Feature

PacifiCorp Gets a Grip On Galloping Conductors

On-line devices tame wind- and ice-induced conductor movement.

By Steve Larson, PacifiCorp

The most dramatic illustration of conductor movement is the violent shift of conductors during galloping. In this scenario, conductors in one span achieve an inverted sag as they reach their maximum upward excursion while adjacent spans retain their original catenaries. Moments later, the spans alternate their movement as conductors swing in the opposite direction. At any time, the line looks like a sine wave as it achieves a full double-amplitude gallop. This event subjects structures to unusual and potentially damaging forces.

The control of galloping has long eluded the research efforts of engineers. Recently, Research Consulting Associates (Lexington, Massachusetts, U.S.) developed a family of devices to prevent the galloping phenomenon.

Fig. 1. Transmission and distribution lines on a single set of poles.

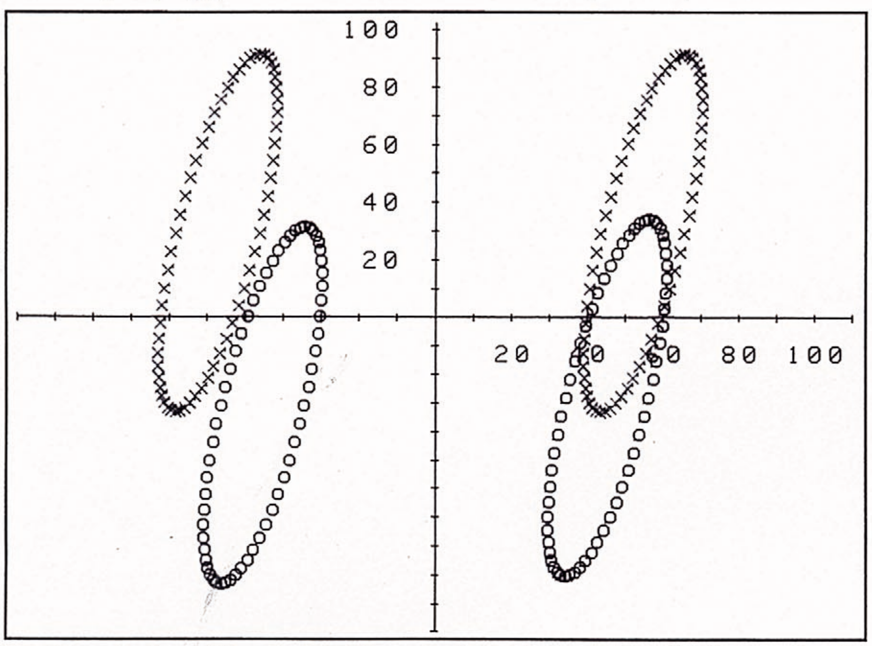

Fig. 2. Conductor orbits calculated for potential galloping on the distribution circuit.

The Galloping Phenomenon

Galloping on overhead lines occurs when the air temperature is at the freezing point of water (32°F or 0°C) and when ice forms on the surface of the conductor and forms a crescent-shaped mass on the windward side. After a thin shape of ice appears and the wind velocity increases, the wind-chill effect causes the temperature to drop even more. The buildup of ice causes the shape of the round conductor to alter. This provides the conditions that lead to violent excursions impairing clearances between phases. Under these circumstances, not only is the physical integrity of the line compromised, but clashing between conductors results in outages.

Using Anti-Galloping Devices

PacifiCorp (Portland, Oregon, U.S.) analyzed the Worland to Thermopolis line in Wyoming to determine the probability of conductor clashing. The construction consisted of T&D circuits on a single set of wood poles with the high-voltage 115-kV line constructed over the 34.5-kV distribution line (Fig. 1). Span lengths were between 290 ft and 350 ft (88 m and 107 m). Ceramic post insulators support the transmission conductor—795 kcmil 26/7 ACSR (Drake)—while pin insulators on crossarms support the distribution conductor—477 kcmil 19-strand all aluminum (Cosmos).

For the distribution circuit, the crossarm separation was 5 ft (1.5 m) with the top crossarm pin insulators installed 54 inches (137 cm) on either side of the pole centerline, and the bottom crossarm pin insulators installed 43 inches (109 cm) on either

The Twister Technology

The study of conductor galloping had its genesis at the Massachusetts Institute of Technology's (MIT) Aerolastic and Structural Research Laboratory in the late 1950s, when its major research project on conductor movement was supported by the Edison Electric Institute (EEI). Albert S. Richardson, who studied at MIT and received the MS degree in Aeronautical Engineering in 1955, managed the project, which found:

- Iced conductors and wind-lift forces cause galloping.
- Changes in tension, mass distribution and stiffness were inconsequential in producing galloping.
- Changes in the aerodynamic features of the iced conductor alleviated conductor movement.
- Mechanical and aerodynamic treatment of the conductor were two methods effective in changing the features of an iced conductor.
- The most effective solution to the problem of galloping was to change the angle of wind attack.

Upon completion of the project, Richardson followed up on the research at MIT by developing the Sandamper and Windamper technologies with grants from the National Science Foundation and the U.S. Department of Energy. The Sandamper was used to control galloping of guy wires on tall TV towers, and the Windamper was used to control galloping on overhead utility lines. The Sandamper uses a rolling drum with loose sand inside the drum, which moves up and down along the galloping steel guy wire. The Windamper uses an aluminum baffle hanging below the conductor to create a twist in the conductor as it gallops. The twist angle alters the angle of attack by the wind and controls the galloping action.

