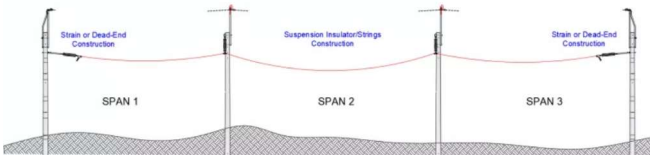
CATENARY SAG-TENSION CALCULATOR (by: Jared Cuchapin, 2018)



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

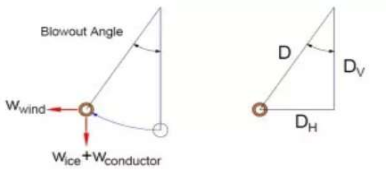
	Variable Symbol	Value	Unit
Span Length (Ruling Span)	**S**	200	m
Conductor Name		Condor	
Conductor Size		***795**	
Stranding		***54/7**	
Diameter	**dia**	**0.027760845**	m
Cross-sectional Area	**A**	**0.0004548**	m^2
Final Modulus of Elasticity	**E**	**59000000000**	N/m^2
Coefficient of Linear Thermal 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 250B

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**	-1	deg C	
2. Wind Load				
Wind Pressure	**P**	430	Pa (N/m^2)	*(Refer to applicable standards, NESC 2017 or ASCE.)*
Additional Conductor Weight due to wind	**W.wind**	**11.937**	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	

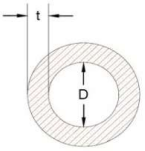


TOTAL EFFECT OF ICE AND WIND

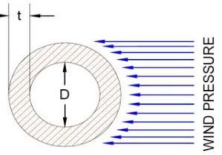
$$W_{ice} = Volume\ x\ density = \rho_{ice}\pi t(D+t)$$

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

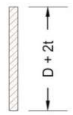
$$W_{total} = \sqrt{(W+W_{ice})^2 + (W_{wind})^2}$$



EFFECT OF ICE



EFFECT OF WIND



Projected Area

NESC "k" constant	**k**	**0.074**	kg/m		
Resultant Conductor Weight	**W.2**	**19.886**	N/m		
Blowout Angle	**theta**	**0.673**	radians	**38.567**	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

$$H_2^3 + H_2^2\left(\frac{(W_1S)^2AE}{24H_1^2} - H_1 + (t_2 - t_1)\alpha AE\right) - \frac{(W_2S)^2AE}{24} = 0$$

ANOTHER FORM OF CSCE:

$$H_2^3 + A\,H_2^2 - B = 0 \quad \text{where:} \quad B = (W_2\,S\,C_1)^2 \qquad C_2 = \alpha\,EA$$

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

Coefficients:

_A	**-30113.05219**
B	**1.76848E+13**
_C1	**1057.378835**
_C2	**517.88076**

$H_2^3 + A\,H_2^2 - B = 0$		0	>>>>>>>>>>>	***Note:*** *To solve the cubic equation, you have 2 options*
Final Horizontal Tension	**H.2**	**40,758.497**	Newtons	***1) MANUALLY:*** *use the* ***"goalseek"*** *command of excel. See Manual.*

<<<<<<<<<<

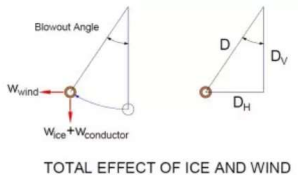
OR

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

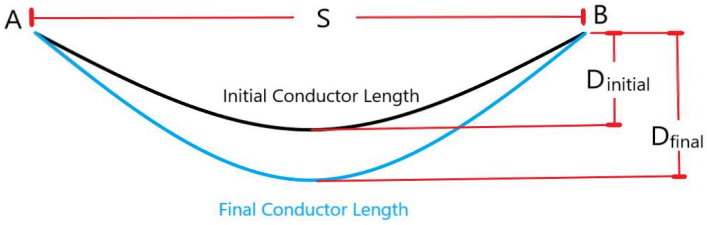
STOP! Do not proceed to "results summary" until "goalseek" have been performed.

RESULTS SUMMARY:

Sags:					
Initial Conductor Sag	**D.1**	**2.358**	m	Difference	*(Negative value represents Cold Uplift.)*
Final Conductor Sag	**D.2**	**2.440**	m	**0.08**	meters
Horizontal Sag	**HD.1**	**1.520**	m	**0.27**	feet
Vertical Sag	**VD.2**	**1.908**	m		
Conductor Lengths:					
Initial Conductor Length	**L.1**	**200.074**	m		
Final Conductor Length	**L.2**	**200.079**	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**	**40,758.50**	Newtons		
Final Tension @ supports	**T.2**	**40,807.02**	Newtons	**32% of Rated Tensile Strength**	



TOTAL EFFECT OF ICE AND WIND



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

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

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