Many Thanks

- **The University of Manchester acts as the host for today's events, sponsoring the meeting room. Lunch and Tea/Coffee Breaks are sponsored by the CIGRE-UK.**

- **CIGRE-UK A2 Team**
  - ✓ Regular Member – Zhongdong Wang (The University of Manchester)
  - ✓ Additional Member – Elizabeth MacKenzie (MacKenzie Consultant)
  - ✓ Technical Panel Secretary – Jose Quintana (SP Energy Networks)
  - ✓ Secretary – Shengji Tee (SP Energy Networks)
  - ✓ Web Master – Christian Pößniker (University of Exeter)

- **Support from CIGRE-UK**
  - ✓ Technical Committee Chair – Ray Zhang
  - ✓ Martin Ansell (Events/Marketing)

cigre
For power system expertise

Agenda

- **10:30 Registration and Tea/Coffee**
- **11:00 Welcome and Introduction to SC A2**
- **11:10 Technical Brochures Published in 2023 | Feedback from Colloquium | New WGs & Future Events | A2 Technical Activities and Working Group Updates**
- **12:30 D1 Relevant Technical Activities**
- **13:00 Networking Lunch**
- **14:00 IEC TC14/TC10 Standards Activities**
- **14:30 Discussion – Papers for 2024 Paris Session**
- **15:00 End of Meeting, Tea/Coffee/Networking**

cigre
For power system expertise

CIGRE UK A2|D1 Liaison

Introduction to CIGRE Study Committee A2

UK A2 Regular Member

Zhongdong Wang (University of Exeter)

09/01/2024

A2 Study Committee

Mission

To facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field of transformers and reactors. To add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing recommendations.

Technological field of activity

- Power transformers including industrial, DC converter and phase-shifting transformers
- Reactors including shunt, series, saturated and smoothing
- Transformer components including bushings, tap changers and accessories

CIGRE A2 Study Committee

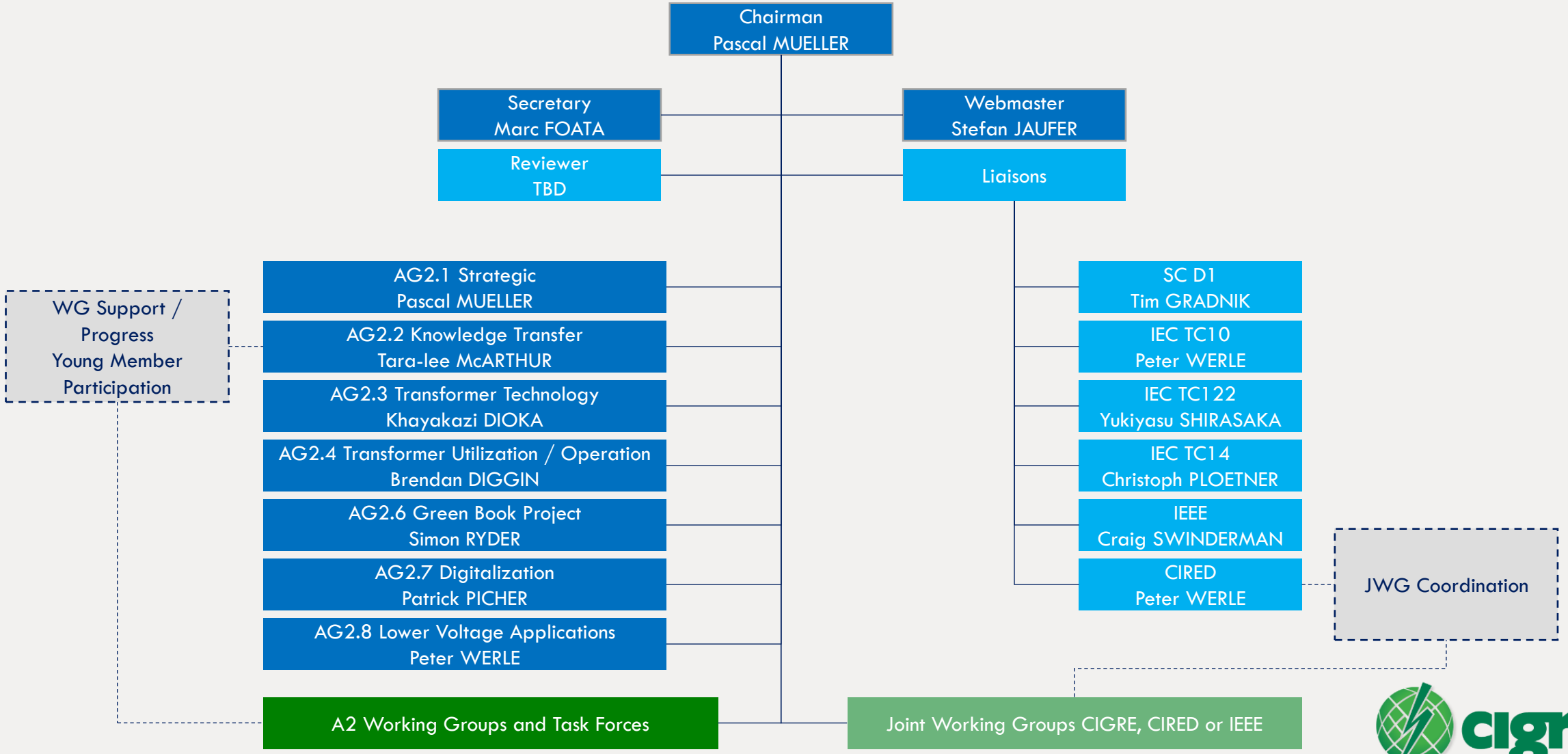
Scope

Within its technical field of activity, Study Committee A2 addresses topics throughout the asset management life-cycle phases; from conception, through research, development, design, production, deployment, operation, and end-of life. At all stages, technical, safety, economic, environmental and social aspects are addressed as well as interactions with, and integration into, the evolving power system and the environment. All aspects of performance, specification, testing and the application of testing techniques are within scope, with a specific focus on the impact of changing interactions and demands due to evolution of the power system. Life cycle assessment techniques, risk management techniques, education and training are also important aspects.

Within this framework additional specific areas of attention include:

- Theory, principles and concepts, functionality, technological development, design, performance and application of materials, efficiency.
- Manufacturing, quality assurance, application guidance, planning, routing and location, construction, erection, installation.
- Reliability, availability, dependability, maintainability and maintenance, service, condition monitoring, diagnostics, restoration, repair, loading, upgrading, uprating.
- Refurbishment, re-use/re-deployment, deterioration, dismantling, disposal.

Latest change on the CIGRE A2 structure



Key Personnel and Activities – CIGRE Study Committee A2

- Chairman
  - **Pascal MUELLER**
- Secretary
  - **Marc FOATA**
- Webmaster
  - **Tim GRADNIK**
- UK Regular Member
  - **Zhongdong WANG**
- UK Additional Regular Member
  - **Elizabeth MACKENZIE**
- Working Groups
  - **Currently 15 working groups under the scope of SC A2**

e-cigre

This website is the online library and bookstore for CIGRE.

There is a wealth of information that can be searched by title, keyword, document type or study committee. It can be downloaded free by Cigre members, or purchased by non-members.

Documents include Technical Brochures, CIGRE SC. & ENG. Electra, Colloquia Papers, Symposia Papers, Green Books, Session Papers, ISH Collection, Reference Papers, Working Group Reports, Webinars, Membership Directory, Tutorials.

CIGRE Session 2024

- The Preferential Subjects for 2024 Paris Session are:
  - **PS 1: Design of resilient transformers**
    - Stresses from the environment: Impact of global warming, high temperatures heavy rain, high winds, offshore installations, etc.
    - Stresses from the system: switching impulses, reverse flow, emergency overloading, harmonics, GIC, short-circuits and internal arcing etc.
    - Specifications: design criteria, materials and testing requirements for new transformers. Suitable maintenance standard and refurbishment strategies.
  - **PS 2: Advances in Transformer Analytics**
    - Data management: digitalisation and information model, online and offline test data, integration of condition and multiple data sources, data preparation for analytics.
    - Diagnostic and on-line monitoring: algorithm/guidelines for on-line monitoring, advanced interpretation of condition data, case studies.
    - Modelling: transformer digital twins (thermal, dielectric, mechanical, etc.), physics-based and hybrid models, failure probability and ageing models, applications of artificial intelligence.
  - **PS 3: Reliability of Transformers for Renewable Energy**
    - Transformers for low carbon technologies: voltage < 100kV, wind and photovoltaic parks, battery energy storage and electric vehicle charger etc.
    - Case studies and lessons learned: type of failure, root cause analysis, mode of operation. Recommendations concerning procurement, design, operation and asset management strategies.
    - Failure Prevention: useful diagnostic methods and monitoring systems. Optimization of operating conditions and additional measures such as overvoltage protection, harmonic reduction, cooling optimisation etc.

CIGRE UK A2|D1 Liaison

SC A2 – Technical Brochure Updates

UK A2 Additional Regular Member

Elizabeth MacKenzie (MacKenzie Consultant)

09/01/2024

Technical Brochure Updates

- Only one WG has published technical Brochures in 2023
- A2|C4.52 – High-Frequency Transformer and Reactor Models for Network Studies
  - TB 900: Part A: White-Box Models
  - TB 901: Part B: Black-Box Models
  - TB 902: Part C: Grey-box models
  - TB 903: Part D: Model interfacing and specifications
  - TB 904: Part E: Measurements and transformer

CIGRE UK A2|D1 Liaison

SC A2 – CIGRE A2 2023 Colloquium

UK A2 Regular Member

Zhongdong Wang (The University of Manchester)

09/01/2024

Cigre A2 2023 Colloquium

- Joint colloquium with the 6th international colloquium on “Transformer Research and Asset Management”, covering traditional topics
  - **Transformer life management, materials, components, and new technologies**

- Cigre A2 preferential subjects
  - **Digital twins, trends in transformer maintenance and design performance in service**

- 104 technical papers

- Two CIGRE tutorials on
  - **High frequency transformer and reactor models for network studies**
  - **Power transformer audible sound requirements**

Cigre A2 2023 Colloquium

- 39 papers on Modelling and Simulation
  - **Thermal modelling especially under dynamic loads, electromagnetic transient modelling** as the majority of the papers & usual suspects
  - Interesting papers which may set the new trend are :
    - **"Enhancements in power transformer arc-resistant specifications"** – Hydro-Quebec, Canada
    - **"Electromagnetic transient simulation and arc pressure development law of on-load tap changer interstage short-circuit fault"** – CEPRI, China
- 30 papers on materials, Components and New technologies
  - Interesting papers which may set the new trend are :
    - **"Containment of high energy internal arc failures in transformers with on-load tap changer"** – Siemens Energy & MR, Austria and Germany
    - **"Effects of oil interventions on transformer solid insulation ageing markers"** – EDPLabelec, Portugal
- 35 papers on Transformer Life Management
  - Interesting papers which may set the new trend are :
    - **"Can winding ageing be modelled ? Scrapping investigation of transformer with stable load"** – SINTEF & Hitachi Energy, Norway
    - **"Effects of selective gas sorption of insulating paper on the interpretation of dissolved gas-in-oil"** – Austria

CIGRE UK A2|D1 Liaison

SC A2 – CIGRE A2 New WGs & Future Events

UK A2 Regular Member

Zhongdong Wang (The University of Manchester)

09/01/2024

New Working Groups for A2|D1 and D1|A2

WG/JWG	ToR	Convenor
A2|D1.71	Modern Insulating Liquid Qualification for OLTC, Bushings and other Accessories	Lars LIDEN (SE)
A2|D1.72	Retrofill of mineral oil in transformers – Motivations, considerations and guidance	Roberto ASANO (BR)
D1|A2.79	Improved understanding of dynamic behaviour of winding insulating materials in liquid insulated power transformers	Orlando GIRLANDA (SE)
D1|A2.80	Functional properties of non-metallic solid materials for liquid filled transformers and reactors and their compatibility	Dejan VUKOVIC (DE)

Future A2 & D1 Sponsored A2 events

Event	Date	Location
CIGRE 2024 Session	August 25th to 30th, 2024	Paris, France
2025 A2 Colloquium	October 19th to 24th, 2025	Seoul, Korea
2025 Symposium	TBD	TBD

CIGRE UK A2|D1 Liaison

Advisory Group AG A2.06:

