

TSDOS

TRANSMISSION &
SUBSTATION
DESIGN &
OPERATION
SYMPOSIUM



THE UNIVERSITY OF TEXAS AT ARLINGTON

CONDUCTOR PROPERTIES & SAG EFFECTS

**A Comparison Between Traditionally Accepted and
Manufacturer Values and an Innovative Approach to
Combat the Difference**

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INTRODUCTION

- Wire (.wir) files
- Industry still using Generic Non-Linear files (LEGACY)
- Legacy vs Manufacturer files
- Sag-Ten differences and ways to design around

The screenshot shows the 'Cable Data' software window. The 'File' field contains the path 'C:\Users\GokulNarayanan\Desktop\All Data\Locker\Misc Work\Research\Wire files\PLS\Cables\Fred-Generics\ACSR\cardinal_acsr.wir'. The 'Description' field is '354 kcmil 54/7 Strands CARDINAL ACSR - Adapted from 1970's Publicly Available Data'. The 'Manufacturer' field is empty, and the 'Stock Number' is 'cardinal_acsr'. The 'Cable Type' is set to 'Unknown' and the 'Display Color' is red. The 'Physical' tab is active, showing a checked 'Bimetallic Conductor' option. The 'Cable Model' section has three radio buttons: 'Nonlinear cable model' (selected), 'Linear elastic with permanent stretch due to creep proportional to creep weather case tension', and 'Linear elastic with permanent stretch due to creep specified as a user input temperature increase'. The 'Cross section area' is 0.8462 in², 'Outside diameter' is 1.196 in, 'Unit weight' is 1.229 lbs/ft, and 'Ultimate tension' is 33800 lbs. The 'Temperature at which strand data below obtained' is 70 deg F. The 'Number of independent wires' is 1. The 'Conductor is a J-Power Systems GAP type conductor' checkbox is unchecked. The 'Outer Strands' section has 'Final modulus of elasticity' at 64000 psi/100 and 'Thermal expansion coeff.' at 0.00128 /100 deg. The 'Core Strands' section has 'Final modulus of elasticity' at 31500 psi/100 and 'Thermal expansion coeff.' at 0.00064 /100 deg. Both sections have 'Polynomial coefficients' for all strains in % and stresses in psi.

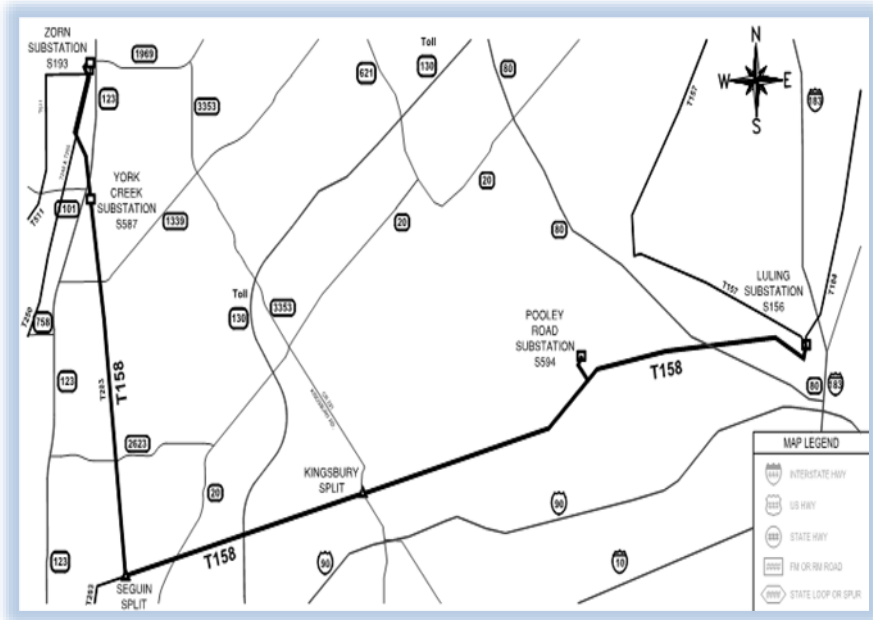


PRESENTATION TOPICS

- Lower Colorado River Authority's T158 Line
- History of cable files
- Property differences between manufacturer and legacy
- Sag and Tension comparisons
- Conclusion
- Interesting discussion points and further research



