AEP Station Bus & Conductor Ampacity Calculation Methodologies

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AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY

Agenda

- Background
- Ambient Temperature
- Wind Velocity & Angle
- Emmisivity & Absorptivity
- Maximum Operating Temperature
- Benchmark with Others
- Conclusions

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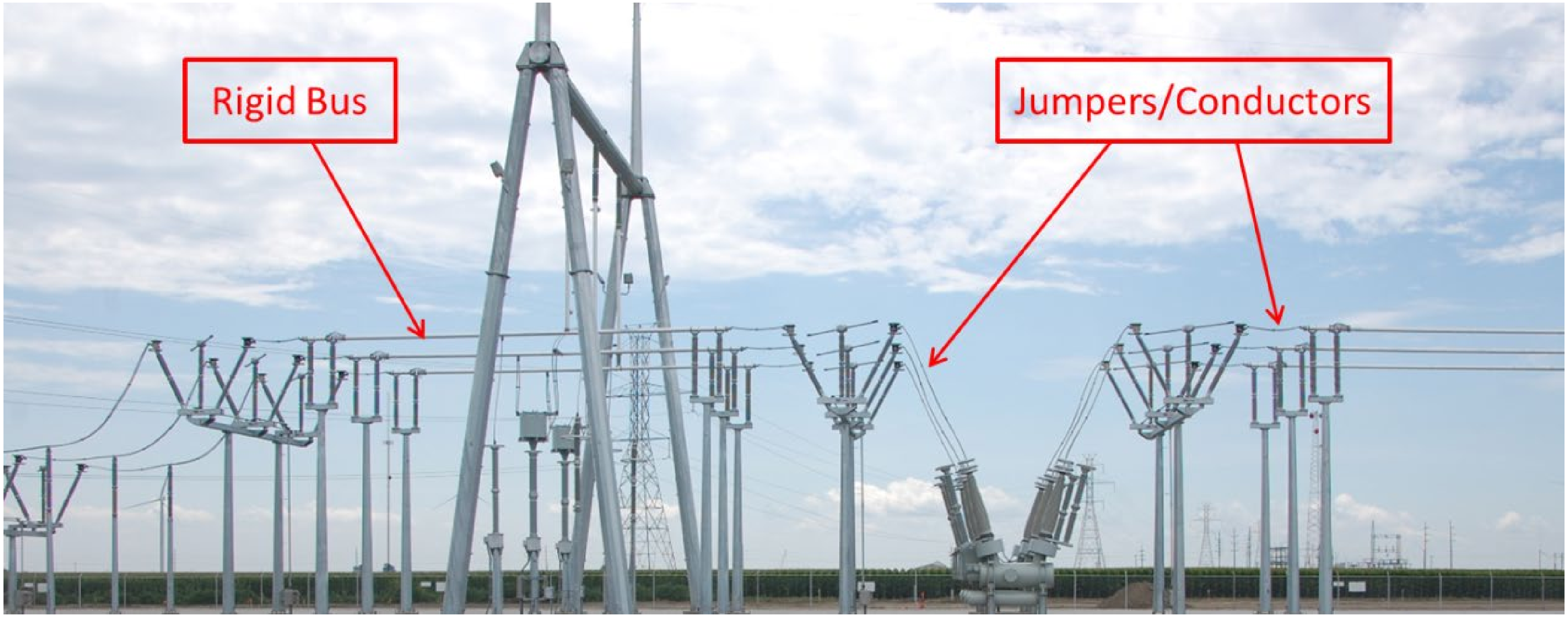
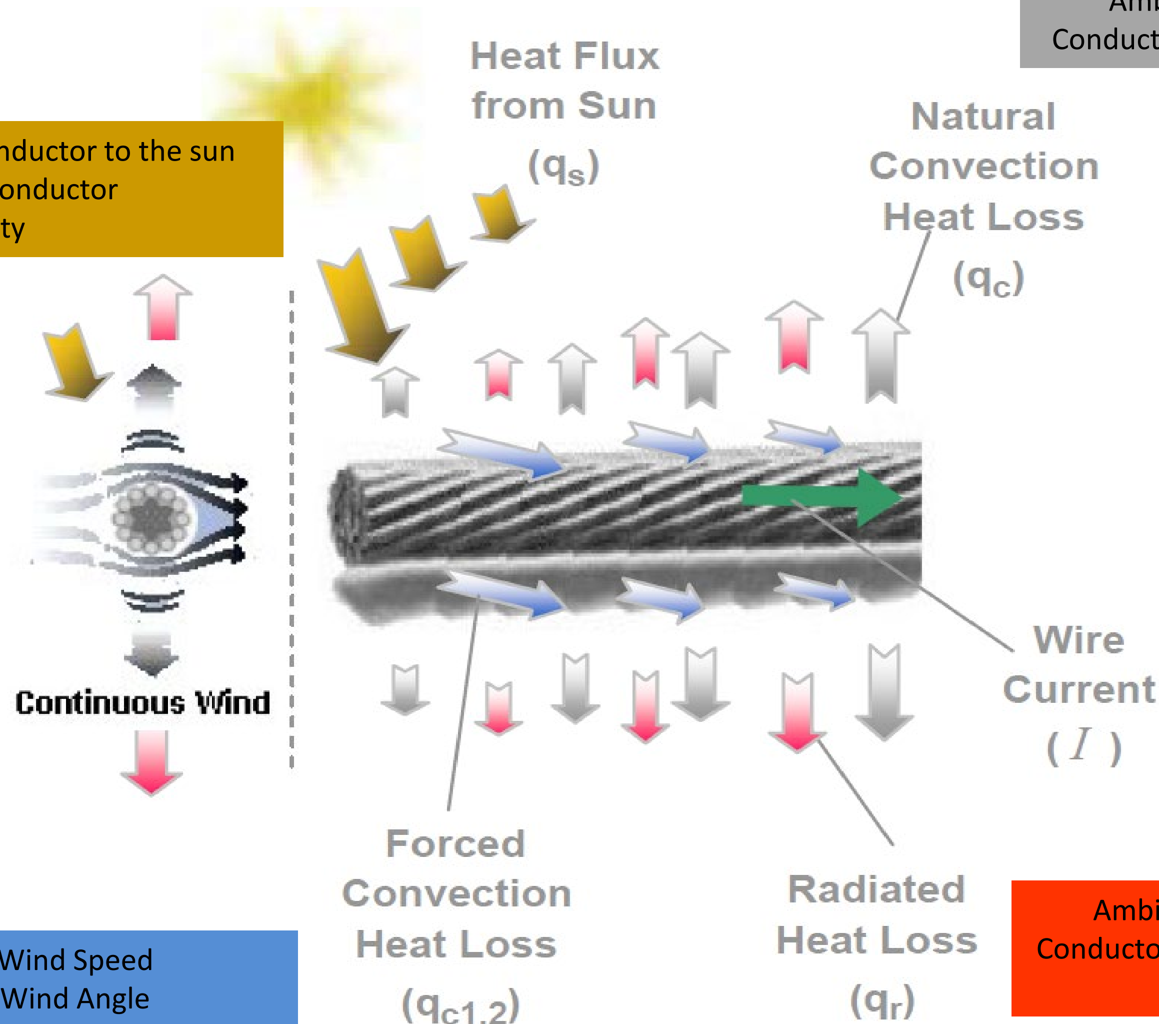
Station Bus Applications



