

# VIBRATION DAMPING REQUIRED FOR OVERHEAD LINES

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## SUMMARY

Transmission line engineers have sought an easy method for evaluating if external dampers are required on any new transmission line. In the past this question has been given to the damper manufacturer who has a vested interest in an affirmative answer. For single conductors (and for bundled conductors) the vibration level of a power line conductor is the result of a complicated aerodynamic process in which energy is taken into the motion from vortex action on the lee side of the conductor. The amount of energy taken in is a non-linear function of vibration amplitude, frequency, conductor diameter, and wind speed. The amount of energy taken out is a non-linear function of vibration amplitude, frequency, conductor mass, conductor tension, and a certain friction constant that varies from conductor to conductor. It is known that a small amount of vibration is allowed without endangering the conductor. This has been called the "IEEE limit loop velocity", and is numerically equal to 200 mm/second.

*This paper explains a simple procedure, applicable to single conductors, which calculates a comparison of energy in vs. energy out. From this process it is shown how to select the initial tension in the conductor so that no external dampers are required.*

The paper introduces an analytical expression for power/energy input from the wind based on wind tunnel testing of two dimensional flow over vibrating circular cylinders.

$$P = 9 \times 10^{-8} \times L \times d^4 \times f^3 \times [2200 \times (y/d)^2 - 13000 \times (y/d)^3 + 36300 \times (y/d)^4] \dots (1)$$

The expression is applied to two popular ACSR conductors known by the code names Drake and Cardinal. The energy input to a 1,000ft. span vibrating at 200mm/sec. loop velocity is shown to follow a smooth monotonically increasing curve when plotted against wind speed. The effect of the different diameters for the two conductors is clearly visible. Wind energy input does not depend upon conductor tension.

The energy loss in a vibrating span of 1,000ft. is calculated from another formula which includes the ratio of tension to conductor mass.

$$W_r = 1/2 \quad H \quad u^2 \quad m^{1.5} \quad S^{-1.5} \quad L \quad f^4 \dots (2)$$

The T/m factor is clearly important for energy loss. In addition the energy loss in the vibrating conductor increases with the vibration frequency (raised to the power of four), and the vibration amplitude (raised to the power of two). An important proportion factor is a constant that increases non-linearly with the diameter of the conductor, slightly decreases with conductor tension, and accounts for the friction loss in the vibrating conductor. In this study the friction constant is based on actual laboratory measurements of similar conductors.

Calculations for a Cardinal conductor are performed at two different levels of conductor tension - 18% and 26% rated breaking strength (RBS). The energy loss curves are compared with the energy input curve for the Cardinal conductor vibrating at the IEEE limit loop velocity limit. The comparison shows that the higher tension will allow the wind energy input to exceed the energy loss, while the lower tension will not allow the wind energy to exceed the energy loss.

