27-05

CIRED Voorbereidingsdag

20 JAAR
DUTCHPOWER

Session 1 - Network Components

SESSION 1: Network Components

Session 1 deals with all aspects related to the components used in the electricity distribution networks: cables, overhead lines, primary and secondary substations, transformers, switchgear, protection and monitoring systems, power electronics. It covers topics related to the life cycle of assets from design to end of life management. The session also covers environmental concern including eco-design and life cycle analysis, standardisation, ergonomics and safety. It aims at providing an overview of the state-of-the-art and proposals for future components, including those needed for smart grids, e-mobility, smart cities and microgrids, as well as components for more resilient networks in the context of climate change anticipation. This session is an opportunity for DSOs and manufacturers to share their objectives.

Components for smart distribution grids +

Components reliability, diagnosis and maintenance strategy +

Components for large cities distribution networks +

Towards "greener components" +

Innovation in design of components +

Components for smart distribution grids –

- Smart substations
- Components with capabilities for data acquisition, information generation, communication and cybersecurity
- Components and sensors for voltage and power flow management
- Power electronics-based grid components
- Components for DC and AC/DC hybrid networks
- Components for integration of distributed generation
- Storage devices
- Components for e-mobility charging stations
- Components for the disconnection and reconnection of microgrids.

Components reliability, diagnosis and maintenance strategy –

- Condition assessment, ageing models, lifetime assessment, diagnostics
- Online monitoring of distribution system assets and related sensors
- Use of new solutions like digital tools, big data, machine learning, and drones for diagnostics and maintenance
- Life extension, upgradeability, retrofit operations of existing components,
- Components for more resilient networks
- Impact of climate change on network components.

Components for large cities distribution networks –

- Compact substations
- Modular components for fast installation and extensibility
- High-reliability solutions
- Short circuit current mitigation solutions
- Components with increased power capabilities.

Towards "greener components" –

- Circular Economy, eco-design, use of bio-sourced and recycled materials, life-cycle analysis
- Reduction of losses
- Limitation of visual and noise impact
- Management of hazardous substances.

Innovation in design of components –

- Modelling including digitalisation e.g. Digital twins of components
- Testing
- New materials
- Safety aspect, ergonomics and usability
- Evolution of standards
- New functional specifications.

Send us

Session 1: Network Components

Tuesday: Round Tables

- Power Electronics in Distribution Grids
- DC and Hybrid AC/DC networks
- Life Cycle Assessment
- Innovation Forum

Conference Room C 09:00-10:30

RT 1: Power Electronics in Distribution Grids: Impact, new functions, new technologies, new challenges

Chair: Uwe Kaltenborn
Presentation type: Round Table or RiF Session
Themes: Theme 1: Network Components

Distribution networks are exposed to an ever-increasing number of power electronic devices. It is obvious that a higher number c
number of converters on the consumer side. The growing demand for active power flow control in the distribution network has al
such as solid-state transformers, STATCOMs, 4-quadrant inverters, semiconductor switching and protection devices. The roundt
devices and the experience gained in practice. The technical implications will be discussed, e.g. the effects of harmonics and hig

Conference Room C 11:00-12:30

RT 3: DC and hybrid AC/DC networks

Chair: Gerhart Jambrich
Presentation type: Round Table or RiF Session

Conference Room C 14:30-16:00

RT 4: How Life Cycle assessment has changed component design and

Chair:
Presentation type: Round Table or RiF Session
Themes: Theme 1: Network Components

Conference Room C 16:30-18:00

RIF Session

Chair:
Presentation type: Round Table or RiF Session
Themes: Theme 1: Network Components

Session 1: Network Components

Wednesday: Main Session

09:00

Conference Room A 09:00-10:30

Theme 1: Oral Session A: Electrification & Disruptive

Chair:
Presentation type: Oral Presentations
Themes: Theme 1: Network Components

6 submissions

11:00

Conference Room A 11:00-12:30

Theme 1: Oral Session B: Diagnostics, Sensors & Auto

Chair:
Presentation type: Oral Presentations
Themes: Theme 1: Network Components

6 submissions

14:30

Conference Room A 14:30-16:00

Theme 1: Oral Session C: Context & Enviro

Chair:
Presentation type: Oral Presentations
Themes: Theme 1: Network Components

6 submissions

16:30

Conference Room A 16:30-18:00

Theme 1: Oral Session D: Model & Prediction (incl. Ageing)

Chair:
Presentation type: Oral Presentations
Themes: Theme 1: Network Components

6 submissions

Session 1: Network Components

Thursday:
Poster Sessions

09:00

Poster Area - Exhibition Hall 09:00-10:30 — R A+18

Poster Tour 1: Electrification & Disruptive

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
20 submissions

Poster Area-Exhibition Hall 09:00-10:30

Poster Tour 2: Diagnostics, Sensors & Auto

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
18 submissions

11:00

Poster Area - Exhibition Hall 11:00-12:30 — J H+19

Poster Tour 3: Electrification & Disruptive

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
21 submissions

Poster Area-Exhibition Hall 11:00-12:30

Poster Tour 4: Diagnostics, Sensors & Auto

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
16 submissions

14:30

Poster Area - Exhibition Hall 14:30-16:00 — N C+15

Poster Tour 5: Context & Enviro

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
17 submissions

Poster Area-Exhibition Hall 14:30-16:00

Poster Tour 6: Model & Prediction (incl. Ageing)