Ampacity Calculation Method

Ambient Temperature
Conductor Temperature (MOT)

Relative position of the conductor to the sun
Elevation of the conductor
Absorptivity



Wind Speed
Wind Angle
Ambient Temperature
Conductor Temperature (MOT)

Ambient Temperature
Conductor Temperature (MOT)
Emmisivity

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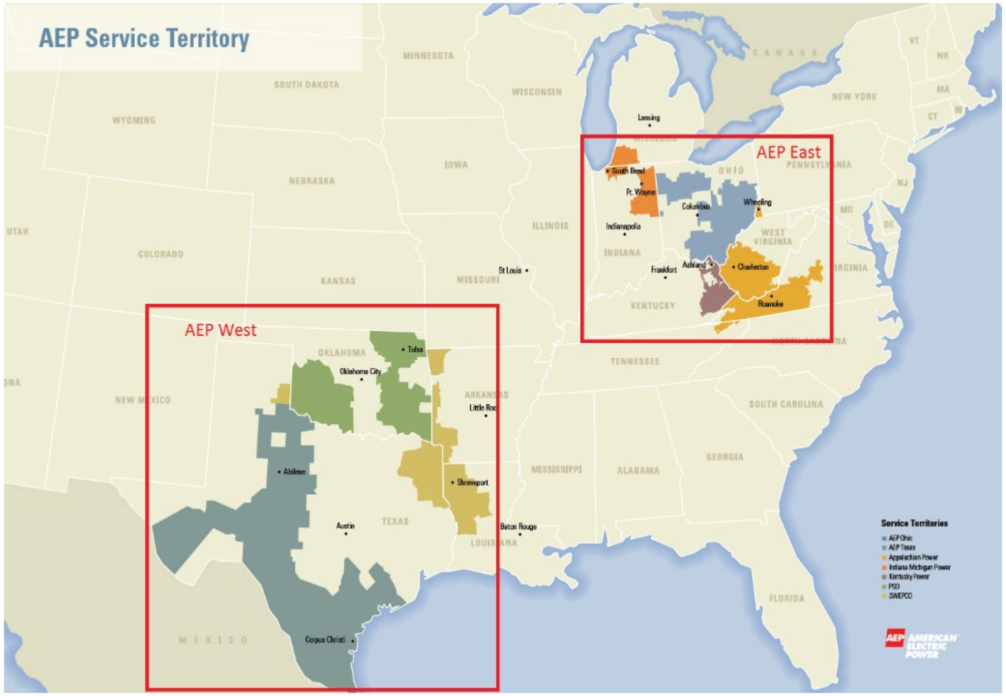
Data Collection



Location	AEP East		AEP West	
Season	Summer (June, July, Aug.)	Winter (Dec., Jan., Feb.)	Summer (June, July, Aug.)	Winter (Dec., Jan., Feb.)
Maximum Average Daily Temperature	27.8 to 30 °C	5 to 9 °C	34.5 to 36.1 °C	16 to 21 °C

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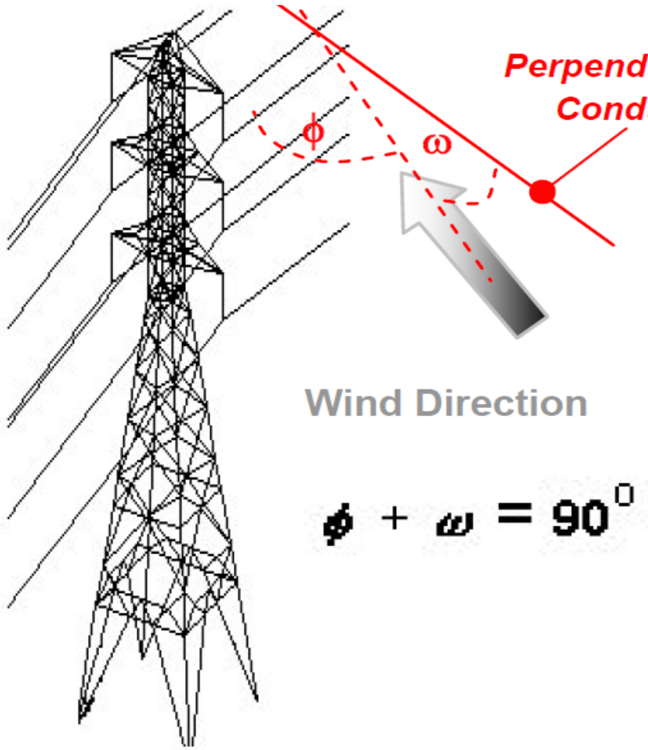
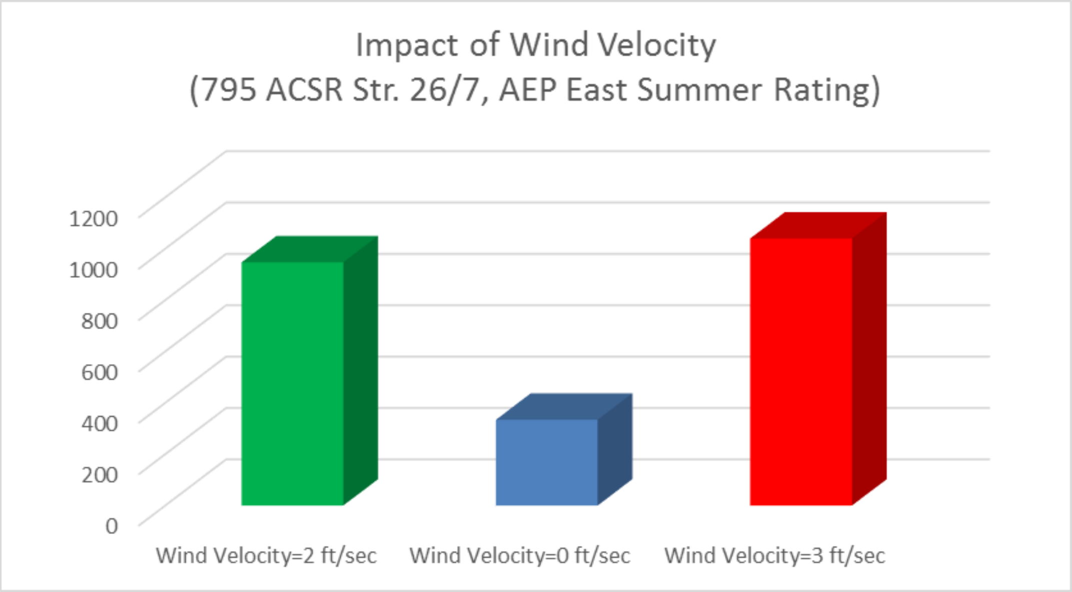
Forced Convection Heat Loss

