Arc Flash Incident Due to Faulty Substation Ground

Lyndal Cost, Alabama Power Co

92nd International Conference of Doble Clients

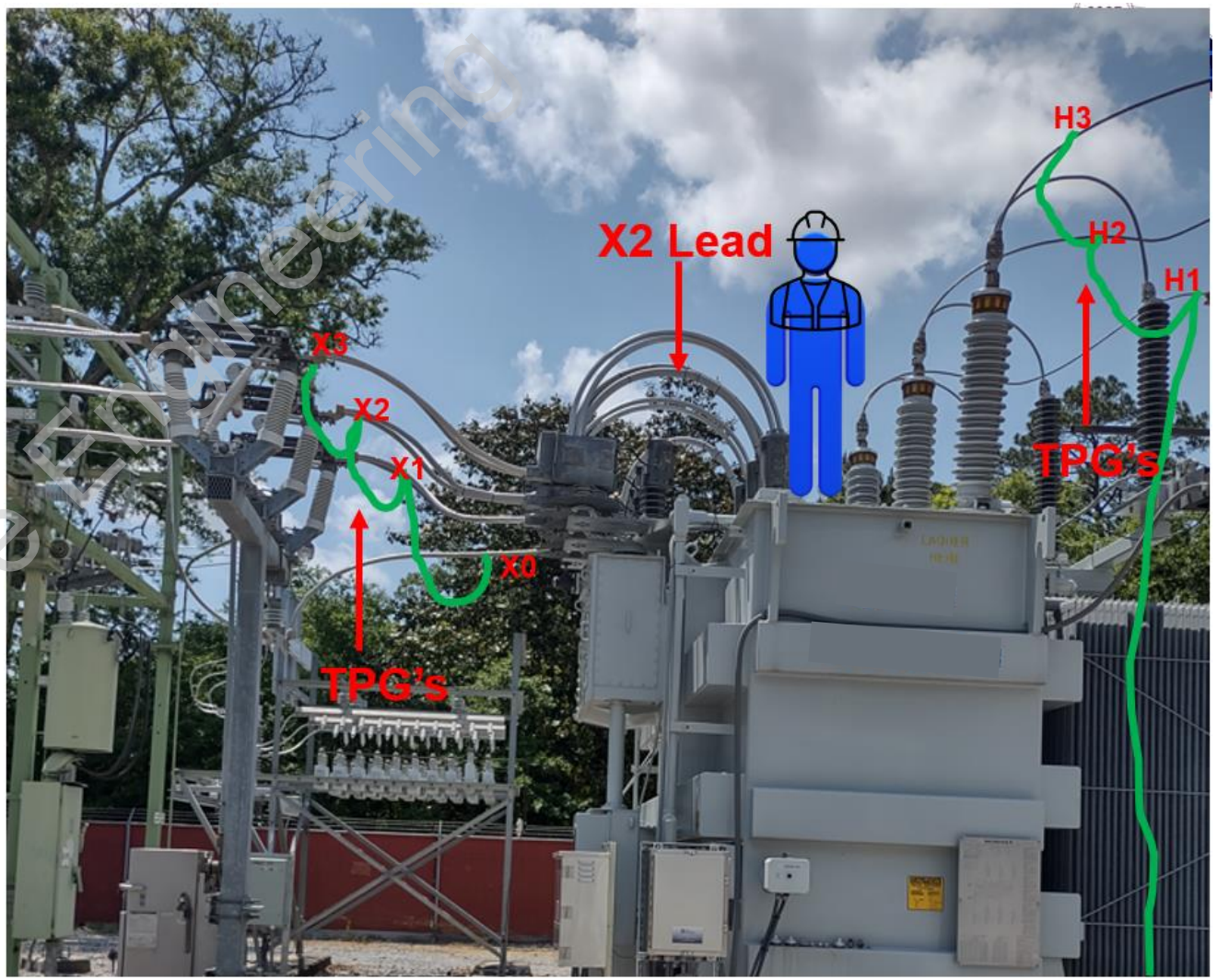
Arc Flash Incident Description

Bank 1 was taken out of service to investigate a bushing monitor alarm which came in on the X2 bushing. The bus tie switch was closed, allowing the Bank 1 feeders to be fed from Bank 2.

Clearance was issued and temporary grounds (TPG) applied as shown in green

The work plan was to perform power factor test on the transformer to validate the bushing monitor alarm.

One journeyman electrician climbed onto the cover. The X2 lead was the first to be removed. When the lead was disconnected and laid down on the tank cover, an arc occurred.

