Attachment B: Electric and Magnetic Field Study

POWER ENGINEERS, INC.

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MEMORANDUM

DATE: March 7, 2014

TO: Andrew S. Degon
Director, Engineering and Construction
Advanced Power
31 Milk Street, Suite 1001
Boston, MA 02109

C: Steve Walker (POWER-FRE), Jon Ferguson (POWER-FTW)
Tyler Kent (POWER-SYR), DMS SR-06/133424.001.001

FROM: Andrea Wood

SUBJECT: 140203 Advanced Power – Carroll County Energy 345 kV Preliminary EMF Study, Rev. B

MESSAGE

Dear Mr. Degon,

This memorandum provides the predicted electric and magnetic field (EMF) effects for the Advanced Power Carroll County Energy proposed 345 kV double circuit transmission line. In addition, it also provides the predicted EMF effects of the existing AEP Tidd-Canton Central 345 kV single transmission line for comparison.

POWER's engineering service for this study was to analyze the electric and magnetic fields for the proposed structure using a two conductor bundle 954 Rail ACSR conductor and for the existing structure using a two conductor bundle of 954 Cardinal ACSR conductor. The field calculations were performed at mid-span with a minimum clearance of 28 feet. The study was performed using version 3.0 of the Bonneville Power Administration's Corona and Field Effects Program.

Proposed 345 kV Double Circuit Line

A study was performed on the proposed conductor to estimate electric and magnetic fields at one meter above ground level for standard 345 kV single pole double circuit steel tangent structures with loading of 3,000 amps per phase and an operating voltage of 105% of nominal (see structure drawing in Appendix A). In order to produce conservative results the phase configuration of both circuits were assumed to be A phase on the top, B phase in the middle, C phase on the bottom.

The field results are summarized in Table 1 compared against the maximum permissible exposure (MPE) limit of IEEE C95.6-2002. Plots of the results throughout the Right-of-Way can be found in Figure 1 and Figure 2.

Table 1: Maximum Calculated EMF Levels on the Edge of ROW and within the ROW of the proposed double circuit line

Effect:	IEEE MPE Limit for General Public Edge of ROW	Calculated Value Edge of ROW	IEEE MPE Limit for General Public within ROW	Maximum Calculated Value Within ROW
Electric Fields (kV/m)	5.0 kV/m	0.158 kV/m	10.0 kV/m	8.8 kV/m
Magnetic Fields (mG)	9,040 mG	218.9 mG	9,040 mG	586.2 mG

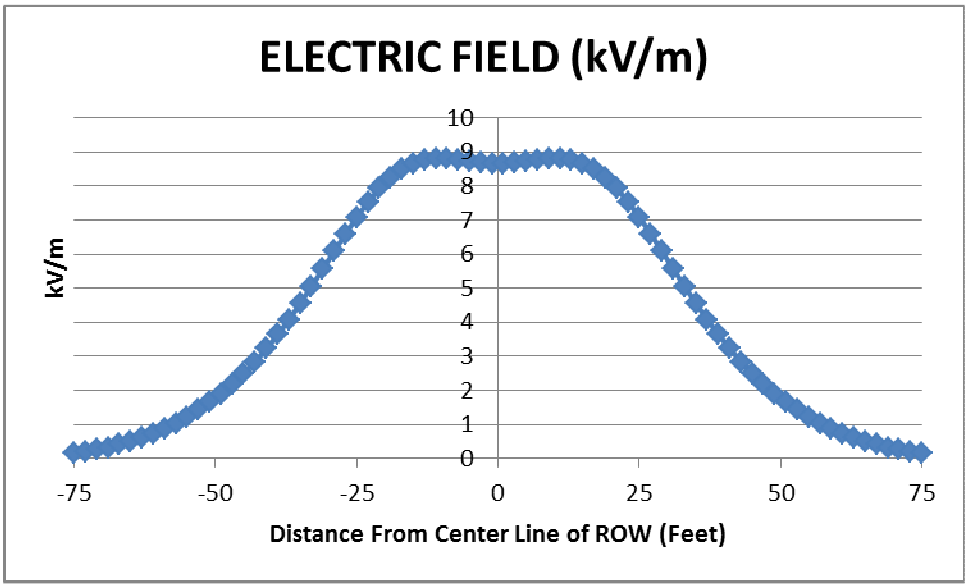


Figure 1: Electric Field within the ROW (Proposed 345 kV line)

