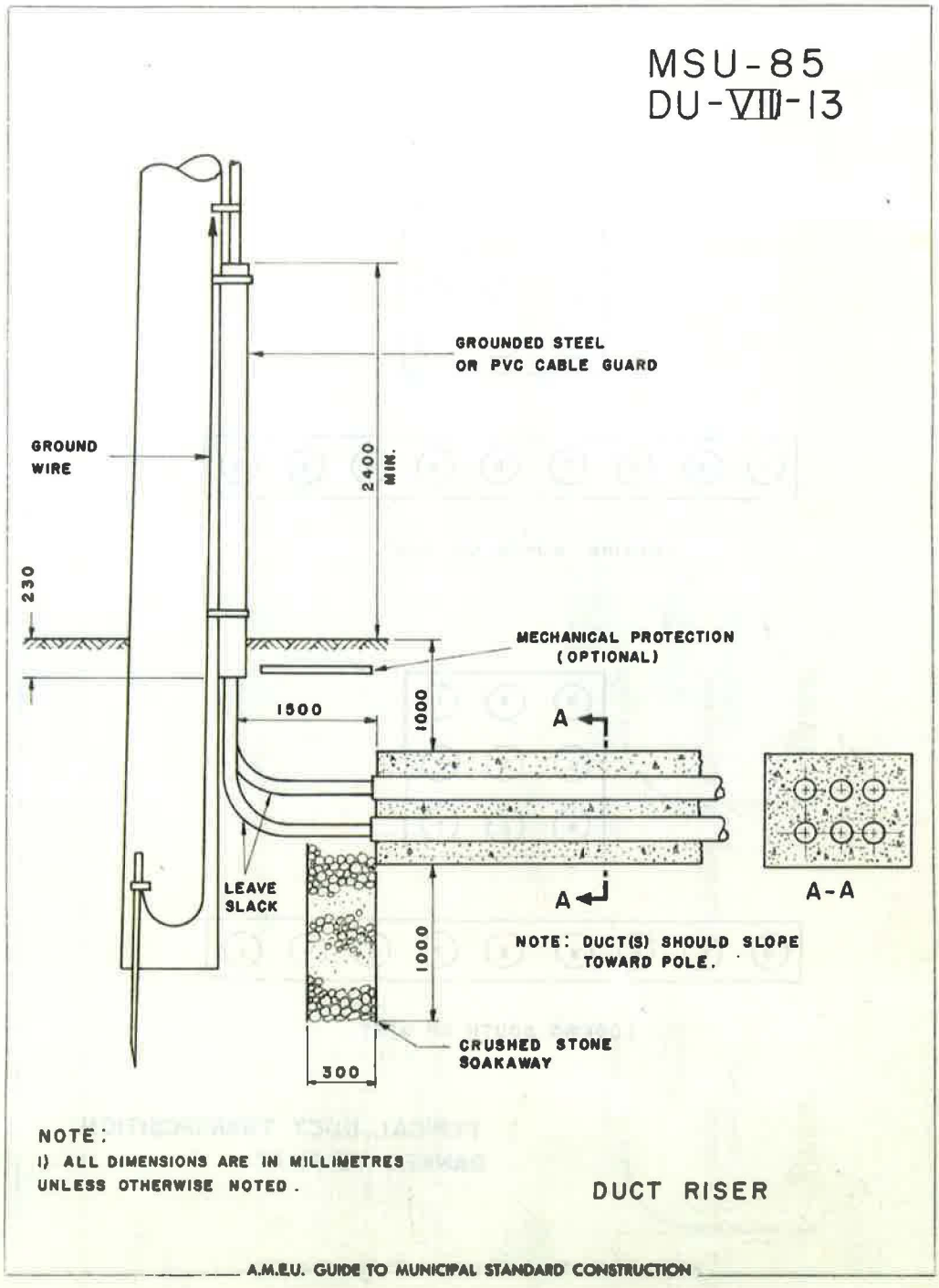
1. ALL DUCTS MUST STOP 1000mm (39") FROM THE POLE.
2. RISER DUCTS, CABLES & GUARDS) ARE TO BE LOCATED ON THE OPPOSITE SIDE OF THE POLE TO THE TRAFFIC FLOW IF ON ROADWAYS.
3. SPARE DUCTS ARE TO BE CAPPED.
4. ALL DUCTS CONTAINING CABLES ARE TO BE PLUGGED WITH CLOTH RAGS FOLLOWED BE EXPANDING FOAM.
5. ALL CABLE GUARDS ARE TO BE EMBEDDED A MINIMUM OF 300mm (12") BELOW FINISHED GRADE.

PRIMARY & SECONDARY CABLE RISER DETAILS
"AFTER 2005"

CHECKED BY: Joseph Bezzina
APPROVED BY: [signature], P.Eng
DATE: Feb 2/05

London Hydro

APPENDIX A – DRAWINGS (Continued)



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