

**Minutes of Meeting**  
**P2682 Working Group: Performance Evaluation of Sulfur Hexafluoride Alternatives**

**Second Meeting: Tuesday, April 30, 2019**  
**Hilton Burlington Lake Champlain, Burlington, VT**  
**Lake Champlain Salon, 08:00 to 09:45 and 10:15 to 12:00**

**Chair: Daniel Schiffbauer**  
**Vice Chair: George Becker**  
**Secretary: Victor Hermosillo**

**Session #1. Lake Champlain Salon, 08:00 to 09:45**

**Agenda**

- Call to Order
- Introductions
- Review IEEE Patent Slides
- WG Scope
- WG Motivations
- Review and vote on approval of fall 2018 MOM
- Related Activities and Regulatory Update
- Revised Table of Contents
- Collaboration Portal
- Discussion of Individual Chapter Content
- Overall Schedule
- Next Meetings
- Individual chapter work – if time permits

**Call to order – 8:00 am**

Chair called to order and presented agenda

**Introduction of Members & Guests, Circulation of Sign-in Sheet**

**IEEE-SA Patent Policy and Copyright Compliance**

Chair: patent and copyright policy presented.

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### **Scope**

Guide will review existing standards and performance criteria for switchgear rated above 1000 V. Each aspect of performance is discussed within the context of Sulfur Hexafluoride (SF<sub>6</sub>) alternatives, how their behavior may differ from existing technologies and how this behavior may lead to changes in the qualification process. Relevant analytical, numerical and test methods are discussed which may contribute to the process of performance evaluation and evolution of the standards.

- This is a new WG coming out of the Alternative Gas Taskforce which published TR64 earlier this year.
- PAR P2682 was approved end of September 2018
- Need a WG number.

### **Motivation**

Pursuit of SF<sub>6</sub> alternatives with new strengths and weaknesses for the purpose of lower environmental impact raises questions related to evaluation/qualification of switchgear. **This activity should provide answers to those questions.**

### **Approval Minutes of the Last Meeting in Kansas City, MO**

Motion to approve:

First: Mike Skidmore

Second: Jon Rogers

Minutes approved unanimously, none against or abstentions.

### **Membership**

There are 57 members and officers of the Task Force.

### **Special Reports**

- CIGRE - A3.41 Interruption and switching performance with SF<sub>6</sub> free switching equipment (ongoing, scheduled 2021) – Dan Schiffbauer

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Present state of the art in interruption, convener, HV and MV switchgear including circuit breakers, disconnect switches for isolation and grounding. Comparisons between SF6 and other alternatives based on fundamental interruption tests (thermal and dielectric performance). Result will be a Technical Brochure. Life-time behavior, field experience, utility guidelines, gas-free update. MV alternatives to vacuum/SF6. Standards and testing. Minimum functional gas mixture. SLF, TRV, electrical endurance, capacitive switching.

- CIGRE - D1.67 Dielectric performance of non-SF6 gases and gas mixtures for gas insulated systems (ongoing, scheduled 2020) – Dan Schiffbauer

Insulating performance only. Insulation characteristics, homogenous non-homogeneous fields, statistical analysis. Various gas mixtures. Several test laboratories involved in round robin testing, results are compared. AC, BIL test, plane, sphere/needle plane. Temperature and gas conditions are verified. Completion summer 2020.

- CIGRE - B3.45 Application of non-SF6 gases or gas mixtures in MV and HV gas-insulated switchgear (ongoing, internal review May 2019) – George Becker

Quality and purity, ageing, gas handling, filling accuracy, leakage rate, interlocking, EHS, maintenance, life-cycle, end of life, decomposition, molecular sieves, material compatibility, gas handling, mixing. AC breakdown without PD inception.

- IEEE – Overview of alternate gases and their impact on existing IEEE standards (TR64 complete 2018)

Report available at IEEE website.

- IEEE - Alternative gas handling (on hold)

First Meeting: to be held June 2-6 at Substation Committee in San Francisco, CA.

- EU F-Gas Regulation Update – Francois Trichon

F-gas regulation includes refrigerants as well as SF6. In first regulation there was no restriction on SF6 gas use for equipment, mandatory end of life recovery, handling training for recovery, labelling requirements. Major source of SF6 leakage are sun-proof windows, cannot be recovered during

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disposal. GWP and label with mass. Leakage detection mandatory if >6kg, training mandatory for entire life cycle. Ban for SF6 use in magnesium die-casting. No restriction for military use.

European Commission (technical branch) is proposing regulation. Tender to hire consultant to report on SF6 usage. Draft final report February 2020 (short-term) to be presented in July to the European Parliament. No consultant has answered the tender. Includes all types of equipment MV, may include HV. Prohibition is an option, need for exceptions. Focus on leakage rates, identify policies for different facilities.

