ACES CATS

Calculation of ADSS Tension and Sag

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PURPOSE STATEMENT / COURSE DESCRIPTION

- ADSS ENGINEERING 102 – Sag and Tension will teach you how to obtain the sag and tension data that you need for your project.

- We will explain and illustrate three methods of obtaining sag and tension data as per industry practice today:
  1. Using tabulated data supplied by cable manufacturers,
  2. Generating data using ACES CATS, and
  3. Using PLS-CADD to perform sag and tension calculations.

- Then we will discover how the preceding is technically incorrect, but why it is nevertheless helpful. This will lead us to consider the difference between mechanically independent versus mechanically coupled spans. From this, we will learn when today's practice is appropriate, and when the ruling span concept should be applied and sag and tension data obtained from computer programs such as PLS-CADD.

- Along the way, we will explain the meaning and importance of a cable's "Maximum Rated Design Tension" (MRDT), and how it should be used in sag and tension calculations. And, we will do likewise for Zero Fiber Strain Margin (ZFSM).

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LEARNING OBJECTIVES

After this class you will be able to:

- Be able to obtain basic sag and tension data for your ADSS cable using these sources:
  1. Tabulated data supplied by cable manufacturers,
  2. Self-generated data using ACES CATS (and be able to use it), and
  3. Computer programs, in particular PLS-CADD.
- Explain the meaning and importance of a cable's Maximum Rated Design Tension (MRDT), Zero Fiber Strain Margin (ZFSM) and how these should be incorporating into sag and tension data.
- State the implicit assumptions of industry practice for ADSS sag and tension data.
- Explain the difference between mechanically independent and mechanically coupled spans.
- Know when it is more appropriate to apply the ruling span concept and use PLS-CADD or other computer software to generate sag and tension data for ADSS.

Incab University "School of Excellence in Fiber Optics" curriculum

Learning Hub

INCABAMERICA.COM

Webinar Rules

- Introduction and sound check
- Presentation: 45 min
- Use chat for questions during presentation
- Q&A (NB! Technical questions only): 15 min
- Let's start!

ADSS sag and tension data

- Let’s begin our study of ADSS sag and tension with three observations…

ADSS sag and tension data

Sag and tension observation 1

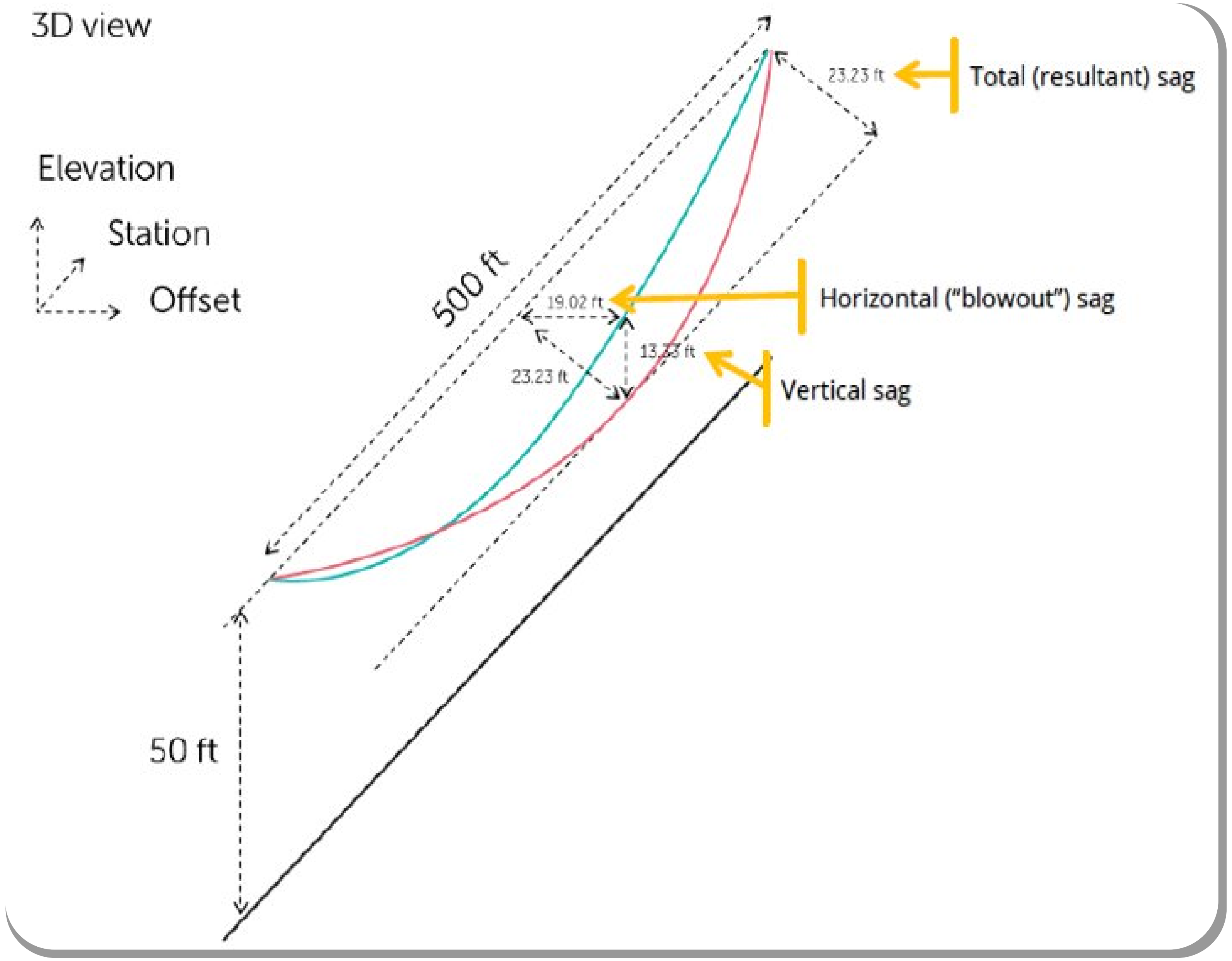
- If someone tells you:
  "Snow and ice don't accumulate on ADSS in the field"
- Please show them this picture
- It is a myth that ice does not accumulate on ADSS!
- Vertical sag under ice loading can exceed ground clearance, and consequently, it must be checked!

Note how large the sag is too

ADSS sag and tension data

Sag and tension observation 2

- Wind conditions are especially important for ADSS
- ADSS is light and elastic
- Consequently, horizontal blowout during wind loading can be significant and must be checked!



ADSS sag and tension data

Sag and tension observation 3

- Because ADSS is very elastic, strength is needed to control fiber strain
  - Fiber strain can lead to optical failure over time

- OK. This prompts the question: What is fiber strain, and why is it important?

ADSS sag and tension data

Side tour: Fiber Strain

What is fiber strain, and why is it important?

- Fiber strain is tension on the fiber

- Optical fiber is strong, but it is glass, so it is brittle
  * Thus, keeping tension off the fiber is a good idea ℗ enhances reliability
    - "No strain, no problems"
  * Fiber is especially vulnerable to adverse effects from cyclic loading

- Fiber Strain Margin is the difference between the tension on the cable and the tension on the fiber
  * The "Zero Fiber Strain Margin" (ZFSM) is the point at which the optical fibers begin to experience tension
  * General Guideline: The higher the ZFSM, the better

ADSS sag and tension data

Let's connect the three observations

- In order to properly check clearances, sag and tension calculations for ADSS need to factor in ice and wind loading

- Note: Industry practice has been to have "installation" or "everyday" sag = 1% or 1.5% of span
  - More recently have seen 0.75% and even 0.5% (risky in my opinion)

And…

ADSS sag and tension data

Let’s connect the three observations, cont’d

- Fiber strain should be minimized (or zero fiber strain margin maximized)

— “Best Practice” is zero fiber strain through “MRDT” (defined on next slide)
Ⓟ This is Incab’s design standard, but sometimes not practical

— Acceptable alternates (with increasing risk):
- Zero fiber strain at nominal (unloaded) tension (“everyday”)
- Limited fiber strain at maximum (loaded) tension (MRDT)
  - * Good, ≤ 0.2%
    - Conservative limit derived from Corning research
  - * Not too bad, ≤ 0.3%
    - Acceptable for today’s fiber, but does have some risk
  - * Risky, ≤ 0.4% 🙈 Greater than this is just plain crazy!