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
18 submissions

16:30

Poster Area - Exhibition Hall 16:30-18:00 — D R+14

Poster Tour 7: Context & Enviro

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
16 submissions

Poster Area-Exhibition Hall 16:30-18:00

Poster Tour 8: Model & Prediction (incl. Ageing)

Chair:
Presentation type: Guided Poster Tours
Themes: Theme 1: Network Components
20 submissions

BEDANKT VOOR UW AANDACHT

27-05

CIRED Voorbereidingsdag

SPREKER:

Rory Leich

DUTCHPOWER 20 JAAR

Session 1: Network components – Transformers

Session 1: Network component - Transformers

- 151 Submissions
  - 29: Cables
  - 44: Switchgear
  - 51: Others
  - 29: Transformers
    - 04: Assetmanagement
    - 13: Design
    - 09: Diagnostics
    - 01: Loadablity
    - 02: Operation

Resilience

Weerbaarheid, **wendbaarheid** of **veerkracht**.
Het is het vermogen om in onverwachte situaties en erna goed te kunnen blijven functioneren.

Paper 1171 – De enige Nederlandse inzending voor transformatoren…

ASSESSING THE TEMPORAL AND SPATIAL IMPACT OF RENEWABLE ENERGY INTEGRATION ON MEDIUM VOLTAGE TRANSFORMER FAILURES

Niek Brekelmans[1], Yifan Zhang[1,2], Phuong Nguyen[1], Anne van der Molen[1,3], Peter van der Wielen[1,2]*

[1]*Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, the Netherlands*
[2] *Asset Management Department, DNV, Arnhem, the Netherlands*
[3]*System Strategy Department, Stedin, Utrecht, the Netherlands*
**n.brekelmans@tue.nl*

It can be concluded that the rapid increase in installed PV and wind capacity in the studied area has not resulted in a significant change in failure rates of distribution transformers.

Nederlandse status quo…

- Belastbaarheid
- Beschikbaarheid
- Maakbaarheid & inpasbaarheid
- (Resilience)

Mijn (objectieve ;-) favorieten:

- 54 – Smart Transformer; een onooglijk groot ding maar wel leuk om te zien wat er bij komt kijken
- 791 – Testen van een Solid State Transformer – héél anders dan (alleen) IEC60076
- 796 – Hybrid Transfomer - Controle over spanning, reactief vermogen, onbalans en harmonischen
- 211 – Verouderingstest olie-/papierisolatie distributietransformatoren
- 273 – Thermische modellering van een variabel koelingsregime
- 325 – Algemene methodes om de “resilience” te verhogen van een transformator
- **807 – Vergelijkende test met Nomex isolatie, conventionele en driehoekskern**
- **1046 – Experiment met nanofluids**

Paper 807 – Improving reliability and performance of transformers for power distribution units in data centres (de-rating of non-lineair loads)

Table 1. Permissible winding rise for different insulation systems (°C) (assumed yearly average ambient of 30°C)

Insulation thermal class		Avg wdg rise	Ambient temp.	Hotspot allowance	Hottest temp.
Class F	155	90	30	25	145
Class H	180	115	30	25	170
Class R	220	140	30	40	210

Figure 1. Concept of triangular wound transformer core

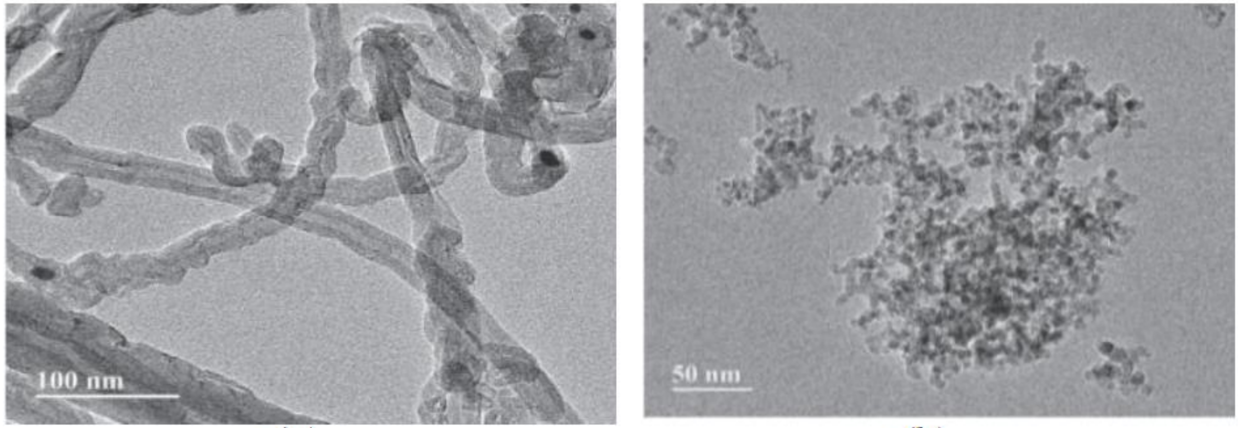
Table 4. Temperature rise test results (°C) on transformers with two different magnetic core technologies

Test condition / winding		Conventional core	Triangular core
No-load			
	Star side	27.4	21.9
	Delta side	4.4	8.1
Full load			
	Star side	128.4	105.1
	Delta side	72.0	86.0
110% load			
	Star side	157.2	131.1
	Delta side	87.4	104.8
120% load			
	Star side	183.6	150.8
	Delta side	109.4	121.9

Table 5. Sound level results on transformers with two different magnetic core technologies

	Conventional core	Triangular core
Sound level [dB(A)]	56.9	48.7

Paper 1046 – Thermal analysis of new generation of distribution transformers: experimental validation (nanofluids)



(a) (b)

Fig. 4. Microscope view of (a) MWCNT and (b) diamond nanoparticles.