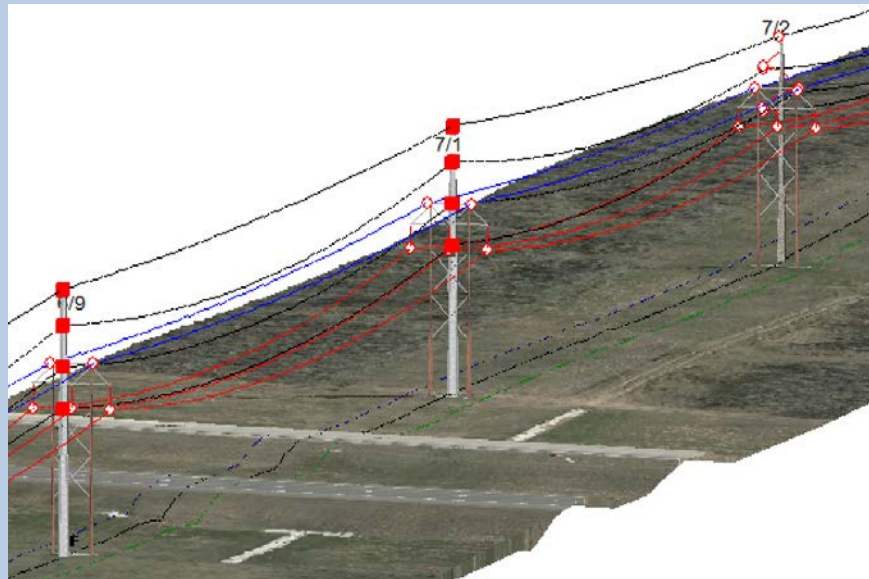
T158 INTRODUCTION



- Zorn-Luling 138kV TL
- 19 miles re-build
- 19 miles + 9 miles OPGW addition
- 336 kcmil LINNET ACSR to 795 kcmil DRAKE ACSR



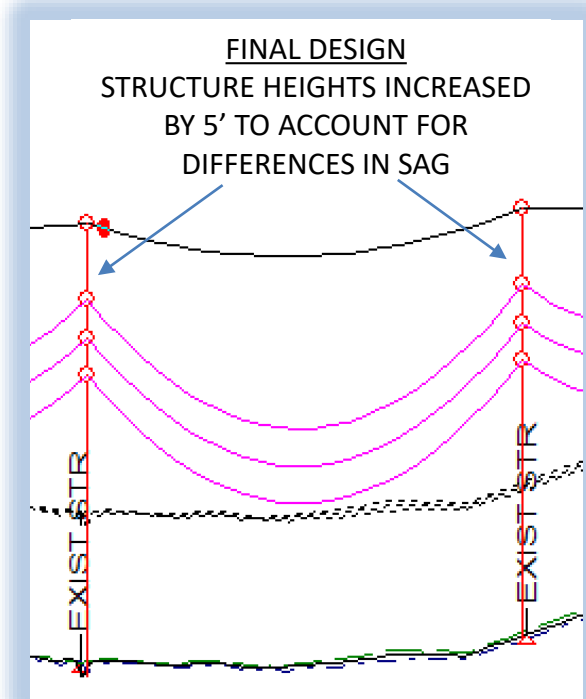
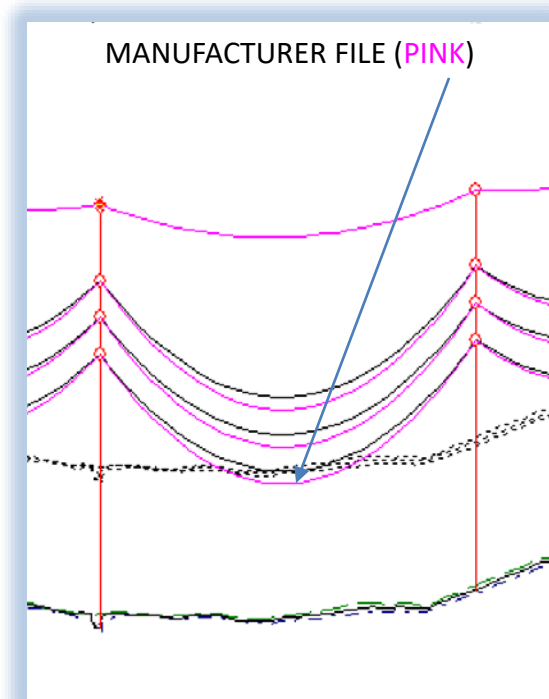
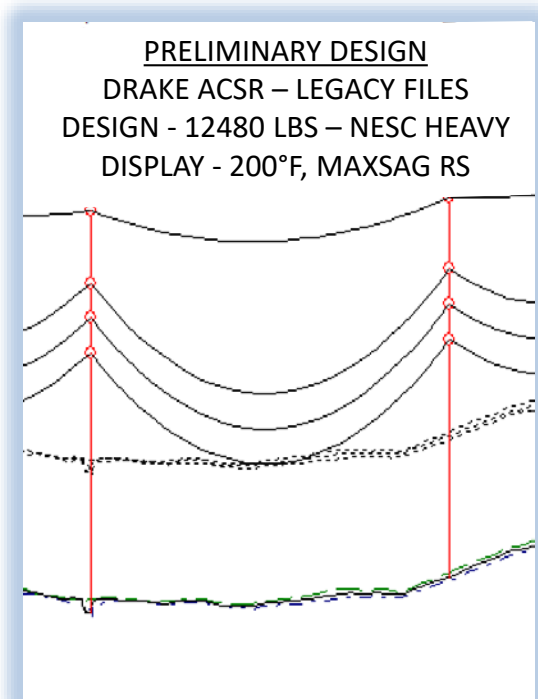
T158 ORIGINAL DESIGN



