# Performance Characteristics Subcommittee (PCS)

**March 22nd, 2023, Hyatt Regency, Milwaukee, WI**

**UNAPPROVED MINUTES**

**Chair: Rogerio Verdolin**

**Vice Chair: Sanjib Som**

**Secretary: Kris Zibert**

## Introduction / Attendance

Quorum was achieved with 70 members present (66% in attendance). In addition, 98 guests were present at the meeting.  The total attendance at the meeting was 168. Guests should contact the Vice Chair to request membership. Their requests for membership and past attendance will be reviewed. If they meet the membership requirements, they will be granted membership before the next meeting in Kansas City, Missouri, October 22-26, 2023.

## Chairman’s Remarks

The Chair was unable to attend so the Vice Chair gave the Chairman’s Remarks.

The Vice Chair introduced himself and secretary and provided the below updates and comments.

The Vice Chair discussed that the meeting would be recorded for minutes purposes and then deleted.

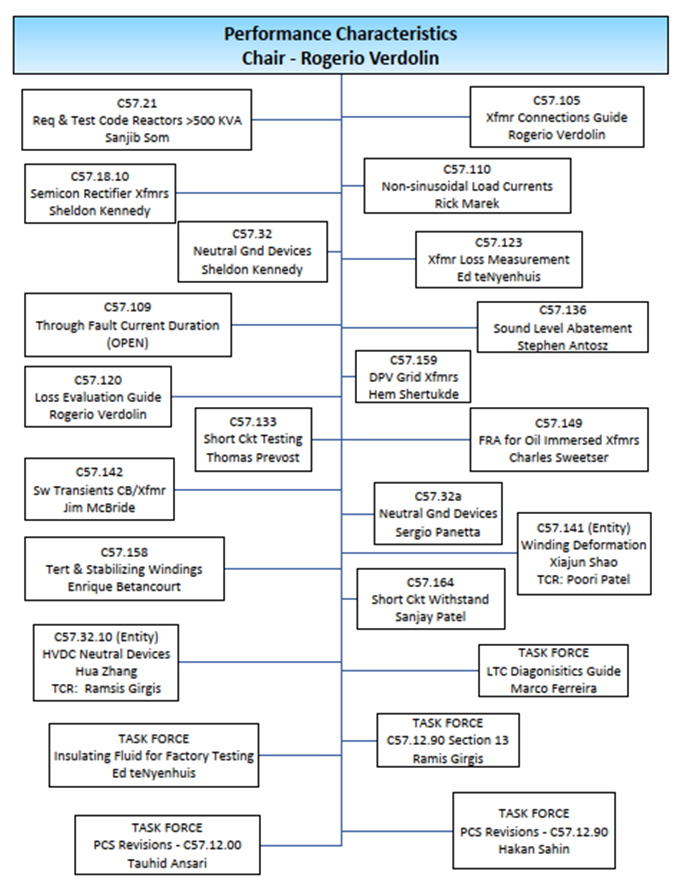
The Vice Chair asked anyone with new business to submit in writing prior to the meeting.

**PCS Responsibilities:** Defined by the Transformers Committee Organization and Procedures Manual.

The Performance Characteristics Subcommittee shall be responsible for the following:

* Studying and reviewing the treatment of loss, impedance, exciting current, inrush current audible sound and vibration, and other performance characteristics and their methods of application, measurement, or test for liquid filled transformers and liquid filled and dry type reactors.
* Studying and reviewing the treatment of the performance characteristics of other special use transformers e.g. photovoltaic, wind, and rectifier transformers.
* Developing and maintaining related standards, recommended practices, and guides for such criteria
* Coordinating with other technical committees, groups, societies, and associations as required

**Standards Supported by PCS:**



* C57.12.00 – TF to provide PCS revisions – T. Ansari
* C57.12.90-2015 – TF to provide PCS revisions – H. Sahin (test code) & R. Girgis (audible sound)
* C57.18.10 – Semiconductor rectifier transformers – S. Kennedy
* C57.21 – Requirements & Test Code For Shunt Reactors >500kVA – S. Som
* C57.32-2015 – Neutral Grounding Devices (2025) – S. Kennedy
* C57.32a – Neutral grounding devices – S. Panetta
* C57.32.10 - new Entity PAR - WG Neutral Grounding Reactors Guide for HVDC Converter Transformers – H. Zhang (TCR: R. Girgis)
* C57.105 – Transformer connections guide – R. Verdolin
* C57.109 – Through Fault Current Duration – OPEN
* C57.110 – Xfrmr Capability when Supplying Nonsinusoidal Load Currents – R. Marek
* C57.120 – Guide for loss evaluation – R. Verdolin
* C57.123 – Transformer Loss Measurement – E. teNyenhuis
* C57.133-exp – Guide for Short Circuit Testing (Expired – now covered by C57.12.90) – T. Prevost
* C57.136 – Sound Abatement Guide – S. Antosz
* C57.141 - Entity - Winding Deformation – X. Shao (TCR: P. Patel)
* C57.142 – Switching Transients Circuit breaker/Transformer – J. McBride
* C57.149 – New SFRA Guide (2022) – C. Sweetser
* C57.158 – Tertiary & Stabilizing Windings (2027) – E. Betancourt
* C57.159 – DPV Transformers (2026) – H. Shertukde
* C57.164 – Short Circuit Withstand (in development) – S. Patel
* TF for Insulating Fluid for Factory Testing – E. teNyenhuis
* TF for LTC Diagnostics Guide – M. Ferreira
* 60076-16 – Wind Turbine Generator Transformers – P. Hopkinson

**Status of Active PAR’s:**

* 2022 PAR’s
  + C57.32.10 Entity WG Guide for the Selection of Neutral-Grounding Devices for HVDC Converter Transformers (PAR Extension Requested)
  + C57.149 SFRA Guide (PAR Extension Requested)
* 2023 PAR’s
  + C57.142 Transient Guide (Ballot Invitation Complete)
* 2024 PAR’s
  + C57.105-2019/Cor 1 (New WG)
  + C57.149 SFRA Guide (Ballot Invitation Complete)
* 2025 PAR’s
  + C57.136 Audible Sound Guide (Recirc Ballot Complete)
  + C57.141 Entity WG Guide for Detection, Monitoring and Evaluation of Winding Deformation
* 2027 PAR’s
  + C57.32 Neutral Grounding Devices (New WG)

**Status of Standards without active PARs**

* C57.159-2016 – DPV Transformers (2026)
* C57.120-2017 – Loss Evaluation Guide (2027)
* C57.158-2017 – Application of Tertiary and Stabilizing Windings Guide (2027)
* 60076-16-2018 – Wind Turbine Generator Transformers (2028)
* C57.109-2018 – Through Fault Current Duration (2028)
* C57.110-2018 – Xfrmr Capability when Supplying Nonsinusoidal Loads (2028)
* C57.105-2019 – Transformer connections guide (2029)
* C57.123-2019 – Loss Measurement Guide (2029)
* C57.164-2021 – Short Circuit Withstand Guide (2031)
* C57.21-2021 – Shunt Reactors over 500kVA (2031)
* C57.18.10-2021 – Semiconductor Rectifier Transformers (2031)

**Performance Characteristics Subcommittee Membership Requirements**

* Voting membership may be requested and granted after attending three of the last five meetings.
* If a voting member misses two consecutive meetings, his or her voting privileges may be revoked. Notification will be sent if voting privileges are revoked.
* Refer to TC P&P 4.3.1 for more information.

**Performance Characteristics Subcommittee WG / TF Leaders**

* Issue agenda at least 30 days ahead of time
* Minutes are due in 15 days, please get a rough draft of them to us today in MS Word (not PDF) format
* Please keep your webpages up to date – review regularly and send any content/files to tc-webmaster@ieee.org.
* A patent and copyright call must occur at every WG/TF meeting

**Performance Characteristics Subcommittee Meeting Minutes**

* Name of the group, time, date, and location of meeting
* Officers’ names, meeting participants, and member status
* Chair’s remarks and reminders of IEEE policies (Patent and Copyright)
* Approval of minutes of previous meeting and agenda
* Technical topics: Brief summary (discussions and conclusions, motions exactly as they are stated, including the names of mover and seconder, and the outcome of each motion)
* Action items, items reported out of executive session
* Recesses and time of final adjournment
* Next meeting—date, time, and location

**WG / TF Balloting Reminder**

* Working Groups must achieve a 2/3 majority to submit a document for Sponsor Ballot.
* The Subcommittee must achieve a simple majority to submit a document for Sponsor Ballot.

**Attendance / Membership – moved to Guest status**

The following 7 Members missed the past 2 meetings and have been moved to “Guest” status:

|  |  |
| --- | --- |
| * Raj Ahuja * Florian Faur * Said Hachichi * Brian Penny | * Mohmed Ali Masood Cheema * Marcos Ferreira * Vinay Mehrotra |

Please contact Sanjib by sending him a message or see him after the meeting if you believe your membership status is not accurate.

**Attendance / Membership – New Members**

The following Guests requested membership at the Fall 2022 meeting and have attended the past 2 of the last 3 meetings.

|  |  |
| --- | --- |
| * Steven Brzoznowski * Sarama Hoffman * Markus Schiessl | * David Caverly * Ramadan Issack * David Wallach |

**Attendance / Membership – Quorum determination**

* Current breakdown of the Subcommittee:
  + 106 Members
  + 54 are needed for a quorum
* Quorum was established with 71 members in attendance.

## Approval of Agenda

The Chair presented the agenda and entertained a motion to approve. The agenda had been sent to the members by email several weeks prior to the meeting. The motion was made by H. Shertukde and seconded by T. Ansari. The motion passed by unanimous consent.

