IEEE PES Transformers Committee
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Power Transformer Tank Specification for Passive Protection Against Internal Arc and Status of CIGRE TF A2 and IEEE C57.156

— Technical Presentation —
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1. Abstract

In September 2022, CIGRE SC A2 Transformers and Reactors set up a task force entitled "Power Transformer Tank Specification for Passive Protection Against Internal Arc." This task force converted to the working group A2.76 in December 2024. Over the next two years, the working group will develop a comprehensive technical brochure that will provide detailed analysis of causes, preventive measures and strategies to create a specification to address the topic of tank rupture.

This tutorial will present the status and findings of the task force which is the basis of working group A2.76.

2. Learning Objectives

This tutorial provides the following learning opportunities:

- CIGRE A2.76 insights on history and status
  - Previous work:
    - EPRI report TR-104994 "Power Transformer Tank Rupture : Risk Assessment and Mitigation" (1995)
    - CIGRE WG A2.33 and Technical Brochure 537 "Guide for Transformer Fire Safety Practices" (2013)
    - IEEE Guide C57.156 "Guide for Tank Rupture Mitigation of Liquid-Immersed Power Transformers and Reactors" (2016) and current revision
  - CIGRE task force report and scope of new working group A2.76
- Customer experience
  - Understand arc-in-oil phenomenology: gas generation, pressure development
  - Return of experience from utilities: worst scenarios, fire and explosion risk
  - What are mitigation methods and their limitations
  - How to specify an arc resistant tank: arc energy and pressure requirements
  - How to verify that the specification has been met

- Supplier challenges
    - History of tank rupture specification and simulation
    - Passive protection design (flexible vs. rigid)
    - Numerical methodologies and their pros and cons
    - State of the art in using FEM to optimize the transformer or reactor tank
    - Tank design strategies
    - Gas generation in mineral oil and alternative insulation fluids
    - Methodologies for tank rupture testing
    - Critical transformer accessories, their risks and strategies on how to avoid the risks
    - Influence on the tank of the location of the internal arc
    - Influence of the size of a tank
- Sub-supplier contributions
    - Pressure relief devices and where it makes sense to use them
    - Reinforced OLTC
    - Reinforced turrets

3. <u>Learning Outcomes</u>

By attending this tutorial, attendees will gain an understanding of the following:

- What are the most critical transformer and reactor components.
- Which numerical method must be chosen to optimize a tank.
- What a rupture proof tank must withstand.
- Possible differences in internal arcing of different insulating fluids.
- Why PRDs or rupture discs are installed and what they can do (and what they can´t).
- Usage of available alternative components for a saver transformer, like a reinforced OLTC.
- Size matters: difference between a small single-phase shunt reactor vs. a big HVDC transformer tank

4. Presenters' Biographies

Jean-Bernard Dastous joined IREQ (Hydro-Québec Research Institute) in Varennes, Canada, in 1989 as a research scientist. Since then, he has specialized in the structural analysis of substation equipment and structures. He has chaired the IEEE working groups responsible for developing Standard 605 (bus design in air-insulated substations) and Standard 1527 (seismic design of buswork between substation equipment). He is currently a member of several IEEE working groups focused on seismic design and transformer tank rupture mitigation. Additionally, he serves as the convener of CIGRE Working Group A2.76, which focuses on power transformer tank passive protection against internal arcing. His research interests include seismic design, the design of bus structures, and arc containment in oil and gas-insulated equipment. Jean-Bernard earned his Bachelor of Science Degree in Mechanical Engineering from the Université de Sherbrooke, Canada and his Master of Engineering Degree from McGill University, Canada.

Peter D. Zhao, P.Eng, FIEEE, has over 35 years of experience in the transformer industry, spanning research and development, original equipment manufacturing, and utility sectors. In 2004, he joined Hydro One as a transformer equipment engineer and then took on the role of transformer assets manager, where he is now responsible for a fleet of 720 large power transformers and 850 station service transformers, including autotransformers, step-down transformers, phase shifters, regulators and reactors with capacities ranging from 25 MVA to 1000 MVA across voltage classes of 115kV, 230kV, 345kV and 500kV at an average annual investment of around $150M. His current role is to ensure that the transformer fleet operates safely, reliably and economically. Peter has been actively engaged in IEEE activities and currently chairs IEEE standard C57.156 and C57.19.00. Peter's academic background includes a BSc in Electrical Engineering, an MSc in Transformer and Insulation Technology, and an MSc in High Voltage Engineering.

Marc Foata was born in Canada in 1961. After receiving his master's degree in engineering mechanics from the University of California, San Diego in 1984, Marc Foata worked for 25 years for Hydro-Québec, where he held different positions in research and development (IREQ), maintenance, and asset management. His field of work covered the development of novel diagnostics methods, failure investigation and prevention, maintenance specifications, procurement and testing of power transformers. He then joined Maschinenfabrik Reinhausen in 2011 and, since 2016, has been based in Germany, where he holds the position of Leading Expert in Asset Management. Marc is a member of IEEE PES and CIGRE, where he has been active in numerous working groups. He has co-authored more than 30 technical papers and was the recipient of a CIGRE Technical Council Award in 2011 and the Distinguished Member Award in 2024. He has been the secretary of CIGRE Study Committee A2 on power transformers and reactors since 2020.

Ewald Taschler is technical lead for structural mechanics in the product development area of Siemens Energy. He joined VA TECH ELIN Transformers in 2003 and moved to the R&D team in 2007, when Siemens bought VA TECH. Since 2009, he has dealt with tank rupture and internal arcing. Ewald was part of the team that developed a methodology to optimize a tank to withstand internal arcing. Since then, over 200 transformer and reactor tanks were optimized by his team. He trained colleagues all over the Siemens Energy power transformer sites in performing tank rupture simulations. Since 2014, he participated in several real tank rupture tests in the company's Wind Power Transformer department. In 2014, together with an external partner, he developed a dynamic methodology to simulate an internal arc and the behavior of its gas bubble in using LsDyna, verified by the wind power tests. From 2012 to 2019, Ewald was workstream leader for mechanical improvement.