- Wood H-frame - Concrete Delta-monopole conversion
- Same number of Structures
- LCRA Standards updates
- DRAKE ACSR sagged at 12480 LBS at NESC Heavy, Initial
- Legacy files used



T158 SAG VARIATIONS



T158 IMPACT

- Changed with Manufacturer wire file at preliminary stages
- Heights increased at 35 of 96 structures

SCHEDULE IMPACT
NONE

MINIMAL COST
IMPACT



WHAT IS A CABLE FILE?

- Physical Properties
 - Area, diameter, unit weight, ultimate tension
 - Bimetallic conductor split into outer/core properties
 - Stress-strain/creep

Cross section area (in²) 0.307 Outside diameter (in) 0.72 Unit weight (lbs/ft) 0.4405 Ultimate tension (lbs) 13500
Number of independent wires (1 unless messenger supporting other wires with a spacer) 1
Temperature at which strand data below obtained (deg F) 75 Conductor split into outer systems and type conductor strand with core supporting all tension.

Outer Strands
Final modulus of elasticity (psi/100) 68500
Thermal expansion coeff. (/100 deg) 0.00128
Polynomial coefficients (all strains in %, stresses in psi)
Stress-strain: a0: -882.9, a1: 58787.6, a2: -60387.1, a3: 6558, a4: 16702
Creep: c0: -325.1, c1: 24984.7, c2: -36576.1, c3: 38037, c4: -14271
Note: Final modulus, stress-strain and creep are actual material values multiplied by ratio of outer strand area to total area.

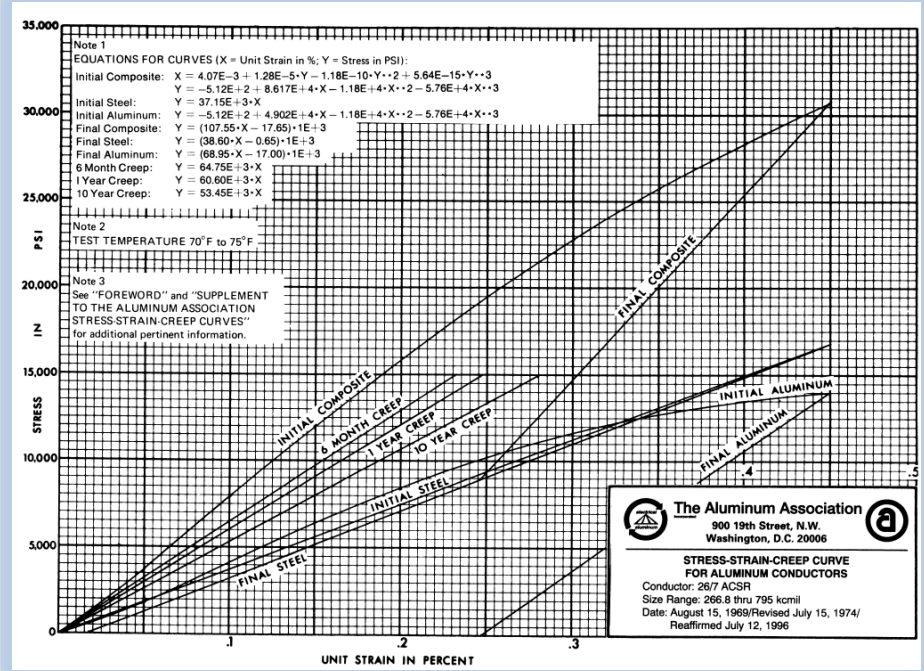
Core Strands
Final modulus of elasticity (psi/100) 39575
Thermal expansion coeff. (/100 deg) 0.00072
Polynomial coefficients (all strains in %, stresses in psi)
Stress-strain: b0: -23.7, b1: 40563.9, b2: -4404.6, b3: -15530, b4: 6976
Creep: d0: 139.1, d1: 36329.4, d2: 12925, d3: -67174, d4: 44219
Note: Final modulus, stress-strain and creep are actual material values multiplied by ratio of core strand area to total area.

