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BY COURIER

December 5, 2008

Ms. Kirsten Walli
Secretary
Ontario Energy Board
Suite 2700, 2300 Yonge Street
P.O. Box 2319
Toronto, ON
M4P 1E4

Dear Ms. Walli:

EB-2007-0709 – Hydro One Networks' Comments on Proposed Amendments to the Distribution System Code

In response to the Board's October 31, 2008 Notice of Proposal to Amend a Code in this proceeding, Hydro One provides the attached Submission of Hydro One Networks Inc. Regarding the Board's Proposed Changes to Amend the Distribution System Code.

An electronic copy of the submission has been filed using the Board's Regulatory Electronic Submission System (RESS) and the proof of successful submission is attached.

Sincerely,

Susan Frank

Attach.

EB-2007-0709

IN THE MATTER OF the *Ontario Energy Board Act, 1998,*
S.O. 1998, c. 15 (Sched. B);

AND IN THE MATTER OF a proceeding pursuant to
subsection 70.2 of the *Ontario Energy Board Act, 1998*
to amend the Distribution System Code

**SUBMISSION OF HYDRO ONE NETWORKS INC.
REGARDING THE BOARD'S PROPOSED CHANGES
TO AMEND THE DISTRIBUTION SYSTEM CODE**

DECEMBER 5, 2008

Contact Information

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Hydro One Networks Inc. ("Hydro One") is pleased to provide comments on the Board's proposed amendments to the Code to deal with farm stray voltages issues. Hydro One supports the goals of the proposed amendments to acknowledge the special needs of electricity supply to farm customers. Hydro One wants to follow good utility practice in a cost effective manner.

Hydro One provides comments on the following specific proposed amendments.

Section 4.7.1

Hydro One submits that the Board should add to the definition of "farm stray voltage" in this section. The section, as proposed, does not define if the ACC or ACV is sustained over a given time period. Since a spot measurement may not give a true indication of a valid stray voltage issue, the testing procedure should require recording voltages and or currents over a prolonged period. Hydro One's practice is to make measurements for 72 hours. Since temporary over-voltages do not have a demonstrable effect on the behaviour of farm animals, the definition should exclude transient over-voltages lasting less than 2 seconds. While the details of the testing procedure will be provided in Appendix H, the definition of stray voltage should be as unambiguous as possible.

Hydro One suggests adding the bolded word to the third bullet in this section as below:

- "farm stray voltage" means **sustained** ACC or ACV at a location on a farm where livestock make contact with it; and

Section 4.7.2:

Hydro One agrees it is appropriate for the Board to develop an Appendix H to define an acceptable testing procedure for distributors in Ontario. Hydro One has recently reviewed and updated its stray voltage processes and testing procedures and completed the training of a number of staff. Adopting different procedures in Appendix H would mean significant costs in terms of new training and potentially new equipment. Hydro One notes that in the Board's Notice of a Proposal to Amend a Code, at the bottom of page 11 and top of page 12 the Notice states: "Moreover, a procedure *as prescribed* can be designed to indicate steps or elements where discretion should be exercised or is otherwise permitted." If the procedure in Appendix H is written in a manner to accommodate Hydro One's testing procedure, it would be more cost effective. Hydro One's testing procedure is extensive and focused on determining all causes of stray voltage, not just those contributed by the distribution system. We are attaching a copy of the procedure for your reference. Hydro One would also like to be part of the team working to develop Appendix H.

Hydro One also notes that given the unique size and nature of the distribution system in Ontario, there will be cases where the only effective solution to address the needs of the farm customer will be to install a tingle voltage filter. The costs to modify the distribution system to meet the standards that will exist in the Code once amended, could be extremely large in some cases. Since the installation of the filter will remove the distribution system as a source of stray voltage, and in no way shifts the problem to the farm customer, the decision should be left at the discretion of the distributor. In Hydro One's experience, farm customers often prefer the installation of a filter as it gives them reassurance long after the testing is complete, that stray voltage is not coming from the distribution system. Distributors would have to base such a decision on the need to find a resolution to a farm stray voltage issue for the customer and also protect the integrity and performance of the distribution system. Another advantage of installing a tingle voltage filter is that it will ensure farm stray voltage from the distribution system will not develop in the future as the system changes due to new load connections, system reconfigurations and the special challenges brought on by the mandate to install renewable distributed generation such as wind farms and biomass onto the distribution system.

