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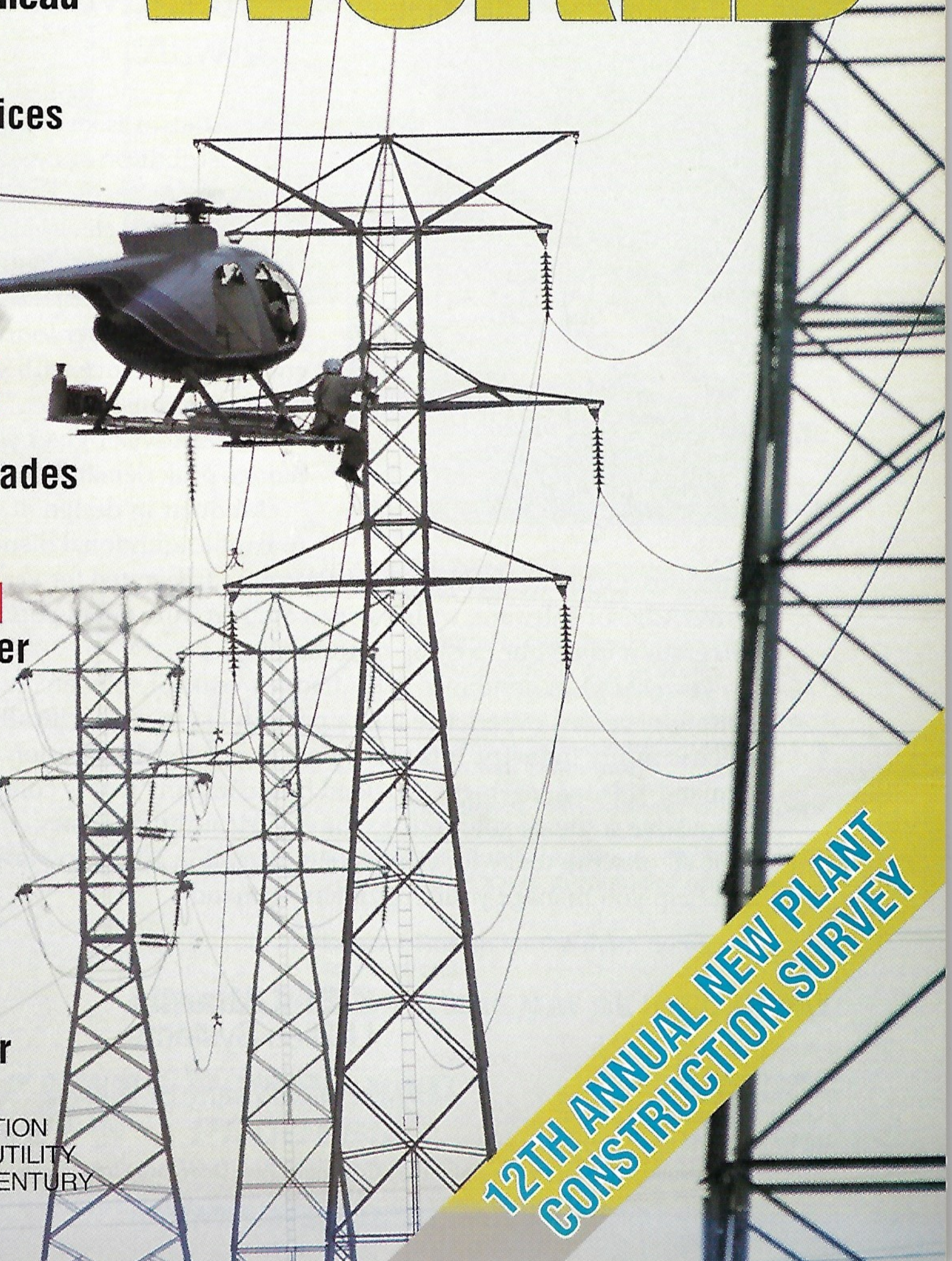

12TH ANNUAL NEW PLANT CONSTRUCTION SURVEY

Anti-galloping devices: Now an accepted solution

Last winter, large industrial companies in northern Indiana noticed severe voltage fluctuations as a result of wind-induced galloping of the transmission lines that serve them. The galloping phenomenon occurs when ice buildup on transmission lines takes on an airfoil shape and causes the conductors to lift under the action of the wind. Galloping can—and often does—cause outages and sometimes damages supporting towers.