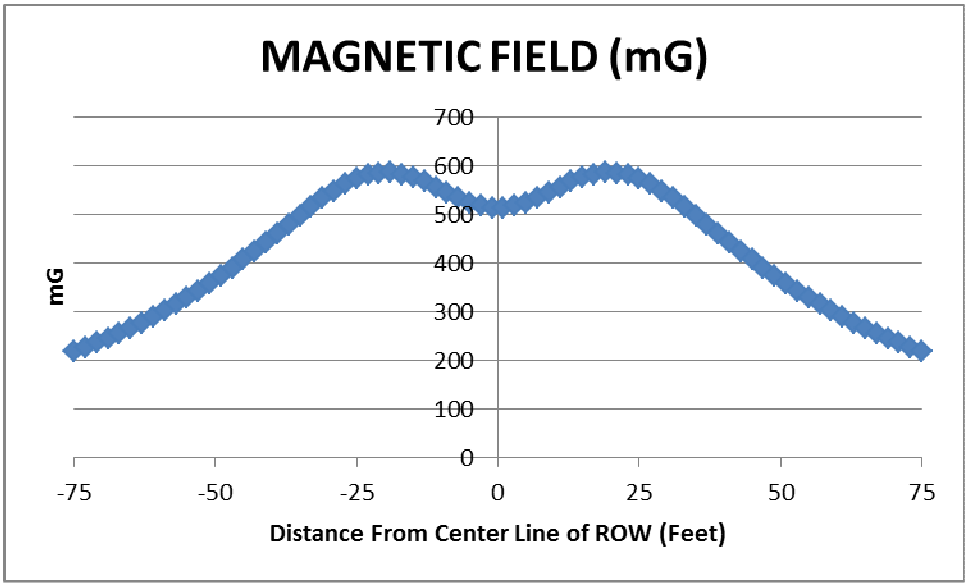


Figure 2: Magnetic Field within the ROW (Proposed 345 kV line)

Existing AEP 345 kV Single Circuit Line

A comparison study was performed on the existing electric and magnetic fields at one meter above ground level for the standard 345 kV single pole single circuit steel horizontal structures with a maximum summer emergency loading of 2,675 amps and an operating voltage of 105% of nominal (see structure drawing in Appendix B).

The field effects results are summarized in Table 2 compared against the maximum permissible exposure (MPE) limit of IEEE C95.6-2002. Plots of the results throughout the Right-of-Way can be found in Figure 3 and Figure 4.

Table 2: Maximum Calculated EMF Levels on the Edge-of-ROW and within the ROW of the existing AEP single circuit line

Effect:	IEEE MPE Limit for General Public Edge of ROW	Calculated Value Edge of ROW	IEEE MPE Limit for General Public within ROW	Maximum Calculated Value Edge of ROW
Electric Fields (kV/m)	5.0 kV/m	2.3 kV/m	10.0 kV/m	7.6 kV/m
Magnetic Fields (mG)	9,040 mG	202.4 mG	9,040 mG	670.1 mG