Nanofluids present a promising alternative for transformers functioning under harsh conditions. They can effectively reduce thermal parameters, thereby enhancing the longevity of the transformer.

Table 4. HST Decrement Value Caused by Nanofluids

Nanofluids	**ONT 1**	**ONT 2**	**ODI 1**	**ODI 2**	**ODI 3**
HST Decrement (°C)	3.3	3.5	3.9	5.1	4.4

BEDANKT VOOR UW AANDACHT

27-05

CIRED Voorbereidingsdag

SPREKER:

Daniël Woldendorp

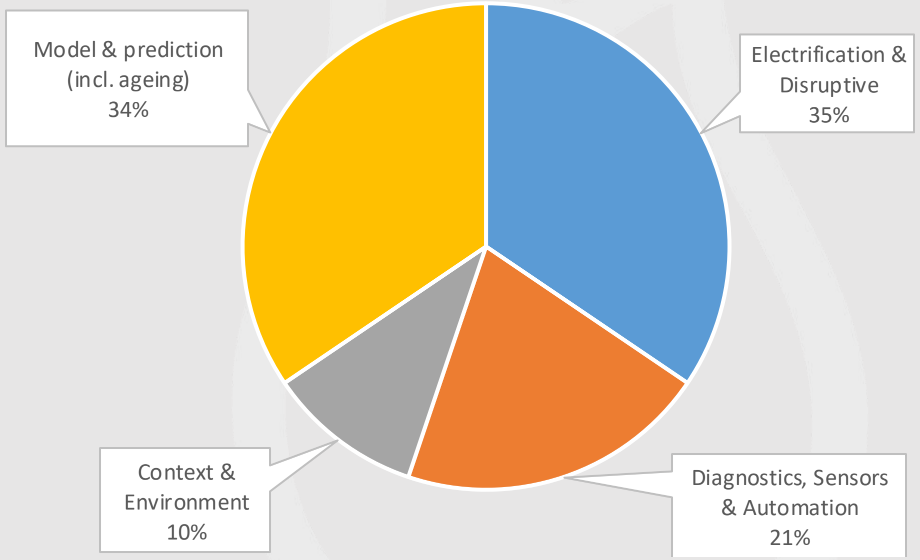
DUTCHPOWER

20 JAAR

Session 1: Network components – Cable systems

Session 1: Network component – Cable systems

- 151 Submissions
  - 29: Transformers
  - 44: Switchgear
  - 51: Others
  - 29: Cables
    - Electrification & disruptive (tour 1 & 3)
    - Diagnostics, sensors & auto (tour 2 & 4)
    - Context & Enviro (tour 5 & 7)
    - Model & prediction (incl. Ageing) (tour 6 & 8)



Five Dutch contributions session 1 – Cable systems

Paper 0133

Investigating the bending stiffness of polymeric cables

Piet Soepboer[1], Tjeerd Broersma[2], Tom Looby[3], Jonathan Moens[4]

[1]Piet Soepboer, Asset Management, Enexis Netbeheer, Zwolle, the Netherlands, piet.soepboer@enexis.nl
[2]Tjeerd Broersma, Network Innovation, Enexis Netbeheer, Zwolle, the Netherlands, Tjeerd.broersma@enexis.nl
[3]Tom Looby, UG Cables Section, ESB Networks, Dublin, Ireland, tom.looby@esb.ie
[4]Jonathan Moens, El. Network Equipment, Engie-Laborelec, Linkebeek, Belgium, Jonathan.moens@engie.com

Paper 466

THERMO-ELECTRICAL AGEING OF PAPER INSULATED MVAC CABLES: EXPERIENCE FROM LABORATORY EXPERIMENTS

Anouk Somhorst[1,2], Pjotr Muis[2], Colin van Wijk[2], Sjoerd Nauta[2]*

[1]Faculty of Science and Technology (TNW), University of Twente, Enschede, The Netherlands
[2]Alliander N.V., Arnhem, The Netherlands
*sjoerd.nauta@alliander.com

Paper 948

Investigating the Impact of RES Integration on Medium-Voltage Cable Joint Failures Based on Geographical Correlation Methods

Yifan Zhang[12], Niek Brekelmans[2], George Rouwhorst[1], Anne van der Molen[23], Phuong Nguyen[2], Peter van der Wielen[12]*

[1] Asset Management Department, DNV, Arnhem, Netherlands
[2] Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, Netherlands
[3] System Strategy Department, Stedin, Rotterdam, Netherlands
*yifan.zhang@dnv.com

STRONGLY REDUCED COMPUTATION TIME OF THERMAL MODELLING OF PRIMARY COMPONENTS USING A CONVOLUTION-BASED APPROACH

Ramon NP Creyghton[1], Thijs van der Hoeven[1], Douwe S de Bruijn[1]*

[1]DEP / Alliander NV, Utrechtseweg 68, Arnhem, the Netherlands
*ramon.creyghton@dep.nl