A detailed analysis of the lines that experienced galloping in Indiana was conducted by Research Consulting Associates Inc, Lexington, Mass (RCA). It showed that at certain combinations of wind speed and ice buildup, the lines could gallop in wind speeds as low as 35 mph with sufficient amplitude to cause conductors to clash with the phase above. To illustrate: Galloping occurred on 138-kV lines with 1-in.-diam ACSR conductors and 13-ft vertical spacing between phases; and on a 345-kV line with 1.75-in.-diam ACSR conductors and 24-ft spacing (Fig 1). The analysis revealed that the 138-kV line conductors would clash at span lengths greater than 900 ft, while the 345-kV conductors could clash at span lengths over 750 ft.

The device chosen to prevent the conductor galloping described above is known as the AR Windamper, manufactured by RCA (Fig 2). It weighs about 30 lb, hangs beneath the conductor, and is designed to twist the ice airfoil formed on the conductor, thereby dumping the lift generated by the wind blowing across it. Two windampers are required on each span, located one-third of the span length from the towers.

Interestingly, the effectiveness of Windampers had been demonstrated in northern Indiana before last winter's storm. In 1991, Bethlehem Steel, one of the companies in the storm area, installed 31 units on a 138-kV line of its own as a trial installation. In the March ice storm, the protected line did not gallop, while an unprotected 138-kV parallel line, not more than 50 ft away did. As a result, Bethlehem Steel installed an additional 133 units on 138-kV lines in 1992. In the same season, Northern Indiana Public Service Co (Nipsco) installed 288 four-foot units on its 138-kV line and 276 six-foot units on its 345-kV line.

Helicopters speed installation

Because the Nipsco 345-kV transmission line crosses farmland, and because the steel industry uses power around the clock, helicopters and crews supplied by Haverfield Corp, Miami, Fla, were used to speed the installation of the anti-galloping devices. Units on the 345-kV line were installed with the line energized, those on the 138-kV line with the line de-energized.

The correct positions for the Win-

1. Transmission Lines serving industries in northern Indiana at 345 and 138 kV were affected by severe galloping

2. Anti-galloping devices known as Windampers are loaded aboard helicopter for live-line installation

3. Windampers are spaced one-third of the span length from each tower. Two devices are needed per span-phase (above)

4. Anit-galloping device (right) is constructed of aluminum and sized for the conductor diameter and length of span. Weight is up to 33 lb

5. Helicopter is electrically bonded to the transmission line for all hot-line installations (left)

6. Windamper is clamped to conductor with two bolts. For higher voltages, bolts are equipped with anticorona donuts (right)

dampers on the 345-kV line (Fig 3) were determined from the air by running a Haverfield-designed measuring wheel along the static wire. Locations on the 138-kV line were determined by Nipsco personel using measurements on the ground.

A total of 564 Windampers were installed over a period of 15 days. Under ideal weather conditions the crews were able to install 90 devices in one day.

To perform the live line work with maximum safety, the line worker sits on a platform attached to the helicopter skids and is dressed in a hooded, conductive suit that is electrically bonded to the helicopter. As the helicopter approaches the live line, the line worker first contacts it with a long conductive wand that is also bonded to the

Galloping of transmission lines: An elusive problem

Galloping of transmission lines occurs only under certain combinations of wind and ice buildup on the conductor. The ice, which may be only a few millimeters thick, or about 10% of the conductor thickness, creates an airfoil that produces lift on the conductor. Galloping motion is elliptical and can reach amplitudes of several feet—often greater than the normal vertical clearance between conductors.

One problem is that galloping often occurs at night when no one is around to witness it. Even when it does occur in daytime, visibility often is poor. Also, not all cases of galloping produce fault currents and breaker operation, though there are known cases where several hundred trips have occurred during a single storm. A multiplicity of factors, many of which cannot be controlled, affect whether or not a given span will gallop. There are even reports of one phase conductor in a span galloping, while the other conductors remain stationary.

Numerous devices have been designed and applied to transmission-line conductors in an attempt to control damping (EW, July 1989, p 43). Some of these act to damp the galloping motion; others prevent the airfoil-like ice buildup on the conductor surface. Biggest problem is the unpredictable nature of galloping, and hence, the difficulty of demonstrating the effectiveness of any one device. Several years of experience may be needed, during which the number of flashovers and breaker trips on unprotected lines can be compared with lines in the same region that are equipped with anti-galloping devices.

