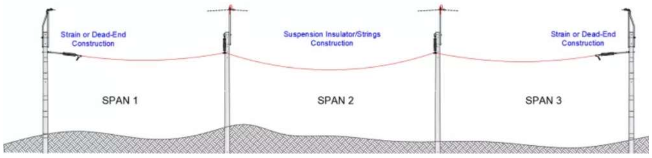
CATENARY SAG-TENSION CALCULATOR (by: Jared Cuchapin, 2018)



References:

1. *NS220 Overhead Design Manual*
2. *RUS Bulletin 1724E-200*
3. *Overhead Power Line Design – F. Kiessling , P. Nefzger, J.F. Nolasco and U. Kaintzyk*
4. *Principles of Power System – K. Mehta*

1. LINE CHARACTERISTICS

	Variable Symbol	Value	Unit
Span Length (Ruling Span)	S	200	m
Conductor Name		Condor	
Conductor Size		*795	
Stranding		*54/7	
Diameter	dia	0.027760845	m
Cross-sectional Area	A	0.0004548	m^2
Final Modulus of Elasticity	E	59000000000	N/m^2
Coefficient of Linear Thermal Expansion	alpha	0.0000193	/deg C
Unit Weight	W.1	14.98140393	N/m
Ultimate Tensile Strength	RTS	127084.0909	N

Important: Creep is not considered in the calculation.

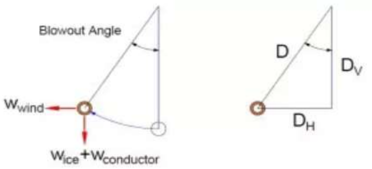
2. LOADING CONDITIONS: NESC RULE 250D (EXTREME ICE WITH CONCURRENT WIND)

Initial Loading *(These are the conditions when the conductor was first strung.)*

Initial Horizontal Tension	H.1	31,771.02	N
Initial Conductor Temperature	t.1	15	deg C

Final Loading *(These are the conditions where conductor will be subjected to wind, ice or max temperature.)*

1. Thermal Load				
Conductor Temperature @ final loading	t.2	-10	deg C	
2. Wind Load				
Wind Pressure	P	110	Pa (N/m^2)	*(Refer to applicable standards, NESC 2017 or ASCE.)*
Additional Conductor Weight due to wind	W.wind	3.054	N/m	
3.Ice Load				
Ice Thickness	t	0	m	*(Refer to applicable standards, NESC 2017 or ASCE.)*
Ice Density	density	915	kg/m^3	
Additional Conductor Weight due to ice	W.ice	0.000	N/m	

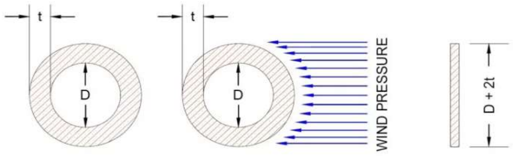


TOTAL EFFECT OF ICE AND WIND

$$W_{ice} = Volume\ x\ density = \rho_{ice}\pi t(D+t)$$

$$W_{wind} = P_{wind}(D+2t)$$

$$W_{total} = \sqrt{(W+W_{ice})^2 + (W_{wind})^2}$$



EFFECT OF ICE EFFECT OF WIND

NESC "k" constant	k	0.000	kg/m		
Resultant Conductor Weight	W.2	15.289	N/m		
Blowout Angle	theta	0.201	radians	11.527	degrees

3. CALCULATION OF FINAL HORIZONTAL TENSION

(Note: Please review the fundamental concepts of the sag-tension to understand the foregoing equations. This is the link to my website.) https://electricalengineerresources.com/engineering_guides/

CONDUCTOR STATE CHANGE EQUATION

$$H_2^3 + H_2^2\left(\frac{(W_1 S)^2 AE}{24 H_1^2} - H_1 + (t_2 - t_1)\alpha AE\right) - \frac{(W_2 S)^2 AE}{24} = 0$$

ANOTHER FORM OF CSCE:

$$H_2^3 + A\,H_2^2 - B = 0 \quad \text{where:}$$

$$B = (W_2\,S\,C_1)^2 \qquad C_2 = \alpha\,EA$$

$$A = C_2(t_2 - t_1) + \left(\frac{W_1 S\,C_1}{H_1}\right)^2 - H_1 \qquad C_1 = \sqrt{\frac{EA}{24}}$$

Coefficients:

_A	-34773.97903
B	1.04546E+13
_C1	1057.378835
_C2	517.88076

$H_2^3 + A\,H_2^2 - B = 0$		0	>>>>>>>>>>>
Final Horizontal Tension	H.2	40,994.801	Newtons

***Note:** To solve the cubic equation, you have 2 options*
***1) MANUALLY:** use the **"goalseek"** command of excel. See Manual.*

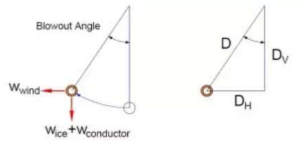
<<<<<<<<<<	*OR* ***2) AUTOMATICALLY:*** *Enable macro and click the button on the left. Trust me, there no hidden virus in the file.*

STOP! Do not proceed to "results summary" until "goalseek" have been performed.

RESULTS SUMMARY:

Sags:

Initial Conductor Sag	**D.1**	**2.358**	m	Difference	*(Negative value represents Cold Uplift.)*
Final Conductor Sag	**D.2**	**1.865**	m	**-0.49**	meters
Horizontal Sag	**HD.1**	**0.372**	m	**-1.62**	feet
Vertical Sag	**VD.2**	**1.827**	m		



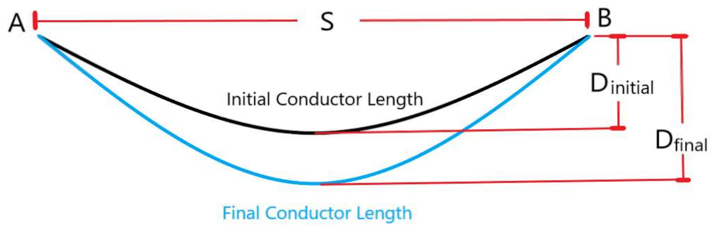
TOTAL EFFECT OF ICE AND WIND

Conductor Lengths:

Initial Conductor Length	**L.1**	**200.074**	m
Final Conductor Length	**L.2**	**200.046**	m

Tensions:

Initial Horizontal Tension	**H.1**	**31,771.02**	Newtons	
Initial Tension @ supports	**T.1**	**31,806.35**	Newtons	**25% of Rated Tensile Strength**
Final Horizontal Tension	**H.2**	**40,994.80**	Newtons	
Final Tension @ supports	**T.2**	**41,023.32**	Newtons	**32% of Rated Tensile Strength**



Cond. LENGTH: $L = S\left[1 + \frac{S^2W^2}{24H^2}\right]$

$SAG: D = \frac{H}{W}\left[\cosh\frac{SW}{2H} - 1\right]$

$T_{average\ at\ supports\ (same\ level)} = H + WD$