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Guide for the Preparation of a Transmission Line Design Criteria

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Design Criteria
What is it?

- The design criteria is the basis for the design of a line.
  - It records the design requirements – electrical, structural, environmental, legal and permitting
  - Just as importantly it records **why** the design requirements were chosen
- It is prepared prior to designing the line

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- "Guide for the Preparation of a Transmission Line Design Criteria Document"
  - Provides a comprehensive table of contents for the criteria that are generally specified
  - Provides a brief description of each of the criteria and the reason for inclusion
  - It does not recommend criteria

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- It forms a permanent record that is as important as the Plan and Profile drawings.
- It guides the disciplines that combine their efforts to complete the design.
  - Avoids C/S designing for 90 mph winds and EE's not providing adequate air gaps for that wind.

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- Preparing a written Design Criteria involves thinking about all the facets of the design and their interactions.
- Mother Nature decides what ambient loads the line will have to resist…
  - Doesn't it make sense to know what Mother Nature is likely to send you way?

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- You can only design a line to be reliable if you have some idea of what loads it is likely to face.
- The NESC prescribes a lot of the loads
  - Newer editions use tables and maps from ASCE and are based on statistics from weather records
  - Operating experience may dictate additional load cases

Electrical Criteria

Transmission Lines really Do Carry Electricity!

- What level of lightning performance do you want the line to have?
- Are there pollution sources in the area that will affect the reliability of the line?
- What regulations exist that establish the allowable magnitudes of electric and magnetic fields?

Electrical Criteria

- What clearances must be maintained for the safety of the public and workers?
  - What construction buffer will you add to ensure that the clearances are met after construction?
- What rating parameters were chosen to calculate conductor ampacity?

Electrical Criteria

- What are the design limits for corona and field effects?
  - AN, RI, TVI
- Why did you select all those values for the electrical criteria?

Structural Criteria

- What ice and wind loads are used for design?
  - What return period does this represent?
- What load factors are applied to the loads?
- What strength factors are applied to the materials?
  - NESC or others

Structural Criteria

- What load combinations are applied to each type of structure?
  - Broken wire or intact cases
- What are the foundation loads?
- What are the foundation performance requirements?
  - Settlement, rotation, translation, differential movement

General Criteria

- Permit requirements
  - Seasonal construction
  - Construction methods
  - Aesthetics
- Legal requirements
- Right of Way agreement terms

