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May 31, 2011

BY COURIER, EMAIL AND RESS

Ms. Kirsten Walli
Board Secretary
Ontario Energy Board
2300 Yonge Street
27th Floor, Box 2329
Toronto, ON M4P 1E4

Dear Ms. Walli:

Re: Intervenor Evidence of Haldimand County Hydro Inc.
Board File No. : EB-2011-0027

We are counsel to Haldimand County Hydro Inc. ("HCHI") in this Proceeding.

Pursuant to Procedural Order No. 6, attached is the intervenor evidence of HCHI prepared by its consultant, Kinectrics. This has been filed on RESS, couriered to the Board's office and will be emailed to each of the participants in this Proceeding.

If there are any questions, please contact the undersigned at your convenience.

Yours truly,

AIRD & BERLIS LLP

Scott A. Stoll
SAS/ hm
Encl.

cc: Applicant
All Intervenors
K. Sebalj, OEB
N. Mikhail, OB
Dr. Petrache, Kinectrics

INDUCTION STUDY FOR HALDIMAND COUNTY HYDRO INC.

Kinectrics Report: 015949-RC-0001-R00

31 May 2011

Emanuel Petrache, PhD
Principal Engineer

Peter Dick, P. Eng.
Associate Engineer

Transmission & Distribution Technologies Business

PRIVATE INFORMATION

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INDUCTION STUDY FOR HALDIMAND COUNTY HYDRO INC.

Kinectrics Report: 015949-RC-0001-R00

Prepared by:

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Reviewed by:

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Dated: ___________________________________

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INDUCTION STUDY FOR HALDIMAND COUNTY HYDRO INC.

1. CONCLUSIONS

The scope of this study was to determine if the 230-kV transmission line draft design provided by NextEra on May 17th, 2011 is likely to create an induction problem on the Haldimand County Hydro Inc. ("HCHI") distribution line that runs in parallel with the proposed transmission line and in very close proximity, for about 2 km.

Kinectrics performed induction calculations considering the geometry given in the 230-kV transmission line draft design provided by NextEra and the HCHI construction standard design for 27.6/16kV lines. This line will connect their new 125MW wind power generation farm to the Hydro One Networks Inc. grid.

Kinectrics studied the voltage unbalance on the distribution phases downstream of 2 km of exposure. The calculated values are very small, about 0.01 % of average line to line voltage for any of the configurations studied. This analysis neglects the effect of the neutral and the overhead ground wire, which should be negligible. The result is well below the 1% limit to voltage unbalance normally accepted by utilities.

Calculations of the induced voltage into distribution phases during a transmission line fault were also performed. The maximum calculated longitudinal voltage induced in the distribution phases was 46 kV when a 63 kA fault on the lowest transmission line phase was considered. To limit these fault induced overvoltages, the protection of distribution equipment may require the installation of surge arresters properly rated for the expected duty on distribution phases at each end of the parallel exposure.

Due to its proximity, the transmission line will provide lightning protection against direct lightning strikes. It is recommended to maintain a minimum distance of 10 m or more between the transmission and distribution poles to limit the GPR (Ground Potential Rise) transfer during lightning strikes to the transmission line and 60 Hz faults.

Kinectrics modelled the neutral to earth voltages considering 2 km length of parallel exposure. Calculations were performed for two ground rod resistances (transformer and customer service ground), 37 ohm and 75 ohm, on the neutral at 100 m spacing. The calculated neutral potential to remote earth remained below 7 V in both cases. The Ontario Electrical Safety Code limits the neutral potential to 10 V, which could be still exceeded depending upon the existing potentials that may be present. In addition, utilities must maintain their contribution to animal contact potentials at customer premises under 0.5 V which could be exacerbated by the new line.

At the request of HCHI another set of calculations were performed considering 20 km length of parallel exposure. Again the calculated neutral potential to remote earth was below 10 V.

The results obtained indicate that the proposed 230-kV transmission line draft design will maintain acceptable phase potentials in the distribution circuit. Neutral potentials should be monitored with and without transmission line currents present to see if they remain acceptable.

This study was based on the draft design information available to date and do not provide a thorough assessment on the impact of the 230 kV line on the HCHI distribution line. A more comprehensive study is recommended when final construction plans will become available.

2. INTRODUCTION

Summerhaven Wind LP is developing a new 125 MW wind power generation farm, Summerhaven Wind Energy Centre, in Haldimand County, Nanticoke, Ontario. The developer is planning to build a new 230 kV transmission line to connect the wind power generation farm to the provincial grid. The proposed 230 kV line route given in Figure 3 indicates that for approximately 2 km the line will run parallel to a HCHI distribution line, on the same side of a road allowance. The latest 230-kV draft design provided by NextEra shows the offset between the transmission line structures and the HCHI distribution line as 3.4 m (see Figure 4).

HCHI was concerned about issues related to inductive coupling between the transmission line and distribution circuits. This inductive coupling is stronger for lines that are closer, with longer parallel runs, with larger voltage differences and larger currents. Considering the 230-kV draft design presented in Figure 4, the inductive coupling from the lowest 230-kV phase to the distribution line is stronger than from the highest phase. Even with the 230-kV currents well balanced, the result is a longitudinal potential induced in all distribution line conductors that may negatively impact the distribution line operation. The following negative consequences can be experienced on the distribution side due to this coupling:

- Difficulty in maintaining voltage levels on the distribution line or keeping unbalanced phase voltages below 1% (causing damage to customer motors).
- Failure of distribution line arresters by induced voltages during transmission line faults.
- Maintenance issues such as induced voltages and currents on the de-energized distribution line when the transmission line remains energized.

- Excessive voltages between the distribution phase conductors and the neutral may appear during transmission-line faults as well as the associated ground potential rise on customer service conductors.
- Stray voltage problems. The Ontario Energy Board since 2009 requires utilities to maintain the cow contact potentials in farm country below 0.5 V (which can be related back to induction to the neutral).

