

**Minutes of Meeting
High Voltage Circuit Breaker Subcommittee**

Spring 2022

Hilton Bonnet Creek, Orlando, FL

April 13, 2022 from 3:45 to 5:30 in Collier/Columbia

Chair called the meeting to order at 3:45.

Introduction of all participants including members and officers.

55 participants in attendance

33 of 52 members present – **quorum OK**.

Chair reviewed IEEE patent slides and asked for participants to report any essential patent claims – none reported.

Chair reviewed IEEE copyright slides and asked participants to report any need for copyright permissions – none reported.

Chair notified participants of the IEEE participant behavior slides via the link in the agenda.

Chair asked for a motion to approve the S22 meeting agenda (attached).

Motion: Dave Mitchell

Second: Andy Keels

Discussion: None

Approved by unanimous consent

Chair asked for a motion to approve the fall 2021 meeting minutes.

Motion: Andy Keels

Second: Mike Skidmore

Discussion: None

Approved by unanimous consent

Chair recognized six new members of the HVCB subcommittee:

Andy Chovanec, Jennifer Hunter, Craig Polchinski, Francois Trichon, Matt Westerdale, Marcus Young

Chairman's report:

- **Requested working group chairs to email their meeting minutes to the subcommittee secretary no later than April 27. daniel.schiffbauer@toshiba.com**
- Recognized retirees Ted Burse (not present) and Tom Pellerito.

External reports:

Technical paper reviews (Kirk Smith):

One paper was submitted for review. The topic was vacuum circuit breakers. Several reviewers submitted comments. These were sent to the authors with instructions to make revisions and resubmit the paper within 6 weeks. The deadline for resubmittal is later in April 2022.

Accredited Standards Committee C37 power switchgear (John Webb):

- Specification guide in development for control cabinets for outdoor circuit breakers
- Comparison of requirements related to arc resistant switchgear relative to IEC
- C37.54 under revision: Indoor AC HVCB applied as removable elements in metal-enclosed switchgear – conformance test procedures
- Otherwise, documents of the C37.5x series are up to date

ADSCOM and other working group, study group and taskforce reports:

C37.100.1 Common requirements for HV power switchgear rated above 1000 V (John Webb):

- No quorum
- Reviewed taskforce activities
- Feedback and virtual meetings between spring and fall
- PAR expires 12/2024

Taskforce to review shunt reactor switching (inductive load switching) (Sushil Shinde):

- No report
- Luke Collette is the new chair
- Craig Polchinski is the new secretary

C37.122.10 Guide for handling non-SF6 gas mixtures for HV equipment (George Becker):

- Met at the Joint Technical Committee Meeting (JTCM) in January 2022
- Billy Lao has taken over responsibilities of the chair from George Becker
- Content is under development
- Next meeting is during the substation committee meeting at the end of May 2022
- PAR expires 12/2023

C57.16 IEEE standard for requirements, terminology and test code for dry-type air core series connected reactors (David Caverly):

- No report

C57.142 Guide to describe the occurrence and mitigation of switching transients induced by transformers, switching device and system interactions (David Caverly):

- Jointly sponsored by transformer and switchgear committees
- Out for ballot

Technology and Innovation Subcommittee reports:

No reports

CIGRE Reports:

Refer to main committee minutes

Old Business:

IEC SC17A and TC17 request for liaison

- John Webb is the informal liaison and will report to HVCB at each meeting
- IEC documents of the -1xx series fall under SC17 and John Webb will act as liaison
- IEC documents of the -1, -2, etc. series fall under TC17 and John Webb will act as liaison
- IEC documents of the -2xx series, Eldridge Byron will act as liaison

New Business:

Technical presentation: Lubrication for circuit breaker mechanisms (Jack Harley)

- Thursday from 11:45 to 3:30

Presentation on vacuum circuit breakers at transmission level voltages and request to form a study group (Arben Bufi, see attachment):

- Arben gave a brief presentation on vacuum circuit breaker technology development at transmission level voltages and made a motion to, “form a working group for studying and reporting the present and future developments of vacuum technology for application to switching devices”. Seconded by Neil Hutchins.
 - Discussion:
 - Focus on vacuum is too specific and should include a broader view of SF6-alternatives.
 - Such work does not belong in HVCB since HVCB develops and maintains standards, not technical reports.
 - IEEE PES already published a technical report, TR64, in 2018 on the broader SF6-alternative topic. The report was sponsored by ADSCOM and contributed to the formation of the T&I subcommittee. The intent was to periodically update TR64 as the technologies evolve. Therefore, an update of TR64 may be the better approach.
 - One participant asked about inclusion of type test concerns in the scope of any potential report on SF6-alternatives. Another responded that this is already the purpose of C37.100.7 and need not be repeated in a separate report.
 - Vote was 13/33 members to approve – the motion failed.
- Arben made a new motion to go to T&I with a request to form a study group reporting on the present and future developments of vacuum technology for application up to and including transmission voltages. Seconded by Neil Hutchins.
 - No additional discussion.
 - Vote was 27 approve, 0 disapprove – the motion passed.

62271-37-013 Standard for AC High Voltage (rated above 1000 V) Generator Circuit Breakers for Use With Generators Rated 10 MVA or More

Chair: **Mirko Palazzo**

Secretary: **Matt Westerdale**

- Document is published
- Corrigendum may be required to resolve an error.
- Motion to pursue a corrigendum by Lukas Zehnder. Seconded by Jan Weisker.
- No discussion
- No objection or abstention – motion approved by consensus

62271-37-082-2012 Standard for Sound Pressure Levels in Switchgear

Chair: **Leslie Falkingham**

Secretary: **Carl Schuetz**

- Intent is for IEEE to go to ballot for reaffirmation and a new stability date. The new stability date would then be approved at the plenary meeting of IEC SC 17A in San Francisco at the end of October 2022.
- A member is checking that the process outlined above is correct.

C37.01 Standard for HVDC Circuit Breakers

Chair: **Joanne Hu**

Secretary: **Steven Chen**

- Met with 22 participants and 5 members present
- Discussion of a PAR extension at fall 2022 meeting

C37.04a Standard for Ratings and Requirements for AC High Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V

Amendment: Changes to construction requirements and clarification of certain related required capabilities

Chair: **John Webb**

Secretary: **Marcus Young**

- First meeting with 59 participants and 20 signing up for membership.
- Meeting consisted of task list review and task force creation.
- The working group chair asked for volunteers for secretary. Marcus Young volunteered by email and was accepted.

C37.09a IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

Amendment: Modifications to test procedures

Chair: **Jan Weisker**

Secretary: **Chris Jarnigan**

- First meeting with 59 participants and 30 signing up for membership.
- Reviewed PAR and task list
- The working group chair asked for volunteers for secretary. Chris Jarnigan volunteered by email and was accepted.

C37.010 Application Guide for AC High-Voltage Circuit Breakers > 1000 Vac Rated on a Symmetrical Current Basis

Chair: **Andy Keels**

Vice Chair: **Luke Collette**

Secretary: **Jeremy Hensberger**

- First meeting Monday morning with 43 participants and 23 requesting membership
- Next meeting is virtual during mid-July

C37.012. IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers

Chair: **Roy Alexander**

Secretary: **Luke Collette**

- Working group membership did not have quorum
- Comment resolution group did have quorum
- Latest ballot results 98% approve with 6 comments
- One more recirculation required

C37.016 IEEE Standard for AC High Voltage Circuit Switchers Rated 15.5kV through 245kV

Chair: **Neil McCord**

Vice Chair: **Luke Collette**

Secretary: **Scott Lanning**

- Corrigendum 1 published in 2022
- Revision PAR approved 12/2021 and expires 12/2025
- Goal is to make more consistent with C37.04 and 09
- Also more clarity for transformer limited fault duties and potentially better consistency with C37.06.1.

