Minutes of Meeting
P2628 Working Group: Performance Evaluation of Sulfur Hexafluoride Alternatives

Kickoff Meeting: Tuesday, October 16, 2018
Marriott Downtown, Kansas City, MO
Trianon A&B, 08:00 to 09:45 and 10:15 to 12:00

Session #1

Agenda

- Call to order
- IEEE-SA Patent and Copyright Policy Compliance
- Scope
- Motivation
- Introductions, Members & Guests Sign in
- Project Outlook
- Future Work
- Others

Call to order

IEEE-SA Patent Policy and Copyright Compliance

Chair: patent and copyright policy presented. No response.

Scope
This guide reviews 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.

New working group, applied for PAR approved end September. Need project number.
Todd Irwin: SWG is discussing the appropriate location and project number now.

Motivation

Pursuit of new switching technologies with lower inherent performance for the purpose of lower environmental impact raises questions related to evaluation/qualification of switchgear. For example:

- Statistical reliability demonstrated by cap. switching tests.
- Consideration of service capability and condition check.
- How might the confidence level of HV tests differ from SF_6?
- Tests performed at min density *and* end of life molar fraction?
- Thermal implications of non-trivial O_2 content in the gas.
- Qualification of pressure vessel and seals.
- Environmental performance based on LCA methodology.
- Adequacy of mechanical test for particle contamination.
- Standard method for determination of arc byproduct toxicity

Introductions, Members & Guests Sign in

Related Work:
Dave J. introduced the work being done in Cigre A3.41 and there was some discussion about the fundamental work being done and how they are searching for financial contributors. The activity is separate from this working group but we will monitor their work for useful content.

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

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.

Introduction

Make an overview of available SF6-free technologies and their associated physical properties.

Environmental (LCA) Performance

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, contribution to global warming. Parameters that have most impact.

Discuss the GWP of individual gases, gas mixtures and byproducts.

What do the regulators say about GWP? How low is low enough? Is there a line below which emissions are not reported or limited? This could steer manufacturer's developments and lead to some industry consolidation.

Session #2

Evaluation of Toxicity → Environmental Health and Safety

- Discuss the wide variation of reported toxicity results
- Discuss the variables (accumulated duty, mass, dilution, etc.)
- Propose a standard test method
- Possibility to perform controlled experiments similar to the CRIEPI work.

Discussion:

Arc byproducts, implications for performance. Information from CIGRE WG B3.

Methods for assessment of toxicity are available (GHS) others use alternative method (Hodge-Sterner).

Reactions with moisture content. This will also be in the handling guide that is being addressed by the substation committee.

Arc byproducts may vary between test duties.

Switching and Short Circuit Performance

- Discuss the thermal, hot and cold dielectric recovery performance relative to SF6
- Discuss the existing test duties and make arguments for no change or revision
- If present, how might the consumption effect require some modification to the test conditions (min. density + min. molar fraction)?
- Is the condition check still adequate for its intended purpose?

Data is available for performance of some of the gases under difference.

Example is short-line fault. Critical SLF test for SF6 is L90. Other gases may have a critical current value at a different short circuit current.

Some gases exhibit consumption. SF6 is tested at minimum density. Do we test at minimum molar fraction of certain gas in the mixture?

Draw from work of CIGRE A3-41.
Limit to circuit breaker or also include disconnect and earthing switch data? Should include DS and ES.
Capacitive current switching performance.
Scope will cover vacuum technology. Discuss results of A3-27/28
What about reactor switching, small inductive current? Are the same chopping numbers obtained? This is part of the task force A3-41.

CIGRE A3.41 liaison will be Dan Schiffbauer

Dielectric Performance

- Discuss the dielectric characteristics relative to SF6
- Revisit the number of impulse tests with respect to statistical confidence level
- Recommend no change or revision necessary to achieve the same confidence level as SF6.
- Discuss the consumption of insulating gases and how this may influence the test condition.
- Also ageing related to PD.

Who is involved in D1-67? John Owens will be liaison

Is the statistical behavior the same? Are the probabilities associated with test sequence yielding the same confidence levels?
Do coatings of electrodes improve performance of these alternative gases? Will not be included, since it is manufacturer specific.
Dielectric characteristics to include effect of molar fraction of some gases or how the operating pressure affects these parameters.