T&D Europe. New associate members that are gas suppliers. Setup objectives, strategy, message, meet with consultants for EC.

European Parliament election in 2019. Results not certain, policies will change depending on results.

- CARB GHG Regulation Update – Todd Irwin

CA Air Resource Board, responsible for regulations. Assembly Bill 22 enacted in 2006. Reduction of emissions by 40% in Senate Bill 32 of 2016

Current regulation went into effect in 2011, emissions based on total installed nameplate capacity. Emissions rate start at 10% and are reduced yearly to 1%.

New proposed draft, request for comments. Phase-out dates established starting in 2025. Has technical infeasibility exclusions. Nameplate capacity revision, accuracy requirement, reporting requirements based on GWP, for emissions CO2 equivalent is considered (GWP).

Some issues: use LCA, zero GWP favored with exception to emissions reporting, economic impact assessment is inaccurate, phase-out needs to consider MV/HV/short-circuit ratings. Utilities proposed phase out depending on distribution or substation class equipment. Utilities have communicated complexity and timeline for project completion. Considered 40-year which is equipment depreciation period.

Other states: Oregon, Washington, New Jersey and other states considering regulation.

## **Review of Guide Status**

### Contents:

1. Introduction
2. Environmental (LCA) Performance
3. Evaluation of Toxicity/ Radiation (EHS)
4. Switching and Short Circuit Performance
5. Dielectric Performance
6. Continuous Current (Temperature Rise) Performance

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7. Mechanical Performance
8. Low and High Temperature Performance
9. Pressure Vessel and Sealing Performance (material compatibility)
10. Conclusions

Collaboration Portal iMeet Central was reviewed. File structure including one folder for each chapter for contributions. Literature index has been prepared with relevant documents related to SF6 alternatives, can be filtered based on chapter topic. Meeting materials will be uploaded.

Discussion and comments by attendees:

- Ch. 3 (toxicity evaluation) should become environmental health & safety
- Describe the composition of each gas alternative
- PD can decompose some of the gases. Consumption to be discussed under dielectric of current interruption.

Each chapter was then discussed in detail.

**Environmental (LCA) Performance**

**Dave Johnson (Consultant)**, John Owens (3M absent), Stephanie Montoya (SCE)

Contents of chapter were presented.

GWP has been the focus so far, life-time performance should be considered based on LCA which calculates CO2 equivalent considering materials, manufacturing, operation, losses, disposal, recycling. Standard methodology by ISO for LCA Life Cycle Assessment. Define assumptions, sample calculations. This is a holistic approach to environmental performance based on total CO2 footprint and several aspects of environmental impact.

**Session #2 Lake Champlain Salon, 08:00 to 09:45 and 10:15 to 12:00**

**Evaluation of Toxicity → Environmental Health and Safety**

Evaluation of Toxicity, EHS: **John Owens (3M absent)**, Justin Palmer, Francois Trichon (Schneider), Li Yu (Eaton)

Update provided by Li Yu.

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To include term definitions, toxicity assessment and safety assessment.

Measures of toxicity, standard test methods. Toxicity in virgin and arced condition of the SF6 alternatives. Byproduct characteristics.

Safety during life of equipment: handling, storage, transportation, filling, retrieval, disposal. Monitoring and leakage for safety purposes. Consider safety effects for indoor or outdoor use.

Data is obtained from MSDS.

Variation in reported test results will be addressed. Coordination with CIGRE B3.35.

**Switching and Short Circuit Performance**

Dave Johnson (Consultant), Dan Schiffbauer (Toshiba), Jon Rogers (Siemens), **Mauricio Aristizabal (ABB absent)**, Neil Hutchins (SoCo), Brian Gerzeny (Powell), Kennedy Darko (G&W)

CIGRE A3.41 collaboration. No report available.

**Dielectric Performance**

Nenad Uzelac (G&W), **Sushil Shinde (ABB absent)**, Eldridge Byron (Schneider), Rahul Jain (S&C), Xi Zhu (GE), Mike Crawford (Mitsubishi), Sangtae (Brandon) Kim (HICO)

Coordination with CIGRE D1-67.

No report available due to absence

**Continuous Current (Temperature Rise) Performance**

Sushil Shinde (ABB), **Stephanie Montoya (SCE)**, Vernon Toups (Siemens), Dave Beseda (S&C), Mike Crawford (Mitsubishi), Sangtae (Brandon) Kim (HICO)

Stephanie Montoya provided update.

Long term performance information to be submitted by manufacturers. Implication of oxygen environment. Overlap with material compatibility. Investigate if the temperature rise limits in standards are still valid.

Differences in temperature limit table between IEC and IEEE. Differences between reactive or non-reactive gases. Will not cover design issues such as thermodynamic characteristics.

