Technology Innovation Project

Project Brief

TIP 156: High-Voltage Power Transformer Base Isolation Technology & Implementation

Context

A potent seismic event could disrupt the Northwest power system and result in significant economic losses to BPA and the Northwest. The loss of power transformers could cost millions of dollars in lost revenues and replacement costs. It could also take up to a year and a half to restore the system to pre-event condition. Thus, base isolation technology for high-voltage power transformers is important for protecting critical substation equipment. This technology is extremely beneficial to BPA and the power industry.

Parts of Oregon and Washington west of the Cascades face a 20% chance of a subduction zone earthquake in the next 40 years. Many BPA system transformers have been anchored, but many still remain relatively unprotected. Study conditions for this project, in collaboration with Portland state University, have included shake testing of new anchors designed to dampen the effects of an earthquake on a 115-kV instrument transformer. Observation of actual earthquake ramifications has shown which parts of transformer anchoring and damping failed, but equally crucial, which parts didn't. It also keyed on existence of and access to spare parts for quicker system restoration, since lead times for transformer units and parts can be in years.

Description

This is the final year of an ongoing project to develop a high-voltage power transformer base isolation system. The goal is develop a demonstration project(s) for implementing the selected isolation system and monitoring equipment for measuring its performance during earthquakes.

The project develops cost-effective seismic protective solutions for transformer bushing systems and other electrical substation equipment considering inertial effects and dynamic interaction between connected equipment.

The purpose is to develop isolation devices and supplemental dampers, test assemblies at small scale with such devices, prepare design recommendations and develop an in-situ full-scale implementation program. The study includes the following measures: (i) survey of the state-of-the-art base isolation and energy dissipation in equipment protection (report provided); (ii) plans of new devices for the seismic protection of substation equipment that have been developed and evaluated analytically and experimentally (report provided); (iii) analytical tools for evaluation that have been verified experimentally (report provided); (iv) development of design procedures for seismic protections systems to be implemented on existing electrical equipment along with design examples (report provided); (v) proposed changes to existing standards for the seismic qualification of substation equipment (report provided); and (vi) development of a plan for the in-situ full-scale implementation and observation of protective systems.

The research identifies cost-effective solutions that might include hybrid base isolations and supplemental dampers, innovative self-damped connectors for adjacent substation equipment items and innovative stiffening techniques for equipment connections (i.e., for bushings or other brittle parts). Solutions will be analyzed and/or tested in assemblies using shake tables or other structural testing setups to characterize and qualify their seismic performance.

Why It Matters

Installation of base isolation technology for high-voltage power transformers would minimize transformer damage and improve BPA's ability to recover from an extreme-event earthquake. Results of this project could influence the future reliability of BPA's transmission power grid during and after an earthquake. BPA's investment in this research also demonstrates the agency's concern about the region's susceptibility to seismic hazards and its commitment to being a responsible steward of the Northwest's power grid.

Goals and Objectives

The project objective is the development of a fully operational base isolation solution(s) that can be implemented on a BPA transformer and/or by a utility in a seismically active region.

Deliverables

- Implementation of design procedures and tools that enable evaluation and further use of protective technologies
- Identify limitations of base isolation systems, which require innovative solutions
- Identify utilities to participate in implementing base isolation of transformers and other equipment
- Identify equipment and sites; select base isolation solution from the methods researched
- Design and implement a protective solution including equipment, connectors to first conductor support, in-situ
- Develop plans for instrumentation and monitoring of demonstartion installation(s)
- Provide guidance to BPA engineers with design or selection of off-the-shelf solutions (instrumentation, protection, and monitoring)
- Provide guidance for monitoring and processing of demonstration installation(s)

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Project Start Date: October 2008

Project End Date: September 2012

Selected Reports & References

- Seismic Protection of Electrical Transformer Bushing Systems by Stiffening Techniques
- Protection of High-Voltage Electrical Equipment Against Severe Shock and Vibration
- Modeling of Electrical Transformers and Seismic Performance Evaluation of High-Voltage Transformer Bushings
- Proceedings of Workshop on Improving Earthquake Response of Substations Equipment
- Evaluation of Transformer Bushings
- Modeling of Conductors in Electrical Equipment and Sensitivity Studies
- Modeling and Seismic Performance Evaluation of High Voltage Transformers and Bushings
- Experimental and Analytical Study of Seismically Isolated Transformers
- Modeling of Transformers: Clarification of Results for “Pinned” and “Gap” Supported Corw Models
- Modeling of Transformers: 500KV and 230KV Cover Amplifications

Funding

Total Project Cost:	$1,938,919
BPA Share:	$1,938,919
External Share:	None
BPA FY2012 Budget:	$350,000

Participating Organizations

Multidisciplinary Center for Earthquake Engineering Research (MCEER),

State University of New York (SUNY) at Buffalo

For More Information Contact:

BPA project manager / advisor:
Dr. Leon Kempner, Jr. – Transmission Engineering, lkempnerjr@bpa.gov

University at Buffalo, NY/MCEER: Dr. Andrei Reinhorn
Expert Industry Consultant: Dr. Anshel Schiff

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