Each year a handful of people are electrocuted, and hundreds more report being shocked, due to electrical wiring problems associated with street and highway lighting systems. Most of these faults would have been safely cleared if the equipment grounding conductors and bonding systems were properly installed and maintained. It is not practical, nor is it cost effective, to test grounding conductors and bonding connections on large-scale lighting systems. Instead, electrical safety pole audits have been used successfully in New York State and Massachusetts for three years to identify these publicly accessible electrical hazards. The findings so far show that the problem is much more extensive than originally thought- initial pole audits show that one in every 337 light poles is unsafe. This article describes the typical pole audit and points out lessons learned from the field.

Northwest Region IMSA Conference 2007- An Accurate Indicator of our Transportation and Lighting Electrical Infrastructure?

In June 2007 a Technical Session was presented at the NW Region IMSA Annual Conference discussing public shock and electrocution cases involving lighting and signal systems. The session focused on 97 previously documented cases that made the news over the past 20 years. What was surprising was the feedback from the 25-30 students attending the class- each relating a story or two of having found a pole or handhole enclosure (junction box) in their maintenance territory that was "hot", that is, had a fault voltage present on it- yet
none of the cases they mentioned were in the 97 incidents presented during the class.

The experiences of these students is typical of what is being found across the US- a large number of electrical hazards that not only puts the DOT/Signals/Lighting worker at risk, but the public as well.

New York State Pole Safety Audit Findings

The 2004 electrocution of a New York City woman resulted in the first US laws requiring electrical safety testing on transportation and utility infrastructure system components. The argument was made at first that the wiring fault that killed the woman was an isolated incident- that mandatory testing wasn’t needed. Statewide testing showed otherwise- in that first year, 1 in every 337 metal light poles was discovered to have fault voltage on it:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Poles Tested</th>
<th>Faults Found</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>237,507</td>
<td>812</td>
<td>1:337</td>
</tr>
<tr>
<td>2006</td>
<td>290,403</td>
<td>672</td>
<td>1:432</td>
</tr>
<tr>
<td>2007</td>
<td>326,377</td>
<td>865</td>
<td>1:377</td>
</tr>
</tbody>
</table>

NY State electrical safety regulations require that energized poles to be made safe (de-energized) immediately, and final repairs may be scheduled sometime later. The faults found in 2006 and 2007 are in addition to the 812 originally found in 2005. That is, in 3 years of testing, 2,349 light poles have been found with an actionable level of voltage.

Special emphasis has been placed on light poles due to the high probability of a human or animal making contact with that surface, but the NY State electrical safety rules requires a number of other DOT/utility system components to be tested as well. These include metal risers on wood poles, handhold enclosures (junction boxes), cable vault and manhole covers, pad-
mounted transformers, signal cabinets, and ITS equipment to name a few. As transportation and lighting professionals we are also concerned with these surfaces, but for this article light poles will be emphasized.

Who Is Responsible?

In many locations, transportation and/or street lighting departments sign maintenance contracts with the local utility or third party electrical contractors. Documents should be carefully reviewed as these agreements often cover only basic maintenance such as bulb replacement and knock down repairs- the issue of public electrical safety is not addressed. Signal and lighting departments should also pay close attention to escape clauses. In one situation, a southern city had been hit by a hurricane. The utility company that had been provided lighting maintenance services for years simply decided to not renew the contract after the storm had hit, leaving the city responsible for hundreds of damaged and missing poles.