3. SCOPE

The scope of this study is to determine if the 230-kV transmission line draft design provided by NextEra on May 17th, 2011 is likely to create an induction problem on the Haldimand County Hydro distribution line that runs in parallel with the proposed transmission line and in very close proximity for about 2 km, and propose a mitigation plan if required.

Previous studies performed by Kinectrics show problems when the parallel exposure exceeds several kilometres for distribution neutrals located below 34-kV collection lines. These have much smaller phase spacings than the proposed 230-kV line, therefore a study specific for this case was required.

4. MODELLING METHODOLOGY AND RESULTS

Kinectrics has been modelling distribution neutrals for more than 25 years, as part of the grounding studies carried out for transformer stations. Distribution neutrals usually contribute significantly to station grounding because they fan out in several directions and are multi-grounded. The models are based on the driving point impedance seen looking into a system of cascaded π circuits. Carson earth return impedances [4] account for the longitudinal branches. Pole, transformer and customer grounds describe the shunt connections to earth. The models also account for inductive coupling between phase conductors and the neutral. This coupling tends to increase the split of current flowing back to the substation on the neutral.

Kinectrics developed a spreadsheet modelling tool capable of calculating the inductive coupling and determining the resulting potentials. This spreadsheet software has been validated against simulation software such as EMTP. The spreadsheet plots the potential along the feeder with rapid updates as parameters are changed. This spreadsheet modelling tool was used in this project to study the inductive coupling between the proposed Summerhaven 230 kV and the HCHI distribution line.

The induction calculations were performed considering the geometry given in the 230-kV transmission line draft design provided by NextEra, and the Haldimand County Hydro construction standard design for 27.6/16kV lines (see Appendix B). 125 MW transmitted power was considered.

4.1 Neutral to Earth Voltages

Kinectrics modelled the neutral to earth voltages considering 2 km length of parallel exposure. The calculated neutral potential along the feeder is given in Figure 1. Calculations were performed for two ground rod resistances (transformer and customer service ground) on the neutral at 100 m spacing: 37 Ω (see Figure 1 blue curve), and 75 Ω (see Figure 1 red curve). The plots show that the maximum induced voltage on the neutral is below 7 V. The Ontario Electrical Safety Code limits the neutral potential to 10 V [2], so the induction should not exceed this limit unless the existing neutral potential exceeds 3 V and happens to have the same phase angle. Smaller increases in neutral potential could still force HCHI to mitigate animal contact potentials in excess of 0.5 V at customer premises as required by the Ontario Distribution System Code [3].

Another set of calculations were performed considering 20 km length of parallel exposure, using same conductor geometry. The calculated neutral potential to remote earth remained below 7 V as shown in Figure 2.

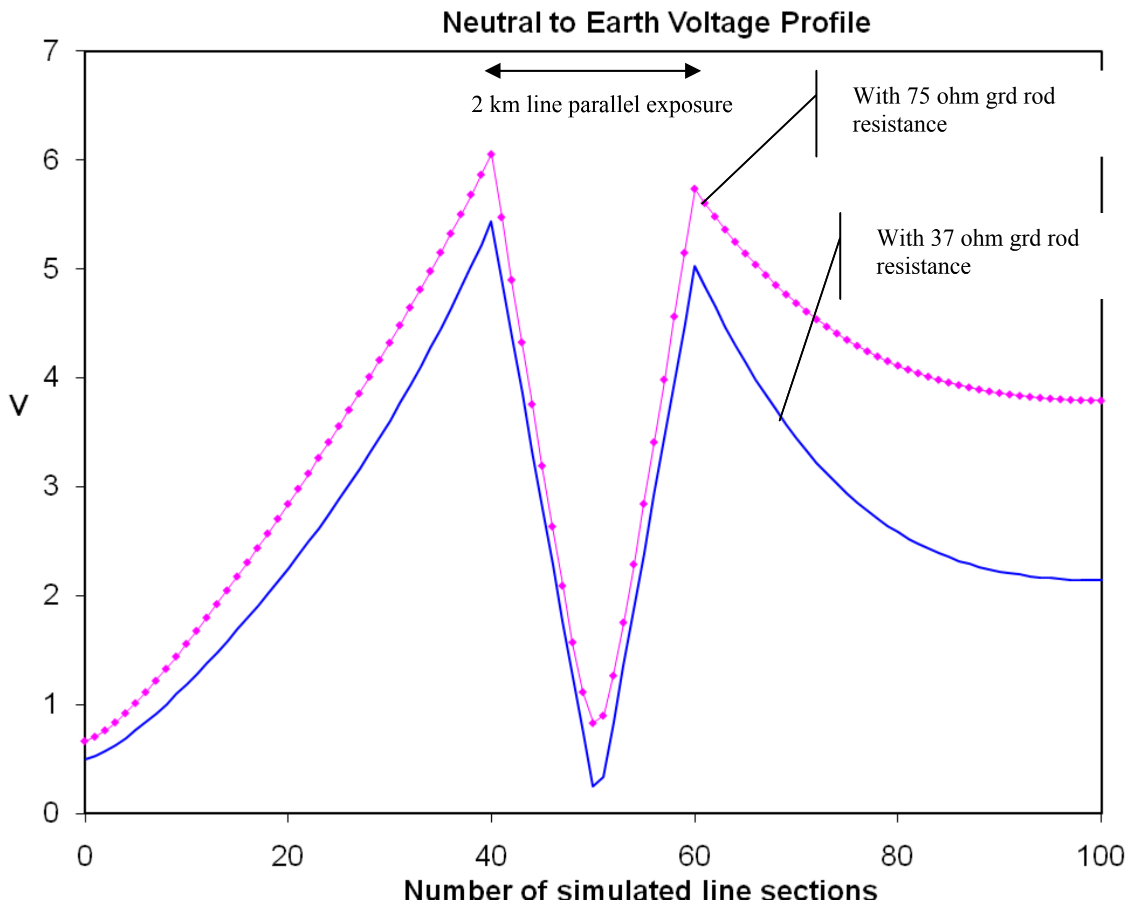


Figure 1 Calculated neutral potential along the distribution feeder considering 2 km length of parallel exposure (2km parallel exposure considered between ground span no. 40 and 60 on x-axis).