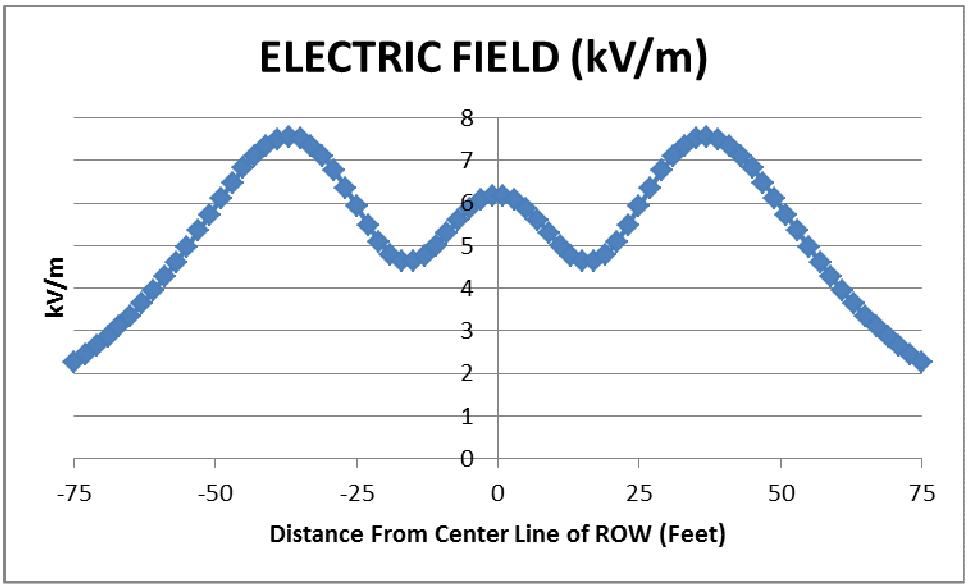


Figure 3: Electric Field within the ROW (Existing 345 kV line)

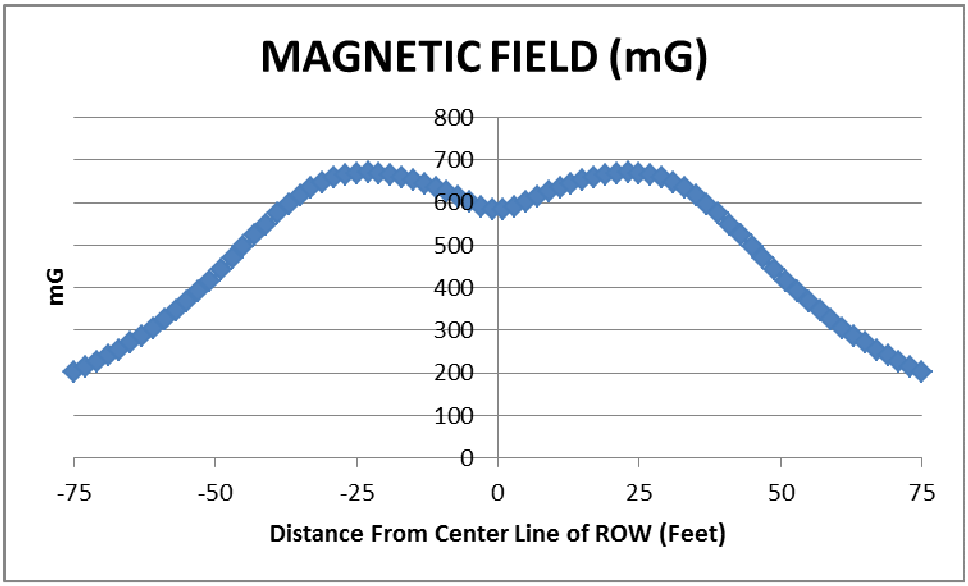


Figure 4: Magnetic Field within the ROW (Existing 345 kV line)