## Approval of Last Meeting Minutes

The Chair presented the minutes of meeting held in October 2022 and entertained a motion to approve. The minutes had been sent to the members by email several weeks prior to the meeting. The motion was made by M. Roussell and seconded by A. Chakraborty. The motion passed by unanimous consent.

## Minutes from Working Groups and Task Force

The following WG and Task Force reports were received (the reports are appended later).

* **WG Guide for FRA for Liquid Filled Transformers C57.149 Charles Sweetser**
* **WG IEEE Neutral Grounding Devices PC57.32 Sheldon Kennedy**
* **TF Audible Sound Revs & WG Sound Guide C57.136 (S. Antosz) Ramsis Girgis**
* **TF Continuous Revisions to C57.12.00 Tauhid Ansari**
* **TF Continuous Revisions to Test Code C57.12.90 Hakan Sahin**
* **WG Sw Transients Ind by TR/Bkr Interaction PC57.142 Jim McBride**

Below are highlights that were discussed at the PCS meeting:

1. **WG Guide for FRA for Liquid Filled Transformers C57.149 C. Sweetser**

**Highlights**:

Meeting held Monday at 9:30 AM

* 62 in attendance, 31 members on the roster, 17 members attended, a quorum was achieved.
* The PAR is extended to 2024. Currently in ballot process. Mandatory Editorial Coordination (MEC) and ballot invitation are complete.
* Created Ballot Resolution Group that will address comments after first ballot is circulated.

1. **WG IEEE Neutral Grounding Devices PC57.32 S. Kennedy**

* This is the first meeting of the WG: 27 attendees; 24 requested membership.
* IEEE Patent Policy Slides and Code of Conduct presented
* Introduction of WG officers
* Presentation of Agenda and Minutes from Fall 2022 TF Meeting (approved without objection)
* The Chair requested volunteers for each device covered within the standard and created the following task force leadership:
  + Neutral Grounding Reactors – Camilo Casallas / Saif Hossain
  + Ground Fault Neutralizers – Klaus Pointner
  + Neutral Grounding Transformers – Don Ayers / Jusuf Krvavac
  + Neutral Grounding Resistors – Ryan Hogg / Sergio Panetta / Jusuf Krvavac
  + Combinational Devices – Sergio Panetta
* New Business – liaison with CSA, IEC and other TC groups (C57.12.00 / 12.90, etc.)
* Meeting adjourned at 5:55 PM

1. **TF on PCS Continuous Revisions to C57.12.00 T. Ansari**

Meeting Date / Time : March 20, 2023, @ 3:15PM to 4:30PM

* 86 total attendees, consisting of 36 Members (out of 58) and 50 Guests; a quorum was established; 17 Guests requested membership.

**Highlights:**

* Old Business
  + WG Item 112, Clarification on ±0.5% tolerance of ratio of three phase transformer, originally submitted by Ryan Hogg.
    - Work is not completed. Discussion will resume in next meeting.
  + WG Item 113, Measurement of auxiliary loss, originally submitted by Ajith Varghese: Some disconnect noticed between what different manufactures are doing for measuring auxiliary and control losses – based on how “integral parts of transformers” is interpreted.
    - It was determined the auxiliary losses need to be split. TF was not prepared to do this at the present meeting. A meeting invitation was sent to Utilities and manufacturers; three meetings are scheduled. Verbiage will be established after these meetings and discussed at the next meeting.
* New Business
  + Andrew Larison from Hitachi suggested adding Section 4.1.10 on DC current injection limit on the distribution transformer. R. Girgis presented TF needs to think about the percentage and the DC current injection limit based on differences in current injection. R. Girgis accepted the request to do more work on it. He will present next meeting.
  + New business was brought to the TF by Ryan to address Table 11 of Section 7. The kVA is different from single phase to three phase. It does not match in two rows. S. Patel mentioned a calculation to come up with it. E. teNyenhuis researched and found we have had this table since 1987. TF will address this at the next meeting.
* The meeting was adjourned at 4:30.

1. **WG on Noise Guide C57.136 S. Antosz**

* Went to ballot at the end of November and closed February 3, 2023, with a 75% return rate (77 of 102) and 98% approval rate (70 approve; 1 disapprove; 6 abstentions).
* 59 comments received and worked through by Ballot Resolution Group (BRG) consisting of working group officers.
* The significant technical comments from the initial ballot were presented for discussion at the WG meeting in Milwaukee.
* New draft was created and recirculated February 27, 2023, with 100% approval rate.
* Two minor comments received from recirc. No additional recirc needed. The guide is finalized and will be submitted to REVCOM.
* This meeting was the last meeting of the working group.
* The WG met as scheduled. The meeting was attended by 32 members (out of 46), and 30 guests, for a total of 87 persons. A quorum was established with 32 / 46 = 70% attendance. The agenda was unanimously approved as was the unapproved minutes from the previous meeting.

1. **TF C57.12.90 Cont. Revision to Audible Sound R. Girgis**

* Received three comments from original ballot. R. Girgis presented text to address these comments at the scheduled TF meeting.
* First comment regarded no load noise. R. Girgis proposed text for the change, and it was accepted with some changes.
* No standard currently exists for averaging sound pressure measurements. TF decided to add ambient sound pressure measurements logarithmically. There was a request to add the equation for the calculations. This equation will be added to the revision.
* The third comment addressed that there is no current standard for measuring load audible sound level for ONAN-rated transformers. A statement was added to measure ONAN-rated transformers at the ONAN measuring contour.
* Barry Beaster, TF secretary, submitted his resignation. Mats Bernesjo is the new secretary of the TF.
* A motion was suggested to pass the changes made by the TF upon presentation of exact verbiage.

1. **TF on Inverter Transf Precautions on Ground Shields C57.159 P. Hopkinson**

**Highlights:**

* Second meeting held on Monday 3/20/23, 4:45 PM
* 100+ attendees
* 2 main issues discussed:
  + Transformers with Y inputs and grounded neutrals failed
  + Moving this activity into C57.159
* P. Hopkinson made a motion and D. Sauer seconded to revise C57.159. It became evident that a revision would not satisfy all of the task force’s desires. D. Sauer made a motion and K. Zibert seconded to table indefinitely. D. Sauer moved the previous question with K. Zibert seconding. Motion passed by a show of hands. The motion to table indefinitely passed by unanimous consent.
* Task force will go back and perform a study to create a title, purpose and scope for a revision to C57.159 and bring back a motion to the subcommittee to get a PAR.

1. **TF on PCS Continuous Revisions to Test Code C57.12.90 H. Sahin**

* Meeting held at 9:30 am to 10:25 am.
* Total attendance = 109
* Members = 27/58; No quorum, Guests = 82
* All old businesses were concluded. TF reviewed Clause “5.1 Determination of cold temperature” with a possibility of bringing clarity to the method for temperature measurement for cold resistance. TF agreed to continue to work on this and propose a revision for next meeting.
* No new business.

1. **WG on HV & EHV Breaker & Transformer Sw. Transients C57.142 J. McBride**

* Quorum not achieved (23/46 Members present). 67 guests with 11 requesting membership.
* Agenda was approved. The minutes of Fall 2022 meeting were also approved.
* New Draft 11 created from the 305 comments received from ballot. Draft 11 addresses 276 comments.
* Comment Resolution Group went over 29 remaining comments. Group has members from both the Transformers and Switchgear Committees.
* Six of the 29 unaddressed comments were presented and discussed. A proposed resolution to most of these comments was agreed on by those in attendance. Based on discussions, we have approximately 23 comments and 10 figures to resolve and update.
* Mitigation Methods Task Force Update – the full list of mitigation methods were presented. Further consideration is being given to adding *“Redesign of transformers to move resonant point”* as a mitigation method. A suggestion was made to develop a presentation to communicate these methods to the Dielectric Test and Performance Characteristics Subcommittees.
* Meeting adjourned at 12:15 PM.

## Unfinished (Old) Business

**Study Group for Continuous Unbalanced Current Operation (Chair: Enrique Betancourt)**

* The Group did not meet; the Chair needs to prepare a “critical mass of information” with support of more volunteers before the first meeting.
* Objective of the Group is “To investigate about relevance of considering continuous unbalanced loading of power transformers as subject of standardization within IEEETC”
* Background
  + Power transformers at generation/transmission levels operate with “balanced” currents, as rotary generators can withstand limited amount of unbalance of line currents (in order of a few %).
  + Two types of load unbalance: line-to-line and line-to-neutral; the latter might have impact on transformers (zero-sequence flux). Distribution networks operators deal with this issue at low-power level (see, for instance NREL Rep. “Modeling and Testing of Unbalanced Loading and Voltage Regulation”, 2007).
  + Some utility representatives believe that electronic converters would eventually be capable to maintain large-power delivery under unbalanced conditions.
* Highlights
  + C57.12.00 does not consider continuous unbalanced loading as abnormal operating conditions (IEC 60076-1 does consider it); it however provides criteria for default dimensioning of stabilizing windings, in case loading not specified.
  + C57.105 and other documents provide recommendations related to unbalanced loading of specific, sensitive transformer connections.
  + IEEE On-Line Dictionary includes definition for “unbalanced loading” taken from Std. C57.158-2017.
* Next Steps
  + “Unbalanced loading” survey among PCS.
  + Confirm relevance of available information to form a TF (identify co-Chair and Secretary). **On-line meeting** with participation of interested individuals (please send e-mail to [ebetanco@ieee.org](mailto:ebetanco@ieee.org), before April 30, 2023).

## New Business

* E. Betancourt made a motion to approve creating a PAR for a revision to C57.158, seconded by J. McBride. Motion passed by unanimous consent.
* J. Kazmierczak made a motion to create a Task Force to form a PAR study group to look at creating a new guide that covers CO2 emissions in the construction of transformers. Seconded by T. Ansari.
  + Discussion was had revolving around what the definition of CO2 emissions are, if it belongs in this Subcommittee, etc.
  + After discussion a vote was held and the motion passed by a show of hands.