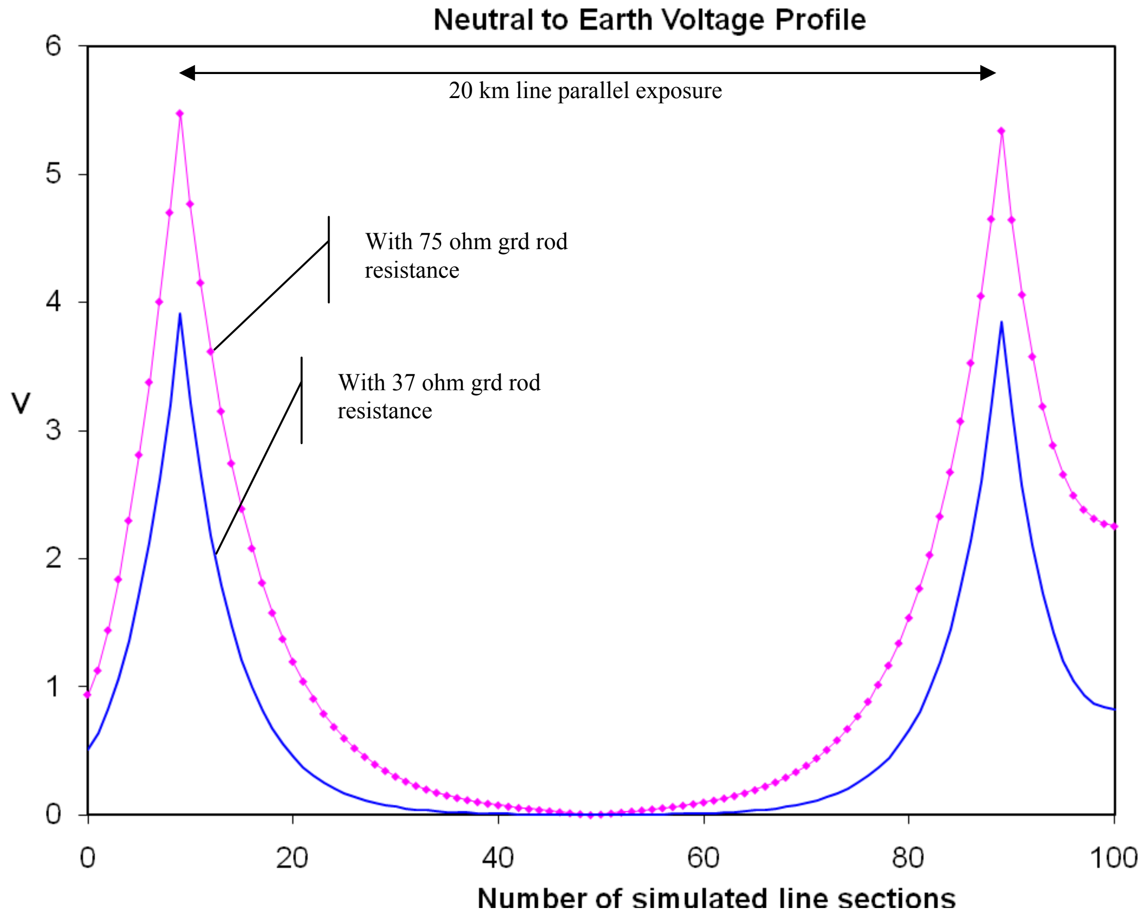


Figure 2 Calculated neutral potential along the distribution feeder considering 20 km length of parallel exposure (20km parallel exposure considered between ground span no. 9 and 89 on x-axis).

4.2 Voltage Unbalance

Kinectrics studied the unbalance in voltages on the distribution phases downstream of 2 km of exposure. The calculation method was implemented in Excel. Details are provided in Appendix C. The calculated unbalance is very small, with the maximum deviation from the average line to line voltage about 0.01 % for any of the configurations studied. This is below the 1% limit [1]. This analysis neglects the effect of the neutral and the overhead ground wire, which should be small.

Calculations of the induced voltage into distribution phases during a transmission line fault were also performed. The maximum calculated longitudinal voltage induced in the distribution phases was 46 kV when a 63 kA fault on the lowest transmission line phase was considered. To limit these fault induced overvoltages, the protection of distribution equipment may require the installation of surge arresters properly rated for the expected duty on distribution phases at each end of the parallel exposure.

5. REFERENCES

[1] http://www.hydroone.com/Generators/Pages/TechnicalRequirements.aspx - Voltage and Current Unbalance, Page 68.

[2] Ontario Electrical Safety Code: Rule 75-412 (3).

[3] Ontario Energy Board, Distribution System Code, 2009.

[4] A. Deri et al. ,"The complex ground return plane a simplified model for homogenous and multi-layer earth return", IEEE Trans. on PAS, Vol. PAS-100, No. 8, August 1981.

