Protecting trees from lightning shock

by Robert E. Cripe

Bill Graham Jr., chief horticulturist with the Morris Arboretum in Philadelphia, decided to include tree lightning protection in one of the arboretum's workshops two years ago.

He wished to include classroom instruction and an actual installation of lightning protection in several trees. I became interested and decided to help with the workshop.

The 175-acre Morris Arboretum at the University of Pennsylvania, consists of rolling hills, rose gardens, greenhouses, statues, ponds, step waterfalls where trees, shrubs and other plants are grown and preserved for scientific and/or educational purposes.

Installing a tree system

The tree we chose for the installation was a stately Bender Oak approximately 80 feet high with a 75-foot spread.

To design this system in accordance with codes, the tree needed two standard downlead cables and two separate grounds, since the tree trunk was more than three feet in diameter.

Three climbers ascended to the uppermost branches of the three main trunk extensions to install three main or standard air terminals and downlead conductors. They were to terminate at the base with two grounds leading from the trunk below grade 180 degrees apart out some 40 feet beyond the tree's drip line.

To provide the tree with umbrella protection, four miniature air terminals and miniature cables were installed on four of the main branch extensions.

Air terminals were fastened to the ends of the standard conductors. They were then pulled up into the main trunk extensions by the three workmen. The air terminals were fastened to main trunk extensions as close to the upper ends as safety would permit, to provide secure fastening.

Drive-type cable fasteners were used to fasten these standard cables to the main trunk extensions every three feet. Cables were not pulled tight but allowed to flow in a gradual downward course following the contour of the trunk extension branches. After the standard cables were brought down to the main crotch of the tree, the climbers ascended to the main branch areas and started installing the miniature air terminals on the uppermost parts of the branches. They then secured the miniature cables down to the branches where they interconnected with the main standard conductors.

With ropes and copper lightning conductor cable in place, the workmen are ready to climb the tree, drop a rope and pull the standard copper cable with point attached to one of the top main trunk branch extensions.

Copper vs. aluminum

Copper air terminals and cables are always used in tree systems. Aluminum conductors or cables are not used for several reasons, the first being that codes and specifications recommend copper cables because of their tensile strength. Aluminum conductors become brittle from the bending and swaying motion of trees.

Another factor is corrosion. Aluminum cables and accessories, when in contact for extended periods with moisture from decaying leaves, moss or just from the moisture absorbed by tree bark, could eventually cause corrosion and deterioration of the system.

Aesthetics are another factor. Copper materials tend to discolor with age and eventually blend in with the bark of the tree, whereas aluminum materials are always bright and shiny and tend to draw attention to the aluminum system rather than the aesthetic beauty of the tree itself.

Grounding

While the climbers were installing the air terminals and tree conductors, workers on the ground were installing the grounding system. Each ground terminal consists of a minimum $1/2$-inch diameter by 10-foot length copperweld ground rod driven $10\frac{1}{2}$ to 11 feet into the ground out beyond the main root area and beyond the drip line. The ground cable is laid in either a trench six to 12 inches below grade. Or in the case of sodded areas, a spade may be inserted into the ground and a small slit or envelope-type insertion made, allowing the cable to be slipped into the pie-shaped insertion and the sod tamped back in place.

For driving the 10-foot length ground rods, we used a special ground rod driver consisting of a three-foot length of a $1/2$-inch steel pipe open on one end. A heavy steel weight is welded onto the other end, similar to a fence post driver used by farmers.

As we drove the ground rod, we periodically measured the ground resistance, since several of those assisting with the ground aspect of the system were not familiar with measuring resistance. This resistance was measured by an ohm meter, providing a direct calibrated reading which eliminated further calculations or interpolation. Code requirements and standards in the lightning protection field state that a newly-driven ground should be in the neighborhood of 50 ohms or less—the lower the ohms resistance reading, the better the ground.

At three feet deep, we took a reading of 450 ohms resistance. At six feet, the resistance was 375 ohms. At eight feet we hit rock or shale and could not drive the ground rod deeper. This gave us an opportunity to use an alternate grounding method—multiple grounds, as provided for in the code.

At a distance of six to 10 feet from the eight-foot-deep ground rod, we drove another ground rod interconnecting the two in parallel fashion. The reading was 50 ohms ground resistance at that point. The 10-foot grounding electrode on the opposite side of the tree was driven to its full depth without difficulty. The ground resistance reading on this ground was 25 ohms. Both standard downlead conductors were tied to their respective grounding electrodes and the three standard main downlead conductors interconnected at the base of the tree. Then, the ground resistance on the entire tree lightning protection system was less than 15 ohms. Additional grounding virtue was obtained by interconnecting the system with an underground abandoned irrigation pipe located near the base of the tree about four feet from one of our ground cables. By 4:30 p.m., the installation was completed.

Bill Graham, Harold Rosner, Lewis Randall and the staff of Morris Arboretum received funding through a federal grant for installing lightning protection on four trees during 1986. The grant application included offering to train arborists and tree expert firms on how to install lightning protection systems in trees.

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