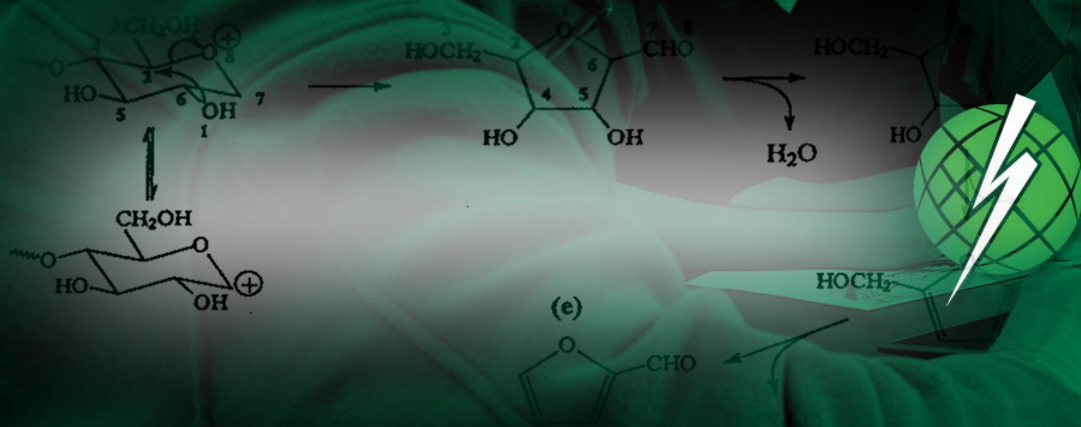


# D1 Materials and Emerging Test Techniques

Presented by Joe Tusek - Convener  
Brisbane – 21/11/2019



**cigre**

For power system expertise



$V_{min}(5.3 \text{ MHz}, N_2): 161 \text{ kV}, 0.13 \mu s$

$V_{min}(20.0 \text{ MHz}, CO_2): 148 \text{ kV}, 0.17 \mu s$

$V_{min}(5.3 \text{ MHz}, CO_2): 120 \text{ kV}, 0.13 \mu s$

## Status August 2018

SC Chair  
R. Pietsch(DE)

AG D1.01: Liquid and liquid impregnated insulation systems [L. Lundgaard (NO)]

AG D1.02: High voltage and current testing and diagnosis [U. Riechert (CH)]

AG D1.03: Solid materials [S. Sutton (GB)]

SC Secretary [J. Seiler (DE)];

Strategic and Customer AG [R. Pietsch (DE)]

Tutorial AG [I. Atanasova-Hoehlein (DE)]

Webmaster [J. Seifert (DE)]