APPENDIX A: PROPOSED 230KV TRANSMISSION LINE ROW AND DRAFT DESIGN

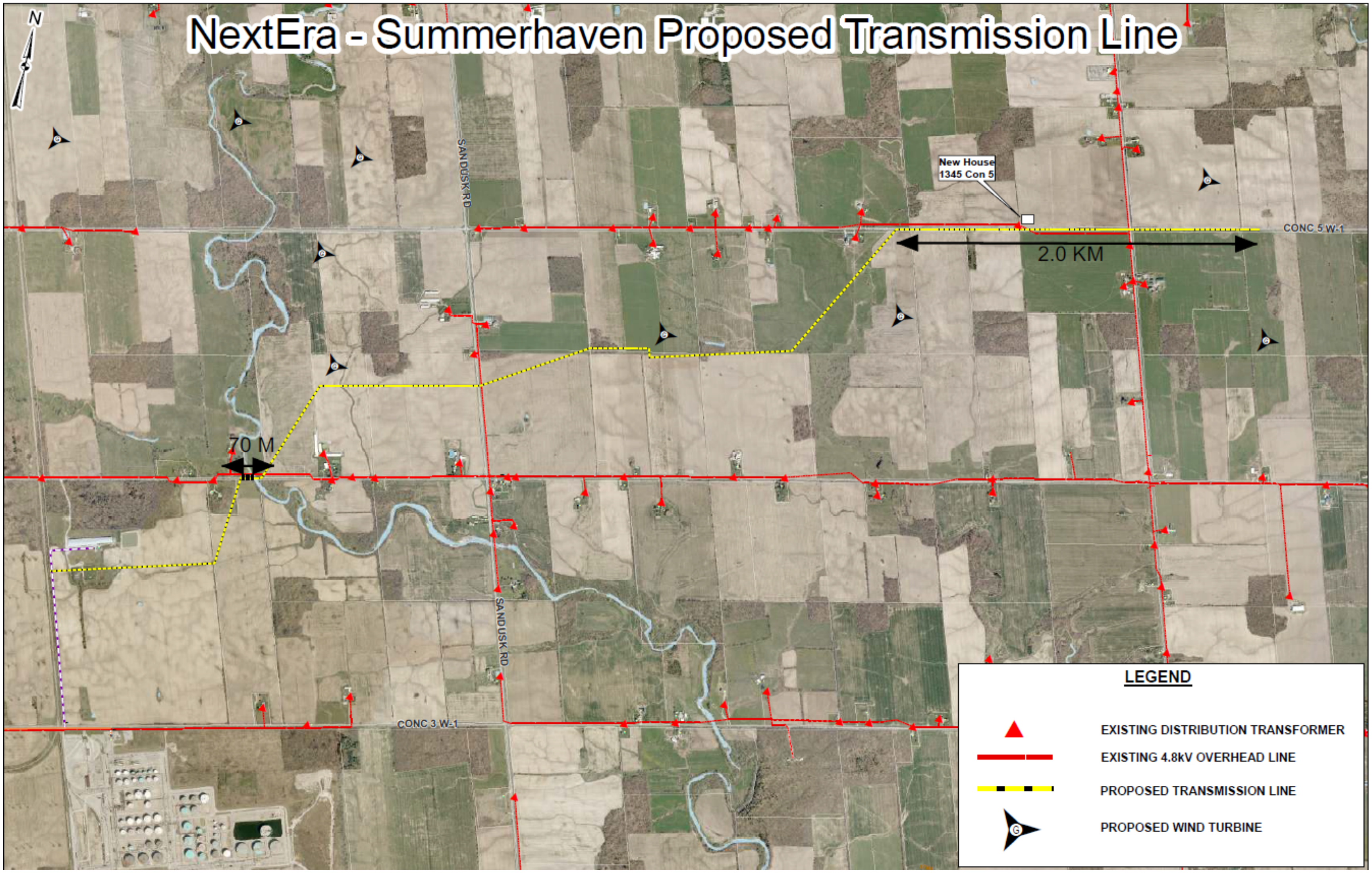


Figure 3 Proposed 230kV transmission line ROW.