Green Book

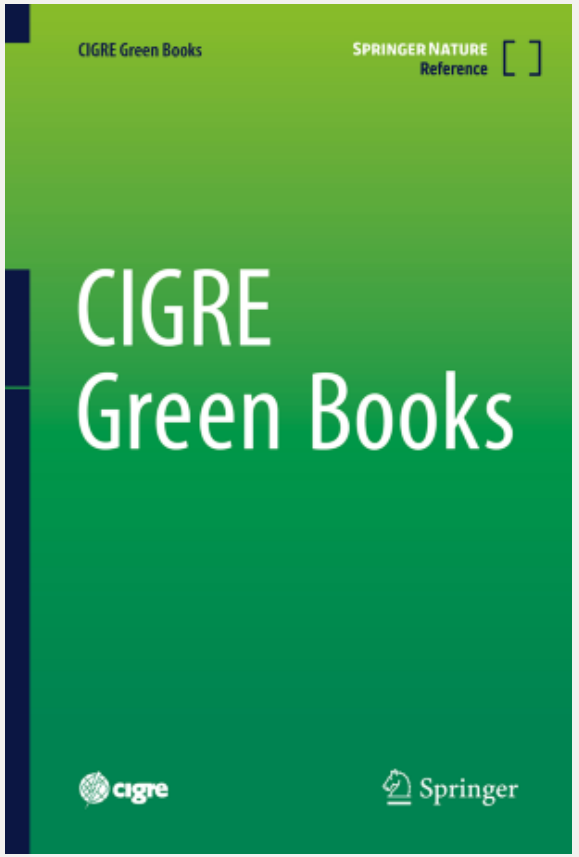
Prepared by:

Simon Ryder (Doble PowerTest Ltd) – Editor in Chief

09/01/2024

AG A2.06 Scope

- Green Books are CIGRE's state of the art, flagship reference publications. CIGRE aims to produce the very best, most comprehensive set of reference publications encompassing all the subjects covered by CIGRE and its Study Committees. Green Books consolidate, in a single book, all the CIGRE knowledge in a domain of work, i.e. all of the Technical Brochures, reorganised and carefully compiled.
- **SC A2 has two Green Books:**
  - **Transformer and Reactor Procurement**
    - Published in September 2022
  - **Transformer and Reactor Life Management**
    - In progress
    - Planned completion 2025



Green Book 2: Editors and Authors

Editor	Country	Chapter Author	Country
Luiz Cheim	US	Werner Boonen	BE
Adesh Gupta	IN	Janine Dickinson	GB
Tara-Lee MacArthur	AU	Khayakazi Dioka	ZA
Simon Ryder	GB	Marc Foata	DE
		Michael Heinz	DE
		Stefan Jaufer	CH
		Deo Nan Jha	IN
		Christoph Krause	CH
		Lars Lundgaard	NO
		Dan Martin	NZ
		Sidwell Mtetwa	ZA
		Pascal Mueller	CH
		Patrick Picher	CA
		Claude Rajotte	CA
		Ralf Schneider	CH

Table of Contents – Green Book 2

Chap	Title	Authors	Status	% Complete
	Dedication	Eds		
	Messages	Various		
	Preface	SR		
	Table of Contents			
	Editor Biographies	Eds		
	List of Contributors			
1	Overview	SR	Draft	80
2	Life Limiting Processes	DM	Draft	80
3	Procurement	KD/SM	Draft	70
4	Economics	MF	Draft	80
5	Operation	Eds (SR)	Final draft	90
6	Losses	Eds (SR)	Draft	80
7	Sound Levels	WB/JD	Work-in-progress	50
8	Temperature Rise	AG	Work-in-progress	50

Table of Contents – Green Book 2

Chap	Title	Authors	Status	% Complete
9	Maintenance	CR	Draft	80
10	Life Extension	RS	Draft	80
11	FMEA	LC/SR	Final draft	90
12	Condition Assessment	TLMcA	Work-in-progress	40
13	Condition Monitoring	LC	Final draft	90
14	Digital Twins	LC/PP	Draft	80
15	Troubleshooting	AKG/DNJ	Draft	80
16	Liquid Condition Assessment	AKG/DNJ	Draft	80
17	Solid Insulation Ageing	LL/CK	Work-in-progress	70
18	Moisture	LL/SR	Draft	80
19	Dielectric Condition Assessment	AKG/DNJ	Draft	80
20	Mechanical Condition Assessment	J-BD/PP	Draft	80
21	Thermal Condition Assessment	SR/TLMcA	Draft	80
22	Bushing Condition Assessment	Eds (SR)	Final draft	90

Table of Contents – Green Book 2

Chap	Title	Authors	Status	% Complete
23	Tapchanger Condition Assessment	MF	Draft	80
24	External Condition Assessment	AKG/DNJ	Draft	80
25	Circular Economy	MH	Draft	80

Timeline – Green Book 2

- Expect to have all chapters complete and ready for review during Q2/2024.

- Assuming all chapters are submitted for publication by end Q2/2024, the Green Book will likely be published (print, e-book, and online) end Q4/2024.

CIGRE UK A2|D1 Liaison

Task Force A2.01:

Power Transformers Sound Levels on Site

Prepared by:

Janine Dickinson (National Grid)

09/01/2024

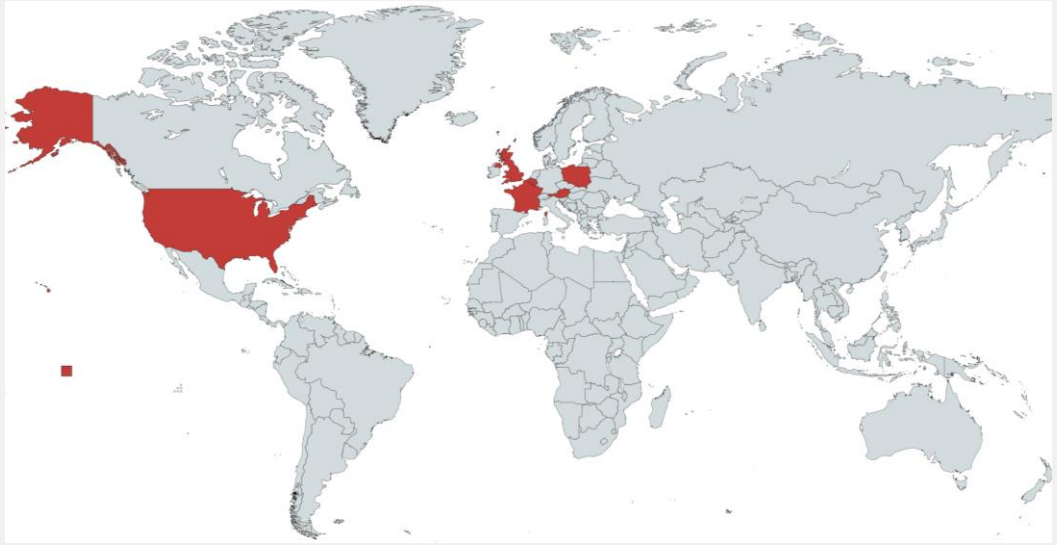
TF A2.01: Power Transformers Sound Levels on Site

- **Context**
  - Sound level measurements on site often differ from FAT
  - Sound levels measured on site tend to be higher than during FAT
  - No clear guidance within the industry as to why this is the case

- **Objectives**
  - Identify differences between FAT and SAT measurements
  - Provide information on these key variables and their effects on sound levels
  - Provide recommendations for Best Practice to improve accuracy between FAT and SAT sound level determination
  - Consider whether a WG is recommended
  - Highlight key areas for further research

TF A2.01: WG Membership

- 10 Members – (8 regular members / 1 Corresponding Member / 1 Next Generation Member) / 1 member on sabbatical / 3 Women
- 6 Countries represented (UK, Austria, Poland, Belgium, US, France)
- Representation
  - 4 from utilities
  - 3 from transformer manufacturers
  - 2 from service providers / consultants
  - 1 from academic / research institutes
- KMS list of members may need updating



TF A2.01: Planning of WG Meetings

Meetings	Location	Date
1	Paris	31st August 2022
2	Virtual	3rd November 2022
3	Brussels	7th/8th February 2023
4	New York	25th/26th April 2023
5	Virtual	27th June 2023
6	Virtual	24th August 2023
7	London	3rd/4th October 2023
8	Split	27th/28th November 2023
9	Vienna	23rd/24th January 2024

TF A2.01: Activity Report

- **Since last SC meeting**
  - Identified and categorised influencing factors (category of effect e.g. measurement, calculation, Lw, propagation
  - Identified root causes (calculation, measurement, design, electrical, mechanical)
  - Developed brochure structure
  - Significant progress with chapter drafting
  - Recommendations for a WG

- **Planning for next year**
  - Meet in Vienna in January for brochure editing
  - Refine content, deal with overlaps and duplication
  - Produce first full Draft
  - Formatting
  - Referencing
  - Produce final draft
- **Requests for SC Input or Assistance**
  - Understanding effect of reverse power flow on sound levels

TF A2.01: Table of Content

Chapter	Title	%
1	Introduction	100
2	Background – Problem Statement	100
3	Variation in Legislation and Noise Limits	100
4	Factors influencing FAT & SAT sound levels	80
5	dB impacts on determination of sound power level	70
6	Recommendations	60
7	Conclusion	0
Appendix A	Direct/Indirect effects on sound level	80

TF A2.01: Expected Delivery Date (TB and Tutorial)

- Draft is 80% complete
- Expected delivery date End April 2024
- Expected delivery date of Tutorial – To be decided

A2 Working Group Updates

1. A2.54 - Power Transformer Audible Noise Requirements
2. A2.56 - Power Transformer Efficiency (No Updates)
3. A2.57 - Effects of DC Bias on Power Transformers
4. A2.58 - Installation and Pre-Commissioning of Transformers and Shunt Reactors
5. A2.60 - Dynamic Thermal Behaviour of Transformers
6. A2.62 - Analysis of AC Transformer Reliability
7. A2.63 - Transformer Impulse Testing
8. A2.64 - Condition of Cellulose Insulation in Oil Immersed Transformers After Factory Acceptance Test
9. A2|D2.65 - Transformer Digital Twin – Concept and Future Perspectives
10. A2|D1.66 - Breathing Systems of Liquid Filled Transformers and Reactors (No UK Reps)
11. A2|D1.67 - Guideline for Online Dissolved Gas Analysis Monitoring
12. A2.68 - Failure Survey of Lower Voltage Generator Step Up Transformers installed in Wind farms and Photovoltaic Parks
13. A2.69 - Guide for Transformer Maintenance Update
14. A2|C3.70 - Life Cycle Assessment (LCA) of Transformers
15. D1|A2.77 - Liquid Tests for Electrical Equipment

cigre
For power system expertise

CIGRE UK A2|D1 Liaison

WG A2.54:

Power Transformers
Audible Sound Requirements

Prepared by: Janine Dickinson (National Grid)

09/01/2024

WG A2.54 Scope

- **Context**
  - Lack of reliable guidance on how to specify Tx sound power levels.
  - Insufficient guidance on the range of typical and achievable sound power levels for Txs of different rated power.
  - Sound power levels for new Txs frequently specified too low. Impossible to achieve without external sound mitigation e.g. sound panels or enclosures.
- **Objectives**
  - To inform the industry by providing:
    - Best practice guidelines for the sound level specification of Txs.
    - Guidance on the range of typical and achievable sound power levels for Txs of different rated power (10kVA….1000MVA).
    - Distinguish components: no load, load and cooling sound and combined sound level.
    - Consider 50Hz/60Hz, 3~/1~, sound level legislation and sound mitigation techniques.
- **Technical Brochure**
  - **Technical work complete with brochure expected Q2 2024.**

CIGRE UK A2|D1 Liaison

WG A2.57

Effects of DC Bias on Power Transformers

UK Members

Paul Jarman (The University of Manchester)

Dongsheng Guo (National Grid)

09/01/2024

WG A2.57 Progress

- Technical brochure (TB) is currently being finalised.
  - **Comments being sought from WG members.**
- An Electra paper has also been drafted to accompany the TB.
- Convenor, Dejan Susa changed job and moved from Norway to Australia.
  - **Resulting in some delays in finalisation of the TB and Electra paper.**

CIGRE UK A2|D1 Liaison

WG A2.58:

Installation and Pre-Commissioning of Transformers and Shunt Reactors

Convenor:

Ross Willoughby

UK members:

John Lapworth (Doble PowerTest Ltd)

Simon Ryder (Doble PowerTest Ltd)

Ian Hunter (Polaris)