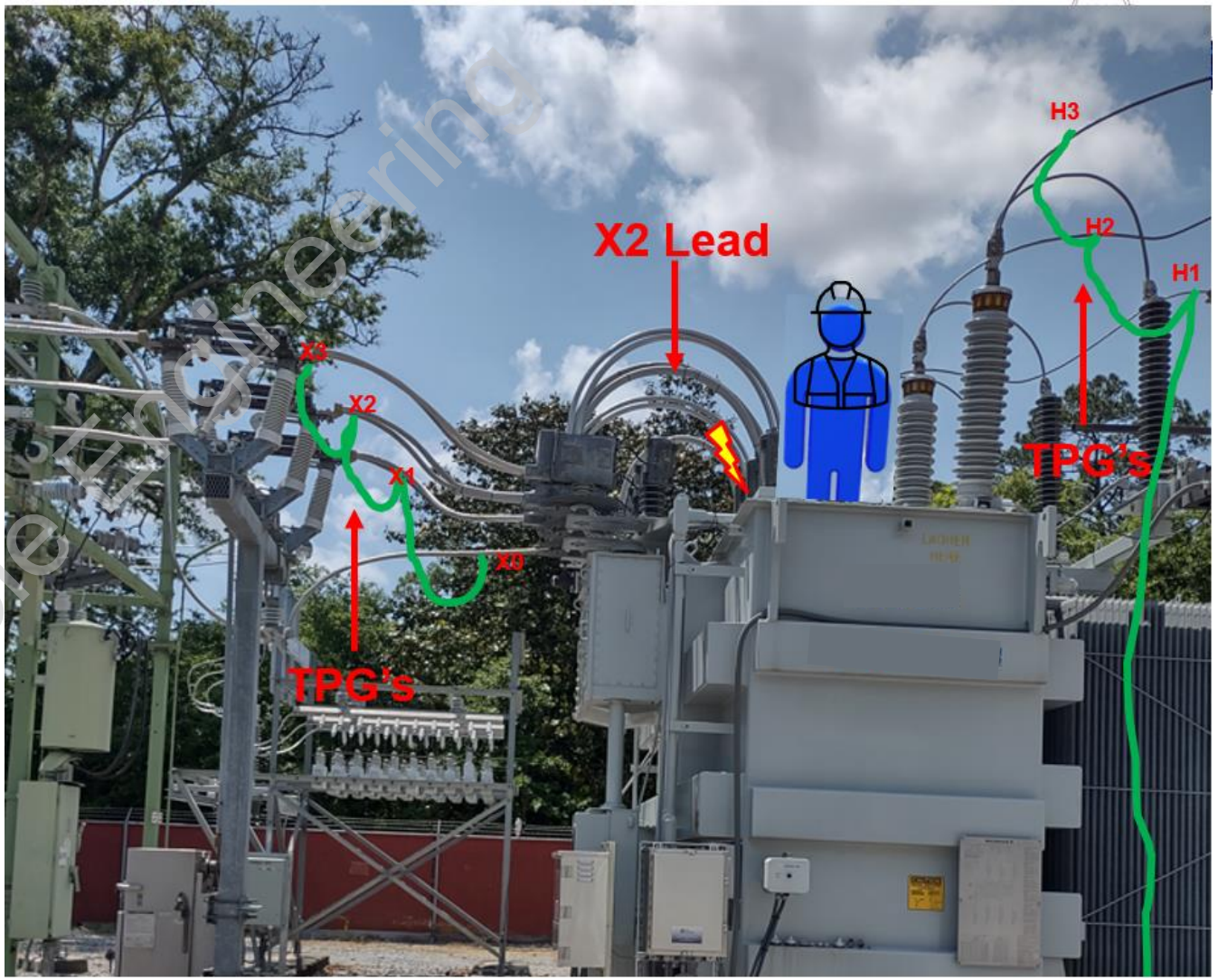


Arc Flash Incident Description

When the 4-hole weldment terminal on the end of the X2 lead touched the tank, personnel on site stated that made a sound like the arc from a welder.

They described seeing sparks as the pad was contacting the tank cover.

Work was stopped immediately.



Current Measured in Temporary Ground

An additional TPG was installed on the neutral and bonded to the transformer tank ground.

A clip-on ammeter was used to read current in the TPG.

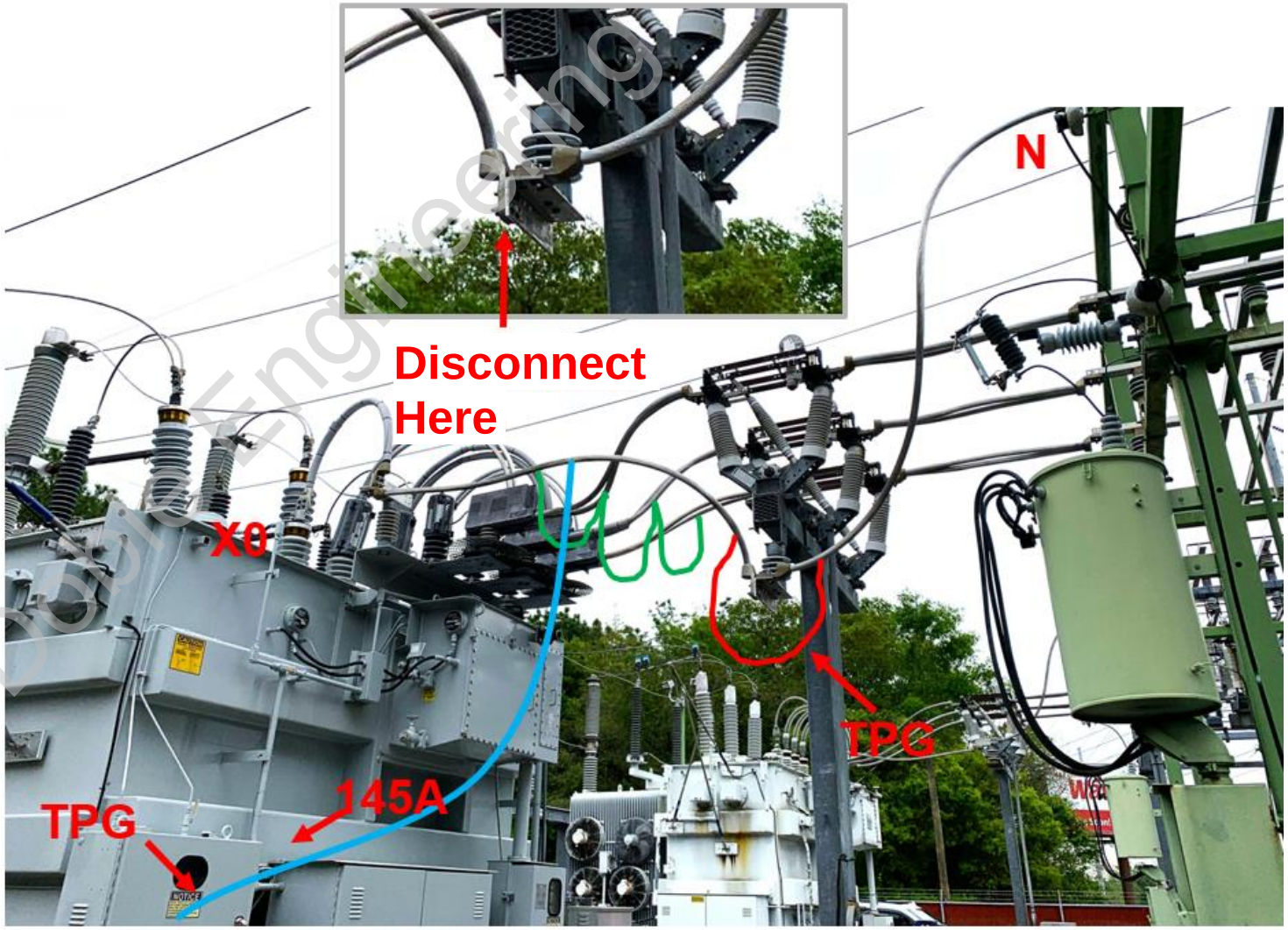
145 amps were measured in the TPG. This is the magnitude of current which would have passed thru the lead when it arced to the tank cover.