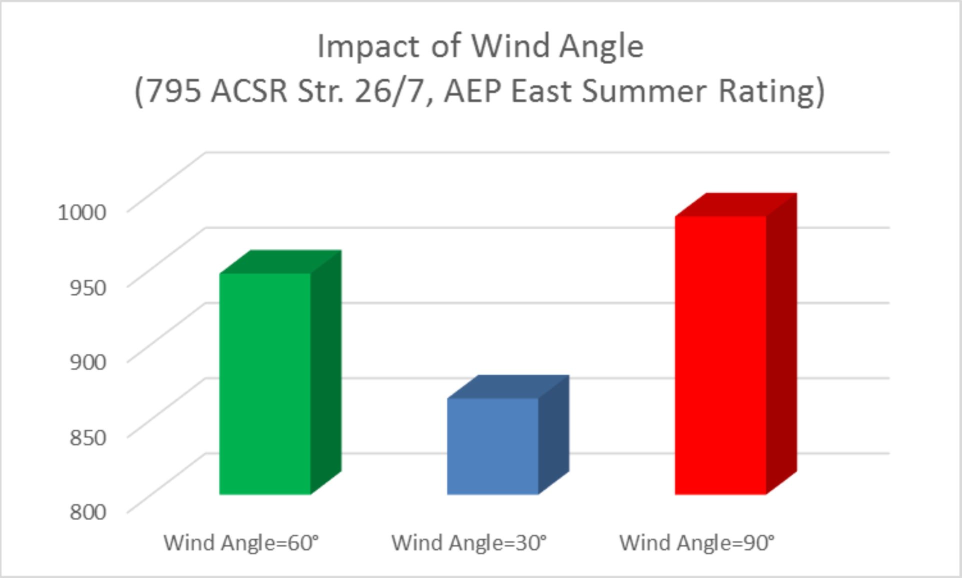


$$q_c = K_{angle}\left[101 + 0.371 \cdot \left({}^{D \cdot \rho_f . v_w}/_{\mu_f}\right)^{0.52}\right] \cdot k_f (T_c - T_a) \quad \text{W/Ft}$$

$$K_{angle} = 1.194 - \sin\omega - 0.194 \cdot \cos(2\omega) + 0.368 \cdot \sin(2\omega)$$