09/01/2024

WG A2.58 Update

- Status:
  - Draft TB (v22 150+ pages) nearing completion, to be submitted to A2 Study Committee for review
- Scope:
  - Detailed guide on installation/processing, site acceptance testing and monitoring during trial operation in warranty period
- Intended Audience:
  - Not only main practitioners from manufacturers, utilities and service companies, but all interested parties, e.g. project managers, asset managers, insurance companies, regulators and second owners (for renewable equipment to be transferred from developers to operators)

WG A2.58 Update

- Recent Work:
  - Detailed recommendations on use of DGA during trial operation, including IEEE C57.104-2019 guidance for new transformers
  - Discussion of DGA signatures for normal/faulty transformers and tap-changers
  - Inspection and test plans
  - Special considerations for alternative fluids and renewable transformers, including off-shore applications

CIGRE UK A2|D1 Liaison

WG A2.60

Dynamic Thermal Behaviour of Power Transformers

Convenor: Tim Gradnik

Secretary: Xiang Zhang

UK members:

Jose Quintana (SP Energy Networks)

Muhammad Daghrah (M&I Materials)

Paul Jarman (The University of Manchester)

Xiang Zhang (Manchester Metropolitan University)

Zhongdong Wang (The University of Manchester)

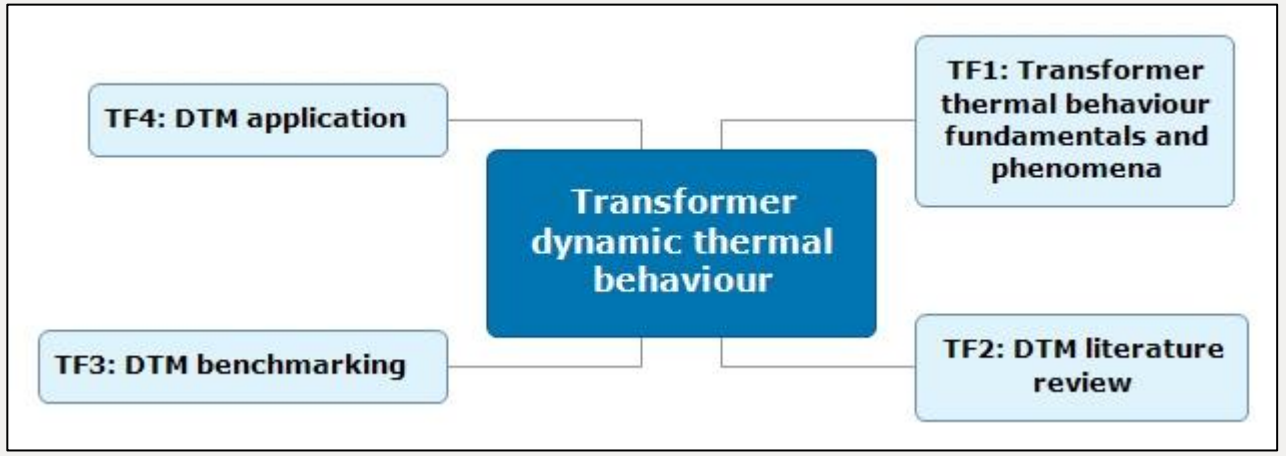
09/01/2024

WG A2.60 Scope

The scope of this working group is to review the state-of-the-art tools and approaches to power transformers' **dynamic thermal modelling (DTM)**, and to **propose suggestions for improving the existing standard models**, with focus on the effects of using **new insulating liquids** and **sub-zero ambient** temperature operational conditions.

Goals (TFs)

1. Explanation of transformer thermal behaviour fundamentals and phenomena
2. Literature review on historical development of DTM
3. DTM Benchmarking and evaluation of possible DTM improvements
4. Applications of DTMs



WG A2.60 Progress and Plans

- **Meetings in 2023**
  - WG plenary meetings in April (online) and November, Split, Croatia(hybrid)
  - TF meetings organised between plenary meetings
- **Plans**
  - TF meetings followed by WG plenary meeting in April 2024 online
  - TF meetings followed by WG plenary meeting in 2024 Paris Session
- **Progress Review**

Define brochure contents and structure	May 2020	√
Technical brochure draft 50% complete	Nov 2023	√
Expected delivery date of TB	Winter 2024	
Expected delivery date of tutorial	Spring 2025	

CIGRE UK A2|D1 Liaison

WG A2.62:

Analysis of AC Transformer Reliability

Convenor: Stefan Tenbohlen

Commenced: November 2019
Expected Completion: Spring 2024

Prepared by: (Tee) ShengJi Tee (SP Energy Networks)

09/01/2024

WG A2.62 Scope and Progress

- Background
  - **WG A2.37 completed failure data survey with 964 major failures that occurred in 1996-2010**
  - **Age distribution of transformer population was not collected**
- Key Tasks
  - **Meeting 1: 18 Nov 2019, Meeting 2: 29 May 2020, Meeting 3: 15 Oct 2020, Meeting 4: 2 Aug 2021, Meeting 5: 7 Apr 2022, Meeting 6: 29 Aug 2022, Meeting 7: 22 Nov 2022, Meeting 8: 16 Mar 2023, Meeting 9: 13 Nov 2023**
  - **Update transformer failure data survey/questionnaire**
  - **Conduct survey on major failures & replacements for 2010-2019 for AC power transformers ≥100kV**
  - **Analyse failure data in terms of failure rate, location, mode and cause**
  - **Determine hazard curve for different transformer populations**
  - **Drafting of brochure (ongoing, expected Spring 2024)**

WG A2.62 Brochure Content

1. Introduction
   - Scope
   - Structure of Brochure
2. Key Country Updates Since 2015
   - ASEAN Transmission Utilities
   - Australia and New Zealand
   - North America
   - Europe
3. Methods for Improving Reliability
   - Technical Specifications
   - Design
     - Dielectric
     - Mechanical
     - Thermal
     - Bushings & Tap-Changers
     - Monitoring & Digital Innovation
     - Materials, Manufacturing & Testing
   - Operation
   - Maintenance
4. Definitions and Guidelines for Reliability Surveys
   - Statistics Overview
     - Poisson Distribution
     - Weibull Distribution
5. Methodology for Failure Data Collection
   - Definition of Failure and Retirement
   - Reliability Questionnaire
   - Classification of Failures
   - Data Collection and Limitations
     - Data Collection
     - Data Limitations
6. Results of Performed Reliability Survey
   - Investigated Population
   - Failure Rate
   - Hazard Curves
     - Age Distribution
     - Failure and Retirement Rates
     - Hazard Curves by Continent
     - Weibull Distributions for Failure and Retirement
     - Effect of Removing Bushings and OLTC on Hazard Rate
     - Meyer Kaplan Estimator
     - Combining Data with the CIGRE A2.37 Survey
     - Summary
   - Failure Data Analysis
     - Failure Mode Analysis
     - Failure Location Analysis
     - Failure Cause Analysis
     - External Effects Analysis
     - Action Analysis
     - Detection Mode Analysis
     - Comparison with CIGRE A2.37 Survey
   - Analysis of Failures of Transformers Connected to GIS, Wind Farm Transformers, Transformers Filled with New Liquids, Shunt Reactors
     - New Liquids
     - Wind and PV Reliability
     - Shunt Reactor Reliability
7. Conclusion and Recommendations
8. References
9. Appendix
   - Questionnaire – Excel Sheets
   - Questionnaire – Content of Pull-Down Menus
   - Determination of Weibull Confidence Limits

CIGRE UK A2|D1 Liaison

WG A2.63:

Transformer Impulse Testing

Convenor: Ebrahim Rahimpour

Secretariat: Alvaro Portillo

Members: 35 (26 regular and 9 corresponding)

UK Member:

Qiang Liu (The University of Manchester)

09/01/2024

WG A2.63 Overview

Background:

- Transformer impulse testing is defined in details in existing standards, for instance, IEC 60060-1, IEC 60076-3 and IEC 60076-4.
- But there are still a lot of unclear or unsolved questions which arise frequently among the test engineers.
- Improvement of standards on transformer impulse testing needs studying of transient phenomena and material properties, and accumulation of best practice of testing.

Scope:

- Full wave lightning impulse test
- Chopped wave lightning impulse test
- Switching impulse test
- Non-standard waveforms and high-frequency overvoltages
- Positive and negative polarities in impulse test
- Use of internal surge arresters

Meetings:

- Meeting 1 – 08 Oct 2019
- Meeting 2 – 17-19 Aug 2020 (online)
- Meeting 3 – 23-24 Nov 2020 (online)
- Meeting 4 – 19-20 April 2021 (online)
- Meeting 5 – 16-17 August 2021 (online)
- Meeting 6 – 29 November 2021 (online)
- Meeting 7 – 04-05 April 2022 (online)
- Meeting 8 – 27-29 June 2022 at Manchester (hybrid)
- Meeting 9 – 26-28 September 2022 at Zagreb (hybrid)
- Meeting 10 – 12-14 December 2022 at Porto (hybrid)
- **Meeting 11 – 27-28 November 2023 at Split (in-person)**

WG A2.63 Task Forces

- **TF1: High Frequency Power System Transients (Bruno Jurišić)**
  - Measurement equipment and measurement techniques
  - Field measurement and simulation – Lightning, switching
  - Comparison of actual overvoltage waveshapes with standard dielectric test
  - Contribution to draft brochure – nearly finished
- **TF2: Power Transformer Testing - Test Equipment and Techniques (Stefan Dragostinov)**
  - Impulse testing (standard comparison)
  - Non-standard waveforms and high-frequency overvoltages
  - Positive and negative polarities in impulse test (dry and liquid immersed)
  - Contribution to draft brochure – nearly finished
- **TF3: Transformer Transient Simulations (Ricardo Castro Lopes)**
  - Transformer transient modelling using a common template)
  - Effects of LI front time, tail time, chopped LI waveform and etc.
  - Effect of non-standard waveforms on winding internal insulation stress
  - Contribution to draft brochure – nearly finished
  - Simulations almost completed, results analysis and writing are ongoing

CIGRE UK A2|D1 Liaison

WG A2.64:

Condition of Cellulose Insulation in Oil-Immersed Transformers after Factory Acceptance Test

Prepared by:

Hongzhi Ding (Doble PowerTest Ltd)

Andrew Fieldsend-Roxburough (National Grid)

09/01/2024

WG A2.64 Scope

- **Fundamental question to be addressed: ”What should a buyer expect from the insulation properties of a new transformer?”**

- **The Working Group shall address:**
  - Which insulation material parameters have a significant impact and are relevant for the long-term function of a transformer
  - If physical cellulosic insulation samples are required, what material to use and how to get representative samples before and after the drying process?
  - Guidelines for acceptance criteria for the properties of the insulation system after completed Factory Acceptance Test, including repeated tests
  - Guidelines for measures and compensation in case the criteria are not met

WG A2.64 WG membership

- 17 regular members of which 5 women (30%)
- 12 Countries represented (NAM, SAM, EU)
- Representation
  - 1 from utilities
  - 4 from transformer manufacturers
  - 2 from component manufacturers
  - 5 from service providers / consultants
  - 1 from academic / research institutes
  - 4 Retirees
- KMS list of members is up to date

WG A2.64 Activity Report

- **Since last SC meeting**
  - Several iterations of editing the document
  - Submitted to SC A2 secretary for SC review and comments

- **Planning for next year (2024)**
  - Final physical meeting
    - WG review of SC A2 comments and integrating these into the final document
    - Tutorial
  - SC A2 to approve and publish the brochure

WG A2.64 Expected delivery date (TB and Tutorial)

- Draft now submitted for review of SC A2
- Final brochure: Expected delivery date February 2024
- Tutorial: Expected delivery date February 2024

WG A2.64 Highlights

- **Acceptance criteria at FAT are proposed to be based on a combination of total moisture in the insulation and DP**. In a Moisture/DP diagram, acceptable values will be defined by an area, not by single values. Moisture and DP should not be specified independently.
- The loading guides provide methods for calculating how long it takes for the paper DP to decrease to a specified level at a given temperature. Using this methods and including the effect of moisture, we can calculate how long insulation would last in service given certain set starting parameters. If this equals or exceeds the lifetimes specified in the loading guides (17,1 y TUP, 15,9 KP), then the insulation directly after FAT would be deemed acceptable.

CIGRE UK A2|D1 Liaison

JWG A2|D2.65:
Transformer Digital Twin – Concept and Future Perspectives

Convenor: Patrick Picher

Secretary: Alexander Alber

Members: 37 regular members from 15 countries

UK Members:

Sicheng Zhao (Manchester Power Solutions Ltd)

Zhongdong Wang (The University of Manchester)

09/01/2024

JWG A2|D2.65 Introduction

- The purpose of the WG is to study the digital twin concept when applied to transformers and propose a CIGRE definition for transformer digital twin – the data, models, analytics and other aspects.