Continuous Current (Temperature Rise) Performance

- Discuss the thermal characteristics of alternatives relative to SF6
- Current approach is to apply the old "in-air" limits for gas mixtures with a reactive component such as O_2.
- What analytical or experimental data do we have to support this approach?
- What are the limits of this approach?
- Should we perform some controlled experiments which might better inform the standards? Or does sufficient data already exist to draw conclusions?

Approach in MV and HV switchgear is the traditional approach.
For temperature rise limits, provide information about thermal capability of the alternatives. Not only at limit temperature also beyond the limit. Consider overload conditions allowed in C37.010.

Material compatibility with relatively high O2 content at high temperature. Effect on insulation, materials, material finish.

Mechanical Performance

- Surface pollution performance and/or particle liftoff behavior may vary significantly compared to SF6.
- IEEE condition check after mechanical endurance is 80% of the routine dry AC value.
- Evaluate this approach and make recommendations for no change or revision.
- Terminal to terminal resistance limits? May be a good opportunity to consider the limits imposed by standards.
- Visual inspection is mandatory to check for any change in plating.

Low Temperature Performance

- 2-hour de-energized requirement
- Discuss possibility of liquefaction and subsequent inhomogeneity.
- Are test procedures necessary to verify the gas mixture is homogeneous after low temperature near or below the liquefaction conditions?
- Are there any other peripheral items to be considered such as gas monitoring, etc.

Could result in changes in test procedure. May have to evaluate mixture after the test.

Pressure Vessel and Sealing Performance → Material Compatibility

- Considering higher pressures associated with SF6 alternatives, are the existing proof test values adequate to predict a lifetime of safe operation?
- While design stress conditions are unchanged, margins may be reduced and/or cast material sections may be increased leading to less favorable grain structure.
- ASME requires at least 1.1x MAWP routine proof test and as much as 1.3xMAWP depending upon the test method. Is does not limit the pressure.
- Propose to research and possibly generate the crack growth data necessary to answer this question.
- Evaluation of elastomeric seal materials for permeability and ageing.

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

Chapter Contributors (chapter leaders in bold)

2. Environmental LCA:**Dave Johnson (Consultant)**, John Owens (3M), Stephanie Montoya (SCE)

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

4. Switching and short-circuit performance: Dave Johnson (Consultant), Dan Schiffbauer (Toshiba), Jon Rogers (Siemens), **Mauricio Aristizabal (ABB)**, Neil Hutchins (SoCo), Brian Gerzeny (Powell), Kennedy Darko (G&W)

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

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

7. Mechanical performance: **Dan Schiffbauer (Toshiba)**, Sushil Shinde (ABB), Brian Roberts (Southern States)

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

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

Introduction and conclusions to be handled separately once other chapters have content.

To be submitted to RevCom end 2020, but dates may be influenced by CIGRE WG schedule.

Next Meeting.

Meeting with chapter leaders on **January 9th** or other date depending on availability, considering conflicts with other activities.
Dan will send out doodle poll.

Next face to face in next IEEE Switchgear Committee Meeting Spring 2019.

Collaboration Portal

Documents will reside in IEEE-SA Central Desktop.