Paper ID950

THERMO-ELECTRICAL AGEING OF 10KV PAPER INSULATED LEAD COVERED CABLES: EXPERIENCE FROM FIELD EXPERIMENTS

Daniël Woldendorp[1], Colin van Wijk[2], Denny Harmsen[1], Stefan Lamboo[1]*

[1]System Operations Alliander N.V., Arnhem, The Netherlands
[2]Asset Management Alliander N.V., Arnhem, The Netherlands
*daniel.woldendorp@alliander.com

Session 1: Network component – Cable systems

- France, Germany, Italy, Netherlands, Norway, Portugal
- Resilience, super conducting, cable ampacity, health assessment(s) and modelling (AI)
- 'Objective' favourites:
  - 133 - Investigating the bending stiffness of polymeric cables
  - **143** - Thermal modelling of the soil to study the impact of climate change on the current rating of underground mv cables
  - 445 - Medium voltage joint design options for higher conductor temperature (110 °c)
  - **466** - Thermo-electrical ageing of paper insulated MVAC cables: experience from laboratory experiments
  - 845 - Influence of high frequencies and harmonic distorted voltages on refractive field grading for medium voltage cable accessories
  - 912 - Strongly reduced computation time of thermal modelling of primary components using a convolution-based approach
  - 948 - Investigating the Impact of RES Integration on Medium Voltage Cable Joint Failures Based on Geographical Correlation Methods
  - **950** - Thermo-electrical ageing of 10kV paper insulated lead covered cables: experience from field experiments
  - 1087 - User-friendly current capacity rating for power cables based on finite element analysis
  - **1237** - Data driven analysis of underground MV joint failure phenomena in the Italian distribution grid

Paper 1237

- 50% MV-network underground
- Reliability is the key for a resilient distribution grid
- 2/3 failure concentrated on the MV-joints: 15702 (2022), 15847 (2023)
- Annual MV joints fault rate is 0,089 fault/km (total 177.533km)

- Pronounced correlation failure and first initial heatwaves (combined with year peak)
- Thermal expansion within joints, formation voids, PD, degradation process, soil
- Double fault rate high concentration area's respect to the low area's

DATA DRIVEN ANALYSIS OF UNDERGROUND MV JOINT FAILURE PHENOMENA IN THE ITALIAN DISTRIBUTION GRID

Ivano Gentilini[1], Luca Baresi[2], Lorenzo Bertolone Citin[3], Alberto Biloslavo[4], Dario Dall'Acqua[5], Giuseppe Dalla Costa[6], Gianluca Di Felice[5], Marco Ferrante[6], Samuele Forciniti[2], Andrea Leggio[7], Michele Lupino[3], Leonardo Melia[4], Marco Proietto[1], Roberto Rossi[7]

[1]Network Engineering and Development, Enel Grids s.r.l., Rome, Italy
[2]Maintenance Engineering, A2A S.p.A., Milan, Italy
[3]Manutenzione e Lavori, IRETI S.p.A., Turin, Italy
[4]Conduzione e Manutenzione Energia Elettrica, AcegasApsAmga S.p.A., Trieste, Italy
[5]Operation and Maintenance, e-distribuzione S.p.A., Rome, Italy
[6]Rete MT e BT, Edyna s.r.l., Bolzano, Italy
[7]Pianificazione e Sviluppo Rete, areti S.p.A., Rome, Italy

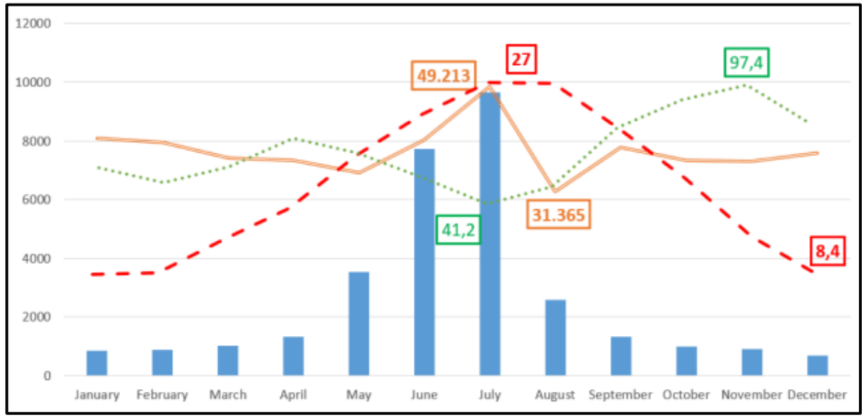


Fig. 1 Number of faults (2 years) in the different months of the year (blue columns), maximum temperatures (red dotted line), precipitations (green pointed line) and national electric energy demand (orange double line)

Paper 143

- Convener workgroup CIGRE B1.91
- Analytical models are implemented to assess the soil temperature and its thermal resistivity
- Models used to forecast the soil characteristics assuming climate change.
- Model for temperature and humidity prediction

Paper 143

THERMAL MODELLING OF THE SOIL TO STUDY THE IMPACT OF CLIMATE CHANGE ON THE CURRENT RATING OF UNDERGROUND MV CABLES

Minh Nguyen Tuan[1], Marie-Laure Parussolo-Paupardin[1]