**Mechanical Performance**

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**Dan Schiffbauer (Toshiba)**, Sushil Shinde (ABB absent), Brian Roberts (Southern States)

Update provided by Dan Schiffbauer

Resistance measurement: IEEE indicates allowance of 200% for contact resistance measurement. This limit becomes significant due to the use of oxygen in some gas mixtures.

Routine pressure test of vessels: stress-strength comparison, fracture mechanics: leak before burst and damage tolerance.

Increase in pressure for some alternative gases requires review of pressure test. Test criteria is no burst or crack. Consider long-term behavior: consider fracture toughness and flaw size versus applied stress.

Low Temperature Performance

Mauricio Aristizabal (ABB absent), Xi Zhu (GE), Carl Schuetz (ATC), **Mike Crawford (Mitsubishi)**, Benson Lo (Toronto Hydro), Scott Lanning (S&C), Sushil Shinde (ABB absent), Sangtae (Brandon) Kim (HICO)

Update presented by Mike Crawford.

Effect of temperature decreases in dielectric performance, pressure temperature curves, interruption performance. Conditions of gas mixture as temperature increases, lockout recovery. Time required to obtain adequate mixture in case of separation during condensation.

CIGRE A3.41 and B3.45 is addressing minimum composition of mixtures.

**Pressure Vessel and Sealing Performance → Material Compatibility**

Brian Roberts (Southern States), Nenad Uzelac (G&W), George Becker (Power Engineers), Eldridge Byron (Schneider), Peter Glaesman (Pcore), **Neil Hutchins (SoCo)**, Li Yu (Eaton)

Will be treated from material compatibility point of view. Include, seals, lubrication, molecular sieve.

**Next Meeting.**

Chair to organize working meetings for various chapters. End of June then end of August. To be held in the Pittsburgh area.

Next face to face during next IEEE Switchgear Committee Meeting Fall 2019 in San Diego, CA.

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Substations is planning to prepare Handling Guide, waiting for output from this group. Difference with CIGRE work is that it does not address EHS aspects.

**Collaboration Portal**

Documents will reside in IEEE-SA iMeet Central.

Adjourned: 11:30 am

Reported by:  
Daniel Schiffbauer  
P2682 Chair



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Attendance:

87 total

39 of 57 members

48 guests

Number	Last Name	First Name	Affiliation	10/16/2018	4/30/2019
1	Almeida	Edwin	Southern California Edison	X	X
2	Aristizabal	Mauricio	ABB	X	
3	Bannink	Herman	KEMA Netherlands	X	X
4	Barbera	Steven	Arizona Public Service		X
5	Becker	George	POWER Engineers	X	X
6	Beseda	David	S&C Electric Co.	X	X
7	Bisewski	Bruno	RBJ Engineering Corp		X
8	Boulus	Michael	PSE&G	X	X
9	Boyce	Russell	Eaton	X	X
10	Brown	Steven	Allen & Hoshall	X	
11	Bufi	Arben	Hitachi T&D Solutions, Inc.		X
12	Byron	Eldridge	Schneider Electric	X	X
13	Chhabra	Mohit	S&C Electric Company	X	
14	Chovanec	Andrew	GE Power	X	X
15	Cleaveland	Charles	Cleaveland/Price Inc.		X
16	Collette	Lucas	Duquesne Light		X
17	Connor	Brad	Xcel Energy	X	
18	Crawford	Michael	Mitsubishi Electric	X	X
19	Cunningham	Jason	Southern States, LLC	X	X
20	Darko	Kennedy	G&W Electric Co	X	
21	Dhawan	Anil	ComEd	X	
22	Di Lillo	Patrick	Consolidated Edison Co. of NY, Inc.	X	X
23	Di Michele	Federico	CESI S.p.A.	X	X
24	Door	Jeffrey	The H-J Family of Companies	X	X
25	Duncan	Kirk	Hitachi T&D Solutions	X	
26	Dwyer	Bernie	PECO		X
27	Edwards	Ken	FirstEnergy Corp.		X
28	Evans	Aaron	HICO America	X	
29	Fender	Karl	Southern States LLC	X	
30	Frazier	Raymond	Ameren	X	
31	French	Christopher	Eaton Corporation	X	
32	Gerzeny	Brian	Powell Electrical Systems Inc	X	X
33	Glaesman	Peter	PCORE Electric Company, Inc.	X	X
34	Hall	John	Tennessee Valley Authority	X	X
35	Hastreiter	Christopher	Eaton		X
36	Heintzelman	Travis	Burns & McDonnell	X	
37	Hensberger	Jeremy	Mitsubishi Electric Power Products Inc.	X	
38	Hermosillo	Victor	GE Grid Solutions	X	X
39	Hester	Edward	Entergy		X
40	Hu	Jingxuan (Joanne)	RBJ Engineering Corporation		X