Conclusion

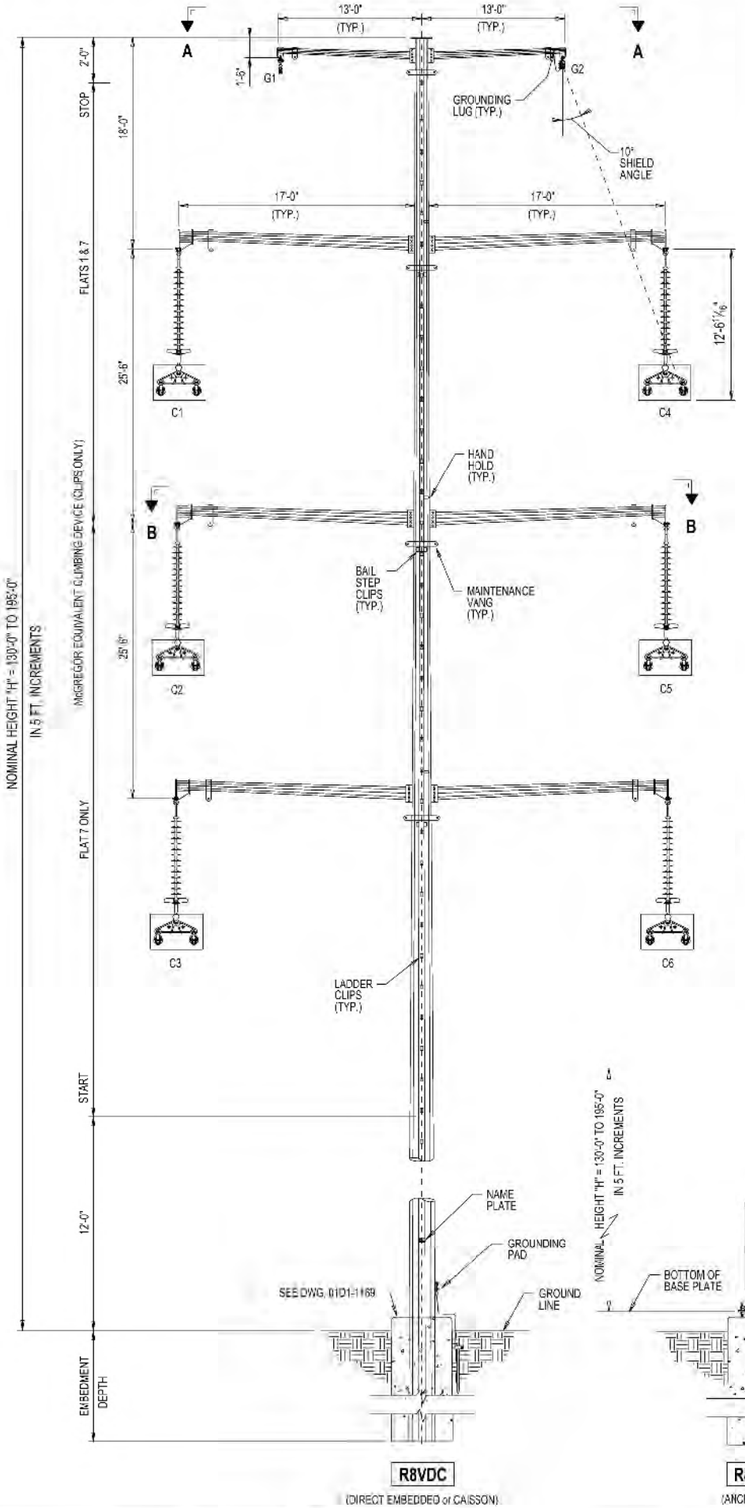
It was found for the two conductor bundle 954 Rail ACSR conductor the predicted electric and magnetic fields levels are below the IEEE Standard C95.6-2002 maximum permissible exposure limits for the general public within and at the edge-of-ROW. In addition, the maximum predicted values are also found to be similar to the existing 345 kV line conditions. To accomplish the cut-in of the existing line, the existing horizontal configuration transforms to a vertical configuration at the dead-end cut-in structures. Since, for the same ampacity and lowest conductor height above ground, a vertical line configuration along the ROW centerline will have a lower magnetic field when measured at one meter above ground at the edge of the ROW than a horizontal configuration, it is reasonable to state that the magnetic field one meter above ground at the edge of the ROW is lowered as the line transitions from horizontal to vertical than it is within the existing (current) horizontal spans. The results presented in this memorandum should be re-verified if the structure geometries, minimum line clearance or loading conditions are modified.

Thank you,

Andrea D Wood

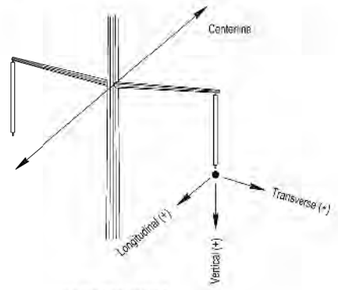
Andrea Wood

APPENDIX A – STRUCTURE DRAWING PROPOSED DOUBLE CIRCUIT 345 KV LINE

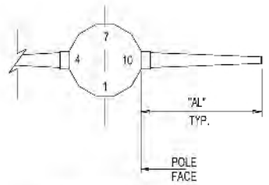


CROSS ARM INFORMATION				
ARM	LENGTH "AL" (FT)	RISE "AR" (FT)	WIRE ATTACHMENT	POLE STANDARD DETAIL
G1, G2	13'-0"	TBD	G.W. ATTACHMENT DETAIL	01D5-1216 - SHT.2
C1 THRU C6	17'-0"	TBD	CONDUCTOR ATTACHMENT DETAIL	01D5-1216 - SHT. 1

