BASIC SUSPENSION

LOAD SCHEDULE (KIPS): ALL LOADS INCLUDE OVERLOAD CAPACITY FACTORS

DESCRIPTION	V_A	T_A	L_A	V_B	T_B	L_B	V_C	T_C	L_C	WIND ON STRUCTURE (psf)
1. NESC HEAVY	2.70	1.90	0.00	30.30	10.90	0.00	7.90	3.40	0.00	10.0
2. NESC EXTREME WIND	0.80	1.30	0.00	13.90	11.20	0.00	3.30	3.40	0.00	23
3. NESC EXTREME WIND- YAW 45°	0.80	0.70	-0.10	13.90	6.20	-0.10	3.30	1.90	-0.10	16.3
4. NESC EXTREME WIND- LONGITUDINAL 90°	0.80	0.20	-0.10	13.90	1.50	-0.10	3.30	0.50	-0.10	23
5. NESC EXTREME ICE WITH CONCURRENT WIND	3.70	1.30	0.00	29.30	6.90	0.00	8.20	2.20	0.00	4.1
6. EVERYDAY	0.80	0.20	0.00	13.90	1.50	0.00	3.30	0.50	0.00	0.0
7. CONSTRUCTION SNUB OFF 3:1	3.10	-0.30	0.30	9.50	-0.70	0.80	33.40	-2.50	2.80	0.0
8. STRINGING INTACT	1.10	0.60	0.00	20.80	5.20	0.00	4.90	1.60	0.00	6.0
9. STRINGING/BROKEN SHIELDWIRE	1.10	0.40	5.00	20.80	5.20	0.00	4.90	1.60	0.00	6.0
10a. STRINGING/BROKEN CONDUCTOR	1.10	0.60	0.00	20.80	4.70	17.00	4.90	1.60	0.00	6.0
10b. STRINGING/BROKEN MRC	1.10	0.60	0.00	20.80	5.20	0.00	4.90	1.10	14.50	6.0
11. TORNADO WIND - STRUCTURE ONLY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.1
12.NESC MEDIUM	1.70	1.30	0.00	25.00	8.90	0.00	6.20	2.70	0.00	10

MEDIUM SUSPENSION

LOAD SCHEDULE (KIPS): ALL LOADS INCLUDE OVERLOAD CAPACITY FACTORS

DESCRIPTION	V_A	T_A	L_A	V_B	T_B	L_B	V_C	T_C	L_C	WIND ON STRUCTURE (psf)
1. NESC HEAVY	3.20	2.10	0.00	35.60	12.30	0.00	9.40	3.80	0.00	10.0
2. NESC EXTREME WIND	0.90	1.50	0.00	16.10	13.10	0.00	3.90	4.00	0.00	23
3. NESC EXTREME WIND- YAW 45°	0.90	0.80	-0.10	16.10	7.20	-0.10	3.90	2.20	-0.10	16.3
4. NESC EXTREME WIND- LONGITUDINAL 90°	0.90	0.20	-0.10	16.10	1.50	-0.10	3.90	0.50	-0.10	23
5. NESC EXTREME ICE WITH CONCURRENT WIND	4.50	1.50	0.00	34.70	7.60	0.00	9.80	2.40	0.00	4.1
6. EVERYDAY	0.90	0.20	0.00	16.10	1.50	0.00	3.90	0.50	0.00	0.0
7. CONSTRUCTION SNUB OFF 3:1	3.10	-0.30	0.30	9.50	-0.70	0.80	33.40	-2.50	2.80	0.0
8. STRINGING INTACT	1.40	0.70	0.00	24.20	5.70	0.00	5.90	1.70	0.00	6.0
9. STRINGING/BROKEN SHIELDWIRE	1.40	0.50	5.00	24.20	5.70	0.00	5.90	1.70	0.00	6.0
10a. STRINGING/BROKEN CONDUCTOR	1.40	0.70	0.00	24.20	5.20	17.00	5.90	1.70	0.00	6.0
10b. STRINGING/BROKEN MRC	1.40	0.70	0.00	24.20	5.70	0.00	5.90	1.30	14.50	6.0
11. TORNADO WIND - STRUCTURE ONLY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.1
12.NESC MEDIUM	2.10	1.50	0.00	29.30	10.10	0.00	7.40	3.10	0.00	10

HEAVY SUSPENSION

LOAD SCHEDULE (KIPS): ALL LOADS INCLUDE OVERLOAD CAPACITY FACTORS

DESCRIPTION	V_A	T_A	L_A	V_B	T_B	L_B	V_C	T_C	L_C	WIND ON STRUCTURE (psf)
1. NESC HEAVY	4.00	2.50	0.00	47.00	14.40	0.00	11.70	4.50	0.00	10.0
2. NESC EXTREME WIND	1.10	1.80	0.00	21.80	15.80	0.00	4.90	4.80	0.00	23
3. NESC EXTREME WIND- YAW 45°	1.10	1.00	-0.10	21.80	8.50	-0.10	4.90	2.60	-0.10	16.3
4. NESC EXTREME WIND- LONGITUDINAL 90°	1.10	0.20	-0.10	21.80	1.50	-0.10	4.90	0.50	-0.10	23
5. NESC EXTREME ICE WITH CONCURRENT WIND	5.60	1.80	0.00	45.00	8.80	0.00	12.10	2.80	0.00	4.1
6. EVERYDAY	1.10	0.20	0.00	21.80	1.50	0.00	4.90	0.50	0.00	0.0
7. CONSTRUCTION SNUB OFF 3:1	3.10	-0.30	0.30	9.50	-0.70	0.80	33.40	-2.50	2.80	0.0
8. STRINGING INTACT	1.70	0.70	0.00	32.70	6.50	0.00	7.30	2.00	0.00	6.0
9. STRINGING/BROKEN SHIELDWIRE	1.70	0.60	5.00	32.70	6.50	0.00	7.30	2.00	0.00	6.0
10a. STRINGING/BROKEN CONDUCTOR	1.70	0.70	0.00	32.70	6.00	17.00	7.30	2.00	0.00	6.0
10b. STRINGING/BROKEN MRC	1.70	0.70	0.00	32.70	6.50	0.00	7.30	1.50	14.50	6.0
11. TORNADO WIND - STRUCTURE ONLY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.1
12.NESC MEDIUM	2.60	1.80	0.00	39.10	11.70	0.00	9.20	3.60	0.00	10

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REV	REVISIONS	DATE	DRN	DSGN	CKD	APPD
A	CONCEPTUAL DESIGN	6/16/14	DVW	CIM	CIM	CIM