Section 4.7.7

Hydro One supports this proposed amendment but submits that farm customers should be required to submit farm stray voltage complaints in writing. The initial conditions as described by the farm customer will become part of the full documentation of the investigation case. Farm customers should also be required to outline what measures they have already taken on their property, if any, and provide other information about the farm property and equipment that will make the investigation by the distributor more focussed and efficient.

Hydro One makes the above recommendations to assist the Board in considering the implications of the proposed amendments to farm customers and to recommend cost effective solutions. As noted above, Hydro One would be pleased to assist the Board in the development of Appendix H.

Supersedes HO PR 0273 R0

Distribution System

Stray Voltage Mitigation

June 26, 2007

DISTRIBUTION STANDARD

LIMITATION OF LIABILITY AND DISCLAIMER

CONTACT/PUBLISHER

This standard is the responsibility of Standards & Policies Department. Please contact the Manager, Standards & Policies, with any queries or suggestions.

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TITLE:	Wardrop Engineering Inc.	Distribution Lines Engineer/Officer	Manager – Technical Services
DATE:	January 2007		

REVISION HISTORY

DATE	VERSION	COMMENTS
January 23, 2007	R0 - Preliminary	Sent for review/comments.
January 31, 2007	R1 - Preliminary	Sent for review/comments.
June 26, 2007	R2 - Preliminary	Revised as per comments

TABLE OF CONTENTS

1.0 SCOPE

This document is the standard test procedure for resolving stray voltage, also known as tingle voltage, when the source of the problem is believed to be the primary distribution system. The objective of the procedure is to isolate any faults or deficiencies that result in the primary neutral-to-earth voltage exceeding the design limit. This procedure is to be performed by Hydro One staff. The complementary test procedure for the secondary customer system is titled "Stray Voltage Mitigation Customer System Standard Test Procedure." That procedure is to be performed by the customer's electrical contractor and is designed to isolate any faults or deficiencies on the customer's system.

2.0 DEFINITIONS & BACKGROUND

Neutral-to-Earth Voltage. Neutral-to-earth voltage (NEV) is the voltage measured between the primary distribution system neutral, or the customer's secondary system neutral, and remote earth.

Stray (Tingle) Voltage. Stray voltage, also known as tingle voltage, is the voltage measured between contact points in a residence, commercial building or a building housing livestock. Stray voltage is typically 40-60% of the NEV.

Neutral-to-Earth Voltage Standard. The maximum NEV on the Hydro One primary distribution is 10 volts under normal operating conditions.

Small electrical potentials or voltages between any metal structure or equipment and floor surfaces, are natural, explainable and expected phenomena in buildings served by grounded neutral electrical systems. The voltage is developed as a result of current returning to the source through the grounded neutral conductors. The neutral conductors on both the primary distribution system and the secondary customer system are connected to earth through ground electrodes or rods. It is the flow of current through these connections to earth that generates NEV and stray voltage. Any metal structure in a building, water lines and case grounds on electrical equipment are all bonded back to the neutral of the system at the service entrance panel, for safety reasons. As a result of these bonds, all of the structure, etc., becomes an integral part of the return path of electrical current to the transformer from which it originates. A human coming in contact with this structure, for example a showerhead, may receive a mild shock which is uncomfortable although it is well below the level considered a hazard. Similarly, livestock which come in contact with stabling, water bowls, etc., can receive a shock, as they become part of this complex configuration of electrical pathways for current flow. See Figure 1 on page 16.