TPG Added and Connection Moved to Transformer Ground

The crew decided they needed to completely isolate the transformer neutral lead from the system to continue work.

They decided to open circuit the neutral lead at the bolted detail located on the low side switch structure.

A TPG was installed across the bolted joint to shunt the neutral current so that the bolted connection could be safely removed without splitting the current.

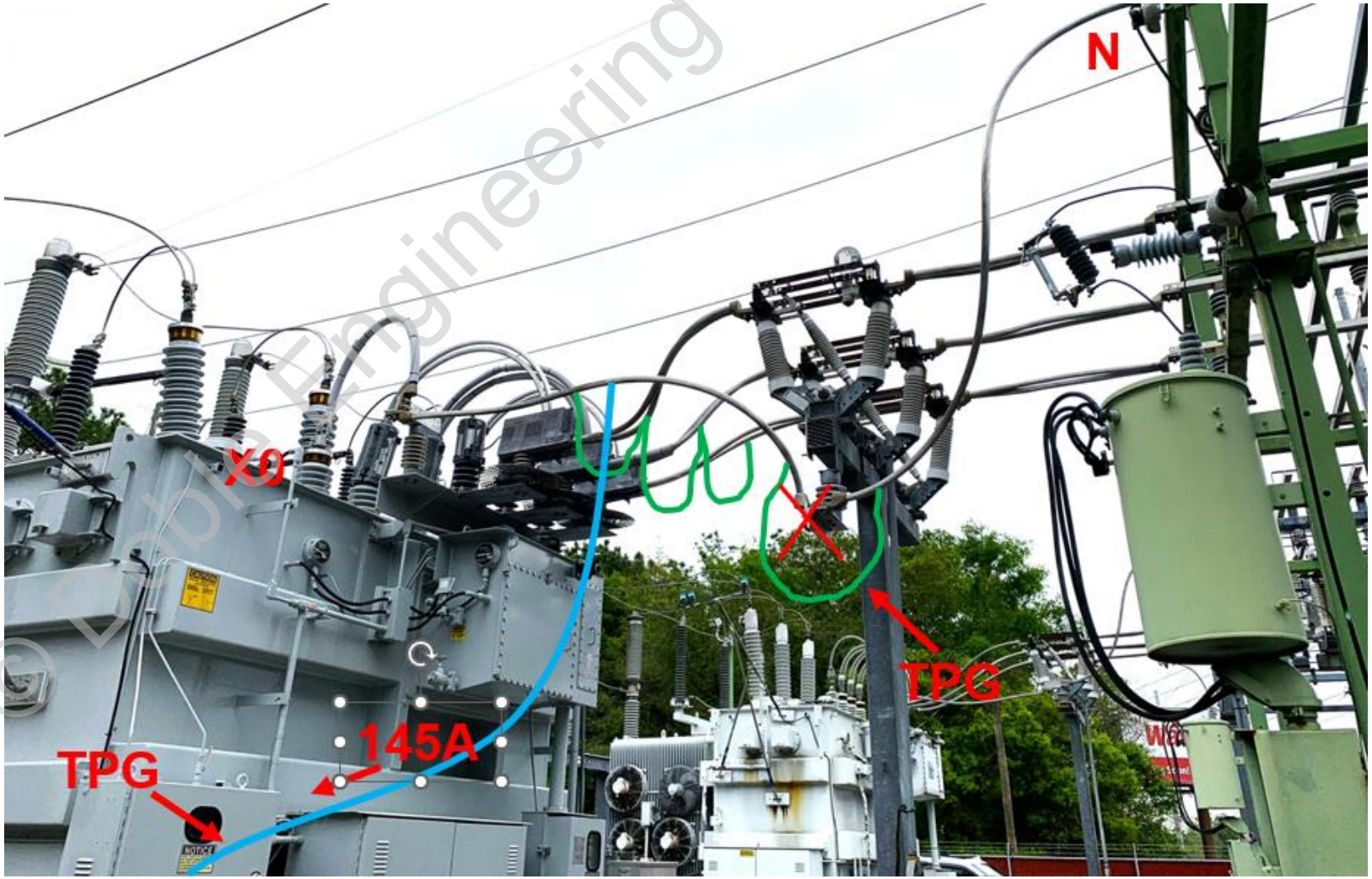


Grounding Point Moved from Neutral Riser to Transformer Ground

The bolted connection was removed.

Then the TPG was removed with a hot stick; effectively splitting the neutral current coming into the station from the feeders and completely isolating the transformer.

Worker continuity to ground was maintained throughout the process.