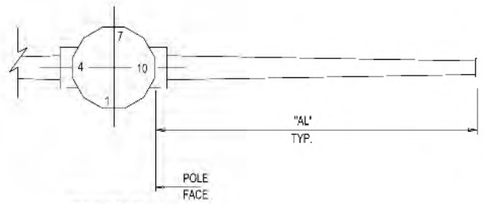
"TBD" - to be determined by Vendor



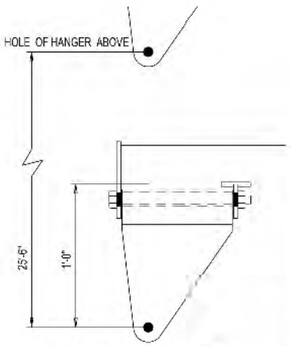
LOAD DIAGRAM



SECTION "A-A"
GROUNDWIRE ARM



SECTION "B-B"
TRANSMISSION ARM



1'-0" FLEXIBLE HANGER

CONDUCTOR CLEARANCE INFORMATION			
INSULATOR LENGTH: "IL"=	13'-6 7/16"	LIMITING SIDESWING ANGLES	
		FIXED α	ACTIVE β
FLEXIBLE HANGER LENGTH "HL"=	1'-0"	18.0°	45.0°
CLEARANCE REQ'D. TO ARM & STRUCTURE=		8'-0"	6'-9"
NOTE: REFER TO DRAWING 01D5-1216-SHT. 1			

NOTES:

1) This structure is intended to be used for a line angle range of 0° to 2°. This range may or may not be valid and will depend on sidewing clearance checks where influencing factors include wind span, weight span, and line angle.

2) The blank sidewing for this structure has been verified for an 1100' ganloping check. The design engineer will need to recheck galloping if a span greater than 1100' is used.

3) Refer to drawing 802-1268-SH. 9 or 21 for structure clearances.

HEAVY SUSPENSION STRUCTURE: R8VDC

ULTIMATE LOAD (KIPS)

NO.	DESCRIPTION	WIND (PSF)	ICE (IN.)		G1	G2	C1	C2	C3	C4	C5	C6	STRUCTURE WIND PRESSURE (PSF)	ALLOWABLE DEFLECTION CRITERIA (% OF POLE HEIGHT)
1	**INTACT** NESC HEAVY 0° F Includes OLF	4.0	0.50	V	3.29	3.29	11.59	11.59	11.59	11.59	11.59	11.59	10	10
				T	2.39	2.39	6.49	6.49	6.49	6.49	6.49	6.49		
				L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
2	**INTACT** NESC MEDIUM 15° F Includes OLF	4.0	0.25	V	2.20	2.20	8.54	8.54	8.54	8.54	8.54	8.54	10	10
				T	1.68	1.68	5.02	5.02	5.02	5.02	5.02	5.02		
				L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3	**INTACT** HIGH WIND 60° F	28.0	NONE	V	1.01	1.01	4.21	4.21	4.21	4.21	4.21	4.21	37	10
				T	2.31	2.31	8.65	8.65	8.65	8.65	8.65	8.65		
				L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
4	**INTACT** WIND & ICE 0° F	6.25	1.0	V	4.45	4.45	13.38	13.38	13.38	13.38	13.38	13.38	10	10
				T	2.35	2.35	5.80	5.80	5.80	5.80	5.80	5.80		
				L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
5	**INTACT** HEAVY ICE 60° F	NONE	1.25	V	5.96	5.96	16.98	16.98	16.98	16.98	16.98	16.98	0	10
				T	0.48	0.48	1.27	1.27	1.27	1.27	1.27	1.27		
				L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
6	**BROKEN GW** 0° F ANY ONE WIRE	12.25	NONE	V	1.01	1.01	4.21	4.21	4.21	4.21	4.21	4.21	17	10
				T	0.55	1.11	4.00	4.00	4.00	4.00	4.00	4.00		
				L	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
7	**BROKEN BUNDLED COND.** 60° F	NONE	NONE	V	1.01	1.01	4.21	4.21	4.21	4.21	4.21	4.21	0	10
				T	0.11	0.11	0.20	0.39	0.39	0.39	0.39	0.39		
				L	0.00	0.00	8.88	0.00	0.00	0.00	0.00	0.00		
8	**UNBALANCED ICE WITH WIND** ONE SPAN BARE OTHER ICE 0° F	6.25	0.5/NONE	V	1.81	1.81	5.98	5.98	5.98	5.98	5.98	5.98	10	10
				T	1.04	1.04	3.11	3.11	3.11	3.11	3.11	3.11		
				L	1.00	1.00	4.88	4.88	4.88	4.88	4.88	4.88		
9	**DEFLECTION** 60° F	1.0	NONE	V	1.01	1.01	4.21	4.21	4.21	4.21	4.21	4.21	2.0	1.5
				T	0.19	0.19	0.67	0.67	0.67	0.67	0.67	0.67		
				L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
10				V	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
				T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
				L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