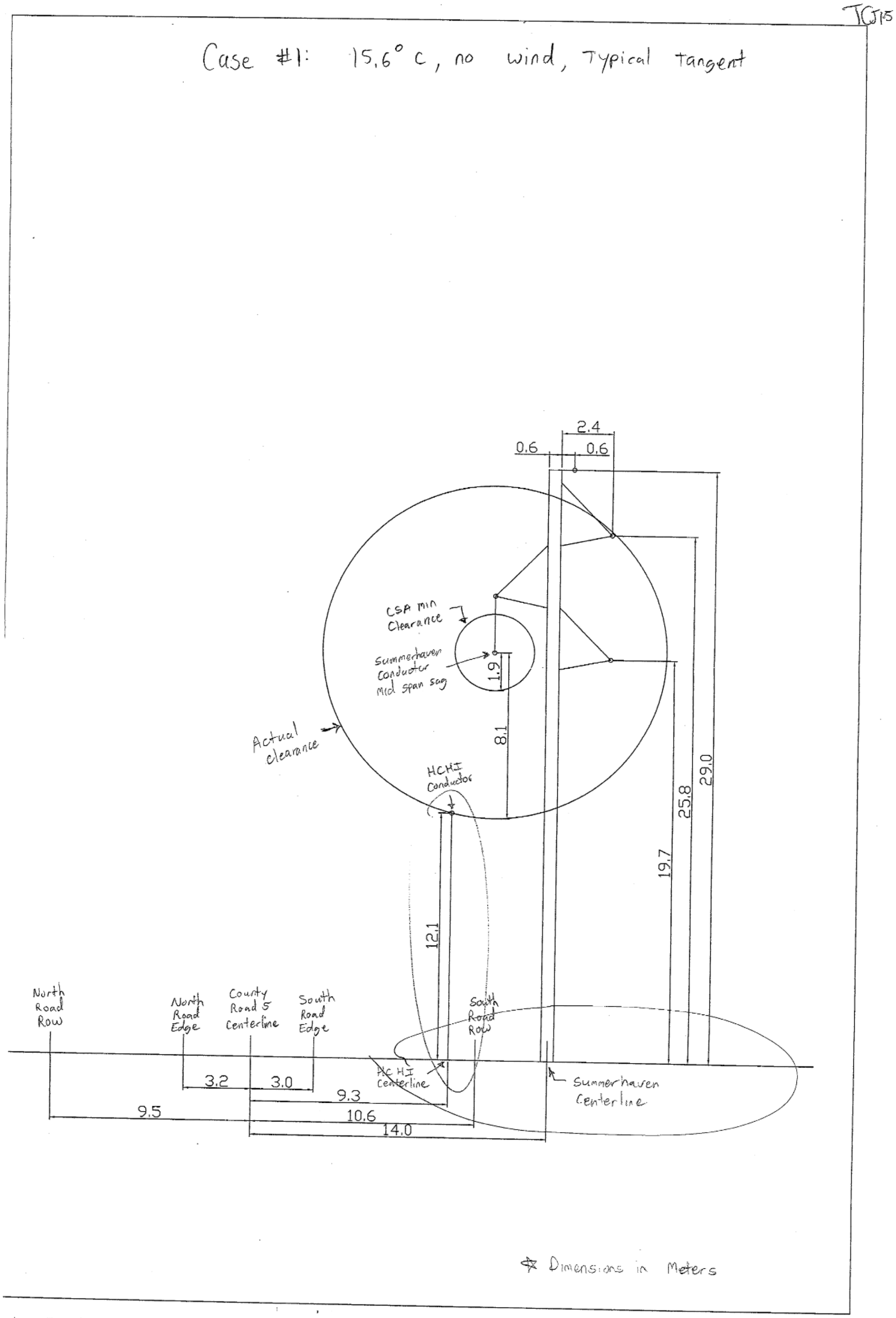
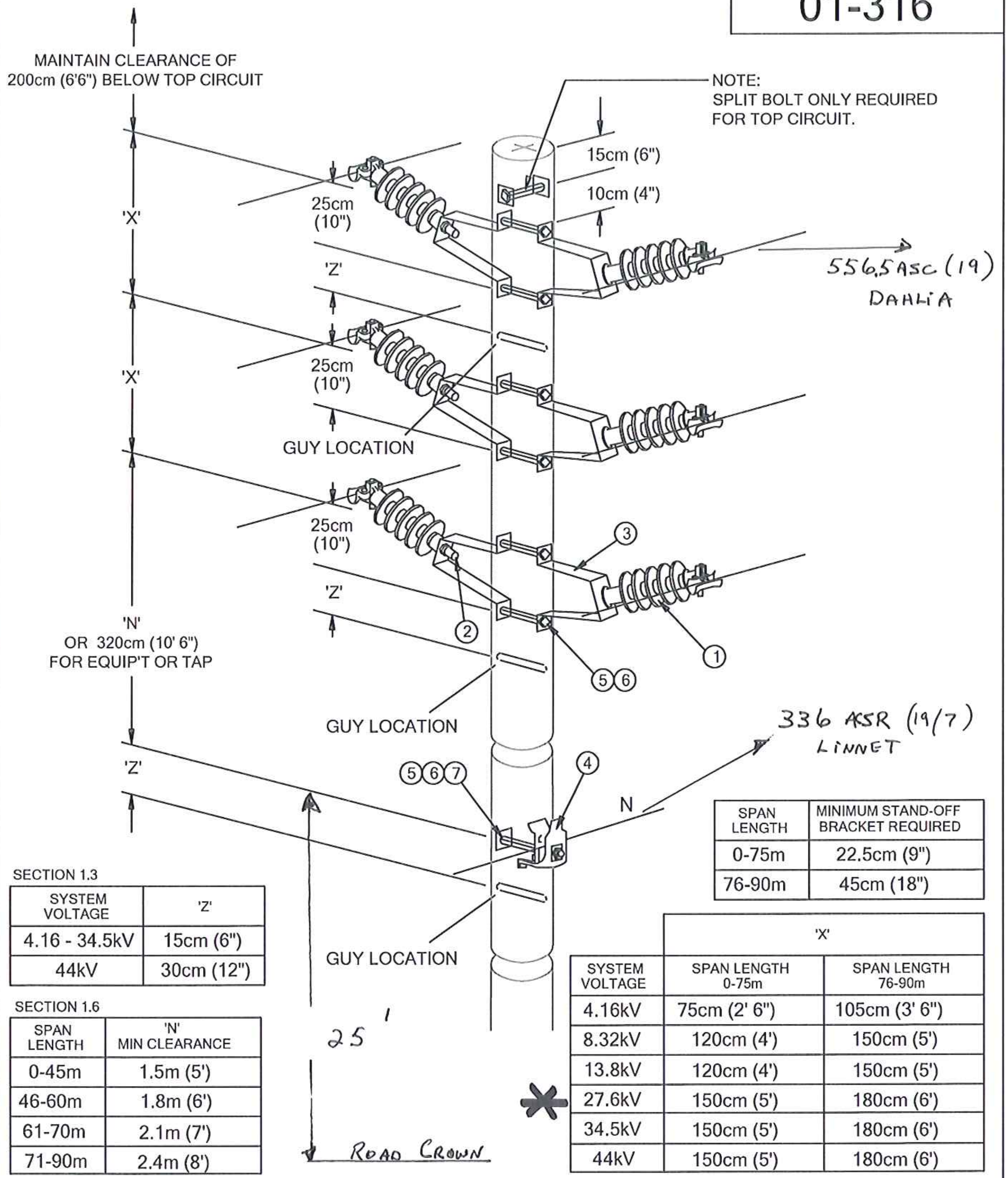


Figure 4 Proposed 230 kV transmission line draft design and distances to HCHI distribution line (all dimensions in meters).

APPENDIX B: HALDIMAND COUNTY HYDRO CONSTRUCTION STANDARD DESIGN FOR 27.6/16KV LINES

01-316



SECTION 1.3

SYSTEM VOLTAGE	'Z'
4.16 - 34.5kV	15cm (6")
44kV	30cm (12")

SECTION 1.6

SPAN LENGTH	'N' MIN CLEARANCE
0-45m	1.5m (5')
46-60m	1.8m (6')
61-70m	2.1m (7')
71-90m	2.4m (8')

SPAN LENGTH	MINIMUM STAND-OFF BRACKET REQUIRED
0-75m	22.5cm (9")
76-90m	45cm (18")

	'X'	
SYSTEM VOLTAGE	SPAN LENGTH 0-75m	SPAN LENGTH 76-90m
4.16kV	75cm (2' 6")	105cm (3' 6")
8.32kV	120cm (4')	150cm (5')
13.8kV	120cm (4')	150cm (5')
* 27.6kV	150cm (5')	180cm (6')
34.5kV	150cm (5')	180cm (6')
44kV	150cm (5')	180cm (6')