C37.10 IEEE Guide for Investigation, Analysis, and Reporting of Power Circuit Breaker Failures

Chair: **Neil Hutchins**

Secretary: **Todd Irwin**

- 35 participants, 11 members and 24 guests
- Next meeting will be virtual in June
- Neil Hutchins made a motion to ask HVCB for conditional approval to form a ballot pool and go to ballot. Motion seconded by Andy Keels. There were no votes against and no abstentions. The motion was approved by consensus.
- Neil Hutchins made a request to other working group chairs to make normative reference to C37.10 wherever appropriate in order to increase awareness and visibility. Normative reference requires that the standard be mentioned in the body of the text.

C37.11 Standard Requirements for Electrical Control for AC High-Voltage (>1000V) Circuit Breakers

Chair: **John Webb**

Secretary: **Tony Ricciuti**

- PAR extension will not be required
- Intend to proceed with publishing
- Document approval is >75% and now in comment resolution
- PAR expires 12/2024

C37.122.2 IEEE Guide for the Application of Gas-Insulated Substations Rated 1 kV to 52 kV

Chair: **Eldridge Byron**

Co-secretaries: **Terry Woodyard and Nicholas Matone**

- Sponsored by substation committee
- 35 attendees present including 10/12 members – quorum achieved
- Latest ballot was successful
- Next ballot will be a 15 day recirculation

C37.122.3 IEEE Guide for Sulphur Hexafluoride (SF6) Gas Handling for High-Voltage (over 1000 Vac) Equipment

Chair: **Billy Lao**

Vice Chair: **Dave Giegel** (outgoing)

Secretary: **Arnaud Ficheux**

- No report

C37.122.10 IEEE Guide for Handling Non-Sulphur Hexafluoride (SF6) Gas Mixtures for High Voltage Equipment

Chair: **Billy Lao**

Vice Chair: **Arnaud Ficheux**

Secretary: **Jorge Marquez**

- No report

Common request to disband the following working groups:

- C37.04 – 2018 Corrigendum 1
- C37.09 – 2018 Corrigendum 1
- P62271-37-013 – 2015
- C37.016 – 2018 Corrigendum 1
- Switchgear committee portion of C37.122 - 2010

General discussion:

- A participant noted that in-person attendance is lower than usual and some working groups are not meeting quorum.
- A participant suggested that membership adjustments be paused until meeting attendance stabilizes.

Motion to adjourn – Neil Hutchins

Second – Pat Dilillo

Attendance:

Family Name	Given Name	Affiliation	Membership	4/13/2022
Adanur	Mehmet	Southern Company Services	Non-Member	
Adigwu	John Paul	Southern California Edison	Non-Member	
Alexander	Roy	RWA Engineering	Member	EA ⁽¹⁾
Alvarado	Natasha	IEEE Standards Association	Non-Member	
Anderson	Michael	Retired	Non-Member	
Aristizabal	Mauricio	Hitachi ABB Power Grids	Member	X

Family Name	Given Name	Affiliation	Membership	4/13/2022
Armstrong	Brad	Meramec Instrument Transformer Co.	Non-Member	
Ashtekar	Koustubh	JST Power	Non-Member	X
Atiq	Aasim	Siemens Industry	Non-Member	
Auguste	Georges	Ameren MO	Non-Member	
Ayers	Roy	Nashville Electric Service	Non-Member	
Bane	William	Nashville Electric Service	Non-Member	
Barnett	Robert	Tennessee Valley Authority	Non-Member	
Baskin	Jerry	Federal Pacific	Non-Member	
Becker	Michael	ENMAX Power Corp.	Non-Member	
Becker	George	POWER Engineers Inc.	Member	X
Berenguela	Diego	Google	Non-Member	
Bergman	W.J. (Bill)	Bergman& Associates Ltd.	Honorary Member	EA ⁽¹⁾
Biasse	Jean-Marc	Schneider Electric	Non-Member	
Billings	Stan		Non-Member	
Bisewski	Bruno	RBJ Engineering Corp	Non-Member	
Bonner	Marcus	GE	Non-Member	
Booth	Dave	Exiscan	Non-Member	
Bosma	Anne	Hitachi Energy	Member	EA ⁽¹⁾
Bottarelli	Alessandro	ABB	Non-Member	
Boulus	Michael	PSE&G	Non-Member	
Brehm	Cody		Non-Member	
Brignac	Andrew	Entergy	Non-Member	
Brogdon	Jeffrey	Georgia Transmission	Non-Member	
Brown	Steven	Allen & Hoshall	Non-Member	
Browning	Raymond	FirstEnergy Corp.	Non-Member	
Brunke	John	Dr. John H. Brunke, P.E.	Honorary Member	X
Bryant	Craig	Duke Energy	Non-Member	
Bray	Elizabeth	Southern Company	Non-Member	X
Bufi	Arben	Meiden America Switchgear, Inc.	Member	X
Burge	Richard	Southern States LLC	Non-Member	
Burns	Dave	Shell Projects & Technology - Innovation R&D	Non-Member	
Burse	Ted	Powell Industries, Inc	Non-Member	
Burt	Ed	BC Hydro	Non-Member	
Byreddy	Sudarshan		Non-Member	
Byron	Eldridge	Schneider Electric	Member	X
Calderon	Fernando	AC Electric Systems	Non-Member	
Cannady	Michael	Southern Company Services	Non-Member	
Cantrelle	Donald	Georgia Power	Non-Member	
Carmona	Gilbert	Southern California Edison	Non-Member	
Cary	Stephen	2-phase solutions	Member	X
Caverly	David	Trench Ltd.	Member	
Chang	Samuel	Pacific Gas & Electric Co	Non-Member	
Cheatham	Jonathan	GE	Non-Member	