- The WG A2/D2.65 was approved in Feb 2022.
  - **Technical Brochure is expected in 2026.**
  - **There are 49 working group members.**

- Four WG meetings since established: June 2022 (on-line), August 2022 (in person), June 2023 (hybrid) and Nov 2023 (in person).
- Regular task force meetings.

JWG A2|D2.65 Brochure Structure

- Through the meetings and discussions, the structure of the technical brochure (TB) was clarified. The TB will be constructed with 8 chapters, including
  - Literature review
  - Definitions of transformer digital twin
  - Applications and benefits
  - Physics-based model
  - Data-driven model
  - Digitalization of transformer asset management
  - Reliability of digital twins
  - Recommendations for future developments

JWG A2|D2.65 Keynote at A2 Colloquium

- A Keynote was given by the convenor Patrick Pitcher and an invited paper was presented in 2023 A2 Colloquium at Split.

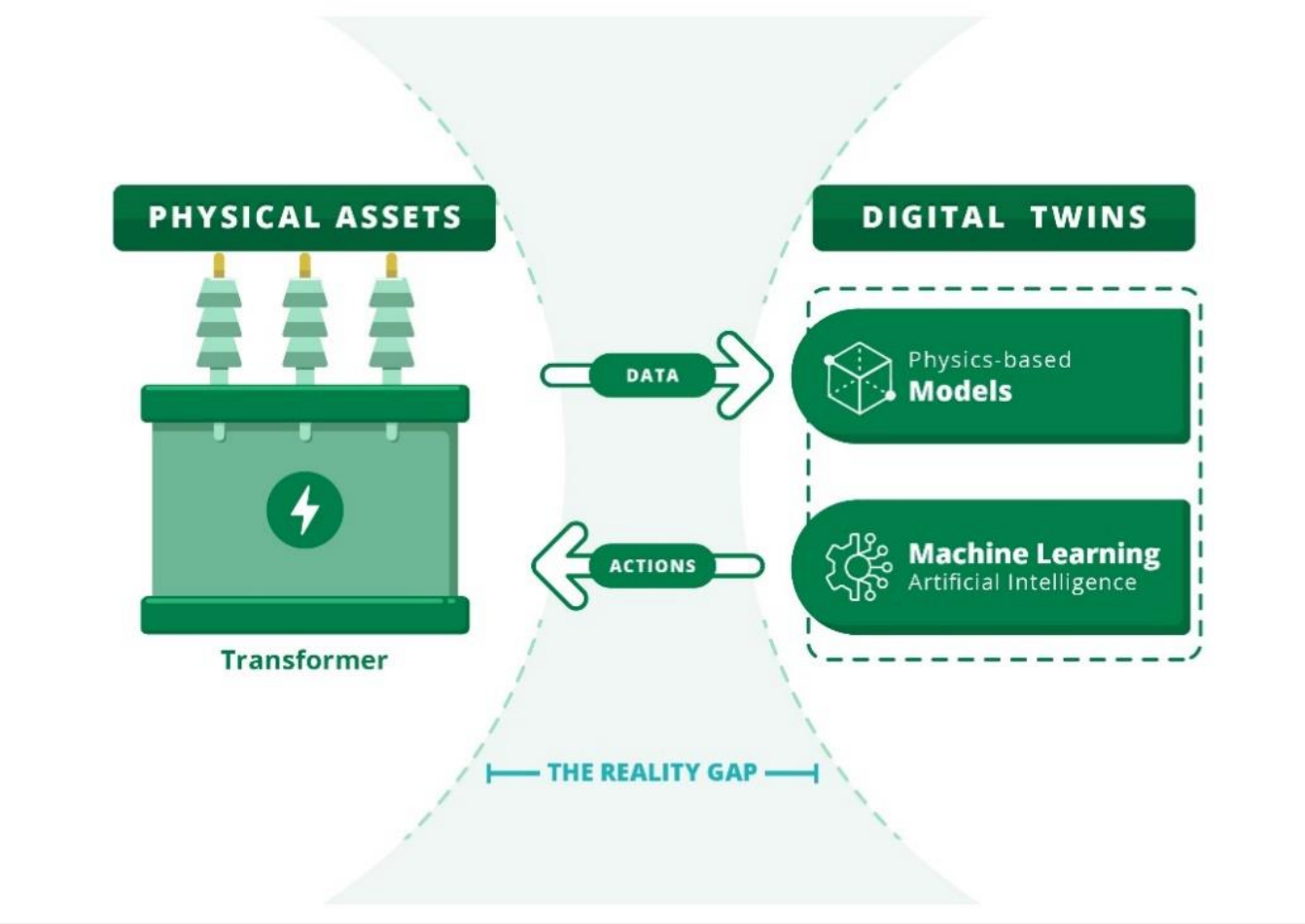
"Transformer digital twin – concept and future perspectives"

Patrick Picher (presenting), Sicheng Zhao, Zhongdong Wang, Sruti Chakraborty, Stephan Voss, Mohamed Ryadi, Tony McGrail, Nima Sadr Momtazi, Alexander Alber

- **Abstract:** The transformation of the power system via digitalisation brings new opportunities for innovation. For example, the digital twin concept has been studied extensively in the scientific literature of recent years, often for the virtual representation of manufacturing processes, but also for modelling of critical assets. Because of their strategic importance in electrical networks, transformers are already the focus of international efforts in power asset digitalisation and, therefore one of the top priorities for asset digital twin developments. The new CIGRE WG A2/D2.65, initiated in 2022, studies the concept and future perspectives of transformer digital twin. This paper reviews the state of the art of the digital twin concept, and presents some potential benefits and use cases.

JWG A2|D2.65 Digital Twin for Power Assets: A Definition

- A digital twin is
  - a virtual representation of an individual/unique asset
  - dynamically updated with data from its physical twin
  - to assess and predict its condition and behaviour
  - providing valuable insights that inform decisions and realise value



CIGRE UK A2|D1 Liaison

JWG A2|D1.67:

Guideline for Online Dissolved Gas Analysis Monitoring

Convenor: Tara-lee MacArthur

UK Members:

Shuhang Shen (University of Exeter)

Michelle Fiddis (GE Grid Solutions)

09/01/2024

JWG A2|D1.67 Activities Summary

Working Group Scope:

- Develop guidelines for users of online gas analysis monitoring equipment delivering: a technical brochure, an Electra article, tutorial & an update at the Paris 2024 Session
- Working group size: 44 members from over 20 countries

- **1st WG Meeting, February, online**
  - WG Introduction & Scope
  - Member Country Presentations (addressing scope & value add)
- **2nd WG Meeting, July, online**
  - Member Country Presentations (addressing scope & value add)
  - Review of Chapter List
  - Task Force Descriptions & Leaders
- **3rd WG Meeting, November, in-person/online (Split Croatia)**
  - Update on Task Force Activities
  - Update on "Definitions" used in WG; e.g. accuracy, online monitoring, off-line monitoring
  - Update on surveys for manufacturers / utilities

JWG A2|D1.67 Task Force Summary

- 4 Focused Task Forces & 2 General Task Forces (Introduction & Case Study TF)
  - **4 Focused Task Forces can be found below along with a summary of activities**

Task Force 2: Data & Analysis

Recommendation to users on data that can be collected & develop guidelines on analysis

- Led by Luiz Cheim – Hitachi
- Team has developed a data collection template
- Carl Wolmorans (GE) developed a chapter template

Task Force 3: Alarm Response

Develop guidelines users can follow or use when an alarm is triggered

- Led by Michelle Fiddis - GE
- Team has been gathering case studies from end-users
- Expectation is to utilize these to create a response matrix

Task Force 4: Specification & Evaluation Criteria

Develop guidelines users can utilise when creating their own ODGA specification criteria

- Led by Khayakazi Dioka - Eskom
- High-level topics discussed:
  - Functional Requirements & Technology Exclusion
  - Accuracy & Repeatability
  - Reliability & Warranty
  - Responsibilities (OEM vs User)

Task Force 5: Maintenance

Develop guidelines to help users understand the maintenance requirements & develop their own maintenance strategy

- Led by Toni Mellin - Vaisala
- High-Level Topics discussed:
  - Survey for manufacturers & utilities
  - Definitions & Responsibilities
  - Maintenance and Repair Actions
  - Experiences & Future Proofing

CIGRE UK A2|D1 Liaison

WG A2.68:

Failure Survey of Lower Voltage GSUs installed in Wind Farms and Photovoltaic Parks

Prepared by: Elizabeth MacKenzie
(MacKenzie Consultant)

09/01/2024

WG A2.68 Overview

- **Start Q1/2023 - End Q1/2026**
- UK: Elizabeth MacKenzie, Denis Nesbitt, Muhammad Dagrah, Huw Owens, Florian Marpaux
- **Context**
  - Due to the energy transition the number of low voltage GSUs installed in wind and photovoltaic parks has increased drastically
  - Various failure scenarios have been reported for such GSUs, thus the reliability of these applications need to be investigated, because it is unknown and may not have been considered in surveys before
- **Objectives**
  - Develop a questionnaire for getting data from wind and photovoltaic park operators in order to
    - Estimate failure rates of different GSUs (wind, photo, dry, liquid)
    - Identify main failure root causes for different GSU technologies
  - Use information to improve reliability in future designed GSUs or transformers with similar applications (e.g. E-charging stations)

WG A2.68 Updates

- **7 meetings held so far, mainly on-line, one in-person**
  - Installed base of transformers identified as far as possible
  - Draft index for TB completed
  - Questionnaire ready in trial mode (in English), first users to try out to see if it is easy to complete
  - Trial cases discussed at last meeting
- **Questionnaire**
  - To be translated into other main languages
  - Some minor changes after trials to make questionnaire easier to fill in
  - Currently available in Excel only – may be made available as a web-page
  - To be rolled out in early 2024
  - Next meeting 25/01/2024 (virtual)
- **If anyone has contacts in wind parks or solar farms, please let us know!**
  - **Contact Elizabeth or another team member**

CIGRE UK A2|D1 Liaison

WG A2.69:

Guide for Transformer Maintenance Update

Convenor: Claude Rajotte

UK Member:

Paul Jarman (The University of Manchester)

09/01/2024

CIGRE UK A2|D1 Liaison

JWG A2/C3.70:

Life Cycle Assessment (LCA) of Transformers

Convenor: Myles Margot

UK Members:

Hang Xu (The University of Manchester)
Steven Vallance (SP energy networks)