Liquid & impregnated systems	Testing & Diagnosis	Gases	Solids	Solids
JWG D1/A2.47 [Duval (CA)/2011-06] New frontiers of DGA interpretation for power transformers and their accessories	WG D1.50 [J. Rickmann (US)/2012-04] Atmospheric and altitude correction factors for air gaps and clean insulators	JWG D1/B3.57 [C. Neumann (DE)/2013-12] Dielectric Testing of Gas-insulated HVDC Systems	JWG D1/B1.49 [M. Jarvid (SE)/2012-04] Harmonized test for the measurement of residual inflammable gases in insulating materials by gas chromat.	WG D1.62 [B. Komanschek (DE)/2014-10] Surface degradation of polymeric insulating materials for outdoor applications
WG D1.65 [Schmidt (DE)/2015-12] Mechanical properties of insulating materials and insulated conductors for oil insulated power transformers	WG D1.54 [B. Dardel (CH)/2013-01] Principles and methods to measure the AC and DC resistance of conductors of cables and overhead lines	WG D1.66 [W. Koltunowicz (AT)/2016-08] Requirements for PDM systems for gas insulated system	WG D1.56 [Hinrichsen (DE)/2013-03] Field grading in electrical insulation systems	WG D1.64 [Hayakawa (JP)/2015-12] Electrical insulation systems at cryogenic temperatures
JWG A2/D1.46 [Mertens (BE)/11-06] Field experience with transformer solid insulating ageing markers	WG D1.60 [Y. Li (AU)/2014-09] Traceable measurement techniques for very fast transients	WG D1.67 [C. Franck (CH)/2016-08] Dielectric performance of non-SF6 gases and gas mixtures for gas-insulated systems	WG D1.58 [Kornhuber (DE)/2014-01] Evaluation of dynamic hydrophobicity of polymeric insulating materials under AC and DC voltage stress	WG D1.71 [J. Tusek (AU)/2017-08] Understanding and mitigation of corrosion
JWG A2/D1.51 [Coenen (DE)/14-02] Improvement to PD Measurements for Factory and Site Acceptance Tests of Power Transformers	WG D1.61 [N. Mahatho (ZA)/2014-09] Optical corona detection and measurement		WG D1.59 [J. Seifert (DE)/2014-01] Methods for dielectric characterisation of polymeric insulating materials for outdoor applications	WG D1.73 [Frechette (CA)/2017-12] Nanostructured dielectrics: Multi-functionality at the service of the electric power industry
WG D1.68 [M. Pompili (IT)/2017-01] Natural and synthetic esters - Evaluation of the performance under fire and the impact on environment	WG D1.63 [R. Plath (DE)/2015-04] Partial discharge detection under DC stress			
WG D1.70 [I. Hoehlein (DE)/2016-11] Functional properties of modern insulating liquids for transformers and similar electrical equipment	WG D1.69 [R. Taylor (AU)/2017-02] Guidelines for test techniques of High Temperature Superconducting (HTS) systems			
	WG D1.72 [Lambrecht (DE)/2018-04] Test of material resistance against surface arcing under DC			

WG under D1 resp.

JWG under D1 resp

JWG not under D1



# Recent Areas Interest in D1

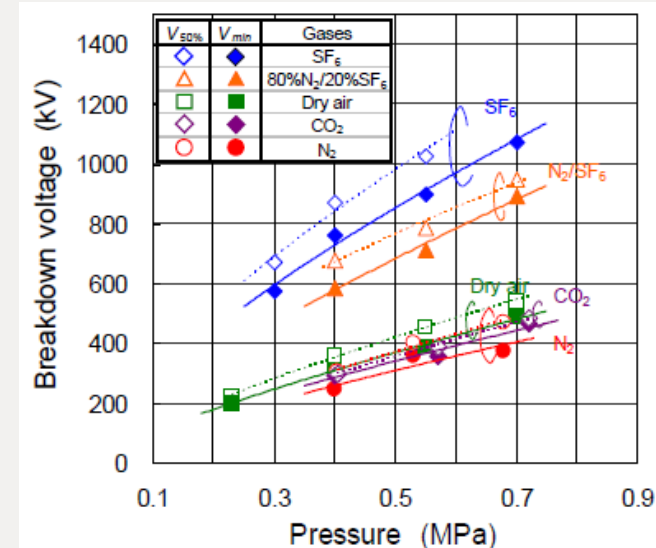
## SF6 Alternatives

The industry is slowly moving to an SF6 free future.

TB 730 from WG D1.51 produced a brochure outlining the potential to use natural-origin gases (dry air, N<sub>2</sub>, CO<sub>2</sub>) and N<sub>2</sub>/SF<sub>6</sub> gas mixtures as a replacement for SF<sub>6</sub>.

Organisations need to start thinking about gas handling, as it is likely that there will be a number of gases in use.

Note : Vacuum breakers at 145kV are now a catalogue item.



## TB 738 - Ageing Of Liquid Impregnated Cellulose

For power Transformers, documents new understanding of ageing mechanisms in paper-oil insulation including thermally upgraded papers.

Identifies that the different types of degradation have different temperature dependant degradation rates.

Paper's mechanical strength is considered the key determinant for condition assessment, ability to withstand shear-stress is key.

The TB also discussing the benefit of various life extension options, such as moisture and oxygen removal. Also, various drying options including low frequency heating.