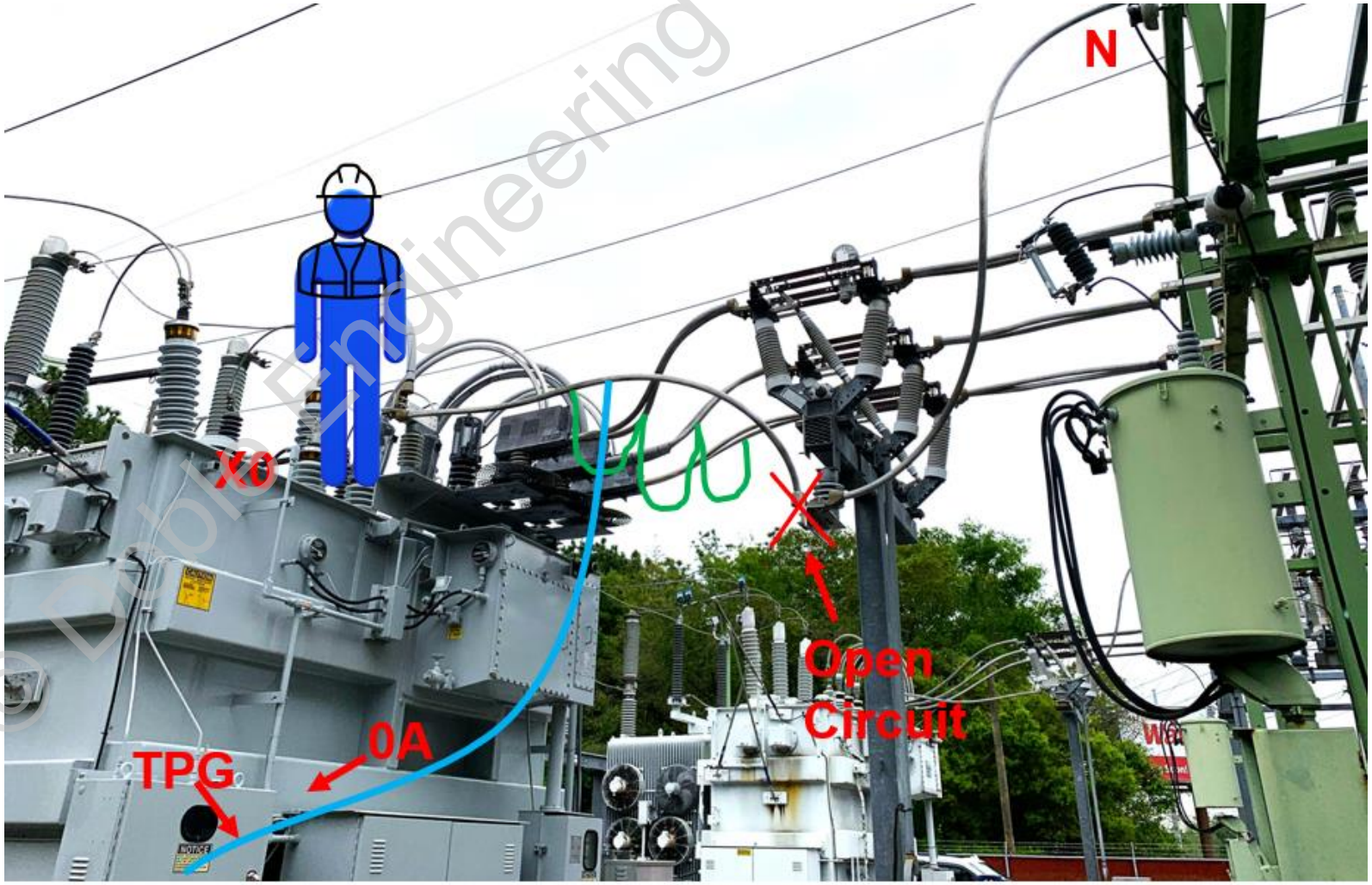


Resumed Testing

Power factor and capacitance testing of the transformer resumed without incident.

Ultimately, the transformer bushing in question tested good. A defective bushing sensor was determined to be the root cause of the bushing alarm and was replaced.

Once the power factor testing was completed, the transformer leads were reconnected to the bushings and the journeyman electrician exited the transformer cover.



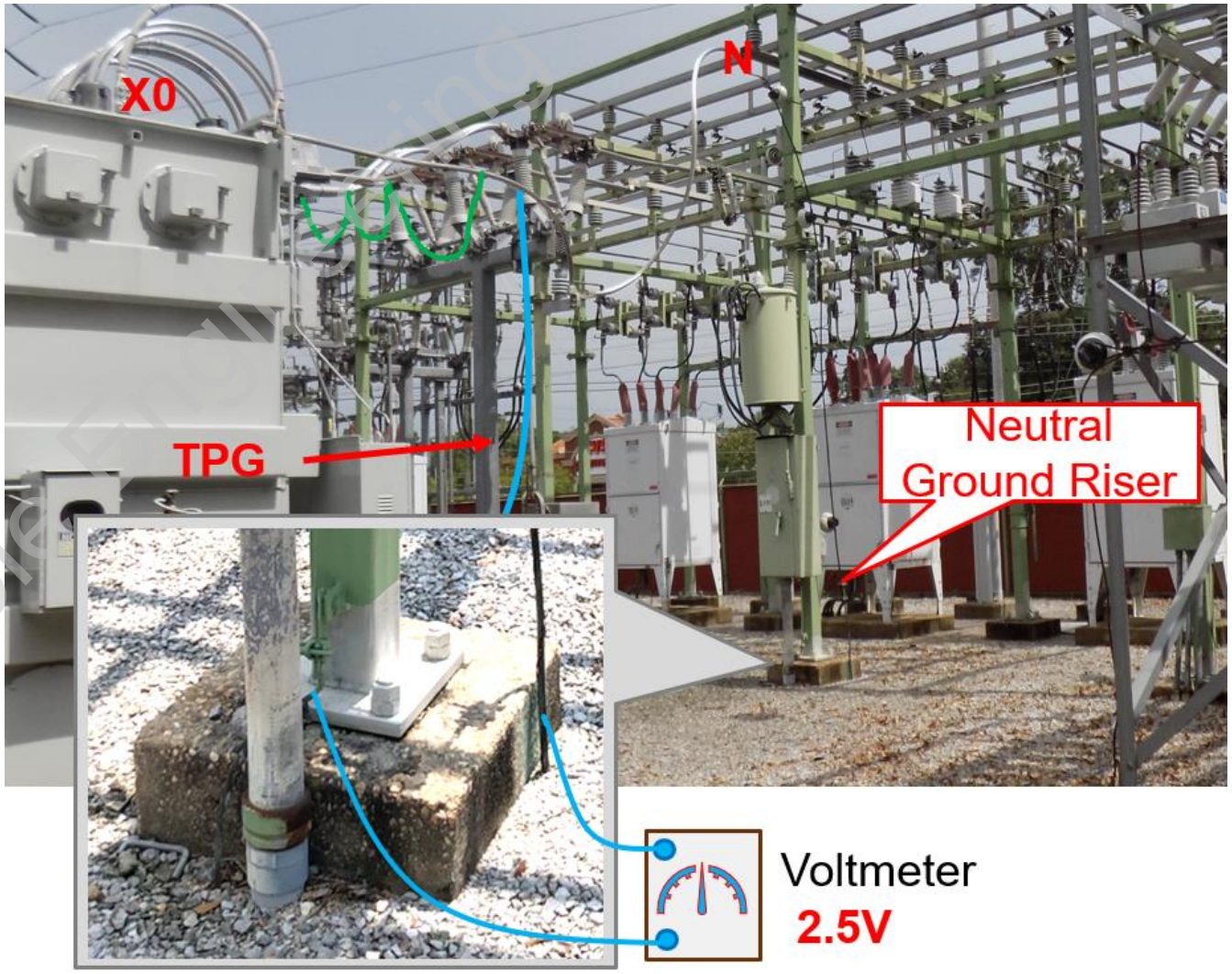
Root Cause Investigation

Next, the investigation began to determine the root cause of the event.