Family Name	Given Name	Affiliation	Membership	4/13/2022
Chen	Steven	Eaton Corporation	Member	X
Chiodo	Vincent	HICO	Non-Member	
Chovanec	Andrew	G&W Electric	Non-Member	X
Christian	Michael	ABB	Non-Member	X
Ciofani	Roggero	Altalink	Non-Member	
Colesanti	Michael	Google	Non-Member	
Collette	Lucas	Duquesne Light	Member	X
Collette	Dave	Mitsubishi Electric	Non-Member	
Corriveau	Philippe	MindCore Technologies	Non-Member	
Cosby	Bianca	San Diego Gas & Electric	Non-Member	
Cox, Jr.	Lee	Efacec	Non-Member	
Crawford	Michael	Mitsubishi Electric	Member	X
Creach	Randall	AZZ Switchgear Systems	Non-Member	
Crist	Daniel	Siemens Industry, Inc.	Non-Member	
Cunningham	Jason	Southern States, LLC	Member	X
Curry	Ellis		Non-Member	
Day	Jerod	Vacuum Interrupters, Inc.	Non-Member	
Degen	Wolfgang	Senior Technical Consultant	Non-Member	
Delisi	Steven	Mitsubishi Electric	Non-Member	
Di Lillo	Patrick	Consolidated Edison Co. of NY, Inc.	Member	X
Di Michele	Federico	CESI S.p.A.	Non-Member	
Door	Jeffrey	The H-J Family of Companies	Member	X
Dotson	Randall	Lakeland Electric, City of Lakeland, FL	Non-Member	
Dufournet	Denis	Retired	Honorary Member	
Duncan	Kirk	Hitachi T&D Solutions	Non-Member	
Dwyer	Pete	Dwyer Enterprises	Honorary Member	
Dwyer	Bernie	PECO	Non-Member	
Earl	Jerry	ABB - Retired	Non-Member	
Eastman	John	ZTZ Services	Non-Member	
Ebbert	Alexander	HICO America	Non-Member	
Edwards	Kenneth	Kittitas PUD	Member	
Edwards	Doug	Siemens Industry, Inc.	Non-Member	
Eftink	Emily	Burns & McDonnell	Non-Member	
Esco	Tanner	Eaton Corporation	Non-Member	
Evans	Aaron	HICO America	Non-Member	
Falkingham	Leslie	Vacuum Interrupters Limited	Member	
Feldmann	David	HICO America	Non-Member	
Fennell	Howard	Nashville Electric Service	Non-Member	
Fentress	Philip	Memphis Light, Gas & Water Div	Non-Member	
Fernihough	William	FMEA Technical Services Ltd	Non-Member	
Ficheux	Arnaud	AREVA T&D	Non-Member	
Figueroa	Hernan	Hubbell Power Systems	Non-Member	
Fink	William	Powell Industries	Non-Member	

Family Name	Given Name	Affiliation	Membership	4/13/2022
Flack	Michael	Southern Company Services, Inc.	Non-Member	
Flores	Sergio	Schneider Electric Inc. USA	Member	X
Ford	Shane	Nashville Electric Service	Non-Member	
Foster	Robert	Megger	Non-Member	
Fox	Paul	Schneider Electric	Non-Member	
Frazier	Raymond	Ameren	Member	
Fulchiron	Didier	Schneider-Electric	Non-Member	
Galatic	John	HICO America	Non-Member	
Galicia	David	Ameren	Non-Member	
Gavazza	Rick	Pacific Gas & Electric	Non-Member	
Gettman	Kenneth	NEMA	Non-Member	
Giraud	Douglas	Powell Industries	Non-Member	
Good	Anne	Netshape Technologies, Inc.	Non-Member	
Gray	Keith	None	Honorary Member	
Groves	David	SMC Electrical Products	Non-Member	
Hall	John	Tennessee Valley Authority	Member	
Hand	Charles	Southern California Edison	Non-Member	
Hanna	Robert	JST Power	Non-Member	X
Harley	John	FirstPower Group LLC	Non-Member	
Heiermeier	Helmut	ABB	Member	
Heintzelman	Travis	Burns & McDonnell	Non-Member	
Hensberger	Jeremy	Mitsubishi Electric Power Products Inc.	Member	X
Herman	Bryan	Isberg-Nott Company	Non-Member	
Hermosillo	Victor	GE Grid Solutions	Member	EA ⁽¹⁾
Hester	Edward	Entergy	Non-Member	
Hirz	Harold	G&W	Non-Member	
Holloman	Luther	Retired	Non-Member	
House	George	Yaskawa Electric America	Non-Member	
Houston	James	Southern Company Transmission	Non-Member	
Hu	Jingxuan (Joanne)	RBJ Engineering Corporation	Member	EA ⁽¹⁾
Huang	Fang		Non-Member	
Hunter	Jennifer	MEPPI	Non-Member	EA ⁽¹⁾
Hurst	Bill	GE	Non-Member	
Hutchins	Neil	Georgia Power Company	Member	X
Hutchinson	Scott	Jacobs Engineering	Non-Member	
Hyjek	Katarzyna	DTE	Non-Member	
Irwin	Todd	GE Grid Solutions	Member	X
Isaac	Carlos	Oncor Electric Delivery	Non-Member	
Jackson	Richard	Detroit Edison	Non-Member	
Jarnigan	Christopher	Southern Company Services	Member	X
Jasinski	Joseph	ITC Holdings Corp.	Non-Member	EA ⁽¹⁾
Johnson	Cory	BPA	Non-Member	
Johnson	David	HVCB	Member	X

Family Name	Given Name	Affiliation	Membership	4/13/2022
Kausek	Joe	FirstEnergy	Non-Member	
Keels	Thomas (Andy)	kEElectric Engineering	Member	X
Kelly	John	Beureau Of Reclamation	Non-Member	
Khan	Aftab	ABB Inc.	Non-Member	
Khosravi	Amir	BC Hydro	Non-Member	
Kim	Hong Jun	HICO	Non-Member	
Kim	Jinho	HICO America	Non-Member	
Kim	SangTae	HICO/HYOSUNG	Non-Member	
kim	jungdae	hyosung	Non-Member	
Kohler	Thomas	Ameren	Non-Member	
Kollar	Alan	FirstEnergy	Non-Member	
Kosakada	Masayuki	Toshiba	Non-Member	
Kulkarni	Sandeep	CG	Non-Member	
Kuntz	Robert	HICO AMERICA	Non-Member	
Kurinko	Carl	ABB Inc.	Non-Member	
Lachimia	Joseph		Non-Member	
Lagerstrom	Thomas	Pedersen Power Products	Non-Member	
LaMantia	William	Mitsubishi Electric Power Products, Inc.	Non-Member	
Lambert	Stephen	Shawnee Power Consulting, LLC	Honorary Member	
Lanning	Scott	Eaton	Non-Member	
LaPlace	Carl	GE Industrial Solutions	Non-Member	
Lavrinoff	Benedict	Kinectrics	Non-Member	
Lawrence	Matthew	Doble Engineering	Non-Member	
Leccia	Brad	Eaton	Non-Member	
Leclerc	Marc	Hydro-Quebec Research Institute	Non-Member	
LEE	CHANG HOON	HYOSUNG Heavy industries	Non-Member	
Lemmerman	David	PECO/Exelon	Member	
Lesse	Werner	Siemens AG	Non-Member	
Lester	George	Boston Edison Retired	Honorary Member	
Leufkens	Paul	DNV	Non-Member	
Li	Wangpei	Eaton	Non-Member	
Ling	Yingjie	GE	Non-Member	
Liu	Li	Eaton	Non-Member	
Liu	Hua Ying	Southern California Edison	Member	EA ⁽¹⁾
Livshitz	Albert	CE Power Engineered Services	Member	X
Lizardo Cochran	Alex		Non-Member	
Lofgren	Bjorn	Siemens Energy	Non-Member	
Long	Russell (Bill)	Retired	Honorary Member	
Lopez	Leo	WIKA Instrument, LP	Non-Member	X
Luehring	Elmer	Hi-Voltage Equipment	Non-Member	
Ma	Chunming	Burns and McDonnell	Non-Member	
Mains	Jess	ABB Inc	Non-Member	
Majeed	Kamran	ENMAX Power Corporation	Non-Member	