ATC Seminar 2019

# Recent Areas Interest in D1

## TB 751 - Electrical properties of insulating materials under VLF voltage

The TB outlines the results of investigations into the properties of materials under VLF, considering the frequency range from 0.01-1.0 Hz.

The various ways in which VLF is produced and the impact of the different waveshapes is considered. As is the breakdown of insulation under VLF and generation of space charge.

An important consideration is the electric field distribution within accessories under VLF conditions.

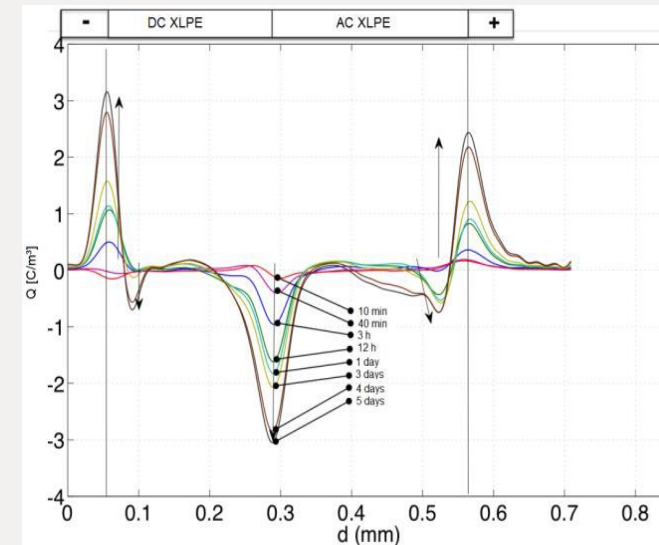
## TB 765 - Understanding and mitigating corrosion

The TB outlines the science and factors associated with corrosion and its prevention.

Its aim is to provide a common understanding and language for corrosion within the Cigre community.

This brochure is the what and how of corrosion and will be followed up by a new Working Group that will look at specific instances and remediations of corrosion within electrotechnical arena.

ATC Seminar 2019



# Recent Areas Interest in D1

## TB 771 - DGA interpretation advances

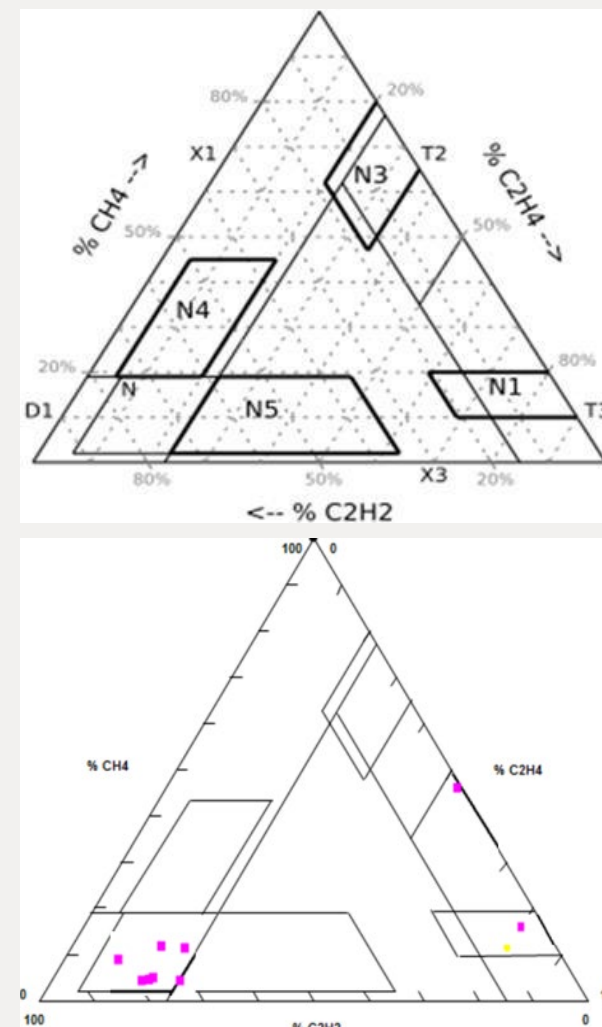
is the output of JWG D1/A2.47, is the long-awaited brochure that contains a comprehensive description of Michel Duval's various analytical tools for interpreting insulating oil Dissolved Gas Analysis results.