Generic Non-Linear 336 26/7 ACSR "Linnet" from PLS-CADD



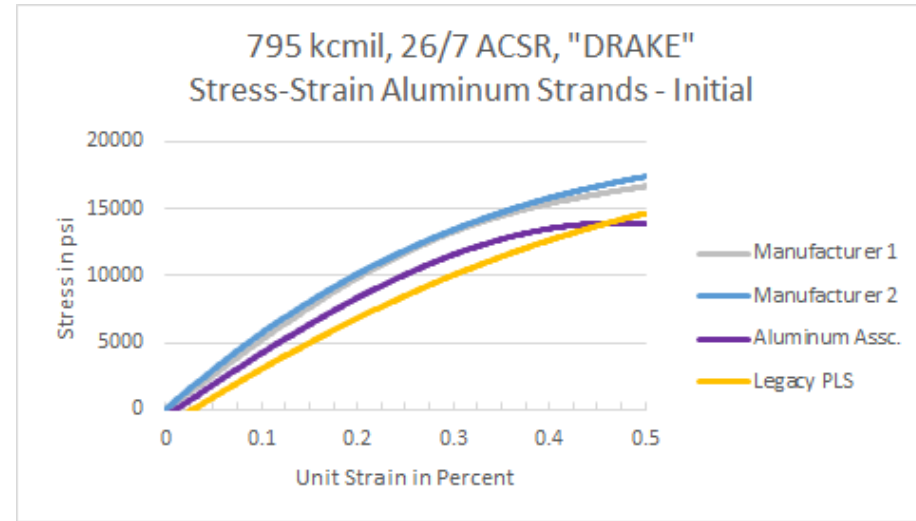
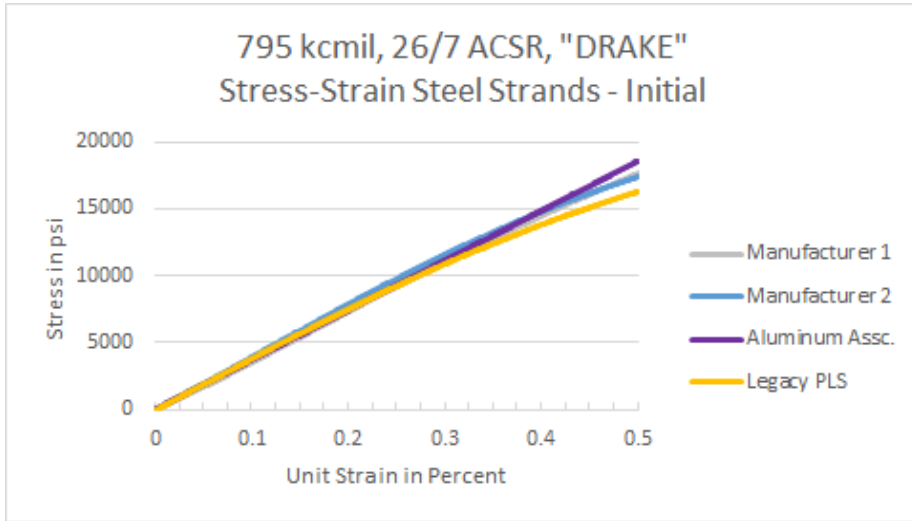
HISTORY OF CABLE FILES

- 1970s – Aluminum Association
- Change in process around 1990's-2000's
- Manufacturers started to update their wire files in the 2000's



