IEEE/PES Transformers Committee
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"Dielectric Frequency Response Testing"

-- Technical Presentation --
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1. Abstract

Several different dielectric frequency response (DFR) testing technologies have been developed over the past few decades to the point that they are presently being used by several manufacturers and utilities to aid in the identification of dielectric characteristics and problems in power transformers, bushings, instrument transformers and other electrical equipment. DFR, which is a type of dielectric spectroscopy, is an off-line electrical measurement of the capacitance and loss of the insulation similar to the power factor measurement, only taken at multiple frequencies, typically between 1 mHz and 1 kHz. DFR testing has several benefits over methods prescribed in standards, including accurate estimation of moisture content in cellulose insulation, and detection of contamination, carbon tracking or other defects that cannot be detected by other tests.

Several utilities are currently specifying that these tests be made in the factory in order to provide a baseline for future maintenance tests in the field. Potentially, DFR testing may be specified in standards in the future to augment or even replace currently specified methods.

2. Learning Objectives

The tutorial provides a technical introduction to the emerging technology of DFR testing, and emphasis will be focused on power transformers. This tutorial presentation concentrates on DFR technology currently being used, and technical aspects covered include history, theory and comparison of different technologies used, types of equipment used, benefits over conventional methods presently prescribed in IEEE C57.12.90, and case studies showing the problems and diagnosis resulting from the use of these technologies. Perspectives of these aspects will be presented by representatives of a DFR instrument supplier, a power transformer manufacturer/service provider, and two utilities that have used this technology in their maintenance programs.

3. Learning Outcomes

Attendees will gain the following information from their attendance at this tutorial:

- Background and benefits of the DFR technology
- Theory and principles of operation
- Different DFR methods and instrumentations
- Application in factory and field
- Information and preparation required for making meaningful tests
- Types of problems that can be diagnosed with DFR testing
- Examples of DFR testing with actual case studies

4. Presenters' Biographies

Donald Chu: Donald Chu is Section Manager of the Substation Equipment Engineering Section of Con Edison Company of New York. Donald has over 30 years of engineering and R&D experience in distribution and substation equipment. He is responsible for the development, design, engineering, construction, failure analysis, and maintenance support for all major electrical equipment in transmission and area substations. Donald received his BS degree (1975) and MSEE degree (1976) from Cornell University, New York, NY, both in electrical engineering. He is a registered Professional Engineer in State of New York and an active member of IEEE, EEI, CEATI and EPRI. He is presently the chairman of the Transformers Committee's working group on the development of the new "Guide for Application of Monitoring of Liquid-Immersed Transformers and Components, C57.143". He is a member of several working groups and subcommittees in the Committee.

Dong S. Kim: Dong Kim is an electrical engineer with 36 years experience in substation apparatus. Early in his career, he worked for General Electric Company for 13 years as an engineer and section manager. His main roles were HV testing, power transformer manufacturing, remanufacturing, and also some involvement with large motors. Dong later joined Southern California Edison Company (SCE), where he began his work as an application engineer in repairs, inspections, modifications and remanufacturing for power transformers. Up until now, he has worked as an apparatus engineer in the engineering section of SCE. As an apparatus engineer, he performs factory audits, qualifications, design reviews, inspections, load studies, overload studies, and specification requirements for power transformers. Now he is also the lead engineer for all substation apparatus in SCE. Dong has broad knowledge and experience with power transformer-related topics like manufacturing, inspection, root cause study, repair, modification, loading studies, load planning, and overloading.

Poorvi Patel: Poorvi Patel is a senior applications engineer in ABB's Transformer Remanufacturing and Engineering Solutions (TRES) group. Dr. Patel's has been the technical lead in coordinating development of the Dielectric Frequency Response technology and implementation of the ABB TEC on-line monitoring system for transformers in North America. She has a M.S. Degree from the Lulea University in Sweden, and a Ph.D in Mechanical Engineering from the Lund University in Sweden. She began her career with ABB in 1999 at the Corporate Research Center in Vasteras Sweden. She joined the ABB TRES group in St. Louis, Missouri in 2006. She is a member of the IEEE and several working groups in the IEEE Transformers Committee.

Mark D. Perkins: Mark Perkins is a principal engineer in ABB's Transformer Remanufacturing and Engineering Solutions (TRES) group. Mark participated in developing the ABB MTMP transformer risk & life assessment technology and advanced field & factory testing techniques; including DGA & oil analysis, FRA, and Dielectric Frequency Response. Mark began his professional career with Westinghouse at their Advanced Systems Technology Division in Pittsburgh, where he performed power system studies, transient analysis, and field testing. In 1988, Mark became a senior test engineer and later the test manager at the Westinghouse large power transformer plant in Muncie, Indiana. In 1998, he joined the development engineering team and later the TRES group at the ABB power transformer division in St. Louis, Missouri. He is the author of numerous technical papers and 4 US patents. Mark graduated from BYU in 1975 with a M.Sc. degree in Electrical Engineering.

Peter Werelius: Peter Werelius was born in Stockholm, Sweden and works as application expert and product manager at Megger Sweden. He has a M.Sc. in Electrical Engineering (1991) and a Ph.D. in Electrical Engineering (2001), both at KTH (Royal Institute of Technology) in Stockholm. He started his professional career starting up a spin-off company, WaBtech in 1996, manufacturing FDS/DFR (Frequency Domain Spectroscopy/Dielectric Frequency Response) test equipment for cables and power transformers. From 1999, Peter continued the work on the FDS/DFR application, within Programma Electric and later within GE Energy Services. In 2005, he and others founded Pax Diagnostics which was acquired by Megger in 2008. He has published a number of papers/articles related to FDS/DFR measurement techniques and application. He is member of IEEE and Cigré and actively participates in work groups and task forces, especially those related to FDS/DFR and SFRA.