The brochure covers the triangle and pentagon analytical methods and contains numerous case studies which demonstrate their use.

## TB 779 - Field experience with transformer solid insulation ageing markers

This brochure demonstrates the applicability of Methanol as another indicator for degree of polymerisation of paper.

It compares the characteristics of Furans and Methanol for paper degradation, showing where each gives the greatest sensitivity.



# 2020 Paris Session

## PS 1 : Testing, Monitoring And Diagnostics

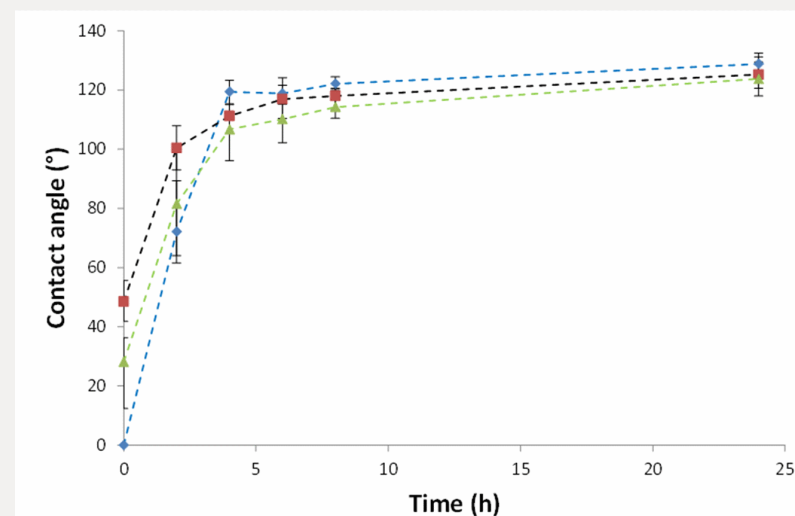
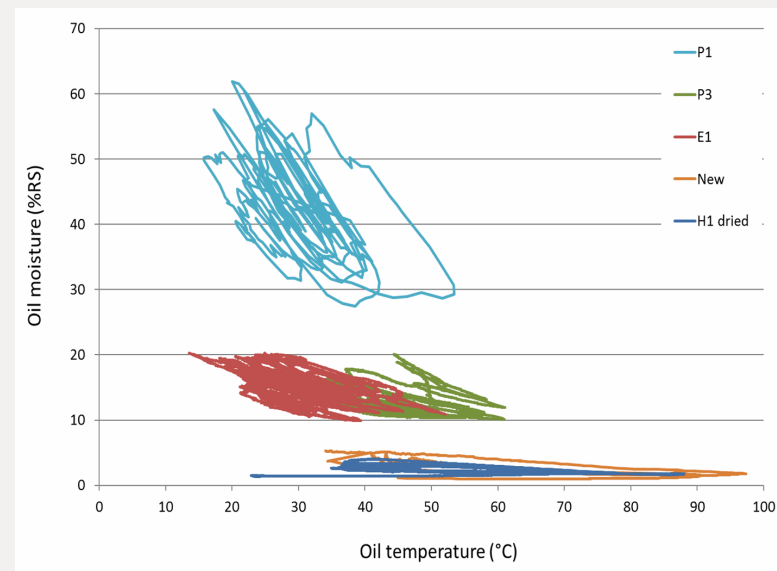
- Experience and insight from monitoring systems.
- Reliability of test equipment and systems for testing, monitoring, and diagnostics.
- Data handling, analytics, and advanced condition assessment.