COMPARISON OF PROPERTIES

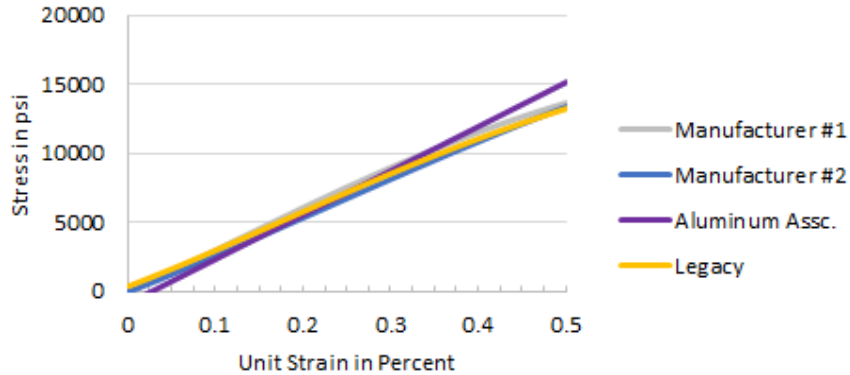
- Stress-strain curves



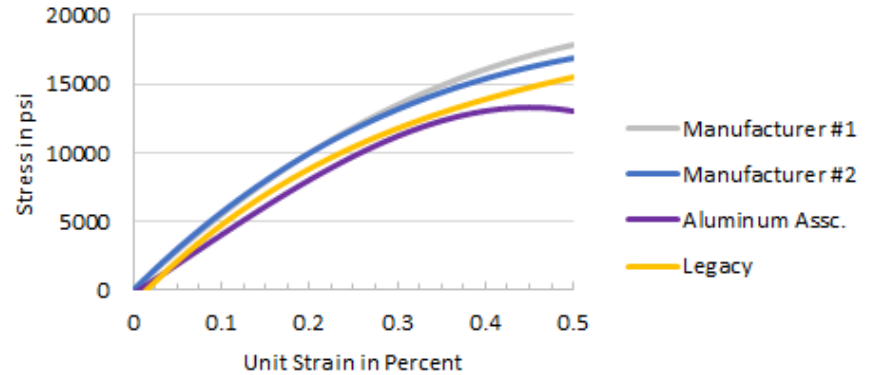
COMPARISON OF PROPERTIES

- Stress-strain curves

1590 kcmil, 54/19 ACSR, "FALCON",
Stress-Strain Steel Strands - Initial



1590 kcmil, 54/19 ACSR, "FALCON",
Stress-Strain Aluminum Strands - Initial



COMPARISON OF PROPERTIES

- Final Modulus of Elasticity

Modulus of Elasticity (psi/100)		
795 kcmil 26/7 ACSR "DRAKE"		
	Aluminum	Steel
Manufacturer 1	69,669	38,507
Manufacturer 2	75,693	38,478
Legacy	64,000	37,000
1590 kcmil 54/19 ACSR "FALCON"		
	Aluminum	Steel
Manufacturer 1	71,444	30,373
Manufacturer 2	75,217	29,918
Legacy	71,200	31,300



COMPARISON OF PROPERTIES

- Steel creep – 795 kcmil 26/7 “DRAKE” ACSR

Man. #1

Polynomial coefficients (all strains in %, stresses in psi)					
	b0	b1	b2	b3	b4
Stress-strain		37454	22543	-73393	35740
Creep		35799	19994	-65408	35041

Man. #2

Polynomial coefficients (all strains in %, stresses in psi)					
	b0	b1	b2	b3	b4
Stress-strain		32518	36454	-92482	60874
Creep		32518	36454	-92482	60874

