Insulation by Nomex®, Innovation by ABB

Rapid recovery transformer initiative succeeds using specially designed ABB transformers

Joint effort

ABB, partnering with the U.S. Department of Homeland Security (DHS), the Electric Power Research Institute (EPRI) and CenterPoint Energy, delivered three modular transformers from its St. Louis, Missouri, facility to a Texas substation within 20 hours in an emergency drill. These "spare tire" transformers, designed with DuPont™ Nomex® high-temperature insulation can be shipped and fully energized in less than a week.

The transmission grids across the United States form the backbone of American electric infrastructure, providing the long-haul delivery of electricity from power generation plants to distribution networks. There are approximately 80,000 miles of extra high-voltage (EHV) transmission lines in the United States, making up the grid, which has always been vulnerable to various long-term outages, the costs of which can potentially run into billions of dollars.

As a result, a consortium was formed over the past decade by the U.S. DHS Science & Technology Directorate (S&T), the EPRI, CenterPoint Energy Inc. and ABB. The goal of this Rapid Recovery Transformer program, or RecX, is to increase the resilience of the nation's electric transmission grid by drastically reducing the recovery time associated with transformer outages.

Successful test run

In early April 2012, DHS announced that a successful emergency drill had been completed during five days in March to move, deploy and energize three single-phase, fast-recovery transformers that serve as prototypes for the utility industry to dramatically reduce the recovery time associated with transformer-related outages. RecX transformers, designed by the consortium and built at ABB's transformer facility in St. Louis, were disassembled and loaded onto lowboy flatbed trucks for the 1,290 km trip to a substation near Houston, Texas. It took around 20 hours to deliver the transformers and within five days they were deployed and energized, including the re-assembly of the cooling systems, conservators, bushings and connection to the grid.

The RecX team worked closely with officials in Missouri, Arkansas and Texas to work out pre-approval and logistics as they drove through highways in these states.

Need for rapid recovery transformers

High-voltage or extra high-voltage (EHV) transformers are the most vulnerable components in the grid. They are often located in remote substations, making them difficult to replace in an emergency. They generally weigh hundreds of tons, and are usually too large to transport by road and can take months, if not years, to replace, if they are built from scratch. This can have extensive social and economic effects, especially if multiple EHV transformers are damaged at the same time, such as in a hurricane.

The RecX prototype was designed to replace the most common EHV transformers used by utilities – the 345/138 kV autotransformer. The RecX design principle was to make the unit modular, transportable and quick to install. The challenge was to reduce the transformer's size and weight such that it was less than 59,000 kg (it actually weighs in at less than 57,200 kg) and small enough that it was truck shippable, while maintaining its performance and reliability.

Nomex® hybrid insulation

From a design standpoint, the RecX transformer has to meet numerous installation requirements, including storage and transportation specifications that requires a small footprint and light weight to ship on trucks. Building on ABB's mobile transformer expertise, they chose a high-temperature hybrid insulation system to reduce both size and weight. Alone or in hybrid solutions with cellulosic pressboard, insulation systems based on Nomex® thermal technology maintain excellent electrical, thermal and mechanical characteristics over a transformer's service life. Reduced aging, high resistance to shrinkage and compression combined with the excellent dynamic mechanical strength of Nomex® brand paper and board all help ensure that coil structures will remain tight and are able to withstand short-circuit forces, even after years of service. Applications such as this one are now supported by the new standard IEEE Std C57.154™.

Final design details

Speed of installation and disassembling was critical, which meant cooling, accessories and mechanical parts needed to be considered. This resulted in a modular cooling and hybrid insulation system. Some other unique design concepts were also incorporated, such as a self-supporting base and transportation system that eliminates the need for large cranes at the site, draw rod bushings and special oil expansion connections. Along with these unique design features, specialized equipment required for hauling and installation of the transformers, subsystems and components was also provided.

Next steps

These rapid recovery transformers were tested and evaluated for over one year at the CenterPoint Energy substation in Texas. "Through this project, DHS S&T was able to partner with ABB and the private sector to develop a solution before a major problem or crisis was experienced," said Sarah Mahmood, DHS S&T program manager. ABB offers the largest variety of transmission and distribution equipment compliant with IEEE/ANSI, IEC and other local standards for the power grid and smartgrid worldwide.

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