Impact of Wind Behaviors





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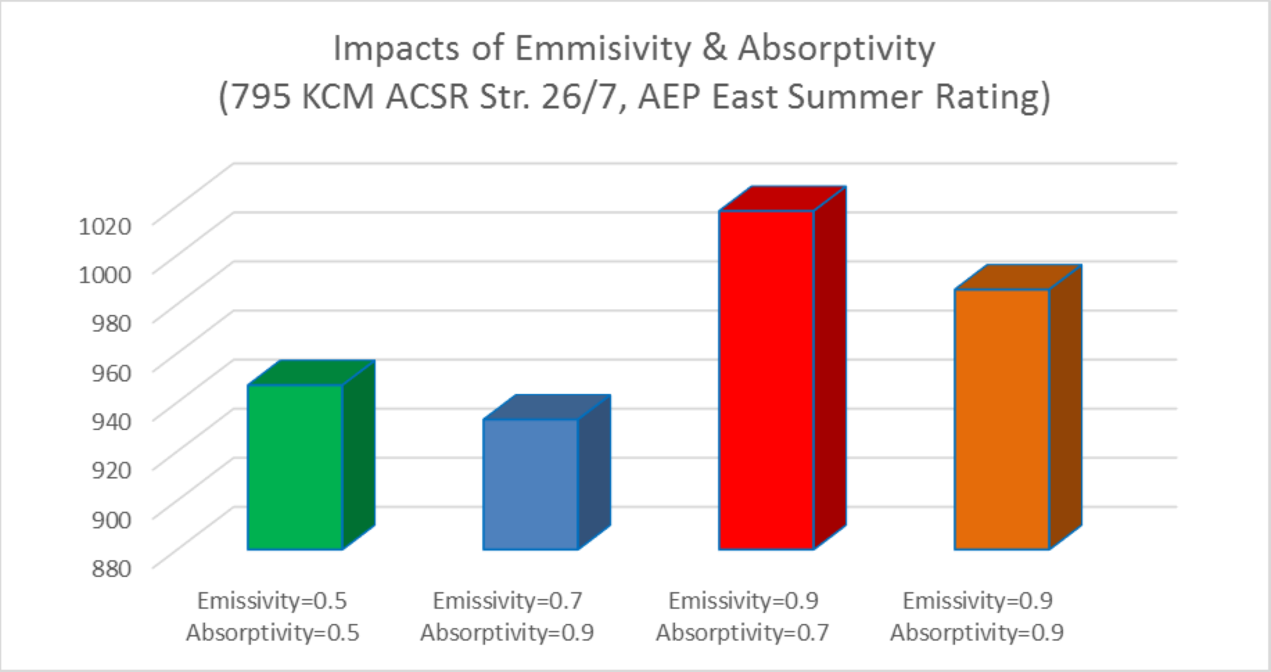
Emmisivity & Absorptivity



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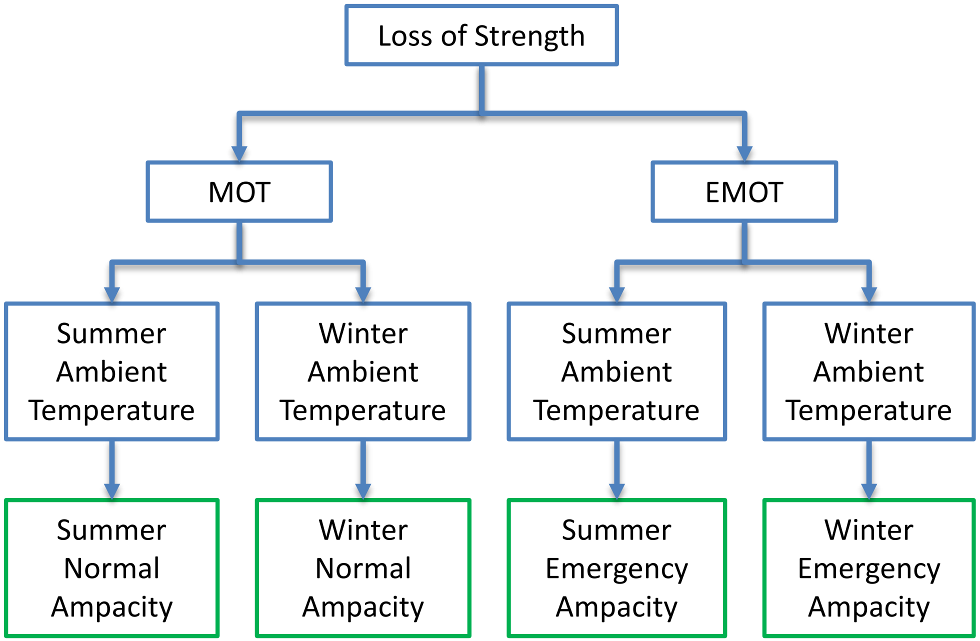
Maximum Operating Temperature

- Maximum Operating Temperature (MOT) is a maximum allowable conductor surface temperature that a conductor can be operated at continuously.
- Emergency Maximum Operating Temperature (EMOT) is a subset of MOT, which can only be allowed to be operated within a short period of time.
- The combined effects of the MOT and EMOT cumulating over a conductor's lifespan result a conductor's loss of strength.