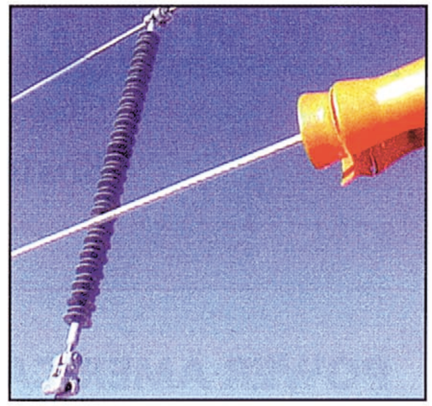

Fig. 3. Twister/Spacer used to suppress galloping on a distribution line.

side of the pole. Two phases were mounted on the top crossarm, and the third phase and neutral were mounted on the bottom arm. Preformed ties and line guards were used to protect the conductor at the pin insulators.

PacifiCorp calculated the conductor orbits (the maximum allowable conductor movement given a fixed set of constraints) during a galloping episode for the T&D lines. For the distribution line, engineering determined the orbits for sags of 60 inches and 88 inches (152 cm and 224 cm) as applied to span lengths of 290 ft and 350 ft (88 m and 107 m), respectively. The 88-inch sag indicated clashing between phase conductors (Fig. 2).

An anti-gallop device, MOD II AR Twister/Spacer (Fig. 3), was installed at the one-third span points, separating

This project illustrates two anti-gallop devices manufactured by AR PRODUCTS, LLC, 3 Wingate Rd. Lexington, MA 02421, PH/FAX 781-862-7200

The first product, AR TWISTER, MOD III is installed on the transmission line. The additional photos show the final position of the device after being installed upside down. The device is initially positioned at 12:00 o'clock. Then it falls to the final position, about 4:00 o'clock. When galloping occurs it tries to go back to 12:00 o'clock. On some occasions it will flip over to 9:00 o'clock. In either case the twisting action on the conductor is the controlling factor to reduce the gallop.

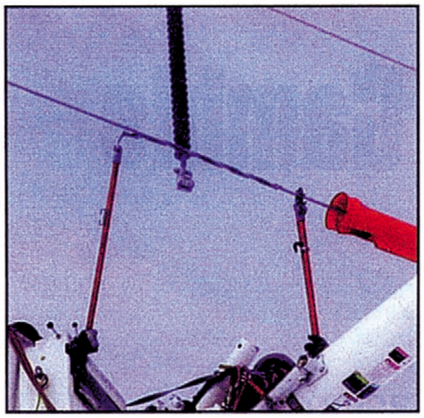

Fig. 4. Using hot-stick techniques to install the Twister/Spacer.

When galloping conditions exist, the conductor begins to move up and down along with the device.

the phase wires from one another and from the neutral. The Twister/Spacer consists of a Sediver 60-inch (152-cm) insulator with eye connectors on both ends. The endpoint clamps attach to the insulator and install at an angle to the conductor to produce twisting whenever galloping occurs.

The phenomenon of conductor twisting, which is the basis for controlling conductor movement, reduces conductor lift when the twist angle is at least 9 degrees. Under these circumstances, clashing between conductors is avoided. Installing the AR devices on the distribution circuit can be accomplished using hot-stick techniques (Fig. 4). The clamps are installed over armor rods that are manufactured to match the conductor and the clamp.

For the transmission line, one MOD III AR Twister was also installed at the one-third span point. The Twister consists of a 20-lb (9-kg) aluminum weight supported by aluminum bracket assemblies mating to an aluminum alligator-gripping clamp. The unit is mounted upside down over armor rods and allowed to fall by gravity to either side of the conductor, reaching equilibrium between 90 and 145 degrees.

When galloping conditions exist, the conductor begins to move up and down along with the device. The up/down movement produces a twist in the conductor, which creates an aerodynamic damping action to reduce the gallop. If the device twists all the way to the other side, the conductor motion stops. For the transmission circuit, linemen install the anti-galloping devices with the line de-energized.

The lines under scrutiny experienced galloping on the T&D lines. The use of the AR devices on these circuits mitigated the harmful effects of galloping and avoided the clashing between conductors. In all, PacifiCorp treated 127 spans, for a total length of 7 miles (11 km).

Steve Larson received the BS degree in electrical and computer engineering from Oregon State University in 1979. Joining Pacific Power (now PacifiCorp) after graduation, he has been involved in a broad range of activities including area engineer, field district engineer, distribution standards and substation design. He is a registered professional engineer in Wyoming and a member of IEEE.

The second product, AR SPACER/TWISTER is installed here on the distribution line, as seen in the additional photos illustrating the method. The top clamp is installed first allowing the unit to hang down toward the lower conductor. The bottom clamp is positioned over the line guards and then tightened. Notice the offset position of the clamps which will twist the conductor whenever galloping occurs. This action, similar to the AR TWISTER device, is what controls the gallop.

All AR PRODUCTS devices embody this feature for gallop control resulting in dynamically modulating the angle of attack of the ice all along the conductor. This is exactly the same principle that the Wright brothers used to control the flight of the first powered aircraft at Kitty Hawk, NC, on December 3rd, 1903. In the case of the airplane the angle of attack was controlled by warping the wing.