A 2.5V difference was measured between the 250MCM neutral ground riser and the 2/0AWG structure ground on the same structure leg. Zero volts would have been expected.

This measurement coupled with the Ductor reading indicated a clear problem with the connection of the neutral ground riser to the buried ground field.

The connection was not completely open circuited but definitely compromised.

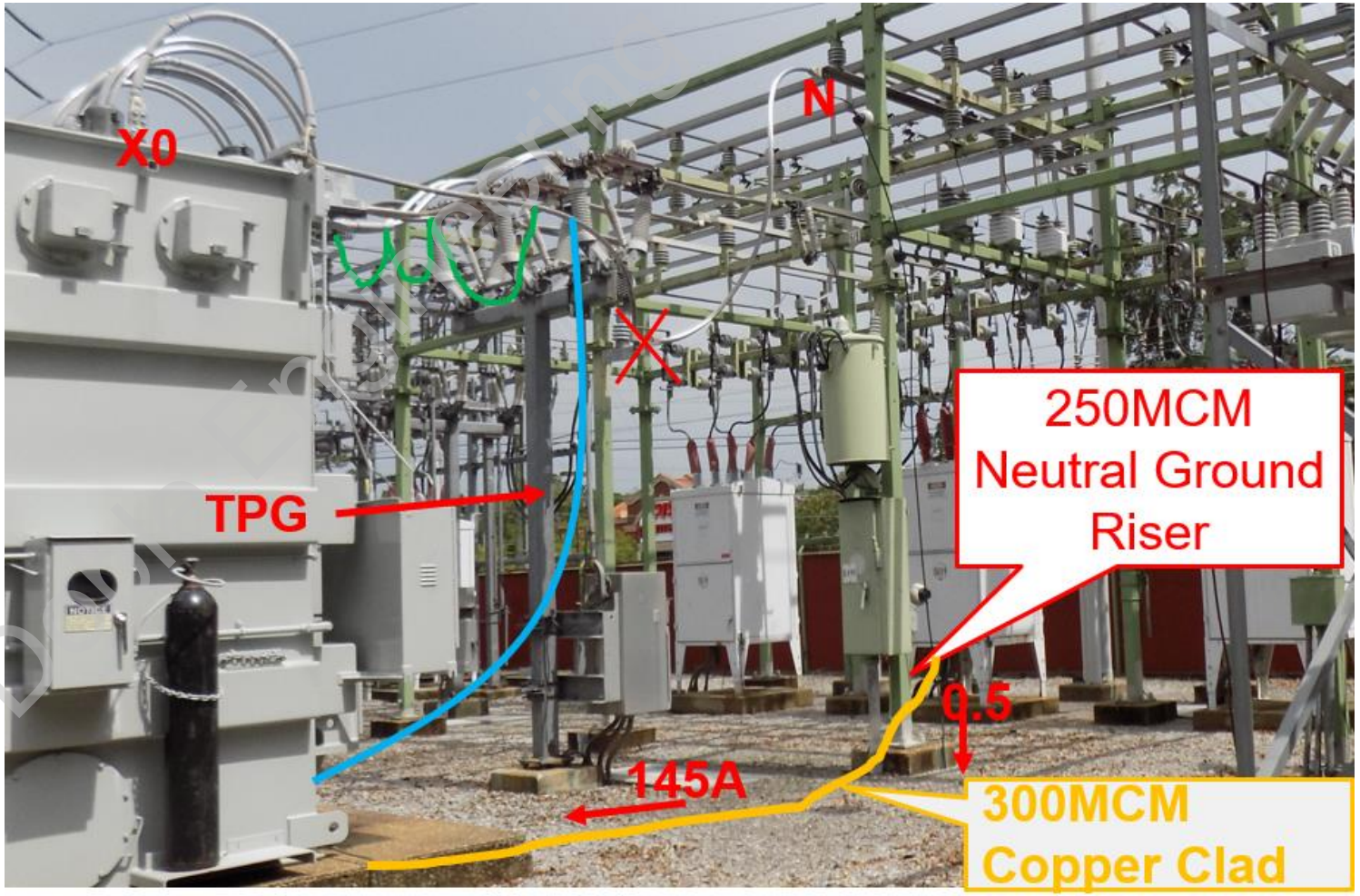


Root Cause Investigation

The crew then installed a 300MCM copper clad ground conductor (yellow) above grade using mechanical clamps from the ground riser to the transformer tank ground. This was intended to be a temporary repair until the problem below grade could be identified.

145 amps were measured flowing in the 300MCM temporary lead and 0.5 amps flowing in the neutral riser into the ground field.

This proved the theory that there was an issue with the connection from the neutral riser to the buried ground field.