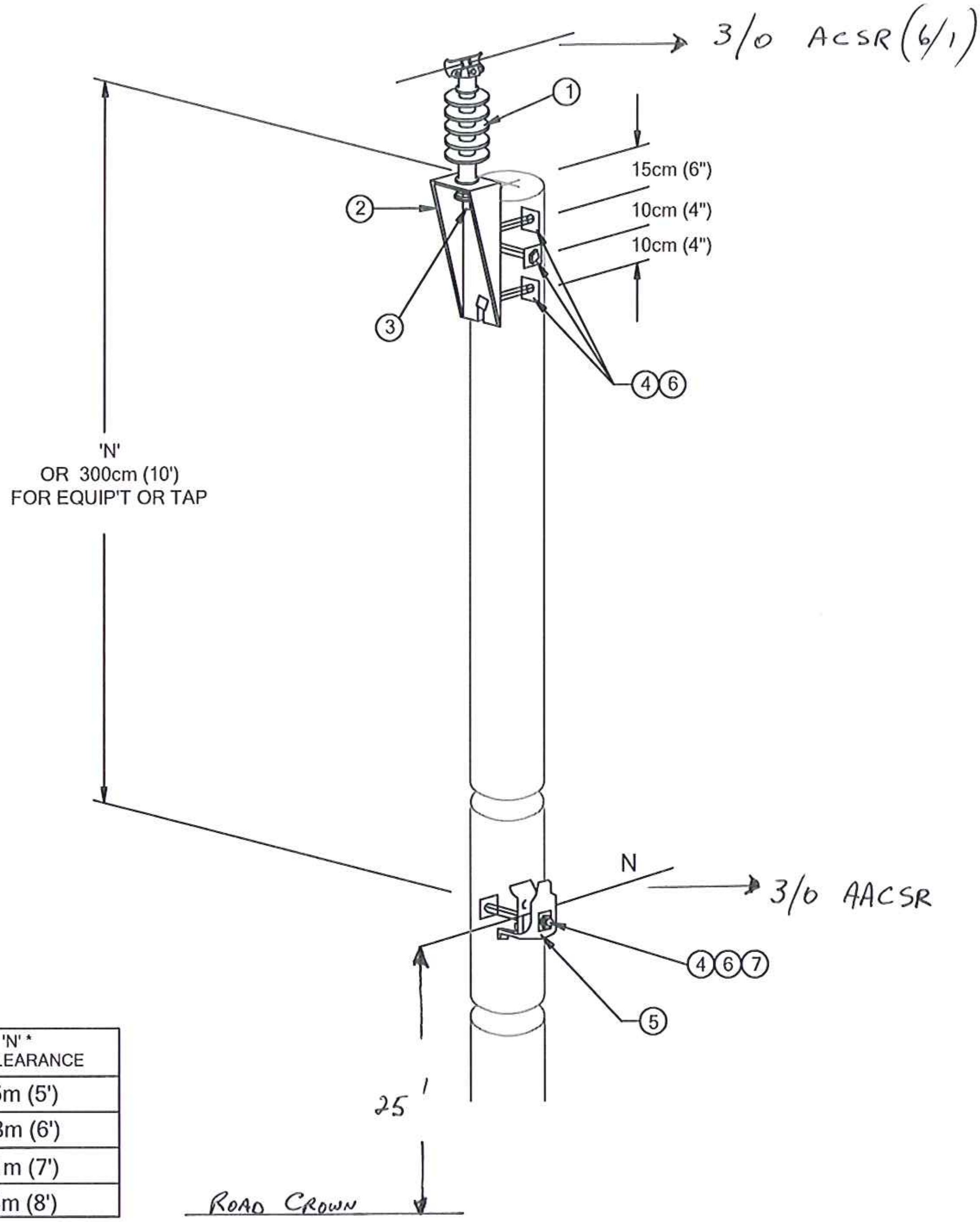
Utilities Standards Forum
USF

Title: PRIMARY 3-PHASE 2-CCT, TANGENT or LINE ANGLE 0° to 15° or UNDER-BUILT 4.16 to 44kV, MAX SPAN 90m

SIZE	FILE NAME:	DWG NO.	REV
A	01-316.DWG	01-316	3

SCALE	DATE:	SHEET
NTS	2008-07-14	1

01-100



SECTION 1.6

SPAN LENGTH	'N' * MIN CLEARANCE
0-45m	1.5m (5')
46-60m	1.8m (6')
61-70m	2.1m (7')
71-90m	2.4m (8')

