Minutes of Meeting
C37.100.7 Working Group: Performance Evaluation of Sulfur Hexafluoride Alternatives

Tuesday, October 8, 2019
San Diego, CA
08:00 to 09:45 and 10:15 to 12:00

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

Agenda

- Call to Order
- Review IEEE Patent Slides
- WG Scope
- WG Motivations
- Introductions
- Review and vote on approval of spring 2019 MOM
- Related Activities and Regulatory Updates
- Discussion of Individual Chapter Content
- ~~Individual chapter work – if time permits~~

Call to order – 8:00 am

Vice-Chair called to order and presented agenda

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 (SF6) 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.

Motivation

Pursuit of SF_6 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.**

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

29 Members (and Contributing Members) were present of 55 total members. There were 86 total attendees in the meetings.

Approval Minutes of the Last Meeting in Burlington, VT

Motion to approve:
First: Neil Hutchins
Second: Mike Crawford

Membership

There are XX members and officers of the Task Force.

Related Activities and Regulatory Updates

- CIGRE - A3.41 Interruption and switching performance with SF6 free switching equipment (ongoing, scheduled 2021) – Dave Johnson

  The A3.41 scope is smaller than the IEEE WG, but similar in nature.
  First draft content is being written
  Complete 2021

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May want to consider aligning our guide with the completion of A3.41

- CIGRE - D1.67 Dielectric performance of non-SF6 gases and gas mixtures for gas insulated systems (ongoing, scheduled 2020) – Dave Johnson
  Formed to document the dielectric properties of the alternative gases.
  D1 has carried out a test program including Dry Air, N2, CO2, and N2/SF6 mixtures.

  This project includes fundamental, public research which will be instructive for both manufacturers and users. Results will inform some of the Chapter 7 and 8 work of our document.

- 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

  Group is about 90% complete on the brochure. Key questions that need to be completed: Material compatibility, humidity, and mixing ratio (especially how and when to check the ratio.)

- EU F-Gas Regulation Update – Francois Trichon

  A consultant summary is due in December 2019 and the final report is due in June 2020.
  (The report has been delayed as there were no tenders in the original request.)
  The report is supposed to contain: overview of existing alternatives and ongoing R&D, the Switchgear EU market that can be impacted, and recommendations for future policies.

  Germany: Voluntary agreement to ban SF6 in the administrative building.
  Spain: Voluntary agreement for a tax on refill (100E/kg)
  Denmark: Tax (80E/kg) unless <= 36kV
  UK: Introduction of SF6 free for 2023-2028 Market regulation

  European commission has a policy to be carbon neutral by 2050. This could impact SF6 in the future.

- CARB GHG Regulation Update – Dave Johnson

  There was another work shop in August. The plan is for the final draft to be completed in early 2020 with the final draft by the end of 2020.

  Some changes:

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Phaseout of SF6 will occur between 2025 and 2031 based on the current draft.
The draft includes phase out exemptions: 2 suppliers required, web based clearing house concept.
The emissions limits and applicability were revised.
The original draft required that any device with a GWP > 0 be reported. This has been changed to GWP > 1. This change favors some alternatives.
Replacement of SF6 GIE with the same product is only possible during the warranty period.

The August Discussion Draft is located here:
https://ww2.arb.ca.gov/sites/default/files/2019-08/sf6-gis-discussion-draft-20190815.pdf

The August Staff Presentation is located here:
https://ww2.arb.ca.gov/sites/default/files/2019-08/sf6-gis-reg-slides-20190815.pdf

Public comments to the August Discussion Draft can be found here:
https://www.arb.ca.gov/lispub/comm2/bccommlog.php?listname=sf6regamendws3-ws

Review of Guide Content

Gas Characteristics (Dave Johnson)

- Section 4.1 covers Equations of State

One important aspect is the Poynting Effect for the mixed gases. The effective temperature range for each mixture can slip up or down compared to the individual gases. These shifts must be considered when reviewing temperature and vapor pressure for applications. A3.41 (Cigre) is also reviewing this.

A plot has been put together to show Isochors and Saturation related to temperature & pressure. The chart shows where leakage and liquefaction may occur and where significant decomposition may occur.

- Section 4.2 covers Minimum Functional Composition (MFC)

The manufacturer must define the MFC. It considers the effect of several factors (temperature, leakage, and decomposition). Most type tests should be performed at MFC. Routine monitoring of the total pressure (compensated by temperature) is required. In addition, some manufacturers may require checking the individual component partial pressures at maintenance intervals.