## PS 2 : Functional Properties And Degradation Of Insulation Materials

- New stresses, e.g. power electronics, load cycling, higher temperatures, and compact applications.
- Materials with lower environmental footprint, during production, operation, and disposal.
- Characterisation methods for validating functional properties.

## PS 3 : Insulation Systems Of Advanced Components

- Materials under high stresses, e.g. field stress, flux, electric current, and frequency.
- Experience and requirements for new test procedures and standards.
- Development of new materials, e.g. 3D printing; lamination; casting; and additive or subtractive manufacturing.

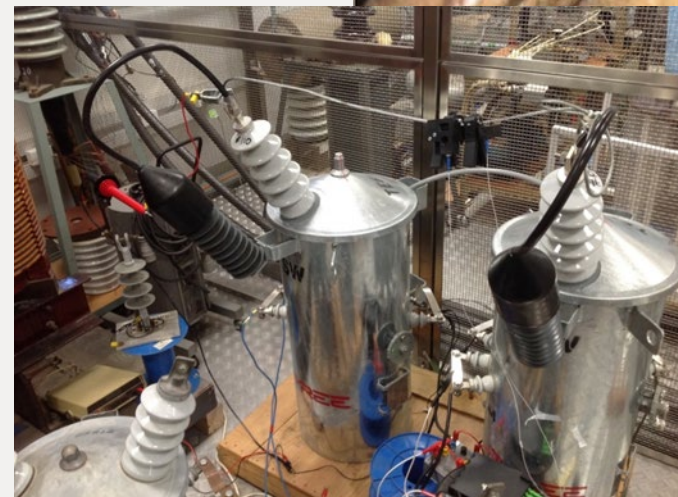


# 2019 AP D1 Activities

## Highlights

- **Meeting held 22 October 2019 in Newcastle**
  - SWER line arching fault monitoring
  - Transformer Frequency Response Analysis
  - Synchronous condenser installation in SA network
  - Technical details of transformer tank design that greatly increase risk of water ingress.
  - Cable testing of very long HV cables.
- **Participating in WG's**

<b>D1.48</b>	Properties of insulating materials under VLF voltages
<b>D1.59</b>	Methods for dielectric characterisation of polymeric insulating materials for outdoor applications
<b>D1.60</b>	Traceable measurement techniques for very fast transients
<b>D1.50</b>	Atmospheric and altitude correction factors for air gaps and clean insulators
<b>D1.69</b>	Guidelines for test techniques of High Temperature Superconducting (HTS) systems





# 2019 AU/NZ D1 Activities

## D1 Papers accepted for Paris Session

- ✓ D1-519 Extended Frequency Range Testing of HV Cables - J. Tusek
- ✓ D1-500 A measurement system for insulator puncture test with the fast-rise impulse voltage – Dr Y. Li
- ✓ D1-511 Characterization of pressboard mechanical properties for understanding the dynamic behaviour of transformer winding clamping pressure – Prof T. Saha.





# 2019 Deliverables

## Technical Brochures

- TB 783 – D1/A2.47 - DGA Monitoring Systems - 2019
- TB 779 – Field Experience With Transformer Solid Insulation Ageing Markers - 2019
- TB 771 - Advances In DGA Interpretation - 2019
- TB 765 - Understanding And Mitigating Corrosion - 2019
- TB 741 - Moisture measurement and assessment in transformer insulation - Evaluation of chemical methods and moisture capacitive sensors - 2018
- TB 738 - Ageing of liquid impregnated cellulose for power transformers- 2018
- TB 730 - Dry air, N<sub>2</sub>, CO<sub>2</sub>, and N<sub>2</sub>/SF<sub>6</sub> mixtures for gas-insulated systems - 2018
- TB 706 - Guidelines for the use of statistics and statistical tools on life data - 2017
- TB 705 - Guidelines for altitude correction of pollution performance of insulators - 2017
- TB 703 - Insulation degradation under fast, repetitive voltage pulses - 2017
- TB 691 - Pollution test of naturally and artificially contaminated insulators - 2017
- TB 676 - Partial discharges in transformers – 2017

ATC Seminar 2019