REFERENCE DRAWINGS

DSGN	CIM	6/9/14
DRN	DVW	6/9/14
CKD	CIM	6/9/14
SCALE:	NTS	

FOR 22x34 DWG ONLY

POWER ENGINEERS

CLEAN LINE ENERGY

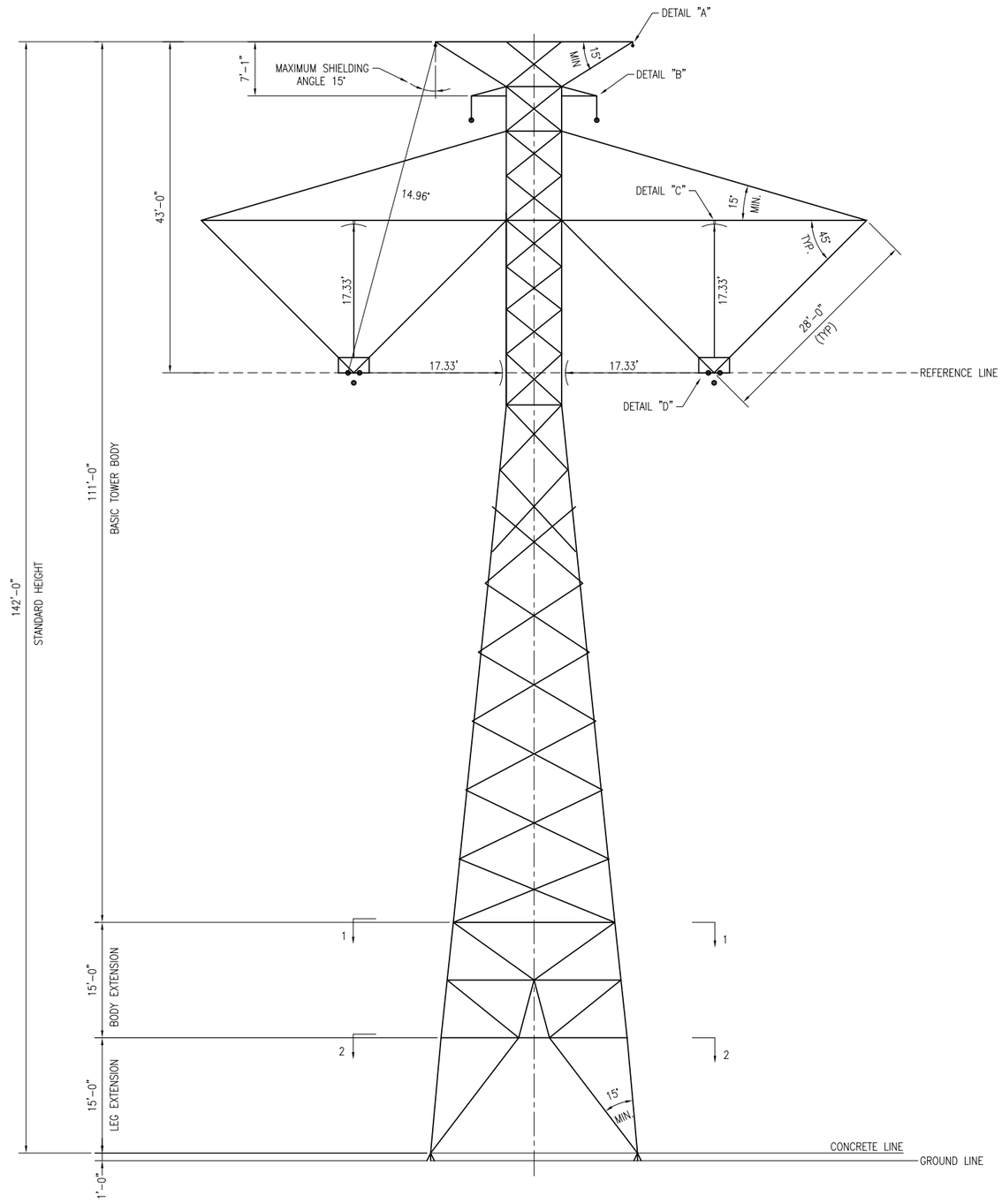
SELF SUPPORTING SUSPENSION POLE 0°-2° MRC ABOVE (V-STRING)-LOAD DRAWING

JOB NUMBER 132836

REV A

DRAWING NUMBER SSP-8-4

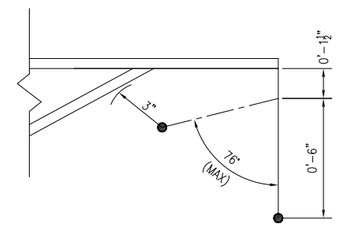
SSP-8-4_B&M_HVY_LOADS_0-2.DWG



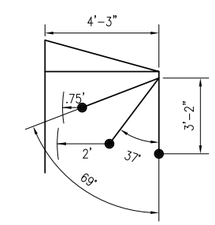
TANGENT SUSPENSION TOWER

NOTES

1. HORIZONTAL SECTION OF TOWER SHALL BE SQUARE ; FROM THE WAIST DOWN BRACING MEMBERS SHALL BE THE SAME ON BOTH THE TRANSVERSAL AND LONGITUDINAL FACES, BUT THE ANGLE SIZES OF MEMBERS MAY DIFFER.
2. THE WIDTH OF THE TOWER BODY IN DIFFERENT SECTIONS IS SUBJECT TO OPTIMIZATION.
3. CLEARANCE DIMENSIONS SHOWN ON TOWER DRAWING ARE THE MINIMUMS TO BE PROVIDED FROM THE SURFACE OF SUPPORTING STEEL AND OUTSTANDING LEGS OF WEBS (NOT FROM CENTER LINES) TO THE CORONA RING HOT BOX.
4. ALL TOWER TYPES SHALL BE DESIGNED TAKING INTO CONSIDERATION THAT ANY COMBINATION (OF ADJACENT OR DIAGONAL OPPOSITE LEGS) OF MINIMUM AND MAXIMUM HEIGHT CAN BE USED WITH A COMMON PART OR WITH ANY TOWER BODY EXTENSION.
5. ALL DIMENSIONS ARE IN FEET.
6. SWING ANGLES, LINE ANGLES, DEPARTURE ANGLES, ETC. ARE BASED ON 360 DEGREES CIRCLES.
7. STEEL WORK CONSTRUCTION IS INFORMATIVE ONLY FOR ESTIMATING PURPOSES.
8. BODY EXTENSIONS: +15FT, +30FT, +45FT, +60FT
   LEG EXTENSIONS: +5FT TO +30FT, IN INCREMENTS OF: 5FT
9. DETAILED VANG ATTACHMENT INFORMATION WILL BE PROVIDED AT FINAL DESIGN.



DETAIL "A"



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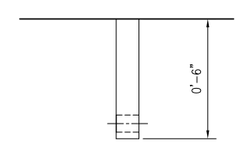
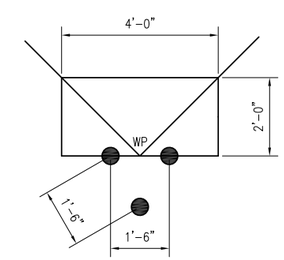
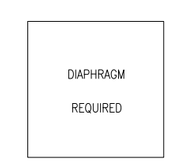


DETAIL "C"
INSTALLATION & MAINTENANCE VANG



DETAIL "D"
CORONA RING HOT BOX



SECTION 1–1 & 2–2

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REV	REVISIONS	DATE	DRN	DSGN	CKD	APPD
A	PRELIMINARY ESTIMATE	3/3/11	KWF	CIM	DJR	TAK

REFERENCE DRAWINGS

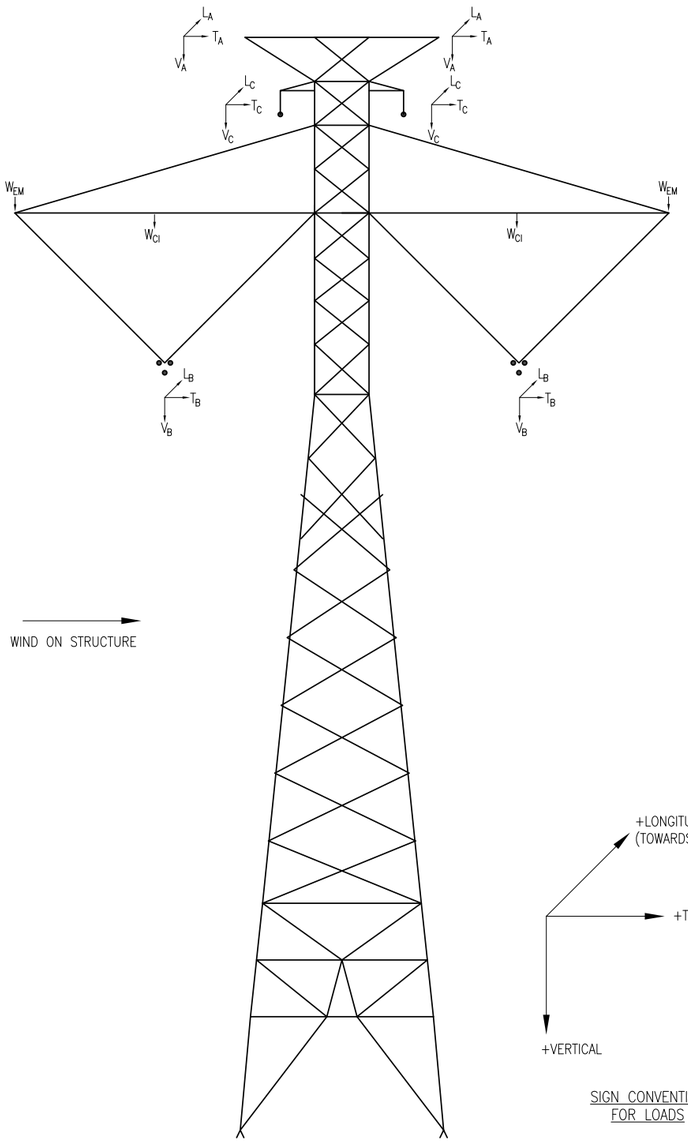
DSGN	CIM	2/1/11
DRN	KWF	2/22/11
CKD	DJR	3/3/11
SCALE:	NTS	

FOR 22x34 DWG ONLY

POWER ENGINEERS

CLEAN LINE ENERGY
± 600kV HVDC LINE
SELF SUPPORTING SUSPENSION TOWER
MRC OPTION–2 0'–2" (V–STRING)

JOB NUMBER 119990
REV A
DRAWING NUMBER SST–8–1



DESIGN PARAMETERS								BASIC	
WIRE	WIRE TYPE	STRAND (al/st)	WEIGHT (lbs./ft.)	DIA. (in.)	INS. WT (lbs.)	ANGLE (deg)	RULING SPAN (ft.)	WIND SPAN (ft.)	WT SPAN (ft.)
A	(1) - OPGW (49AY 85ACS-28 1-1427)	NA	0.473	0.591	25	2°	1500	1500	2250
B	(3) - 2156 KCM ACSR "Bluebird"	84/19	2.511	1.762	(SEE NOTE 5)	2°	1500	1500	2250
C	(1) - 1780 KCM ACSR "Chukar"	84/19	2.075	1.602	105	2°	1500	1500	2250

WEATHER CASES				OVERLOAD FACTORS			WIRE TENSIONS		
DESCRIPTION	TEMP (ºF)	RADIAL ICE (in.)	WIND (psf)	WIND OLF	TENSION OLF	VERTICAL OLF	A (lbs.)	B (lbs.)	C (lbs.)
1. NESC HEAVY	0	0.50	4.0	2.50	1.65	1.50	8826	23724	22191
2. NESC EXTREME WIND	60	0.00	24.3	1.00	1.00	1.00	7366	22276	19862
3. NESC EXTREME WIND - YAW 45°	60	0.00	12.2	1.00	1.00	1.00	5133	16836	15485
4. NESC EXTREME WIND- LONGITUDINAL 90°	60	0.00	0.0	1.00	1.00	1.00	3646	14177	13308
5. NESC EXTREME ICE WITH CONCURRENT WIND	15	1.25	4.1	1.00	1.00	1.00	14652	34177	29992
6. EVERYDAY	60	0.00	0.0	1.00	1.00	1.00	3646	14177	13308
7. CONSTRUCTION SNUB OFF 3:1	0	0.00	0.0	1.50	1.50	1.50	4089	15636	15894
8. STRINGING INTACT	0	0.00	4.0	1.50	1.50	1.50	4305	15971	16151
9. STRINGING/BROKEN SHIELDWIRE	0	0.00	4.0	1.50	1.50	1.50	4305	15971	16151
10. STRINGING/BROKEN CONDUCTOR	0	0.00	4.0	1.50	1.50	1.50	4305	15971	16151
11. TORNADO WIND - STRUCTURE ONLY	60	0.00	63.1	1.00	-	1.00	-	-	-

BASIC SUSPENSION - MAX WEIGHT

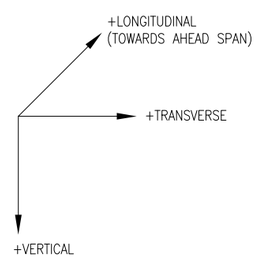
LOAD SCHEDULE (KIPS): ALL LOADS INCLUDE OVERLOAD CAPACITY FACTORS

DESCRIPTION	T_A	L_A	V_A	T_B	L_B	V_B	T_C	L_C	V_C	WIND ON STRUCTURE (psf)
1. NESC HEAVY	2.50	0.00	3.92	14.84	0.00	46.56	4.54	0.00	11.57	10.0
2. NESC EXTREME WIND	2.05	0.00	1.09	19.31	0.00	21.55	5.59	0.00	4.77	26.1
3. NESC EXTREME WIND- YAW 45°	1.08	0.00	1.09	10.29	0.00	21.55	3.00	0.00	4.77	18.5
4. NESC EXTREME WIND- LONGITUDINAL 90°	0.13	0.00	1.09	1.48	0.00	21.55	0.46	0.00	4.77	26.1
5. NESC EXTREME ICE WITH CONCURRENT WIND	2.10	0.00	7.53	10.29	0.00	53.15	3.15	0.00	14.75	4.1
6. EVERYDAY	0.13	0.00	1.09	1.48	0.00	21.55	0.46	0.00	4.77	0.0
7. CONSTRUCTION SNUB OFF 3:1	0.21	0.00	3.68	2.46	0.00	55.78	0.83	0.00	30.61	0.0
8. STRINGING INTACT	0.67	0.00	1.63	6.04	0.00	32.32	2.05	0.00	7.16	6.0
9. STRINGING/BROKEN SHIELDWIRE	0.33	6.46	0.84	-	-	-	2.05	0.00	7.16	6.0
10. STRINGING/BROKEN CONDUCTOR	-	-	-	6.70	31.62	32.32	2.05	10.66	7.16	6.0
11. TORNADO WIND - STRUCTURE ONLY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.1