## Adjournment

* The meeting was adjourned at 4:15PM**.**

## Minutes of Meetings of Working Group (WG) and Task Force (TF) Reports (all unapproved)

### WG Guide for FRA for Liquid Filled Transformers C57.149

**Working Group “Guide for FRA for Liquid-Filled Transformers” C57.149**

**(Performance Characteristics Sub-Committee)**

Meeting Date/Time: March 20, 2023 0930 H

Meeting Location: Milwaukee, WI

Chairman: Charles Sweetser [CS] (Omicron)

Vice-Chair: Poorvi Patel (EPRI)

Secretary: James Cross (Kinectrics)

Meeting was convened at 0930 H by Chairman Charles Sweetser with 62 total attendees, consisting of 17 members and 45 guests. A quorum (17/31) was achieved.

AGENDA

1. Introductions and Attendance Sheets

2. IEEE-SA Standards Board Bylaws on Patents in Standards

3. Approval of Minutes from October 17, 2023

4. Approval of Agenda

5. Discussions

1. Ballot Process Update
2. Seeking motion to create Ballot Resolution Group

7. Old Business

8. New Business

9. Adjourn

CS reviewed the IEEE Working Group meeting guidelines and the standard patent disclosure info. (No response from attendees to request for patent info.)

The membership list shows 31 WG members.

The agenda and minutes were approved:

Agenda - Diego Robalino moved; seconded Paminder Panesar, carried unanimously.

Minutes - Mickel Saad moved; seconded by Diego Robalino, carried unanimously.

Noted Discussions:

CS reviewed the editorial changes required by MEC.

1. Updating all dates in the copyright statements on the first page, the header, and the footer.
2. Reviewing and revising the use of ensure, ensuring, and minimize.
3. Add the new mandatory Word Usage subclause in Clause 1.

CS reviewed the results of the Ballot Invitation. 102 joined the group and it is balanced.

Motion to create a ballot resolution group:

Mani Kumar moved; seconded Mario Locarno, carried unanimously.

The following individuals have volunteered for the BRG: Wes Schrom, Mario Locarno, Diego Robalino, Kumar Mani, Evgenii Ermakov, Rakesh Patel, Abdulmajid Shaikh

Meeting adjourned at 0950 H

List of meeting participants with membership status at the end of the meeting:

Charles Sweetser Omicron Member

Poorvi Patel EPRI Member

James Cross Kinectrics Member

Fernando Leal Prolec GE Member

Mario Locarno Doble Member

Akash Joshi Mott MacDonald Member

Will Knapek Omicron Member

Jonathan Sinclair PPL Member

Scott Reed MVA Member

Kumar Mani Duke Energy Member

Evgenii Ermakov Hitachi Energy Member

Ajith Varghese Prolec GE Member

Diego Robalino Megger Member

Mickel Saad Hitachi Energy Member

Parminder Panesar Virginia Transformer Member

James McBride JMX High Voltage Member

Ismail Guner Hydro Quebec Member

Anthony Natale HICO

Brian Sparling Dynamic Ratings

Marco Espindola Hitachi Energy

Eric Davis Burns & McDonnell

Qasim Khan NEETRAC-GT

Bernard LaBean Consumers Energy

Raymond Frazier Ameren

Michael Richardson Ameren

Daniel Crockett Ameren

Cole Van Dreel ATC

Alaor Scardazzi Siemens Energy

Justin Mimikel Eaton

Roger Hayes GE Grid Solutions

Tommy Spitzer City Transformer

Deanna Woods Alliant Energy

Mauricio Soto Hitachi Energy

Kayland Adams Waukesha

Kannan Veeran Virginia Transformer

Thrinadha Katapalli Virginia Transformer

Jesse Duffy Nashville Electric Service

Cameron Vant Prolec GE

Vivek Bhatt Prolec GE

Jusuf Krvavac Sargent & Lundy

Bertrand Poulin Hitachi Energy

Chris Slattery First Energy

Stephanie Denzer Weidmann

Brian McBride Cargill

Eduardo Tolcachir TTE

Monil Patel PG&E

Jorge Cantu Alliant Energy

Bruce Forsyth Bruce Forsyth and Associates, LLC

Abdulmajid Shaikh Delta Star

Kevin Wirtz Cargill

Drew Welton Intellirent

Lorna Gara Shermco

Juliano Montanha Siemens Energy

Polo Orozco GE Grid Solutions

Salahuddin Shaikh Hitachi Energy

Duvier Bedoya Hitachi Energy

Evan Knapp Eaton

Rakesh Patel Hitachi Energy

Rich Frye Eaton

Alex Alahmed Evergy

Gabriel Mamede Siemens Energy

Fabian Stacy Hitachi Energy

Respectfully submitted,

Charles Sweetser

Chair

C57.149 WG

### WG PC57.32 Neutral Grounding Devices

**IEEE Neutral Grounding Devices Working Group Meeting**

Meeting Date/Time: March 21, 2023 4:45 PM – 6:00 PM

Meeting Location: Milwaukee, Wisconsin

Chairman: Sheldon P. Kennedy

Vice-Chair: Thomas Melle

Secretary: Ed teNyenhuis

1. Welcome and Chair’s Remarks
2. Circulation of attendance sheets. (Quorum achieved – 25 of 25 new Members; 2 Guests present)
3. Patent Call
4. Copyright and IEEE Ethics Policies
5. Approval of minutes from previous Task Force. (Motion to approve by Don Ayers, Second by Klaus Pointner – motion passed without objection)
6. Introduction of New Officers and WG
7. Review of PAR Approval from NESCOM
8. TF Leader Assignments

**Neutral Grounding Reactors –** Camilo Casallas, Saif Hossain

**Neutral Ground Fault Neutralizers –** Klaus Pointner, Sheldon Kennedy

**Neutral Grounding Transformers –** Don Ayers, Jusuf Krvavac

**Neutral Grounding Resistors –** Ryan Hogg, Sergio Panetta

**Combinational Devices -** Sergio Panetta, Jusuf Krvavac

1. Old Business

Reminder that all IEEE Standards and Guides require permission for drawings and diagrams. The approval forms can be downloaded from IEEE.org per Maria Zaman.

1. New Business
   * + Preliminary discussions of different test sections including impedance of zig-zag transformers (Sergio Panetta); relationship of HVDC and instrument transformers to NGT’s and the possible inclusion of the effects of switching transients in the new Standard (Jim McBride and Tom Melle).

- Brief discussion of the importance of the test sections of C57.12.00 and 12.90. Further discussion of whether it may be possible to create a single section for all tables containing test voltages; the Vice-Chair and Chair commented that this was considered in the prior revision of the Standard and found to be difficult considering the variety of Neutral Grounding Devices.

- Brief discussion of relationship to CSA (C22.2 No. 295-15, Neutral Grounding Devices) and IEC (60076-25:2023, Neutral Grounding Resistors). Each TF will review relevant standards and guides.

- The incorporation of active Ground Fault Neutralizers will be looked into by the GFN TF (Klaus Pointner)

- Future remote meeting notices will be clarified and posted on the WG website

1. Next in-person meeting – Fall 2023 (IEEE TC October 23rd-26th in Kansas City, MO)
2. Adjournment at 6 PM CDT (motion by Don Ayers; Seconded by Sergio Panetta)

List of Meeting Attendees from Spring 2023 meeting (including affiliation & member status).

Anton Koshel Delta Star Guest

Areeb Wazir Eaton Guest

Sheldon Kennedy Niagara Transformer Chair

Thomas Melle HIGHVOLT Vice-Chair

Robert Arritt EPRI Member

Donald Ayers Ayers Consulting Member

Sankey Bolar ONCOR Member

Susan Bonfiglio WAPA Member

Camilo Casallas Trench Ltd. Member

Arup Chakraborty Delta Star Member

Juan Carlos Cruz Valdes Prolec-GE Waukesha Member

Huan Dinh Hitachi Energy Member

Ryan Hogg Bureau of Reclamation Member

Darren Hoppins SensorLink Guest

Saif Hossain Trench Ltd. Member

Jusuf Krvavac Sargent & Lundy Member

Jim McBride JMX High Voltage Member

Sergio Panetta I-Gard Corp. Member

Klaus Pointner Trench Austria Member

Ulf Radbrandt Hitachi Energy Member

Kyle Stechschulte AEP Member

Mike Sharp Trench Ltd. Member

Cody Vanwyck Commonwealth Associates Member

Trenton Williams Advanced Power Technologies Member

Alan Washburn Burns & McDonnell Member

Maria Zaman IEEE Guest

Kris Zibert Allgeier, Martin & Assoc. Member

### TF PCS Continuous Revisions to Test Code C57.12.90

**Working Group “PCS Task Force Continuous Revision to Test Code C57.12.90”**

**(Performance Characteristics Sub-Committee Working Group Report)**

Meeting Date/Time: March 21, 2023 9:30 AM – 10:45 AM

Meeting Location: Milwaukee, Wisconsin

Chairman: Hakan Sahin

Vice-Chair: Pugal Selvaraj

Secretary: Adam Sewell

Meeting was called to order at 9:30 AM, March 21, 2023.