Utilities Standards Forum
USF

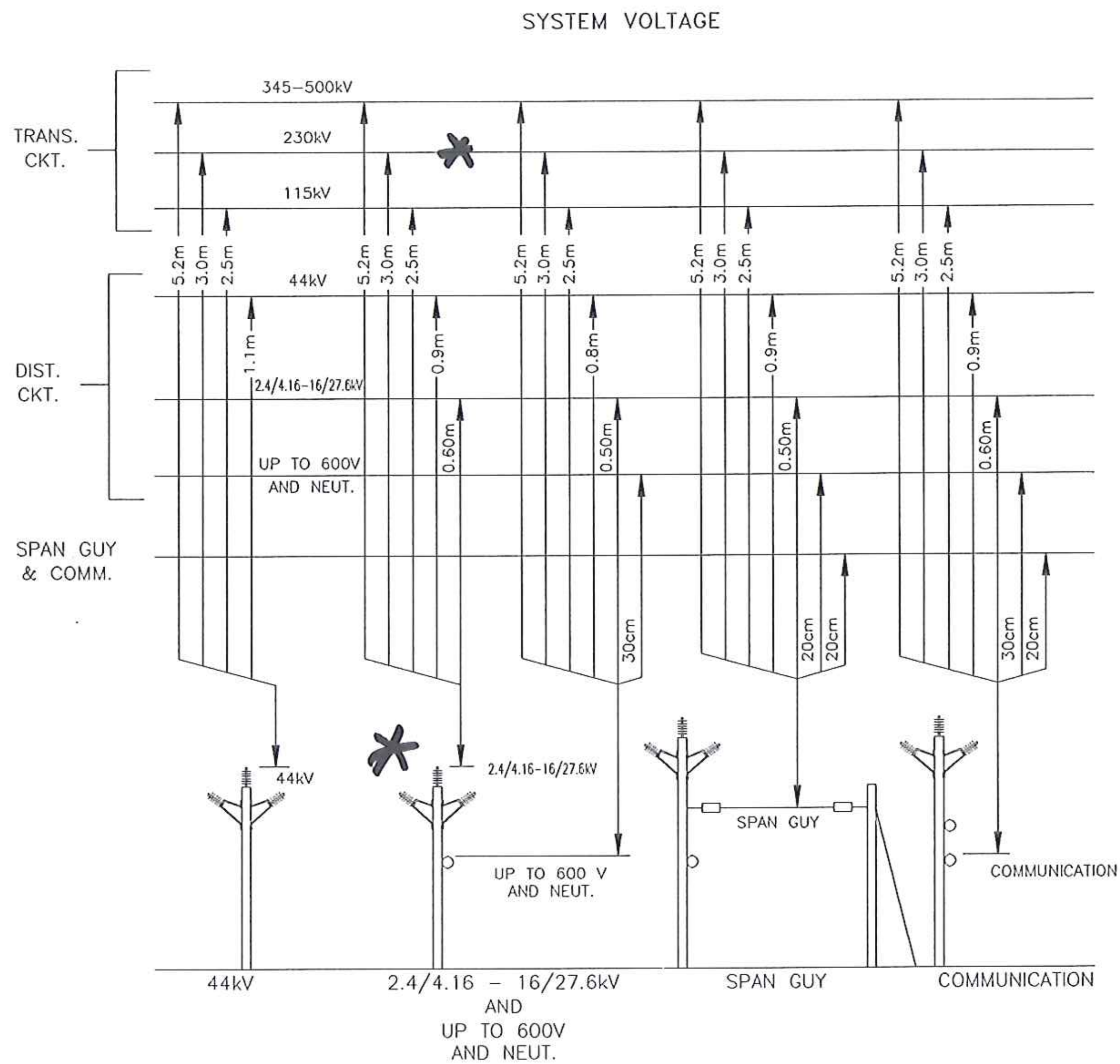
Title: PRIMARY 1-PHASE TANGENT
2.4 to 20kV, MAX SPAN 90m

SIZE	FILE NAME:	DWG NO.	REV
A	01-100.DWG	01-100	0

SCALE	DATE:	SHEET
NTS	2006-06-26	1

MINIMUM VERTICAL CLEARANCES BETWEEN WIRES OR CONDUCTORS CROSSINGS IN-SPAN

DL6-102



NOTE:

ALL VERTICAL CLEARANCES APPLY WITH THE UPPER CONDUCTOR AT MAXIMUM SAG AND THE LOWER CONDUCTOR ASSUMED TO FORM A STRAIGHT LINE BETWEEN ITS POINT OF SUPPORT

CONVERSION TABLE	
METRIC	IMPERIAL (APPROX)
20cm	8"
30cm	1'-0"
0.50m	1'-3"
0.60m	2'-0"
0.80m	2'-8"
0.90m	3'-0"
1.10m	3'-7"
2.5m	8'-2"
3.0m	10'-0"
5.2m	17'-0"

APPENDIX C: VOLTAGE UNBALANCE DETAILED CALCULATIONS

HCHI Induction on Phases

closer 27.6 kV line

length(km)	rho	Vdist(kV)	Vhv(kV)	P(MW)
2	100	27.6	230	125

distribution phase positions

	a	b	c
x(m)	-3.9	-3.9	-3.9
y (m)	13.6	12.1	10.6

distribution - substation end of exposure

	Va	Vb	Vc
mag	15.93	15.93	15.93
pha	0	-120	-240
cmplx	.93486742963337148168337148168		

as sequence components

V1	V2	V0
15.93	0.00	0.00
0.0	0.0	0.0
37+2.96059084111342626167013		

230 kV phase postions

	x(m)	y(m)
A	2.7	24
B	-2.7	21
C	2.7	17.9

matrix of separation distances (m)

a	b	c
12.3	13.6	14.9
7.5	9.0	10.5
7.9	8.8	9.8

	I mag	I pha	cmplx
A	313.8	0	3.7773202117
B	313.8	-120	.05877-271.73
C	313.8	-240	05877+271.73

matrix of induced V in phases

			mag			pha		
49869+0.204849869+0.199869+0.19			0.207363	0.202727	0.198392	79.7	79.5	79.2
38364-0.14570311-0.14153985-0.137			0.23052	0.222089	0.214937	-39.2	-39.6	-39.9
96117-0.08069579-0.07792079-0.075			0.228207	0.223109	0.21782	-159.3	-159.6	-159.8

distribution - remote end of exposure

	Va	Vb	Vc
cmplx	2609-0.0223523111-13.820721995+13.78		
mag	15.94	15.95	15.92
pha	-0.1	-120.0	120.0

as sequence components

V1	V2	V0	V2 (%)	V0 (%)	Vab	Vbc	Vca	Vavg	NEMA (%)
5883-0.000532976-0.00120237-0.02									
15.94	0.0017	0.02	0.0104	0.1272	27.60146	27.6019	27.60597	27.60311	0.0104
0.0	-65.1	-91.3							

63 kA fault on lowest HV conductor, longitudinal V induced (kV)