BASIC SUSPENSION - MIN WEIGHT

LOAD SCHEDULE (KIPS): ALL LOADS INCLUDE OVERLOAD CAPACITY FACTORS

DESCRIPTION	T_A	L_A	V_A	T_B	L_B	V_B	T_C	L_C	V_C	WIND ON STRUCTURE (psf)
1. NESC HEAVY	2.50	0.00	0.21	14.84	0.00	8.66	4.54	0.00	0.66	10.0
2. NESC EXTREME WIND	2.05	0.00	0.07	19.31	0.00	5.35	5.59	0.00	0.31	26.1
3. NESC EXTREME WIND- YAW 45°	1.08	0.00	0.07	10.29	0.00	5.35	3.00	0.00	0.31	18.5
4. NESC EXTREME WIND- LONGITUDINAL 90°	0.13	0.00	0.07	1.48	0.00	5.35	0.46	0.00	0.31	26.1
5. NESC EXTREME ICE WITH CONCURRENT WIND	2.10	0.00	0.36	10.29	0.00	6.76	3.15	0.00	0.76	4.1
6. EVERYDAY	0.13	0.00	0.07	1.48	0.00	5.35	0.46	0.00	0.31	0.0
7. CONSTRUCTION SNUB OFF 3:1	0.21	0.00	2.15	2.46	0.00	31.48	0.83	0.00	23.92	0.0
8. STRINGING INTACT	0.67	0.00	0.11	6.70	0.00	8.03	2.05	0.00	0.47	6.0
9. STRINGING/BROKEN SHIELDWIRE	0.33	6.46	0.07	-	-	-	2.05	0.00	0.47	6.0
10. STRINGING/BROKEN CONDUCTOR	-	-	-	6.70	31.62	8.03	2.05	10.66	0.47	6.0
11. TORNADO WIND - STRUCTURE ONLY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.1



SIGN CONVENTION
FOR LOADS

NOTES

1. WIRE TENSIONS PROVIDED PER SUBCONDUCTOR. VECTOR LOADS PROVIDED PER PHASE.
2. LOAD CASE (9) TO BE APPLIED TO ONLY 1 SHIELD WIRE ATTACHMENT POINT (MOST SEVERE). APPLY LOAD CASE (8) TO ALL OTHER ATTACHMENT POINTS.
3. LOAD CASE (10) TO BE APPLIED TO ONLY 1 CONDUCTOR ATTACHMENT POINT (MOST SEVERE). APPLY LOAD CASE (8) TO ALL OTHER ATTACHMENT POINTS.
4. ALL LOAD CASES SHALL INCLUDE AN ADDITIONAL 800LB LOAD (W_{EM}) AT THE TIP OF EACH ARM TO ACCOUNT FOR MAINTENANCE WITH TWO MEN AND EQUIPMENT. APPROPRIATE OLF SHALL BE APPLIED.
5. ALL TOWER MEMBERS TO WITHSTAND A VERTICAL LOAD OF 350LBS APPLIED AT THEIR MIDPOINT WITH NO OTHER LOADS ACTING.
6. APPLY AN OLF OF 1.5 ON STRUCTURE WEIGHT FOR LOAD CASES 1,7,8,9, & 10.
7. APPLY AN OLF OF 1 ON STRUCTURE WEIGHT FOR LOAD CASES 2,3,4,5,6 & 11.
8. THE WIND PRESSURE ON THE STRUCTURE SHALL BE APPLIED WITH THE WIND SHAPE FACTORS PER NESC 2007 RULE 252.B.
9. THE STRUCTURE SHALL BE DESIGNED FOR AN ADDITIONAL LOAD CASE 12, FOR LOADS ANTICIPATED DUE TO RIGGING FOR WIRE CLIP IN DURING CONSTRUCTION. LOADS SHALL BE APPLIED AS FOLLOWS;

   AT ONE PHASE LOCATION, APPLY LOAD (W_{CI}) DIRECTLY ABOVE THE WORKPOINT. EACH LOCATION SHOULD BE ANALYZED SEPARATELY;

   DC–BASIC W_{CI} = 26,650 LBS.

   APPLY LOAD CASE (6) TO ALL OTHER ATTACHMENT POINTS.

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REV	REVISIONS	DATE	DRN	DSGN	CKD	APPD
A	PRELIMINARY ESTIMATE	3/3/11	KWF	CIM	DJR	TAK

REFERENCE DRAWINGS

DSGN	CIM	2/1/11
DRN	KWF	2/22/11
CKD	DJR	3/3/11

SCALE: NTS

FOR 22x34 DWG ONLY

POWER ENGINEERS

CLEAN LINE ENERGY

± 600kV HVDC LINE

SELF SUPPORTING SUSPENSION TOWER 0°–2° MRC OPTION–2 (V–STRING)–LOAD DRAWING

JOB NUMBER 119990

REV A

DRAWING NUMBER SST–8–2

POLE CONDUCTOR CLEARANCES TABLES

Comparison of Clearances for Clean Line +/- 600 kV Project

Case	**NESC- DC** V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	**NESC- AC Equivalent** V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom)	**EPRI** T/L Reference Book HVDC Lines	**MAD* for Tools** (IEEE 516-2009) **+ Working Space** (NESC Rule 236& 237)	**Conclusion**: Minimum possible value that can be used
Conductor to Ground:	Rule 232 D.3:	Rule 232 B and 232 C:	Not addressed.	N/A	
a. Track rails of railroads	38.68' (bare) 39' (rounded) 42' (w/3' buffer)	40.6' (bare) 41' (rounded) 44' (w/3' buffer)			**42'**
b. Streets, Alleys, roads, driveways, and parking lots	30.68' (bare) 31' (rounded) 34' (w/3' buffer)	32.6' (bare) 33' (rounded) 36' (w/3' buffer)			**34'**
c. Spaces and ways subject to pedestrians or restricted traffic:	26.68' (bare) 27' (rounded) 30' (w/3' buffer)	28.6' (bare) 29' (rounded) 32' (w/3' buffer)			**30'**
d. Vehicular areas	30.68' (bare) 31' (rounded) 34' (w/3' buffer)	32.6' (bare) 33' (rounded) 36' (w/3' buffer)			**34'**
Conductor to Water:	Rule 232 D, Table 232-3:	Rule 232, Table 232-1:	Not addressed.	N/A	
e. Water areas not suitable for sail boating or where sail boating is prohibited	28.46' (bare) 29' (rounded) 32' (w/3' buffer)	31.1' (bare) 32' (rounded) 35' (w/3' buffer)			**32'**
f. Water areas suitable for sail boating, including rivers, lakes, ponds, canals with unobstructed surface area:					
1) less than 0.08 km^2 (20 acres)	31.96' (bare) 32' (rounded) 35' (w/3' buffer)	34.6' (bare) 35' (rounded) 38' (w/3' buffer)			**35'**
(2) over 0.08 to 0.8 km^2 (20 to 200 acres)	39.96' (bare) 40' (rounded) 43' (w/3' buffer)	42.6' (bare) 43' (rounded) 46' (w/3' buffer)			**43'**
3) over 0.8 to 8 km^2 (200 to 2000 acres)	45.96' (bare) 46' (rounded) 49' (w/3' buffer)	48.6' (bare) 49' (rounded) 52' (w/3' buffer)			**49'**
(4) over 8 km^2 (2000 acres) Mississippi River Crossing	51.96' (bare) 52' (rounded) 55' (w/3' buffer)	54.6' (bare) 55' (rounded) 58' (w/3' buffer)			**55'**

Case	**NESC- DC** V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	**NESC- AC Equivalent** V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom)	**EPRI** T/L Reference Book HVDC Lines	**MAD* for Tools** (IEEE 516-2009) **+ Working Space** (NESC Rule 236& 237)	**Conclusion**: Minimum possible value that can be used
Conductor to Own Structure No Wind	12.96' (bare) 13' (rounded) 13.5' (w/ 0.5 ' buffer) Rule 235 E.3b	12.95' (bare) 13' (rounded) 13.5' (w/0.5' buffer) Rule 235E, Table 235-6, item 4b	16.4' No Wind Case corresponds to Lightning Impulse, required clearance from Figure 10-13, page 150. Lightning Surge will be at least 30% higher than Switching Surge: 1080*1.3=1404 kV Surge Factor: Ti=1.8	12.83'+4.5'=17.33' MAD+WS	**13.5'**
Conductor to Own Structure Medium Wind 6 psf	12.96' (bare) 13' (rounded) 13.5' (w/0.5' buffer) Rule 235 E.3b	12.95' (bare) 13' (rounded) 13.5' (w/0.5' buffer) Rule 235E, Table 235-6, item 4b	9.8 ' Medium Wind Case corresponds to Switching Impulse, required clearance from Figure 10-13, page 150 Switching Surge=1.8*600 =1080 kV Surge Factor: Ti=1.8	12.83'+4.5'=17.33' MAD+WS	**13.5'**
Conductor to Own Structure Extreme Wind 24.3 psf	Not addressed	Not addressed	4.1' (no buffer) 5' (w/0.9' buffer) Extreme Wind corresponds to Steady State required clearance from Fig.10-3 , Page 145 and Fig.10-4, Page 146.	Not addressed	**5'**

*MAD=Minimum Approach Distance.