1. Administrative
   1. IEEE Patent Policy and Call for Patents and IEEE SA Copyright Policy
      1. No comments from group
   2. Review of Spring 2023 agenda
      1. No comments from group
   3. Introductions of the attendees
      1. Attendance sheets were passed out. Due to time constraints, chair did not have each attendee announce their name/affiliation. Name/affiliation was announced as attendees spoke during the meeting.
      2. Secretary asked all who wanted on email distribution for the C57.12.90 PCS Task Force to send him an email at: adamsewell@ieee.org
   4. Updated membership review and count for quorum
      1. 58 members were listed and 23 were counted as present by hand count. Based on the hand count, the chair announced there was NO QUORUM for this meeting.
      2. Attendance sheets after meeting completed showing 26 members attended.
      3. **Members are expected to attend and stay in the meeting so business can be conducted.**
      4. **Member requests should be sent to secretary –** [**adamsewell@ieee.org**](mailto:adamsewell@ieee.org)
   5. Approvals needed but not made due to lack of quorum – chair will email out to members for approval:
      1. Spring 2022 unapproved minutes
      2. Fall 2022 unapproved minutes
      3. Spring 2023 agenda
2. Old Business
   1. All old businesses were completed and no additional new business was brought up from the group
3. New Business
   1. Chair opened up discussion on “Clause 5.1: Determination of cold temperature” with a possibility of bringing clarity to the tools and methods for temperature measurement for cold resistance to clarify the verbiage; “As accurately as possible”, as seen below from the current document.

Graphical user interface, text, application

Description automatically generated with medium confidence

Group agreed to continue to work on this and propose a revision.

* + 1. Task force – Hakan Sahin, Kerwin Stretch, Leopoldo Rodriguez
  1. Kumar Mani brought up a question/discussion about “Insulation Resistance Test” values to be added to the “Certified Test Report”. Group agreed that this goes under C57.12.00

1. Membership changes
   1. Officers will look at attendance of members and change membership based on attendance before Fall 2023 meeting.
   2. Secretary will work on completing missing information from attendance lists and email lists for this task force until new IEEE TC membership system is functional.
2. **Next meeting: October 24, 2023, at Fall 2023 Transformer Committee Meeting scheduled for October 22-26, 2023, Kansas City, MO, USA.**
3. Close of meeting
   1. Meeting adjourned at 10:45am
4. Attendee’s list is provided in Annexure - A

Submitted by: Hakan Sahin Date: 04/08/2023

**Meeting Attendance:**

Kayland Adams Prolec-GE Waukesha Guest-RM2

Alex Alahmed Evergy Guest-RM1

Tauhid Ansari Hitachi Energy Guest

Stephen Antosz Stephen Antosz & Associates, Inc. Member

Elise Arnold SGB Member

Javier Arteaga Hitachi Energy Member

Alex Ayala Power Partners Guest

Donald Ayers Ayers Transformer Consulting Member

Gilles Bargone FISO Technologies Inc. Guest-RM2

Chris Baumgartner We Energies Member

Duvier Bedoya Hitachi Energy Guest-RM2

Mats Bernesjo Hitachi Energy Guest-RM2

JeanNoel Berube Guest

Enrique Betancourt Prolec-GE Waukesha Guest

Daniel Blaydon Baltimore Gas & Electric Member

William Boettger Boettger Transformer Consulting LLC Member

Sanket Bolar Oncor Guest

Christopher Borck Eaton Guest

Michael Botti Hyosung HICO Guest-RM1

Darren Brown Howard Industries Guest

Jorge Cantu Alliant Energy Guest

Arup Chakraborty Delta Star Inc. Member

Vivian Chan Hitachi Energy Guest

Thomas Dauzat AEP Guest-RM2

Scott Digby Duke Energy Guest

Nikolaus Dillon Dominion Energy Guest

Jeffrey Door The H-J Family of Companies Guest

Jesse Duffy Nashville Electric Service Guest-RM2

Samragni Dutta Roy Siemens Energy Guest-RM2

William Elliott AEP Member

Qusai Elnimri Vantran Industries Guest

Marco Espindola Hitachi Energy Guest

Florin Faur Prolec-GE Waukesha Guest

Hugo Flores Hitachi Energy Member

Raymond Frazier Ameren Member

Richard Frye EATON Corporation Guest

Renjie Fu ERMCO Guest

Ramsis Girgis Hitachi Energy Member

Jeff Gragert Xcel Energy Guest

Bill Griesacker Duquesne Light Co. Member

Ravi Gupta Megger Guest-RM1

Michael Hall Mid Central Guest

Kyle Heiden EATON Corporation Guest

Giovanni Hernandez Virginia Transformer Corp. Guest

John Herron Raytech USA Member

Saramma Hoffman PPL Guest

Philip Hopkinson HVOLT Inc. Guest

Ramadan Issack AEP Guest-RM2

John John Virginia Transformer Corp. Member

Christopher Johnson Oncor Guest

Sheldon Kennedy Niagara Transformer Guest

Stacey Kessler Ulteig Transformer Guest

Duritriy Klempner Southern California Edison Guest

Anton Koshel Delta Star Inc. Guest

Bernard LaBean Jr. Consumers Energy Guest

Mark Lachman Doble Engineering Co. Member

Andrew Larison Hitachi Energy Guest

Fernando Leal Prolec-GE Waukesha Member

Weijun Li Braintree Electric Light Dept. Guest

Kumar Mani Duke Energy Guest

Kenneth McKinney UL LLC Guest

Kent Miller Retired Guest

Francis Mills Power Engineers Guest

Rhea Montpool Schneider Electric Guest

Tyler Morgan Duke Energy Guest-RM1

Marta Munoz Hitachi Energy Guest

Hugo Murillo The H-J Family of Companies Guest-RM1

David Murray TVA Member

Ismael Naja Eaton Guest-RM1

Dwight Parkinson EATON Corporation Guest

George Partyka PTI Transformers Guest

Monil Patel PG&E Guest-RM1

Sanjay Patel Smit Transformer Member

Vinay Patel Consolidated Edison Co. of NY Guest-RM1

Harry Pepe Phenix Technologies, Inc. Member

Sylvain Plante Hydro-Quebec Guest

Jarrod Prince ERMCO Guest

Ion Radu Hitachi Energy Member

Michael Richardson Ameren Guest

Leopoldo Rodriguez Transformer Testing Services LLC Guest

Hakan Sahin Virginia/Georgia Transformer Chair

Fernando Salinas Power Partners Guest

Albert Sanchez KUB Guest

Markus Schiessel SGB Member

Eric Schleismann Southern Company Guest-RM2

Dan Schwartz Quality Switch, Inc. Guest

Pugal Selvaraj Virginia Transformer Corp. Vice-Chair

Adam Sewell Quality Switch, Inc. Secretary

Jeremy Sewell Quality Switch, Inc. Guest

Jaber Shalabi Vantran Industries Guest-RM1

Mike Sharp Trench Ltd. Guest

Ibrahim Shteyh Shteyh Guest-RM1

Christopher Slattery FirstEnergy Corp. Guest-RM2

Sanjib Som Pennsylvania Transformer Guest-RM2

Andrew Steineman Delta Star Inc. Guest

Kerwin Stretch Siemens Energy Guest-RM2

Marc Taylor JFE Shoji Power Canada Inc. Guest

Ed teNyenhuis Hitachi Energy Member

Scott Thomas Hitachi Energy Guest

Reinaldo Valentin Duke Energy Guest

Cole Van Dreel American Transmission Company Guest-RM2

Jason Varnell Doble Engineering Co. Member

Pragnesh Vyas Sunbelt Solomon Guest-RM2

Shelby Walters Howard Industries Guest

Bruce Webb KUB Guest

Fei Yang Hitachi Energy Guest-RM1

Anand Zanwar Siemens Energy Guest

Waldemar Ziomek PTI Transformers Guest-RM2

### WG PC57.136 Noise Guide

**Unapproved Minutes of Spring 2023 WG IEEE PC57.136, “Guide for Audible Sound of Liquid-Immersed Power Transformers” and TF “Audible Sound Revision to Test Code”**

The WG and TF met at 1:45 PM, on Monday, March 20, 2023, as part of the WG PCS Guide for Audible Sound of Liquid-immersed Power Transformers and PSC Audible Sound Revision to Test Code.

Steve Antosz, Chairman of the WG presided over the meeting with Dr. Ramsis Girgis being the Vice-Chair, and Mats Bernesjo, Secretary.

The Chairman welcomed the audience to this meeting, reviewed the agenda, and initiated an applause thanking Barry Beaster for his many years of service as the secretary of the Task Force. He then announced that Mats Bernesjo is taking over this responsibility as the Secretary of the TF.

The WG meeting was attended by 32 out of 46 members and 30 Guests for a total meeting attendance of 87.

The agenda was unanimously approved as was the unapproved minutes of the Fall 2022 WG meeting in Charlotte.

The Chairman of the WG gave an update of status of the Noise Guide and commented on the last recirculation of the Guide, that was initiated February 27, 2022, for a 10-day duration. A few editorial changes were suggested and incorporated. The only previous negative vote on the ballot was changed into an “approve” vote. He reviewed several ballot comments that are technical in nature and the resolutions. With these final notes, the Chairman stated that the Guide will be finalized and submitted for publication by the WG Chair. He thanked everyone who participated in contributing to the Guide. He also announced that this was the last meeting of the WG as the work is finished. He then turned the podium over to Dr. Girgis for the second part of the meeting.

The TF meeting was attended by 23 out of 40 members and a total meeting attendance of 87. A quorum was established. Eight attendees requested membership at this meeting (listed below) \*\*. The agenda was unanimously approved as was the unapproved minutes of the fall meeting of the TF.

