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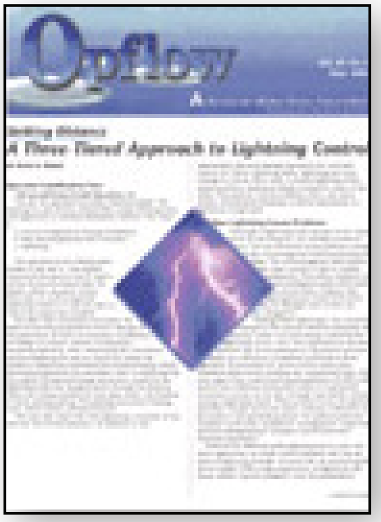

A THREE-TIERED APPROACH TO LIGHTNING CONTROL

Striking Distance

OPERATOR CERTIFICATION TEST
ADVANCED EXTRA CREDIT QUESTION #6

You are the operator of a water treatment plant. The bearings on one of your submersible pumps fail frequently and apparently at random during the summer. The cause is

A. incorrect alignment during installation

B. tiny microorganisms with wrenches

C. lightning

The operator of one Florida plant, certain it was not ‘a’, was almost convinced the answer was ‘b’ until a review of records showed that the failures always occurred within three days or so of suspected lightning strike to or near the tank in which the pump was installed.

Just after that correlation was noted, the plant instituted a program to reduce damage at the plant from all types of temporary oscillations of voltage or current-known as transients- including lightning. After considering the correlation and investigating the way in which the pump was installed, inspectors concluded that internal arcing within the bearing caused by the secondary effect of lightning was the culprit. The ground charge movement caused by the lightning strike was trying to move through the bearing. When the charge reached the tiny gaps within the bearing, it arced, causing pitting. This pitting accelerated bearing wear, which caused premature failure,

The cure, like much else with lightning, consisted of not just one, but several measures. In addition to the catastrophic physical damage caused by the heat and current of a direct lightning strike, lightning can cause damage in several other ways. A nearby lightning strike causes a motion of ground charge toward the point of the strike. This motion, called secondary effect, can cause arcing. Annoying in a bearing, it can be spectacular in a chemical storage tank.

HOW LIGHTNING CAUSES PROBLEMS

Although a lightning strike appears to the human eye to be one long arc, it is actually a series of arcs. This on-off-on-off action produces motion in the electromagnetic field surrounding the strike. The electromagnetic field motion can cause current to flow in nearby conductors. This effect, Similar to an electromagnetic pulse effect from a nuclear blast, explains why microprocessor-based electronics can be damaged even if they are not plugged in.

Damage from lightning is also caused by changes in the ground reference potential (the pressure of the electrical charge created by the lightning) across site. Any separation in distance between two service grounds or equipment grounds results in a difference in ambient potential at those results in a difference in ambient potential at those grounds. If your main AC power service enters your treatment plant at one location and is grounded there, and your supervisory control and data acquisition (SCADA) cable system has a different entry point where it is grounded, unwanted current can be sent through your facility wiring during a lightning storm. When a strike occurs, the ground potential changes across the plant, creating a difference in potential at each grounding point. The ground potential equalizes inside your equipment, causing power surges and possibly damaging your computer system and other electrical equipment.

With all the different paths lightning has t enter and affect operations; no single control measure will stop all types of lightning damage. Ground rods, an uninterruptible power supply (UPS), surge suppressors, or lightning rods alone cannot stop the problem. And, the problems of lightning interference and damage will become worse as microprocessor-based equipment becomes faster. It is not possible to make electricity go faster. Therefore, to make equipment faster, the distances over which the electricity travels must be reduced. As the distances are reduced, arc-over voltage becomes lower, making devices more susceptible to all forms of transients, including lightning.

THREE-STEP PROGRAM

The solution is a coordinated systems approach consisting of proper bonding and grounding, transient voltage surge suppression, and structural lightning protection.