	WIRE		NESC HEAVY TENSION (LBS)	NESC MEDIUM TENSION (LBS)	RULING SPAN (FT)	VERTICAL SPAN (FT)	WIND SPAN (FT)	LINE ANGLE
G	OPGW - 0.646 Dia. Wt = 0.578	AHEAD	8070 PER WIRE	5950 PER WIRE	1100	1680	1400	0° 2°
C	2 - 954,000 ACSR, 54/7 Cardinal	AHEAD	11900 PER WIRE	9250 PER WIRE	1100	1680	1400	0° 2°

POLE ATTACHMENTS FURNISHED BY VENDOR				
ITEM	POLE STANDARD DETAIL	LOCATION	REFERENCE POINT	ORIENTATION
POLE CAP	01D0-1158 (DETAIL 'A')	0.0'	TOP OF POLE	AS NOTED
HAND HOLD (TOP)	01D0-1158	0.0'	TOP OF POLE	FLATS 6, 12
HAND HOLD (OTHER)	01D0-1158	2.0'	ABOVE & OF CROSSARM BRACKET	FLATS 6, 12
BAIL STEPS	01D0-1158	4.0'	BELOW HAND HOLD	FLATS 6, 12
MAINTENANCE VANGS	01D5-1273	0.0'	BELOW CROSSARM BRACKET	FLATS 4, 10
LADDER CLIPS	01D0-1159	AS NOTED	AS NOTED	AS NOTED
GROUND LUG	01D1-1163	AS NOTED	AS NOTED	AS NOTED
GROUND PAD	01D1-1169	1.5'	ABOVE REVEAL BASEPLATE, OR AS NOTED	FLATS 1, 7
NAME PLATE	01D1-1153	3.5'	ABOVE GROUND LINE	FLAT 1
ANCHOR BOLT ASSY.	01D1-1166	AS NOTED	BASE PLATE	
DIRECT EMBEDDED	01D1-1169 OR 01D3-1180	AS NOTED	BOTTOM OF POLE	
STEEL POLE NOTES	01D0-1179			

POLE ATTACHMENTS FURNISHED BY AEP				
ITEM	POLE STANDARD DETAIL	LOCATION	REFERENCE POINT	ORIENTATION
AERIAL PATROL SIGN	70A0-1163	0.5'	TOP OF POLE	FLATS 1, 7
DANGER SIGN	70A0-1164	11.0'	ABOVE GROUND LINE	FLATS 1, 7
McGREGOR LADDER	01D0-1159 01D0-1160 01D0-1161	AS NOTED	AS NOTED	FLATS 1, 7

REV	REVISION DESCRIPTION	DATE	BY	REV	REVISION DESCRIPTION	DATE	BY
X	ENTER REVISION INFORMATION	XX/XX/XXXX	XXX	X	ENTER REVISION INFORMATION	XX/XX/XXXX	XXX

