IEEE PES Transformers Committee
Fall 2024 Meeting
St. Louis, Missouri

Part 1: Introduction to IEEE PC57.170 Guide for the Condition Assessment of Liquid Immersed Transformers, Reactors and Their Components

— Technical Presentation —
Thursday, October 31, 2024

By Brian Sparling and James Cross

1. Abstract

The objective of this guide is to adequately equip transformer users and asset managers with a process and tool to properly assess the technical condition of their in-service transformer fleet and their fleet of spare units, giving them a basis to identify units that may be suitable for major or minor repairs or for making critical decisions about operations, refurbishment, or replacement.

Many asset managers currently use a 'health index' for the purpose of identifying assets in need of attention. However, in many cases the index does not provide any indication of how quickly the worst transformers on the list need to be assessed, nor does it provide any indication of the type of action needed, i.e. replace, repair or refurbish. Many indices also fail to provide any indication of the confidence the asset manager should have in the index's assessments. Furthermore, many asset managers use their 'health index' to help determine which transformers in their fleet to replace. However, some "unhealthy" transformers can be (relatively) easily repaired and, therefore, do not need to be replaced. A 'health index' may, therefore, not be the ideal tool to determine transformer replacement.

Chapters 1 through 7 of the guide introduce a process that can be used to assess a transformer and develop transformer assessment indices to suit the needs of the user. These chapters also introduce the concept of a scoring matrix, which can be developed and used to ensure that consistent scores are allocated to each transformer failure mode or mechanism being assessed, thereby offering a time scale for action.

Chapters 8 through 12 and Annexes A and B deal with the subcomponents of a transformer and discuss failure modes and mechanisms as well as methods of diagnosing the failure modes and mechanisms for each subcomponent. These sections contain mostly existing knowledge.

Annex A provides tables of diagnostic information that are formatted to allow assessment using the methods described in the technical brochure. The information is from IEC and IEEE guides, CIGRE experts, and other industry experts. Users can use these values as a starting point when assessing a transformer but should evaluate if the values are suitable for their fleet of transformers, taking into consideration operating conditions, maintenance practices, and the time scales used in the scoring matrix mentioned above. Annex B provides several examples illustrating how to generate different types of transformer assessment indices and how to use the different scoring methods.

2. Learning Objectives

This technical presentation provides attendees with opportunities to learn about the following:

- Overview of transformer asset management and condition assessment requirements.
- Analysis of different types of indices, how they may be constructed, and their limitations.
- Guidance on dealing with missing or obsolete information, including actual examples.
- Detailed examples on developing diverse types of indices, including replacement, refurbishment and repair indices.
- Guidance on key transformer components that are considered necessary to build a transformer assessment index, along with suitable diagnostic techniques.

3. Learning Outcomes

By attending this technical presentation, attendees will gain an understanding of the five key steps to developing a transformer assessment index (TAI):

1) Determine the purpose of the transformer assessment score and index.
2) Identify the failure modes to be included in the TAI.
3) Determine how each failure mode will be assessed.
4) Design a calibrated system for categorizing failure modes (scoring matrix).
5) Calculate a TAI score for each transformer.

4. Presenters' Biographies

Brian Sparling is a Life Senior Member of IEEE and a senior transformer technical manager at Kinectrics with over 20 years of experience in the field of power and distribution transformers. For the last 31 years, he has been involved in all aspects of on-line monitoring, diagnostics and condition assessment of power transformers. Brian has authored and co-authored more than 34 technical papers on several topics dealing with the monitoring and diagnostics of transformers and has worked on many guides and standards with the Canadian Electricity Association, IEEE Transformers Committee and CIGRÉ A2 Transformer Committee.

James G. Cross is currently the director of transformer services at Kinectrics in Toronto, Canada, where he leads Kinectrics' testing and consulting efforts in the areas of power, distribution, and specialty transformers. As a subject matter expert in the field of transformer engineering, he lends his knowledge and expertise in transformer design and manufacturing to related project areas at Kinectrics, including asset management, transformer condition appraisals, design reviews, in-plant test witnessing, field testing, forensic and failure mode analyses, component and materials evaluation, and transformer diagnostics.