Legacy

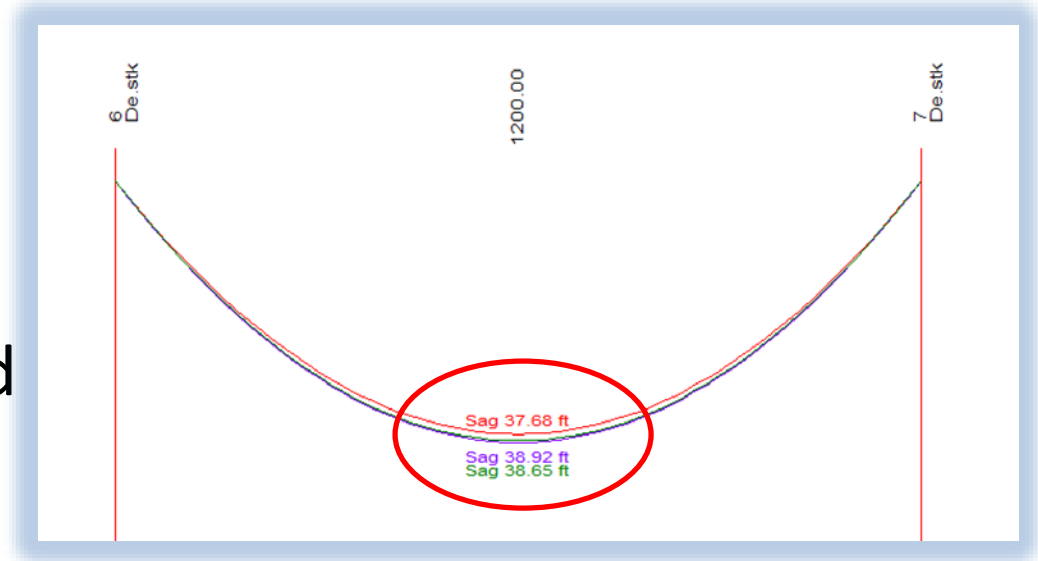
Polynomial coefficients (all strains in %, stresses in psi)					
	b0	b1	b2	b3	b4
Stress-strain	-69.3	38629	3998.1	-45713	27892
Creep	47.1	36211.3	12201.4	-72392	46338



ACSR SAG-TEN COMPARISON

SAG COMPARISON – RULING SPAN

- Cardinal ACSR
- 54/7 Stranding
- 1200' DE-DE span
- 3 wire files compared
- 212°F, MaxSag RS
- 1.24' sag difference