[1]EDF R&D, Moret-Loing-et-Orvanne, France

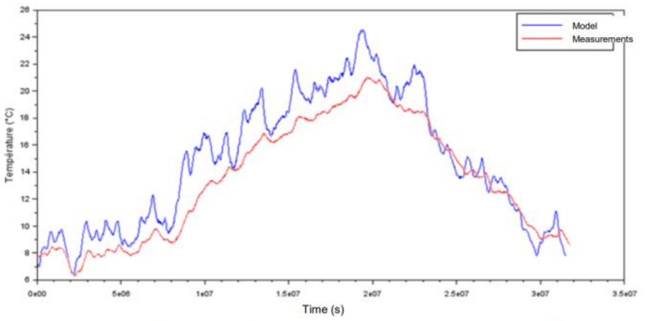


Figure 7 Soil model with coupled heat and humidity transfers

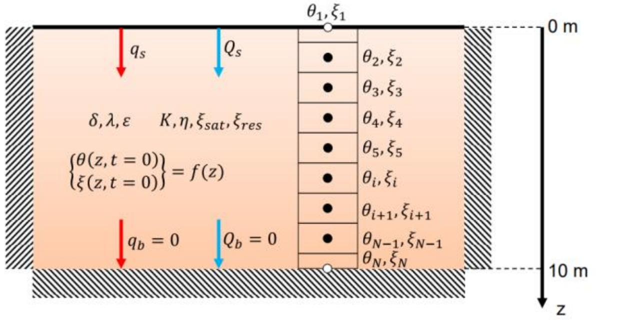


Figure 6 Soil model with coupled heat and humidity transfers

5. Conclusion and future work

The analytical models investigated in this work constitute effective tools to tackle the question of the impact of climate change on the environment of underground cables.
Ongoing and future work includes:

- Comparison with laboratory measurements;
- Application on climate projections and extreme weather events such as heatwaves, floods, and droughts, which may become more common due to climate change.

20 JAAR
DUTCHPOWER

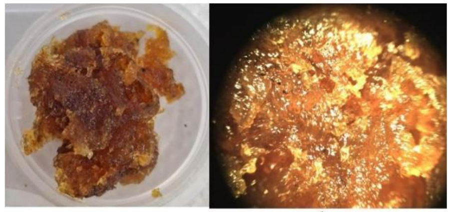
Paper 466

Paper 466

THERMO-ELECTRICAL AGEING OF PAPER INSULATED MVAC CABLES: EXPERIENCE FROM LABORATORY EXPERIMENTS

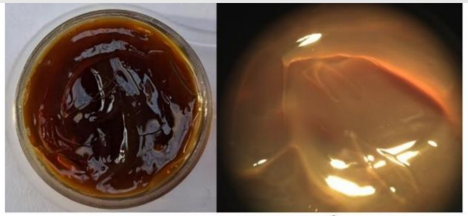
Anouk Somhorst[1,2], Pjotr Muis[2], Colin van Wijk[2], Sjoerd Nauta[2]*

[1]Faculty of Science and Technology (TNW), University of Twente, Enschede, The Netherlands
[2]Alliander N.V., Arnhem, The Netherlands
[*]sjoerd.nauta@alliander.com



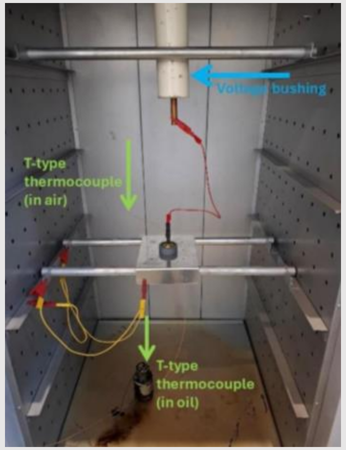
a *b*

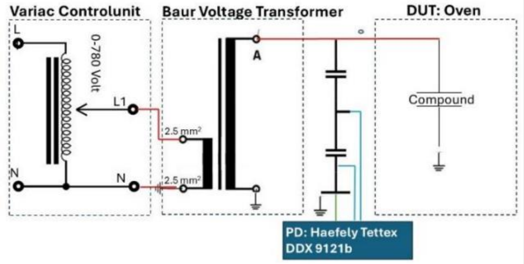
Figure 1: Waxed impregnating compound extracted from the filler wires of a 3x150Cu PILC cable, label CV. (a) Collected compound in container, (b) Microscope picture of CV in container, no magnification applied.



a *b*

Figure 2: Impregnating compound extracted from the insulation over the three conductors of a 3x95Cu PILC cable, label E. (a) Collected compound in container, (b) Microscope picture of E in container, no magnification applied.





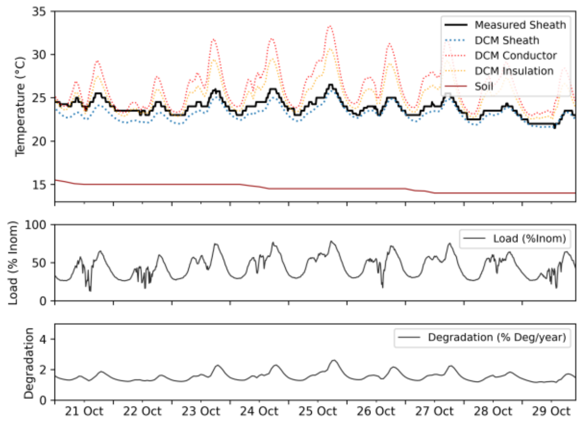
Paper 950

Paper ID950

THERMO-ELECTRICAL AGEING OF 10KV PAPER INSULATED LEAD COVERED CABLES: EXPERIENCE FROM FIELD EXPERIMENTS

Daniël Woldendorp[1], Colin van Wijk[2], Denny Harmsen[1], Stefan Lamboo[1]*

[1]System Operations Alliander N.V., Arnhem, The Netherlands
[2]Asset Management Alliander N.V., Arnhem, The Netherlands
[*]daniel.woldendorp@alliander.com



