Substation Maintenance Tasks Expand with SMEPA's System
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Imagine the force required to break the current flow at 161,000 volts into or from a transmission substation. Like any switch or breaker in your home, the circuits that connect South Mississippi Electric's various lines and substations all have protective equipment to isolate sections that experience a fault.

The power on each three-phase line, whether 69kV, 161kV or 230kV, passes through a circuit breaker as it enters or exits a substation on the way to a transformer or switch, either to feed a Member delivery point or to tie into other lines added over the years to reliably feed SME's expanding system. Each line and all major pieces of equipment within a substation are protected by a relaying system that monitors the flow of power and interrupts that flow if any problem or excessive current is detected. If the relay system senses a fault, massive breakers–which under normal operations are closed–are forced open, breaking the circuit in order to prevent the potential problem from affecting the rest of the system.

SME's transmission system has 270 breakers, 65 transformers, 142 motor-operated switches, 28 circuit switchers, 100 battery banks and chargers and 56 control buildings. Of course, as the system expands, those numbers steadily increase, but many of the components have been in service since their initial installation as far back as the late 1960s.

Although the technology related to circuit breakers has changed dramatically over the years, the mechanical process has not; whenever a fault is detected, a strong mechanism using either a spring, air or hydraulics displaces a mechanical linkage inside the breaker to physically break the electrical connection, interrupting the fault current on that circuit. Doing so causes a massive arc, which is suppressed either by mineral oil, a vacuum, or a very dense inert gas (sulphur hexofluoride, or SF6), depending on the technology used by the breaker interrupters inside each tank.

"The entire system is designed to prevent any kind of fault from causing more damage to the transmission system," said John Gilbertson, substation and communications manager. "Our breakers are able to interrupt an arc within three to five cycles (0.05 to 0.083 seconds) if necessary and will reclose if the fault clears. However, the arc caused by opening a faulted circuit is significant and could cause quite a lot of damage if not contained within the breaker."

And because there are relatively frequent faults and breaker operations somewhere on the system, there is a continuing need for maintaining the equipment that responds to such incidents. "SMEPA has always placed a high priority on maintenance," said Supervisor of Substation Maintenance Jeff Ladner, who has been with the Association for 31 years. "The substation maintenance crews are responsible for regularly maintaining all the equipment in our stations, as well as transformers, motor-operated switches, battery banks and substation control buildings. We do routine inspections, make repairs and paint equipment as needed.

"The equipment we maintain is built to last–much of it was here before I got here and most of it will be here long after I'm gone."

Precise records are kept on each piece of equipment, and maintenance is performed on regular schedules. The crews also respond to any needs revealed through monthly visual inspections. "If there is a leak, we fix it," Ladner noted. "If something is not right, we fix it. All substation equipment is on a preventive maintenance (PM) schedule, and we will adjust the schedule whenever necessary to ensure that all components continue to function properly."

The older breakers can be ten to twelve feet tall and hold about one thousand gallons of mineral oil in each of three tanks that house the interrupters. Whenever a breaker operates, the resulting arc creates carbon residue and gases that will eventually reduce the oil's capability to properly contain the violent event. During maintenance, the oil is drained, filtered and tested to ensure its dielectric capacity to perform. Maintenance crew members must also physically climb into the close confines of the breaker to clean the tank interiors and inspect the interrupters. Then the filtered oil is returned.

Technicians Josh Beech and Matt Simpson both have an associate's degree in electronics, which have helped them adapt to the new testing equipment, electronic controls and equipment in the field, and to the computers that are now part of the maintenance program. While many of the tests still measure the same kinds of mechanical processes performed by components on the system, the diagnostic equipment has evolved, which helps with maintaining performance records for each component.

"As much as we work with a wide variety of technology, it can still be a tough, physical job," said Beech. "We are responsible for so many different components; we have to crawl in tanks and change out bad bushings. We work on oil breakers at least once every three to five years and gas breakers every five years. Transformers are also on a three-year schedule. Motor-operated switches, circuit switchers and battery banks are on a semi-annual schedule.

"Our substation equipment is in amazingly good condition, especially the older pieces. The maintenance program has obviously helped prolong the effective life of all the equipment."

Circuit breaker maintenance also includes inspecting the interrupter contacts and mechanisms that control the operation and breaker contact travel and speed, and checking and testing all other components and functions, including alarms, breaker timing, current transformer ratios, saturation and insulation, and power factor tolerances.

Transformer maintenance has many parts. Measurements are taken for the power factor of transformer windings and bushings, transformer turns ratio (TTR), oil dielectric level, and insulation resistance. Tests are performed on current transformers (CTs), all electronic and analog gauges, nitrogen regulation systems, sudden pressure relays, and all transformer alarms and indications that are monitored by the control center. Typical maintenance also involves testing, inspecting, and cleaning the load tap changer (LTC), as well as collecting oil samples for dissolved gas analysis (DGA).

"Gaining experience working with all the different equipment is the most important aspect of our jobs," said Simpson. "There are so many different kinds of controls and equipment that it really takes being out here for several years to know what to expect on each job, especially when we are troubleshooting."

The eleven-man substation maintenance group shares the wide variety of continuous tasks required all around the system. These employees also are available to provide help to Members, as needed, with oil handling equipment and breaker and transformer testing equipment–which many Members do not have–and with helping to set up the mobile substations whenever and wherever needed. The technicians also make annual infrared inspections for most Members, as well as for the Association's transmission and generation sites.

Many of the jobs require working closely with the system operators and Bulk Power Operations planners in order to schedule outages, especially for transformers and breakers that must be off line to undergo maintenance. “We work closely in order to maintain reliability and compliance with NERC regulations,” said Ladner. “Scheduling can become difficult if we experience weather delays and system loading issues, especially as the system expands. There are only so many months in the year when we can take outages at most of our substations, and we try to plan two weeks to several months ahead for outages at major facilities.” One of the more overlooked but important jobs assigned to the substation maintenance crews is maintaining the DC (direct current) batteries located at each facility. The batteries provide an isolated, continuous power supply to operate protective relays, equipment control circuits, and circuit breakers in the substation.

“While there are components of a station that run on AC (alternating current), the batteries provide the stable power supply to operate the substation equipment when it is needed the most–during a fault on the transmission system,” explained Kenny Casanova, technician I. “It is essential that we can maintain the critical communication and operations functions within our facilities at all times, so the battery banks are inspected regularly to make sure they stay at full strength.”

Inspections include load testing, internal cell conductance, and specific gravity measurements, as well as ensuring that the cell connections are clean and functioning properly. Each substation may have up to 60 cells for a 125vdc battery bank that acts as a combined source of power for the operation of protective circuits and equipment. The battery banks are attached to a charger to keep the cells at full strength; generally the batteries last about twenty years if maintained properly.