Loss of Strength Calculation

ACSR Anneal Calculator

Conductor Name:	Turkey
Stranding:	6/1
Aluminum Diameter (in):	0.0661
Steel Diameter (in):	0.0661
Catalog Rated Strength (lbs):	1,190
Area of Aluminum (in^2):	0.0206
Area of Steel (in^2):	0.0034
Net Aluminum Strength (lbs):	563
Net Steel Strength (lbs):	626
Calculated Rated Strength (lbs):	1,189

Step 1

- Select the name of the ACSR conductor using the drop down list, or simply type the name.
- If you are using a conductor not in the AEP system, use the sheet titled "Unknown ACSR".

Step 2

- Enter in the number of test cases you want to run.
- If you are using the AEP criteria to check MOT, select 2.

Step3

- Enter in the time (hours) and temperature (degress Celsius) for each test case.
- If you are checking the MOT using AEP criteria, enter in 437,300 hours at system normal (95 °C) followed by 1,000 hours at the Maximum Operating Temperature for the conductor.

Number of test cases: 2 Clear

Case Number	time (hours)	Temp (°C)	$t_{equivalent}$	t_{new}	(-0.24xT+134)	RS_{1350} (%)	RS_{ACSR} (%)	Loss of Strength (%)
1	437,300	95		437300.000	111.2	100.000	100.000	0.000
2	1,000	130	1.000	1001.000	102.8	69.363	90.224	9.776

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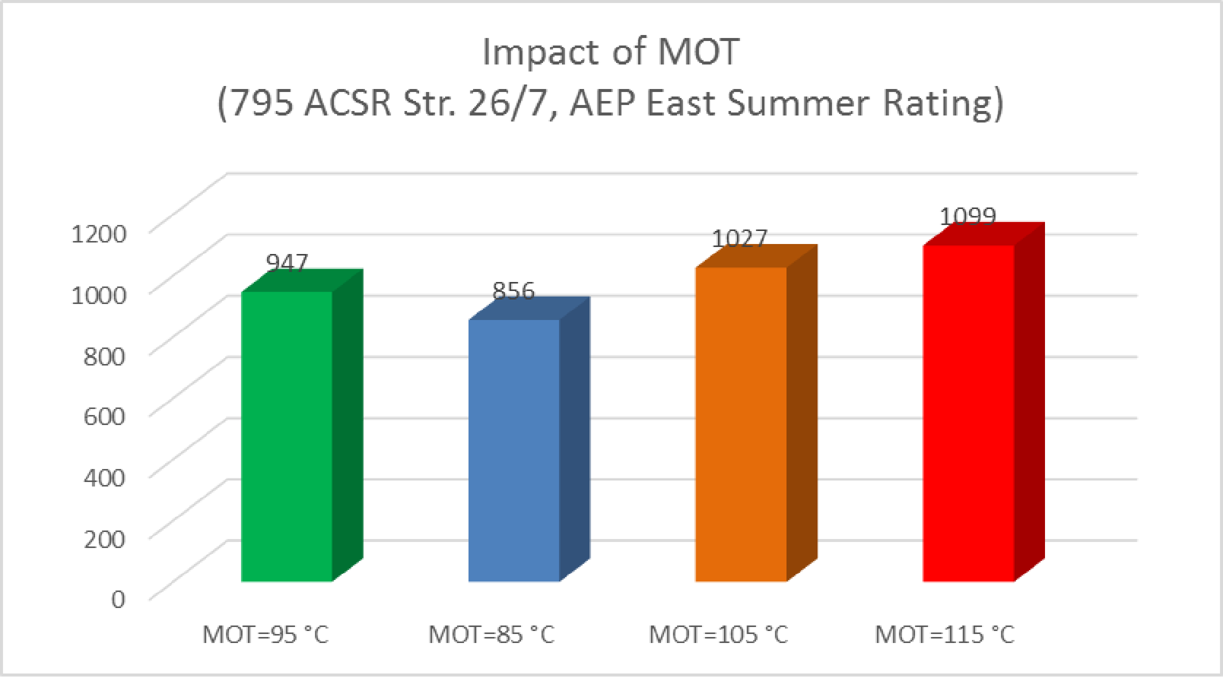
AEP MOT/EMOT Table

