CIGRE Study committe A2
PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

JWG A2/D1.82

NAME OF THE CONVENOR
teNyenhuis Ed (CANADA)

TITLE
Possibilities, limits and risk for increasing transformer overload capability

THE WG APPLIES TO DISTRIBUTION NETWORKS: YES

ENERGY TRANSITION
5 / Grids and Flexibility

POTENTIAL BENEFIT OF WG WORK
1 / commercial, business, social, economic benefits

STRATEGIC DIRECTION
2 / Making the best use of the existing systems

SUSTAINABLE DEVELOPMENT GOAL
7 / Affordable and clean energy

BACKGROUND :

Grid transformers are normally loaded well below their rated capacity due to load sharing in accordance with N-1 criterion. In the case of emergency overloading when one transformer fails, limits are imposed on the maximum temperature and loading of the remaining transformer(s) carrying the full N-1 load. Current limits for overload levels and overload durations are generally considered conservative, particularly for units with low ageing rates associated with a dry insulation system. These limits restrict power grid loadability during normal operation and reduce the operational flexibility required to carry out maintenance on equipment. Increasing permissible emergency overloading, where justified, could enable the use of otherwise “reserved” ampacity under normal operation. The induced risks depend strongly on transformer design, condition, and ambient conditions (e.g., arctic winter vs. tropical climates).

PURPOSE / OBJECTIVE / BENEFIT OF THIS WORK :

The WG will evaluate the possibilities and limits for increased long- and short-term emergency overloading of transformers by performing a structured failure mode, effects and criticality analysis (FMECA) of the transformer and its components, while explicitly accounting for transformer design, condition and operating environment. Based on this FMECA method, overloading limits, risks and consequences will become more transparent, leading to an effective decision process.

The main failure mechanisms relevant to windings include accelerated thermal ageing of cellulose and the risk of water vapour bubble formation due to the release of moisture from wet cellulose at high temperatures. Both risks depend on parameters such as the hot-spot temperature and the local moisture content. Additional mechanisms include increased winding pressure leading to potential visco-plastic deformation of cellulose driven by thermal expansion, problems caused by liquid expansion, and other thermally induced stresses.

The WG will leverage advances in ageing knowledge, moisture conditions, dynamic thermal modelling, and continuous monitoring (sensors) to assess whether and how overloading rules may be revised.

Increasing the overloading capability of transformers can unlock latent capacity in power grids and reduce the need for new investments at a time when supply chains are under significant pressure and the energy transition is placing increased stress on existing infrastructure.

The benefit of increased loading, such as the alleviation of bottlenecks, effect on pricing, and reduced investment

needs, should be evaluated together with the requirements for risk control when operating transformers under increased overloading conditions.

Recommendations for improvement of loading guides (IEC, IEEE) will be provided where appropriate.

SCOPE :

An FMECA related to transformer overloading shall be performed to evaluate the potential for increasing limits for emergency overloading. Possibilities for hazard control, using sensor data such as fibre optic hot-spot measurement and water-in-oil sensors, combined with modelling of temperature rise and moisture migration, shall be considered. In addition, early warning of incipient failures using tools such as DGA shall be evaluated.

Topics relevant to the brochure include, but are not limited to:

- Possible refurbishment actions enabling increased overloading of existing transformers (e.g. improved cooling, replacement of components)
- Cost-benefit and risk analysis of increased loading and emergency overloading limits of grid transformers
- Understanding of dynamic temperature rise through measurement and modelling
- Evaluation of bubble formation risk under temperature increase and precipitation of free water from oversaturated oil during temperature decrease
- Evaluation of thermal ageing and reduction of tensile strength (or DP) of normal and thermally upgraded kraft paper at elevated temperatures
- Sensor-based modelling of moisture content in high-temperature regions
- Visco-plastic deformation of cellulose under increased clamping pressure due to thermal expansion of copper and cellulose, potentially leading to reduced clamping forces after overloading
- Risk of degradation of critical components such as bushings and tap-changers under high-current operation
- Risks related to defects in splices and contacts
- Consequences of oil expansion
- Core heating and stray losses
- Use of alternative insulation materials (esters, aramid, etc.)
- Consequences of high temperature on CTC with epoxy resin bonding
- Overloadability of spare and mobile transformers
- Consideration of thermal pre-conditions on overloadability

Remarks:

The following document shall be considered by the WG:

- TB 323 Ageing of cellulose in mineral-oil-insulated transformers
- TB 393 Thermal Performance of Transformers
- TB 659 Transformer Thermal Modelling
- TB from CIGRE WG A2.60 (to be published) on dynamic thermal behaviour
- IEEE C57.91 Guide for Loading Mineral- Oil-Immersed Transformers and Step-Voltage Regulators
- IEC 60076-7 Power transformers – Part 7: Loading guide for mineral-oil-immersed power transformers

DELIVERABLES AND EVENTS

Deliverables Types

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

Time schedule

Q2	2026	Recruit members (National Committees, WiE, NGN)
Q4	2026	Develop final work plan
Q4	2029	Draft Technical Brochure for Study Committee review
Q2	2030	Final draft Technical Brochure
Q3	2030	Tutorial
Q4	2030	Webinar

APPROVAL BY TECHNICAL COUNCIL CHAIRMAN:
Rannveig Loken
May 08th, 2026