The Issue of Equipment Grounding and Bonding

**Equipment grounding and bonding** cannot be over emphasized for the proper operation of overcurrent devices such as circuit breakers and fuses. In this case the equipment is the light or signal pole as well as handhole enclosures, controller cabinets, transformers, and whatever else you have on your system that uses electricity or contains conductors. Despite years of National Electrical Code (NEC) changes and corrections, grounding and bonding is still the most misunderstood and misapplied section of code. In some cases you may have to also include National Electrical Safety Code (NESC) grounding and bonding requirements if you are connecting directly to the utility low voltage system. It is not the intent of this article to cover grounding and bonding, except to point out that if you are using an earth grounding electrode system (such as ground rods) as the exclusive method to clear a pole fault, your standard plans and specifications are wrong. Sending low voltage (<480 vAC) to earth will never permit an overcurrent device to operate. Although now a
banned product in the USA, many fishermen may recall a device called a “worm getter” (or it’s twin the “mole getter”) that used 120 volts from an electrical receptacle being sent directly to the earth via a metal probe (i.e., ground rod) and then returning on a second probe placed some distance away. These products never tripped the house circuit breaker or fuse, and user deaths occurred when the operator would step across different voltage gradients collecting worms that were forced to the surface of the earth, or when moving the “safe” probe connected to the grounded side of the receptacle.

Many States and municipalities have their standard plans and specifications available online. Take a look and you’ll see some that are very well thought out, but far too many still use earth grounding alone for safety without including an equipment grounding conductor (EGC). This is not permitted by code.

The National Electrical Code does permit the use of metallic conduit as an equipment grounding conductor, but this method is subject to extreme degradation and damage over time reducing it’s effectiveness, or ultimately, the ability to trip the overcurrent device. Strong consideration should be given to pulling an EGC with the phase and grounded or neutral conductors.

**Voltage Action Levels- How Much Is Too Much?**

The fundamental purpose of an electrical safety pole audit is to ensure that none of the conductive surfaces of a pole has hazardous voltage present on it. 50 volts AC is generally recognized by OSHA and the NEC as being a level that will not be fatal to humans, but will certainly be felt. New York and Massachusetts have taken into consideration the effect of voltage on animals that may make contact with an energized surface and established 8 vAC as the action level. No documented cases exist of humans being electrocuted by 50 volts (or less) are known of at this time, but many animals have been killed at these levels. The difference is that the electricity flows internally through the animal’s nose, mouth or urine stream and exits via one or all four paws.

When establishing your pole audit program you will have to make a decision early on as to what your action level is- at what voltage will you dispatch a repair crew to take immediate corrective action? This is strictly the Authors opinion, but the legal precedent has already been set by NY and MA and will likely become the national standard.

**The Electrical Safety Pole Audit**

Pole audits can be as basic or as complex as you wish to make them. In the simplest form, you are looking for an actionable voltage level on any conductive surface that the public could make contact with during normal operation- that is, testing the pole then moving on to the next one.

A more complex pole audit may include GPS data collection, GIS mapping, documenting the pole condition and an inventory of other third party equipment attached to the structure. The complex pole audit yields more usable
data, but significantly decreases what is known as the daily production rate- how many poles can be tested in one day?

Both methods require the use of a contact voltage detector (CVD) that is capable of detecting the predetermined voltage action level. Ones found in the typical electrician's toolbox or at the hardware store are usually rated for 50 vAC or above, but several companies make versions that can detect down to 5 vAC. One model has available a pocket tester that allows you to verify the operation of the voltage detector throughout the day.

Voltage detectors are highly susceptible to detecting induced (phantom, ghost) voltages on surfaces. As a result all positive indications by the voltage detector must be verified using a voltmeter to prove or disprove the presence of electricity. Keep in mind that digital voltmeters with high internal impedance are also prone to showing phantom voltages. A traditional analog meter will resolve this problem.

NY and MA rules require the use of a 500 ohm shunt (parallel) resistor across the test leads to simulate a human/animal resistance and to eliminate phantom voltages, but this is practice is not listed nor is it an approved measuring method described in the operating manual of the meter. The National Electrical Manufacturers Association (NEMA) has issued Bulletin 88 stating: “In order to help minimize the likelihood of reaching a wrong conclusion from this phenomenon, NEMA recommends the use of a Listed low impedance multimeter in place of a high impedance multimeter or other high impedance measuring device for testing on open conductors where there is no hard electrical connection.”

The correct application of a 500 ohm resistor (if used) is to place it inline (series) with the test lead and use the current measurement function of the meter to read the total amps or milliamps flowing through that load.