The "threshold of perception" for humans is defined in terms of current. For the adult male, the literature suggests 1 mA. The adult female and children are more sensitive, 0.6 mA and 0.5 mA respectively. The "threshold of perception" should not be confused with hazard levels which are an order of magnitude higher. To translate the "threshold of perception" from levels of current into levels of voltage, it is necessary to consider the total resistance of the pathway from the electrical source, through the body and back to the source. Skin resistance is the largest component of the total body resistance. Skin resistance varies widely and depends on skin condition and the path through the human body. The most frequent complaints originate from individuals receiving shocks in the shower or in the area of swimming pools where the pathway through the body is from the hands to the feet. In these wet environments, a skin resistance as low as 10,000 is possible. At that body resistance, and a threshold of perception of 1 mA, the voltage that would be required to initiate a response would be 10 volts. Lower resistances are possible but only under abnormal skin conditions such as a cut where the flesh is exposed. **Experience has shown complaints involving humans originate from customer sites where the voltage between contact points exceeded 3 volts.**

The body resistance of livestock is substantially lower than humans. According to one study, the average body resistance of a dairy cow is 359 ohms from the mouth to the all-hooves pathway. It is 738 ohms from the front to rear hooves pathway. See reference /3/, page 6, item 12. For the purpose of testing, a value of 500 ohms has emerged as a standard in Canada and the US to simulate the body resistance of an animal when making stray voltage measurements. See section 5.0 below for instruction on making voltage measurements.

Earlier studies, which focused on defining the "sensitivity" of livestock, resulted in recommendations for corrective action at very low voltage levels. A further understanding of tolerance levels resulting from more recent trials indicates that there is little cause for concern in the 0.5–2 volt range commonly found between surfaces contacted by livestock. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) are recommending a level of 1 volt as the safe exposure limit. The vast majority of research to date supports this limit. **In many cases, this level can only be achieved and maintained by the addition of mitigating devices installed on the customer's secondary system or at the supply transformer.** For additional information on the effects of stray voltage on livestock see the OMAFRA site, www.omafra.gov.on.ca/english/livestock/dairy/facts/strayvol.html.

3 0 NORMAL LEVELS OF NEV AND SYSTEM DESIGN

Levels of NEV on the primary distribution system are directly proportional to neutral current. On single phase lines, this translates into being directly proportional to line loading. On three phase lines, it is the degree of unbalance that determines the neutral current and hence the NEV. The level of current to supply a specific load is inversely proportional to voltage level. For example, a 100 kVA single phase load supplied at 4.8 kV will draw 22.3 A. The same load supplied at 16 kV will draw 6.25 A. If all other parameters were equal, converting the customer to 16 kV would reduce the NEV to 27 % of the value measured on the 4.8 kV supply. Other factors that determine the level of NEV are the impedance of the neutral conductor and the number and resistance of the ground rods. The impedance of the neutral conductor is related to size and condition. The resistance of a ground rod depends on the type and condition of the soil where it resides. Wet soil will have a lower resistance than dry soil; rocky soil will have a higher resistance than clay or loam. Because of all the variables, the only way to determine what the normal level for NEV at a particular point on the system is through a series of tests. **The NEV design limit is 10 volts. However, on most lines the NEV peaks at less than 5 volts. Any NEV over 5 volts requires additional investigation in a timely manner. In this way, any necessary improvements can be made before the 10 volt limit is exceeded**.

TEST EQUIPMENT REQUIREMENTS

The following test equipment is required:

- 2 x True RMS responding voltmeter, the Fluke 187 multi-meter or equivalent.
- 2 x 10 Kilo-ohm resistors, 2 watts, ≥5% accuracy. Each resistor must be mounted on a dual banana plug such as a HH Smith 1676 or equivalent. This is referred to as a bridging resistor in the procedure and is used when taking neutral-to-earth voltage measurements.
- 1 x Stainless Steel portable ground rod. The rod must be at least 1 M in length and 1.5 cm in diameter. It should be sharpened at one end to ease the insertion into the earth. The 0.5 M point from the sharpened point should be marked. The rod should be equipped with an appropriate terminal that permits connection to it via an alligator clip.
- 2 rolls of insulated #18 stranded wire, 50 M in length. One end should be equipped with an alligator clip of suitable size to connect to the ground rod. The other end should be equipped with a banana plug to connect to the multimeter.
- True RMS responding Clip-On Ammeter with switch stick attachment. Scale should be 0-10 A AC and 0-100 A AC **(Model to be determined.)**
- Digital Earth Test Clamp, Megger Model DET10C or equivalent.
- Candura Power Pro
- Electronic Recording Voltmeters (ERV) with a scale of 0-10 VAC and 0-30 VAC. **(Model to be determined.)**
- Pocket calculator.

