Uprating of high voltage overhead transmission lines using intermediary catenary suspenders

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Introduction

- Technology solutions and innovations that impact on Transmission Design Elements.
  - HTLS Conductors
- Cigre study committee SCB2 has three main goals:
  - Increase acceptability of overhead lines.
  - Increase capacity of existing overhead lines.
  - Increase reliability and availability of overhead lines.

Problem statement

- The problem of uprating of existing overhead lines is a main strategic directive because of the congestion of servitudes in urban areas.
- Current solutions include:
  - Re-tensioning of existing conductors.
  - Re-conductoring / re-stringing of the existing line under live conditions with HTLS conductors.
  - Probabilistic study of the line operating under increased loading conditions.

Scale of the problem

- Using steady-state heat balance equation, the load capacity can be calculated:
  - $P_J + P_S + P_M + P_i = P_c + P_r + P_w$

$$P_J = I^2 R_{dc}\left[1 + \alpha\left(T_{avg} - 20\right)\right]$$

$$P_S = a_s SD$$

$$P_c = \pi\lambda_f (T_s - T_a) Nu$$

$$Nu = B_l (Re)^n$$

$$P_r = \pi \mathrm{D}\varepsilon\sigma_B [(T_s + 273)^4 - (T_a + 273)^4]$$

$$\frac{1}{R_{dc}} = \frac{\pi {d_s}^2}{4\rho_s}\left[1 + \sum_1^{n_s} \frac{6n_s}{k_{ns}}\right] + \frac{\pi {d_a}^2}{4\rho_a}\left[1 + \sum_1^{n_a} \frac{6n_a}{k_{na}}\right]$$

$$k_j = \frac{R_{ac}}{R_{dc}} \qquad k_n = \sqrt{1 + \left(\frac{\pi D_n}{l_n}\right)^2}$$

$$P_J = k_j I^2 R_{ac}\left[1 + \alpha\left(T_{avg} - 20\right)\right]$$

Increase in sag vs. increase in current

An algorithm was used to calculate the increase in current for the increase in temperature from 50 – 75 °C for different weather conditions.

Conductor current rating for different weather conditions and a conductor temperature of 50 °C

Current (Ampere)	Wind speed (m/s)	Wind direction (deg)	T_{amb} (°C)	Solar (Watt/m^2)
560.857	0.88	14.85	6.6	500.5
555	3.4	270	35.6	1036
566.24	0.598	43.73	18.5	0

Conductor current rating for different weather conditions and a conductor temperature of 75 °C

Current (Ampere)	Wind speed (m/s)	Wind direction (deg)	T_{amb} (°C)	Solar (Watt/m^2)	Increase in current (%)
740.25	0.88	14.85	6.6	500.5	24
707.5	3.4	270	35.6	1036	22
966.64	0.598	43.73	18.5	0	41

Problem statement summary

- The conductor temperature difference between the core and the surface will increase at high current densities for ACSR conductors.
- In some cases the temperature of the core will increase and cause an increase in sag.
- The reason for the increase in sag is because the conductor weight and tension will remain constant for a given span even if the conductor extends in length due to temperature increase.