All cable suppliers have a design policy on fiber strain!
(Though not always clearly disclosed)

Sag and tension data generation

MAXIMUM RATED DESIGN TENSION (MRDT)

- MRDT (= MRCL “maximum rated cable load”) is an especially important cable specification!
  - MRDT = The tension the cable should *NEVER, EVER* exceed under *any* loading condition!
  - MRDT (MRCL) is *NOT* the same as Rated Breaking Strength (RBS)!
  - Typically, MRDT (MRCL) is 50 – 65% of RBS

Sag and tension data generation

DATA GENERATION IN 3 EASY STEPS!

- Step 1 = Review your loading criteria
- Step 2 = Get the cable specifications
- Step 3 = Get or generate the data

Let’s explore each step…

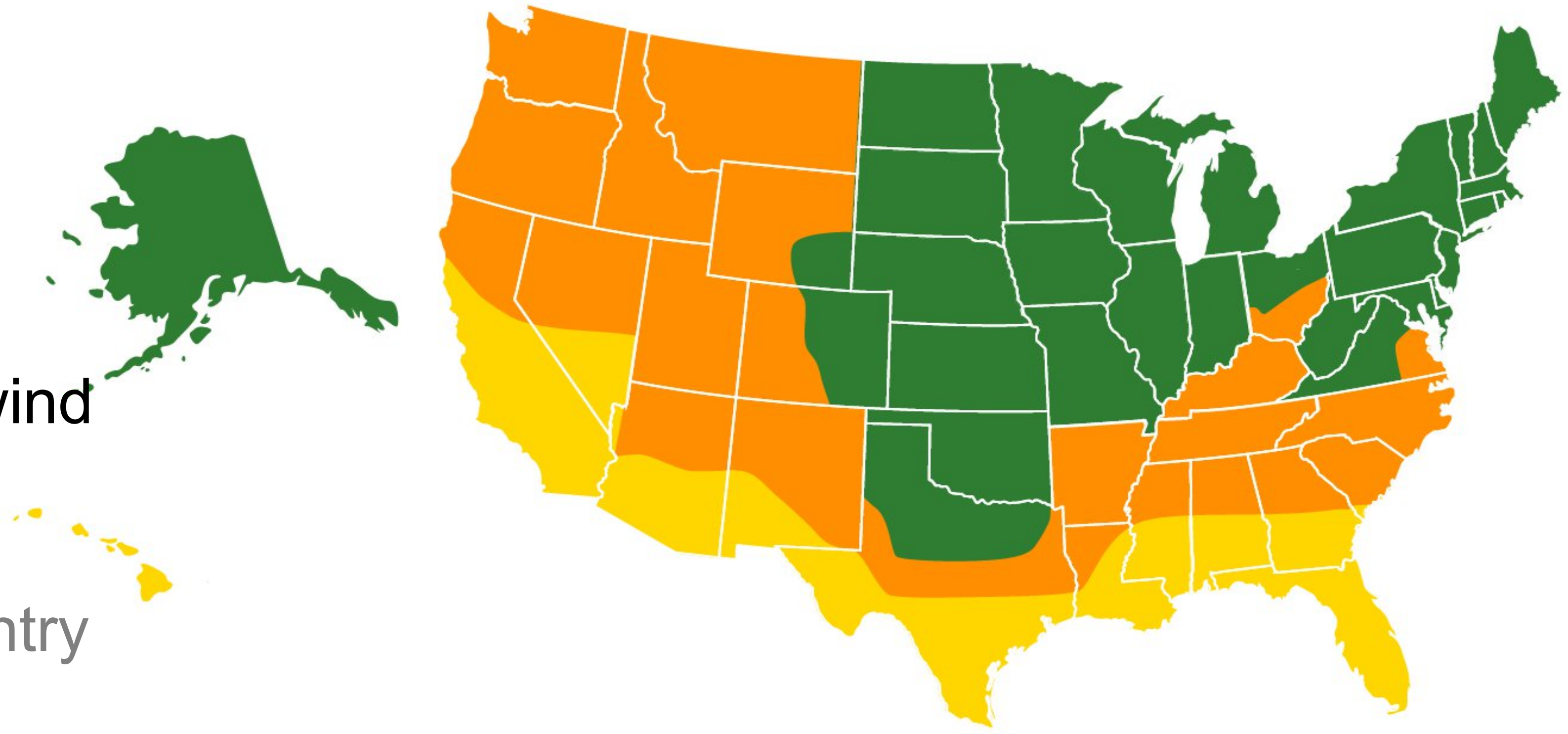
Sag and tension data generation

STEP 1: REVIEW YOUR LOADING CRITERIA

- Determine your base loading criteria
    * NESC Rule 250B loading zone
    * Alternate for your state or country

Few do, but…

- Do you have "extreme ice" or "concurrent wind and ice" conditions?
    * NESC Rule 250C and D
    * Additional criteria for your state or country
- Criteria unique to your utility or project?
    * Tension limits?
    * Sag limits?



Sag and tension data generation

STEP 2: GET THE CABLE SPECIFICATIONS

- Basic cable specifications are needed to generate sag and tension data:

  1. Outside diameter (inches or mm)
  2. Unit weight (lb/ft or kg/km)
  3. Maximum Rated Design Tension (MRDT)
  4. Cable modulus (Which to use? We'll come back to that.)
  5. Linear expansion coefficient
  6. Strain limit. Ideally the "zero fiber strain margin" (ZFSM)

- You'll find these on the cable datasheet or ask the cable manufacturer

℗ Let's look at typical cable datasheets from various suppliers and see how they present this information….

Sag and tension data generation

STEP 2: GETTING THE SPECIFICATIONS – INCAB

- **InAir ADSS-MT Aramid DJ-144U (12x12)-13kN**

	Design details		
	Fiber count		144
	Number of loose tubes		12
	Fibers per loose tube		12
	Number of fillers		-
	Loose tube diameter	mm (in)	3.0 (0.118)
	Inner jacket thickness	mm (in)	0.7 (0.028)
	Outer jacket thickness	mm (in)	1.6 (0.063)
① →	Cable diameter ± 0.2 (0.008)	mm (in)	20.3 (0.799)
② →	Cable weight	kg/km (lb/ft)	298.1 (0.2)
③ →	Maximum rated design tension	kN (lb)	13.0 (2923)
⑥ →	Zero fiber strain margin	kN (lb)	10.6 (2383)
	Stringing tension (STT)	kN (lb)	3.25 (731)
	Rated breaking strength (RBS)	kN (lb)	20.0 (4497)
④ →	Modulus of elasticity, initial	kN/mm^2 (ksi)	3.87 (561)
	Modulus of elasticity, final	kN/mm^2 (ksi)	4.17 (606)
	10-year modulus of elasticity, creep	kN/mm^2 (ksi)	3.01 (438)
	Cable cross-sectional area	mm^2 (in^2)	322.4 (0.5)
⑤ →	Coefficient of thermal expansion, 10^{-6}	1/°C (1/°F)	15.52 (8.62)

Note: We will discuss modulus later

Sag and tension data generation

STEP 2: GETTING THE SPECIFICATIONS – PRYSMIAN

- 72F SM ADSS LONG SPAN PKP 1581LB (12F/T) TR (#ADLT1581-12-HB-072)

Cable Specifications:

③ →	Maximum Rated Cable Load: = MRDT	1581	lb
① →	Cable Diameter:	0.508	in
	Cross Sectional Area:	0.203	in²
② →	Cable Weight:	0.099	lb/ft
	Ultimate Tensile Strength:	3954	lb
	Sheath Configuration:	Dual Jacket	
	Outer Jacket Type:	Track Resistant	

Additional Design Information for PLS-CADD & SAG10:

④ →	Initial Modulus of Elasticity:	918	kpsi
	10-year Modulus of Elasticity:	843	kpsi
	Final Modulus of Elasticity:	918	kpsi (See note 2)
⑤ →	Coefficient of Thermal Expansion:	1.80E-05	1/°F

Maximum Tension At Maximum Span:

⑥ Long Term: (See note 1) 638 lb ≤ ZFSM

Short Term: 1575 lb ≤ MRDT = OK

Note 1: Fiber Strain Margin ⑥ is not directly shown, but is factored into their sag & tension data (will see this later)

Note 2: Initial = Final = Not really. This is a simplification that's OK in the distribution world…More on this later

Sag and tension data generation

STEP 2: GETTING THE SPECIFICATIONS – OFS

- **AT-XXX27D6-048-TMEE-JX**

Tension @ Maximum Span for 1 % Installation Sag				
③ →	Short Term	Used as MRDT	1815 kg	4002 lb
⑥ →	Long Term	(See note)	898 kg	1979 lb
Specifications:				
	Maximum Span		389 m	1276 ft
② →	Cable Weight		0.185 kg/m	0.124 lb/ft
① →	Cable Diameter		15.2 mm	0.599 in
	Installation Temp		20 C	68 F
④ →	Cable Modulus		1002.1 kg/mm^2	1425.6 kpsi
⑤ →	Linear Expansion Coefficient		0.00000451 1 / C	0.00000251 1 / F
	Estimated Break Load		3283 kg	7240 lb

Note ⑥ Fiber Strain Margin is not directly shown. The “Long Term” tension is used as the maximum “everyday” (no ice, no wind) tension, but this tells you nothing about the fiber strain or ZFSM

Sag and tension data generation

STEP 2: GETTING THE SPECIFICATIONS – AFL

- **AE0489C521AA1**

	Physical / Mechanical / Electrical Characteristic		Metric	English
① →	Approximate Cable Diameter		12.7 mm	0.500 in
② →	Approximate Cable Weight		123 kg/km	0.083 lbs/ft
	Approximate Cable Breaking Strength		564 kg	1,244 lbs
	Minimum Bending Radius	Static	127 mm	5 in
		Dynamic	256 mm	12 in
③ →	Maximum Rated Cable Load (MRCL) = MRDT		285 kg	628 lbs
⑤ →	Coefficient of Linear Expansion		3.64E-05 1/°C	2.02E-05 1/°F
④ →	Cable Modulus	Initial	2.00 kN/mm²	290.7 kpsi
		10 Year	1.67 kN/mm²	242.3 kpsi
		Final	2.16 kN/mm²	313.5 kpsi

⑥ Fiber Strain Margin - Not provided by this supplier, nor an “everyday” or long-term limit. Must ask.

ADSS sag and tension

STEP 3: GETTING SAG AND TENSION DATA

- Three sources
  Traditionally: Manufacturer-provided tables
    - Generally limited to standard NESC loading conditions
    - Ask cable supplier if you need other conditions

- ACES CATS – A new, fun, and useful way to generate the data that you need!
    - Can be used for any supplier's cable!

- Generate your own data using Power Line® Systems PLS-CADD or Southwire™ Sag10®
    - Will only consider PLS-CADD today

Let's look at each source, starting with data tables from the same four suppliers

Sag and tension data generation

DATA TABLES – INCAB

ACES CATS | Advanced Cable Engineering System for Calculation of ADSS Tensions and Sags

ADSS Sags And Tensions Data

Cable Specifications:

Cable Specs

Cable Diameter	20.3	mm	0.799	in
Cable Weight	298.1	kg/km	0.200	lb/ft
Cable Modulus	3.9	kN/mm^2	561	kpsi
Coefficient of Thermal Expansion	27.94	1/°C, 10^{-6}	15.52	1/°F, 10^{-6}

Cable Description:

InAir ADSS MT Aramid DJ-144U (12x12)-13kN

Maximum Operating Tension:

MRDT Max Load	13.0	kN	2923	lbs
Max. Everyday	10.6	kN	2383	lbs

MRDT → MRDT Max Load

"Maximum Everyday" = ZFSM → Max. Everyday

Loading Condition:

	NESC Heavy			
Ice Thickness	12.70	mm	0.50	in
Wind Pressure	191.50	N/m^2	4.00	psf
K Factor	4.38	N/m	0.30	lbf/ft

Loading Conditions

Sag and tension data generation

DATA TABLES – INCAB

Nominal/No Loading. Installation Temperature 68 F°			
Span (ft)	Sag (ft)	Sag (%)	Tension (lb)
50	0.75	1.5	83
100	1.50	1.5	167
150	2.25	1.5	250
200	3.00	1.5	334
250	3.75	1.5	417
300	4.50	1.5	501
350	5.25	1.5	584
400	6.00	1.5	668
450	6.75	1.5	751
500	7.50	1.5	835
550	8.25	1.5	918
600	9.00	1.5	1002
650	9.75	1.5	1085
700	10.50	1.5	1168
720	10.80	1.5	1202

Data for “Everyday” condition (no wind, no ice)

At Loading Condition. Temperature -4 F°				
Sag (ft)	% Span (%)	H Sag (ft)	V Sag (ft)	Tension (lb)
0.94	1.9	0.48	0.81	493
2.43	2.4	1.24	2.09	758
4.21	2.8	2.14	3.62	987
6.17	3.1	3.15	5.31	1196
8.29	3.3	4.23	7.13	1390
10.54	3.5	5.38	9.07	1575
12.90	3.7	6.58	11.10	1752
15.36	3.8	7.83	13.21	1922
17.90	4	9.13	15.40	2088
20.52	4.1	10.46	17.65	2248
23.21	4.2	11.83	19.96	2405
25.96	4.3	13.24	22.33	2558
28.78	4.4	14.68	24.76	2708
31.65	4.5	16.14	27.23	2856
32.82	4.6	16.74	28.23	2914

Data for loaded condition

“Sag” is total.

“H Sag” = horizontal component to check blowout

“V Sag” = vertical component to check ground clearance

Sag and tension data generation

DATA TABLES – PRYSMIAN

ADSS SAG AND TENSION PROPERTIES

Requirements of: **Customer**

Fiber Count:	72	Fibers
Maximum Span:	775	ft
Installation Sag:	1.5	%
Installation Temperature:	60	ºF
Fiber Strain:	SafeStrain	

= Fiber strain = 0 at “everyday” and ≤ 0.2% (?) at MRDT. Ask to confirm.

Cable Specifications:

Cable Specifications

MRDT → Maximum Rated Cable Load

Maximum Rated Cable Load:	1581	lb
Cable Diameter:	0.508	in
Cross Sectional Area:	0.203	in²
Cable Weight:	0.099	lb/ft
Ultimate Tensile Strength:	3954	lb
Sheath Configuration:	Dual Jacket	
Outer Jacket Type:	Track Resistant	

For comparison.
“ZeroStrain” = Fiber strain = 0 at “everyday” and 0 at MRDT

Loading Conditions: **NESC Medium**

Loading Conditions

Ice Thickness:	0.25	in	
Wind Pressure:	4.0	psf	
Temperature:	15	ºF	
Safety Factor:	0.20	lb/ft	
Maximum Space Potential:	25.0	kV	Low Pollution per IEEE 1222-2011
Maximum Space Potential	15.0	kV	High Pollution per IEEE 1222-2011

Cable Description: **72F SM ADSS LONG SPAN PKP 1581LB (12F/T) TR**
Part Number: **ADLT1581-12-HB-072**

Sag and tension data generation

DATA TABLES – PRYSMIAN

Installation

Span ft	Installation Sag ft	Installation Sag % Span	Install. Tension lb
77.5	1.2	1.5%	64
155.0	2.3	1.5%	128
232.5	3.5	1.5%	191
310.0	4.7	1.5%	255
387.5	5.8	1.5%	319
465.0	7.0	1.5%	383
542.5	8.1	1.5%	447
620.0	9.3	1.5%	510
697.5	10.5	1.5%	574
775.0	11.6	1.5%	638

Data for "Everyday" condition (no wind, no ice)

Maximum Loading Conditions

Span ft	Loaded Vert. Sag ft	Loaded Horiz. Sag ft	Maximum Tension lb	Cable Angle Degrees	No Wind Vert. Sag ft
77.5	1.1	1.1	317	45	1.5
155.0	2.8	2.9	505	45	3.6
232.5	4.8	4.9	668	45	6.2
310.0	7.1	7.1	817	45	9.0
387.5	9.4	9.5	956	45	12.0
465.0	11.9	12.0	1089	45	15.2
542.5	14.6	14.6	1216	45	18.5
620.0	17.3	17.4	1339	45	22.0
697.5	20.1	20.2	1459	45	25.5
775.0	23.0	23.1	1575	45	29.2

Data for loaded condition

Notice: "Ice Only" vertical sag

"Horiz. Sag" = horizontal sag to check blowout

"Vert. Sag" = vertical sag to check ground clearance

Sag and tension data generation

DATA TABLES – OFS

Product Description: AT-XXX27D6-048-TMEE-JX - Maximum Span 1276 ft

8 Positions
0.7 mm Inner Jacket
2.5 mm Tubes

Loading Conditions ***USER DEFINED***

Loading Conditions

Ice Thickness	0 mm	0 in.
Wind Pressure	1061 N/m^2 (149.9 km/hr)	22 psf (93.1 MPH)
Temperature	-1.1 C	30 F
Safety Factor	0 N/m	0 lb/ft

Tension @ Maximum Span for 1 % Installation Sag

MRDT → Short Term

"Maximum Everyday" ≠ ZFSM → Long Term
(no info about fiber strain!
You should ask.)