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A chart was created to help define the expected the required characteristics for the In Service and the Laboratory type tests, and the MFC.

- Preconditioning, Capacitive (C2) switching and extended electrical endurance tests may be performed at a "nominal" condition.
- MFC characteristic tests may include: Terminal fault test duties, short line fault test duties, Capacitive switching C1 tests, and IEEE service capability.

Conversation that a real time monitoring system may be needed in order to create charts/trends for actual use cases. A counter argument was made that the decomposition of the arcing nozzle material is an issue today and the manufacturer is expected to provide life data for the users (it would be assumed that requirement would carry over to the gas mixtures.)
There may be some methods which can be used to compensate for the temperature and decomposition impacts.

Notes: SF6 is also consumed (just at a lower rate.) We have a test today (E2) which was inserted for contact material, but it would apply here as well.

Homogeneity of the mixture and liquification: The big question is how quickly do the mixtures come to a homogeneous state after liquification? It's typically 2 hours for a large dead tank breaker.

This raises a question of how much liquification is allowed for the testing.

- Section 4.3 covers Gas Leakage and Permeation

  In multi-component mixtures, some constituents may leak more readily than others depending on their viscosity and may be treated analytically as Hagen-Poiseuille type flow.

  Some charts showing test data for Permeation (related to specific gasket/seal materials) were shared.

- Section 4.4 covers Gas Mixture Homogeneity

  The major difference between the gas mixtures and SF6 is not the chance of a leak, but of the need to measure the mixture composition.

  There is some test data which has been published to show the time it takes to re-establish homogeneity after liquification.

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- Section 5 covers Environmental Performance

  The section includes a short history and an overview of GWP (including how it is calculated). LCA (Life Cycle Assessment) is explained and contrasted to GWP.

  In addition, this section plans to discuss what parameters that Regulators are looking at in addition to what regulations are proposed/ in place that need to be considered.

- Section 6 covers Health and Safety

  80% of the content has been drafted and will be reviewed in the upcoming months.
  A determination of appropriate hazard zone (in comparison to various criteria of toxicity) was added.
  The toxicity of "used gases" was rewritten including adding testing results of accumulated fault duty vs acute toxicity and the calculation method of acute toxicity value based on byproducts and arc energy.

  There is still some work to be done regarding storage and transportation.

- Section 7 covers Switching and Short Circuit Performance

  The presenter shared some Figures that were created by CIGRE A3.41 which may be useful in this section. One covers the "relative clearing performance" (as related to SF6) and the other shows the "post arc current duration" of SF6, CO2, and CO2+CSF100.

  Some information on EMTP modelling was presented.

- Section 8 covers Dielectric Performance

  Focus areas include: Number of impulse tests, consumption of Novec gases, arc byproducts, and relevance for dielectric testing, discussion of zero gauge pressure, and discussion of particle sensitivity.

  The presenter shared some factors (related to dielectric strength) that will be included: Characterization of the strength as a function of pressure and temperature, partial pressure of each gas mixture component, time dependence, polarity effects, Behavior in uniform and non-uniform fields, and Effect of surface area and roughness.

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The group plans to discuss how preconditioning impacts the Dielectric performance.

- Section 9 covers Continuous Current Performance

  The group working on this section reported that they need to "research the contact systems used in legacy high pressure air blast breakers" to understand the field experience and what special measures were taken to address the reactive nature of large partial pressures of O2 as well as what temperature limits were applied to these designs. In addition, they plan to coordinate with contemporary manufacturers applying higher partial pressures or O2 to help answer these questions.

- Section 11 covers Low Temperature Performance

  One major concern is the liquefication and homogeneity topic covered in Section 4.
  There is some industry available test equipment for monitoring gas concentration.

Next Meeting.

The Chapter Leads will continue to organize working meetings between now and the next face-to-face meeting.
Next face to face during next IEEE Switchgear Committee Meeting Spring 2020 in Reno, NV.

Collaboration Portal

Documents will reside in IEEE-SA iMeet Central.