5.0 TEST MEASUREMENTS

Throughout this procedure, the following measurements are required:

5.1 NEUTRAL-TO-EARTH VOLTAGE (NEV) MEASUREMENTS.

- Refer to the Fluke manual for instruction on the use of the multi-meter to measure voltage.
- Connect one lead of the voltmeter to the ground wire that connects the neutral to the ground rod at the service entrance serving the problem area. When taking measurements on the primary distribution system, connect to the bare ground wire that connects the primary system neutral to the ground rod.
- Insert a portable ground rod 0.5 M into the earth 15 M from the ground rod under test. This becomes the remote ground reference point.
- Using the #18 test lead wire to extend the second voltmeter lead, connect it to the portable ground rod.
- Install a 10 K resistor across the input of the meter. Note the reading. Install a second 10 K across the input of the meter. The reading should not decrease by more than 10%. A reading of more than 10% indicates that the portable ground rod is a high resistance. Move the rod to another location to reduce the resistance. When a good connection to earth has been established, remove the second 10 K resistor from the meter.
- Read and record the NEV. When performing NEV measurements at a substation, the remote reference ground rod should be placed a distance of 100 M from the station fence.
- To install the Candura Power Pro as a recording voltmeter to measure NEV, see section 5.3 below.

5.2 STRAY VOLTAGE (SV) MEASUREMENTS

- Refer to the Fluke manual for instruction on the use of the multi-meter to measure voltage.
- To measure SV for humans, insert a 10,000 ohm bridging resistor across the input of the multi-meter. To measure SV for animals, use a 500 ohm bridging resistor.
- Connect one lead of the multi-meter to one contact point. This could be a shower head for a complaint involving humans, or a water bowl for a complaint involving livestock.
- Connect the second lead of the meter to the floor contact plate placed where the human or animal would stand. Move the plate around the site to obtain the highest reading and record.
- Measure the NEV again and calculate the ratio between the stray voltage and NEV. These two readings should be taken simultaneously to achieve maximum accuracy which requires two multi-meters. The stray voltage should always be less than the NEV. If it is not, this is an indication of a secondary ground fault.

- To install the Candura Power as a recording voltmeter to measure SV, see section 5.3 below.

5.3 CANDURA RECORDING VOLTMETER MEASUREMENTS

At the customer's premises, the Candura Power Pro is used to obtain a 72 hour record of both the primary and secondary neutral voltage and the secondary current.

1. Channels are setup as per the diagram on the cover to measure both line currents and neutral current assuming a standard 120/240 volt service. Channel 1 voltage (red), setup as per the diagram, supplies power to the unit and measures the line-to-neutral voltage.

2. Drive a remote ground rod 15 M from any service ground. All other voltage measurements are to this remote ground.

3. Channel 2 voltage (yellow), connect the input lead to the primary neutral at the transformer pole and the common to remote ground.

4. Channel 3 voltage (blue), connect the input lead to the secondary neutral at the service panel and the common to remote ground.

5. The neutral channel (white) may be used to measure voltage between contact points. For example, connect the channel between a shower head and the floor for a complaint involving shocks in the shower. For installations where a Hammond Tingle Voltage Filter is installed, connect the input lead to the ground at the service panel and the common to remote ground.

6. Set the trigger levels to the minimum, 1.2 V, on voltage channels 2 and 3 to obtain a waveform capture. The neutral channel does not have a waveform capture trigger.

7. Set the recording period to obtain the desired record length. This should be 72 hours minimum.

5.4 MEASURE GROUND ROD & NEUTRAL RESISTANCE.

Refer to the Megger DET10C manual for instructions.

5.5 MEASURE GROUND ROD CURRENT.

Refer to the Megger DET10C manual for instructions.

5.6 MEASURE PRIMARY PHASE AND NEUTRAL CURRENT.

Refer to the XXXX manual for instructions. If the current is too low, it may be necessary to use the DET1OC or a current clamp with a multi-meter.

6.0 TEST PROCEDURE

All test results are to be recorded on the Excel spreadsheet forms in Appendix 1. They can be recorded on a paper copy in the field and transferred to the electronic copy in the office. Both the original and a printout of the electronic copy should be retained in the job file. The electronic copy should be filed locally for future reference and forwarded to the Distribution Planner.