NESC-Clearance Conductor to Ground calculation:

NESC- DC:	**NESC- AC Equiv**
V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom)
Rule 232D, table 232-3: a. Track rails of railroads: H ref=22' b. Streets, Alleys, roads, driveways, and parking lots: H ref=14' c. Spaces and ways subject to pedestrians or restricted traffic: H ref=10' d. Vehicular areas: H ref=14' For Ref Altitude < 1500 ft: V max=1.05*V nom=632 kV C ref=3.28*(632*1.8*1.15/(500*1.15)^1.667*1.03*1.2=15.96' For assumed maximum altitude for this line (worst case scenario): 3000 ft: Altitude Adder: (3000'-1500')/1000'*3%=4.5% C alt=C ref*1.045=15.96'*1.045=16.68' a. Track rails of railroads: C total=H ref + C alt=22' + 16.68'=**38.68' (bare)** **39' (rounded)** **42' (w/3' buffer)** **CHOSEN** b. Streets, Alleys, roads, driveways, and parking lots: C total=H ref + C alt=14' + 16.68'=**30.68' (bare)** **31' (rounded)** **34' (w/3' buffer)** **CHOSEN** c. Spaces and ways subject to pedestrians or restricted traffic: C total=H ref + C alt=10' + 16.68'=**26.68' (bare)** **27' (rounded)** **30' (w/3' buffer)** **CHOSEN** d. Vehicular Areas: C total=H ref + C alt=14' + 16.68'=**30.68' (bare)** **31' (rounded)** **34' (w/3' buffer)** **CHOSEN**	Equivalent max ac system voltage=735*1.05=772 KV Equivalent max ac system voltage, phase-to-ground=772/sqrt(3)=446 kV NESC Rule 232, Table 232-1, open supply conductor up to 22 kv: a. Track rails of railroads: H basic=26.5' b. Streets, Alleys, roads, driveways, and parking lots: H basic=18.5' c. Spaces and ways subject to pedestrians or restricted traffic: H basic=14.5' d. Vehicular areas: H basic=18.5' Voltage Adder: C adder=(446-22)*0.4"/12=14.1' Altitude adder : zero a. Track rails of railroads: C total=H basic + C adder= 26.5' + 14.1'=**40.6' (bare)** **41' (rounded)** **44' (w/3' buffer)** b. Streets, Alleys, roads, driveways, and parking lots: C total=H basic + C adder= 18.5' + 14.1'=**32.6' (bare)** **33' (rounded)** **36' (w/3' buffer)** c. Spaces and ways subject to pedestrians or restricted traffic : C total=H basic + C adder= 14.5' + 14.1'=**28.6' (bare)** **29' (rounded)** **32' (w/3' buffer)** d. Vehicular Areas: C total=H basic + C adder= 18.5' + 14.1'=**32.6' (bare)** **33' (rounded)** **36' (w/3' buffer)**

NESC- Clearance Conductor-to-Own Structure calculation

for Cases: Medium Wind (6 psf) and No Wind:

NESC- DC:	**NESC- AC Equiv**
V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230H V max=772 KV (5% over V nom)
Rule 235E3b For Ref Altitude < 1500 ft: V max=1.05*V nom=632 kV C ref=39.37*(630*1.8*1.15/(500*1.2))^1.667*1.03=147.9”=12.33’ For assumed maximum altitude for this line (worst case scenario): 3000 ft: Altitude Adder: (3000’-1500’)/1000’*3%=4.5% C alt=C ref*1.045=12.33’*1.045=12.88’ C alt=**12.88’ (bare)** **13’ (rounded)** **13.5’ (w/0.5’ buffer)** **CHOSEN**	Equivalent max ac system voltage=735*1.05=772 KV Equivalent max ac system voltage, phase-to-ground=772/sqrt(3)=446 kV NESC Rule 235 E, 4b, open supply conductor up to 50 kv: H basic=11”=0.917’ Voltage Adder: C adder=(772-50)*0.2”/12=12.033’ Altitude adder : zero C total=H basic + C adder= 0.917’ + 12.033’=**12.95’ (bare)** **13’ (rounded)** **13.5’ (w/0.5’ buffer)**

NESC- Clearance to Anchor Guys calculation:

for Cases: Medium Wind (6 psf) and No Wind:

NESC- DC:	**NESC- AC Equiv**
V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230H V max=772 KV (5% over V nom)
Rule 235E3b For Ref Altitude < 1500 ft: V max=1.05*V nom=630 kV Cref=39.37*(630*1.8*1.15/(500*1.2))^1.667*1.03=147.9”=12.33’ For assumed maximum altitude for this line (worst case scenario): 3000 ft: Altitude Adder: (3000’-1500’)/1000’*3%=4.5% C alt=C ref*1.045=12.33’*1.045=12.882’ C alt=**12.88’ (bare)** **13’ (rounded)** **13.5’ (w/0.5’ buffer)**	Equivalent max ac system voltage=735*1.05=772 KV Equivalent max ac system voltage, phase-to-ground=772/sqrt(3)=446 kV NESC Rule 235 E, 4b, open supply conductor up to 50 kv: H basic=16”=1.333’ Voltage Adder: C adder=(772-50)*0.25”/12=15.041’ Altitude adder : zero C total=H basic + C adder= 1.333’ + 15.041’=**16.374’ (bare)** **16.4’ (rounded)** **16.9 ’ (w/0.5 ’ buffer)** **CHOSEN**

NESC-Clearance to Right –of-Way (Blowout):

for Cases: Medium Wind (6 psf) and No Wind:

NESC- DC: V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	**NESC- AC Equiv** V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230H V max=772 KV (5% over V nom)
Rule 234H, Alternate Clearances, DC Calculations: Clearance to ROW is like clearance to buildings; V pole-to-ground, max=630 kV Table 234-5: H ref=3' (horizontal): Rule 234H3, horizontal electrical clearance: c=1.0: D=3.28*(630*1.8*1.15/(500*1.15))^1.667*1.03*1.0=13.23' With Altitude Adder, assumed Altitude=3000' (worst case): (3000'-1500')/1000'*3%=4.5% D alt =D*1.045=13.23*1.045=13.83' C total=H ref+D alt=3'+13.83'=16.83**' (bare) C total=17' (rounded)** **C total=20' (w/3' buffer)**	Equivalent max ac system voltage=735*1.05=772 KV Equivalent max ac system voltage, phase-to-ground=772/sqrt(3)=446 kV NESC Rule 234B, clearance to buildings, open supply conductor up to 22 kv: H basic=4.5' (**with 6 psf wind)** H basic=7.5' (**with no wind**) Voltage Adder: C adder=(446-22)*0.4"/12=14.133' Altitude adder : zero **Medium Wind (6 psf):** C total=H basic + C adder= 4.5' + 14.133'=**18.633' (bare)** **19' (rounded)** **22' (w/3' buffer)** **CHOSEN** **No Wind (0 psf):** C total=H basic + C adder= 7.5' + 14.133'=**21.633' (bare)** **22' (rounded)** **25' (w/3' buffer)** **CHOSEN**

NESC- Clearance Conductor-to-Water calculation

NESC- DC: V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	**NESC- AC Equiv** V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230H V max=772 KV (5% over V nom)
Rule 232D, Table 232-3 item: e. Water areas not suitable for sail boating or where sail boating is prohibited: H ref=12.5' f. Water areas suitable for sail boating, including rivers, lakes, ponds, canals with unobstructed surface area: (1) less than 0.08 km^2 (20 acres): H ref=16' (2) over 0.08 to 0.8 km^2 (20 to 200 acres): H ref=24' (3) over 0.8 to 8 km^2 (200 to 2000 acres): H ref=30' (4) over 8 km^2 (2000 acres): Mississippi River Crossing: H ref=36' For Ref Altitude < 1500 ft: V max=1.05*V nom=630 kV C ref=3.28*(630*1.8*1.15/(500*1.15))^1.667*1.03*1.2=15.88' PU=1.8-maximum switching surge factor for +/- 600 kV DC Altitude at Mississippi River Crossing location: Alt=300' from PLS-CADD Model 300' < 1500' results: Altitude Adder=0, results: C alt=C ref=15.87' e. Water areas not suitable for sail boating or where sail boating is prohibited: C total=H ref+C alt=12.5'+15.88'=**28.38' (bare) C total=29' (rounded up)** **C total=32' (w/3' buffer)** **CHOSEN** Water areas suitable for sail boating, including rivers, lakes, ponds, canals with unobstructed surface area: (1) less than 0.08 km^2 (20 acres): C total=H ref+C alt=16'+15.88'=**31.88' (bare)** **C total=32' (rounded)** **C total=35' (w/3' buffer)** **CHOSEN** (2) over 0.08 to 0.8 km^2 (20 to 200 acres): C total=H ref+C alt=24'+15.88'=**39.88' (bare)** **C total=40' (rounded)** **43' (w/3' buffer)** **CHOSEN** (3) over 0.8 to 8 km^2 (200 to 2000 acres): C total=H ref+C alt=30'+15.88'=**45.88' (bare)** **C total=46' (rounded)** **49' (w/3' buffer)** **CHOSEN** (4) over 8 km^2 (2000 acres): Mississippi River Crossing: C total=H ref+C alt=36'+15.88'=**51.88' (bare)** **C total=52' (rounded)** **55' (w/3' buffer)** **CHOSEN**	Equivalent max ac system voltage=735*1.05=772 KV Equivalent max ac system voltage, phase-to-ground=772/sqrt(3)=446 kV NESC Rule 232, Table 232-1, open supply conductor up to 22 kV: 6. Water areas not suitable for sail boating or where sail boating is prohibited: H basic=17' 7. Water areas suitable for sail boating, including rivers, lakes, ponds, canals with unobstructed surface area: (1) less than 0.08 km^2 (20 acres): H basic=20.5' (2) over 0.08 to 0.8 km^2 (20 to 200 acres): H basic=28.5' (3) over 0.8 to 8 km^2 (200 to 2000 acres): H ref=34.5' (4) over 8 km^2 (2000 acres): Mississippi River Crossing: H ref=40.5' Voltage Adder: C adder=(446-22)*0.4"/12=14.1' Altitude at Mississippi River Crossing location: Alt=300' from PLS-CADD Model 300' < 1500' results: Altitude Adder=0, results: C alt=0 e. Water areas not suitable for sail boating or where sail boating is prohibited: C total=H basic + C adder= 17' + 14.1'=**31.1' (bare)** **C total=32' (rounded)** **C total=35' (w/3' buffer)** f. Water areas suitable for sail boating, including rivers, lakes, ponds, canals with unobstructed surface area: (1) less than 0.08 km^2 (20 acres): C total=H basic + C adder= 20.5' + 14.1'=**34.6' (bare)** **C total=35' (rounded)** **C total=38' (w/3' buffer)** (2) over 0.08 to 0.8 km^2 (20 to 200 acres): C total=H basic + C adder= 28.5' + 14.1'=**42.6' (bare)** **C total=43' (rounded)** **C total=46' (w/3' buffer)** (3) over 0.8 to 8 km^2 (200 to 2000 acres): C total=H basic + C adder= 34.5' + 14.1'=**48.6' (bare)** **C total=49' (rounded)** **C total=52' (w/3' buffer)** 4) over 8 km^2 (2000 acres): Mississippi River Crossing: C total=H basic + C adder= 40.5' + 14.1'=**54.6' (bare)** **C total=55' (rounded)** **C total=58' (w/3' buffer)**