Short Term	1815 kg	4002 lb
Long Term	898 kg	1979 lb

Specifications:

Cable Specs

Maximum Span	389 m	1276 ft
Cable Weight	0.185 kg/m	0.124 lb/ft
Cable Diameter	15.2 mm	0.599 in
Installation Temp	20 C	68 F
Cable Modulus	1002.1 kg/mm^2	1425.6 kpsi
Linear Expansion Coefficient	0.00000451 1 / C	0.00000251 1 / F
Estimated Break Load	3283 kg	7240 lb

Maximum Cable Length: Dependent on construction and/or fiber type

Singlemode	7,700 m	25,262 ft
62.5/125 Multimode	7,700 m	25,262 ft

Sag and tension data generation

DATA TABLES – OFS

Data for "Everyday" condition (no wind, no ice)

Data under loaded conditions

"H Sag" = horizontal sag to check blowout
"V Sag" = vertical sag to check ground clearance

No Loading @ Install Temperature 68 F

Span ft	Sag ft	Install Sag %	Tension lb
100	1.0	1.00	155
200	2.0	1.00	310
300	3.0	1.00	465
400	4.0	1.00	620
500	5.0	1.00	775
600	6.0	1.00	930
700	7.0	1.00	1085
800	8.0	1.00	1241
900	9.0	1.00	1396
1000	10.0	1.00	1551
1100	11.0	1.00	1706
1200	12.0	1.00	1861
1276	12.8	1.00	1979

All Loading Conditions @ Temperature 30 F

Vertical Sag % of Span	Tension lb	Vertical Sag ft	Horizontal Sag ft	Angle Deg
0.2	618	0.2	2.2	84
0.3	1027	0.6	5.4	84
0.3	1378	1.0	9.0	84
0.4	1699	1.5	13.0	84
0.4	2001	1.9	17.3	84
0.4	2286	2.4	21.8	84
0.4	2560	2.9	26.5	84
0.4	2826	3.5	31.3	84
0.4	3084	4.0	36.3	84
0.5	3335	4.6	41.5	84
0.5	3581	5.2	46.7	84
0.5	3822	5.8	52.1	84
0.5	4002	6.3	56.3	84

Notice how much blowout!

Sag and tension data generation

DATA TABLES – AFL

Tel: 1 800 235 3423
Fax: 1 864 433 5560

AE0489C521AA1

Cable Specs

MRDT

Physical / Mechanical / Electrical Characteristic		Metric	English
Approximate Cable Diameter		12.7 mm	0.500 in
Approximate Cable Weight		123 kg/km	0.083 lbs/ft
Approximate Cable Breaking Strength		564 kg	1,244 lbs
Minimum Bending Radius	Static	127 mm	5 in
	Dynamic	256 mm	12 in
Maximum Rated Cable Load (MRCL)		285 kg	628 lbs
Coefficient of Linear Expansion		3.64E-05 1/°C	2.02E-05 1/°F
Cable Modulus	Initial	2.00 kN/mm^2	290.7 kpsi
	10 Year	1.67 kN/mm^2	242.3 kpsi
	Final	2.16 kN/mm^2	313.5 kpsi

Note: Neither "Maximum Everyday" nor ZFSM/fiber strain info shown. You should ask.

Sag and tension data generation

DATA TABLES – AFL

Note: Just for one span length (which allows them to show multiple loading conditions)

Span Length (ft) 400

Condition	Wind (mi/hr)	Radial Ice (inches)	Add'l Load (lbs/ft)	Input Data Vert. (ft)	Input Data Horiz. (ft)	Input Data Vector (ft)	Resultant Data Vert. (ft)	Resultant Data Horiz (ft)	Resultant Data Vector (ft)	Resultant Data Tension (lbs)
Installation	---	---	---	4.0	---	---	4.00	---	4.0	415
Ice Alone	---	---	---	---	---	---	---	---	---	---
Wind Alone	---	---	---	---	---	---	---	---	---	---
Ice and Wind	---	---	---	---	---	---	---	---	---	---
NESC Light	60.0	---	0.1	---	---	---	3.09	14.3	14.6	605
Other	---	---	---	---	---	---	---	---	---	---

Standard NESC / CSA condition based on Ice Density of 57 lbs/ft³

Data for "Everyday" condition (no wind, no ice)