Neutral Connection to Ground Grid Repaired

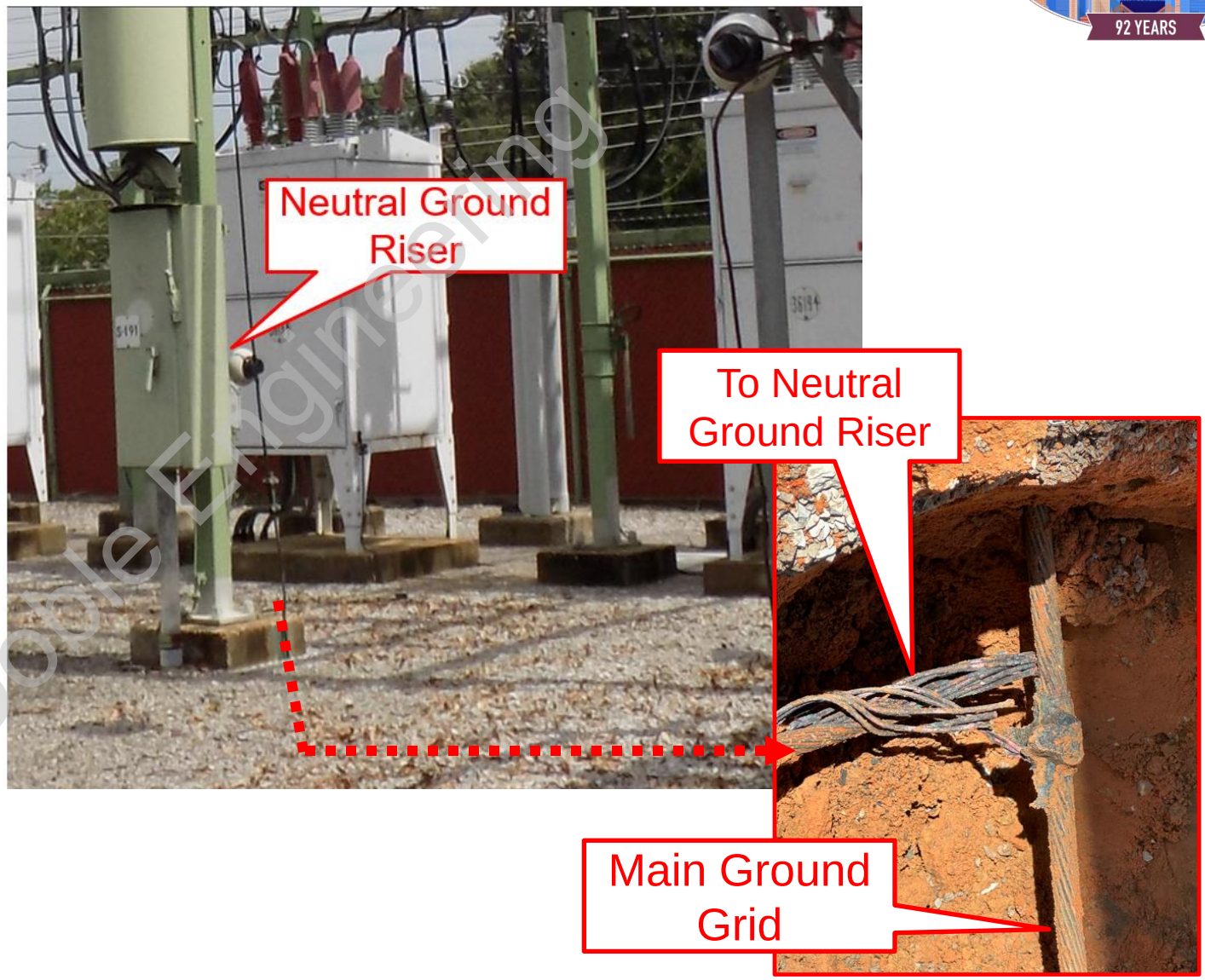
The cut in the neutral was made normal.

The crew removed their grounds on the HV and LV, released their clearance, and energized the transformer.

Compromised Connection Discovered

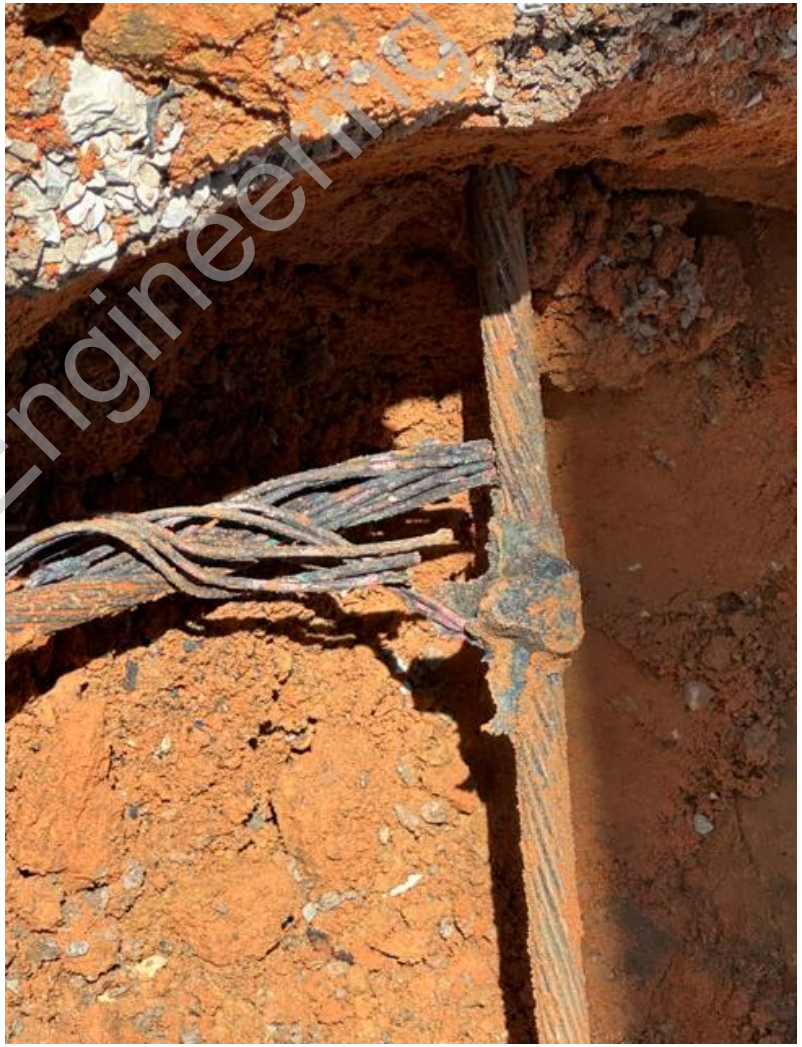
Next, the neutral ground riser was unearthed and traced to the T-connection at the main ground field.

The exothermic cold abutment (CAD) weld at the T-connection was extremely compromised with only a few strands of conductor still making connection



Compromised Connection

The CAD weld appeared to have high porosity and missing much of the expected weld material indicating that this defect likely occurred when the station was constructed.