	Va	Vb	Vc
mag	45.8	44.8	43.7

more distant 27.6 kV line

dist (km)	rho	Vdist(kV)	Vhv(kV)	P(MW)
2	100	27.6	230	125

distribution phase positions

	a	b	c
x(m)	-5.5	-5.5	-5.5
y (m)	13.6	12.1	10.6

distribution - substation end of exposure

	Va	Vb	Vc
mag	15.93	15.93	15.93
pha	0	-120	-240
cmplx	.93486742963337148168337148168		

as sequence components

V1	V2	V0
15.93	0.00	0.00
0.0	0.0	0.0
37+2.96059084111342626167013		

230 kV phase postions

	x(m)	y(m)
A	2.7	24
B	-2.7	21
C	2.7	17.9

matrix of separation distances (m)

a	b	c
13.2	14.5	15.7
7.9	9.3	10.8
9.3	10.0	11.0

	I mag	I pha	cmplx
A	313.8	100	79838+309.0
B	313.8	-20	72962-107.31
C	313.8	-140	524978-201.69

matrix of induced V in phases

			mag			pha		
4126+0.00161258+0.0023531+0.003			0.203988	0.199928	0.196048	179.5	179.3	179.1
55021+0.19843556+0.1918753+0.185			0.228001	0.220308	0.213615	60.7	60.3	60.0
12265-0.19009455-0.18746473-0.184			0.220664	0.21687	0.212722	-59.7	-59.8	-60.0

distribution - remote end of exposure

	Va	Vb	Vc
cmplx	469+0.0099372508-13.79342415+13.80		
mag	15.95	15.92	15.93
pha	0.0	-120.0	119.9

as sequence components

V1	V2	V0	V2 (%)	V0 (%)	Vab	Vbc	Vca	Vavg	NEMA (%)
834+0.0019090359+0.001567+0.006									
15.93	0.002	0.02	0.0114	0.1212	27.60276	27.59753	27.59885	27.59971	0.0110
0.0	45.9	20.2							

63 kA fault on lowest HV conductor, longitudinal V induced (kV)

	Va	Vb	Vc
mag	44.3	43.5	42.7

old 8 kV line

dist (km)	rho	Vdist(kV)	Vhv(kV)	P(MW)
2	100	8.32	230	125

distribution phase positions

	a	b	c
x(m)	-5.5	-4.7	-3.9
y (m)	11	11.4	11

distribution - substation end of exposure

	Va	Vb	Vc
mag	4.80	4.80	4.80
pha	0	-120	-240
cmplx	303554239657771198288771198288		

as sequence components

V1	V2	V0
4.80	0.00	0.00
0.0	-87.4	0.0
77+2.96059E-16-3.256297366166		

230 kV phase postions

	x(m)	y(m)
A	2.7	24
B	-2.7	21
C	2.7	17.9

matrix of separation distances (m)

a	b	c
15.4	14.6	14.6
10.4	9.8	10.1
10.7	9.8	9.5

	I mag	I pha	cmplx
A	313.8	100	79838+309.0
B	313.8	-20	72962-107.31
C	313.8	-140	524978-201.69

matrix of induced V in phases

			mag			pha		
3352+0.00284249+0.0024289+0.0024			0.197064	0.199414	0.199519	179.2	179.3	179.3
93096+0.18617425+0.18926816+0.188			0.215315	0.217987	0.216741	60.1	60.2	60.2
2695-0.1851018395-0.18850618-0.189			0.213847	0.217782	0.219229	-60.0	-59.8	-59.7

distribution - remote end of exposure

	Va	Vb	Vc
cmplx	938+0.00430378727-4.15678431+4.161		

as sequence components

V1	V2	V0	V2 (%)	V0 (%)	Vab	Vbc	Vca	Vavg	NEMA (%)
35+0.0005873182+0.0008998+0.002									

mag	4.82	4.79	4.80	4.80	0.001	0.02	0.0176	0.3842	8.319477	8.317668	8.317033	8.318059	0.0170
pha	0.1	-119.8	119.8	0.0	74.5	9.3							

63 kA fault on lowest HV conductor, longitudinal V induced (kV)

	Va	Vb	Vc
mag	42.9	43.7	44.0

closer 27.6 kV line, reversed phasing

length(km)	rho	Vdist(kV)	Vhv(kV)	P(MW)
2	100	27.6	230	125

distribution phase positions

	a	b	c
x(m)	-3.9	-3.9	-3.9
y (m)	10.6	12.1	13.6

distribution - substation end of exposure

	Va	Vb	Vc
mag	15.93	15.93	15.93
pha	0	-120	-240
cmplx	.93486742963	33714816	8337148168

as sequence components

V1	V2	V0
15.93	0.00	0.00
0.0	0.0	0.0
37+2.96059	08411134	2626167013

230 kV phase postions

	x(m)	y(m)
A	2.7	24
B	-2.7	21
C	2.7	17.9

matrix of separation distances (m)

a	b	c
14.9	13.6	12.3
10.5	9.0	7.5
9.8	8.8	7.9

	I mag	I pha	cmplx
A	313.8	0	3.7773202117
B	313.8	-120	.05877-271.73
C	313.8	-240	05877+271.7

matrix of induced V in phases

49869+0.194	849869+0.199	9869+0.20
33985-0.1379	70311-0.1415	8364-0.145
72079-0.0752	69579-0.0779	6117-0.080

mag

0.198392	0.202727	0.207363
0.214937	0.222089	0.23052
0.21782	0.223109	0.228207

pha

79.2	79.5	79.7
-39.9	-39.6	-39.2
-159.8	-159.6	-159.3

distribution - remote end of exposure

	Va	Vb	Vc
cmplx	2306-0.0182	523111-13.820	18961+13.77
mag	15.93	15.95	15.91
pha	-0.1	-120.0	120.0

as sequence components

V1	V2	V0	V2 (%)	V0 (%)	Vab	Vbc	Vca	Vavg	NEMA (%)
418+0.00014	456723+0.001	706913-0.02							
15.93	0.0019	0.02	0.0118	0.1272	27.59953	27.59786	27.59403	27.59714	0.0113
0.0	102.7	-91.3							

63 kA fault on lowest HV conductor, longitudinal V induced (kV)

	Va	Vb	Vc
mag	43.7	44.8	45.8