Family Name	Given Name	Affiliation	Membership	4/13/2022
Mannarino	Antonio	PSE&G	Non-Member	
Marshall	Vincent	Southern Company Services	Non-Member	X
Martin	Gary	Entergy	Non-Member	
Martinez	Ricardo	CFE-LAPEM	Non-Member	
Marx	Benjamin	Sargent and Lundy	Non-Member	
Marzec	Peter	S&C Electric Co.	Non-Member	
Mason	Douglas	ComEd	Non-Member	
Matsko	Joseph	Eaton Corp	Non-Member	
May	Steven	Southern Company	Member	
McBride	James	JMX Services, Inc.	Non-Member	
McCord	Neil	KEC Precision	Member	X
McGlown	Kevin		Non-Member	X
Meyer	Peter	S&C Electric Company	Non-Member	
Milnikel	Henning	Siemens	Non-Member	
Mitchell	Dave	Mitch and Associates	Member	X
Monahan	Terry	Schneider Electric	Non-Member	
Montano	Oscar	Salt River Project	Non-Member	
Montoya	Stephanie	Southern California Edison	Non-Member	
Moran	Ashley	IEEE Standards Association (IEEE-SA)	Non-Member	
Moser	Darryl	ABB	Non-Member	
Musa	Yasin	AEP	Non-Member	
Naranjo	Volney	GERS USA	Non-Member	
Natale	Anthony	HICO America	Non-Member	X
Nayar	Raj	Siemens Energy Inc.	Non-Member	
Nelson	Jeffrey	Tennessee Valley Authority	Member	
Norfolk	Jeff	RWE INNOGY	Non-Member	
Nyberg	Dave	3M Company	Non-Member	
Olsen	T	Retired, formerly with Siemens Industry, Inc.	Honorary Member	
Orlando	Nicholas	IEEE-SA	Non-Member	
Orosz	Miklos	Myers Controlled Power	Non-Member	
Osorio	Luis	The H-J Family of Companies	Non-Member	
Owens	John	3M	Non-Member	
Palazzo	Mirko	Hitachi Energy	Member	EA ⁽¹⁾
Palmer	Justin	ELECTRONSYSTEM MD	Non-Member	
Parker	Donald	Alabama Power Company	Non-Member	
Parthasarathi	Raghunath	Bechtel Power	Non-Member	
Patel	Amit	GE	Non-Member	
Pattison	Mark	H-J Family of Companies	Non-Member	X
Pellerito	Thomas	DTE Energy	Member	X
Perrin	Damian	Entergy Services, LLC	Non-Member	
Peterson	Andrew	ABB	Non-Member	
Peterson	Alan	Utility Service Corporation	Non-Member	
Peterson	Mark	Xcel Energy	Non-Member	

Family Name	Given Name	Affiliation	Membership	4/13/2022
Phan	Lise	Pacific Gas and Electric Company	Non-Member	
Phelps	Kevin	Nashville Electric Service	Non-Member	
Phouminh	John	PEPCO HOLDINGS, INC.	Member	
Pintado	Zachary	Entergy	Non-Member	
Poeltl	Anton	ABB	Non-Member	
Polchinski	Craig	MEPPI	Non-Member	X
Polk	Matt		Non-Member	
Profir	Iulian	Rockwell Automation	Non-Member	
Qasem	Ahmad	Bechtel	Non-Member	
Quinones	Jose	Mitsubishi Electric Power Products INC	Non-Member	
Rahman	Syed	The United Illuminating Company	Non-Member	
Raymond	Russell	Northeast Utilities	Non-Member	
Reddy	Samala Santosh	Powell Industries	Non-Member	
Ricard	Frank	FirstPower Group LLC	Non-Member	
Ricciuti	Anthony	Eaton Corporation	Member	X
Rich	Bobby	Dominion Energy	Member	
Riffe	Dave	Westinghouse Electric Company	Non-Member	
Riley	Caryn	Georgia Tech/NEETRAC	Non-Member	
Riopel	Sebastien	HPS - Electro Composites (2008) ULC	Non-Member	
Roberts	Brian	Southern States, LLC	Non-Member	
Rogers	Jon	Siemens Energy, Inc	Non-Member	
Ross	Hugh	Ross Engineering Corporation	Honorary Member	
Rostron	Joe	Southern States LLC	Non-Member	
Salinas	Alex	Doble	Non-Member	X
Santos	Leonel	Schneider Electric	Non-Member	
Sauls	Roderick	Southern Company Services	Non-Member	
Sauro	Fabrizio	Eaton	Non-Member	
Savulyak	Victor	DNV GL KEMA Laboratory	Non-Member	
Schacherer	Christian	ABB Switzerland Ltd	Non-Member	
Schacker	Michael	American Electrical Testing Co.	Non-Member	
Schiffbauer	Daniel	Toshiba International Corporation	Member	X
Schneider	Carl	Schneider Electric	Non-Member	
Schoonenberg	Gerard	Eaton	Non-Member	
Schuetz	Carl	American Transmission Company (ATC)	Member	X
Schumann	Jon	American Transmission Company	Non-Member	
Shaikh	Moin	Siemens	Non-Member	
Sharifi	Behzad	ABB	Non-Member	
Sharma	Devki	Entergy	Member	X
Sharma	Harish	Southern Company	Non-Member	
Shen	Zheng	Illinois Institute of Technology	Non-Member	
Sherry	Ryan	ITC Holdings Corp.	Non-Member	
Shinde	Sushil	Hitachi ABB Power Grids	Member	
Shullaw	John	Retired	Honorary Member	

Family Name	Given Name	Affiliation	Membership	4/13/2022
Siena	Matthew	Duke Energy	Non-Member	X
Sicker	Robert	FirstEnergy Corp	Non-Member	
Sigmon	Dean	Eaton Corporation	Non-Member	
Sippel	Kevin	Eaton Electric	Non-Member	
Skidmore	Michael	AEP	Member	X
Slattery	Christopher	FirstEnergy	Non-Member	
Smith	Zachary	Mitsubishi Electric Power Products, Inc.	Non-Member	
Smith	Robert (Kirk)	Retired	Honorary Member	
Smith	H. Mel		Honorary Member	
Snider	Jordan	Pacific Gas & Electric Co.	Non-Member	
Song	Hongbiao	Bechtel	Non-Member	
Spiewak	Erin	IEEE	Non-Member	
Stacy	James	Schneider Electric	Non-Member	
Stage	James	Dominion Energy	Non-Member	
Staley	Bradley	Salt River Project	Non-Member	
Starcevic	Kresimir	KEMA-Powertest, LLC	Non-Member	
Steigerwalt	Don	Duke Energy	Member	X
Stone	David	DTS Technical Services	Honorary Member	
Stone	Ryan	Mitsubishi Electric Power Products, Inc.	Non-Member	
Storms	Alan	Storms Advisory Services	Non-Member	
Swing	Donald	Powell Industries	Non-Member	
Tabakovic	Dragan	Meramec Hubbell Power Systems	Non-Member	
Tariq	Humayun	American Electric Power	Non-Member	
Toney	John	GE	Non-Member	
Toolis	Elizabeth	MEPPI	Non-Member	
Torres	Jean-Marc	EATON	Non-Member	
Toups	Vernon	Siemens	Non-Member	X
Trichon	Francois	Schneider Electric	Non-Member	X
Trussler	Richard	Schneider Electric	Non-Member	
Tsvetanoff	Jordan	First Energy	Non-Member	
Usner	Joseph	AEP	Non-Member	X
van de Ligt	Jim	Spark Power Corp.	Non-Member	
Wadsworth	Wes	Hitachi HVB, Inc.	Non-Member	
Wagner	Charles	Consultant	Honorary Member	
Wahid	Waqar	Mitsubishi Electric Power Products Inc.	Non-Member	
Walgenbach	Jacob	Siemens Industry	Non-Member	X
Wallace	Keith	Southern Company	Non-Member	
Ward	Jeffrey	Doble Engineering Company	Member	X
Warren	Robert	KEMA Powertest	Non-Member	
Wear	Jonathan	JST Power	Non-Member	X
Webb	John	ABB	Member	X
Weeks	Casey	Siemens Energy	Non-Member	X
Weishuhn	William	ABB	Non-Member	