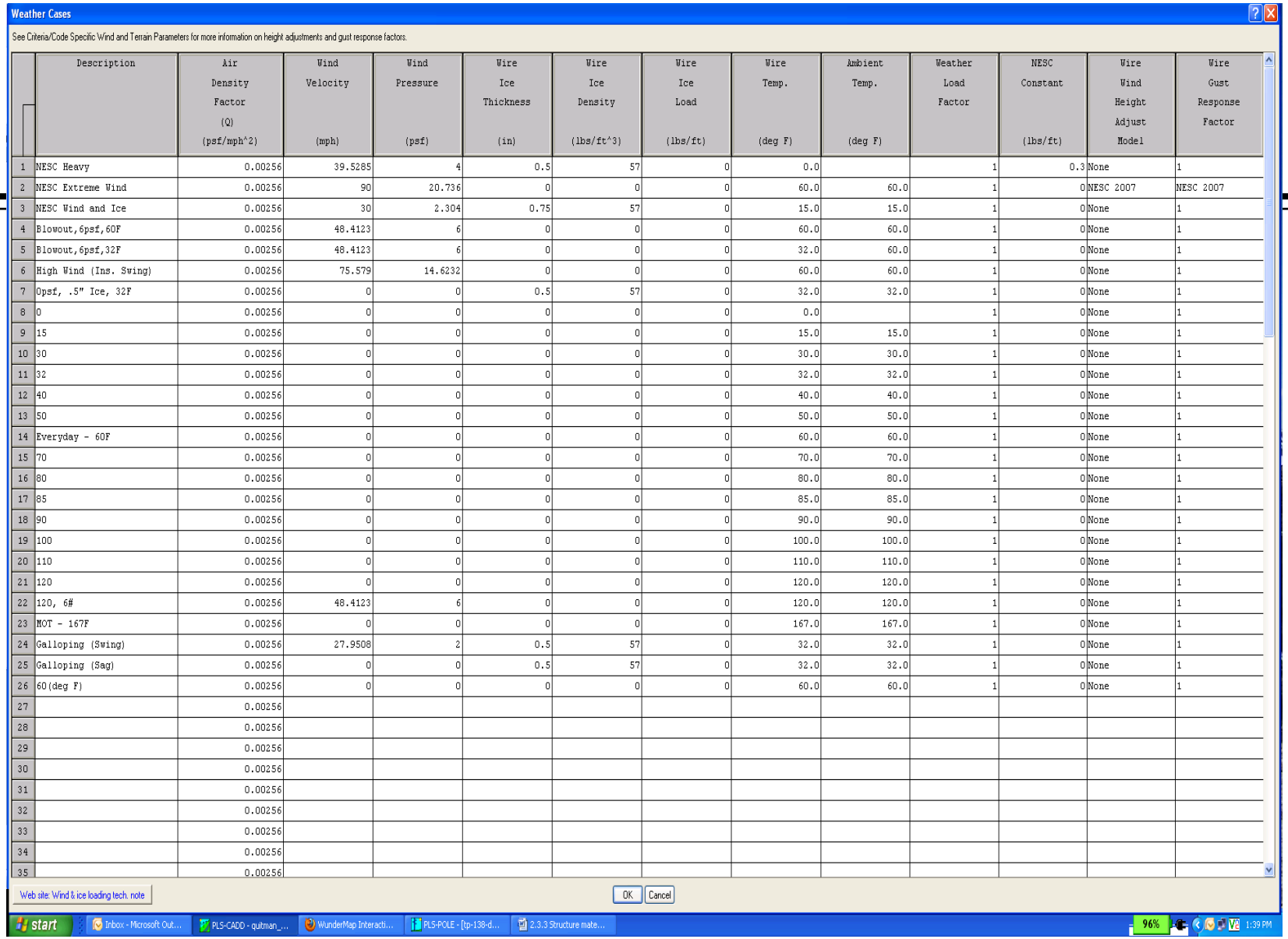
I Could Keep Going Forever

IEEE 1724 has an exhaustive list of criteria

- These are all things that you have to consider when designing a line
- Sometimes it seems like you don't have to think too hard because there are company standards that you just use
  - Have you ever thought seriously about them?
  - Try writing a criteria to see how they are justified

But

- “I really don’t have to write them down, I just enter them in PLSCADD.”
  - I have heard this a lot of times
  - Lets take a look…..



Weather Cases

See Criteria/Code Specific Wind and Terrain Parameters for more information on height adjustments and gust response factors.

	Description	Air Density Factor (Q) (psf/mph^2)	Wind Velocity (mph)	Wind Pressure (psf)	Wire Ice Thickness (in)	Wire Ice Density (lbs/ft^3)	Wire Ice Load (lbs/ft)	Wire Temp. (deg F)	Ambient Temp. (deg F)	Weather Load Factor	NESC Constant (lbs/ft)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	NESC Heavy	0.00256	39.5285	4	0.5	57	0	0.0		1	0.3	None	1
2	NESC Extreme Wind	0.00256	90	20.736	0	0	0	60.0	60.0	1	0	NESC 2007	NESC 2007
3	NESC Wind and Ice	0.00256	30	2.304	0.75	57	0	15.0	15.0	1	0	None	1
4	Blowout,6psf,60F	0.00256	48.4123	6	0	0	0	60.0	60.0	1	0	None	1
5	Blowout,6psf,32F	0.00256	48.4123	6	0	0	0	32.0	60.0	1	0	None	1
6	High Wind (Ins. Swing)	0.00256	75.579	14.6232	0	0	0	60.0	60.0	1	0	None	1
7	Opsf, .5" Ice, 32F	0.00256	0	0	0.5	57	0	32.0	32.0	1	0	None	1
8	0	0.00256	0	0	0	0	0	0.0		1	0	None	1
9	15	0.00256	0	0	0	0	0	15.0	15.0	1	0	None	1
10	30	0.00256	0	0	0	0	0	30.0	30.0	1	0	None	1
11	32	0.00256	0	0	0	0	0	32.0	32.0	1	0	None	1
12	40	0.00256	0	0	0	0	0	40.0	40.0	1	0	None	1
13	50	0.00256	0	0	0	0	0	50.0	50.0	1	0	None	1
14	Everyday - 60F	0.00256	0	0	0	0	0	60.0	60.0	1	0	None	1
15	70	0.00256	0	0	0	0	0	70.0	70.0	1	0	None	1
16	80	0.00256	0	0	0	0	0	80.0	80.0	1	0	None	1
17	85	0.00256	0	0	0	0	0	85.0	85.0	1	0	None	1
18	90	0.00256	0	0	0	0	0	90.0	90.0	1	0	None	1
19	100	0.00256	0	0	0	0	0	100.0	100.0	1	0	None	1
20	110	0.00256	0	0	0	0	0	110.0	110.0	1	0	None	1
21	120	0.00256	0	0	0	0	0	120.0	120.0	1	0	None	1
22	120, 6#	0.00256	48.4123	6	0	0	0	120.0	120.0	1	0	None	1
23	MOT - 167F	0.00256	0	0	0	0	0	167.0	167.0	1	0	None	1
24	Galloping (Swing)	0.00256	27.9508	2	0.5	57	0	32.0	32.0	1	0	None	1
25	Galloping (Sag)	0.00256	0	0	0.5	57	0	32.0	32.0	1	0	None	1
26	60(deg F)	0.00256	0	0	0	0	0	60.0	60.0	1	0	None	1
27		0.00256											
28		0.00256											
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Web site: Wind & ice loading tech. note