Loading Conditions

"Horiz." = horizontal sag to check blowout

"Vert." = vertical sag to check ground clearance

Sag and tension data generation

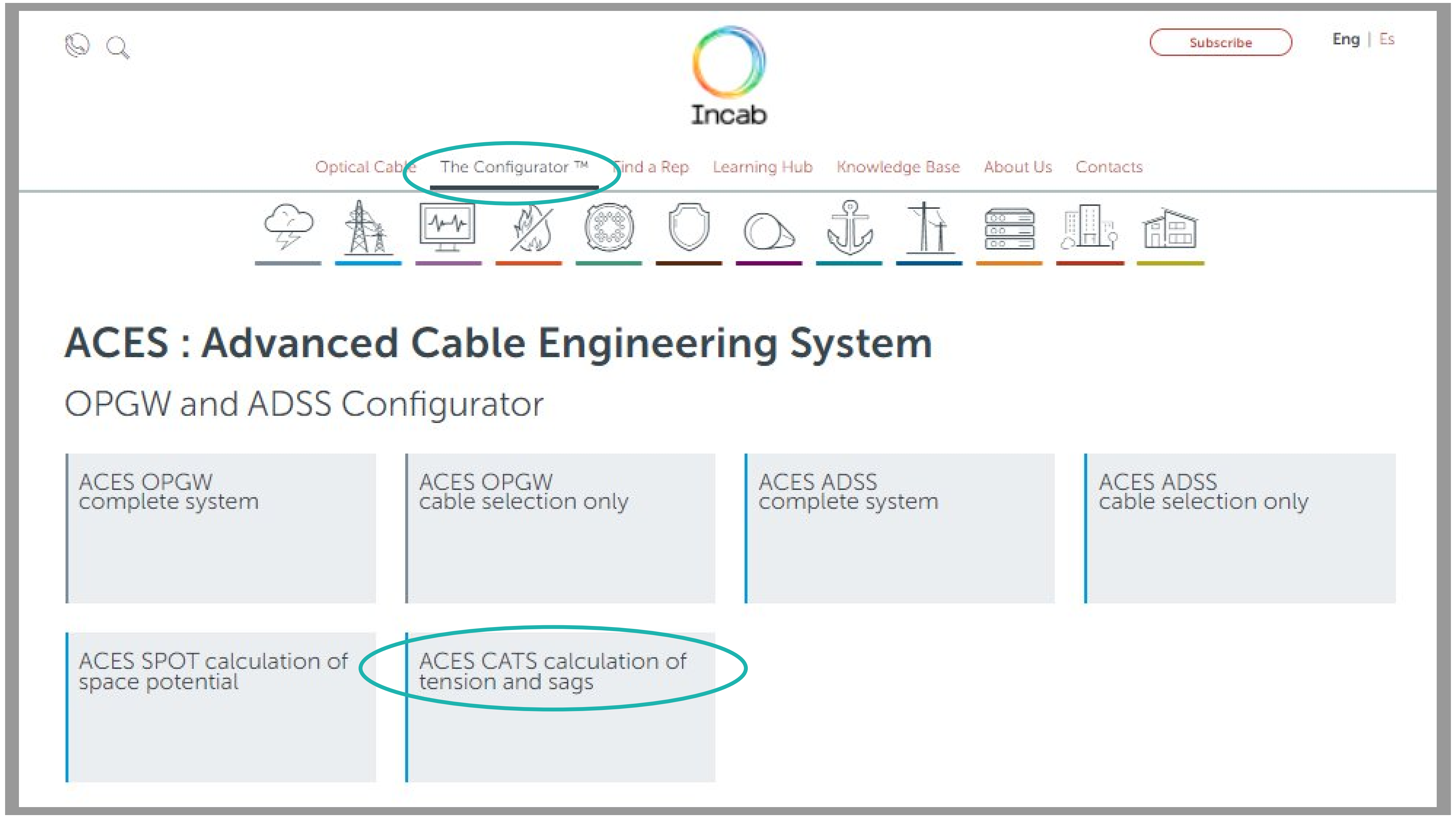
GENERATING YOUR OWN DATA USING ACES CATS

- It’s your data and you need it now!
- Greatly facilitates “what if” analysis
- Fast, easy, and fun
  (Perhaps I’ve been working with aerial cables too long)
- Can use for *any* supplier’s cable!
  - You just need the basic cable data that we have discussed

Sag and tension data generation

GENERATING YOUR OWN DATA USING ACES CATS

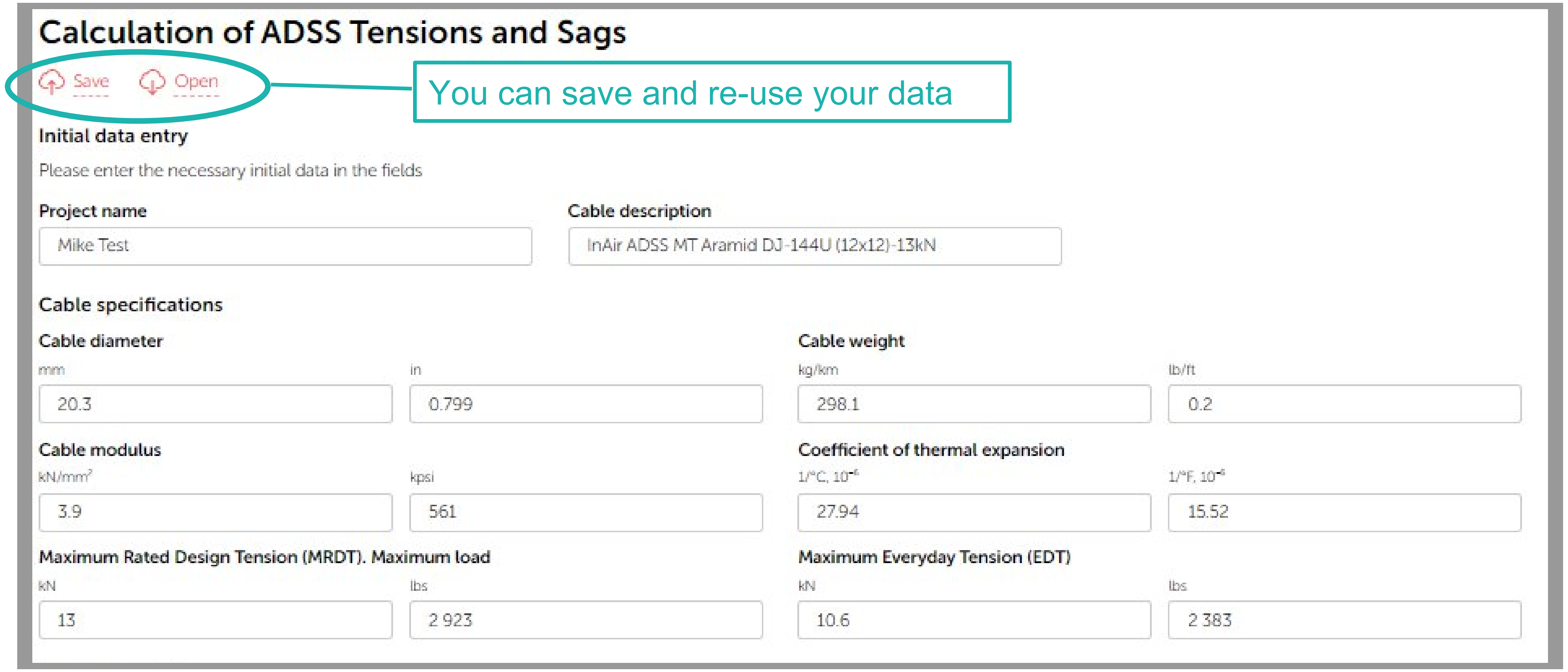
- Go to www.incabamerica.com and then select The Configurator™ followed by ACES CATS…



Sag and tension data generation

GENERATING YOUR OWN DATA USING ACES CATS

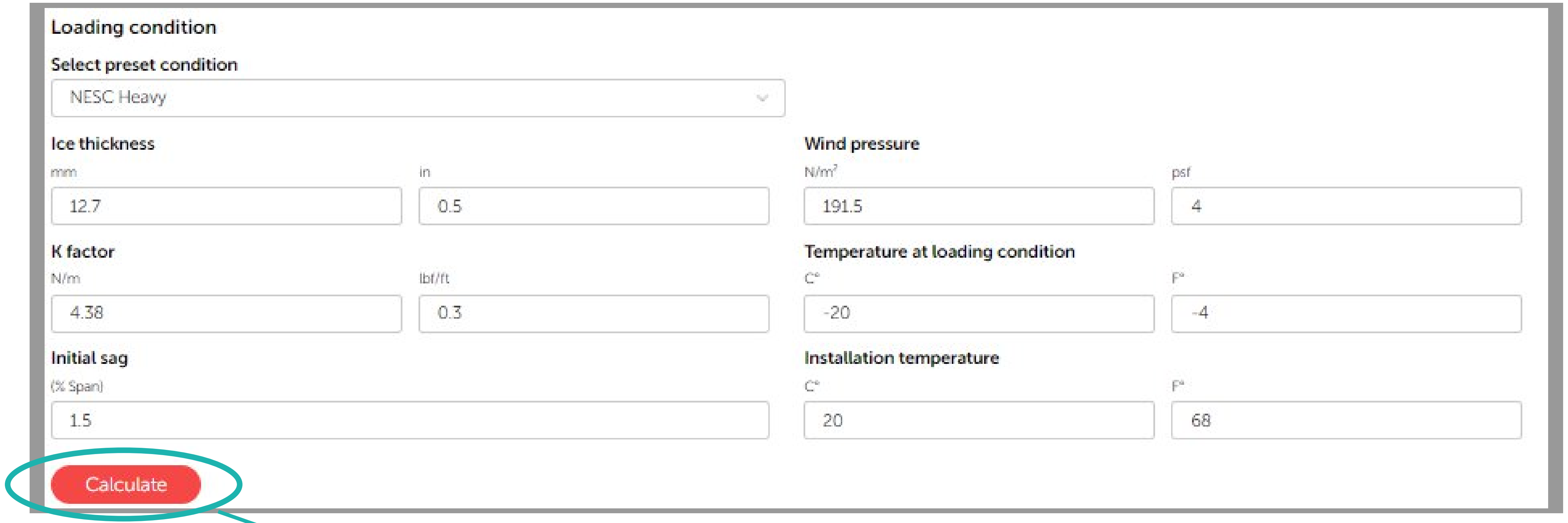
- Enter the cable data (all as we have discussed) in either customary or metric units (enter in either units…program automatically converts to the other)



Sag and tension data generation

GENERATING YOUR OWN DATA USING ACES CATS

- Select loading conditions or enter your own



Then hit "Calculate"

Sag and tension data generation

GENERATING YOUR OWN DATA USING ACES CATS

- Receive your data!