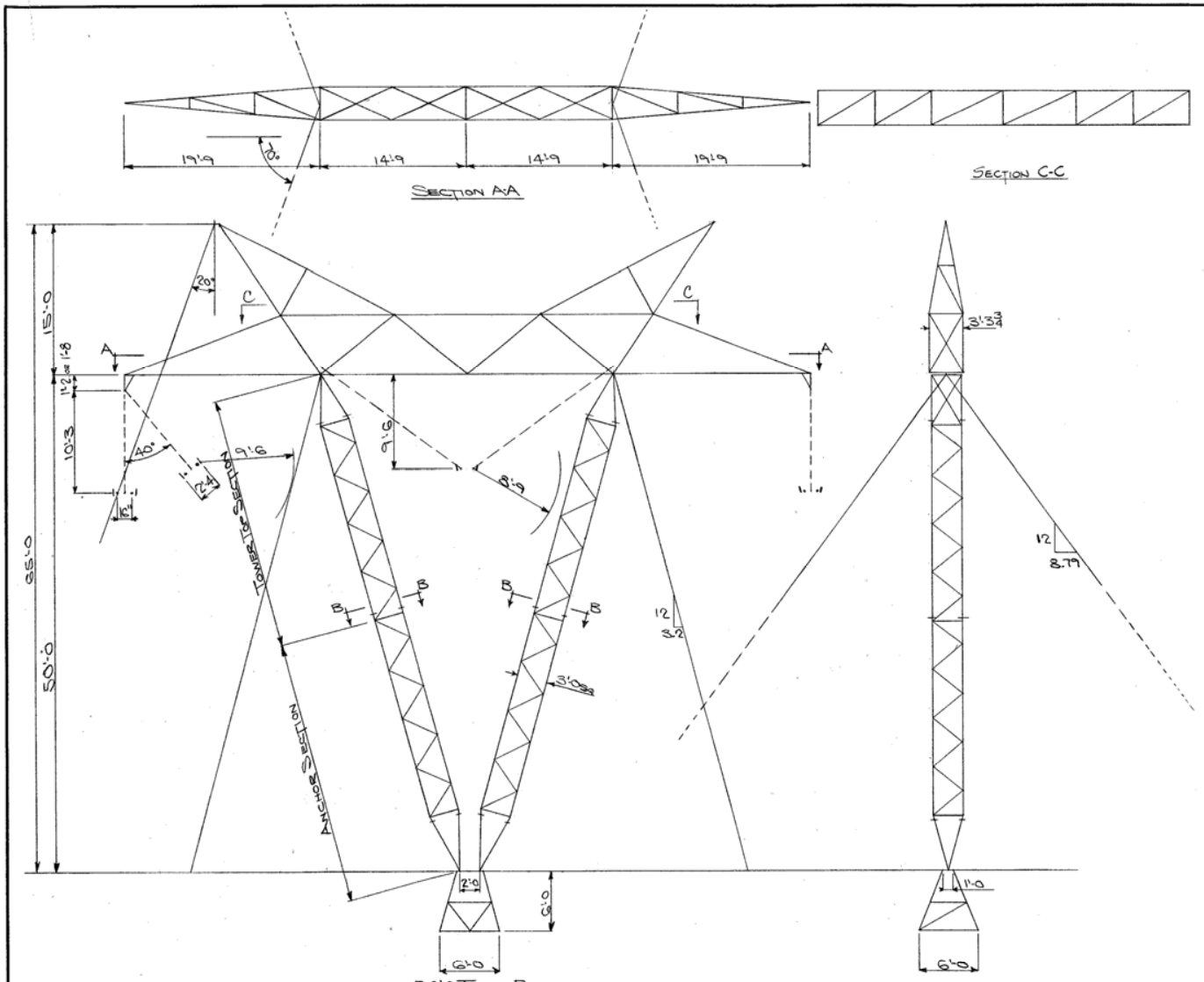
ETT Electric Transmission Texas

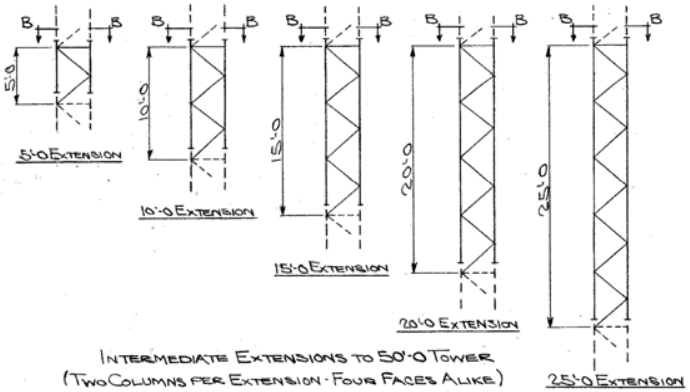
345kV SINGLE POLE STEEL TANGENT STRUCTURE NAME: R8VDC
BUNDLED SUSPENSION INSULATOR ASSEMBLY
DOUBLE CIRCUIT DIRECT EMBED AND ANCHOR BOLT FOUNDATION
LINE ANGLE 0° - 2°

AEP

ENGR:	MJM 02/27/2013	APPROVED:	N. TILDEN 03/04/13
DRAWN:	SAF 03/19/2013	JOB:	SUB:
CHECKED:	XXX XX/XX/XXXX	DWG: 502-1268	SHEET: 8 OF 21 REV: 0