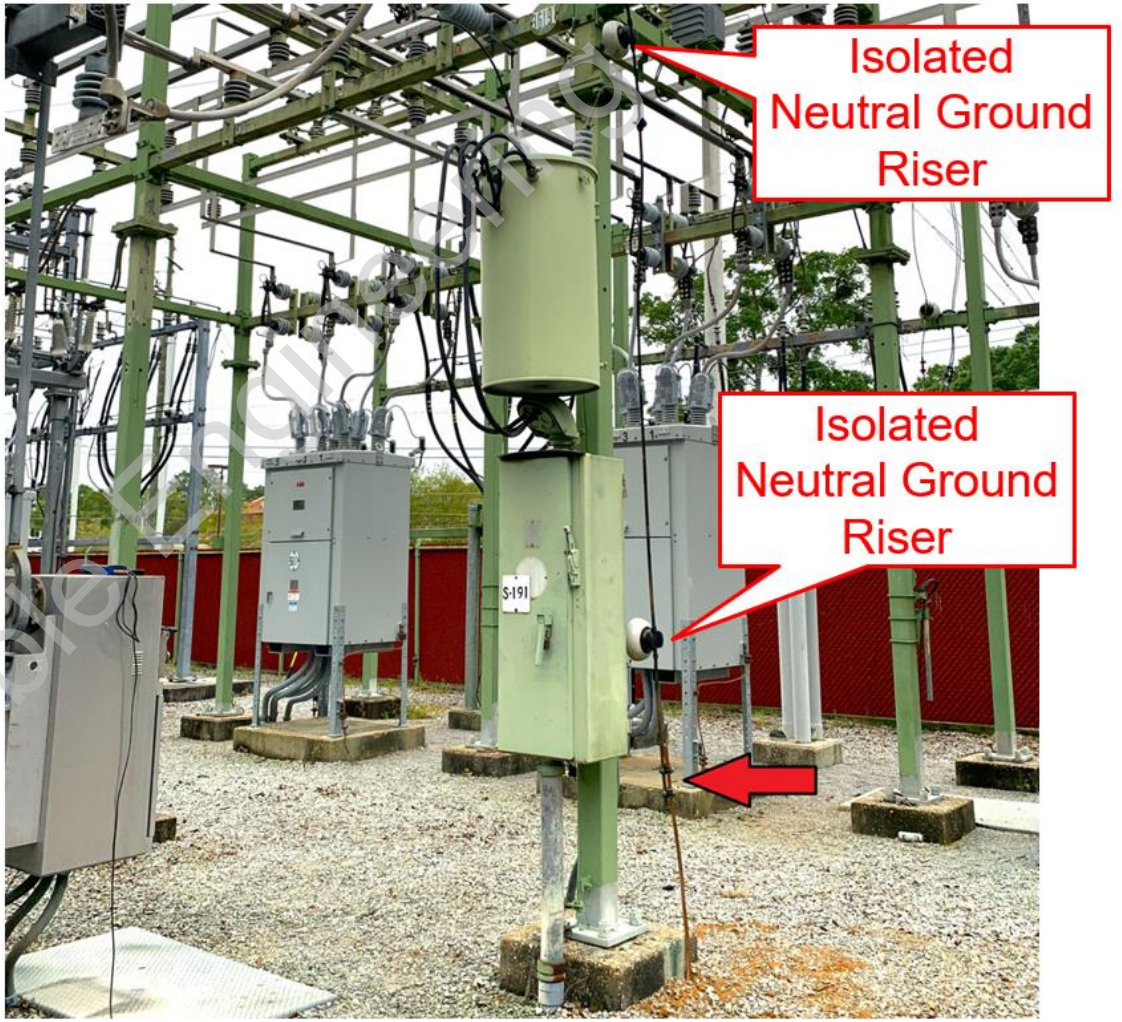


Repair Begins

The neutral buss on the Bank #1 transformer only has one earth grounding connection point.

The neutral buss and earth ground are isolated from the steel structure by porcelain standoff insulators.

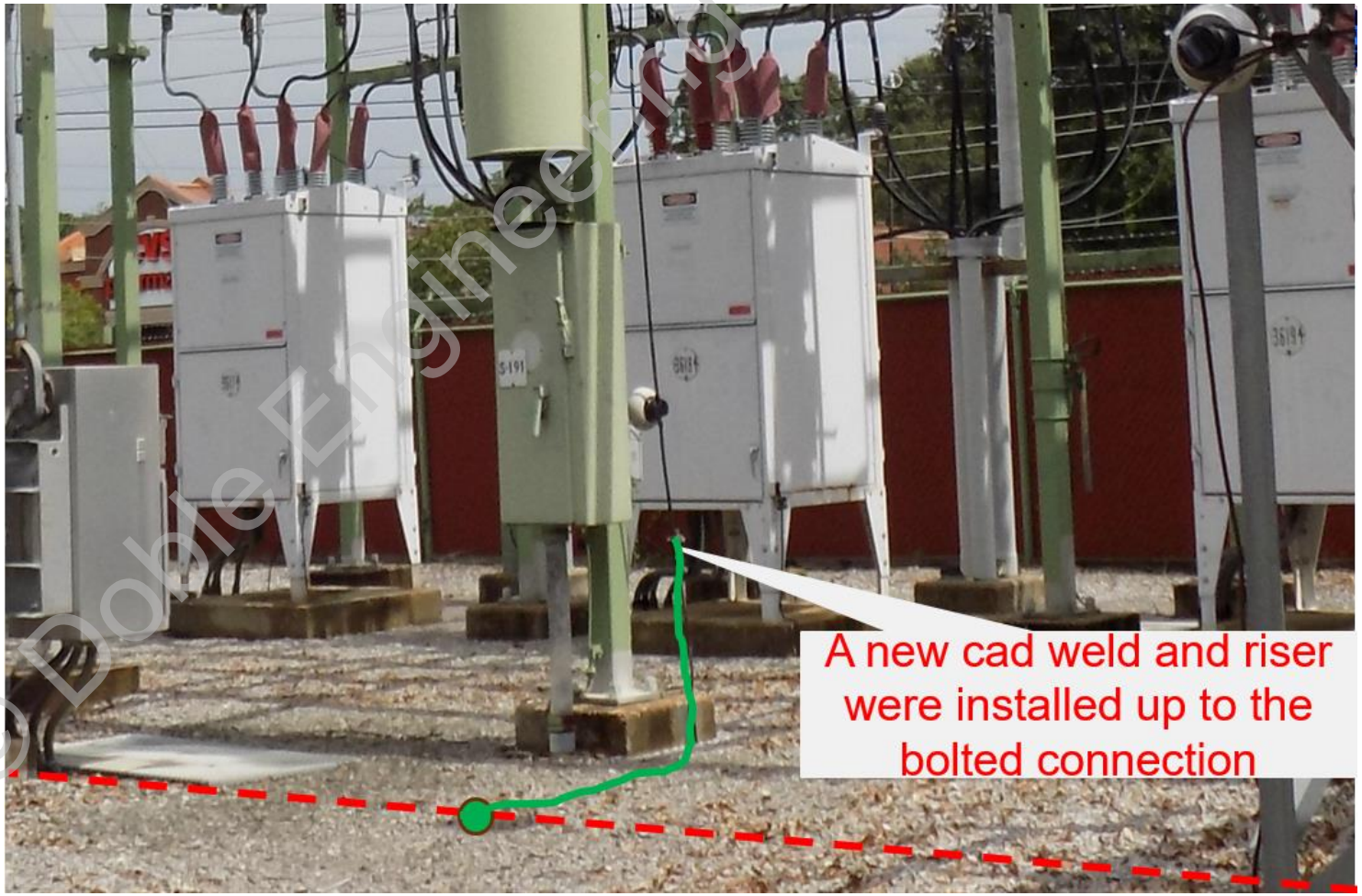
The break below grade created a single point of failure in the neutral grounding system at the station.