Conductor	Normal Maximum Operating Conditions	Emergency Maximum Operating Conditions
Stranded aluminum conductor (SAC or AAC)	95°C	115°C
Aluminum pipe, angle, or rectangular bar	95°C	115°C
Stranded copper conductor	85°C	115°C
Copper pipe or rectangular bar	85°C	115°C
Aluminum conductor, steel reinforced (ACSR)	95°C	130°C
Aluminum conductor, alloy reinforced (ACAR)	95°C	125°C
Aluminum conductor, steel-supported (ACSS)*	250°C	250°C

Impact of MOTs

Varying MOT/EMOT can significantly impact the conductor normal/emergency ampacity values.



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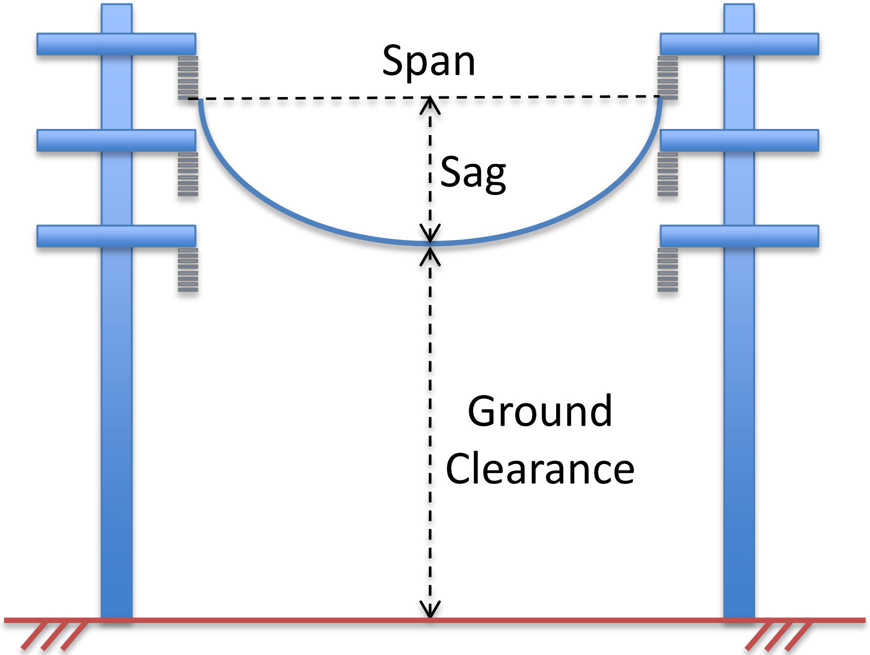
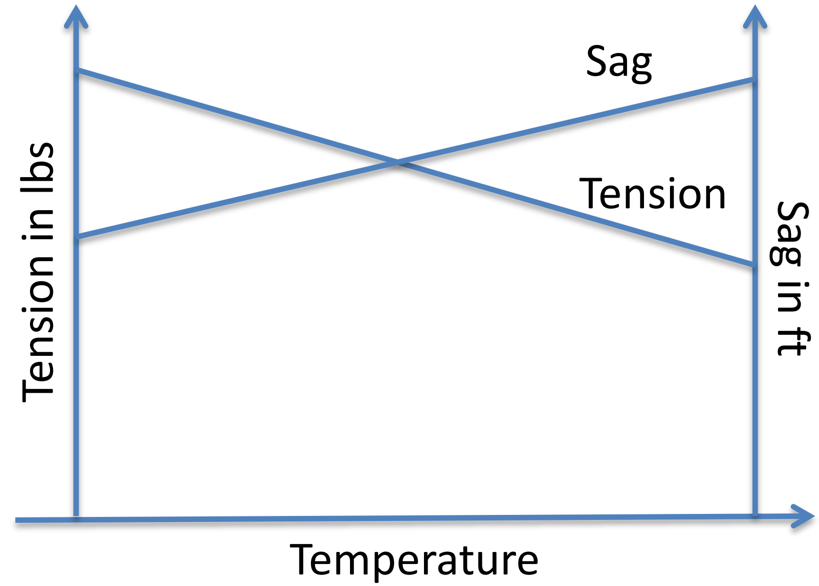
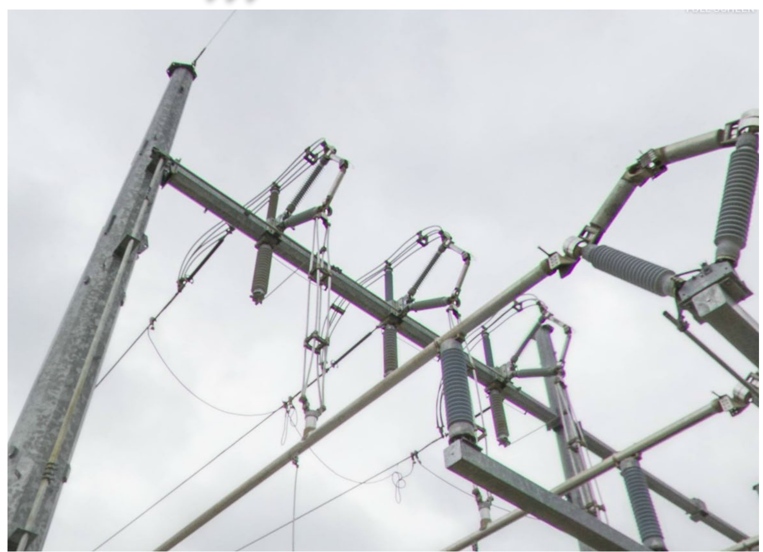
Rethink?







