EPRI

2024

AT A GLANCE

Circuit Breaker Life Management

Program 37.102

Research Value

- A quantitative understanding of aging and deterioration rates.
- A better understanding of the expected life of circuit breaker materials.
- Knowledge for implementing a condition-based maintenance and replacement approach.
- Reduced unplanned expenses and increased benefits and value of planned work.
- Controlled life-cycle costs and risks, which contribute to reduced operating costs.

Member Benefits

- Effective knowledge transfer through the Circuit Breaker Guidebook and regular technical webinars. The guidebook is a comprehensive collection of circuit breaker knowledge designed specifically for utility owners and operators.
- Novel techniques for sealing SF_6 leaks in circuit breakers and GIS components —which, in turn, translates into reduced emissions, O&M and improved reliability through life extension.
- Quantifiable data on breaker materials and subsystem performance – which, in turn, translates into development and implementation of effective maintenance and replacement strategies.

The life-cycle performance of a circuit breaker is determined by the performance and condition of its materials and components. Together, these performance criteria drive the requirements for maintenance and refurbishment or replacement. However, there is little quantifiable data on breaker materials and subsystem performance available to inform decisions and design cost-effective, condition-based maintenance or replacement programs.

Utility maintenance practices vary widely, as do manufacturers' recommendations. This research addresses the need to develop information, techniques, and methodologies to support best practices in high-voltage circuit breaker life management. The methods developed for transmission classes may be adapted so that these methods can be applied to medium-voltage (13.8–69 kV) breakers. It is anticipated that the research efforts could result in:

- Methods to assess aging of gas-insulated switchgear (GIS) and circuit breaker component and subsystems, including identification of failure modes and degradation mechanisms
- Innovative SF_6 leak-sealing techniques for breakers and GIS
- Noninvasive condition assessment techniques
- Assessment of diagnostic effectiveness of online monitoring as well as offline testing
- Guidance for handling SF_6
- Maintenance guidelines
- Reference books, guidelines, videos, field guides, and technology transfer workshops
- Collaborative forums for sharing lessons learned and best practices

Research Highlights

Circuit Breakers Online Monitoring Effectiveness Assessment develops and applies assessment metrics to various circuit breaker online monitors to determine which monitors and tests provide the most useful information. The objective is to provide utilities guidance on the most informative and cost-effective procedures for nonintrusive diagnostics to support condition-based maintenance.

Efforts to date have identified commercially available as well as emerging technologies and documented the claimed capabilities as well as utility experience from using specific online monitors. Based on the findings, a plan has been formulated to evaluate their effectiveness. Efforts in 2024 intend to work with funders to identify specific circuit breaker monitors of the highest interest and implement the evaluation approach to make comparisons and assess their efficacy. If successful, the results provide valuable assistance in monitor specification, reliability, interpretation, and adoption.

Circuit Breakers Diagnostics Effectiveness Assessment develops and applies metrics to assess the effectiveness of various circuit breaker diagnostic techniques. The objective is to provide utilities guidance on the most informative and cost-effective procedures for nonintrusive diagnostics to support condition-based maintenance.

- **Assessing the efficacy of circuit breaker dynamic resistance measurements (DRM):** Work is underway to assess the effectiveness of DRM, an offline non-intrusive diagnostic test to assess the condition of circuit breaker interrupter arcing contacts. Laboratory and field tests continue in 2024 to determine the relationship between the DRM waveform and contact condition and build a library for different circuit breaker interrupter models.
- Efforts in 2024 also intend to expand efficacy assessment to other techniques, for example, x-rays, timing and travel etc. and explore opportunities to utilize relays for circuit breaker monitoring.

SF_6 Leak Sealing for Circuit Breakers and Gas-Insulated Substations investigates methods that can be used by utilities to cost-effectively seal SF_6 leaks. The emphasis is on identifying materials and techniques that can seal while maintaining equipment operating pressures and are easy to apply and remove by utility personnel without having to resort to outside service providers, clamps, or molds. Efforts to date have developed novel techniques for sealing leaks on circuit breaker and GIS component geometries at ground potential. Three successful techniques identified in the laboratory testing are being tested in the field at utility sites. Efforts in 2024 intend to:

- Develop techniques for other geometries. For example, leaks in the bushing flange interface. Some of these new geometries may not be at ground potential.
- Investigate scaling application of existing techniques to larger flange diameters.
- Continue search for innovative methods used by other industries.
- Continue investigations to find sealants that cure at lower temperatures.
- Monitor the performance of the field trials.
- For techniques that are successful in the field develop application guides and “how-to” videos.

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