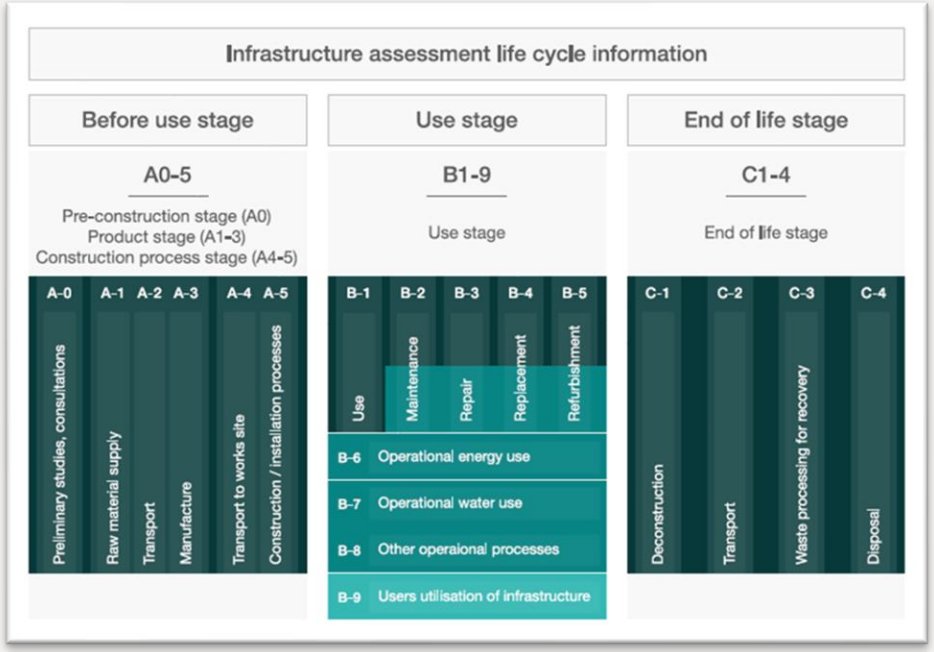
09/01/2024

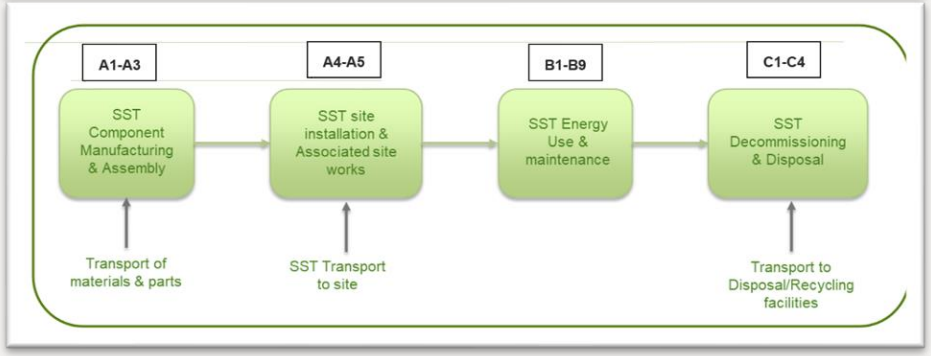
JWG A2/C3.70 Background

- **Background:**
  - Life Cycle Assessments (LCA) measure the greenhouse gas impacts of a product over the expected lifecycle of a product. This includes the greenhouse gas emissions associated with manufacturing, transporting and installing the equipment, operating the equipment and decommissioning the equipment at its end of life.
  - Life Cycle Assessments are an important step in reducing global greenhouse gas emissions – 'we can't manage what we don't measure'.
  - There is an increasing demand for LCA of Transformers, which is driven by various stakeholders.
  - The sub-elements and methodology for LCA of transformers are complex and need to be defined.
  - Although standards for Life Cycle Assessments exists, these are open to interpretation, and there is a need to standardize methodology across the industry.

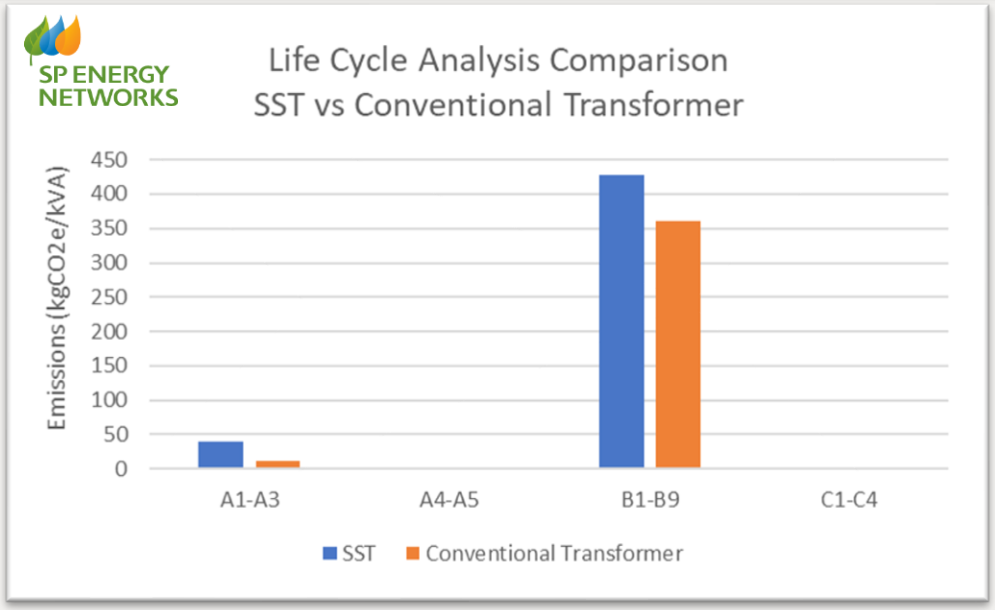
JWG A2/C3.70 Background – Example Transformer LCA (SST)

Comparison of a Solid State Transformer and Conventional Transformer





Life cycle Stage	Carbon Emissions ($kgCO_2eq/kVA$) SST	Conventional Transformer
A1-A3	38.8	11.09
A4-A5	1.932	0.355
B1-B9	428.48	360.44
C1-C4	0.0568	0.783
Total	**469.27**	**372.64**



LV Engine | ENA Innovation Portal (energynetworks.org)

JWG A2/C3.70 Scope

- **Purposes of this working group:**
  - Alignment of the various guidelines/procedures/standards (including the influence or integration from product to system level).
  - Comparability and evaluation basis for manufacturers, customers and other regulatory entities.
  - Investigate and establish the influence of different technologies, manufacturing techniques, operational influence and end of life (Circularity).
  - Best practices and/or framework for CO_2 reduction.
- **Scope:**
  - Define emission databases for materials and energy use during the lifetime.
  - Define a valid Product Category Rule (PCR) for transformers (either based on existing or new).
  - Agree on standard parameters (lifetime, load-factor, etc.) for above mentioned PCR and methodology for End of Life (EoL).
  - Impact and influence the energy mix has on the parameters or baseline.
  - Environmental impact of transport of materials and transformer (distance, type of transport).
  - Evaluation of sustainability measures linked to Transformers (Lifetime).

JWG A2/C3.70 Progress and Plans

- **Start date and end date (expected):**
  - October 2023 - December 2024

- **Meetings in 2023:**
  - First meeting held virtually on 27th November 2023.

- **Work plan:**
  - Nominate secretary to support convenor.
  - Set up next meeting for idea collection and create task forces.

- **Deliverables:**
  - Annual progress and activity report
  - Technical brochure
  - Electra report
  - Tutorial

CIGRE UK A2|D1 Liaison

JWG D1|A2.77:

Liquid Tests for Electrical Equipment

Convenor: Fabio Scatiggio

Secretariat: Carl Wolmarans

Members: >72 full time members and corresponding members

UK Members:

Russell Martin (M&I Materials)
Attila Gyore (M&I Materials)
Qiang Liu (The University of Manchester)
Dave Walker (SP Energy Networks)
Gordon Wilson (National Grid)

09/01/2024

JWG D1 | A2.77 Overview

- The mission of this group is to improve and to extend the current knowledge on chemical and electrical tests applicable to electrical equipment to other liquids than mineral oil.
- Membership:
  - >72 full time members and corresponding members
  - Convenor: Fabio Scatiggio
  - Secretary: Carl Wolmarans
- The team first met in October 2020 and has most recently met in Split, Croatia, 27 & 28 Nov 2023
- The main group has been split into 3 working groups to research separate areas for the brochure

JWG D1 | A2.77 Topics Under Discussion in Recent Meetings

- **Task Force 1 – Measurement Aspects**
  - Verification of Ostwald coefficients, given large differences between values given in different standards
  - Verification of new DGA detectors (helium, NDIR, PAS) not in accordance with existing standards
  - Lab Based – focusing on Helium Detector
  - Online – focusing on photoacoustic and NDIR? Input from TB 783?

- **Task Force 2 – Data Handling and Categorisation**
  - Recommend a data format or template for DGA and other liquid tests, with respect to transformer design and service data suited for data storage and exchange
  - Clustering of oil test results (DGA, furans, alcohols, chemical and physical tests) as function of the transformer age, type, liquid preservation system, etc.
  - Providing guidance to differing gas levels/patterns in different transformer types i.e. small distribution transformers, wind & solar transformers, traction vs large power transformers

- **Task Force 3 – Modelling and Case Studies**
  - Investigate, based on real failure cases, if different DGA interpretation criteria (Rogers, IEC, IEEE, Duval, etc.) lead to the same conclusion
  - Improving interpretation models for natural and synthetic esters
  - Literature survey
  - Analytical approach (considering ester chemistry, expected reactions & thermodynamics)

JWG D1 | A2.77 Topics Under Discussion in Recent Meetings

- Crash Tests : Evaluation of different methods of DGA diagnosis e.g. ratios, triangles, pentagons etc.
- Correlation between electrical and chemical test
- DGA bibliographic survey
- Updated chapter - gas formation from oil and other liquids
- DGA interpretation history
- Statistics of DGA
- Degassing performance RRT
- Cooperation with IEEE on data repository
- Definition of fault or other synonymous (IEC WG 45)
- DGA devices on-line and portable

Draft brochure has been written on Cigre KMS

The group expects to publish the brochure by the end of 2024

D1 Updates

Materials and Emerging Test Techniques

- **UK Regular Member**
  - **Thomas Andritsch (University of Southampton)**

cigre
For power system expertise

D1 - Materials and Emerging Test Techniques

Dr Thomas Andritsch - D1 UK Regular Member

9th January 2024

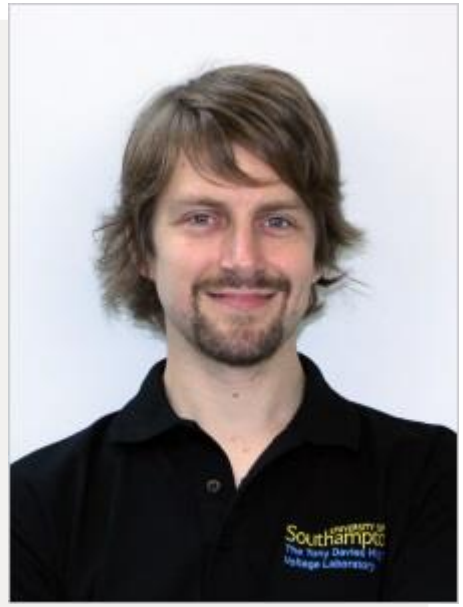
cigre

For power system expertise

Introduction

Dr Thomas Andritsch - D1 UK Regular Member

T.Andritsch@soton.ac.uk



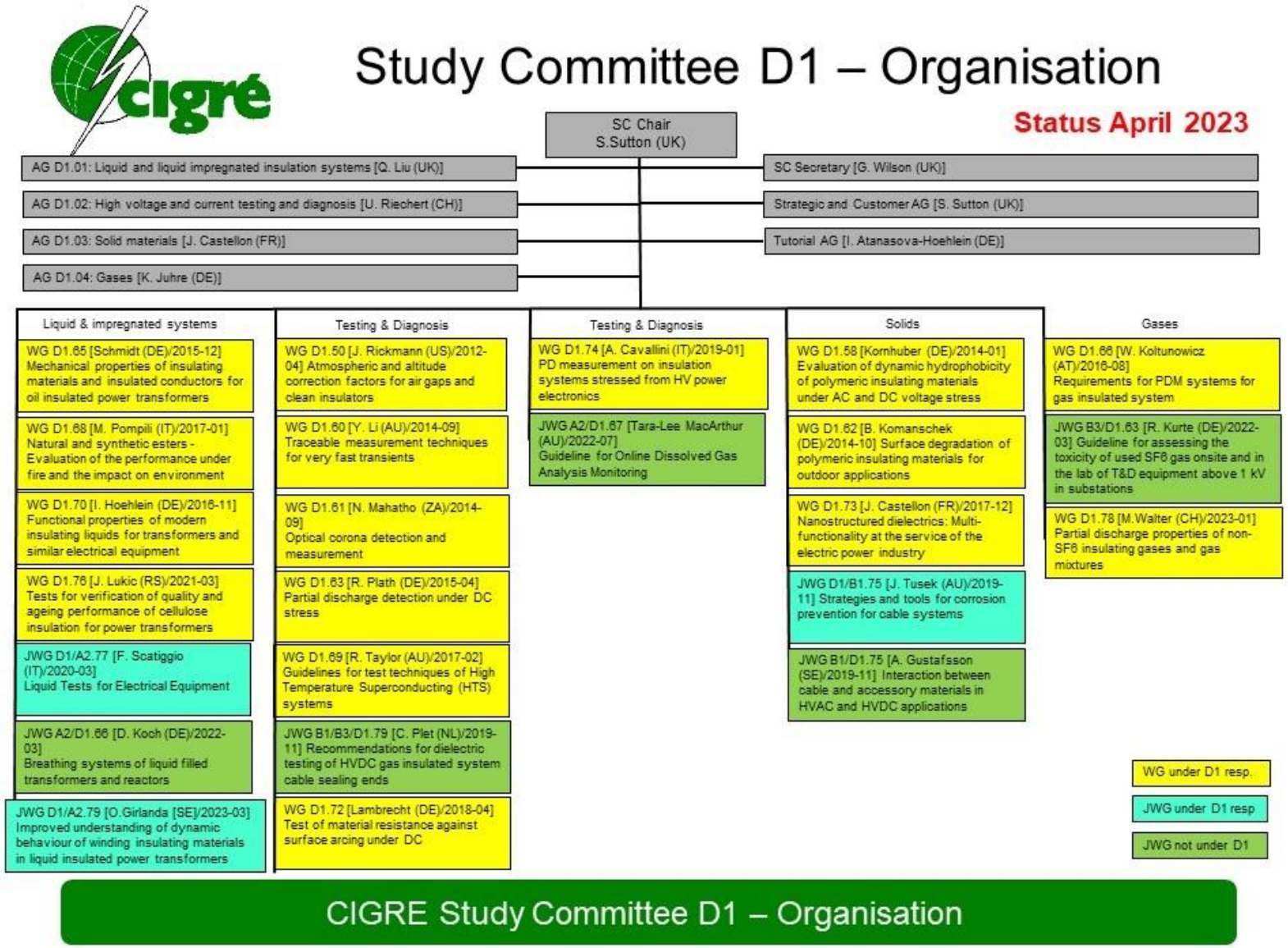
- Associate Professor, University of Southampton
- Role includes Education (UG and MSc), Research (Industry and research council funded R&D on materials for HV systems, PhD supervision), Enterprise (HV consultancy) and Management (Tony Davies HV Laboratory)
- Previously roles at TU Delft (NL),TU Graz (AT), and Prince Songkhla University (TH)
- Cigre activities include UK member of D1.73, B1/D1.75 and previously D1.40
- Also active in IEEE (Senior Member, DEIS Administrative Committee, TC on Transport Electrification, Smart Grids, Nanodielectrics)