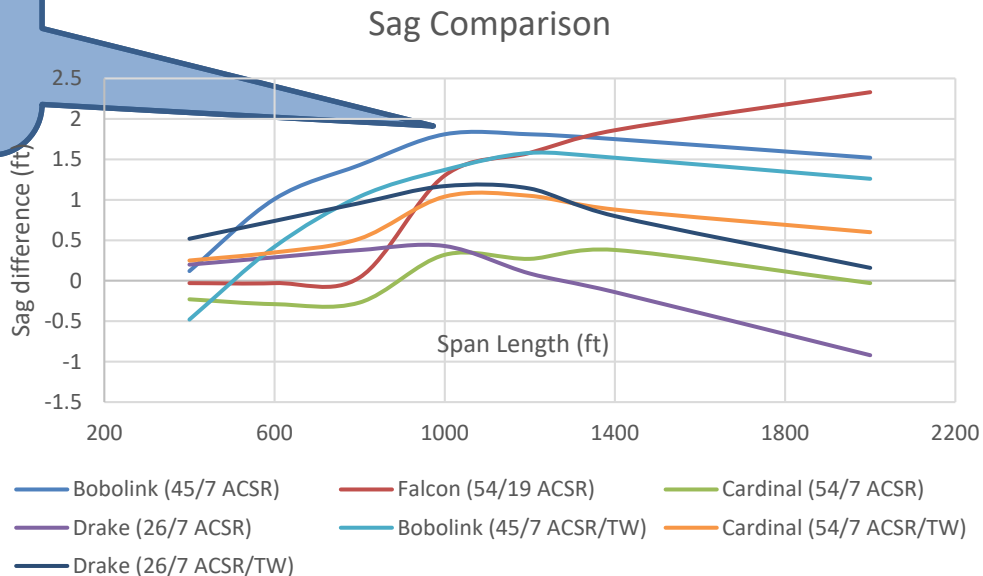


SAG DIFFERENCE - MODERN .WIR FILES

212°F, MAXSAG RS

RULING-SPAN-DELTA APPROACH

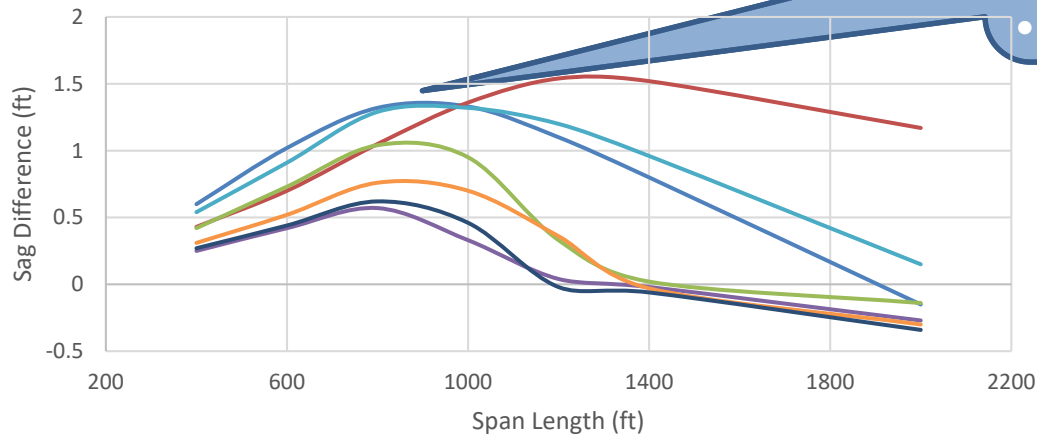
- Inflection point around 1000'
- Sag difference reversal
- 54/19 Outlier



SAG DIFFERENCE – MODERN .WIR FILES

32°F, 1" ICE, MAXSAG RS
RULING-SPAN-DELTA APPROACH

Sag Comparison

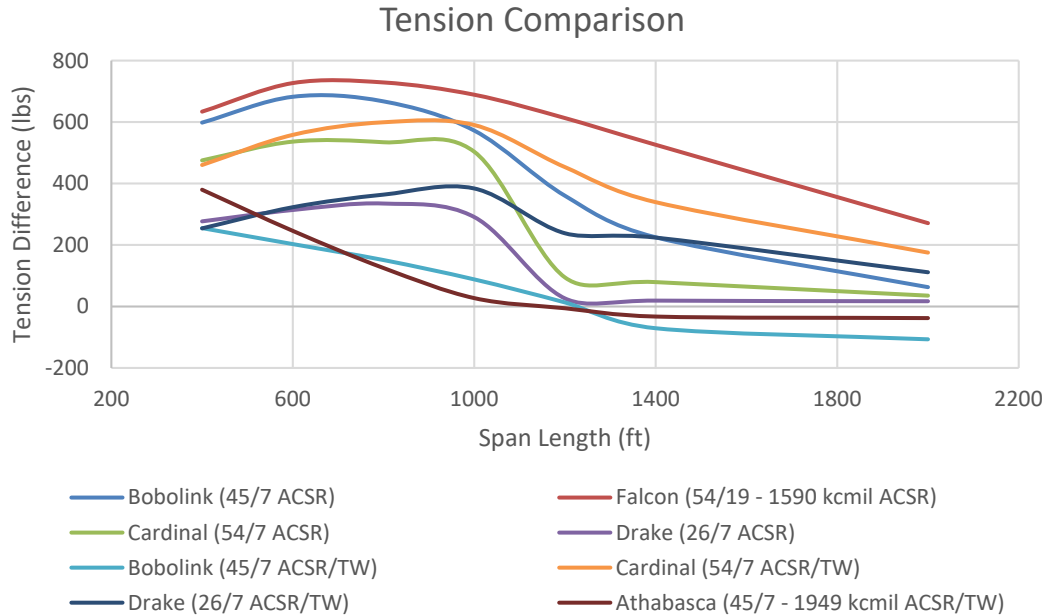


- Inflection point ~ 800'-1200'
- Sag difference reversal
- 54/19 Outlier

- Bobolink (45/7 ACSR)
- Drake (26/7 ACSR)
- Drake (26/7 ACSR/TW)
- Falcon (54/19 ACSR)
- Bobolink (45/7 ACSR/TW)
- Cardinal (54/7 ACSR/TW)
- Cardinal (54/7 ACSR)



TENSION DIFFERENCE



Design Considerations

Vibration

Galloping

Blowout

Uplift

Structure deflection

Swing clearances



CONCLUSION

- Generic Non-linear = Generally **NON-USABLE** for new design
- As much as feasible, **ONLY USE** Manufacturer wire files
- Be **CAUTIOUS** of wire files not from your manufacturer
- If manufacturer unknown during design, take the ruling-span-delta approach for '**WIRE BUFFER**'



FURTHER RESEARCH

- More wire files (ACSR/AW and other strandings)
- Green-field vs Brown-field
- NERC compliance rating
- Discover wire manufacturer only knowing wire type