6.1 INFORMATION VERIFICATION & VISUAL INSPECTION

When the complaint is received:

- Review all the information provided by the Distribution Operations Management Centre (DOMC).
- Verify that this is a stray voltage problem
- Make arrangements with the customer for a site visit.
- Obtain any additional relevant information from the customer not contained in the information provided by the DOMC
- While en-route to the site, perform a visual inspection of the distribution system for signs of problems.
- Note the size of the neutral conductor.
- Look for broken neutrals, the location and condition of splices, especially McIntyre splices which have a high failure rate, and broken neutral-to-ground rod connections.
- The inspection should be carried out for a 5 km radius from the site of the complaint.

Upon arrival at the site of the complaint:

- Perform a visual inspection of the property and all the services.
- Look for signs of damaged or defective wiring and the general condition of the electrical service and equipment.
- Inquire about any recent wiring changes or equipment changes that could impact on the level of SV.

6.2 INITIAL NEV & SV MEASUREMENTS

6.2.1 Measure the NEV at the service entrance with the problem.

6.2.2 Measure the SV in the problem area.

6.2.3 Calculate SV /NEV ratio.

6.2.4 Install a Candura to measure the NEV. It should be located indoors at the service entrance in the building with the SV problem in an area where it is secure and will not interfere with the customer's normal activities. The Candura may also record the stray voltage directly if it is practical to place test leads in the problem area. The Candura should be left on for a period of 72 hours minimum to ensure all load cycles on both the primary and secondary systems are recorded.

6.3 INTERPRETATION OF THE 72 HOUR RECORD

- Retrieve the records from the Candura
- Convert the NEV readings to stray voltage readings by using the ratio obtained in 6.2.3 above.
- If the highest stray voltage is less than the acceptable limit, inform the customer that there is no stray voltage problem.
- If the limit is exceeded, proceed to section 6.4.

6.4 As Found Ground Resistance & Current Distribution Tests

Prior to making any changes or improvements to the primary system or the secondary system, conduct the following "as found tests" at the transformer pole. Because of changing loads, measurements of NEV and current should be taken simultaneously. If the load is changing rapidly, readings should be repeated to ensure accuracy. Record all measurements in the forms contained in Appendix 1.

***With the Customer's Service on load*,**

6.4.1 Measure the NEV.

6.4.2 Measure the transformer ground rod current.

6.4.3 Calculate the transformer ground rod resistance. It is the NEV divided by the ground rod current.

6.4.4 Measure the primary phase current.

6.4.5 Measure the primary neutral current.

6.4.6 Measure the secondary neutral current.

6.4.7 Measure and record the transformer ground rod resistance.

Take the Customer's service off load*, (remove all Customer load on the transformer)*

6.4.8 Measure the NEV.

6.4.9 Measure the secondary neutral current.

6.4.10 Calculate the composite secondary ground rod resistance by dividing the NEV by the secondary neutral current.

6.5 AS FOUND PRIMARY NEUTRAL RESISTANCE TESTS

6.5.1 Remove all Customer Load(s) except the service under test on the Transformer in question.

6.5.2 At the service under test, energize **only** 240 volt loads. For this test, the larger the load, the more accurate the result.

6.5.3 Measure the NEV.

6.5.4 Measure the secondary neutral current.
Note: The secondary neutral current should be very small. It should be equal to the NEV divided by the composite secondary ground rod resistance obtained in 6.4.10. If the current is larger, this indicates some 120 volt load is energized. Investigate and correct as required.

6.5.5 Measure the primary neutral current on the line side of the transformer ground rod. The current should be at least ten times the off load value obtained in 6.1.1 above to get accurate results.

6.5.6 Calculate the primary neutral resistance by dividing the NEV by the neutral current. The resistance should be 1 ohm or less.

6.5.7 De-energize the transformer and check the primary neutral current to ensure the current is no more than 10% of the on load value.