Bonding and grounding enhances both personnel safety and equipment operation. Low-impedance grounding of a structure that is likely to be struck directly by lightning gets the lightning energy off the structure and into ground quickly and safely. Single-point ground potential referencing for services and equipment removes the source of unwanted ground reference current flow through equipment, such as a utility's SCADA system.

Transient voltage surge suppression should be installed on all incoming services and on services between structures. A water treatment plant consists of structures separated by relatively large distances. These distances assure that the structures are rarely at the same ground potential, particularly during a lightning storm. This difference in ground potential can produce current flow in AC power, telephone, and data wires connecting the structures. Therefore, appropriate, all-mode surge suppressors should be installed in a staged protection scheme on AC power lines. Fast-response, low-clamping voltage devices should be installed on both ends of all telephone and data lines, and care should be taken not to route protected wires adjacent to unprotected or ground wires where transients may be coupled to them downstream of the surge suppressors.

Last, structural lightning protection should be installed on all structures. Remember, the purpose of a conventional lightning rod system is to keep the structure from burning down. That is why conventional rod systems are covered under an National Fire Protection Association standard, NFPA 780. Back in the old days when all we had were barns full of hay and horses, that was fine. The barn would be struck, and the lightning energy would be conducted around the barn to ground. The barn would not burn down, and everyone would be happy, particularly the horses. Then we took the hay and horses out and put computers in the barn. Lightning would strike the barn, and the lightning energy would be conducted around the barn to the ground. The barn still would not burn down, but none of the computers would work. So everyone was not happy.

The conventional structural lightning protection system needed to be modified to reduce the indirect effects of direct lightning strikes. This was done by creating air terminals that have streamer-delaying properties that interrupt the lightning-completing streamers that form on the surface of the earth.

When a lightning strike occurs, it happens in a series of steps. The first step is the formation of stepped leaders coming down from the storm cloud. When these stepped leaders reach to within about 500ft or so off the ground, their presence triggers the formation of streamers jumping up from objects on the ground. The first streamer to reach a stepped leader completes the strike.

The streamer –delaying air terminals slightly reduce the accumulation of ground charge and delay the formation of streamers from the protected structure, allowing streamers from another area to win the competition to the stepped leaders, completing the strike elsewhere.

OTHER TRANSIENT PROBLEMS

Lightning damage is not the only problem solved with this tree-tiered protection approach. Lightning is just the most dramatic form of transient. By solving the lightning problem, you automatically protect your equipment from the more pedestrian types of transients caused by such incidents as an electric utility company switching, trees brushing against power lines, and traffic accidents with utility poles. Not only are you protecting your equipment from catastrophic damage, you are creating an environment in which it will last longer and operate more reliably.

Damage from transients accumulates. It may cause microscopic damage that leads to intermittent or unreliable operations. In many cases, this type of fault may be worse than catastrophic failure. It certainly is more aggravating.

Lightning Facts

- At any given moment, up to 1,800 electrical storms are active around the world, producing 100 lightning flashes/second, or about 8 million flashes/day.
- Lightning strikes average 2 to 3 miles in length but can be as long as 5 miles.
- The average strike carries a current of 10,000 amperes at 100 million volts.
- The temperature of a typical lightning bolt is 40,000° F (22,200° C)—seven times hotter than the surface of the sun.
- A typical lightning bolt has a diameter of about the size of a quarter or half-dollar. The light a bolt generates makes it look much bigger.
- Lightning bolts are actually a series of flashes arcing toward the ground.
- US insurance companies annually pay out a total of $332 million to settle some 300,000 claims for lightning damage.
- Lightning is one of the leading causes of weather-related deaths and injuries.

BENEFITS TO THE BOTTOM LINE

Water plants are highly susceptible to lightning-related damage to SCADA systems, communications system, AC power systems, tanks, and other structures. Nationally, lightning-induced problems cause water plants to lose millions of dollars in equipment, repair costs, customer service interruptions, total or partial system outages, and downtime.

So, to protect the equipment in your plant, make it more reliable and extend its service life, take the systems approach to transient protection. Keep in mind the various ways in which lightning can cause damage and then design and implement a coordinated systems approach to damage control.

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