Family Name	Given Name	Affiliation	Membership	4/13/2022
Weisker	Jan	Siemens AG	Member	X
Wen	Jerry	BC Hydro	Non-Member	
Westerdale	Matt	Bureau of Reclamation	Non-Member	
Williams	Terry	Bureau of Reclamation	Non-Member	
Williams	Sharon	Puget Sound Energy	Non-Member	
Williford	Matthew	Schneider Electric	Non-Member	
Wirz	Torsten	ABB AG	Non-Member	
Woodyard	Terrance	Siemens Industry Inc.	Member	X
Yoon	Dong Sun	HICO America	Non-Member	
York	Richard	Mitsubishi Electric Power Products Inc.	Member	X
Younce	Colin	Burns & McDonnell	Non-Member	
Young	Marcus	Mitsubishi Electric Power Products, Inc.	Non-Member	X
Yu	Li	EATON	Non-Member	
Zehnder	Lukas	ABB Power Grids Switzerland Ltd.	Non-Member	X
Zhang	Wei	Southern Company	Member	
Zhang	Jiong	MEPPI	Non-Member	
Zhong	Jim	American Transmission Company	Non-Member	

NOTE 1 – EA, Excused Absence, does not count against membership and does not count toward quorum.

Attachments:

HVCB Meeting Agenda:

HVCB Switchgear Subcommittee Agenda, 04/13/2022, 3:45-5:30 PM CST, Orlando, FL

1) Introduction of Members and Guests Carl Schuetz / Dan Schiffbauer

Welcome, Introductions

Need to reach quorum.

2) IEEE Patent and Copyright Policy Review patent & copyright policy requirements

<https://standards.ieee.org/wp-content/uploads/import/documents/other/Participant-Behavior-Individual-Method.pdf>

Quorum check.

3) Approval of Minutes of Previous Meeting

Approval of Minutes of F21, online meeting. Sent to all members and guests via e-mail.

motion for approval:
second.

4) Membership

	ROLE AS MEMBERS	ROLE AS NON-MEMBER (GUEST)	EXCUSED	REQUIRED* FOR QUORUM COUNT	TOTAL
HVCB Committee Roster	51		5	≥ 50% membership at meeting (≥ 26 members)	

*Quorum Count includes: Members, Chair, Secretary but not excused members

Excused members (5): Joanne Hu, Anne Bosma, Hua Liu, Victor Hemosillo, Kirk Smith

Participants that have been newly elevated to HVCB SC member status:

Chovanec	Andy	G&W Electric
Hunter	Jennifer	MEPPI
Polchinski	Craig	MEPPI
Trichon	Francois	Schneider Electric
Westerdale	Matt	Bureau of Reclamation
Young	Marcus	MEPPI

HVCB Switchgear Subcommittee Agenda, 04/13/2022, 3:45-5:30 PM CST, Orlando, FL

5) Chairman's Report

Chairman (Carl Schuetz): carl.schuetz@ieee.org (262) 506-6962
Secretary (Dan Schiffbauer): daniel.schiffbauer@toshiba.com (713) 540-2968

- WG chairs need to email minutes of their WG meetings to the subcommittee secretary no later than Wednesday, April 27.
- Recognition of retirees (Ted Burse, Tom Pellerito and any other person that has, or will retire before Fall meeting in Burlington)

6) Reports of Working Groups

- a) **Technical Paper Reviews** Kirk Smith
One paper was submitted for review. The topic was vacuum circuit breakers. Several reviewers submitted comments. These were sent to the authors with instructions to make revisions and resubmit the paper within 6 weeks. The deadline for resubmission is later in April 2022.
- b) **ASC C37 Power Switchgear Report** John Webb

c) HVCB Document Status

Document	Title	Subcommittee	WG Chair	PAR	IEEE Status	Comments
PC37.01	Standard for High Voltage Direct Current Circuit Breakers Above 3200 Vdc	HVCB	Joanne Hu	PAR approved May 15, 2020	PAR expires Dec.31, 2024	Formerly PAR 2880
C.37.04-2018	Standard for Ratings and Requirements for AC High Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V	HVCB	Stephen Cary		Approved 12.05/2018	Published on May 31, 2019.
PC37.04a	Standard for Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Amendment: Changes to construction requirements and clarification of certain related required capabilities	HVCB	John Webb	PAR approved Dec. 08, 2021	PAR expires Dec.31, 2025	
C.37.04-2018 Cor 1	Standard for Ratings and Requirements for AC High Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V	HVCB	John Webb			Published on Sept. 24, 2021
C.37.06.-2009 ANSI	IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V	HVCB		Included in PC37.04	Document expired	
C.37.06.1-2018	Recommended Practice for Preferred Ratings for High-Voltage (> 1000 volts) AC Circuit Breakers Designated Definite Purpose for Fast Transient Recovery Voltage Rise Times	HVCB	Sushil Shinde			Published in 2018
C.37.09-2018	IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	HVCB	Xi Zhu			Published on April 11, 2019.
PC37.09a	Standard Test Procedures for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Amendment: Modifications to test procedures	HVCB	Jan Wesker	PAR approved Dec. 08, 2021	PAR expires Dec.31, 2025	
C.37.09-2018 Cor 1	IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	HVCB	Jan Wesker			Published on June 3, 2021

PC37.010	Application Guide for AC High-Voltage Circuit Breakers > 1000 Vdc Rated on a Symmetrical Current Basis	HVCB	Andy Keels	PAR approved Dec. 08, 2021	PAR expires Dec.31, 2025	
C.37.011-2018	IEEE Guide for the Application of Transient Recovery Voltage for AC High-Voltage Circuit Breakers	HVCB	Denis Dufournet			Published in 2019.
PC37.012-2014	IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers	HVCB	Roy Alexander	PAR approved 03/24/2022	PAR expires 12/31/2024	
PC.37.012a- Amendment	IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers	HVCB	Roy Alexander			Published on Aug. 7, 2020
P02271-37-013-2015	Standard for AC High Voltage (rated above 1000 V) Generator Circuit Breakers for Use With Generators Rated 10 MVA or More	HVCB	Mirko Palazzo	PAR approved 12/07/2016	PAR expires 10/01/2022	WG established and work continues on document.
P02271-37-082-2012	High-voltage Switchgear and Circuit Breakers - Part 37-082: Standard Practice for the Measurement of Sound Pressure Levels on Alternating Current Circuit-breakers	HVCB	Leslie Falkingham	PAR approved Dec. 08, 2021	PAR expires Dec.31, 2025	
C.37.015-2018	IEEE Guide for the Application of Shunt Reactor Switching	HVCB	Anne Bosma			Published on Mar.15, 2018
PC37.016	Standard for AC High Voltage Circuit Switchers Rated 15.5kV through 245kV	HVCB	Neil McCord	PAR approved Dec. 08, 2021	PAR expires Dec.31, 2025	
PC37.016-2018 Cor 1	Standard for AC High Voltage Circuit Switchers Rated 15.5kV through 245kV	HVCB	Neil McCord			Document published in 2022
C.37.017-2010	IEEE Standard for Bushings for High-Voltage (over 1000 V (ac)) Circuit Breakers and Gas-Insulated Switchgear	HVCB-GIS	Devki Sharma			Published on Jan. 29, 2021
PC37.18-2011	IEEE Guide for Investigation, Analysis, and Reporting of Power Circuit Breaker Failures	HVCB	Neil Hutchins	PAR approved Dec.3, 2020	PAR expires Dec.31, 2024	
C.37.10.1-2018	IEEE Guide for the Selection of Monitoring for Circuit Breakers	HVCB	Dave Mitchell			Document published in 2018.
PC37.11-2014	Standard Requirements for Electrical Control for AC High-Voltage (>1000V) Circuit Breakers	HVCB	John Webb	PAR approved 02/08/2019	PAR expires 12/31/2023	
C.37.12-2018	IEEE Guide for Specifications of High-Voltage Circuit Breakers (over 1000 Volts)	HVCB	John Webb			Published in 2018