6.6 POLE TOP INSPECTION

With the transformer isolated and de-energized:

6.6.1 If the resistance measurement of the transformer ground rod of 6.1 above indicates the resistance is greater than 25 ohms, inspect the connection to the rod at the neutral and at the rod. If repairs are required, make the repairs and re-test the ground rod resistance. If resistance is still above 25 ohms, drive additional ground rods to obtain 25 ohms or less. When adding additional rods, they should be installed as noted in the Distribution Standards.

6.6.2 Bring all neutral connectors up to present standards.

6.6.3 Check the switch (cut-out) for signs of tracking. Replace as required.

6.6.4 Check the dead-end assemblies for signs of tracking. Replace as required.

6.6.5 Check the surge arrester for signs of leakage. Replace as required.

6.6.6 If any changes were made, repeat the tests in 6.4 and 6.5 above.

6.7 NEUTRAL POTENTIAL SURVEY

If the NEV measured in 6.5 above is 5 volts or greater, or the primary neutral resistance is greater than 1 ohm, a neutral potential survey is required. The survey should be carried out in both directions, towards the supply DS and away from it for a distance of at least 1km in each direction or until a cause for the high NEV and/or the high primary neutral resistance is determined.

While performing the survey, a visual inspection of the neutral should be carried out. The most common problem on the neutral is defective splices. The splice can be checked by measuring the voltage across the splice with a multi-meter and measuring the current with a clip on ammeter to verify that load is present. The voltage across the splice should be practically zero with load present.

At each ground rod location measure:

6.7.1 The ground rod resistance.

6.7.2 The ground rod current.

6.7.3 The NEV.

6.7.4 The System Neutral resistance on the supply side.

6.7.5 The System Neutral resistance on load side.

6.7.6 The red phase current.

6.7.7 The white phase current.

6.7.8 The blue phase current

6.7.9 The neutral current.

Because the load is always changing, it may be necessary to repeat the voltage and current readings more than once to ensure accurate results.

6.7.10 On single phase lines, calculate the ratio of neutral current/phase current.

6.7.11 Calculate the ground rod resistance which is NEV / ground rod current.

6.7.12 Due to the changing load, it is difficult to compare NEV readings from one location to another and draw any conclusions. The NEV at any particular location is a function of the neutral current, the neutral to ground resistance and the neutral conductor impedance. To correct for the changing neutral current, the neutral current reading at the first location is used as the base value. The NEV readings at the other locations are adjusted to this base value by dividing the reading by the current at that location. For example:

Location 1 NEV= 4 V, Neutral Current = 7A
Location 2 NEV =5 V, Neutral Current = 10 A
Location 2 Adjusted NEV = 5 V x (7 A/10 A) = 3.5 V.
Location 3 NEV = 3 V, Neutral Current = 5 A
Location 3 Adjusted NEV = 3 V x (7 A /5 A) = 4.2 V

The spreadsheet in Appendix 1 performs this calculation automatically.

Interpreting NEV survey results can be a challenge. Some points to keep in mind are:

- NEV should follow the load. Sudden increases in NEV without a corresponding increase in neutral current indicate a ground fault condition which could be on the primary or secondary system. In that case, it is necessary to sectionalize to isolate the fault. The adjusted NEV will be highest near the fault.

- On a single phase line, the percentage of current returning on the neutral versus the earth is an indicator of the function of these two paths. There is no absolute norm for this ratio. In areas of high resistivity soil, more current will return by the neutral than the earth as compared to an area where there is low resistivity soil.

- A defective splice will be characterized by a high NEV and a higher ratio of current returning through the earth near the defect.

- The neutral resistance measurement is the parallel combination of all the ground rods on one side of the test point in series with the parallel combination of all the ground rods on the other side of the test point. If the neutral to earth resistance of each parallel combination were 1 ohm, the DET10C would indicate 2 ohms.

7.0 DISTRIBUTION SYSTEM IMPROVEMENTS TO RESOLVE STRAY VOLTAGE PROBLEMS

Where the NEV is above acceptable limits on the primary distribution system, the most economical method of reducing the voltage should be employed. Listing the alternatives from least costly to most costly, the solutions are:

- Repair any defects such as defective splices.
- Improve load balancing on three phase lines.
- Improve the grounding by adding more ground rods.
- Increase the neutral conductor size.
- Convert single phase lines to three phase lines.
- Convert lower voltages to higher voltages, e.g. 8/4.8 kV to 27.6/16 kV.