The Chairman then presented and discussed proposed text in response to 3 Technical Comments received when C57.12.90 was originally balloted. Below is the approved proposed text in response to these 3 comments. Note that the text in red is the proposed updated / added text:

**Item 1: Proposed modified text in response to comment on “Measuring no-load sound level at the highest sound producing tap position”**

*When measuring no-load audible sound level, the transformer shall be connected and energized at rated voltage and rated frequency and shall be at no load with the tap changer, if any, on the rated tap position, unless otherwise specified.*

*When a transformer is equipped with a tap changer, the transformer may, on certain tap changer positions, produce sound levels that are higher than the audible sound level at the rated tap position. For these transformers, the measurements shall be made with the transformer on the highest sound producing tap position.*

*Also, other excitation conditions may occur in service leading to lower, or higher, core noise. For example, transformers designed to operate with variable flux the core audible sound level is strongly impacted by the tapping position. The**same is true for SVC transformers when connected to a Capacitive Load; Again, for these transformers, the measurements shall be made with the transformer operating at the highest sound producing condition.*

**Item 2: Proposed modified text – Clause 13.5.5.1 Measuring ambient sound pressure level**

*The ambient sound shall be measured at a minimum of four locations around the transformer immediately preceding and immediately following the sound measurements with the transformer energized. The ambient sound pressure level shall be established by calculating the Logarithmic average of measured values of the ambient sound pressure levels. The measuring instruments shall be in conformance with ….*

**Item 3: Proposed text for Clause 13.3.3.2: Load audible sound level**

**Proposed added text in red**

*Since load audible sound becomes a contributor to the total audible sound of the transformer at higher loads, the load audible sound level shall be measured at the ONAF measuring contour.**For transformers with only an ONAN rating, load noise is to be measured at the ONAN Sound Measuring Contour.*

New business proposed by Ajith Varghese: Look into the IEC Wall Sound Reflection coefficient was developed based on some test results from Prolec GE Waukesha. Vice-Chair Steve Antosz requested that manufacturers of power transformers send him test data, in particular where measurements were made in two different test rooms.

*\*\* They are Gabriel Mamede (Siemens-Energy), Arup Chakraborty (Delta Star), Camilo Casallas (Trench), Subash Tuli (CT&RA), David Murray (TVA), Cole Van Dreel (AEP), Salahuddin Shaikh (Hitachi Energy), and Samson Debass (EPRI).*

With no new additional business raised, the meeting was adjourned upon unanimous approval.

Respectfully submitted,

Mats Bernesjo, WG / TF Secretary

Spring 2022 WG Meeting Attendance and Affiliation is as follows:

Kayland Adams Prolec-GE Waukesha Member

Alex AlAhmed Evergy Wolf Creek Guest

Carlos Alonso Arteche Guest

Stephen Antosz Stephen Antosz & Associates, Inc. Chair

Elise Arnold SGB Member

Donald Ayers Ayers Transformer Consultants Guest

Jason Beaudoin Weidmann Guest

Duvier Bedoya Hitachi Energy Guest

Mats Bernesjo Hitachi Energy Secretary

Enrique Betancourt Prolec-GE Waukesha Member

Edwin Betancourt Siemens Energy Guest

William Boettger Boettger Transformer Consulting LLC Member

Darren Brown Howard Industries Guest

Camilo Casallas Trench Limited Guest\*

Arup Chakraborty Delta Star Guest\*

Euhyoung Cho HICO America Guest

Daniel Crochett Ameren Guest

Juan Carlos Cruz Valdes Prolec-GE Waukesha Member

Juan Alfredo Cuyrizales Prolec-GE Waukesha Guest

Samson Debass EPRI Guest\*

Scott Digby Duke Energy Member

Jesse Duffy Nashville Electric Service Guest

Evgenii Ermakov Hitachi Energy Guest

Hugo Flores Hitachi Energy Member

Eduardo Garcia Wild Siemens Energy Member

Ramsis Girgis Hitachi Energy Vice-Chair

Ismail Guner Hydro-Quebec Member

Derek Hollrah Burns & McDonnell Guest

Saif Hossain Trench Ltd. – Siemens Energy Guest

Nicholas Jensen Delta Star Inc. Member

John John Virginia Transformer Corp. Member

Joshi Akash Mott MaeDonedal Member

Lee Junho Hyundai Electric Guest

Jerzy Kazmierczak Hitachi Energy Member

Zan Kiparizoski Howard Industries Member

Anton Koshel Delta Star Inc. Guest

Rafal Kowalski Hitachi Energy Guest

Mark Lachman Doble Guest

Fernando Leal Prolec-GE Waukesha Guest

So-young Lee Hyundai Electric Guest

Jose Machain Prolec-GE Waukesha Guest

Gabriel Mamede Siemens Energy Guest\*

Jim McBride JMX High Voltage Guest

Francis Mills Power Engineers Guest

Marta Munoz Hitachi Energy Guest

David Murray TVA Guest\*

Joe Nims Allen & Hoshall Guest

Sanjay Patel Smit Transformer Member

Poorvi Patel EPRI Guest

Monil Patel PG&E Guest

Klaus Pointner Trench Austria GmbH Member

Bertrand Poulin Hitachi Energy Member

Ulf Radbrandt Hitachi Energy Guest

Ion Radu Hitachi Energy Guest

Tim Rocque Prolec-GE Waukesha Guest

Leopoldo Rodriguez TTS Guest

Ronchi Rodrigo WEG Transformer Guest

Hakan Sahin Virginia/Georgia Transformer Member

Dinesh Sankarakurup Duke Energy Member

Daniel Sauer EATON Corporation Member

Markus Schiessl SGB Member

Eric Schleismann Southern Company Guest

Cihangir Sen Duke Energy Member

Abdulmajid Shaikh Delta Star Guest

Salahuddin Shaikh Hitachi Energy Guest\*

Michael Sharp Trench Ltd Canada Guest

Andre Simons JFE Shoji Member

Christopher Slattery FirstEnergy Corp. Member

Jonathan Snalgrass Texas A&M University Guest

Jason Snyder FirstEnergy Corp. Guest

Sanjib Som Pennsylvania Transformer Member

Andrew Steineman Delta Star Inc. Guest

Troy Tanaka Burns & McDonnell Guest

Marc Taylor JFE Shoji Power Canada Inc. Member

Subhash Tuli CT&DA Guest\*

Cameron Vant Prolec-GE Waukesha Guest

Ajith Varghese SPX Transformer Solutions, Inc. Member

Kannan Veeran Virginia/Georgia Transformer Guest

Dharam Vir SPX Transformer Solutions, Inc. Member

Mike Waldrop Memphis Light, Gas and Water Guest

David Wallach Duke Energy Member

Jeffrey Wright Duquesne Light Guest

Fei Yang Hitachi Energy Guest

Anand Zanwar Siemens Energy Guest

Kris Zibert Allgeier Martin Guest

\**Requested membership*

### TF PCS Continuous Revisions to C57.12.00

*PCS Task Force on General Requirements C57.12.00*

*Performance Characteristics Subcommittee*

*IEEE / PES Transformers Committee*

*March 20, 2023*

*Milwaukee, Wisconsin (USA)*

***UNAPPROVED MINUTES***

The TF PCS Continuous Revisions to C57.12.00 met at 3:15 PM on Monday, March 20, 2023. Chairman Tauhid Ansari presided over the meeting with Enrique Betancourt being the Vice-chair, and Mats Bernesjo acted as Secretary. The meeting was called to order and the Chairman reminded the group of the purpose and scope of this Task Force. The copyright and patent statements from IEEE were presented to the group; none of the members and guests present were aware of any issues related to this TF’s activities.

The meeting was attended by 36 members (out of 58), 50 guests, for a total meeting attendance of 86 persons, including 17 requests for membership at this meeting. A quorum was established with 36 / 58 = 62 % attendance.

The agenda was unanimously approved (1st Hugo Flores, 2nd David Wallach) as was the unapproved minutes (1st Sanjib Som, 2nd Eduardo Garcia) from the previous meeting (Fall meeting, Charlotte 2022).

The following 17 guests requested membership:

Alan Traut Howard Industries

Angela Leigl Eaton Corp

Charles Sweetser Omicron Electronic Corp, USA

Cole Van Dreel American Transmission Company

David Murray TVA

Edward Orozco GE Grid Solutions

Elise Arnold Starkstrom Geretebau GmbH

Ion Radu Hitachi Energy

Michael Botti Hyosung HICO

Monil Patel PG&E

Nick Jensen Delta Star

Nik Dillon Dominion Energy

Pugal Selvaraj Virginia Transformers

Raymond Frazier Ameren

Ryan Hogg USBR

Samragni Dutta Roy Siemens Energy

Subhash Tuli ET&DA

Next, the Chair briefly provided background and relevance of each item brought up for Group’s discussion in the agenda. The Chair started Group’s regular business.

Next, the Chair briefly provided background and relevance of each item brought up for Group’s discussion in the agenda. The Chair started Group’s regular business.

**WG Item 112, Clarification on ±0.5% tolerance of ratio of three phase transformer**

Originally submitted by Ryan Musgrove.

*“During the Spring 2022 meeting in Denver, the motion “Create a TF to review Section 9.1 of C57.12.00 and provide recommendation on phase-to-phase ratio tolerance to this task force by Fall 2022” was proposed by Dan Sauer and seconded by Phil Hopkinson. A short discussion preceded the vote: 14 agree, 9 oppose, and 5 abstain. With only 28 votes (out of 33 members), the validity of the vote to pass the motion was questioned (Sanjib Som) since “abstain” votes does not count towards # of votes. A second quorum check (by raised hands) showed that a quorum was no longer maintained within the TF and hence, the motion to create a TF did not pass. However, Ryan Musgrove will spearhead a group with the support of Sanjay Patel.”*

Unfortunately, the group was not able to meet. Dan Sauer asked to come back to the Chair of this TF before the next meeting (Fall 2023) in Kansas City.

**WG Item 113, Measurement of Auxiliary Loss**

Submitted by Ajith Varghese:

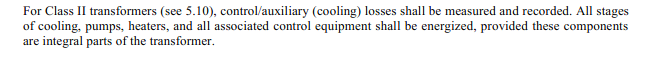
“I see there is some disconnect between what different manufacturers are doing for measuring control losses – based on how one interprets ‘integral parts of transformers’.”