Reported by:
Daniel Schiffbauer
P2628 Chair
11/10/2018

10/16/2018 Attendance

	Last Name	First Name	Company	Role	Attendance 10/16/2018
1	Almeida	Edwin	Southern California Edison	Member	X
2	Aristizabal	Mauricio	ABB	Member	X
3	Bannink	Herman	KEMA Netherlands	Guest	X
4	Becker	George	POWER Engineers	Vice-Chair	X
5	Beseda	David	S&C Electric Co.	Guest	X
6	Boulus	Michael	PSE&G	Guest	X
7	Boyce	Russell	Eaton	Member	X
8	Brown	Steven	Allen & Hoshall	Guest	X
9	Byron	Eldridge	Schneider Electric	Member	X
10	Chhabra, Ph.D.	Mohit	S&C Electric	Guest	X
11	Chovanec	Andrew	GE Power	Member	X
12	Connor	Brad	Xcel Energy	Member	X
13	Crawford	Michael	Mitsubishi Electric	Member	X
14	Cunningham	Jason	Southern States, LLC	Guest	X
15	Darko	Kennedy	G&W Electric Co	Member	X
16	Dhawan	Anil	ComEd	Guest	X
17	Di Lillo	Patrick	Consolidated Edison Co. of NY, Inc.	Member	X
18	Di Michele	Federico	CESI S.p.A.	Guest	X
19	Door	Jeffrey	The H-J Family of Companies	Guest	X
20	Duncan	Kirk	Hitachi T&D Solutions	Guest	X
21	Evans	Aaron	HICO America	Guest	X
22	Fender	Karl	Southern States LLC	Guest	X
23	Frazier	Raymond	Ameren	Guest	X
24	French	Christopher	Eaton Corporation	Guest	X
25	Gerzeny	Brian	Powell Electrical Systems Inc	Member	X
26	Glaesman	Peter	PCORE Electric Company, Inc.	Guest	X
27	Hall	John	Tennessee Valley Authority	Member	X
28	Heintzelman	Travis	Burns & McDonnell	Guest	X
29	Hensberger	Jeremy	Mitsubishi Electric Power Products Inc.	Guest	X
30	Hermosillo	Victor	GE Grid Solutions	Secretary	X
31	Hunter	Jennifer	MEPPI	Guest	X
32	Hutchins	Roy	Southern Company Services	Member	X
33	Irwin	Todd	GE Grid Solutions	Member	X
34	Jagadeesan	Bharatwaj	Southern States LLC	Member	X
35	Jain	Rahul	S&C Electric Company	Member	X
36	Jarnigan	Christopher	Southern Company Services	Member	X
37	Johnson	David	Self-Employed	Member	X
38	Johnson	Travis	Xcel Energy	Guest	X
39	Jung	Wolfgang	Siemens AG	Member	X
40	Kim	SangTae	HICO America	Member	
41	Lanning	Scott	S&C Electric	Guest	X
42	Li	Wangpei	Eaton	Guest	X
43	Lo	Benson	Toronto Hydro	Member	X
44	Ma	Chunming	Burns and McDonnell	Member	X
45	Martin	Donald	G&W Electric Co.	Guest	X
46	Marzec	Peter	S&C Electric Co.	Guest	X
47	Meiners	Steven	GE	Member	X
48	Midkiff	Jacob	Dominion Energy	Guest	X
49	Montoya	Stephanie	Southern California Edison	Member	X
50	Nelson	Jacob	HPS	Member	X
51	Owens	John	3M	Member	X
52	Palmer	Justin	ELECTRONSYSTEM MD	Member	X
53	Patel	Pathik	Duke Energy	Member	X
54	Pellerito	Thomas	DTE Energy	Guest	X
55	Peterson	Mark	Xcel Energy	Guest	X
56	Phan	Lise	Pacific Gas and Electric Company	Member	
57	Pruitt	Al	The Durham Company	Guest	X
58	Putman	Larry	Powell	Member	X
59	Riley	Caryn	Georgia Tech/NEETRAC	Member	X
60	Roberts	Brian	Southern States, LLC	Member	X
61	Rogers	Jon	Siemens Energy, Inc	Member	X
62	Rohr	Richard	Powell Electrical Systems	Guest	X
63	Schaben	Chase	Burns & McDonnell	Guest	X
64	Schiffbauer	Daniel	Toshiba International Corporation	Chair	X
65	Schuetz	Carl	American Transmission Company (ATC)	Member	X
66	Schumann	Jon	American Transmission Company	Member	X
67	Shinde	Sushil	ABB Inc.	Member	X
68	Sims	Daniel	Eaton Corp.	Guest	X
69	Skidmore	Michael	AEP	Guest	X
70	Steigerwalt	Don	Duke Energy	Member	X
71	Tabakovic	Dragan	Meramec Hubbell Power Systems	Member	X
72	Toups	Vernon	Siemens	Member	X
73	Trichon	Francois	Schneider Electric	Member	X
74	Trost	Karla	G&W Electric	Guest	X
75	Uzelac	Nenad	G&W Electric	Member	X
76	Wilkie	William	Eaton	Member	X
77	Wolf	Robert	Hubbell Power Systems, Inc.	Member	X
78	York	Richard	Mitsubishi Electric Power Products Inc.	Member	X
79	Yu	Li	Eaton Corporation	Member	
80	Zhang	Wei	Hitachi T&D Solutions, Inc.	Member	X
81	Zhu	Xi	GE Energy Management	Member	X