Motion to adjourn by Ken Edwards, second by Neil Hutchins
Adjourned: 11:44 am

Reported by:
Daniel Schiffbauer

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Attendance:
85 total
44 of 67 members (66%)
41 guests

Number	Last Name	First Name	Affiliation	10/16/2018	4/30/2019	10/8/2019
1	Aldakka	Qais	Los Angeles Department of Water and Power			X
2	Almeida	Edwin	Southern California Edison	X	X	X
3	Aristizabal	Mauricio	ABB	X		X
4	Baker	Daniel	LADWP			X
5	Bannink	Herman	KEMA Netherlands	X	X	X
6	Barbera	Steven	Arizona Public Service		X	
7	Becker	George	POWER Engineers Inc.	X	X	X
8	Beseda	David	S&C Electric Co.	X	X	X
9	Bisewski	Bruno	RBJ Engineering Corp		X	
10	Boulus	Michael	PSE&G	X	X	
11	Boyce	Russell	Eaton	X	X	X
12	Brown	Steven	Allen & Hoshall	X		
13	Bufi	Arben	Hitachi T&D Solutions, Inc.		X	
14	Burse	Ted	Powell Industries, Inc			X
15	Byron	Eldridge	Schneider Electric	X	X	X
16	Cary	Stephen	Eaton			X
17	Chhabra	Mohit	S&C Electric Company	X		
18	Chiodo	Vincent	HICO			X
19	Chovanec	Andrew	GE Power	X	X	
20	Cleaveland	Charles	Cleaveland/Price Inc.		X	
21	Collette	Lucas	Duquesne Light		X	
22	Collette	Dave	Mitsubishi Electric			X
23	Connor	Brad	Xcel Energy	X		
24	Cosby	Bianca	San Diego Gas & Electric			X
25	Crawford	Michael	Mitsubishi Electric	X	X	X
26	Crist	Daniel	Siemens Industry, Inc.			X
27	Culhane	Michael	Eaton			X
28	Cunningham	Jason	Southern States, LLC	X	X	X
29	Darko	Kennedy	G&W Electric Co	X		X
30	Dhawan	Anil	ComEd	X		X

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31	Di Lillo	Patrick	Consolidated Edison Co. of NY, Inc.	X	X	X
32	Di Michele	Federico	CESI S.p.A.	X	X	X
33	Door	Jeffrey	The H-J Family of Companies	X	X	X
34	Duncan	Kirk	Hitachi T&D Solutions	X		
35	Dwyer	Bernie	PECO		X	
36	Edwards	Ken	FirstEnergy Corp.		X	X
37	Eftink	Emily	Burns & McDonnell			X
38	Evans	Aaron	HICO America	X		
39	Fender	Karl	Southern States LLC	X		X
40	Fennell	Howard	Nashville Electric Service			X
41	Frazier	Raymond	Ameren	X		
42	French	Christopher	Eaton Corporation	X		X
43	Frye	Richard	Eaton			X
44	Gerzeny	Brian	Powell Electrical Systems Inc	X	X	X
45	Glaesman	Peter	PCORE Electric Company, Inc.	X	X	
46	Grahor	Lou	Eaton Corporation			X
47	Hall	John	Tennessee Valley Authority	X	X	X
48	Hastreiter	Christopher	Eaton		X	
49	Heintzelman	Travis	Burns & McDonnell	X		
50	Hensberger	Jeremy	Mitsubishi Electric Power Products Inc.	X		X
51	Hermosillo	Victor	GE Grid Solutions	X	X	X
52	Hester	Edward	Entergy		X	
53	Hu	Jingxuan (Joanne)	RBJ Engineering Corporation		X	
54	Hunter	Jennifer	MEPPI	X	X	
55	Hutchins	Roy	Southern Company Services	X	X	X
56	Hyjek	Katarzyna	DTE		X	
57	Irwin	Todd	GE Grid Solutions	X	X	X
58	Jagadeesan	Bharatwaj	Southern States LLC	X		X
59	Jain	Rahul	S&C Electric Company	X	X	X
60	Jarnigan	Christopher	Southern Company Services	X	X	X
61	Jasinski	Joseph	ITC Holdings Corp.		X	
62	Johnson	David	HVCB	X	X	X