On transmission lines in the US, the most widely used device is the Windamper. The utility with the most experience in the use of this device is Niagara Mohawk Power Corp. Another device in use is the AR Twister—a aluminum weight that is clamped at an angle to the conductor. When galloping begins, this device twists the conductor and dumps the aerodynamic lift effect of the ice aerofoil. Also available for bundled transmission lines is the spacer/damper, which creates damping by absorbing energy in the movement of the subconductors in a bundle.

helicopter. Once contact is made, the helicopter closes on the line and bonding jumpers are clamped to it so all equipment and the lineworker are at line potential.

With the helicopter hovering, the line worker clamps the Windamper to the line with two bolts, equipped with corona donuts if required (Figs 4-6). When the installation is complete, the wand is again placed on the line before the bonding jumpers are removed. As the helicopter flies away, the line worker keeps the wand in contact with the line until he/she is well clear of the arc that is drawn out upon electrical separation.

Because airborne lineworkers can detect minor line problems from the air that may not be visible from the ground, they are generally equipped and prepared to do additional unexpected repairs. During the Windamper installation at Nipsco, Haverfield lineworkers made two armor-rod repairs on phase conductors and two similar repairs on overhead ground wires. ■

—John Reason, Senior Editor

1. Anchor being driven by truck-mounted installer. Correct anchor size and depth ensure trouble-free guying

GUYED TOWERS

How to minimize problems when installing anchors

Correct anchoring is the key to trouble-free guyed tower. To install a guyed tower that doesn't lean or require frequent adjustment throughout it life, installers must:

1. Know the soil down to the depth at which the anchor is installed.
2. Use guys that are as long as practical to minimize loads.
3. Make allowances for seasonal changes in soil conditions, such as rising water table or thawing of frozen soil.
4. Install anchors that are the right size for the expected load and at the right depth for the soil conditions (Fig 1).

Soils are best understood by dividing them into two major categories: cohesive and noncohesive. Cohesive soils can be further classified as soft, firm, etc; noncohesive soils can be classified as loose, dense, etc. The problem is further complicated by the fact that soil is seldom homogeneous and the different types are often interspersed in layers of different thicknesses. Several soil classification schemes exist, included one related to anchor selection (table) offered by A. B. Chance Co, Centralia, Mo.

In a typical situation, a stiff soil is overlain by a soft stratum. If the anchor is installed only in the soft soil, the soil may flow around the anchor under load. Result is a low pull-out load, even though the anchor itself remains intact. If Class 7 or 8 soils are found to be overlaying Class 5 or 6, it is advisable to install anchor extensions so that the helix penetrates the Class 5 or 6 soil.

If the anchor only penetrates the hard soil by a short distance (less than three times the helix diameter for a screw anchor) it may still pull out at less than the load that would be expected from the properties of the hard soil and/or the final installation torque. This is because of insufficient support above the helix. Helical anchors must always be driven at least three diameters into the intended bearing stratum. If capacity is to be estimated from capacity/torque correlation, torque must be averaged over the final three diameters of embedment only.

Frozen soil behaves like a stiffer soil and generally provides greater holding capacity. However, when the spring thaw

2. Test probe is driven into the ground with a calibrated torque wrench that slides up and down the square shaft

Soil classifications and relative anchor holding capacity

Class	Common soil type	Geological soil classification	Probe torque, in.-lb	ASTM blow-count no.
0	Sound hard rock, unweathered	Granite, basalt, massive limestone	NA	NA
1	Very dense and/or cemented sands; coarse gravel and cobbles	Caliche, nitrate-bearing gravel/rock	750-1600	60-100+
2	Dense fine sand; very hard silts and clays	Basal till; boulder clay; caliche; weathered aminated rock	600-750	45-60
3	Dense clays, sands and gravel; hard silts and clays	Glacial till; weathered shales, schist, gneiss, and siltstone	500-600	35-50
4	Medium dense sand and gravel; very stiff to hardsilts and clays	Glacial till; hardpan; marls	400-500	24-40
5	Medium dense coarse sand and sandy gravels; stiff to very stiff silts and clays	Saprolites, residual soils	300-400	14-25
6	Loose to medium dense fine to coarse sand; firm to stiff clays and silts	Dense hydraulic fill; compacted fill; residual soils	200-300	7-14
7	Loose fine sand; alluvium; loess; soft-firm clays; varied clays; fill	Flood-plain soils; lake clays; adobe; gumbo, fill	100-200	4-8
8	Peat, organic silts; inundated silts, flyash	Miscellaneous fill, swamp marsh	<100	0-5

Class 1 soils are difficult to probe consistently and the ASTM blow count may be of questionable value