HVCB Switchgear Subcommittee Agenda, 04/13/2022, 3:45-5:30 PM CST, Orlando, FL

C37.12.1-2018	IEEE Guide for High Voltage (>1000V) Recommended Practice for Circuit Breaker Instruction Manual Content	HVCB	Ken Edwards			Published in 2018
C37.20.6-2015	4.76 kV to 38 kV Rated Grounding and Testing Devices Used in Enclosures	ADSCOM joint HVCB/SA	T. W. Olsen			Published in 2015
C37.39-2018	Requirements for Conversion of Power Switchgear Equipment	ADSCOM joint HVCB, SA, and LVSD	Dean Sutton			
PC37.122-2010	Standard for High Voltage Gas-Insulated Substations Rated above 52 kV	Joint SUB/SWG HVCB	Ryan Stone			Published on August 25, 2021
PC37.122.2-2011	Guide for the Application of Gas-Insulated Substations Rated 1 kV to 52 kV	Joint SUB/SWG HVCB	Eldridge Byron	PAR approved 06/03/2019	Document Expires 12/31/2021 PAR expires 12/31/2023	Co-sponsored with Substation Committee.
PC37.122.3-2011	IEEE Guide for Sulphur Hexafluoride (SF6) Gas Handling for High-Voltage (over 1000 Vac) Equipment	Joint SUB/SWG HVCB	Billy Lao	PAR approved 09/05/2019	PAR expires 12/31/2023	PAR revised to show co-sponsored with Substation Committee.
PC37.122.10	Guide for Handling Non-Sulphur Hexafluoride (SF6) Gas Mixtures for High Voltage Equipment	Joint SUB/SWG HVCB	George Becker	PAR approved 06/03/2019	Document Expires 12/31/2023	Co-sponsored with Substation Committee.

Note: Only those working groups highlighted and with PAR information are currently active. WG highlighted w/out PAR information have completed work and are not disbanded

7) Reports of AdCom WG/TF/Study Group

C37.100.1 Common Requirements for High Voltage Power Switchgear Rated Above 1000 V	John Webb
TF to review Shunt Reactor (inductive load) Switching	Sushil Shinde
C37.122.10 Guide for Handling Non-SF6 Gas Mixtures for HV Equipment	George Becker
C57.16: IEEE Standard for Requirements, Terminology and Test Code for Dry-Type Air-Core Series Connected Reactors	David Caverly
C57.142: Guide to Describe the Occurrence & Mitigation of Switching Transients Induced by Transformers, Switching Device, & System Interactions Jointly sponsored by TRFCOM and SWGCOM. Report to Subcommittee.	David Caverly
Technology and Innovation Subcommittee	Nenad Uzelac

8) CIGRE Reports

Report to Subcommittee Working Groups in 2020:	Nenad Uzelac
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- New WGs
JWG B3/A3.60: User guide for non-SF6 gases and gas mixtures in Substations
A3.47: Lifetime Management of Medium Voltage Indoor Switchgear
- WGs Disbanded
Two working groups finished their work: A3.31 (Electra Paper), A3.36 (TB830)
- Total number of active, WGs, JWGs
8 active WGs and one JWG under A3 lead, 5 JWG participation under lead of other SCs
- Number of WG meetings held by electronic means (video or phone conferences):
Due to the Pandemic the Working Group work was only done by remote meetings.
(Last face-to face meetings took place in the beginning of 2020!!)

Publications

- Publications during 2021 of Electra papers - excluding the executive summary of a TB), Reference papers, Technical brochures, CSE papers, Future Connections.
 - o Electra Paper of A3.31
 - o Technical Brochure TB830 of A3.36

- Publication plan for the coming year
We expect 2 TB's (A3.41 and A3.39).
- CSE Papers are planned and will be chosen out of the CIGRE Papers
- Green Books progress
Support the Green book activities of C1 on Asset Management
Support the Green book activities of E4: chapter about HVDC CBs (draft submitted in April 2021)
Second edition of A3 green book under preparation
- Reference papers progress
We plan to organise a reference paper on alternatives gases in conjunction with B3 and D1.

9) Old Business

- a) Request for liaison to IEC TC17 /SC17A

10) New Business

- a) Technical presentation
Lubrication for Circuit Breaker Mechanisms by Jack Harley, 11:45-3:30
- b) Documents Approved by RevCom or Published since last meeting
C37.04 Corrigendum 1
C37.09 Corrigendum 1
62271-37-013
C37.016 Corrigendum 1
C37.122
- c) Request from the floor to address the subcommittee
- d) 62271-37-013 Standard for AC High Voltage (rated above 1000 V) Generator Circuit Breakers for Use With Generators Rated 10 MVA or More
Chair: Lukas Zehnder for **Mirko Palazzo**
Secretary: **Matt Westerdale**
- e) 62271-37-082-2012 Standard for Sound Pressure Levels in Switchgear
Chair: Carl Schuetz for **Leslie Falkingham**
Secretary: **Carl Schuetz**
Communication with the IEEE SWG liaison was made in F21 to request a harmonized revision date with IEC but no update has been provided. The official

process for establishing such a request should be made to ADSCOM and this request for assistance will be made tomorrow at the ADSCOM meeting. The request will be to try and align the IEC and IEEE revision dates. Assuming that the dates can be aligned the chair will try to get the standard extended without change.