We can’t have each and every component listed in IEEE, but I think there needs to be some additional clarity needed. Some of the disconnects:

* Heaters
* When dual temp heaters, many are taking only one stage
* Heaters in Cubicles/bus duct (supplied with transformer) are not included
* Heaters in LTC cubicles
* Breathers
* Power for LTC Motor
* Power consumed by N2 generator
* Power consumed by Oil Filters.

Also – Need clarity of inrush/starting power needed for cooling fans, etc.”

**Present wording from C57.12.00 Sec 5.9.**



The group did meet prior to the meeting. Unfortunately, the only Utility (ComEd) in this small workgroup could not attend. Hence, only manufacturers participated. The group came up with some new wording, *The recommended additional paragraph.*

*If the device cannot be energized or not present at the time of auxiliary loss*  *measurement, the power information from the data sheet of device shall be identified and*  *included in the total auxiliary losses*.

A very interesting and informative discussion was held on this topic with input from both Manufacturers and Utilities. The bottom line of the discussion seemed to be that all losses consumed by the transformer including all associated losses drawn by heaters, tap changer motor, fans, light, etc. must be considered in the total losses of the transformer. The consensus was also that the design of the control cabinet electronics must be such that it would not trip when all accessories are loaded.

The participants in the meeting agreed upon that Ajith Varghese & Tauhid Ansari will go through the wording one more time before the TF can vote on this topic. Dan Blaydon (BG&E), Chris Slattery (FirstEnergy), and Subhash Tuli (ET&DA) will also work with the Chairman on this topic.

**WG Item 113, Measurement of Auxiliary Loss**

Submitted by Andrew Larison:

“Adding Sec 4.1.10 on DC current injection limits”.

A quick motion to approve (1st Steve Snyder, 2nd Phil Hopkinson) was not voted upon but rather discussed in detail. It appears that the proposed wording includes a 0.5 % DC. Note that, if this is on the secondary side of the distribution transformer, which in a low secondary voltage (480V or 120 V) could be significant (for example, the DC current could be 35 A in a 7000 A low voltage winding) which is not reasonable. First, DC needs to be written out as “Direct Current” before “injection” and there is a need to specify on which side on the transformer this is for (primary / secondary) for sure.

Dr. Ramsis Girgis will help looking into this topic with the focus on determining whether the 0.5 % should be 0.05 %, or different. The proposed wording, *4.1.10 DC Injection for Distribution Transformers.*

*Unless otherwise specified the acceptable DC Injection limit shall be 0.5% for distribution class transformers.  DC injection is defined in IEEE 1547.  Refer to IEEE 1547.2 for the application guide and background information.*

does not describe the scope fully which is very dangerous. Steve Antosz proposed to study this topic a little further to gather enough information to take a vote on this which was verbally approved by the audience.

Chairman Tauhid Ansari asked whether there was any new business. Ryan Hogg suggested to look into the background of Table 11 (section 7) due to that some of the information does not appear to make sense. It appears that some of the KVA information is not correct and has not been updated since at least before 1987. The Chairman will discuss further with Hogg with the support of Dan Sauer.

With a quiet floor, the Chairman asked for the meeting to be adjourned.

Meeting was adjourned at 4:30 PM.

Respectfully submitted,

Tauhid Ansari Enrique Betancourt Mats Bernesjo

WG Chair Vice-Chair Secretary

Attendance Spring 2023 Meeting – PCS TF to Revision C57.12.00

Kayland Adams Prolec-GE Waukesha Guest

Greg Anderson GW Anderson & Associates, Inc. Guest

Tauhid Haque Ansari Hitachi Energy Chair

Stephen Antosz Stephen Antosz & Associates, Inc. Member

Elise Arnold Starkstrom Geratebau GmbH Guest (RM)

Donald Ayers Ayers Transformer Consultants Guest

Christopher Baumgartner WE Energies Member

Jason Beaudoin Weidmann Guest

Mats Bernesjo Hitachi Energy Secretary

Enrique Betancourt Prolec GE Vice Chair

Daniel Blaydon Baltimore Gas & Electric Member

William Boettger Boettger Transformer Consulting LLC Member

Christopher Borck Eaton Corporation Guest

Michael Botti Hyosung HICO Guest (RM)

Jeffrey Britton Phoenix Tech, Div. of Doble Guest

Samuel Brodeur Hitachi Energy Guest

Darren Brown Howard Industries Member

Eric Davis Burns & McDonnell Guest

Nikolaus Dillon Dominion Energy Guest (RM)

Samragni Dutta Roy Siemens Energy Guest (RM)

Qusal Einimri Vantron Industries Guest

William Elliott Prolec-GE Waukesha Member

Hugo Flores Hitachi Energy Member

Raymond Frazer Ameren Guest (RM)

Eduardo Garcia Wild Siemens Energy Member

Ramsis Girgis Hitachi Energy Member

Bill Griesacker Duquesne Light Guest

Ravi Gupta Megger Guest

Michael Hall Midcentral Electrical Guest

John Herron Raytech USA Member

Ryan Hogg USBR Member

Phil Hopkinson HVOLT Inc. Member

Nick Jensen Delta Star Inc. Guest (RM)

John John Virginia Transformer Corp. Member

Christopher Johnson Oncor Guest

Akash Joshi Black & Veatch Inc. Member

Kevin Juchem Hitachi Energy Guest

Sergiusz Kapka Hitachi Energy Guest

Jerzy Kazmierczak Hitachi Energy Guest

Sheldon Kennedy Niagara Transformer Guest

Rafal Kowalski Hitachi Energy Guest

Mark Lachman Doble Member

Angela Leigl Eaton Corporation Guest (RM)

Kevin Mazzei Black & Veatch Inc. Guest

Brian McBride Cargill Guest

Tom Melle HVOLT Inc. Guest

Juliana Montanha Siemens Energy Guest

Marta Munoz Hitachi Energy Guest

David Murray TVA Guest (RM)

Ryan Musgrove OG&E Member

Shankar Nambi Bechtel Energy, Inc. Member

Joe Nims Allen & Hoshall Member

Rudolf Ogajanov Hitachi Energy Guest

Eduardo Orozco GE Grid Solutions Guest (RM)

George Partyka PTI Transformers Member

Sanjay Patel SMIT Transformers Member

Monil Patel PG&E Guest (RM)

Harry Pepe Phoenix Technologies, Inc. Guest

Bertrand Poulin Hitachi Energy Member

Jarrod Prince ERMCO Member

Ion Radu Hitachi Energy Guest (RM)

Rodrigo Ronchi WEG Transformers Guest

Marnie Roussell Entergy Member

Hakan Sahin Virginia / Georgia Transformers Member

Dinesh Sankarakurup Duke Energy Guest

Amitabh Sarkar Virginia Transformers Member

Alaor Scardazzi Siemens Energy Guest

Markus Schiessl SGB Member

Jeffrey Schneider Power Partners Guest

Pugal Selvaraj Virginia Transformers Guest (RM)

John Sen Duke Energy Member

AbdulMajid Shaikh Delta Star Inc. Guest

Jaber Shalabi Vantron Industries Guest

Hemchandra Shertukde University of Hartford Guest

Christopher Slattery FirstEnergy Corp Member

Andrew Steineman Delta Star Inc. Guest

Tuli Subhash ET&GA Guest (RM)

Charles Sweetser Omicron Electronics Corp USA Guest (RM)

Ed teNyenhuis Hitachi Energy Member

Scott Thomas Hitachi Energy Guest

Alan Traut Howard Industries Guest (RM)

Cole Van Dreel American Transmission Co Guest (RM)

Ajith Varghese Prolec-GE Waukesha Member

Dharam Vir Prolec-GE Waukesha Member

David Wallach Duke Energy Member

Kris Zibert Allgeier Martin Member

### WG HV & EHV Breaker & Transformer Sw. Transients C57.142

**IEEE / PES Transformers Committee**

**Performance Characteristics Subcommittee**

**WG to Investigate the Interaction between Substation Transients**

**And Transformers in HV and EHV Applications and Revision of C57.142**

Milwaukee, WI

Tuesday, March 21, 2023

11:00 AM – 12:15 PM Central Time Zone – USA

Executive Ballroom (2)

**Chairman – Jim McBride**

**Vice Chair – Xose Lopez-Fernandez**

**Secretary – Tom Melle**

1. Meeting called to order at 11:00 AM Central Daylight Time.
2. Welcome and Chair’s Remarks
3. Circulation of Attendance Sheets - 88 Attendees were present (22 Members were present and 66 Guests)

Quorum was not achieved (24 members present required for quorum)

4) IEEE Patent Policy Slides

5) Approval of Agenda and Minutes from Fall 2022

6) C57.142 SA Ballot and Comment Resolution status – Jim McBride: presentation of open comments before the ballot resolution group (BRG) and discussion of several key comments (latest documents to be posted on WG website).

* Comment on Page 16, Section 5: alignment of Guide with theory in IEC 62271-306, Section 16.4 (Tom Melle to review)
* Comment - Page 20, Section 5.2: magnitude of re-ignition versus load power factor. The Chair provided examples of transients in shunt reactors illustrating 1.2 MV(pp) transients on transformer with 1.4 MV BIL (Jeffrey Britton to review)
* Comment - Page 6, Section 3.4.1: discussion of transient recovery voltages (The Chair and Phil Hopkinson will review/survey with SWG BRG members and any experienced users or manufacturers)
* Comment - Page 34, Section 7.6: de-energizing transformers with disconnectors (Bertrand Poulin suggested to leave the informative paragraph and insert a note that is can be dangerous to de-energize with switch)
* Comment - Page 30, Section 7: mitigation method of “moving” the transformer’s resonant frequency (such as with CCVT). A straw ballot was conducted and the results were split. Chair will conduct a survey of the BRG.
* Comment - Page 33, Section 7.3: controlled switching to mitigate reignitions (the sentence will be rewritten to provide more clarity)
* Comment – Page 5, Section 3.3: discussed “ground-fault neutralizer” terminology. Jeff Britton suggested coordination with WG C57.32. Tom Melle is Vice-Chair of that Standard and will coordinate matching terminology.