Repair Continued

A new ground riser and CAD weld (green) was installed.

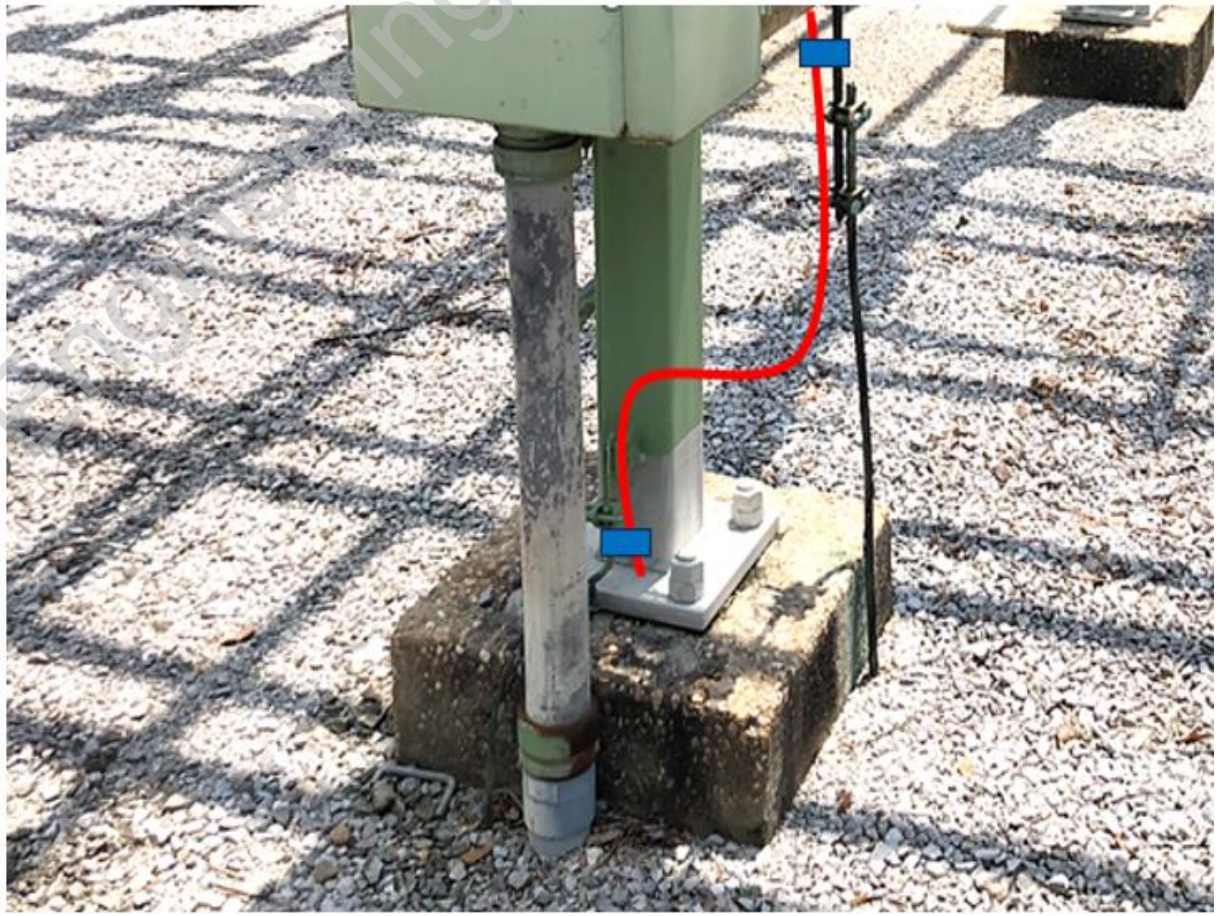
The station was back to normal.



Repair Completed

Neutral bus ground riser is bonded to the structure leg ground before going below grade.

This effectively turns each structure leg into a parallel path for neutral current to flow into the ground field.



Comprehensive Ground Grid Test Revealed More Problems

The Bank #2 high-side Series 2000 Circuit Switcher structure had no earth ground reference on either of the two support legs. Each leg was bonded together with a common ground wire, but neither was connected to the ground field.

If Bank 2 were removed from service and the HV leads grounded, one of these two risers would have been used to ground the transformer.

Comprehensive Ground Grid Test Revealed More Problems

The Bank #1 distribution Capacitor Bank had high resistance readings on each leg of the structure going to the Ground field. All four grounding wires were bonded together to a single common wire that had a bad connection to the Ground grid.

Southern Company Action Items

- Implemented new preventative maintenance inspection activity on a recurring basis
  - ✓ Ground Grid Testing of all substations within four years beginning with the highest short circuit locations.
  - ✓ All stations will be tested within four years, then routine testing will occur every eight years.
  - ✓ “For Cause” testing must be completed after construction projects, copper theft, direct lightening strike, or when TPGs are accidentally energized.

Ground Test Equipment

Serious Safety Question

Do you know the condition of your ground grids?

Thank you.