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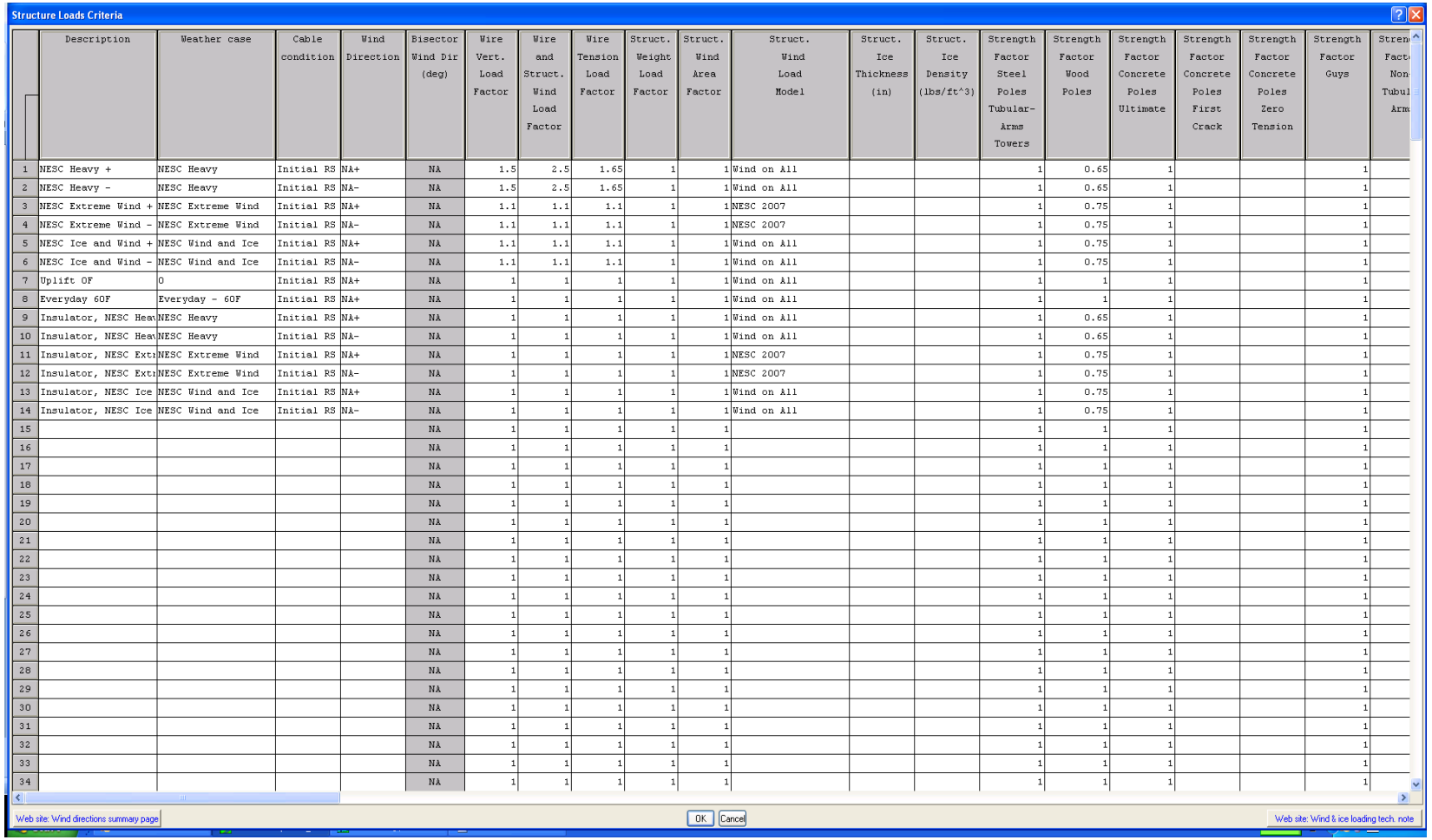