NESC-Clearance Conductor to Grain Bins calculation:

NESC- DC:	**NESC- AC Equiv**
V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom)
Rule 234H2, Table 234-5, item b: “other installation”” grain bins: V ref=9’; H ref=3’ Rule 234H3a : Electric Clearances: For Ref Altitude < 1500 ft: V=V max=1.05*V nom=1.05*600=630 kV: C ref=3.28*(V*PU*a/(500*k))^1.667*b*c C ref V =3.28*(630*1.8*1.15/(500*1.15))^1.667*1.03*1.2=15.88’ C ref H=3.28*(630*1.8*1.15/(500*1.15))^1.667*1.03*1.0=13.23’ Rule 234H3, b: For assumed maximum altitude for this line (worst case scenario): 3000 ft: Altitude Adder: (3000’-1500’)/1000’*3%=4.5% C alt V =C ref V *1.045=15.88’*1.045=16.59’ C alt H =C ref H *1.045=13.23’*1.045=13.83’ Grain Bins: **Vertical:** V total=V ref + C alt V = 9’ + 16.59’=**25.59’ (bare)** **26’ (rounded)** **29’ (w/3’ buffer)** **Horizontal:** H total=H ref + C alt H = 3’ + 13.89**’ =16.83’ (bare)** **17’ (rounded)** **20’ (w/3’ buffer)**	Equivalent max ac system voltage=735*1.05=772 KV Equivalent max ac system voltage, phase-to-ground=772/sqrt(3)=446 kV **CASE 1: Rule 234 F1: PERMANENT ELEVATOR** **NESC Figure 234-4 (a):** **Vertical:** NESC Rule 234F1.a, open supply conductor up to 22 kV: Grain Bins: V basic=18’ Rule 234G1: Voltage Adder: C adder=(446-22)*0.4”/12=14.1’ Altitude adder : zero (Altitude, worst case assumed: 3000 ft , which is less than 3300 ft) V total=V basic+ C adder=18’+14.1’=**32.1’ (bare)** **32.1’ (rounded)** **35.1’ (w/3’ buffer)** **CHOSEN** **Horizontal (At Rest, No Wind):** NESC Rule 234F1.b, open supply conductor up to 22 kV: Grain Bins: H basic=15’ Rule 234G1: Voltage Adder: C adder=(446-22)*0.4”/12=14.1’ Altitude adder : zero (Altitude, worst case assumed: 3000 ft , which is less than 3300 ft) H total=H basic+ C adder=15’+14.1’=**29.1’ (bare)** **29.1’ (rounded)** **32.1’ (w/3’ buffer)** **CHOSEN** **Horizontal (Displaced, 6 psf Wind):** NESC Rule 234D1b, open supply conductor up to 22 kV: Grain Bins with permanent elevator under wind are considered as “Building” under wind: H basic=4.5’ Rule 234G1: Voltage Adder: C adder=(446-22)*0.4”/12=14.1’ Altitude adder : zero (Altitude, worst case assumed: 3000 ft , which is less than 3300 ft) H total=H basic+ C adder=4.5’+14.1’=**18.6’ (bare)** **18.6’ (rounded)** **21.6’ (w/3’ buffer)** **CHOSEN**

CASE 2: RULE 234 F 2: PORTABLE ELEVATOR
ARE CONSIDERED BY NESC ONLY AT REST, NO WIND DISPLACEMENT:

CASE 2.1: LOADED SIDE
NESC Figure 234-4 (b):

Vertical:

32.1' (rounded)
35.1' (w/3' buffer)
CHOSEN

Horizontal (At Rest, No Wind):

32.1' (rounded)
35.1' (w/3' buffer)
CHOSEN

CASE 2.2: UN-LOADED SIDE
NESC Figure 234-4 (b):

UNLOADED SIDE is considered by NESC as "Buildings" Rule 234C

Vertical:

Rule 234 C, Table 234-1, 1.Building, b.Vertical,(1)
"building not accessible to pedestrians" (the elevator):

V basic=12.5' (No Wind)

Rule 234G1:
Voltage Adder: C adder=(446-22)*0.4"/12=14.1'

Altitude adder : zero
(Altitude, worst case assumed: 3000 ft , which is less than 3300 ft)

V total=V basic+ C adder=12.5'+14.1'=**26.6' (bare)**
26.6' (rounded)
29.6' (w/3' buffer)
CHOSEN

Horizontal (At Rest, No Wind):
Rule 234 C, Table 234-1, 1Building, a. Horizontal :

H basic=7.5' (No wind)

Rule 234G1:
Voltage Adder: C adder=(446-22)*0.4"/12=14.1'

Altitude adder : zero
(Altitude, worst case assumed: 3000 ft , which is less than 3300 ft)

H total=H basic+ C adder=7.5'+14.1'=**21.6' (bare)**
21..6' (rounded)
24.6' (w/3' buffer)
CHOSEN

Calculations of Required Vertical and Horizontal Clearances +/- 600 kV DC Pole Conductor to

Under-Crossing Lines or Parallel/Adjacent Lines

500 kV, 345 kV, 230 kV, 161 kV, 138 kV,115 kV, 69 kV, 35 kV, 25, 12.5 KV AC Conductors and 0 KV Groundwire

Different Structures, Different Utilities, Different Circuits

Upper Circuit:

$V_{dc,\ crest\ (peak),\ pole\text{-}to\text{-}ground}$=600 kV dc Equivalent to: $V_{ac,\ rms,\ phase\text{-}to\text{-}phase}$=$600\ kV * \frac{\sqrt{3}}{\sqrt{2}} = 735\ kV\ ac$

Lower Circuit (Crossing or Parallel):

Vertical Clearance: NESC Rule 233 C.2.a, Table 233-1:

$$V = \frac{\left[24 + \left(735 * \frac{1.05}{\sqrt{3}} + V_{lower} * \frac{1.05}{\sqrt{3}} - 22\right) * 0.4\right]}{12}$$

Horizontal Clearance: NESC Rule 233 B.1.a:

$$H = \frac{\left(735 * \frac{1.05}{\sqrt{3}} + V_{lower} * \frac{1.05}{\sqrt{3}} - 22\right) * 0.4}{12}$$

Altitude: Maximum 3000' in the entire P&E line, less than 3300', results: Altitude adder=0 (Rule 233C2.b for Vertical and Rule 233B.2 for Horizontal).

Circuit Type	Upper Circuit: 600 kV dc (equivalent 735 kV ac)				
	Crossing or Parallel: Lower Circuit: V lower [kV]	V [ft] (Bare)	**V [ft] (with 3'buffer)**	H [ft] (Bare)	**H [ft] (with 3'buffer)**
Transmission	500	26.2	**29.2**	24.2	**27.2**
	345	23.1	**26.1**	21.1	**24.1**
	230	20.8	**23.8**	18.8	**21.8**
	161	19.4	**22.4**	17.4	**20.4**
	138	18.9	**21.9**	16.9	**19.9**
	115	18.5	**21.5**	16.5	**19.5**
	69	17.5	**20.5**	15.5	**18.5**
Distribution	35	16.8	**19.8**	14.8	**17.8**
	25	16.6	**19.6**	14.6	**17.6**
	12.5	16.4	**19.4**	14.4	**17.4**
Groundwire	0	16.1	**19.1**	14.1	**17.1**

Required Vertical Clearances are used for Under-Crossing Lines, for following loading cases:

1. Upper 600 KV dc conductor at MOT or at 32 F, with Ice (0.5" for Heavy NESC locations; or 0.25" for Medium NESC locations), which ever results in greater sag, and Under-Crossed Line conductor at 60 F Bare.

2. Upper 600 KV dc conductor at 60 F, and Under-Crossed Line conductor at 60 F, 6 psf transverse wind (the transverse wind, from both directions, on the Under-Crossing Line is parallel to the 600 kV dc line, thus having no effect on the 600 kV dc line, but having an effect on the Under-Crossing Line, raising its conductor and getting it closer to the 600 kV dc conductor).

Required Vertical and Horizontal Clearances are used for Parallel or Adjacent Lines, for following cases:

1. Upper 600 kV dc conductor and Parallel Line conductor, both under 6 psf transverse wind, from both directions.

2. Upper 600 KV dc conductor at MOT or at 32 F, with Ice (0.5" for Heavy NESC locations; or 0.25" for Medium NESC locations), which ever results in greater sag, and Parallel or Adjacent Line conductor at 60 F Bare.