Where it is not possible to meet the 10 volt NEV standard by repairing defects, load balancing or bringing the grounding up to standard, contact the Dx Planner to have a Filter installed until a permanent solution is put in place.

REFERENCES

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/3/ Review of Literature on the Effect of the Electrical Environment on Farm Animals, 6 November 2003 Draft, Douglas J. Reinemann, Ph. D., University of Wisconsin-Madison

/4/ Hydro One, Resolution of Tingle Voltage Complaints, PR 0273 R0, Oct. 2002.

/5/ Ontario Hydro, Tingle Voltage, Customer Service Reference Manual, Section 10, , May 7, 1987.

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/7/ Ontario Hydro, The Resolution of Tingle Voltage Complaints, Line Trade Reference and Work Methods Manual, Section 14, January 30, 1984.

/8/ Ontario Electrical Safety Code, 23rd Edition/2002.

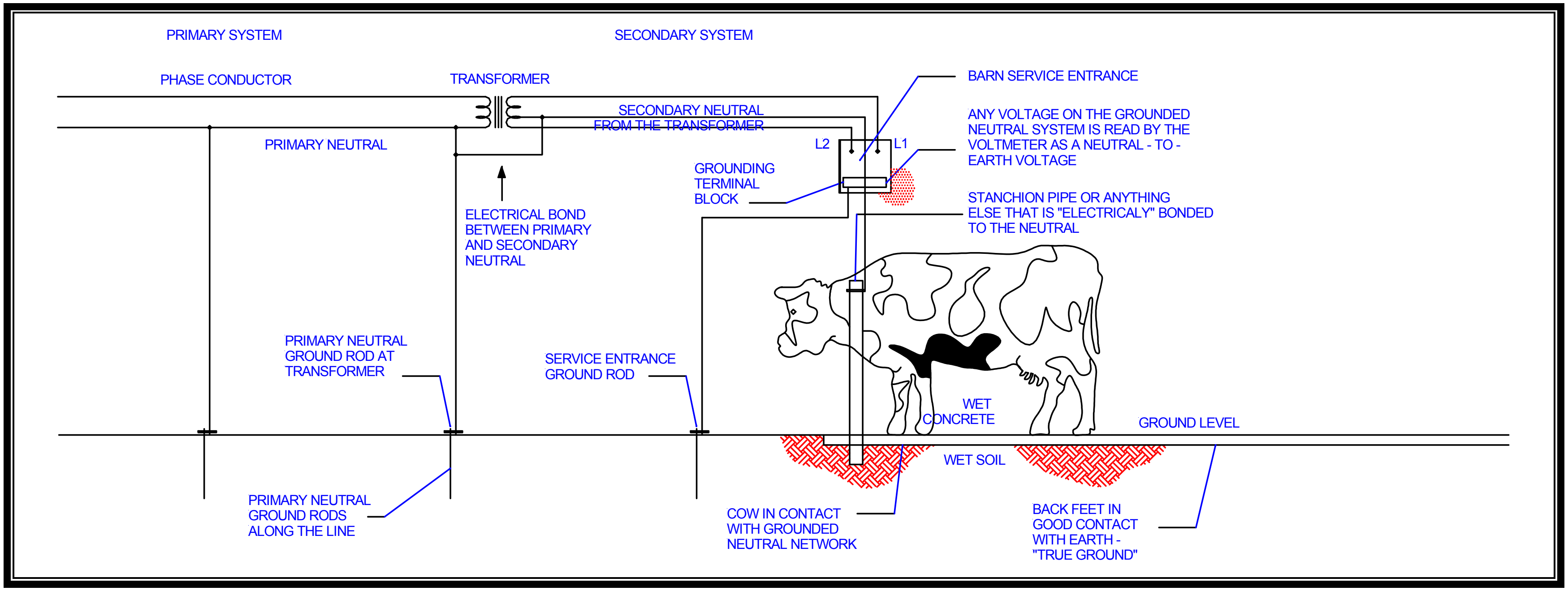

Figure 1
Dairy Cow Subjected to Neutral-to-Earth Voltage