



## Eaton circuit protection expertise helps a southeast hydroelectric facility power the future

**Location:**

Southeast United States

**Segment:**

Utility – Hyrdro

**Challenge:**

Modernize outdated generator circuit protection to meet electrical industry requirements, reduce planned downtime and simplify routine maintenance.

**Solution:**

Custom vacuum-based replacement breakers incorporating stainless steel enclosures, drawout design and IEEE Design Certificate for Qualification Testing to ensure reliable operation and reduction in maintenance-related outages.

**Results:**

Estimated 25–35 years of service life with no unscheduled outages reported since 2011 installation.

**Background**

This hydroelectric station is an integral part of supplying power in the southeast and central United States. When water is routed through the powerhouse turbines, the station's four generators can produce up to 55 megawatts each, for a total capacity of 220 megawatts.

Commercial operation of the powerhouse dates back to 1963. Today the facility is used for continuous, peaking, or black start power for other generating plants on the grid.

**Challenges**

The original four circuit breakers installed at the station in 1963 used oil as an interrupting medium. These bulk oil circuit breakers were not designed to meet generator circuit breaker standards, as the original C37.013 IEEE Standard was not written until 1989.

The circuit breaker technology required regular care and de-tanking to access contacts for routine maintenance. Prior to de-tanking, the insulating fluid was removed and filtered. The de-tanking process was expensive and required an outage of up to

a week for one substation team. This became costly; the estimated lost revenue for one of the generators could reach more than \$550,000 a week. Additionally, spare parts were becoming difficult to obtain and increasingly expensive.

In December 1991, the four bulk oil circuit breakers were replaced with conversions that used fixed-mounted vacuum circuit breaker elements rated and manufactured to distribution circuit breaker standards.

The enclosure mountings and termination locations were designed to interface with the original bulk oil circuit breakers to reduce total installation costs. Since the C37.59-1991 IEEE Standard had not been published at the time the conversion circuit breakers were manufactured, there was no IEEE Standard to cover their design and testing.



The circuit breakers provided satisfactory performance, but some of the maintenance issues related to the original bulk oil circuit breakers remained and a few new issues came along with the vacuum conversions.

- The vacuum-based breakers still required long outages for maintenance and repair
- Substantial rigging was required for removal and transport to a maintenance area
- The air filters within the circuit breakers still required planned outages
- If a fault occurred anywhere in the circuit breaker enclosure, it could quickly spread throughout the circuit breakers bus conductor system
- The complete assembly was not designed or tested to any IEEE Standard

The vacuum-based replacements provided a service life of 19 years, but maintenance costs were continuing to increase and management was eager to develop a new solution to improve reliability and to compensate for an increase in short circuit requirements.

As a result, management consulted with Eaton® in 2010 to develop a new generator circuit protection solution. Because its transmission grid had increased in capacity, and industry standards were developed for large system circuit protection, the new solution needed:

- Design and testing to meet C37.59-2007 IEEE Standard with an IEEE Test Certificate
- Design and testing to meet C37.013 and C37.013a IEEE generator standards
- Drawout construction with a spare circuit breaker element
- Station class bus system with a metal-clad circuit breaker compartment
- To eliminate the need for bus torquing and cleaning
- To eliminate filters and moisture issues

## Solution

Eaton quickly realized the only way to meet the requirements was to manufacture a custom circuit breaker enclosure. Existing IEEE Standards did not meet the utility's multiple requirements, but various parts of different IEEE Standards were grouped under the blanket of C37.59-2007 IEEE Conversion Standard. This provided a qualified design and established certification testing to ensure the circuit breaker would perform as required.

To meet the utility's "wish list," Eaton incorporated the following design elements:

- 304 non-magnetic stainless steel enclosures with stainless steel hardware to eliminate enclosure maintenance and painting
- Double-louvered venting with stainless steel wire mesh to prevent the entry of blowing rain, snow and insects without the need of separate filters
- Oversized space heaters with thermostatic controls
- Thermally compensating porcelain roof bushings to prevent conductor movement resulting from load and temperature fluctuation
- Belleville compression washers at all bus connection joints to eliminate bus re-torquing
- Semi-station class main bus compartments to provide phase isolation
- Drawout construction for the circuit breaker with metal-clad isolation between the circuit breaker and bus compartments
- IEEE Certificate for Qualification Testing

To simplify future maintenance and help ensure reliable operations, Eaton also provided a standard instruction manual for the circuit breaker and a supplemental interactive digital video with support for maintenance and testing of the new circuit breakers.

## Results

All design tests were performed successfully and the replacement breakers were installed by the end of March 2011. Since installation, there have been numerous rain and snowstorms, several hurricanes and one earthquake. Despite these events, no generator circuit breaker outages have been reported and no unscheduled maintenance has been required.

The drawout design of the spare generator circuit breaker can be rotated with the other four circuit breakers to enable extremely short outages for scheduled maintenance. This reduced the outage time needed to change circuit breakers from several days to 3–4 hours. Additionally, if an in-service circuit breaker requires an unscheduled outage, it can quickly be exchanged with the spare circuit breaker in a matter of hours.

Further, since the enclosures are all stainless steel, no maintenance is required for painting or environmental protection. The louvers and screens have also prevented the intrusion of water and insects.

Based on the capabilities and the rugged design of the system, the facility estimates 25–35 years of service life and reliable performance from the Eaton engineered solution.

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