Vertical Clearances +/- 600 kV DC Pole Conductor (PC) to +/- 53 KV DC Metal Return Conductor (MRC):

Different Circuits, Same Supports, Same Utility

NESC- DC:	NESC- AC Equiv
Pole Conductor (PC): V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom) Metal Return Conductor (MRC): V nom=53 KV peak, pole-ground V max=56 KV (5% over V nom)	Pole Conductor (PC): V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom) Metal Return Conductor (MRC): V nom=65 KV rms, phase-to-phase 65=53*sqrt(3)/sqrt(2) Rule 230 H V max=68 KV (5% over V nom)
V max= V H = 630 KV dc pole to ground > 138 kV dc pole to ground **Therefore Alternative DC Calculations are applicable.** **NESC Rule 235C3: "Alternate Clearances":** can be used, if switching surge factor is known, but it cannot be less than the values from Rule 233C3 (crossing): **Vertical: Rule 233 C3.b (1): Electrical Component:** D=3.28*[((V H*PU+V L)*a)/(500*k)]^1.667*b*c Where: V H = 600*1.05=630 KV, dc, max, pole-to-ground V L = 53*1.05=56 KV, dc, max, pole-to-ground a =1.15 b = 1.03 c = 1.2 k=1.4 PU = 1.8 (switching surge factor) Results: D=12.40' DC Line Altitude Adder ("threshold" value:1500'): Assumed Altitude=3000' (worst case)> 1500', results: (3000'-1500')/1000'*3%=4.5% D alt =D*1.045=12.40*1.045=12.95' LIMITS: Rule 233 C3c:, Table 233-1. Vertical: the "Alternate Clearance" shall not be less than the clearances required by Rule 233C1 & 233C2, with the lower voltage circuit at ground potential: D=2+0.4/12*[600*1.05/sqrt(2)+0KV-22]=16.12', **rounded up: 17' (bare)** **D=17'+3' buffer=20' (with 3' buffer)**	**NESC Rule 235 C :** **Vertical Clearance of Different Circuits, Same Supports, Same Utility:** **Rule 235.C.2a, Table 235-5, 2d: SAME UTILITY, AT SUPPORTS:** V=[16/12+(50-8.7)*0.4/12]+[(735*1.05/sqrt(3)+65*1.05/sqrt(3)-50)*0.4/12]= =2.71' + 14.50'=17.2', **rounded up: 17.5' (bare)** **V=17.5'+3' buffer=20.5' (with 3' buffer) CHOSEN** **Rule 235.C.2.b(1),(b): SAME UTILITY, IN SPAN:** V=[16/12+(50-8.7)*0.4/12]*0.75 +[(735*1.05/sqrt(3)+65*1.05/sqrt(3)-50)*0.4/12]= =2.03' + 14.50'=16.53', **rounded up: 17' (bare)** **V=17'+3' buffer=20' (with 3' buffer) CHOSEN** AC Line Altitude Adder ("threshold" value 3300'): Assumed 3000' (worst case) < 3300', results: Altitude Adder=0.

Horizontal Clearances +/- 600 kV DC Pole Conductor (PC) to +/- 53 KV DC Metal Return Conductor (MRC):

Different Circuits, Same Supports, Same Utility

NESC- DC:	NESC- AC Equiv
Pole Conductor (PC): V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom) Metal Return Conductor (MRC): V nom=53 KV peak, pole-ground V max=56 KV (5% over V nom)	Pole Conductor (PC): V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom) Metal Return Conductor (MRC): V nom=65 KV rms, phase-to-phase 65=53*sqrt(3)/sqrt(2) Rule 230 H V max=68 KV (5% over V nom)
V max= V H = 630 KV dc pole to ground > 138 kV dc pole to ground **Therefore Alternative DC Calculations are applicable.** **NESC Rule 235B3: "Alternate Clearances":** can be used, if switching surge factor is known, but it cannot be less than the values from Rule 235B3.b: **Vertical: Rule 235 B3: Electrical Component:** D=3.28*[(V L-L*PU*a)/(500*k)]^1.667*b Where: V L-L = maximum dc operating voltage between poles of different Cricuits, same support structure: V L-L = V H+ V L = 630 + 56 =686 KV, dc, max, pole-to-pole V H = 600*1.05=630 KV, dc, max, pole-to-ground V L = 53*1.05=56 KV, dc, max, pole-to-ground PU = 1.8 (switching surge factor) a=1.15 b=1.03 k=1.4 **Results:** D=10.99' DC Line Altitude Adder ("threshold" value:1500'): Assumed Altitude=3000' (worst case)> 1500', results: (3000'-1500')/1000'*3%=4.5% **D alt**=D*1.045=10.99*1.045=**11.48' (bare)** **D alt=11.48't+3' buffer=14.48' (with 3' buffer)** **Limit: Rule 235B.3.b: the clearance derived from Rule 235B3a Should not be less than the basic clearance given in Table 235-1 computed for 169 kV ac:** **C limit=28.5/12+0.4/12*(169*1.05-50)=6.62' (bare)** **D =11.50' (bare)> C limit=6.62' (bare), OK** **Results:** **H=14.48' (with 3' buffer)**	**NESC Rule 235 B :** **Horizontal Clearance of Different Circuits, Same Supports, Same Utility:** **Rule 235B.1.a, Table 235-1: Supply Conductors of different circuits:** H=28.5/12+0.4/12*(735*1.05/sqrt(3)+65*1.05/sqrt(3)-50)= =2.375'+14.50'=16.875'**, rounded up: 17' (bare)** **H=17'+3' buffer=20' (with 3' buffer) CHOSEN** **Rule 235B.1b, Clearance according to Sags:** C=0.3/12*(735*1.05/sqrt(3)+65*1.05/sqrt(3))+8/12*sqrt(56.195*12/12)= =12.125'+5'=**17.125', rounded: 17' (bare)** results**: C=17'+3' buffer=20' (with 3' buffer) CHOSEN** S=sag in ft, at 60 F, final, unloaded sag, no wind, no ice: 600 KV dc : ACSR Bluebird: S 60 F, final=56.81' in RS=1500' 53 kV dc: ACSR Chukar: S 60 F, final=55.58' in RS=1500' S avg = (56.81'+55.58')/2=56.195' AC Line Altitude Adder ("threshold" value 3300'): Assumed 3000' (worst case) < 3300', results: Altitude Adder=0.

Vertical Clearances +/- 600 kV DC Pole Conductor (PC) to 0 KV Shieldwire (OPGW):

Different Circuits, Same Supports, Same Utility

NESC- DC:	**NESC- AC Equiv**
Pole Conductor (PC): V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	Pole Conductor (PC): V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom)
NESC Rule 235C3: "Alternate Clearances": can be used, if switching surge factor is known, but it cannot be less than the values from Rule 233C3 (crossing): **Vertical: Rule 233 C3.b (1): Electrical Component:** D=3.28*[((V H*PU+V L)*a)/(500*k)]^1.667*b*c Where: V H = 600*1.05=630 KV, dc, max, pole-to-ground V L = 0 kV (shieldwire) a =1.15 b = 1.03 c = 1.2 k=1.4 PU = 1.8 (switching surge factor) Results: D=11.44' DC Line Altitude Adder ("threshold" value:1500'): Assumed Altitude=3000' (worst case)> 1500', results: (3000'-1500')/1000'*3%=4.5% D alt =D*1.045=11.44*1.045=11.95' LIMITS: Rule 233 C3c:, Table 233-1. Vertical: the "Alternate Clearance" shall not be less than the clearances required by Rule 233C1 & 233C2, with the lower voltage circuit at ground potential: D=2+0.4/12*[600*1.05/sqrt(2)+0KV-22]=16.12', **rounded : 16' (bare)** **D=16'+3' buffer=19' (with 3' buffer)**	**NESC Rule 235 C :** **Vertical Clearance of Different Circuits, Same Supports, Same Utility:** **Rule 235.C.2a, Table 235-5, 2d: SAME UTILITY, AT SUPPORTS:** V=[16/12+(50-8.7)*0.4/12]+[(735*1.05/sqrt(3)+0*1.05/sqrt(3)-50)*0.4/12]= =2.71' + 13.19'=15.9', **rounded up: 16' (bare)** **V=16'+3' buffer=19' (with 3' buffer) CHOSEN** **Rule 235.C.2.b(1),(b): SAME UTILITY, IN SPAN:** V=[16/12+(50-8.7)*0.4/12]*0.75 +[(735*1.05/sqrt(3)+0*1.05/sqrt(3)-50)*0.4/12]= =2.03' + 13.19'=15.22', **rounded up: 15.5' (bare)** **V=15.5'+3' buffer=18.5' (with 3' buffer) CHOSEN** AC Line Altitude Adder ("threshold" value 3300'): Assumed 3000' (worst case) < 3300', results: Altitude Adder=0.

Horizontal Clearances +/- 600 kV DC Pole Conductor (PC) to 0 KV Shieldwire (OPGW):

Different Circuits, Same Supports, Same Utility

NESC- DC:	**NESC- AC Equiv**
Pole Conductor (PC): V nom=600 KV peak, pole-ground V max=630 KV (5% over V nom)	Pole Conductor (PC): V nom=735 KV rms, phase-to-phase 735=600*sqrt(3)/sqrt(2) Rule 230 H V max=772 KV (5% over V nom)
NESC Rule 235B3: "Alternate Clearances": can be used, if switching surge factor is known, but it cannot be less than the values from Rule 235B3.b: **Vertical: Rule 235 B3: Electrical Component:** D=3.28*[(V L-L*PU*a)/(500*k)]^1.667*b Where: V L-L = maximum dc operating voltage between poles of different Cricuits, same support structure: V L-L = V H+ V L = 630 + 0 =630 KV, dc, max, pole-to-pole V H = 600*1.05=630 KV, dc, max, pole-to-ground V L = 0*1.05= 0KV, dc, max, pole-to-ground (shieldwire) PU = 1.8 (switching surge factor) a=1.15 b=1.03 k=1.4 **Results:** D=9.53' DC Line Altitude Adder ("threshold" value:1500'): Assumed Altitude=3000' (worst case)> 1500', results: (3000'-1500')/1000'*3%=4.5% **D alt**=D*1.045=9.53*1.045=**9.96' (bare)** **Dalt=9.96'+3' buffer=13' (with 3' buffer, rounded)** i **Limit: Rule 235B.3.b: the clearance derived from Rule 235B3a Should not be less than the basic clearance given in Table 235-1 computed for 169 kV ac:** **C limit=28.5/12+0.4/12*(169*1.05-500=6.62' (bare)** **D =10' (bare)> C limit=6.62' (bare), OK** **Results:** **H=13' (with 3' buffer)**	**NESC Rule 235 B :** **Horizontal Clearance of Different Circuits, Same Supports, Same Utility:** **Rule 235B.1.a, Table 235-1: Supply Conductors of different circuits:** H=28.5/12+0.4/12*(735*1.05/sqrt(3)+0*1.05/sqrt(3)-50)= =2.375'+13.19'=15.565'**, rounded up: 16' (bare)** **H=16'+3' buffer=19' (with 3' buffer) CHOSEN** **Rule 235B.1b, Clearance according to Sags:** C=0.3/12*(735*1.05/sqrt(3)+0*1.05/sqrt(3))+8/12*sqrt(48.345*12/12)= =11.139'+4.635'=**15.774', rounded: 16' (bare)** results**: C=16'+3' buffer=19' (with 3' buffer) CHOSEN** S=sag in ft, at 60 F, final, unloaded sag, no wind, no ice: 600 KV dc : ACSR Bluebird: S 60 F, final=56.81' in RS=1500' 0 kV dc: Shieldwire (OPGW): S 60 F, final=39.88' in RS=1500' S avg =(56.81'+39.88')/2=48.345' AC Line Altitude Adder ("threshold" value 3300'): Assumed 3000' (worst case) < 3300', results: Altitude Adder=0.