Study Committee D1 Scope

The scope of SC D1 is concerned with the monitoring and evaluation of:

- New and existing materials for electrotechnology,
- Diagnostic techniques and related knowledge rules,
- Emerging test techniques which may be expected to have a significant impact on power systems in the medium to long term.
- Support of other study committees in their analysis of recently introduced and developing materials, emerging test techniques and diagnosis techniques

Study Committee D1 - Organisation



New 2022:

SC Chair: Simon Sutton, UK

Secretary: Gordon Wilson, UK

Strategic Advisory Groups:

AG D1.01 Liquids and Liquid Impregnated Insulation Systems (Qiang Liu, UK)

AG D1.02 High Voltage and Current Testing and Diagnostic (Uwe Riechert, CH)

AG D1.03 Solid Materials (Jerome Castellon. FR)

AG D1.04 Gases (Karsten Juhre, DE)

Tutorial AG (Ivanka Atanasova-Hoehlein, DE)

Strategic and Customer AG (Simon Sutton, UK)

Study Committee D1 Active Working Groups

CIGRE UK SC A2/D1 Liaison Meeting, 9th January 2024

Study Committee D1 – Active Working Groups

WG	Title
D1.50	Atmospheric and altitude correction factors for air gaps and clean insulators
D1.60	Traceable measurement techniques for very fast transients
D1.61	Optical corona detection and measurement
D1.62	Surface Degradation of Polymeric Insulating Materials for Outdoor Applications
D1.63	Partial Discharge Detection under DC voltage stress
D1.65	Mechanical properties of insulating materials and insulated conductors for oil insulated power transformers
D1.66	Requirements for partial discharge monitoring systems for gas insulated systems
D1.68	Natural and synthetic esters - Evaluation of the performance under fire and the impact on environment
D1.69	Guidelines for test techniques of High Temperature Superconducting (HTS) systems

Study Committee D1 – Active Working Groups

WG	Title
D1.70	Functional Properties of modern insulating liquids
D1.72	Test of material resistance against surface arcing under DC
D1.73	Nanostructured dielectrics: Multi-functionality at the service of the electric power industry
D1.74	PD measurement on insulation systems stressed from HV power electronics
D1.76	Tests for verification of quality and ageing performance of cellulose insulation for power transformers
D1.78	Partial discharge properties of non-SF6 insulating gases and gas mixtures
D1.81	Methods and common data file format for Time-Domain Reflectometry

Study Committee D1 – Active Joint Working Groups

WG	Title
B1/B3/D1.79	Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends
B1/D1.75	Interaction between cable and accessory materials in HVAC and HVDC applications
D1/B1.75	Strategies and tools for corrosion prevention for cable systems
D1/A2.77	Liquid Tests for Electrical Equipment
A2/D1.66	Breathing systems of liquid filled transformers and reactors
B3/D1.63	Guideline for assessing the toxicity of used SF6 gas onsite and in the lab of T&D equipment above 1 kV in substations
A2/D1/67	Guideline for online dissolved gas analysis monitoring
D1/A2.79	Improved understanding of dynamic behaviour of winding insulating materials in liquid insulated power transformers
D1/A2.80	Functional properties of non-metallic solid materials for liquid filled transformers and reactors and their compatibility with insulating liquids

Study Committee D1 – New Working Groups (approved 2023)

WG	Title	UK Member
D1.78	Partial discharge properties of non-SF6 insulating gases and gas mixtures	Fraser Cook
D1.81	Methods and common data file format for Time-Domain Reflectometry	TBC
D1/A2.79	Improved understanding of dynamic behaviour of winding insulating materials in liquid insulated power transformers	TBC
D1/A2.80	Functional properties of non-metallic solid materials for liquid filled transformers and reactors and their compatibility with insulating liquids	TBC

D1.50

Atmospheric and altitude correction factors for air gaps and clean insulators

- Convenor: Johannes Rickmann
- UK Member: -
- Start Date: 2012
- Completion Date: 2021?

Scope of Activities:

- Correction factors for T, P and humidity for AC, SI, LI and DC test voltages greater than 1000 V
- Relevant for cable terminations and bushings

Status Update:

- No meeting since Paris 2018, but claim will finish 2021. Only one chapter to finalise 'pending finalization of comments'.
- Many CIGRE and IEC groups waiting on the output – been disseminating work via ISH

D1.63

Partial discharge detection under DC voltage stress

- Convenor: Ronald Plath
- UK Member: Malcom Seltzer-Grant
- Start Date: May 2015
- Completion Date: 2021

Scope of Activities:

1. Physical process: difference between AC and DC PD behaviour.
2. Operating conditions (polarization, temperature etc.) of different insulation systems under DC stress and effects on PD phenomena.
3. Basic PD parameters useful for PD measurements under DC voltage.
4. Preferred PD measurement techniques at DC voltage.
5. Procedures for measuring PD under DC voltage (suppression and/or discrimination of noise and other external disturbances from relevant PD).

Status Update:

- WG activities on above distributed in four task forces: TF-1 Physics, TF-2 Solid Insulation, TF-3 Liquid Insulation, TF-4 Gas Insulation
- An interim report has been presented at CIGRE Colloquium SCA2 /SCB2/ SCD1, New Delhi, India, 21st November 2019, https://www.cigreindia.org/colloquium2019/web/index.html - Download Proceedings - D1 Proceeding
- If anyone has any case studies or general interest please get in touch: malcolm.seltzer-grant@hvpd.co.uk

D1.66

Requirements for partial discharge monitoring systems for gas insulated systems

- Convenor: W. Koltunowicz
- UK Member:
  - ✓ **Graeme Coapes**
    graeme.coapes@siemens-energy.com
  - ✓ **Fraser Cook, Carl Johnstone**
- Start Date: 2016
- Completion Date: 2024

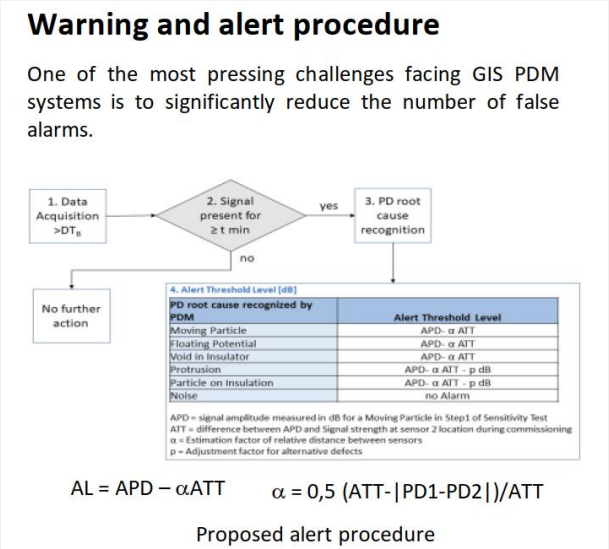
Scope of Activities:

The WG activity will concentrate on the technical requirements of PDM. A survey on UHF PDM technology will be performed to collect available knowledge from the field and understand the expectations and needs of the users. The technical advantages and disadvantages of different monitoring solutions will be described.

The new WG will prepare a technical guidance and help users to choose a PDM system best fitting to their needs and their level of PD knowledge.

Status Update:

- Short paper + poster presented at Paris 2022
- Full technical brochure due for release 2024



D1.68

Natural and synthetic esters - Evaluation of the performance under fire and the impact on environment

- Convenor: Massimo Pompili
- UK Member: Russel Martin
- Start Date: 2017
- Completion Date: 2023

Scope of Activities:

1. Fire behavior comparison between natural and synthetic esters and mineral insulating oils;
2. Environmental impact comparison in case of spills of natural and synthetic esters and mineral insulating oils.

Status Update:

- Large interest of IEC TC10 for natural and synthetic ester insulation liquids
- Activities practically stopped during pandemic
- Activities restarted in Autumn 2021
- Questionnaire circulated to the 34 WG members on local fire and environmental rules
- TB expected to be ready in 2023

D1.69

Guidelines for test techniques of High Temperature Superconducting (HTS) systems

- Convenor: Richard Taylor
- UK Member: Bartek Glowacki
- Start Date: Q1/2017
- Completion Date: 2020*

Scope of Activities:

To study the existing HTS power installations and compile the relevant data that will assist the power industry to test HTS technology used in the transmission and distribution grid

Status Update:

- TB is being reviewed and chapters reconfigured before sending it out to WG members to comment, will pay attention to:
- The present and future need for HTS power installations.
- Update on the status of field test experience of HTS power installations and comparison with existing guidelines.
- Aging of electrical insulation, superconductors and cooling systems.
- Failure mode analysis

D1.70

Functional properties of modern insulating liquids for transformers and similar electrical equipment

- Convenor: Ivanka Hoehlein-Atanasova
- UK Member: Qiang Liu, Attila Gyore, Zhongdong Wang
- Start Date: 01/2017
- Completion Date:

Scope of Activities:

Review the need for revising or establishing standards concerning traceability of origin and thermal stability of liquids.

Review the requirements and test standards of dielectric liquids as seen from a transformer designer.

Review the test methods for establishing thermal performance parameters of liquids.

Status Update:

- TF3 has published a technical brochure 856 in Dec 2021.
  - ✓ Pre-breakdown and breakdown phenomena in transformer liquids
  - ✓ Review of IEC liquid breakdown test methods
  - ✓ Transformer insulation design
  - ✓ Suggestions for future work
- A tutorial was delivered during ICDL2022, at Seville, Spain on 29th May 2022.
- An A2/D1 joint webinar was delivered online on 13th June 2023.
- Another brochure from TF1 and TF2 is expected to be ready by end of 2023.

D1.73

Nanostructured dielectrics: Multi-functionality at the service of the electric power industry

- Convenor: Jerome Castellon
- UK Member: Thomas Andritsch and Raed Ayoob
- Start Date: 01/2020
- Completion Date: 10/2023 (delayed)

Scope of Activities:

- Review of recent progress in the field of nano-dielectrics.
- Design, manufacture, and characterisation of nano-dielectrics with improved properties.
- Propose different possible applications for the use of nano-dielectrics in the power industry.