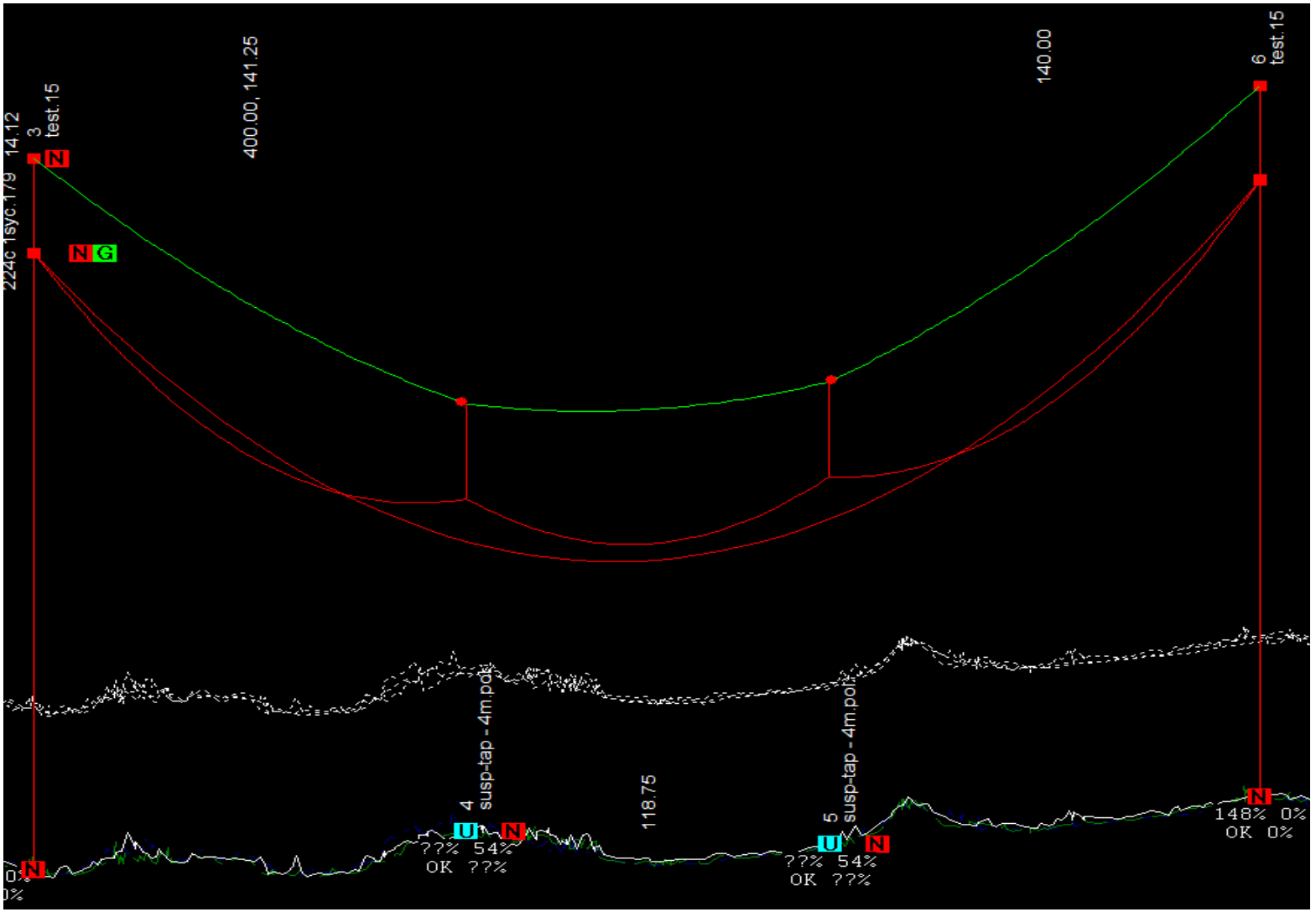
Solution

- The use of intermediary catenary suspenders aims to be the cheapest and easiest solution to the problem.
- The intermediary suspender is connected to the earth wire and uses a low weight insulator and extension links to connect to the conductor.
- The suspender places a small uplift force on the conductor in the case of increased operating temperature (increased sag).

Solution

- The increase in tension in the suspender is transferred to an increase in tension in the earth wire.
- The increase in temperature would simultaneously result in a decrease in conductor tension and hence not a deterioration in the conductor core strength.
- The operator of the line could increase the current while knowing that the sag would not increase even if the ambient conditions were not known.

PLS Cadd model



Increase in earth wire tension

- The tension in the earth wire increases by 15 – 17 % (2470 m).
- This increase is only for short periods of time while the line is running at increased capacity and the ambient conditions are worst. The earth wire will not run at very high temperatures.

Installation and cost

- The intermediary suspenders can be installed live using an insulated bucket truck.
- Cost of installation is considerably lower than that of HTLS conductor installation or re-tensioning of the existing conductor.