After graduating from the University of Manitoba with a Bachelor of Science Degree in Electrical Engineering, James has worked with different transformer OEMs in project design engineering for applications up to 500kV, 500 MVA class transformers while also serving as the technical liaison between the factories and customers around the world. His employment history also includes time with Weidmann as its manager of R&D/innovation for 18 years before joining Kinectrics.

James is a Life Senior Member of IEEE and a former Chairperson of the IEEE Winnipeg Section. He is currently active in the IEEE Standards Association on several working groups developing the C57 series of standards and guides. He is a registered Professional Engineer in the Province of Manitoba, co-authoring several papers related to electrical insulating materials, testing and transformer diagnostics. He has also presented on insulation design and transformer materials testing at several technical conferences.

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Part 2: Application of Probabilistic Bayesian Networks on Transformer Condition Assessment

— Technical Presentation —
Thursday, October 31, 2024

By Dr. Luiz Cheim, Alan Sbravati and Kumar Mani

1. Abstract

Traditional transformer assessment techniques are developed based on available data extracted from transformers. Aiming to estimate the risk of transformer failure, most conventional approaches were developed centered on combining results from online monitoring systems and offline test results, focusing more on ranking units based on the data. Common strategies include, among others: weighted averages, criticality indexes and traffic lights, focusing more on maintenance prioritization, interventions, and budget allocations. The method currently applied by the company represented by some of the authors already incorporates the probability of failure estimation, based on proprietary knowledge and experience. The current method expands the approach, allowing users' knowledge and experience, as well as user-specific statistics, to be incorporated in the analytical process, adding a probabilistic layer to the typical tree of failure modes. Rather than the test results themselves, the input data to the model is the "belief" that the data indicates the probability the component or system will fail or not. For instance, abnormal results in a DGA test may impact the risk of failure in different components of the event tree, which will further impact associated risks of the transformer failing. Based on the concept of conditional probabilities in Bayesian statistics, this method allows inferring the expected impact/criticality of each type of issue (evidence propagation) on the continuous operation of the transformer. The likelihood of each failure mode can be estimated either based on the statistics of international transformer reliability surveys or on the experience of each asset management group. The Bayesian network analysis allows the bi-directional assessment of the system, both for checking the impact of each root cause on transformer operation (inference) and to investigate the likelihood of a given cause, should a situation be identified (diagnostics).

2. Learning Objectives

This technical presentation provides attendees with opportunities to learn about the following:

- A probabilistic method to assess transformer condition
- Combination of probabilistic techniques and failure modes effects analysis (FMEA)
- Belief propagation networks

3. Learning Outcomes

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

- A sound statistical technique to be used in support of transformer condition assessment
- Application examples of technique

4. Presenters' Biographies

Dr. Luiz Cheim has been with ABB/Hitachi Energy since 2009, working as a senior principal in the Global R&D organization, with an extensive list of publications and work carried out as a Senior Member of the IEEE Transformers Committee and a Distinguished Member of CIGRE since 2006. His major activities are on the development of power transformer condition assessment and performance models, with the application of sophisticated statistical tools, AI/machine learning algorithms, holding a PhD in Electrical Engineering and AI Certificate courses from MIT and Stanford University. Luiz already holds more than 20 granted patents with several new applications in progress.

Alan Sbravati has over 20 years of experience in the transformer industry, having spent most of this time in positions related to R&D on power transformers and insulation materials. Alan is currently the R&D principal engineer and innovations program manager for power transformers with Hitachi Energy. He is a member of the IEEE PES Transformers Committee, occupying positions of secretary of the Insulating Fluids Subcommittee (IFSC) and chair of working groups and task forces.

Kumar Mani is a Senior Member of IEEE. He has been working for the last 21 years with Duke Energy in various roles and is currently a transformer subject matter expert for Duke Energy's Renewable and Regulated Energy Generation Group. He is an active member of the IEEE PES Transformers Committee and is responsible for developing asset management strategies for the entire Duke Energy generation transformer fleet.