(a) *(b)* *(c)*

BEDANKT VOOR UW AANDACHT

27-05

CIRED Voorbereidingsdag

SPREKER:

Martin Binnendijk

20 JAAR
DUTCHPOWER

alliander ENEXIS STEDIN CIRED

Session 1: Network components – Switchgear

Session 1: Network component - Switchgear

- 151 Submissions
  - 29: Cables
  - 44: Switchgear
    - 10 papers: SF6-free Switchgear
    - 10 papers: Digital and Sensors
    - 5 papers: Vacuum Interrupters
    - 4 papers: DC / Semiconductors
    - Other papers on TRise, Aging, FEM, Endurance, Overhead, LCA, Arc Flash, PD
  - 51: Others
  - 29: Transformers

SF6-free switchgear

Paper no	
38	SYNTHESIS OF THE DIFFERENT TECHNOLOGIES FOR SF6 FREE MEDIUM VOLTAGE SWITCHGEAR
88	COMPACT GREEN MV GIS WITH ATMOSPHERIC AIR
267	Next Generation Gas-Insulated Switchgears with Natural Origin Gases for 40.5 kV Level
290	AGING AND LIFESPAN PREDICTION OF BUSBAR CONNECTION IN GIS: A DETAILED STUDY IN SF6 FREE DRY AIR ATMOSPHERE
296	Application of Thermal Network Modelling for MV GIS Design Optimization
310	Characteristics of arcs in air with axial blowing
521	PUFFER-TYPE LOAD BREAK SWITCH FOR MEDIUM VOLTAGE GAS INSULATED SWITCHGEAR FILLED WITH DRY AIR
565	STUDY ON THE TEMPERATURE RISE CHARACTERISTICS OF A 126KV CIRCUIT BREAKER USING C4F7N/CO2 MIXED GAS
819	Challenges of new technologies non-based in SF6 for operating and protecting MV power transformers of distribution networks
996	DESIGN OF AN INNOVATIVE SF6 FREE RING MAIN UNIT WITH DIRECT CONNECTION TO TRANSFORMER)
1132	ALTERNATIVES TO PFAS FOR NOZZLE LOAD BREAK GAS SWITCHGEAR

SF6-free switchgear

Alternatieve gassen vallen af

- Novec, HFO
- Switching in Air

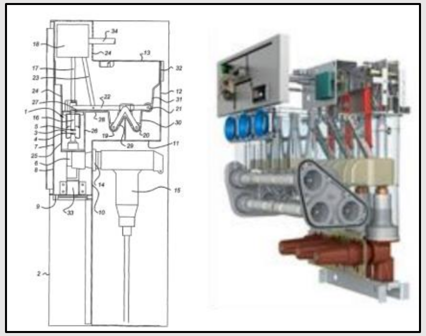
Roet, PFAS, Toxisch

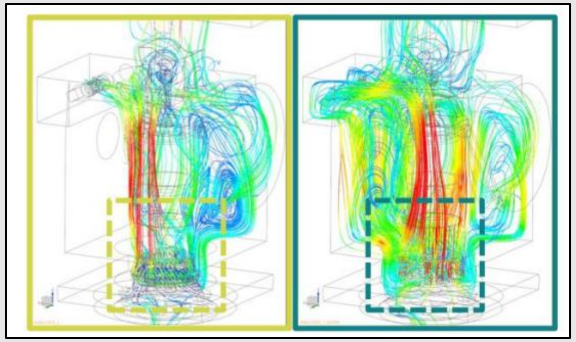
Insulation Technologies

Atmospheric Air / E-Field Control

Pressurized Air

	gas mixtures with C4N	gas mixtures with C5K	HFO 1336mzzE	Hybrid insulation (solid and air)
Carcinogenic, Mutagenic and Reprotoxic non toxicity of pure gas	- - -	- - -	?	+ + +
Neurotoxic non toxicity	- - -	+ + +	?	+ + +
No risk of ban (PFAS)	- -	- -	- -	+ + +
Patent free gas	- -	- -	- -	+ + +
Ageing	-	-	-	+ +
Market acceptance	- - -	- - -	-	+ + +





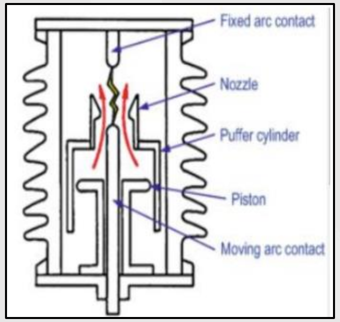
Switching Technologies

(Shunt) Vacuum Interruption

Puffer Switching

Table 3: comparison of breaking solutions ("+": good – "-":=' bad)

	C4N and C5K gases mixtures use as breaking medium	Air used as breaking medium	HFOs with vacuum interrupters	Air with vacuum interrupters
Toxicity after making and breaking	- - -	-	-	+ + +
Electrical endurance	-	-	+ + +	+ + +
Switch fuse transfer current	+	- -	+ + +	+ + +
Market acceptance	- - -	-	- -	+ + +



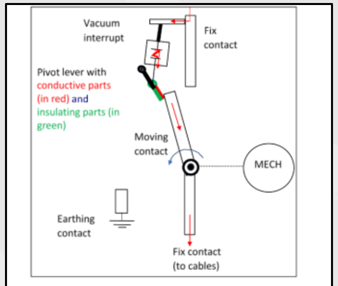


Fig 2: "innovative solution" with vacuum interrupters in parallel with a 3-positions disconnector