APPENDIX B – STRUCTURE DRAWING EXISTING AEP 345 KV SINGLE CIRCUIT LINE





INTERMEDIATE EXTENSIONS TO 50'-0 TOWER
(TWO COLUMNS PER EXTENSION - FOUR FACES ALIKE)

SECTION B-B

MEDIUM SUSPENSION, GUYED "V" TYPE "V1TA"

THIS TOWER IS DESIGNED TO SUPPORT 2-GROUNDWIRES OF 7#8 ALUMOWELD (3/8") WIRE AND 3-BUNDLES OF 2 EACH 954000 CM 54/7 ACSR CONDUCTORS ON A MAXIMUM TANGENT SPAN OF 2010', OR AT AN ANGLE IN LINE OF 3° WITH A SPAN OF 955', OR ANY COMBINATION OF ANGLE AND SPAN NOT EXCEEDING THE LOADS SHOWN BELOW.

THE CABLES ARE ASSUMED TO BE SO STRUNG THAT THE MAXIMUM TENSION WILL NOT EXCEED 6400# FOR EACH GROUNDWIRE AND 24000# FOR EACH BUNDLE OF 2 CONDUCTORS.

TOWER LOADING IS BASED ON A CONDITION OF 12# WIND ON BARE CABLES AND THE ABOVE MAXIMUM TENSIONS FOR ANGLE LOADS. VERTICAL LOADS ARE ASSUMED FOR BARE CONDUCTORS ON 1.5 TIMES THE MAXIMUM TANGENT SPAN. HEAVY VERTICAL LOADS ARE CALCULATED ON A BASIS OF 3/4" RADIAL COATING OF ICE ON ALL CONDUCTORS ON 1.5 TIMES THE MAXIMUM TANGENT SPAN.

THE LONGITUDINAL LOADING IS BASED ON A CONDITION OF 1/2" RADIAL ICE, 0°F, NO WIND ON ONE SPAN AND NO ICE @ 0°F, NO WIND ON AN ADJACENT SPAN (DIFFERENTIAL ICE LOAD)

LOADS

1.) VERTICAL
- 2-GROUNDWIRES @ 800# = 1600#
- 3-BUNDLES OF 2 CONDUCTORS @ 7450# = 22350# 23950#

2.) TRANSVERSE
- 2-GROUNDWIRES @ 1040# = 2080#
- 3-BUNDLES OF 2 CONDUCTORS @ 4800# = 14400# 16480#

3.) LONGITUDINAL (DIFFERENTIAL ICE LOAD)
- 2-GROUNDWIRES @ 2000# = 4000
- 3-BUNDLES OF 2-CONDUCTORS @ 5780# = 17340# 21340#

4.) TORSIONAL
- 1-BUNDLE OF 2 CONDUCTORS @ 6725#

5.) WIND ON TOWER OF 13 5/8" x 1 1/2 FACES.

6.) DEAD LOAD OF TOWER

7.) HEAVY VERTICAL
- 2-GROUNDWIRES @ 4000# = 8000#
- 3-BUNDLES OF 2-CONDUCTORS @ 18400# = 55200# 63200#

COMBINE:
- (1, 2, 5+6) x1.9
- (1, 3/3 of 2, 3+4+6) x1.5
- (1, 3/3 of 2, 4, 5+6) x1.5
- (7) x1.5
- (1/2 of 5) x C.C (N.E.S.C. WIND ON TOWER)

FOR ULTIMATE UNIT STRESSES, MAT'L, COATING, CONNECTIONS & SPECIFICATIONS, SEE A.B.D. DWG NO T-10347

NOTE: EXTENSIONS TO POSTS TO BE BUTT SPLICED.

AMERICAN ELECTRIC POWER SERVICE CORP
345 K.V. SINGLE CIRCUIT TRANSMISSION LINE
MEDIUM SUSPENSION, GUYED "V" TYPE "V1TA"

AMERICAN BRIDGE
DIVISION
UNITED STATES STEEL CORP.

TOWER DEPARTMENT

DRAWING NO. T-10348
INQUIRY NO. T-9562
DATE: 4-10-61 CONTRACT NO.

PR 4541-459

Summary: Exhibit (Attachment B) electronically filed by Mr. Michael J. Settineri on behalf of Carroll County Energy LLC