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Benchmarks with Other Utilities/RTOs

Assumptions		AEP Station	PJM	SPP	Utility "A"	Utility "N"	Utility "K"	Utility "C"
Ambient Temperature	East Summer	35°C	35°C	N/A	32.2°C	N/A	37.7°C	N/A
	East Winter	2°C	10°C	N/A	3.3°C	N/A	0°C	N/A
	West Summer	40°C	N/A	N/A	N/A	40~48.9°C	N/A	36°C
	West Winter	20°C	N/A	N/A	N/A	N/A	N/A	4°C
Wind Velocity		2.0 ft/s	2.0 ft/s	2.0 ft/s	1.1~1.3 ft/s	2.0 ft/s	2.0 ft/s	2.0 ft/s
Wind Direction		60°	90°	90°	90°	90°	90°	90°
Emissivity Factor		0.5 for Aluminum 0.8 for Copper	0.7	0.23~0.9 for Aluminum 0.03~0.8 for Copper	0.8	0.7	0.85	0.7
Solar Absorptivity Factor		0.5 for Aluminum 0.8 for Copper	0.9	0.43~1 for Aluminum 0.23~1 for Copper	0.8	0.8	1.0	0.9
Maximum Normal Operating Temperature	ACSR/AAC	95°C	105°C	85°C	93°C	100°C for ACSR 95°C for AAC	93°C	90°C
Maximum Emergency Operating Temperature	ACSR/AAC	130°C for ACSR 115°C for AAC	130°C	100°C	135°C	N/A	100°C	120°C

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Conclusions

- This paper describes AEP's methodology of calculating station bus/conductor ampacity ratings.
- IEEE 605 and IEEE 738 equations are used to calculate the conductor heat gains and losses impacted by current magnitude, ambient temperature, wind speed and direction, sun and conductor positions, conductor absorptivity and emissivity, and the maximum operation temperature.
- In addition, a benchmark with other utilities/RTOs is provided.
- Connectors/fittings are not considered in this paper, but should be taken into account in projects, because they are most likely the limiting elements.
- More industry collaborations on station bus ampacity calculations and applications are beneficial.

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Future Work (with Industry)

- High Temperature Operation for Station Conductors (Possible Failure Mechanism)
- High Temperature Operation for Station Connectors (Possible Failure Mechanism)
- Connection between Station and T-Line
- Legacy Station Challenges (Methodology Changes)


Thank you