Structure Loads Criteria

	Description	Weather case	Cable condition	Wind Direction	Bisector Wind Dir (deg)	Wire Vert. Load Factor	Wire and Struct. Wind Load Factor	Wire Tension Load Factor	Struct. Weight Load Factor	Struct. Wind Area Factor	Struct. Wind Load Model	Struct. Ice Thickness (in)	Struct. Ice Density (lbs/ft^3)	Strength Factor Steel Poles Tubular-Arms Towers	Strength Factor Wood Poles	Strength Factor Concrete Poles Ultimate	Strength Factor Concrete Poles First Crack	Strength Factor Concrete Poles Zero Tension	Strength Factor Guys	Stren Fact Non Tubul Arm
1	NESC Heavy +	NESC Heavy	Initial RS	NA+	NA	1.5	2.5	1.65	1	1	Wind on All			1	0.65	1			1	
2	NESC Heavy -	NESC Heavy	Initial RS	NA-	NA	1.5	2.5	1.65	1	1	Wind on All			1	0.65	1			1	
3	NESC Extreme Wind +	NESC Extreme Wind	Initial RS	NA+	NA	1.1	1.1	1.1	1	1	NESC 2007			1	0.75	1			1	
4	NESC Extreme Wind -	NESC Extreme Wind	Initial RS	NA-	NA	1.1	1.1	1.1	1	1	NESC 2007			1	0.75	1			1	
5	NESC Ice and Wind +	NESC Wind and Ice	Initial RS	NA+	NA	1.1	1.1	1.1	1	1	Wind on All			1	0.75	1			1	
6	NESC Ice and Wind -	NESC Wind and Ice	Initial RS	NA-	NA	1.1	1.1	1.1	1	1	Wind on All			1	0.75	1			1	
7	Uplift 0F	0	Initial RS	NA+	NA	1	1	1	1	1	Wind on All			1	1	1			1	
8	Everyday 60F	Everyday - 60F	Initial RS	NA+	NA	1	1	1	1	1	Wind on All			1	1	1			1	
9	Insulator, NESC Hea	NESC Heavy	Initial RS	NA+	NA	1	1	1	1	1	Wind on All			1	0.65	1			1	
10	Insulator, NESC Hea	NESC Heavy	Initial RS	NA-	NA	1	1	1	1	1	Wind on All			1	0.65	1			1	
11	Insulator, NESC Ext	NESC Extreme Wind	Initial RS	NA+	NA	1	1	1	1	1	NESC 2007			1	0.75	1			1	
12	Insulator, NESC Ext	NESC Extreme Wind	Initial RS	NA-	NA	1	1	1	1	1	NESC 2007			1	0.75	1			1	
13	Insulator, NESC Ice	NESC Wind and Ice	Initial RS	NA+	NA	1	1	1	1	1	Wind on All			1	0.75	1			1	
14	Insulator, NESC Ice	NESC Wind and Ice	Initial RS	NA-	NA	1	1	1	1	1	Wind on All			1	0.75	1			1	
15					NA	1	1	1	1	1				1	1	1			1	
16					NA	1	1	1	1	1				1	1	1			1	
17					NA	1	1	1	1	1				1	1	1			1	
18					NA	1	1	1	1	1				1	1	1			1	
19					NA	1	1	1	1	1				1	1	1			1	
20					NA	1	1	1	1	1				1	1	1			1	
21					NA	1	1	1	1	1				1	1	1			1	
22					NA	1	1	1	1	1				1	1	1			1	
23					NA	1	1	1	1	1				1	1	1			1	
24					NA	1	1	1	1	1				1	1	1			1	
25					NA	1	1	1	1	1				1	1	1			1	
26					NA	1	1	1	1	1				1	1	1			1	
27					NA	1	1	1	1	1				1	1	1			1	
28					NA	1	1	1	1	1				1	1	1			1	
29					NA	1	1	1	1	1				1	1	1			1	
30					NA	1	1	1	1	1				1	1	1			1	
31					NA	1	1	1	1	1				1	1	1			1	
32					NA	1	1	1	1	1				1	1	1			1	
33					NA	1	1	1	1	1				1	1	1			1	
34					NA	1	1	1	1	1				1	1	1			1	

Web site: Wind directions summary page | OK | Cancel | Web site: Wind & ice loading tech. note

I could show a lot more

- PLSCADD requires you to specify the criteria
  - If you don't PLSCADD doesn't fill them in for you, it just designs the line with what you gave it.