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41	Hunter	Jennifer	MEPPI	X	X
42	Hutchins	Roy	Southern Company Services	X	X
43	Hyjek	Katarzyna	DTE		X
44	Irwin	Todd	GE Grid Solutions	X	X
45	Jagadeesan	Bharatwaj	Southern States LLC	X	
46	Jain	Rahul	S&C Electric Company	X	X
47	Jarnigan	Christopher	Southern Company Services	X	X
48	Jasinski	Joseph	ITC Holdings Corp.		X
49	Johnson	David	HVCB	X	X
50	Johnson	Travis	Xcel Energy	X	
51	Jung	Wolfgang	Siemens AG	X	
52	Kim	SangTae	HICO America		X
53	kim	jungdae	hyosung		X
54	Kowalik	Peter	Cleaveland/Price Inc.		X
55	Kurinko	Carl	ABB Inc.		X
56	Lanning	Scott	S&C Electric	X	X
57	Leccia	Brad	Eaton		X
58	LEE	CHANG HOON	HYOSUNG Heavy industries		X
59	Leufkens	Paul	Power Projects Leufkens		X
60	Li	Wangpei	Eaton	X	X
61	Lo	Benson	Toronto Hydro	X	X
62	Lopez	Leo	WIKA Instrument, LP		X
63	Ma	Chunming	Burns and McDonnell	X	
64	Mannarino	Antonio	PSE&G		X
65	Martin	Donald	G&W Electric Co.	X	X
66	Marzec	Peter	S&C Electric Co.	X	X
67	Mason	Douglas	ComEd		X
68	May	Steven	Southern Company		X
69	Meiners	Steven	GE	X	
70	Methling	Ralf	Leibniz Institute for Plasma Science and Technology		X
71	Midkiff	Jacob	Dominion Energy	X	X
72	Montoya	Stephanie	Southern California Edison	X	
73	Nelson	Jacob	HPS	X	
74	ONeil	Brian	RMS Energy		X
75	Owens	John	3M	X	
76	Palmer	Justin	ELECTRONSYSTEM MD	X	X
77	Patel	Pathik	Duke Energy	X	X
78	Pattison	Mark	H-J Family of Companies		X
79	Pellerito	Thomas	DTE Energy	X	X
80	Peterson	Mark	Xcel Energy	X	X

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81	Phan	Lise	Pacific Gas and Electric Company		
82	Pruitt	Al	The Durham Company	X	
83	Putman	Larry	Powell	X	X
84	Reid	Laura	Hubbell Power Systems		X
85	Riley	Caryn	Georgia Tech/NEETRAC	X	X
86	Roberts	Brian	Southern States, LLC	X	
87	Rogers	Jon	Siemens Energy, Inc	X	X
88	Rohr	Richard	Powell Electrical Systems	X	
89	Rostron	Joe	Southern States LLC		X
90	Salinas	Alex	Director of Operations		X
91	Santos	Leonel	Schneider Electric		X
92	Savulyak	Victor	DNV GL KEMA Laboratory		X
93	Sazanowicz	Robert	Avangrid - United Illuminating		X
94	Schaben	Chase	Burns & McDonnell	X	
95	Schiffbauer	Daniel	Toshiba International Corporation	X	X
96	Schuetz	Carl	American Transmission Company (ATC)	X	X
97	Schumann	Jon	American Transmission Company	X	
98	Sharma	Devki	Entergy		X
99	Shinde	Sushil	ABB Inc.	X	
100	Sicker	Robert	FirstEnergy Corp		X
101	Sims	Garett	Eaton Corp.	X	X
102	Skidmore	Michael	AEP	X	X
103	Steigerwalt	Don	Duke Energy	X	X
104	Tabakovic	Dragan	Meramec Hubbell Power Systems	X	
105	Toups	Vernon	Siemens	X	X
106	Trichon	Francois	Schneider Electric	X	X
107	Trost	Karla	G&W Electric	X	X
108	Tuveson	Lars	Burns & McDonnell		X
109	Uzelac	Nenad	G&W Electric	X	
110	Weeks	Casey	Siemens Energy		X
111	Weisker	Jan	Siemens AG		X
112	Wilkie	William	Eaton	X	
113	Wirz	Torsten	ABB AG		X
114	Wolf	Robert	Hubbell Power Systems, Inc.	X	
115	York	Richard	Mitsubishi Electric Power Products Inc.	X	X
116	Yu	Li	Eaton Corporation		X
117	Zhang	Wei	Hitachi T&D Solutions, Inc.	X	X
118	Zhong	Jim	American Transmission Company		X
119	Zhu	Xi	GE Energy Management	X	X