Status Update:

- Literature review ongoing.
- Some samples have been manufactured and are currently being characterised in different laboratories.
- 5 meetings have been held so far.
- WG meeting at Paris 2022 session.
- Delays due to materials lost in transit and RRT

D1.74

PD measurement on insulation systems stressed from HV power electronics

- Convenor: Andrea Cavallini
- UK Member: -
- Start Date: 2019
- Completion Date:

Scope of Activities:

Transversal sub-WGs

Measurements, UHF, Antennas, Systems, Electrical, Acoustic, Optical, Propagation

Apparatus-specific sub-WGs

Rotating machines, power electronics

Status Update:

Rotating Machines

- Review of antennas suitable for PD detection
- Analysis of PD emission spectra
- Comparison between different detection mechanisms
- Most likely failure modes -> sensor position

Power Electronics

- Review of failure modes
- Oil- or gel-filled modules (RRT)

D1.76

Tests for verification of quality and ageing performance of cellulose insulation for power transformers

- Convenor: Jelena Lukic
- UK Member: Attila Gyore, Richard Heywood, Qiang Liu, Mike Munro, Shanika Matharage and Gordon Wilson
- Start Date: Apr 2021
- Completion Date:

Scope of Activities:

- DPv method acc. to IEC 60450
- Correlations of DPv to Mechanical properties of insulating papers
- Ageing tests of oil paper insulations
- Paper ageing mechanisms and kinetic models

Status Update:

- TF1 DP measurement method
  - ✓ RRT1 based on IEC60450 was complete
  - ✓ RRT2 on DP measurements with new recommendations is ongoing.
- TF2 Ageing tests of oil paper insulations
  - ✓ RRT 1 is ongoing (Non-thermally upgraded paper with various liquids)
  - ✓ RRT 2 is ongoing (Thermally upgraded paper with various liquids)
- TF3 Paper ageing kinetics
  - ✓ Literature review complete
  - ✓ Collecting case study data
  - ✓ Evaluating post-mortem data
  - ✓ Comparisons of Kinetic and Ageing Maker models

D1.78

Partial discharge properties of non-SF6 insulating gases and gas mixtures

- Convenor: M. Walter
- UK Member:
  - ✓ **Graeme Coapes (NGN)**
    graeme.coapes@siemens-energy.com
  - ✓ **Fraser Cook**
- Start Date: 2023
- Completion Date: 2026

Scope of Activities:

The Working Group will collect and summarize the current knowledge on the PD properties of major natural-origin and fluorinated non-SF6 insulating gases and gas mixtures which are currently proposed by the equipment manufacturers. Wherever required and feasible, further studies shall be conducted (e.g. by testing).

Status Update:

- First meeting in Zurich June 2023
  - ✓ Structure of technical brochure defined
  - ✓ Chapter sub-groups have been nominated
- Second meeting scheduled Berlin Nov 2023

Plan is to complete literature review on state-of-the-art knowledge. This will be followed by defining experiments to be completed at various laboratories upon different gas mixtures.

JWG D1/A2.77

Liquid Test for Electrical Equipment

- Convenor: Fabio Scatiggio
- UK Member: Gordon Wilson, Russell Martin, Attila Gyore, Dave Walker, Qiang Liu
- Start Date: Oct 2020
- Completion Date:

Scope of Activities:

1. Verification of Ostwald coefficients
2. Improving interpretation models for natural and synthetic esters.
3. Recommend a data format/template for DGA and other liquid tests
4. Providing guidance to differing gas levels/patterns in different transformer types
5. Clustering of oil test results
6. Investigate, based on real failure cases, if different DGA interpretation criteria (Rogers, IEC, IEEE, Duval, etc.) lead to the same conclusion.
7. Verification of new DGA detectors

Status Update:

- TF1 – Measurement aspects
  - ✓ RRT 1 on partition/Oswald's coefficients (completed)
  - ✓ RRT 2 considering aged liquids
  - ✓ Evaluation of alternative DGA techniques
- TF2 – Data handling and categorisation
  - ✓ Template has been agreed (completed)
  - ✓ NDA for perpetual data collection
  - ✓ Correlation between chemical and electrical tests
- TF3 – Modelling and case studies
  - ✓ DGA interpretation models literature survey (completed)
  - ✓ Simulations with new types of liquids planned
  - ✓ Liaison with IEC WG 45 started
  - ✓ Models simulation with real cases
- Cooperation with JWG A2/D1.67 on "Guidelines for Online DGA Monitoring" was established.

JWG D1/B1.75

Strategies and tools for corrosion prevention for cable systems

- Convenor: Joe Tusek
- UK Member:-
- Start Date: 02/2020
- Completion Date: mid-2023

Scope of Activities:

1. Collect case studies of unexpected corrosion and detail the root cause of the problem.
2. Report on practical measures adopted by asset owners to mitigate against corrosion, either through enhanced specifications, factory audits, onsite testing etc.
3. Strategies adopted by asset owners to safeguard against corrosion in service

Status Update:

- Follow on from more general D1.71
- Collect case studies on unexpected corrosion
- Report on practical measures to mitigate corrosion
- Specifications, factory audits, onsite testing
- Strategies to safeguard against corrosion in service
- Hoping to complete mid-2023

JWG B1/D1.75

Interaction between cable and accessory materials in HVAC and HVDC applications

- Convenor: Anders Gustafsson
- UK Member: Thomas Andritsch
- Start Date: 02/2020
- Completion Date: imminent

Scope of Activities:

- Generate reference guide on interface issues in HV cables
- Propose testing methodologies to assess compatibility
- HVAC, HVDC, land and submarine cables in scope

Status Update:

- TB drafted, includes development tests
- We are still looking for input from manufacturers and utilities on field experience
- 25 meetings so far (of which 17 were online)
- Plan to be finished before the Paris 2024 session

Study Committee D1 New Technical Brochures

CIGRE UK A2/D1 Liaison Meeting, 9th January 2024

Study Committee D1 – New Technical Brochures

In the past 12 months the following technical brochures have been published:

- TB888 Atmospheric and altitude correction factors for air gaps and clean insulators (WG D1.50)

  e-Cigre link

- TB894 Basic principles and practical methods to measure the AC and DC resistance of conductors of power cables (WG D1.54)

  e-Cigre link

TB 888

Atmospheric and altitude correction factors for air gaps and clean insulators (WG D1.50)

- 317 page document, 8 main chapters and 6 appendices
- Addresses all stakeholders of T&D equipment and technology and all those involved in selection, specification, design, manufacture and exploitation of MV and HV equipment
- Implementation of correction factors for air gaps and clean insulators as used in OHL and HV substations
- Overview of existing AAFC methodologies (IEC standards)
- Presents current and expected future trends in the revision of standards and procedures

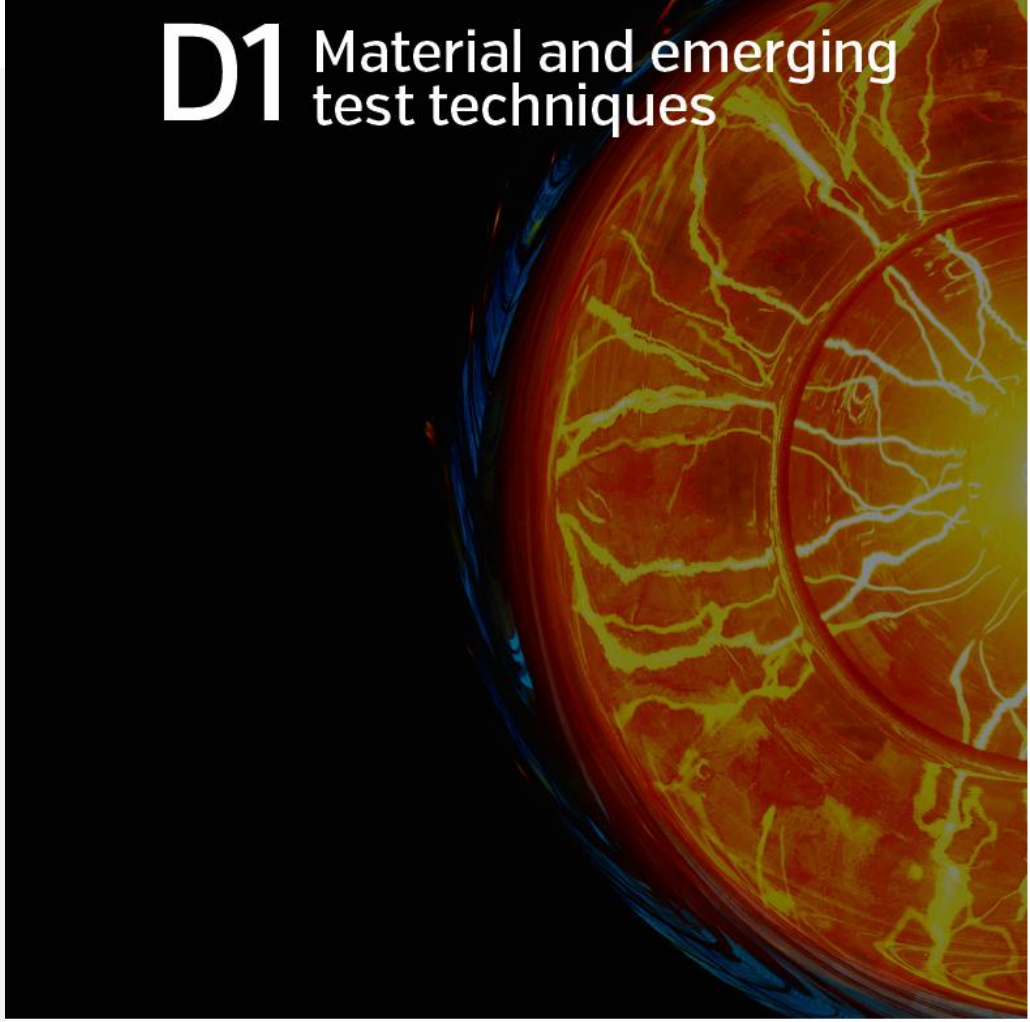
https://e-cigre.org/publication/888-atmospheric-and-altitude-correction-factors-for-air-gaps-and-clean-insulators

TB894

Basic principles and practical methods to measure the AC and DC resistance of conductors of power cables (WG D1.54)

- Theoretical background of AC loss mechanisms and describing critical influences in the electrical measurements of complex conductors
- State of the art in measurement systems (AC and DC)
- Best practice in connection systems and temperature measurement and stabilisation
- Results of a RRT presented
- Proposed recommendations for accurate measurement of AC and DC resistances using the electrical method
- Measurement procedure described and new metric proposed to be used as a future performance rating value

https://e-cigre.org/publication/894-basic-principles-and-practical-methods-to-measure-the-ac-and-dc-resistance-of-conductors-of-power-cables



Thank you for your attention!

CIGRE UK A2/D1 Liaison Meeting, 9th January 2024

IEC Updates

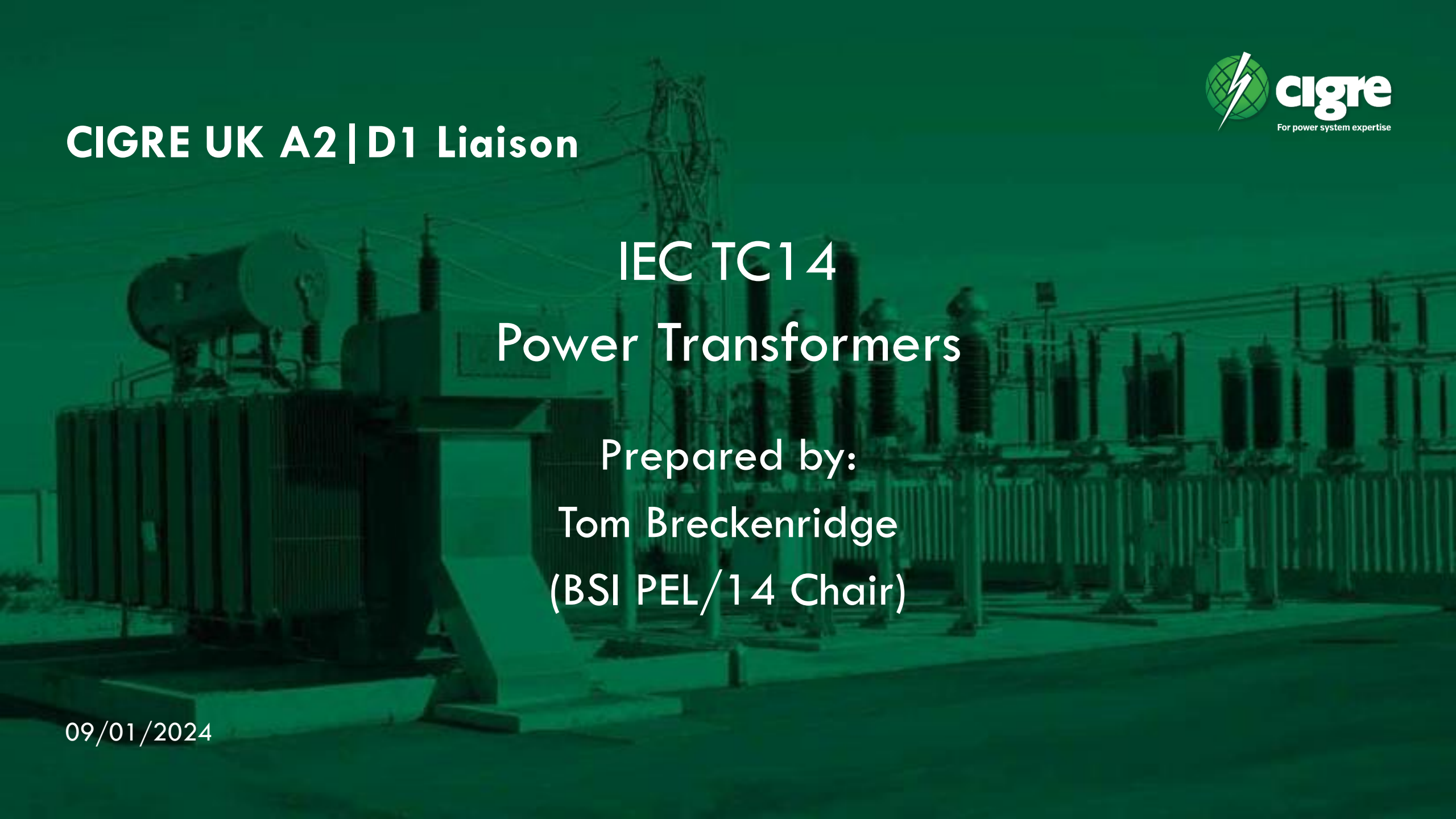
IEC TC14 Power Transformers

- Tom Breckenridge (TB TCS)