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63	Johnson	Travis	Xcel Energy	X		
64	Jung	Wolfgang	Siemens AG	X		
65	Keels	Thomas	kEElectric Engineering			X
66	Kim	SangTae	HICO America		X	X
67	kim	jungdae	hyosung		X	
68	Kowalik	Peter	Cleaveland/Price Inc.		X	
69	Kurinko	Carl	ABB Inc.		X	X
70	Lanning	Scott	S&C Electric	X	X	
71	Leccia	Brad	Eaton		X	
72	LEE	CHANG HOON	HYOSUNG Heavy industries		X	
73	LEE	JOOHYUN	HYOSUNG			X
74	Leufkens	Paul	Power Projects Leufkens		X	
75	Li	Wangpei	Eaton	X	X	
76	Ling	Yingjie	GE			X
77	Lo	Benson	Toronto Hydro	X	X	
78	Lopez	Leo	WIKA Instrument, LP		X	X
79	Ma	Chunming	Burns and McDonnell	X		
80	Mannarino	Antonio	PSE&G		X	
81	Marshall	Vincent	Southern Company Services			X
82	Martin	Donald	G&W Electric Co.	X	X	X
83	Marx	Benjamin	Sargent and Lundy			X
84	Marzec	Peter	S&C Electric Co.	X	X	
85	Mason	Douglas	ComEd		X	
86	May	Steven	Southern Company		X	X
87	Meiners	Steven	GE	X		
88	Methling	Ralf	Leibniz Institute for Plasma Science and Technology		X	
89	Midkiff	Jacob	Dominion Energy	X	X	
90	Montoya	Stephanie	Southern California Edison	X		X
91	Mulakken	Nikil	Facebook			X
92	Natale	Anthony	HICO America			X
93	Nelson	Jacob	HPS	X		
94	ONeil	Brian	RMS Energy		X	

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95	Owens	John	3M	X		
96	Palmer	Justin	ELECTRONSYSTEM MD	X	X	
97	Patel	Pathik	Duke Energy	X	X	
98	Pattison	Mark	H-J Family of Companies		X	
99	Pellerito	Thomas	DTE Energy	X	X	
100	Perrin	Damian	Entergy Services, LLC.			X
101	Peterson	Mark	Xcel Energy	X	X	
102	Phan	Lise	Pacific Gas and Electric Company			X
103	Phouminh	John	PEPCO HOLDINGS, INC.			X
104	Pruitt	Al	The Durham Company	X		X
105	Putman	Larry	Powell	X	X	
106	Reid	Laura	Hubbell Power Systems		X	
107	Rich	Bobby	Dominion Virginia Power			X
108	Riley	Caryn	Georgia Tech/NEETRAC	X	X	X
109	Roberts	Brian	Southern States, LLC	X		X
110	Rogers	Jon	Siemens Energy, Inc	X	X	X
111	Rohr	Richard	Powell Electrical Systems	X		X
112	Rostron	Joe	Southern States LLC		X	
113	Ruebensam	James	S&C Electric Co.			X
114	Salinas	Alex	Director of Operations		X	
115	Santos	Leonel	Schneider Electric		X	X
116	Savulyak	Victor	DNV GL KEMA Laboratory		X	
117	Sazanowicz	Robert	Avangrid - United Illuminating		X	
118	Schaben	Chase	Burns & McDonnell	X		
119	Schiffbauer	Daniel	Toshiba International Corporation	X	X	
120	Schuetz	Carl	American Transmission Company (ATC)	X	X	X
121	Schumann	Jon	American Transmission Company	X		
122	Sharma	Devki	Entergy		X	X
123	Shinde	Sushil	ABB Inc.	X		X
124	Sicker	Robert	FirstEnergy Corp		X	
125	Sims	Garett	Eaton Corp.	X	X	
126	Skidmore	Michael	AEP	X	X	

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127	Slattery	Christopher	FirstEnergy			X
128	Stage	James	Dominion Energy			X
129	Steigerwalt	Don	Duke Energy	X	X	X
130	Tabakovic	Dragan	Meramec Hubbell Power Systems	X		
131	Toups	Vernon	Siemens	X	X	X
132	Trichon	Francois	Schneider Electric	X	X	X
133	Trost	Karla	G&W Electric	X	X	X
134	Tuveson	Lars	Burns & McDonnell		X	X
135	Uzelac	Nenad	G&W Electric	X		
136	Ward	Jeffrey	Doble Engineering Company			X
137	Weeks	Casey	Siemens Energy		X	
138	Weisker	Jan	Siemens AG		X	
139	Wen	Jerry	BC Hydro			X
140	Whitney	Michael	CSA America			X
141	Wilkie	William	Eaton	X		X
142	Wirz	Torsten	ABB AG		X	X
143	Wolf	Robert	Hubbell Power Systems, Inc.	X		X
144	Woodyard	Terrance	Siemens Industry Inc.			X
145	York	Richard	Mitsubishi Electric Power Products Inc.	X	X	X
146	Youssef	Mina	Eaton Corporation			X
147	Yu	Li	Eaton Corporation		X	
148	Zhang	Jiong	MEPPI			X
149	Zhang	Wei	Hitachi T&D Solutions, Inc.	X	X	X
150	Zhong	Jim	American Transmission Company		X	
151	Zhu	Xi	GE Energy Management	X	X	