Confusing the shunt resistor situation, Fluke Corporation makes a product called the “Stray Voltage Eliminator”. Fluke is a leading manufacturer of multimeters and electrical test equipment, and a member of NEMA, but their device is at a significantly higher resistance than the 500 ohms required by NY and MA. The reason is simple- resistors are rated on how much power they can handle before they degrade or are physically destroyed. Using ohms power law \( P = \frac{E^2}{R} \), a single 500 ohm, ¼ watt resistor can only handle 11 volts. A single 500 ohm, 10 watt resistor can only handle 70 volts. Assuming the Fluke Stray Voltage Eliminator has a 5000 ohm resistor in it, applying 120 volts would generate 2.9 watts of power- easily handled by a 5 watt resistor.

The actual pole audit involves approaching the pole or surface to be tested with the CVD extended at arms length. Touch the pole and observe the CVD indicators. If it does not alarm, then simply move on to the next surface. If it does alarm, then confirm using the voltmeter.

**Confirm Your Findings**

When confirming, keep in mind the concept of voltage gradients- concentric rings or circles expanding away from the surface where it makes contact with the earth. If you measure an odd reading, such as 63 volts on a
pole that is supplied 120 volts single phase, then you are measuring within the gradient. For a majority of the cases, using 20 foot test leads will put you outside the last ring and you will read the full and correct voltage on the surface of the pole. Use a screwdriver with a 6” shaft to make a probe that you can stick into the earth 20’ away, and then use an alligator clip on one of your voltmeter test leads to connect to the screwdriver.

Although not required, it is good practice to map out the gradient if possible by plotting the voltage level in four directions and taking a reading every 1-2 feet. This can assist in locating the source of the fault, especially if it originates inside the conduit.

If you are working in an area with paved sidewalks, remember that concrete conducts electricity. Use a saltwater mixture to make better contact with the concrete surface by applying a spot about the size of a quarter there you want to place your test lead.

You Found an Unsafe Light Pole- Now What?

In six words- guard it or make it safe. If you find an electrical hazard in the public right of way, you have a responsibility to physically guard that location to prevent injury to passers by. You can also de-energize that pole or surface by removing the fuses or turning off the breaker. You cannot abandon the location with the intention of returning sometime in the future, or to consolidate all faults and repair them on the same day. You are now legally on the hook because you have identified a known hazard. It is common practice, but placing traffic cones on or around an electrical hazard is not an acceptable safeguard.
Worker Safety

Work boots with an electrical hazard (EH) rating are a must. These should be in good repair with no cracks in the soles or tears in the leather. These will prevent you from getting shocked or electrocuted if you happen to step across different voltage gradients.

Follow the manufacturer's directions when using the contact voltage detector—some require you to be bare handed for the device to operate properly while others permit the use of gloves. (Some models rely on the capacitance of your body to work and therefore require good contact between you and the device.)

When working in an area that you suspect has an electrical fault, never kneel down or touch the earth with your bare hands—doing this may complete a circuit shocking or killing you.

Foot Patrol or Mobile Survey?

Two companies have technologies that will permit the drive by detection of energized surfaces. These mobile surveys can cover a large area in a short amount of time, but cannot identify other safety hazards such as missing & crushed handhole enclosure lids or exposed, non energized conductors. The nature of their technology is that they must cast a large net to detect poles in the clear recovery zone resulting in a number of “false positives” that must be further examined by the vehicle operator stopping the truck and using a voltmeter to prove or disprove a “hit”.

Foot patrols permit a much more detailed examination of a particular structure, but average less than 10 miles per day.

The electrical testing industry is battling out which method is superior, but in reality it is a combination of the two methods that work the best.

Conclusion

Large scale testing has shown the extent of light pole electrical safety hazards. The Institute of Electrical and Electronics Engineers is presently developing a recommended standard to address this issue with an expected delivery date in 2011. The public is becoming more aware of these hazards due to Internet and news media coverage. Lighting, signal and transportation departments must start examining, and planning, how to address this problem. Somewhere in your electrical system you have a fault waiting to be found. Who will find it first— you or a pedestrian?

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