- f) C37.01 Standard for HVDC Circuit Breakers
Chair: **Steven Chen** for **Joanne Hu**
Secretary: **Steven Chen**
- g) C37.04a Standard for Ratings and Requirements for AC High Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V
Amendment: Changes to construction requirements and clarification of certain related required capabilities
Chair: **John Webb**
Secretary: **TBD**
- h) C37.09a IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
Amendment: Modifications to test procedures
Chair: **Jan Weisker**
Secretary: **TBD**
- i) C37.010 Application Guide for AC High-Voltage Circuit Breakers > 1000 Vac Rated on a Symmetrical Current Basis
Chair: **Andy Keels**
Secretary: **TBD**
- j) C37.012. IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers
Chair: **Luke Collette** for **Roy Alexander**
Secretary: **Luke Collette**
- k) C37.016 IEEE Standard for AC High Voltage Circuit Switchers Rated 15.5kV through 245kV
Chair: **Neil McCord**
Vice Chair: **Luke Collette**
Secretary: **Scott Lanning**
- l) C37.10 IEEE Guide for Investigation, Analysis, and Reporting of Power Circuit Breaker Failures
Chair: **Neil Hutchins**
Secretary: **Todd Irwin**

- m) C37.11 Standard Requirements for Electrical Control for AC High-Voltage (>1000V) Circuit Breakers
Chair: **John Webb**
Secretary: **Tony Ricciuti**
- n) C37.122.2 IEEE Guide for the Application of Gas-Insulated Substations Rated 1 kV to 52 kV
Chair: **Eldridge Byron**
Co-secretaries: **Terry Woodyard** and **Nicholas Matone**
- o) C37.122.3 IEEE Guide for Sulphur Hexafluoride (SF6) Gas Handling for High-Voltage (over 1000 Vac) Equipment
Chair: **Billy Lao**
Vice Chair: **Dave Giegel** (outgoing)
Secretary: **Arnaud Ficheux**
- p) C37.122.10 IEEE Guide for Handling Non-Sulphur Hexafluoride (SF6) Gas Mixtures for High Voltage Equipment
Chair: **Billy Lao**
Vice Chair: **Arnaud Ficheux**
Secretary: **Jorge Marquez**

Future Meetings

- a) Fall 2022: Burlington, VT
- b) Spring 2023: Clear Water/Tampa, FL
- c) Fall 2023: San Diego, CA

1) Adjourn

Motion:
Second:

PROPOSAL TO IEEE HVCB SUBCOMMITTEE:

PRESENT AND FUTURE DEVELOPMENTS OF
VACUUM CIRCUIT BREAKERS

(AS SF₆ ALTERNATIVE)



Presented by: Arben Bufl, Ph.D., Senior IEEE Member



THE MISSION: To eliminate and reduce emission of [SF₆] - potent greenhouse gas through new designs, cost-effective technical and management solutions.



CARB Proposed Regulation: July 21, 2020

VOLTAGE [kV]	Short-Circuit Current [kA]	Phase-out Date
38 < kV ≤ 145	< 63	End of 2024
	≥ 63	End of 2028
145 < kV ≤ 245	< 63	End of 2026
	≥ 63	End of 2030
> 245	ALL	End of 2032

SF₆ Phase-out Starting in 2025



Impact of Alternate Gases on Existing IEEE Standards



C37.100.7 Performance Evaluation of SF₆ Alternatives



Strategy Considerations with Respect to SF₆ Alternatives

9. SF₆ alternative equipment using "technical grade air" and vacuum interrupters operates at a significantly higher pressure than SF₆ equipment. The static seals and dynamic seals presently used in switchgear will be challenged to cope with the higher pressures.

10. Vacuum interrupters in equipment using "technical grade air" are presently limited to maximum operating voltages of 145 kV and below and interrupting ratings of 40 kA.

11. High-pressure gas interrupters using gas mixtures are presently limited to maximum operating voltages of 145 kV and below and interrupting ratings of 40 kA.



Reference from CIGRE Working Groups



Reference from CIGRE A3.41: "Interrupting and switching performance with SF6 free switching equipment".



Reference from CIGRE B3.45: "Application of non-SF6 gases or gas-mixtures in medium and high voltage gas-insulated switchgear".



Reference from CIGRE D1.67: "Dry air, N2, CO2, and N2/SF6 mixtures for gas-insulated systems".



The Beginning of Vacuum Technology

Vacuum Switching Experiments at California Institute of Technology

ROYAL W. SORENSEN*
Pasadena, A. I. E. E.

and

HALLAN E. MENDENHALL*
Amesbury, A. I. E. E.

Synopsis.—Successful experiments in switching or breaking a circuit in a high vacuum have been made at the California Institute of Technology. This paper is a report on three sets of experiments which extended over a period of three years. The results show that switching in vacuum affords the advantages of no arcing of contacts, quick break, the arc always going out on the pole, small voltages rise across the switch, and small dimensions which extended over a period of three years. The vacuum switch practical calls for a solution of the problem of making commercial apparatus with vacuum-tight joints, and the elimination of the use of liquid air with the vacuum pump.

Sept. 1926

A noticeable feature of the vacuum-switch tests is that every oscillographic record shows that the arc produced at the opening of the switch is extinguished at the end of the first half-cycle after the separation of the contacts. Only the very best oil-switch operations give this result.

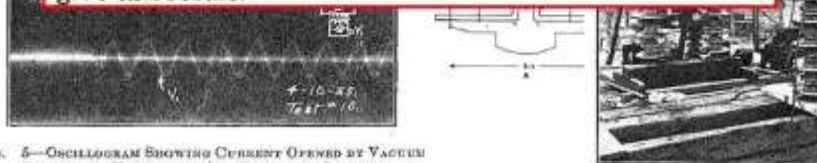


FIG. 5—OSCILLOGRAM SHOWING CURRENT OPENED BY VACUUM SWITCH AND VOLTAGE ACROSS SWITCH AT OPENING



VACUUM TECHNOLOGY DEVELOPMENTS



The Impact of the Application of Vacuum Switchgear at Transmission Voltages

WG A3.27

Published in 2014



TABLE OF CONTENT

1	INTRODUCTION	3.1.3	Reliability data
1.1	High-voltage SF6 switchgear	3.2	Interruption and switching performance
1.2	High-voltage vacuum switchgear	3.2.1	Load current switching (high power factor)
1.2.1	Introduction	3.2.2	Capacitive current switching
1.2.2	History of high-voltage vacuum breaker	3.2.3	Capacitor bank switching
1.2.3	Status	3.2.3.1	Inductive current switching
1.3	Motivation of this Working Group and content of the Brochure	3.2.3.2	Current chopping
2	DIFFERENCES BETWEEN SF6 – VACUUM: DEVICE IMPLICATIONS	3.2.3.3	Multiple re-ignitions
2.1	Interruption Media and Dielectric Comparison	3.2.4	Multiple re-ignitions
2.1.1	The interruption process	3.2.5	Overvoltage mitigation techniques
2.1.1.1	Thermal recovery	3.3	Dielectric performance and breakdown statistics
2.1.1.2	Dielectric recovery	3.3.1	Non-sustained disruptive discharges (NSDD)
2.1.2	Technical properties of the insulating and arc quenching gas SF6	3.4	Electrical and mechanical life, life-line management
2.1.3	Environmental properties of SF6	3.4.1	Electrical life
2.1.4	High Voltage application of SF6 circuit breakers	3.4.2	Mechanical life
2.1.5	Properties of the arc extinction in vacuum	3.4.3	Maintenance of SF6 CB and VCB
2.2	Impact of vacuum/SF6 technology on breaker design	3.4.4	Electrical lifetime monitoring
2.2.1	Comparison of VCB/SF6 CB of a typical 72.5 kV live tank circuit breaker	3.4.5	Supervision of gas pressure/level of SF6 CB
2.2.1.1	Drive energy	3.4.6	Loss of vacuum in vacuum interrupters
2.2.1.2	Size	3.4.7	Supervision of vacuum state of interrupter
2.2.1.3	Costs	3.4.8	X-ray emission
2.2.2	Impact of VCB / SF6 technologies on customer specifications	3.4.9	Low-temperature without operation of circuit breakers
2.2.2.1	Voltage level	4	EXISTING EXPERIENCE
2.2.2.2	Normal current	4.1	Japanese experience
2.2.2.3	Short circuit current	4.1.1	Numbers and types of installed HV VCB
2.2.2.4	Steep TRV withstand capability	4.1.2	Application of HV VCB
2.2.2.5	Number of operations	4.1.3	Concerns on the application of HV VCB
2.3	State of the art	4.1.4	Reliability of HV VCB
3	DIFFERENCES BETWEEN SF6 – VACUUM: SYSTEM IMPLICATIONS	4.1.5	Application Cases
3.1	Overall service experience	4.2	Recent past projects outside of Japan
3.1.1	Existing service experience of vacuum in medium voltage	4.2.1	HV vacuum circuit breakers
3.1.2	Number of units in the field	4.2.1.1	China
		4.2.1.2	Europe/Canada/Australia/USA
		4.2.2	Vacuum load bank switches in USA
		5	EXPECTATIONS, HESITATIONS OF APPLICATION ON HV VCB IN FUTURE
		5.1	Context of inquiry
		5.2	Participants
		5.3	Numerical results
		5.3.1	Technology considerations
		5.3.2	Experience with HV VCB and future considerations
		5.3.3	Financial considerations on implementing HV VCB
		5.4	Comments
		6	PRODUCTS ON THE MARKET AND IN DEVELOPMENT
		6.1	China
		6.2	Europe
		6.3	Russia
		6.4	Japan
		6.5	North America
		7	STANDARDIZATION AND TESTING