Can change unit system

Unit system

Imperial

Nominal / No loading. Installation temperature 68 F°			
Span (ft)	Sag (ft)	Span (%)	Tension (lb)
50	0.75	1.5	83
100	1.5	1.5	167
150	2.25	1.5	250
200	3	1.5	334
250	3.75	1.5	417
300	4.5	1.5	501
350	5.25	1.5	584
400	6	1.5	668
450	6.75	1.5	751
500	7.5	1.5	835
550	8.25	1.5	918
600	9	1.5	1002
650	9.75	1.5	1085
700	10.5	1.5	1168
720	10.8	1.5	1202

At loading condition. Temperature -4 F°				
Sag (ft)	Span (%)	H Sag (ft)	V Sag (ft)	Tension (lb)
0.94	1.9	0.48	0.81	493
2.43	2.4	1.24	2.09	758
4.21	2.8	2.14	3.62	987
6.17	3.1	3.15	5.31	1196
8.29	3.3	4.23	7.13	1390
10.54	3.5	5.38	9.07	1575
12.9	3.7	6.58	11.1	1752
15.36	3.8	7.83	13.21	1922
17.9	4	9.13	15.4	2088
20.52	4.1	10.46	17.65	2248
23.21	4.2	11.83	19.96	2405
25.96	4.3	13.24	22.33	2558
28.78	4.4	14.68	24.76	2708
31.65	4.5	16.14	27.23	2856
32.82	4.6	16.74	28.23	2914

Download pdf file

Can download as a pdf for reference or to share with colleagues, friends, or family!

Sag and tension data generation

CRITICALLY IMPORTANT NOTES!

All of the preceding reflects current industry practice, but strictly speaking, it is *not* correct!

- Two things are "not quite right"…

  1. Using only the initial value for modulus implies that ADSS is perfectly elastic with no difference between initial and final modulus, plus no creep!
     * We know this is *not* the case
     * Confirmed by the fact that 3 of 4 manufacturers gave different modulus values for initial, final, and 10-year/creep

Sag and tension data generation

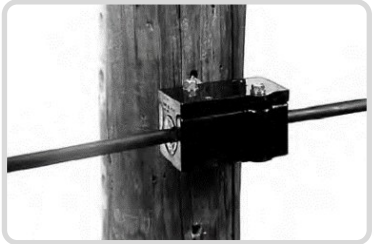
CRITICALLY IMPORTANT NOTES! (Continued)

- 2. Spans are treated individually, as if each is double-dead-ended
  - * Only true if each span strung and clipped individually
    - - “Mechanically Independent” spans (Illustrated on next slide)
    - - Such as “moving reel” installation with trunnion-type support clamps
  - * More commonly, “controlled tension” stringing (tensioner and pulling line) across multiple spans is used
    - - Plus, utilizing suspension clamps instead of trunnion-type supports
    - - “Mechanically coupled” spans
    - - Therefore, the “ruling span” concept governs the sag and tension
    - - Tension equalizes across all spans with sag greatest in longer spans
      - - Effectively, a weighted average (exact formula to follow soon)

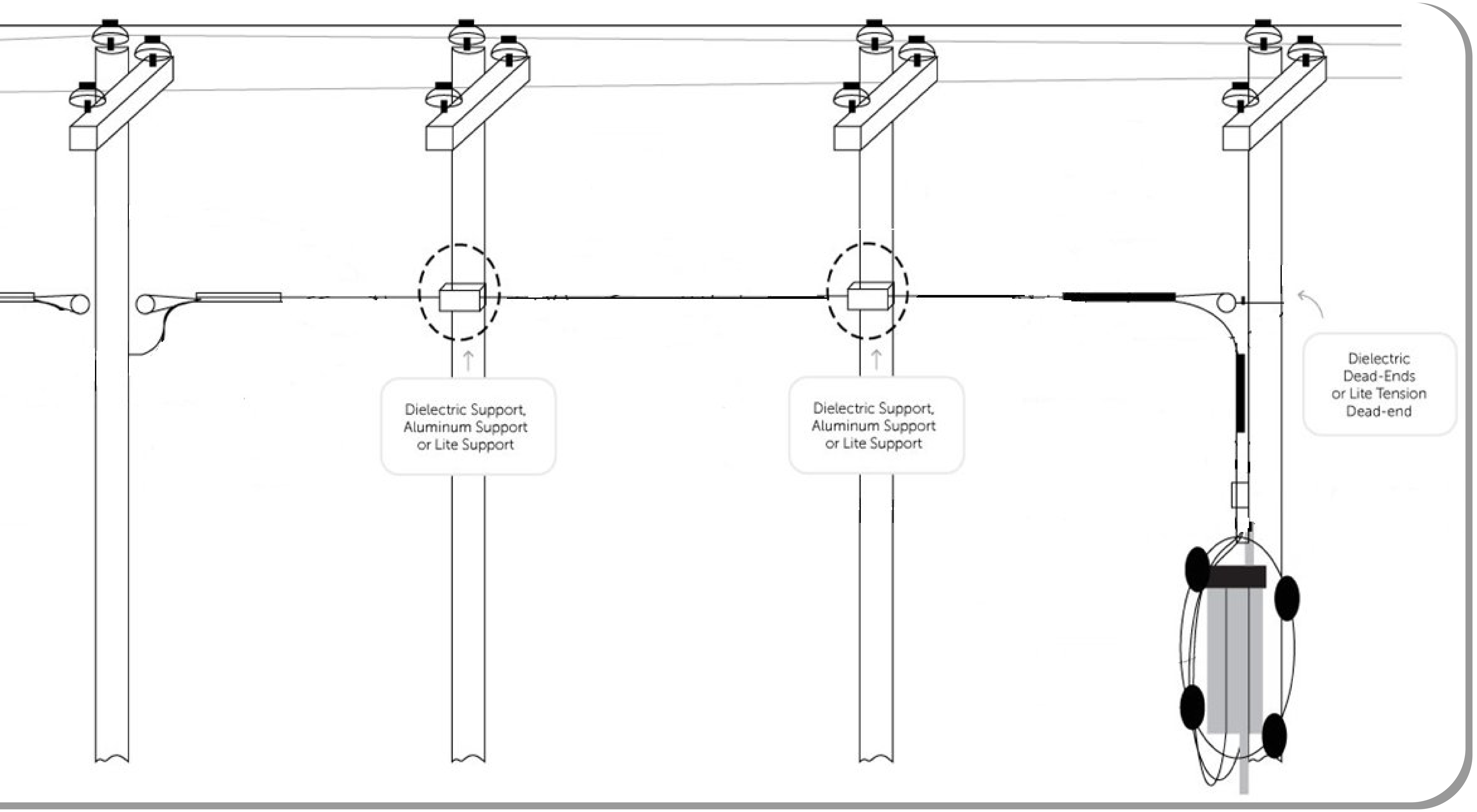
Yikes! Was everything to this point just a waste?