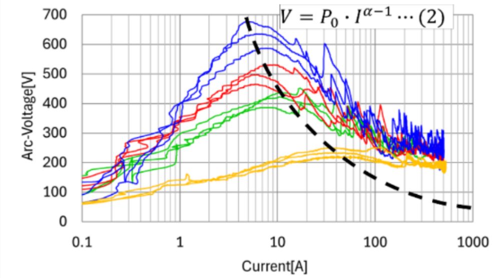


Fig.4 Arc voltage-current characteristics

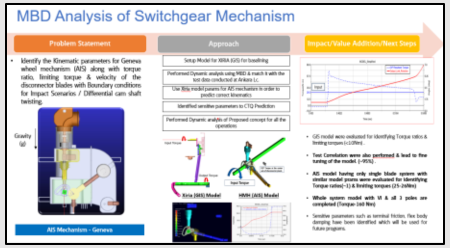
Vacuum Interrupters

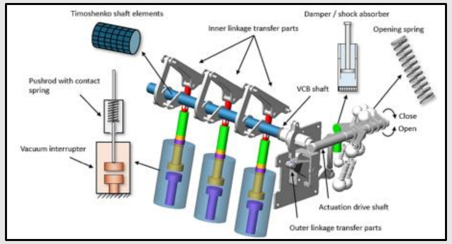
Paper no	Title
93	IMPROVEMENT OF VACUUM CIRCUIT BREAKER MODEL BASED ON LABORATORY RESULTS
509	MULTIBODY ANALYSIS OF DYNAMIC CHARACTERISTICS IN VACUUM CIRCUIT BREAKERS
752	DEVELOPMENT OF NEW OPTIMIZED RANGE OF MEDIUM VOLTAGE VACUUM INTERRUPTERS
863	Vacuum Contacts: Analysing Contact Lifespan for Enhanced Performance in Grids
955	CHALLENGES OF CLIMATE NEUTRALITY FOR THE EXTERNAL INSULATION OF VACUUM INTERRUPTER

93 - SF6 -> Vacuum

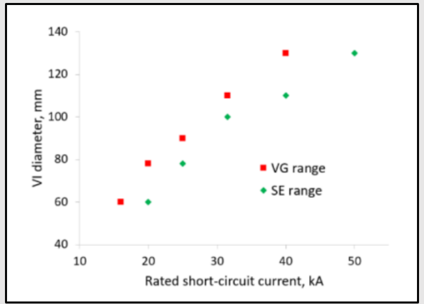
509 -

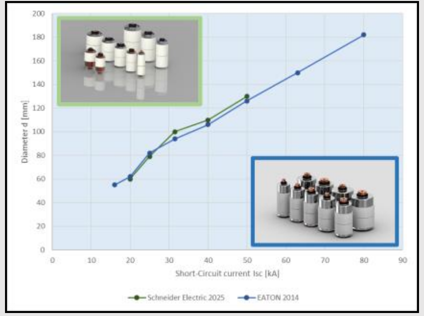
FEM Optimizations





752 - New VI ranges





863 - Higher ratings

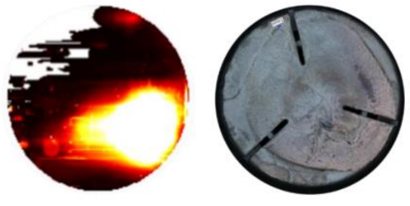


Figure 8: Anode from test series 3 equipped with AMF-contacts; Left: automated charge distribution evaluation; Right: Photography of the anode; Q=3063.52 As

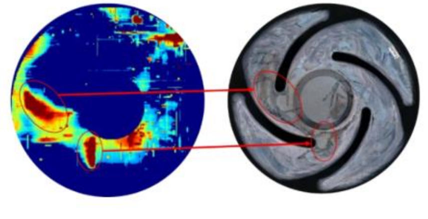


Figure 11: High-stress area of charge distribution with threshold filter from Figure 10

955 - Electrical Field Control to fit in VIs in SF6-free

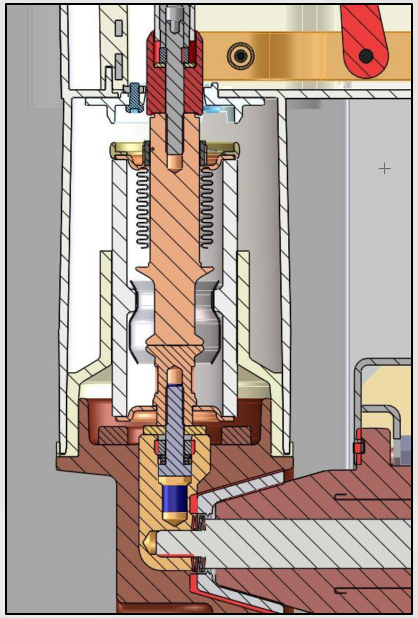


Fig. 2 Tested Arrangements of VI and field control elements, Ref: VI as reference, CC: VI with copper coils and FCS: VI with field control system