Vertical Clearances +/- 53 kV DC Metal Return Conductor (MRC) to 0 KV Shieldwire (OPGW):

Different Circuits, Same Supports, Same Utility

NESC- DC:	NESC- AC Equiv:
Metal Return Conductor (MRC): V nom=53 KV peak, pole-ground V max=56 KV (5% over V nom)	Metal Return Conductor (MRC): V nom=65 KV rms, phase-to-phase 65=53*sqrt(3)/sqrt(2) Rule 230 H V max=68 KV (5% over V nom)
V max= 56 KV dc pole to ground < 138 kV dc pole to ground **Therefore Alternative DC Calculations are N/A.** But, if is necessary to know what would be the values, here are the calculations: **NESC Rule 235C3: "Alternate Clearances":** can be used, if switching surge factor is known, but it cannot be less than the values from Rule 233C3 (crossing): **Vertical: Rule 233 C3.b (1): Electrical Component:** D=3.28*[((V H*PU+V L)*a)/(500*k)]^1.667*b*c Where: V H = 53*1.05=56 KV, dc, max, pole-to-ground V L = 0 KV (shieldwire) a =1.15 b = 1.03 c = 1.2 k=1.4 PU = 1.8 (switching surge factor) Results: D=0.2' DC Line Altitude Adder ("threshold" value:1500'): Assumed Altitude=3000' (worst case)> 1500', results: (3000'-1500')/1000'*3%=4.5% D alt =D*1.045=0.2*1.045=0.21' LIMITS: Rule 233 C3c:, Table 233-1. Vertical: the "Alternate Clearance" shall not be less than the clearances required by Rule 233C1 & 233C2, with the lower voltage circuit at ground potential: D=2+0.4/12*[53*1.05/sqrt(2)+0KV-22]=2.58'**, rounded up: 3' (bare)** **D=3'+1' buffer=4' (with 1' buffer)**	**NESC Rule 235 C :** **Vertical Clearance of Different Circuits, Same Supports, Same Utility:** **Rule 235.C.2a, Table 235-5, 2d: SAME UTILITY, AT SUPPORTS:** **Because : 68/sqrt(3)=39.4 KV, ac, max, phase-to-ground, which is less than 50 KV, there is no additional adder of 0.4 "/ per each KV over 50 KV:** V=[16/12+(50-8.7)*0.4/12]=2.71'**, rounded up: 3' (bare)** **V=3'+1' buffer=4' (with 1' buffer) CHOSEN** **Rule 235.C.2.b(1),(b): SAME UTILITY, IN SPAN:** V=[16/12+(50-8.7)*0.4/12]*0.75=2.03'**, rounded : 2' (bare)** **V=2'+1' buffer=3' (with 1' buffer) CHOSEN** AC Line Altitude Adder ("threshold" value 3300'): Assumed 3000' (worst case) < 3300', results: Altitude Adder=0.

Horizontal Clearances +/- 53 kV DC Metal Return Conductor (MRC) to 0 KV Shieldwire (OPGW):

Different Circuits, Same Supports, Same Utility

NESC- DC:	NESC- AC Equiv
Metal Return Conductor (MRC): V nom=53 KV peak, pole-ground V max=56 KV (5% over V nom)	Metal Return Conductor (MRC): V nom=65 KV rms, phase-to-phase 65=53*sqrt(3)/sqrt(2) Rule 230 H V max=68 KV (5% over V nom)
V max= 56 KV dc pole to ground < 138 kV dc pole to ground **Therefore Alternative DC Calculations are N/A.** But, if is necessary to know what would be the values, here are the calculations: **NESC Rule 235B3: "Alternate Clearances":** can be used, if switching surge factor is known, but it cannot be less than the values from Rule 235B3.b: **Vertical: Rule 235 B3: Electrical Component:** D=3.28*[(V L-L*PU*a)/(500*k)]^1.667*b Where: V L-L = maximum dc operating voltage between poles of different circuits, same support structure: V L-L = V H+ V L = 56 + 0 =56 KV, dc, max, pole-to-pole V H = 53*1.05=56 KV, dc, max, pole-to-ground V L = 0*1.05=0 KV (shieldwire) PU = 1.8 (switching surge factor) a=1.15 b=1.03 k=1.4 **Results:** D=0.17' DC Line Altitude Adder ("threshold" value:1500'): Assumed Altitude=3000' (worst case)> 1500', results: (3000'-1500')/1000'*3%=4.5% **D alt**=D*1.045=0.17*1.045=**0.18' , rounded up: 1'(bare)** **D alt=1 ' +1' buffer=2' (with 1' buffer)**	**NESC Rule 235 B :** **Horizontal Clearance of Different Circuits, Same Supports, Same Utility:** **Rule 235B.1.a, Table 235-1: Supply Conductors of different circuits:** **Because : 68/sqrt(3)=39.4 KV, ac, max, phase-to-ground, which is less than 50 KV, there is no additional adder of 0.4 "/ per each KV over 50 KV:** H=28.5/12=2.375', **rounded up: 2.5' (bare)** **H=2.5'+1' buffer=3.5' (with 1' buffer)** **Rule 235B.1b, Clearance according to Sags:** C=0.3/12*(65*1.05/sqrt(3)+0 kV) + 8/12*sqrt(47.73*12/12)= =0.985'+4.6'=**5.5' (bare);** results**: C=5.5' +1' buffer=6.5' (with 1' buffer) CHOSEN** S=sag in ft, at 60 F, final, unloaded sag, no wind, no ice: 53 kV dc: ACSR Chukar: S 60 F, final=55.58' in RS=1500' 0 KV dc: Shieldwire (OPGW): S 60 F, final=39.88' in RS=1500' S avg =(55.58'+39.88')/2=47.73' AC Line Altitude Adder ("threshold" value 3300'): Assumed 3000' (worst case) < 3300', results: Altitude Adder=0.

Calculations of Required Vertical and Horizontal Clearances +/- 600 kV DC Pole Conductor to

Other Utility Structure, Signs, Billboards, Fences, Buildings (Roof Accessible and Not Accessible to Pedestrians),

Bridges Super Structure (No Personnel Access), Bridge Deck, Swimming Pools

Summary Table: "AC EQUIVALENT CALCULATIONS"

(CHOSEN, because result in the highest values for all cases, except "other utility structure"):

Case	Reference Clearance 234B, 234C, 234D, 234E		Voltage Adder: Rule 234G1		Total Clearance Without Buffer		**Total Clearance With 3' Buffer**	
	Vertical [ft]	Horizontal [ft]	D Vertical [ft]	D Horizontal [ft]	Vertical [ft]	Horizontal [ft]	**Vertical [ft]**	**Horizontal [ft]**
From Other Supporting Structures (Other Utility Structure)	5.5	5.0 (at rest) 4.5 (displaced)	13.2	13.2 (at rest) 14.2 (displaced)	18.7	18.2 (at rest) 18.7 (displaced)	**21.7**	**21.2 (at rest)** **21.7 (displaced)**
From Signs, Billboards, Fences, except Bridges and Buildings, above or under catwalks (Accessible to Pedestrians)	13.5	7.5 (at rest) 4.5 (displaced)	14.1	14.1 (at rest) 14.1 (displaced)	27.6	21.6 (at rest) 18.6 (displaced)	**30.6**	**24.6 (at rest)** **21.6 (displaced)**
From Signs, Billboards, Fences, except Bridges and Buildings, no catwalks (Not-Accessible to Pedestrians)	8.0	7.5 (at rest) 4.5 (displaced)	14.1	14.1 (at rest) 14.1 (displaced)	22.1	21.6 (at rest) 18.6 (displaced)	**25.1**	**24.6 (at rest)** **21.6 (displaced)**
From Buildings (Roof Accessible to Pedestrians)	13.5	7.5 (at rest) 4.5 (displaced)	14.1	14.1 (at rest) 14.1 (displaced)	27.6	21.6 (at rest) 18.6 (displaced)	**30.6**	**24.6 (at rest)** **21.6 (displaced)**
Buildings (Roof Not-Accessible to Pedestrians)	12.5	7.5 (at rest) 4.5 (displaced)	14.1	14.1 (at rest) 14.1 (displaced)	26.6	21.6 (at rest) 18.6 (displaced)	**29.6**	**24.6 (at rest)** **21.6 (displaced)**
From Bridges Super Structure (No Personnel Access)	12.5	7.5 (at rest) 4.5 (displaced)	14.1	14.1 (at rest) 14.1 (displaced)	26.6	21.6 (at rest) 18.6 (displaced)	**29.6**	**24.6 (at rest)** **21.6 (displaced)**
From Bridge Deck	18.5	7.5 (at rest) 4.5 (displaced)	14.1	14.1 (at rest) 14.1 (displaced)	32.6	21.6 (at rest) 18.6 (displaced)	**35.6**	**24.6 (at rest)** **21.6 (displaced)**
From Swimming Pools (V=Dim. "A") (H=Dim. "B")	25	17 (at rest) (not defined displaced)	14.1	14.1 (at rest) (not defined displaced)	39.1	31.1 (at rest) (not defined displaced)	**42.1**	**34.1 (at rest)** **(not defined displaced)**

Summary Table: ALTERNATE CALCULATIONS (Known Switching Surge Factor): Rule 234H2+Rule 234H3: H ref+D

(NOT CHOSEN, because it does not result in the highest value for any case, except for "other utility structure"):