Sag and tension data generation

MECHANICALLY INDEPENDENT SPANS



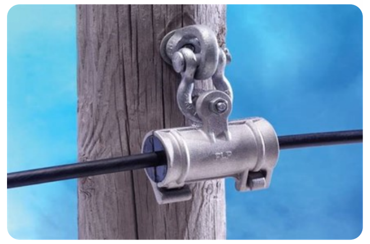
or



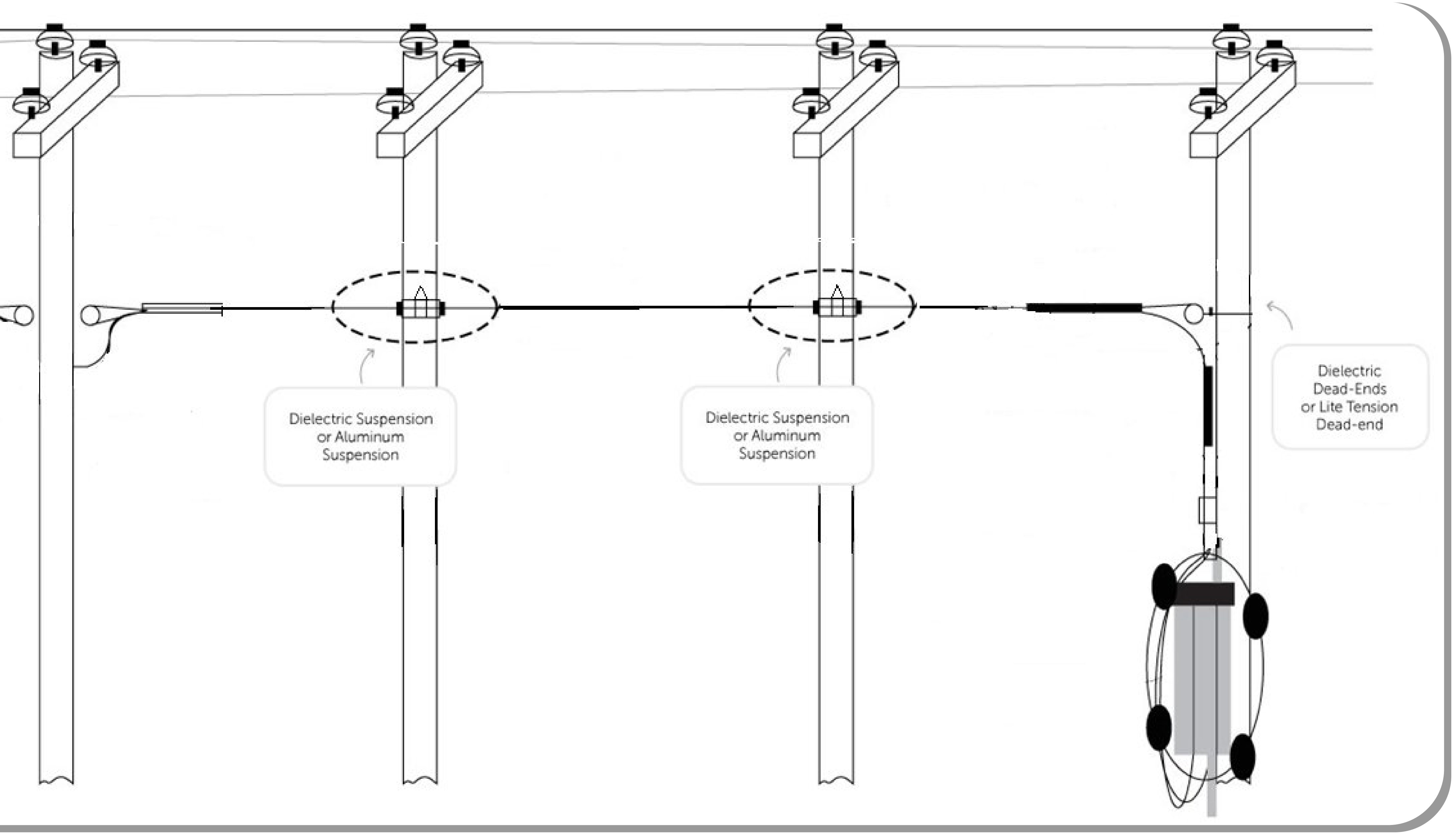
Supports create fixed points at each pole, so spans are mechanically <u>independent</u>

Sag and tension data generation

MECHANICALLY COUPLED SPANS



or



The articulation of a suspension clamp makes the spans mechanically coupled

Sag and tension data generation

UNDERSTAND THE LIMITATIONS

No! It just means you need to understand the limitations of our methodology so far!

- For “short” to “medium” spans in a distribution environment, the theoretical error is acceptable
  - * We know this is from experience, i.e. No problems in reality
  - * For ADSS, the change in sag and tension between installation (initial modulus) and final (final plus creep modulus) conditions is much lower than for metal cables (about half)
  - * Consider too sagging inaccuracies in the field
    - - This “real world factor” alone likely washes out the theoretical error

- Consider our method thus far the “Simplified Sag and Tension Solution”

Sag and tension data generation methods

WHEN TO USE WHAT

- OK, but now this leads to two questions:

1. When is it appropriate to use the so-called Simplified Solution?
   * First consider: What's a "short" and "medium" span?
     - Spans under 500 – 600 ft (≈ 150 – 200 m) and standard NESC loading conditions (or similar if outside the US)
   * Distribution circuits

2. What should I use when the so-called Simplified Solution is *not* appropriate?
   ℗ Use the **Ruling Span** concept in conjunction with sag and tension analysis software such as Power Line® Systems **PLS-CADD** or Southwire™ **Sag10**®
     - Recall that these are the third source of sag and tension data

Sag and tension data generation methods

RULING SPAN CONCEPT - DEFINED

- Mathematically: $$S_R = \sqrt{\frac{\sum S^3}{\sum S}} = \sqrt{\frac{S_1^3 + S_2^3 + \dots S_n^3}{S_1 + S_2 + \dots S_n}}$$

  where:

  S_R = the theoretical ruling span

  $S_1, S_2, \dots S_n$ = are the 1st, 2nd, … n^{th} span length respectively

- In words: The square root of the sum of the spans cubed divided by the sum of the spans
  - Effectively a weighted average leaning towards the longer spans

Note: The ruling span is very easily calculated in Excel from a list of the spans. PLS-CADD can also do it for you.

RULING SPAN CONCEPT - EXAMPLE

Span	Section	Span Length	
		ft	m
1	Pole 1 - Pole 2	217	66
2	Pole 2 - Pole 3	197	60
3	Pole 3 - Pole 4	246	75
4	Pole 4 - Pole 5	213	65

$S_R = \sqrt{(217^3 + 197^3 + 246^3 + 213^3)/(217 + 197 + 246 + 213)} =$ **220.4** ft

$S_R = \sqrt{(66^3 + 60^3 + 75^3 + 65^3)/(66 + 60 + 75 + 65)} =$ **67.2** m

Compare: Average span = 218.25 ft or 66.5 m

Sag and tension data generation methods

BACK TO PLS-CADD… SET-UP YOUR .WIR FILE

- Hint: It's good to know how to do this procedure and to understand what's in a .WIR file, but...
  - It's easier if you just ask for a .WIR file from the cable manufacturer
  - You can find a library of .WIR files by cable manufacturer at www.powline.com/files/cables

*Consequently, we will talk about this process very generally and very quickly

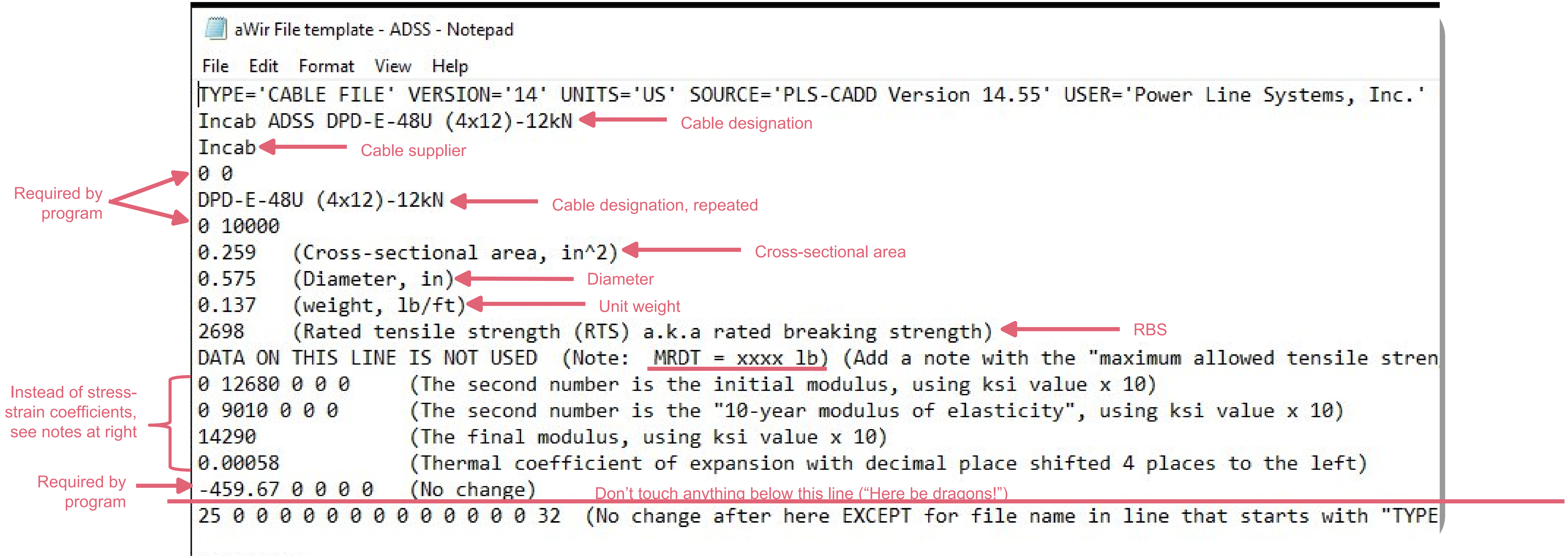
è Editing .WIR files for ADSS is not for the faint of heart!