Digital

Paper no	Title
33	DIGITALIZATION OF MEDIUM VOLTAGE SWITCHGEARS FOR ASSET MANAGEMENT AND PREDICTIVE MAINTENANCE
107	A thermal twin of medium-voltage switchgears for predictive maintenance
281	INTEGRATING PHYSICS-BASED TWINS TO ENHANCE PARTIAL DISCHARGE EVALUATION
575	CHALLENGES AND LESSONS LEARNED TOWARDS DIGITAL NATIVE MEDIUM VOLTAGE SWITCHGEARS
689	ADVANCED ASSET ANALYTIC VIA THERMAL & PARTIAL DISCHARGE SENSORS ON PRIMARY EQUIPMENT IN TNB DISTRIBUTION NETWORK
754	Monitoring and aging evaluation in MV smart circuit breaker for special applications
766	Smart Medium Voltage Switchgear with LPITs and IEC 61850 - Experiences after 10 years and the next evolution
770	UTILIZATION OF SMART MEASUREMENT TECHNOLOGIES TO IMPROVE MEDIUM VOLTAGE SWITCHGEAR SUSTAINABILITY
774	Digital twin of the tripping coils for health monitoring and diagnostics of medium voltage circuit breakers

33 – Digitization for predictive maintenance

Table 1 Predominance of the main failure modes in switchgears with SF_6 switchgears [2]

Main failure mode	%
Not closing properly	28.2
Locking into a certain position	25.1
Not opening properly	16.4
Loss of mechanical integrity	8.1
Opening without having to do it	5.4
Others	16.8

Secondary failure mode	%
SF_6 leak	35.6
Leaks in pneumatic/hydraulic actuating mechanisms	20.3
Modification of the functional characteristics of auxiliary circuits	18.3
Modification of mechanical functional characteristics	6.8
Modification of electrical functional characteristics	3.3
Oil leak in grading condensers	1.0
Unanswered	0.4
Others	14.2

107 – Digital Twin Temp Rise

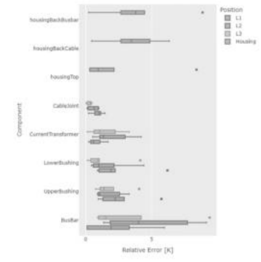


Figure 2 Absolute relative error between the simulations and tests

774 – Digital Twin Tripping Coil

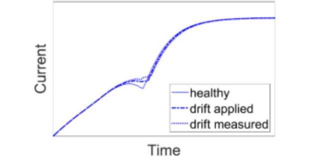


Figure 8: Results of the soft sensor approach based on the coil current.

281 – More fundamental discharge analysis

The streamer initiation and dynamics are governed by the following set of equations:

$$\frac{dn_e(s)}{ds} = (\alpha(s) - \eta(s)) \cdot n_e(s) \quad (1)$$

$$n_e(d) = n_e(0) \cdot exp\left\{\int_0^d (\alpha(s) - \eta(s))ds\right\} \quad (2)$$

$$K_{str} = ln\left\{117 \cdot \frac{\varepsilon_0}{e_0} \cdot \left(\frac{E}{n_0}\right)_{cr} \cdot \int_0^{z_{cr}} \frac{nD_{Te}(z)}{v_{de}(z)} dz\right\} \quad (3)$$

$$A_0 = \pi \cdot r^2 \quad (4)$$

$$Q_{PD} = \varepsilon \cdot E_s \cdot A_0 \quad (5)$$

With:

- α…Ionization growth coefficient
- η…Attachment growth coefficient
- n_e…Number of electrons
- K_{str}…Streamer constant
- v_{de}…Electron drift velocity
- nD_{Te}…Diffusion coefficient
- A_0…Area streamer head
- r…Radius streamer head
- Q_{PD}…Transferred charge

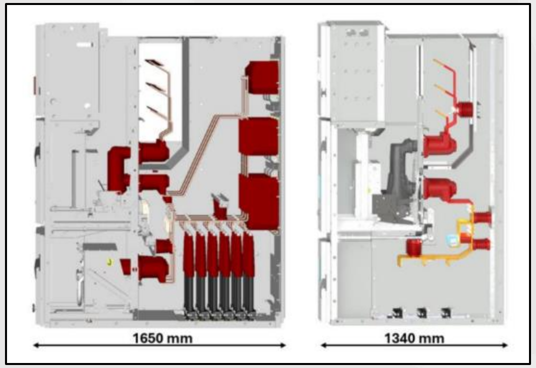
The results of the PD analysis are:

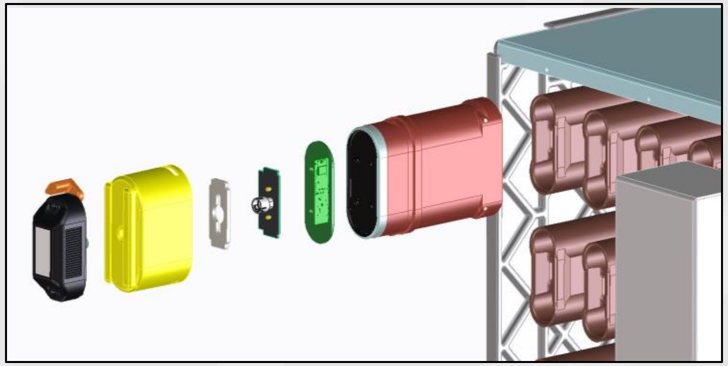
- The streamer initiation voltage, U_{str},
- The streamer-leader-transition voltage, U_{ldr},
- the capacity C_{PD} of the remaining and bridged insulation gap and
- transferred charge of the event Q_{PD}.

766 – Experiences LPITs

Compact - Low Loss - Accurate - Wide band – Improved Standards & Testing

575 – Sensors / Digital





BEDANKT VOOR UW AANDACHT