Characteristics of Various Gas Mixture

	Sulfur-hexafluoride	Clean-Air	Carbon Dioxide and Oxygen	C4-Fluoronitrile	C5-Fluoroketone	
Base Gas	Chemical Formula	SF_6	80% N_2 + 20% O_2	70% CO_2 + 30% O_2	$(CF_3)_2CFCN$	$(CF_3)_2CFC(O)CF_3$
	CO_2 (GWP)	23,500	0	<1	2,210	1
	Boiling Point	-64°C	<-183°C	-50C	-5°C	+27°C
	Dielectric Strength	1.00	0.43	0.77	2.20	1.70
Gas Mixture	Background (gases)	Pure or with N_2 or CF_4	80% N_2 + 20% O_2	70% CO_2 + 30% O_2	~90% CO_2	~90% O_2 With N_2 or CO_2
	CO_2 (GWP)	23,500	0	<1	~380	<1
	Lowest Operating Temperature	-30°C *	-50°C	-50C	-30°C	0°C to +5°C -20°C possible
Internal Arc Reaction	Decomposition Products	HF, S_2F_6 , SOF_2 , F_2 , SO_2 , CF_4	If applicable: O_2 , NO_x	CO, HF, O_2	CO, HF, C_nF_{2n+2} , other Fluorinated Compounds	CO, HF, COF_2 , C_nF_n , other Fluorinated Compounds
	Toxicity of Decomposition Products	Slightly toxic (Hodge-Sterner)	Typically None	Relatively harmless (Hodge-Sterner)	Practically non-toxic (Hodge-Sterner)	Practically non-toxic (Hodge-Sterner)

5. 15 years of HV - VCB experience in North America.



The biggest HV Utilities are transitioning to new HV Vacuum Circuit Breakers using vacuum bottles as interrupters and clean air as insulating medium to eliminate the potent greenhouse gas.

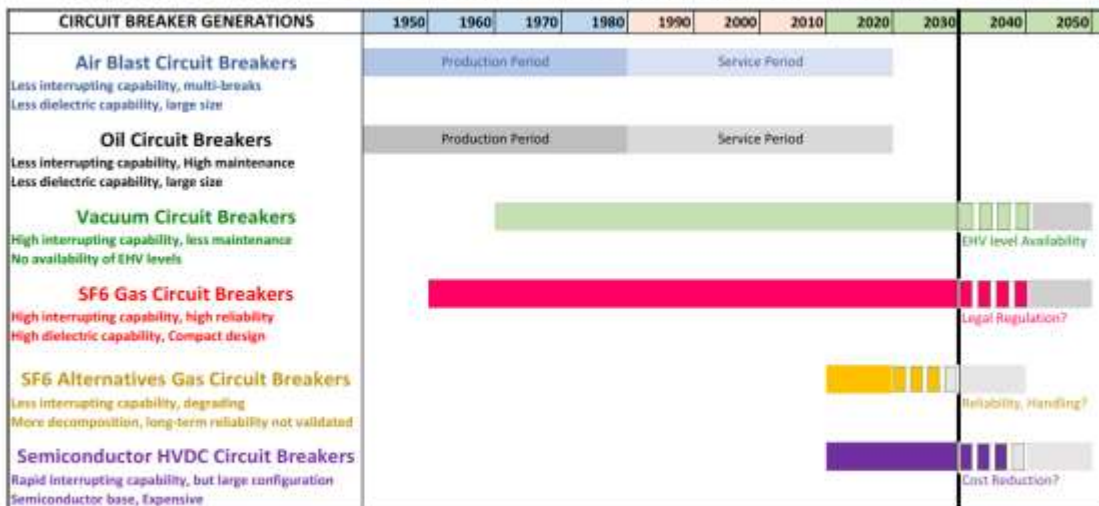
1. Transition to New Power Systems with Clean and No-CO₂ Energy

- Utilities to perform the major tasks for Building a **New Power Systems**.
- Transition to New Power Systems with **Clean and No-carbon Energy** using 3 directions:

CIGRE 2021 Observations: “Decarbonization, Digitalization, Resiliency”



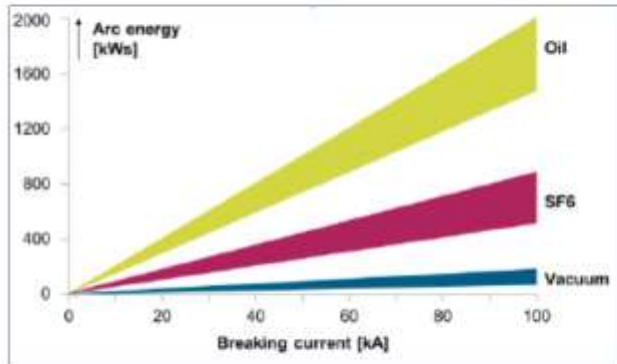
Circuit Breakers Generations according to CIGRE A3 – T&D



The next generation Circuit Breakers are **Vacuum Circuit Breakers**



Arc Energy Competition and VCB Advantages



1. Excellent interrupting performance
2. High number of operations
3. High reliability industry wide
4. Low temperature limits
5. Minimum maintenance.

Future trends on VCB Development

1. Expansion of voltage class networks;
2. Increasing RCC to 3000 A at 50°C ambient temperature;
3. Increasing RSCC to 50 kA and 63 kA ($X/R > 17$);
4. Reducing maintenance by implementing Monitoring;
5. New VI technology without bellow (Self Actuating Vacuum Interrupter - SAVI).

Proposal to IEEE HVCB Subcommittee:

To form a Working Group for studying and reporting the present and future developments of vacuum technology for application to switching devices

April 13, 2022



Vacuum Technology is predominant in MV networks



Developments of HV-VCBs



DT- VCB 204 kV (SF6)



LT- VCB 145 kV



LT- VCB 145 kV



DT - VCB 72.5 kV

Developments of V-GIS (DAIS) (as SF6 Alternative).



Siemens V-GIS-145 kV

First vacuum GIS with
clean air 145 kV
Type: 8VN1 145 kV / 40
kA with vacuum CB and
clean air-insulation
References: 155 bays



Meiden V-GIS-145 kV