- Proceed with extreme care!

Sag and tension data generation

BACK TO PLS-CADD - SET-UP YOUR .WIR FILE

- It's best to start with a "donor" .WIR file for ADSS and edit the data as in this example:



aWir File template - ADSS - Notepad

File Edit Format View Help

```
TYPE='CABLE FILE' VERSION='14' UNITS='US' SOURCE='PLS-CADD Version 14.55' USER='Power Line Systems, Inc.'
Incab ADSS DPD-E-48U (4x12)-12kN
Incab
0 0
DPD-E-48U (4x12)-12kN
0 10000
0.259   (Cross-sectional area, in^2)
0.575   (Diameter, in)
0.137   (weight, lb/ft)
2698    (Rated tensile strength (RTS) a.k.a rated breaking strength)
DATA ON THIS LINE IS NOT USED  (Note:  MRDT = xxxx lb) (Add a note with the "maximum allowed tensile stren
0 12680 0 0 0       (The second number is the initial modulus, using ksi value x 10)
0 9010 0 0 0        (The second number is the "10-year modulus of elasticity", using ksi value x 10)
14290               (The final modulus, using ksi value x 10)
0.00058             (Thermal coefficient of expansion with decimal place shifted 4 places to the left)
-459.67 0 0 0 0     (No change)
25 0 0 0 0 0 0 0 0 0 0 0 0 0 0 32  (No change after here EXCEPT for file name in line that starts with "TYPE
```


Continued on next slide…

Sag and tension data generation

BACK TO PLS-CADD - SET-UP YOUR .WIR FILE

Don't touch anything below this line ("Here be dragons!")

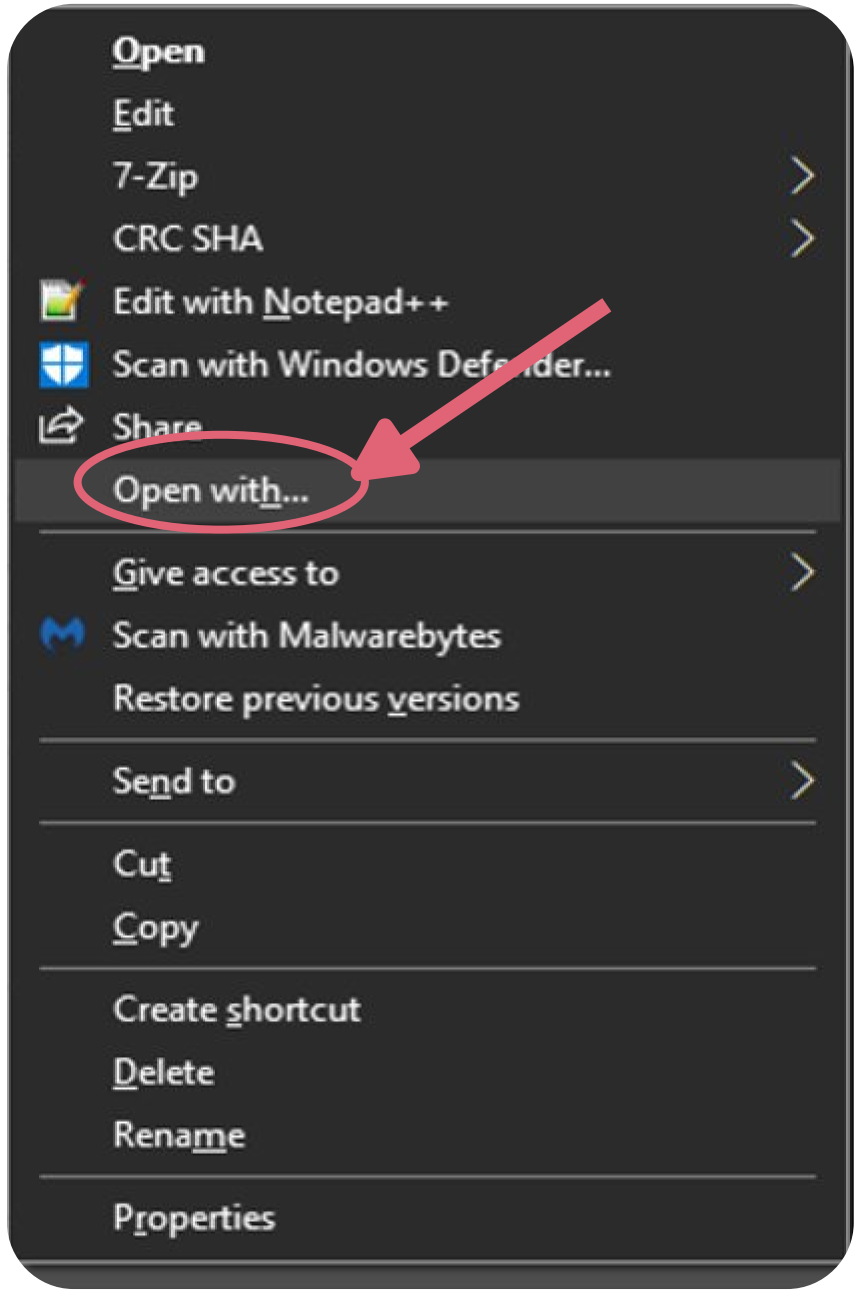
```
25 0 0 0 0 0 0 0 0 0 0 0 0 0 0 32  (No change after here EXCEPT for file name in line that starts with "TYPE

0 0 0 0 0
0 0 0 0 0
0
0
70
0 ; num_pts
0 ; num_pts
1 ; cable_file_type
0 0 32 32 0 0 0 0 0 0
1
0
0
0 2 0 0 0 0
0 1 0 0 0 0
255
TYPE='Property Notes File' VERSION='1' UNITS='US' SOURCE='PLS-CADD Version 14.55' USER='Power Line Systems
4 168
{\rtf1\ansi\ansicpg1252\deff0\deflang1033{\fonttbl{\f0\fmodern\fprq1\fcharset0 Courier New;}}
{\colortbl ;\red0\green0\blue0;}
\viewkind4\uc1\pard\cf1\f0\fs20
```

Required by program

Sag and tension data generation

WORKING WITH .WIR FILES

- You can open a .WIR file by right-clicking on it, selecting "Open With", and then selecting "Notepad"
  - It's a text file, so Notepad works best
- After editing it, save the new .WIR file
- Then, load the new .WIR file into PLS-CADD, complete your problem file, and let the program compute the sag and tensions for you



Sag and tension data generation

CRITICAL FINAL STEP

Remember MRDT? It's critical! And, ZFSM is darn important too!

- You must manually check in both PLS-CADD and Sag10 that tension never, ever exceeds the cable's MRDT!
  * If it does, you risk optical problems (short or long term)!
  * if it does, you risk a voided warranty!
- **Repeat:** The tension under any and all conditions must never, ever exceed the cable's MRDT! Important
- You should also check the Fiber Strain Margin or ZFSM as appropriate

ACES: Advanced Cable Engineering System

ADSS Configurator

- Our Advanced Cable Engineering System (ACES) is a unique software tool to help engineers select the optimal ADSS design along with the associated accessories, including dead-ends, suspensions, down leads, splice enclosures, and dampers

- ACES ADSS will also help engineers and planners prepare cost estimates, generate a complete bill of materials, determine reel lengths, and plan logistics

optimal cable selection

cost estimates

specifications generation

design calculations

ACES was developed by Incab in partnership with Preformed Line Products, and we very much appreciate their assistance.

Start ACES

Incab

Thank you!

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INCABAMERICA.COM