IEC TC10 Fluids for Electrotechnical Applications

- Russell Martin (M&I Materials)

cigre
For power system expertise



CIGRE UK A2|D1 Liaison

IEC TC14
Power Transformers

Prepared by:
Tom Breckenridge
(BSI PEL/14 Chair)

09/01/2024

New Approved TC14 Scope

- Standardization in the field of:
  - **power transformers**
  - **reactors (inductors)**
  - **their auxiliary equipment (tap changers, cooling systems, etc.), fittings and accessories**
  - **neutral grounding devices (transformers, reactors, resistors etc. for grounding)**
- for use in power generation, transmission and distribution as well as for industrial applications.

- Power transformers and reactors covered by TC14 have at least one highest voltage for equipment above 1000 V and a power rating equal or above 1 kVA per phase.
- TC14 technical standards may be applied to power transformers and reactors with lower voltages if the application is not covered by another TC.
- Insulated bushings are covered by SC 36A and insulating fluids are covered by TC 10.

- Excluded:
  - Instrument transformers
  - Testing transformers
  - Traction transformers mounted on rolling stock
  - Welding transformers
  - Transformers for applications covered by TC 96

TC14 Structure

- Chair – Christoph Ploetner (Germany)
- Secretary – Stephanie Lavy (UK)
- IEC Personnel
  - Technical Officer
  - Standards Project Administrator
  - Editor
- 3 Working Groups
- 2 Project Teams
- 16 Maintenance Teams
- 1 Joint Working Group
- 1 Advisory Group
- 1 Ad-hoc Group

38 Participating Countries

13 Observer Countries

Last plenary meeting –
22-23 June 2023 in
Boston, USA

Next plenary meeting –
18 April 2024 in Rome, and
20 October 2024 in Edinburgh

TC14 Role

- IEC TC14 is responsible for developing and maintaining the following international standards
  - **IEC 60076 series – 32 documents and sub-documents**
  - **IEC 60076-57 series – 2 documents jointly published with IEEE**
  - **IEC/IEEE 60076-16**
  - **IEC 60214**
  - **IEC TR 60616 – in process of being integrated as IEC 60076-9**
  - **IEC 61378 series – 2 documents**
  - **IEC 62032**

TC14 Update

- New Standards published in 2023:
  - **IEC 60076-19-1: 2023 - Rules for the determination of uncertainties in the measurement of the losses of power transformers**
  - **IEC 60076-22-7: 2020/ COR1:2023 - Accessories and fittings**
  - **IEC 60076-25: 2023 - Neutral grounding resistors**

TC14 Update

- Current Work in Progress Includes:
  - **IEC 60076-1 – Major update started 2018**
  - **IEC 60076-2 – Major update started 2018**
  - **IEC 60076-4 – Guide to impulse testing – supporting IEC 60076-3**
  - **IEC 60076-5 – Short circuit withstand**
  - **IEC 60076-6 – Reactors**
  - **IEC 60076-9 – This is an update to IEC 60616 terminal marking**
  - **IEC 60076-18 – This is the SFRA measurement standard**
  - **IEC 60076-19-2 – Uncertainty in loss measurement for reactors**
  - **IEC/IEEE 60076-57-135 – This is essentially maintenance of IEC 62032**

TC14 Update

- **IEC 60076-1 – Power transformers - Part 1: General**
- **MT Convener Paul Jarman (UK)**
  - Meeting virtually since 2020 which has slowed progress
  - Major update bringing specified parameters into 76-1 from 76-2 and 76-14 – becomes the location for all critical parameters
  - Developing a more general approach to reference temperature to allow easier integration of new technologies and alignment with IEEE
  - First CD published in May 2023 for comment
  - 117 Pages of Comments received, UK submitted 10 pages of comments
  - Next meeting in Rome, 16/17 April 2024

TC14 Update

- **IEC 60076-2 – Power transformers - Part 2: Temperature rise for liquid-immersed transformers**
- **MT Convener Dejan Susa (was NO, now AUS)**
- **This work is closely linked to that of IEC 60076-1 and meetings have been running in parallel – all virtual meetings since 2020**
  - Specification of temperature rise limits being moved from 76-2 to 76-1
  - 76-2 then becomes a document specifically about how to test the transformer
  - Hoping that this will provide better guidance on testing, but IEC don't permit guidance in documents.
  - First CD published in May 2023 for comment
  - 108 pages of comments received; UK submitted 14 pages of comments

TC14 Update

- **IEC 60076-4 – Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors**
- **MT Convener Thang Hochanh (CA)**
- **This document has been in maintenance since just after the publication of IEC 60076-3 Ed 3 in 2013:**
  - CDV document issued July 2023 – Can't find results of the vote anywhere
  - Forecast date of publishing new standard is now early 2025

TC14 Update

- **IEC 60076-5 – Power transformers - Part 5: Ability to withstand short circuit**
- **MT Convener Jean-Christophe Riboud (FR)**
- **The MT working on this has been meeting for a number of years and have had quite a lot of meetings but with not a lot of progress – however:**
  - First CD issued for comment just before Christmas 2022
  - Comment resolution still ongoing 1 year later – expected completion in March 2024
  - Following comment resolution, a decision will be made to either progress the document to CDV stage, or move to a CD2 stage

TC14 Update

- **IEC 60076-6 – Power transformers - Part 6: Reactors**
- **MT Convener Rob Verhoeven (NL)**
- **The MT working on this has met quite a few times:**
  - First CD currently out for comment with comments due to BSI by end of January
  - UK represented by David Walker and Paul Jarman

TC14 Update

- **TC14 Plenary Meeting Decisions of Note:**
  - Relocate Table 1 in IEC 60076-5 on minimum impedances to IEC 60076-1
  - New Annex 'K' to be produced for IEC 60076-1 to provide more background on the concept of "Rated temperature of external cooling medium"
  - IEC MT 60076-18 given mandate to harmonise with IEEE C57.149
  - Decides to join revision of IEC/IEEE 60076-57-129 (HVDC Standard)
  - A number of working groups/ ad hoc groups status changed to Maintenance Teams

CIGRE UK A2|D1 Liaison

IEC TC10 GEL 10
Fluids for Electrotechnical Applications

National Committee Update

Prepared by:
Russell Martin (M&I Materials)

09/01/2024

GEL 10 (UK National Committee for TC 10)

- Chair: Dave Walker
- 15 members meet 2/year

GEL 10 Standards and groups under review

- MT36A – Updating IEC 62770 Unused Natural Esters for Electrical Equipment Convenor Russell Martin
  - **At FDIS stage. The IEC posed some questions on the FDIS draft which I have answered and returned. Should be published sometime in 2024.**

- IEC 60567 Oil-filled electrical equipment - Sampling of gases and analysis of free and dissolved gases – Guidance
  - **FDIS was voted approved (100% of P members). Should be published soon.**

- IEC 63360 ED1 Fluids for electrotechnical application Mixtures of gases alternative to SF6
  - **The CDV document was approved (94.7% of P members) with comments. The team will now review these in order to draft the FDIS document.**

GEL 10 Standards and groups under review

- IEC 60422 Ed. 5 “Mineral insulating oils in electrical equipment Supervision and maintenance guidance” MT22 D. Walker
  - **Now at FDIS stage and should be published in the new year. There is also an IEC Webinar planned for the 1st of February to review the updated version.**

- IEC 61203 Synthetic organic esters for electrical purposes – Guidefor maintenance of transformer esters in equipment. R. Martin
  - **CDV 100% approved with comments. Next meeting 17th January 2024 to draft FDIS.**

- Maintenance of IEC 61039:2008 Ed.2 “Classification of insulating liquids” (actual SD 2021) Russell Martin
  - **CDV approved with comments. Next meeting 23rd January 2024 to draft FDIS.**

- IEC 60156 (2018) Insulating liquids - Determination of the breakdown voltage at power frequency - Test method
  - **CDV approved with comments. Massimo has circulated these to the team for review – expect a meeting to be called soon.**

GEL 10 Standards and groups under review

- IEC TC10/TC14 JWG 46 - Guide for retrofilling mineral oil immersed transformers with alternative insulating liquids
  - **New group had its first meeting 10th November in Rome to tie in with a workshop on retrofilling transformers with ester liquids. Both Bruce and David attended and are members of this joint WG.**
  - **Group is looking to get a view form industry to understand current progress, and to provide a guidance document on the retrofilling topic for use within the industry, this will include best practices and technical guidance.**
- EC WG 45 Preparation of a new TR/IS on interpretation of DGA analysis in natural and synthetic esters – Ivanka Atanasova-Hoehlein
  - **Several online and in person meetings held and a draft text written. Last meeting. At the end of the last meeting (13th November) it was decided to circulate the draft to a wider audience for constructive comment.**
- TOR-JWG A2_C3_70 Life Cycle Assessment (LCA) of Transformers
  - **New group being driven by Siemens who is believed to want to complete the work quickly.**

Papers for 2024 Paris Session

UK A2 Regular Member

Zhongdong Wang (The University of Manchester)

cigre
For power system expertise

CIGRE 2024 Session – UK A2 Contributions

SC	PS	Title	Author	Email Addresses	Author in Paris
A2	1	Thermal and Electrical Designs of Transformers by Considering Different Insulating Liquids	Qiang LIU	qiang.liu@manchester.ac.uk	yes
A2	2	Data Analytics for Transformer Dissolved Gas Analysis to Aid Asset Management	Zhongdong WANG	zhongdong.wang@manchester.ac.uk	Yes
A2	2	Data Mining for Targeted PCBs Management of Pole Mounted Transformers	Sheng Ji TEE	stee@spenergynetworks.co.uk	Yes
A2	2	Summary of In-Service Assessment of Synthetic Ester Filled Transformers	Muhammad DAGHRAH	MuhammadDaghrah@mimaterials.com	Yes

Agenda

- **10:30 Registration and Tea/Coffee**
- **11:00 Welcome and Introduction to SC A2**
- **11:10 Technical Brochures Published in 2023 | Feedback from Colloquium | New WGs & Future Events | A2 Technical Activities and Working Group Updates**
- **12:30 D1 Relevant Technical Activities**
- **13:00 Networking Lunch**
- **14:00 IEC TC14/TC10 Standards Activities**
- **14:30 Discussion – Papers for 2024 Paris Session**
- **15:00 End of Meeting, Tea/Coffee/Networking**

cigre
For power system expertise

Many Thanks

- **The University of Manchester acts as the host for today's events, sponsoring the meeting room. Lunch and Tea/Coffee Breaks are sponsored by the CIGRE-UK.**

- **CIGRE-UK A2 Team**
  - ✓ Regular Member – Zhongdong Wang (The University of Manchester)
  - ✓ Additional Member – Elizabeth MacKenzie (MacKenzie Consultant)
  - ✓ Technical Panel Secretary – Jose Quintana (SP Energy Networks)
  - ✓ Secretary – Shengji Tee (SP Energy Networks)
  - ✓ Web Master – Christian Pößniker (University of Exeter)

- **Support from CIGRE-UK**
  - ✓ Technical Committee Chair – Ray Zhang
  - ✓ Martin Ansell (Events/Marketing)

cigre
For power system expertise