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Date: August 30, 2010
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** indicates revisions

To: John Magura, Maintenance Supervisor
Putnam County Schools
1400 East Spring Street
Cookeville, Tennessee 38506

Subject: Electrical Evaluation Report

Location: Baxter Elementary School
125 Elmore Town Road
Baxter, TN 38544

Preformed by: Gary D. Loftis, PE
Maffett Loftis Engineering, LLC

The Problem:
Sometime between late Wednesday evening and early Thursday morning (August 26th, 2010), an electrical short occurred in a 480 volt, 3 phase, 800 amp circuit that supplied power to a sub-panel from the main switchboard. The short took place in a junction box mounted in the crawl space of the main facility. The conductors in this junction box were spliced together with split-bolts that were taped with 3M Scotchfil Electrical Insulation Putty. One of the split-bolts was jammed against the bottom of the junction box creating pressure on the electrical splice. This pressure caused a breakdown of the insulation around the splice instigating the short. It is my opinion that the short would have occurred without the flood. However, the flood exacerbated the issue. Under normal circumstances, during a fault, the electrical grounding system would have created enough fault current to allow the upstream overcurrent protection device to open and clear the fault. However, in this case, the grounding system failed. Because of the failure, much of the exposed metal throughout the facility (ie, conduit, electrical equipment enclosures, building steal, chain-link-fence, etc.) was energized with 480 volts AC.

Evaluation:
Best efforts were made to fully evaluate the power distribution and grounding systems. All panel covers were removed to evaluate breakers, fuses, connections, conductors, conduit terminations, and splices. Under floor junction boxes were also evaluated. During the electrical evaluation the following items were found:

1. Unfused 480 volt, 3 phase feeder that had recently shorted against the frame of the main switchboard.
2. Resistance to ground at the main switchboard was measured at 142 ohms. By code this should be 15 ohms or less. This is one of the indications of a failed grounding system.
3. Abandoned conductors hanging loose in the main switchboard and in several sub-panels.
4. A second junction box was found under the floor similar to the junction box that caused the problem originally. This box contained tapped split-bolt conductor splices as well.
5. Several overcurrent protection devices that were sized too large to fully protect branch circuits. This is a code violation.
6. The overall grounding system was found to be antiquated and of questionable service. Multiple bonding junctions appeared to be broken. Bonding bushings at conduit joints were found to be missing.
7. Newer electrical installations had proper grounding conductors and were found to be in good shape.

Immediate Recommendations:

1. Establish a new grounding system to include the following:
    a. At the service entrance, install three exterior grounding electrodes in a triangular pattern, six feet apart. Connect the rods with #3/0 THWN.
    b. Install a grounding bar (similar to Storm #SCGB-8) in the main switchboard.
    c. Run a #250 KCM grounding electrode conductor from exterior grounding electrodes to grounding bar. The resistance to ground shall be checked to verify proper grounding per code. If not, additional ground shall be made to satisfy code.
    d. Bond corner of Delta service (line side of main disconnect) to new grounding bar with a #400 KCM conductor. Verify that the phase grounded is the same as that grounded by the Utility Company. .
    e. ** Run new grounding conductor to all sub-panels and transformers though-out the facility. Each grounding conductor shall be sized according to NEC 250.122. Running grounding conductor exterior of feeder conduit shall not be allowed.
    f. Install bonding bushing on all feeder conduits if not already installed.
    g. Install a new ground bus bar in each sub-panel.
    h. Bond all electrical enclosures and junction boxes. Remove paint as required to ensure proper bonding.

    i. Bond all exposed metal that could potentially become energized during future electrical shorts or faults (ie. walkway canopy structure, chain-link fence, building metal, copper water pipe, etc.).
2. Remove abandoned conductors where possible. If these conductors can not be removed or may likely be used for future circuits, then bond them to the grounding bus bar within each enclosure.
3. Rework the spliced conductors in the second junction box under the floor with approved splice blocks.
4. Install new pull box under the floor that feeds 120/208 volt, 225 amp, three phase sub-panel. Clem Rogers with Lakeland Electric has knowledge of location and scope of work.
5. Fix the unfused 480 volt, three phase circuit (Lakeland has already fixed the circuit).
6. The following items in the electrical room in the Kindergarten building need to be addressed:
    a. Cut off threaded studs in pull/junction box located.
    b. Install insulation barrier between taped splices and enclosure.
    c. Clean out concrete debris in disconnect switch and plug knock-out in top of disconnect switch.
7. Replace all 30 amp fuses that feed 12 AWG conductors with a 20 amp fuse. This will need to happen at several locations throughout the facility.
8. Clean out debris and storage items from electrical rooms and electrical work spaces.
9. ** In the main switchgear, replace the fuse in the ground phase conductor with a 3000 amp rated bus bar.
10. ** In the main switchgear, remove the volt and amp meter and associated wiring. Plug holes in front panel after removing meter equipment.
11. The electrical inspector having jurisdiction shall have oversight and final approval of all electrical work preformed.
12. After approval, the utility shall energize the facility with the main disconnect and all sub-disconnects in the open position. Then the main shall be closed with out load. Then each sub-disconnect shall be closed one at a time, verify proper operation of electrical system.
13. All GFCI circuits shall be tested for proper operation.

Future Recommendations (with-in six months):

1. Replace antiquated 225 amp, 120/208 volt, three phase panel in Gym. Install proper size breakers to protect branch circuit conductors.
2. Install 100 amp conductor (#3 THWN) to HVAC unit that is located on the north side of the Kindergarten facility.
3. Install 125 amp conductor (#1 THHN) to step down transformer located in the Gym office.
4. Keep electrical rooms and electrical work spaces clear. These areas are not storage locations.

Summary:
There were two failures of the electrical systems during this recent event, the first being the electrical shorts that were precipitated by the flood. These problems were relatively easy to identify and repair, thus allowing power to be turned back on to the facility. The second problem was the failure of the antiquated electrical grounding system. The installation of a new grounding system will take more time and effort to install, but it is critical to overall safety. Improvements to the grounding system will prevent future electrical shorts from not being detected. A fully functional grounding system will allow the electrical systems to detect shorts and shut power off immediately and automatically.

End of Report