Case	Reference Height Rule 234H2		Electrical Component Rule 234H3a		Alternate Clearance Total Without Buffer		**Alternate Clearance Total With 3' Buffer**	
	Vertical [ft]	Horizontal [ft]	D Vertical [ft]	D Horizontal [ft]	Vertical [ft]	Horizontal [ft]	**Vertical [ft]**	**Horizontal [ft]**
From Other Supporting Structures (Other Utility Structure)	6	5	16.7	13.9	22.7	18.9 (rest & displaced)	**25.7**	**21.9** (rest & displaced)
From Signs, Billboards, Fences, except Bridges and Buildings, above or under catwalks (Accessible to Pedestrians)	9	3	16.7	13.9	25.7	16.9 (rest & displaced)	**28.7**	**19.9** (rest & displaced)
From Signs, Billboards, Fences, except Bridges and Buildings, no catwalks (Not-Accessible to Pedestrians)	9	3	16.7	13.9	25.7	16.9 (rest & displaced)	**28.7**	**19.9** (rest & displaced)
From Buildings (Roof Accessible to Pedestrians)	9	3	16.7	13.9	25.7	16.9 (rest & displaced)	**28.7**	**19.9** (rest & displaced)
Buildings (Roof Not-Accessible to Pedestrians)	9	3	16.7	13.9	25.7	16.9 (rest & displaced)	**28.7**	**19.9** (rest & displaced)
From Bridges Super Structure (No Personnel Access)	9	3	16.7	13.9	25.7	16.9 (rest & displaced)	**28.7**	**19.9** (rest & displaced)
From Bridge Deck	15	3	16.7	13.9	31.7	16.9 (rest & displaced)	**34.7**	**19.9** (rest & displaced)
From Swimming Pools (V=Dim. "A") (H=Dim. "B")	18	14	16.7	13.9	34.7	27.9 (at rest) (not defined displaced)	**37.7**	**30.9** (at rest) (not defined displaced)

Note 1: Limits: Rule 234H4 The Alternate Clearance shall not be less than the clearance required by Rule 234B, Table 234-2, 234-3, as applicable, computed for 98 kV ac rms to ground or 139 kV dc peak to ground by Rule 234G.

Rule 234H3, b: DC Line Altitude Adder ("threshold" value: 1500'): Assumed Altitude=3000' (worst case)> 1500', results: (3000'-1500')/1000'*3%=4.5%, **apply K alt=1.045 to Electrical Components Rule 234H3a: D Vertical and D Horizontal.**

The Clearances specified in Rule 234B, 234C, 234D, 234E (Equivalent AC) are compared to Clearances using Alternate Clearances per Rule 234H2 & 234H3, because: **V max= 630 KV dc pole to ground > 139 kV dc pole to ground, therefore Alternative DC Calculations can be applied for Pole Conductor (with known switching surge factor: PU=1.8), but they do not control.**

To be safe, and covered for majority of cases, are used "AC Equivalent" Calcs: Rule 234 B ,C , D, & E, which result in the highest required clearances for all cases (except for "other utility structure").

$V_{dc,\ crest\ (peak),\ pole\text{-}to\text{-}ground}$=600 kV dc Equivalent to: $V_{ac,\ rms,\ phase\text{-}to\text{-}phase}=600\ kV * \frac{\sqrt{3}}{\sqrt{2}} = 735\ kV\ ac$

Clearances of Wires from Other Supporting Structures (Other Utility Structure, Light or Traffic Light Stand):

Standard Clearances Calculations per **Rule 234B:**

Bare values:

234B1a: H=5.0'+0.4/12*[735*1.05/sqrt(3)-50]= 18.2' (at rest)

234B1b: H=4.5'+0.4/12*[735*1.05/sqrt(3)-22]=18.7' (displaced, 6 psf wind)

234B2: V=5.5'+0.4/12*[735*1.05/sqrt(3)-50]=18.7'

These values obtained per **Rule 234B (AC Equivalent) are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, d+ 234H3a:**

Bare values:

H=18.9' (at rest and displaced 6 psf)

V=22.7'

Clearances of Wires from Signs, Billboards, Chimneys, Antennas, Tanks, Other Installations, except Bridges and Buildings, above or under catwalks and other surfaces upon which personnel walk (Accessible to Pedestrians):

Standard Clearances Calculations per **Rule 234C:**

Bare values:

Rule 234C1a, Table 234-1, item 2.a(1): H=7.5'+0.4/12*[735*1.05/sqrt(3)-22]=21.6' (at rest)

Rule 234C1b: H=4.5'+0.4/12*[735*1.05/sqrt(3)-22]=18.6' (displaced)

Rule 234C1a, Table 234-1, item 2.b (1): V=13.5'+0.4/12*[735*1.05/sqrt(3)-22]=27.6'

These values obtained per **Rule 234C (AC Equivalent) are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, b+ 234H3a:**

Bare values:

H=16.9' (at rest and displaced 6 psf)

V=25.7'

Clearances of Wires from Signs, Billboards, Chimneys, Antennas, Tanks, Other Installations, except Bridges and Buildings, no catwalks (or other portions that are Non-Accessible to Pedestrians):

Standard Clearances Calculations per **Rule 234C:**

Bare values:

Rule 234C1a, Table 234-1, item 2.a(2): H=7.5'+0.4/12*[735*1.05/sqrt(3)-22]=21.6' (at rest)

Rule 234C1b: H=4.5'+0.4/12*[735*1.05/sqrt(3)-22]=18.6' (displaced)

Rule 234C1a, Table 234-1, item 2.b (2): V=8.0'+0.4/12*[735*1.05/sqrt(3)-22]=22.1'

These values obtained per **Rule 234C (AC Equivalent)** **are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, b+ 234H3a:**

Bare values: H=16.9' (at rest and displaced 6 psf)

V=25.7'

Clearances of Wires from Buildings (Roof Accessible to Pedestrians):

Standard Clearances Calculations per **Rule 234C:**

Bare values:

Rule 234C1a, Table 234-1, item 1.a: H=7.5'+0.4/12*[735*1.05/sqrt(3)-22]=21.6' (at rest)

Rule 234C1b: H=4.5'+0.4/12*[735*1.05/sqrt(3)-22]=18.6' (displaced)

Rule 234C1a, Table 234-1, item 1.b(2): V=13.5'+0.4/12*[735*1.05/sqrt(3)-22]=27.6'

These values obtained per **Rule 234C (AC Equivalent)** **are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, a + 234H3a:**

Bare values:

H=16.9' (at rest and displaced 6 psf)

V=25.7'

Clearances of Wires from Buildings (Roof Not Accessible to Pedestrians):

Standard Clearances Calculations per **Rule 234C:**

Bare values:

Rule 234C1a, Table 234-1, item 1.a: H=7.5'+0.4/12*[735*1.05/sqrt(3)-22]=21.6' (at rest)

Rule 234C1b: H=4.5'+0.4/12*[735*1.05/sqrt(3)-22]=18.6' (displaced)

Rule 234C1a, Table 234-1, item 1.b(1): V=12.5'+0.4/12*[735*1.05/sqrt(3)-22]=26.6'

These values obtained per **Rule 234C (AC Equivalent)** **are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, a+ 234H3a:**

Bare values:

H=16.9' (at rest and displaced 6 psf)

V=25.7'

Clearances of Wires from Bridges Super Structure (No Personnel Access):

Standard Clearances Calculations per **Rule 234D:**

Standard Clearances Calculations per **Rule 234D:**

Bare values:

Rule 234D1a, Table 234-2, item 2.a(2): H=7.5'+0.4/12*[735*1.05/sqrt(3)-22]=21.6' (at rest)

Rule 234D1b: H=4.5'+0.4/12*[735*1.05/sqrt(3)-22]=18.6' (displaced)

Rule 234D1a, Table 234-2, item 1.b: V=12.5'+0.4/12*[735*1.05/sqrt(3)-22]=26.6'

These values obtained per **Rule 234D (AC Equivalent**) **are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, c+ 234H3a:**

Bare values:

H=16.9' (at rest and displaced 6 psf)

V=25.7'

Clearances of Wires from Bridge Deck:

Standard Clearances Calculations per **Rule 234D:**

Standard Clearances Calculations per **Rule 234D:**

Bare values:

Rule 234D1a, Table 234-2, item 2.a(2): H=7.5'+0.4/12*[735*1.05/sqrt(3)-22]=21.6' (at rest)

Rule 234D1b: H=4.5'+0.4/12*[735*1.05/sqrt(3)-22]=18.6' (displaced)

Rule 234D1a, Table 234-2, item 1.b+Commentary: V=12.5'+6'+0.4/12*[735*1.05/sqrt(3)-22]=32.6'

These values obtained per **Rule 234D (AC Equivalent**) **are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, c+ 234H3a:**

Bare values:

H=16.9' (at rest and displaced 6 psf)

V=31.7'

Clearances of Wires from Swimming Pools (Vertical=Dimension "A"; Horizontal=Dimension "B"):

Standard Clearances Calculations per **Rule 234E:**

Bare values:

Rule 234E1, Table 234-3, item B (Figure 234-3, Dim."B"): H=17'+0.4/12*[735*1.05/sqrt(3)-22]=31.1' (at rest) (not defined displaced, under wind)

Rule 234E1, Table 234-3, item A (Figure 234-3, Dim."A"): V=25'+0.4/12*[735*1.05/sqrt(3)-22]=39.1' (at rest)

These values obtained per **Rule 234E (AC Equivalent**) **are not replaced** by Alternate Clearance Calculation (Switching Factor Calculation) per **Rule 234H: 234H2, Table 234-5, e,f+ 234H3a:**

Bare values:

H=27.9' (at rest) (not defined displaced, under wind)

V=34.7'

Rule 234H2, Table 234-5: Reference Heights (used in Alternate Calculations only):

Case	Reference Height Rule 234H2	
	Vertical [ft]	Horizontal [ft]
a) Buildings	9	3
b) Signs, Billboards	9	3
c) Bridge Super Structure	9	3
d) Supporting Structure of Another Line	6	5
e) Swimming Pools (Dim.” A”) - used for Vert.	18	N/A
f) Swimming Pools (Dim.” B”) - used for Hor.	14	14

Rule 234 H3, a: Electrical Component:

D=3.28* [(V*(PU)*a)/(500*k)]^1.667*b*c [ft]

Where:

V, nom, dc, pole-to-ground [kV]	600
V = V max, dc, pole-to-ground [kV]	632

a	1.15
b	1.03
(Vertical) c	1.2
(Horizontal) c	1.0
k	1.15
PU	1.8

Results:

Electrical Component Rule 234H3a		Electrical Component Rule 234H3a With Altitude Adder: k alt=1.045 (see Rule 234H3b calculation)	
D Vertical [ft]	D Horizontal [ft]	D Vertical [ft]	D Horizontal [ft]
15.96	13.30	15.96 * 1.045 = 16.7	13.30 * 1.045 = 13.9