Question…

- You have a project to reconductor an old line to increase its ampacity. You need to replace 4/0 ACSR 6/1 with 397.5 kcmil 26/7 ACSR.
- Can you do it?
- (This is the interactive part of this presentation. It's all right to answer the question.)

Have You Ever……?

- Looked at an old Plan and Profile (or Plan only) drawing and wondered…?
  - What loads and tensions was the line designed for?
  - What conductor did they use?
  - What the load cases were used to design the structures?
  - How did they decide how many insulators to use?

A True Story

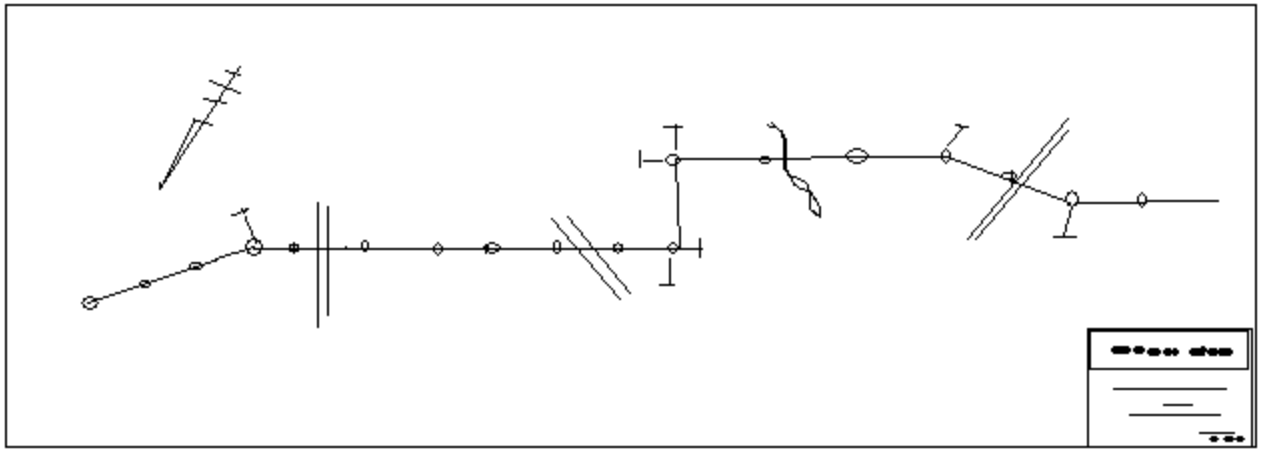
- I started working at Jersey Central Power & Light
  - One of my first jobs was to reconductor a 40 year old 115kV line.
    - No Sweat! Just pull out the P&P drawings and learn all there was to know about the line

–NOT!!

True Story continued

- The “Plan and Profile” drawing was plan only.
- It did not have span lengths
- It did not have structure types or heights or numbers
- It did not have wire sizes
- It did not have any design notes

- THE CLOSEST DESCRIPTION I COULD MAKE OF IT WAS TO CALL IT A “CARTOON”



I Don’t Have a Clue How they Built It

- It didn’t even have a scale!
- We were sure the wire was 4/0 ACSR because it had burned down a few times and had to be replaced
- We needed to reconductor it to get a 600 Amp rating
- We wanted to use 397.5 kcmil 26/7ACSR Ibis

Comparison

- 4/0 ACSR
  - Dia = .563 in
  - Wgt = .2895#/ft
  - RTS = 8,350#

397.5 kcmil ACSR Ibis

- Dia = .783 in
- Wgt = .5466#/ft
- RTS = 16,300#

Is This a Problem?

- It is a problem
  - But…
- It is not an unusual problem, except maybe an extreme (but really true) example

What would have helped me?

- Something in writing to give me a clue about how the line was designed

Another True Story

- I designed a 138 kV line for a client
- I prepared and gave a complete design criteria to the client along with all the drawings, catalog cuts, sag charts, assembly drawings, etc.
- Three years later I got a call asking me to try to remember why I did something a certain way

What did I say??

- “Read your design criteria book.”
- “We can’t find it.”
- (I kept mine, made him a copy, and sent it off)
- Would you care to guess what call I got three years later?????
- The moral is, if you write it, keep it. It comes in handy.