

CIGRE Study committee A2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG A2.84

NAME OF THE CONVENOR

Martin Daniel (AUSTRALIA)

TITLE

Guide for power transformer failure investigations

THE WG APPLIES TO DISTRIBUTION NETWORKS: YES

ENERGY TRANSITION

- 3 / Digitalization
- 4 / Sustainability and Climate Change
- 5 / Grids and Flexibility

POTENTIAL BENEFIT OF WG WORK

- 1 / commercial, business, social, economic benefits
- 3 / likely to contribute to new or revised industry standards
- 5 / Guide or survey on techniques, or updates on past work or brochures
- 6 / work likely to contribute to improve safety

STRATEGIC DIRECTION

- 1 / The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-of-the-art technological advances
- 2 / Making the best use of the existing systems

SUSTAINABLE DEVELOPMENT GOAL

- 7 / Affordable and clean energy
- 9 / Industry, innovation and infrastructure

BACKGROUND :

Executive summary:

The strategic benefit of this work is to support CIGRE's Horizon 2030 vision by contributing to the energy transition towards decarbonisation and by promoting best practices for the management of electrical infrastructure, smart networks and sustainability. In particular, lessons learned from transformer failures can support future strategic and technical decision making.

A guide is required to ensure that transformer failure investigations are conducted in a systematic and meaningful manner. This need is highlighted by the findings of WG A2.62, where 16% of recorded failures were attributed to unknown causes. Strengthening the industry's capability to conduct effective failure investigations will reduce these unknowns, improve understanding of failure mechanisms, and support more informed decisions regarding transformer design, operation, maintenance and asset management.

Background:

Learning from failures is an integral part of asset lifecycle management, enabling improvements to be implemented and reducing the likelihood of similar events occurring in the future. Asset management seeks to optimise cost, risk and performance, although excessive emphasis on a single dimension may increase the probability of failure.

Understanding why a transformer has failed is essential, particularly as new technologies are introduced, failure mechanisms evolve, and monitoring approaches become more sophisticated. The WG A2.62 survey identified a significant number of failures for which the cause remained unknown. Effective failure investigations require a

high level of expertise, including knowledge of appropriate diagnostic techniques, interpretation of evidence, and management of uncertainty, especially as conclusions may change when additional information becomes available.

It is therefore proposed to establish a CIGRE Working Group to provide guidance and best practices for conducting transformer failure investigations and to illustrate their application through practical case studies.

PURPOSE / OBJECTIVE / BENEFIT OF THIS WORK :

The overall objective of this Working Group is to improve power system reliability by strengthening the industry's capability to conduct effective failure investigations and to apply the resulting lessons learned.

The guide will address the complete failure investigation process, from initial event assessment and diagnostic testing to root cause determination, reporting and implementation of lessons learned.

Although many utilities currently possess experienced personnel, a significant proportion of this expertise will retire in the coming years. Documenting best practices will therefore support knowledge transfer to the next generation of engineers and specialists.

One of the primary challenges in conducting a failure investigation is that the direction of the analysis may evolve as additional evidence becomes available. Understanding which tests should be performed, when they should be performed, and how different observations should be correlated is essential. Accordingly, the Working Group will develop a decision framework illustrating the relationships between diagnostic tests, their capabilities, and the failure modes they can identify.

Failure investigations should also identify potential risks affecting similar transformer populations and propose practical mitigation measures. Such recommendations typically require consideration of technical effectiveness, cost and resource implications.

CIGRE Technical Brochure 735, Transformer Post-Mortem Analysis, focused primarily on the destructive examination of transformers at end of life. In contrast, this Working Group will focus on investigations conducted following in-service failures, including cases where the transformer is repaired and returned to service.

The economic value of an investigation must also be considered, ensuring that the scope of testing and analysis remains justified by the expected benefits to the asset owner.

The final deliverables will provide guidance on managing failure investigations, explain the technical basis and value of diagnostic methods, and demonstrate how investigation findings can be used to improve future asset management practices.

SCOPE :

- 1) Introduce transformer failure modes, causes and occurrence statistics using findings from the WG A2.62 reliability brochure.
- 2) Discussion of the various failure modes and how they are detected by different test diagnostics.
- 3) Present how to conduct the initial failure analysis, which is normally performed immediately after a failure and is used to direct the field staff.
 - a. Identify the failed component(s) and gather as much evidence as possible regarding the sequence of events and underlying causes.
 - b. Discuss what information should be immediately collected, how it is relevant, and how it can be used to form the test plan. When a transformer fails the available information is pieced together and the investigation is planned. Contradictory information or uncertainty may be experienced. This is the preliminary desktop study where some failure modes are discounted while others are highlighted for further examination. Examples include the collection of loading history, protection records, OLTC operating history, voltage records, weather conditions and maintenance history to reconstruct the events leading to the failure.
 - c. In this section the group will work together to discuss what questions are normally asked, relevance of data, and how to build a preliminary picture what could have failed. Particular emphasis will be placed on maintaining an objective and evidence-based approach, recognising that initial hypotheses may change as additional information becomes available.
- 4) The production of the test plan. An initial list of tests is presented which should be performed with reasons and justifications for cost. The test plan might be fluid because the focus can change as more measurements become available. A decision flowchart will be developed illustrating how diagnostic tests complement one another and progressively narrow the range of potential failure mechanisms.
- 5) When to conduct an internal inspection. The options for an investigation are normally open on site versus return to factory. The WG will develop decision criteria to support the selection of on-site versus factory-based investigations. The main constraint is cost.
- 6) How to write a failure inspection report. Recommended contents and structure of a failure investigation report will be presented, including consideration of updates to maintenance practices, specifications and asset management strategies.
- 7) How to apply the root cause analysis process to establish causal relationships using evidence, operational data and physical inspection.

8) Considerations given to safe working practices at all times.

DELIVERABLES AND EVENTS

Deliverables Types

Annual progress and activity report to Study Committee
Technical Brochure and Executive Summary in Electra
Tutorial
Webinar

Time schedule

- Q3

2026

Recruit members (National Committees, WiE, NGN)
- Q1

2027

Develop final work plan
- Q4

2028

Draft Technical Brochure for Study Committee review
- Q3

2029

Final draft Technical Brochure
- Q4

2029

Tutorial
- Q4

2029

Webinar

APPROVAL BY TECHNICAL COUNCIL CHAIRMAN:

Rannveig S. J. Loken
September 01st, 2026



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