1. Mitigation Methods Task Force Update – Jim McBride / Phil Hopkinson

All prior mitigation methods proposed by the TF are included in the Guide. The TF will review/consider CCVT, Capacitive Shields and any other potential mitigation methods suggested by comment resolution.

1. New Business – Ajith Varghese suggested preparing an updated presentation for sharing with any liaison groups (SWG, CIGRE, PCS and the TC at-large).
2. Next Meeting (Fall 2023 – Kansas City, MO, Oct. 23, 2023)
3. Adjournment at 12:15 PM CDT

Spring 2023 WG Meeting Attendance and Affiliation is as follows:

James McBride JMX High Voltage Chair

Thomas Melle HIGHVOLT Secretary

Enrique Betancourt Prolec GE Member

William Boettger Boettger Transformer Consulting LLC Member

Jeffrey Britton Phenix Technologies, Inc. Member

Eduardo Garcia Wild Siemens Energy Member

Kyle Heiden EATON Corporation Member

Philip Hopkinson HVOLT Inc. Member

John John Virginia Transformer Corp. Member

Akash Joshi Black & Veatch Member

Egon Kirchenmayer Siemens Energy Member

Weijun Li Braintree Electric Light Dept. Member

Klaus Pointner Trench Austria GmbH Member

Bertrand Poulin Hitachi Energy Member

Marnie Roussell Entergy Member

Amitabh Sarkar Virginia Transformer Corp. Member

Cihangir Sen Duke Energy Member

Michael Sharp Trench Limited Member

Mike Spurlock Spurlock Engineering Services, LLC Member

Ajith Varghese SPX Transformer Solutions, Inc. Member

Dharam Vir Prolec-GE Waukesha Member

Waldemar Ziomek PTI Transformers Member

Robert Arritt EPRI Guest

Jean-Noel Berube Rugged Monitoring Guest

Christopher Borck EATON Corporation Guest

Cole Casey Invenergy Guest

Vivian Chan Hitachi Energy Guest

Alex Cochran U.S.E. Guest

Michael Craven Qualus Corporation Guest

Gabriel Delgado Zamora Invenergy Guest

Scott Digby Duke Energy Guest

Nikolaus Dillon Dominion Energy Guest

Paul Dolloff East Kentucky Power Guest

Evgenii Ermakov Hitachi Energy Guest

Marco Espindola Hitachi Energy Guest

Esseddik FerdJallah Trench Group Guest

Raymond Frazier Ameren Guest

Jose Gamboa H-J Family of Companies Guest

Lorne Gara Shermco Guest

Miguel Garcia Hitachi Energy Guest

Carlos Gaytan Prolec-GE Waukesha Guest

Detlev Gross Power Diagnostix Consultant Guest

John Harley FirstPower Group LLC Guest

JC Hernandez Georgia Tech – NEETRAC Guest

Saramma Hoffman PPL Electric Utilities Guest

Saif Hossain Trench Limited Guest

Patrycia Jarosz IEEE SA Guest

Thrinadha Katapalli Virginia Transformer Guest

Stacey Kessler Ulteig Engineers Guest

Qasim Khan Georgia Tech – NEETRAC Guest

Dmitriy Klempner Southern California Edison Guest

Evan Knapp EATON Corporation Guest

Bernard Labean, Jr. Consumers Energy Guest

Mark Lachman Doble Engineering Co. Guest

Kumar Mani Duke Energy Guest

Omar Mendez Prolec-GE Waukesha Guest

Marian Mohamed XCEL Energy Guest

Juliano Montanha Siemens Energy Guest

Paul Mushill Ameren Guest

Joe Nims Allen & Hoshall, Inc. Guest

Dwight Parkinson EATON Corporation Guest

Monil Patel PG&E Guest

Uros Pleceyic Invenergy Guest

Goran Plisic Siemens Energy Guest

Ulf Radbrandt Hitachi Energy Guest

Ion Radu Hitachi Energy Guest

Bradley Rainbolt EATON Corporation Guest

Ana Restrepo Hitachi Energy Guest

Michael Richardson Ameren Guest

Tim Rocque Prolec-GE Waukesha Guest

Rodrigo Ronchi WEG-Voltran Guest

Markus Schiessl SGB Guest

Salahuddin Shaikh Hitachi Energy Guest

Hemchandra Shertukde University of Hartford Guest

Ibrahim Shteyh Consultant Guest

Stephen Shull BBC Electrical Services, Inc. Guest

Fabian Stacy Hitachi Energy Guest

Brad Staley Leeward Renewable Energy Guest

Andrew Steineman Delta Star Inc. Guest

Eduardo Tolcachir TTE Guest

Cameron Vant Prolec-GE Waukesha Guest

Jos Veens SMIT Tranformatoren B.V. Guest

Alan Washburn Burns & McDonnell Guest

Eric Weatherbee PCORE Electric Guest

Joshua Yun Virginia Transformer Corp. Guest

Malia Zaman IEEE Guest

Shibao Zhang PCORE Electric Guest

### TF Inverter Transformer Precautions on Ground Shields C57.159

**TF Inverter Transformer Precautions on Ground Shields C57.159**

**Unapproved Meeting Minutes**

**Spring 2023 Meeting**

**Milwaukee, WI**

**4:45 pm, Monday, March 20**

1. **Introduction:**
2. **PJ Hopkinson. Task Force Leader**
3. **Hemchandra Shertukde: Past Chair of IEEE C57.159 & Proposed New Chair**
4. **Jonathon Stewart: Secretary, NEMA Staff**
5. **Minutes of Meeting held in Charlotte**
6. **Attendance was recorded on the roll**
7. **Technical Presentation on Inverter transformer Issues in C57.159**
8. **Paragraph 5.1.2**:
   1. Needs to state that inverters are well filtered line to line and line to neutral but are not filtered line to ground.
   2. Needs to provide for inverters for IGBT switching devices that have pulse rates from 2 kHz to 20 kHz, with peak amplitudes from -2500 volts to + 2500 volts.

Chart, histogram

Description automatically generated

1. **Paragraph 5.1.4** Needs to be revised to state that if a neutral is present that it must not be grounded, not just recommended.  The reason for this is to prevent the following:

Diagram

Description automatically generated

* 1. If a Y-connected winding is grounded, then pulsed energy passes only through one winding and goes to ground and does not return through either of the other windings.
  2. If the energy, which comes from a dc source passes through only one winding, the core becomes magnetized and saturates.
  3. The high frequency pulses from the inverter, shown in figure 5 of paragraph 5.1.2 pass into the inverter transformer and draw high LV current due to core saturation, which result in damage or failure of the inverter transformer.
  4. It is not clear whether nameplates need to specify that grounded neutrals are not allowed for inverters, but OK for ac only transformers.
  5. Any testing should result in only power frequencies in the output voltage.  This would not be the case when the LV is grounded.

1. **Paragraph 5.5.4 Electrostatic shield:**
   1. A shield needs to be included surrounding the core and grounded to prevent capacitive coupling of the core by the LV winding with resulting high interlaminar sheet to sheet core voltages that exceed the dielectric strength of the core sheet insulation
   2. A shield between LV and HV is normally included to prevent pulses to enter the HV winding.
   3. Any testing of core ground currents should be void of pulsed currents.

It was noted that on a Delta or Wye connected winding, pulses show up between neutral and ground or between line and ground. Then the high voltage (and pulses) is going to be at the start of the winding and capacitance will be present, which means that pulse energy will be sent to the core. There will be capacitance from the winding to the outside of the core and on either end. But in the middle there would be a ground current that results from capacitance.

Core material isn’t able to take voltages between the laminations that are closest to the outside. Core can take 1/10 of a volt between laminations. For example, in a 3,000kVA transformer the volts per turn are equal to the square root of voltage on a single phase = 30-35 volts per turn.

A shield between the ground and the core makes sense for inverter transformers and mitigates the issue.

The current guide should be a standard. Recommendations should become mandates i.e. you may not ground the neutral.

1. **Development of PAR: Hemchandra**

*Hemchandra introduced himself and further explained the issue. Invited others to join him on working on this issue. He plans to initiate the language for the PAR and will put this on the agenda for the subcommittee at the upcoming PCS meeting. He will try to have the PAR ready by the Fall meeting.*

*There was a suggestion that the scope should include testing as well.*

1. **Next Steps**

* C57.159: Assigned to Performance Characteristics Subcommittee.
* Chair, proposed to be Hemchandra Shertukde.
* Identification of Secretary:

1. **Next Meeting Kansas City October 23, 2023**
2. **Adjournment**

Chair: Phil Hopkinson

Secretary: Jonathan Stewart

## Performance Characteristics Subcommittee Attendance List

|  |  |  |  |
| --- | --- | --- | --- |
| **First Name** | **Last Name** | **Affiliation** | **Status** |
| Kayland | Adams | Prolec-GE | Guest |
| Alex | Alahmed | Evergy | Guest |
| Mihir | Amin | EATON | Guest |
| Tauhid Haque | Ansari | Hitachi Energy | Member |
| Stephen | Antosz | Stephen Antosz & Associates, Inc | Member |
| Elise | Arnold | SGB | Guest |
| Javier | Arteaga | Hitachi Energy | Member |
| Alex | Ayala | Power Partners | Guest |
| Donald | Ayers | Ayers Transformer Consulting | Member |
| Robert | Ballard | DuPont | Member |
| Gilles | Bargone | FISO Technologies Inc. | Member |
| Christopher | Baumgartner | We Energies | Member |
| Barry | Beaster | H-J Family of Companies | Member |
| Jean-Noel | Berube | Rugged Monitoring Inc. | Guest |
| Enrique | Betancourt | Prolec GE | Member |
| Edwin | Betancourt | Siemens-Energy | Guest |
| Vivek | Bhatt | Prolec-GE | Guest |
| Daniel | Blaydon | Baltimore Gas & Electric | Member |
| William | Boettger | Boettger Transformer Consulting LLC | Member |
| Sanket | Bolar | Oncor Electric Delivery | Member |
| Susan | Bonfiglio | WAPA | Guest |
| Michael | Botti | Hyosung HICO | Guest |
| Jeffrey | Britton | Phenix Technologies, Inc./Doble Eng. | Member |
| Juan Alfredo | Carrizales | Prolec GE | Guest |
| Camilo | Casallas | TRENCH | Guest |
| Arup | Chakraborty | Delta Star Inc. | Guest |
| Vivian | Chan | Hitachi Energy | Guest |
| Eunyoung | Cho | HICO-America | Guest |
| Rhett | Chrysler | ERMCO | Guest |
| Craig | Colopy | Retired - EATON Corporation | Member-retired |
| Michael | Craven | Qualus Power Services | Guest |
| Daniel | Crockett | Ameren | Guest |
| Juan Carlos | Cruz Valdes | Prolec GE | Guest |
| Samson | Debass |  | Guest |
| J. Arturo | Del Rio | Siemens Energy | Member |
| Craig | DeRouen | ERMCO | Guest |
| Scott | Digby | Duke Energy | Guest |
| Nikolaus | Dillon | Dominion Energy | Guest |
| Samragni | Dutta Roy | Siemens Energy | Member |
| William | Elliott | AEP-SWEP CO | Guest |
| Evgenii | Ermakov | Hitachi Energy | Guest |
| Marco | Espindola | Hitachi Energy | Guest |
| Reto | Fausch | RF Solutions | Member |
| Marcos | Ferreira | Engineering Consultant Services | Guest |
| Hugo | Flores | Hitachi Energy | Member |
| Raymond | Frazier | Ameren | Member |
| Jose | Gamboa | H-J Family of Companies | Member |
| Miguel | Garcia | Hitachi Energy | Guest |
| Eduardo | Garcia Wild | Siemens Energy | Member |
| Carlos | Gaytan | Prolec GE | Guest |
| Rob | Ghosh | General Electric | Guest |
| Ramsis | Girgis | Hitachi Energy | Member |
| Rafael | Grajeda | EATON | Guest |
| Bill | Griesacker | Duquesne Light Co. | Member |
| Ismail | Guner | Hydro-Quebec | Member |
| Ravi | Gupta | Megger | Guest |
| Corey | Hanson | Advanced Power Technologies | Guest |
| Sergio | Hernandez Cano | Hammond Power Solutions | Member |
| Jean | Hernandez-Myia | Georgia Tech | Guest |
| John | Herron | Raytech USA | Member |
| Saramma | Hoffman | PPL Electric Utilities | Member |
| Ryan | Hogg | Bureau of Reclamation | Guest |
| Derek | Hollrah | Burns & McDonnell | Guest |
| Philip | Hopkinson | HVOLT Inc. | Member |
| Darren | Hoppins | Sensor Link Corp | Guest |
| Saif | Hossain | Trench Limited | Guest |
| Nicholas | Jensen | Delta Star Inc. | Guest |
| John | John | Virginia Transformer Corp. | Member |
| Akash | Joshi | Mott MacDonald | Member |
| Jerzy | Kazmierczak |  | Guest |
| Sheldon | Kennedy | Niagara Transformer | Member |
| Christoph | Kerschenbauer | Siemens Energy | Guest |
| Stacey | Kessler | Ulteig Engineers | Member |
| Egon | Kirchenmayer | Siemens Energy | Member |
| Dmitriy | Klempner | Southern California Edison | Guest |
| Anton | Koshel | Delta Star Inc. | Guest |
| Jusuf | Krvavac | Sargent & Lundy | Guest |
| Krzysztof | Kulasek | Delta Star Inc. | Guest |
| Bernard | LaBean, Jr. | Consumers Energy | Guest |
| Mark | Lachman | Doble Engineering Co. | Guest |
| Andrew | Larison |  | Guest |
| Moonhee | Lee | Hammond Power Solutions | Member |
| Weijun | Li | Braintree Electric Light Dept. | Member |
| Colby | Lovins | Federal Pacific | Guest |
| Jose Luis | Machain | Prolec GE-Waukesha | Guest |
| Tim-Felix | Mai | Siemens Energy | Member |
| Kumar | Mani | Duke Energy | Guest |
| James | McBride | JMX Services, Inc. | Member |
| Tim | Menter | Lincoln Electric System | Guest |
| Kent | Miller | T&R Electric Supply Co., Inc. | Guest |
| Francis | Mills | Power Engineers | Guest |
| Juliano | Montanha | Siemens Energy | Guest |
| Emilio | Morales-Cruz | Qualitrol Company LLC | Member |
| Hugo | Murillo | H-J Family of Companies | Guest |
| David | Murray | Tennessee Valley Authority | Member |
| Ryan | Musgrove | Oklahoma Gas & Electric | Member |
| Paul | Mushill | Ameren | Guest |
| Ismael | Naja | EATON | Guest |
| Aniruddha | Narawane | EATON Corporation | Member |
| Poorvi | Patel | Electric Power Research Institute (EPRI) | Member |
| Monil | Patel | Pacific Gas & Electric | Guest |
| Rakesh | Patel | Hitachi Energy | Guest |
| Harry | Pepe | Phenix Technologies, Inc. | Guest |
| Sylvain | Plante | Hydro-Quebec | Member |
| Klaus | Pointner | Trench Austria GmbH | Member |
| Bertrand | Poulin | Hitachi Energy | Guest |
| Jarrod | Prince | ERMCO | Member |
| Ulf | Radbrandt | Hitachi Energy | Member |
| Ion | Radu | Hitachi Energy | Member |
| Adnan | Rashid | Measurement Canada / ISED | Guest |
| Michael | Richardson | Ameren | Guest |
| Tim | Rocque | Prolec GE Waukesha | Member |
| Rodrigo | Ronchi | WEG-Voltran | Guest |
| Marnie | Roussell | Entergy | Member |
| Hakan | Sahin | Virginia/Georgia Transformer | Guest |
| Albert | Sanchez | Knoxville Utilities Board | Guest |
| Alberto | Sandoval Moreno | EATON Corporation | Guest |
| Dinesh | Sankarakurup | Duke Energy | Guest |
| Manish | Saraf | Hammond Power Solutions | Guest |
| Amitabh | Sarkar | Virginia Transformer Corp. | Guest |
| Daniel | Sauer | EATON Corporation | Member |
| Markus | Schiessl | SGB | Member |
| Ewald | Schweiger | Siemens Energy | Guest |
| Cihangir | Sen | Duke Energy | Guest |
| Salahuddin | Shaikh | Hitachi Energy | Guest |
| Abdul Majid | Shaikh | Delta Star, Inc. | Guest |
| Michael | Sharp | Trench Limited | Guest |
| Samuel | Sharpless | Rimkus Consulting Group | Member |
| Hemchandra | Shertukde | University of Hartford | Member |
| Stephen | Shull | BBC Electrical Services, Inc. | Guest |
| Christopher | Slattery | FirstEnergy Corp. | Member |
| Steven | Snyder | Hitachi Energy | Member |
| Jason | Snyder | First Energy | Guest |
| Sanjib | Som | Pennsylvania Transformer | Vice-Chair |
| Mauricio | Soto | Hitachi Energy | Guest |
| Brad | Staley | Leeward Renewable Energy | Guest |
| Kyle | Stechschulte | American Electric Power | Member |
| Andrew | Steineman | Delta Star Inc. | Guest |
| Charles | Sweetser | OMICRON electronics Corp USA | Member |
| Ali | Syed | Comed | Guest |
| Valeriu | Tatu | Powersmiths | Guest |
| Vijay | Tendulkar | EATON Corporation | Member |
| Ed | teNyenhuis | Hitachi Energy | Member |
| Jacob | Thielbar | WAPA | Guest |
| Scott | Thomas | Hitachi Energy | Guest |
| Subhash | Tuli | Electrical T&D Apparatus Consultant Inc. | Guest |
| Olivier | Uhlmann | Reinhausen Canada Inc. | Guest |
| Cole | Van Dreel | ATC | Guest |
| Cameron | Vant | Prolec GE-Waukesha | Guest |
| Ajith | Varghese |  | Member |
| Jason | Varnell | Doble Engineering Co. | Member |
| Joshua | Verdell | ERMCO | Guest |
| Dharam | Vir | Prolec-GE | Member |
| Richard | vonGemmingen | Dominion Energy | Guest |
| Pragnesh | Vyas | Sunbelt-Solomon | Guest |
| David | Wallach | Duke Energy | Member |
| Alan | Washburn | Burns & McDonnell | Guest |
| Joe | Watson | JD Watson and Associates Inc. | Member |
| Bruce | Webb | Knoxville Utilities Board | Member |
| Drew | Welton | Intellirent | Guest |
| Joe | White | Power Engineers | Guest |
| Jeffrey | Wright | Duquesne Light Co. | Member |
| Fei | Yang | Hitachi ABB Power Grids | Guest |
| Guang | Yuan | Hitachi Energy | Guest |
| Joshua | Yun | Virginia Transformer Corp. | Member |
| Malia | Zaman | IEEE | Guest |
| Kris | Zibert | Allgeier, Martin and Associates | Secretary |
| Waldemar | Ziomek | PTI Transformers | Member |