Annex J Performance Characteristics Subcommittee (PCS)

March 30th, 2022, Hyatt Regency Convention Center, Denver, CO

UNAPPROVED MINUTES

Chair: Rogerio Verdolin
Vice Chair: Sanjib Som
Secretary: Kris Zibert

J.1 Introduction / Attendance

Quorum was not achieved, however, later in the meeting quorum was achieved with 61 members present (52% in attendance). In addition, 65 guests were present at the meeting. The total attendance at the meeting was 127. 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 Charlotte, NC, October 16-20, 2022.

J.2 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.

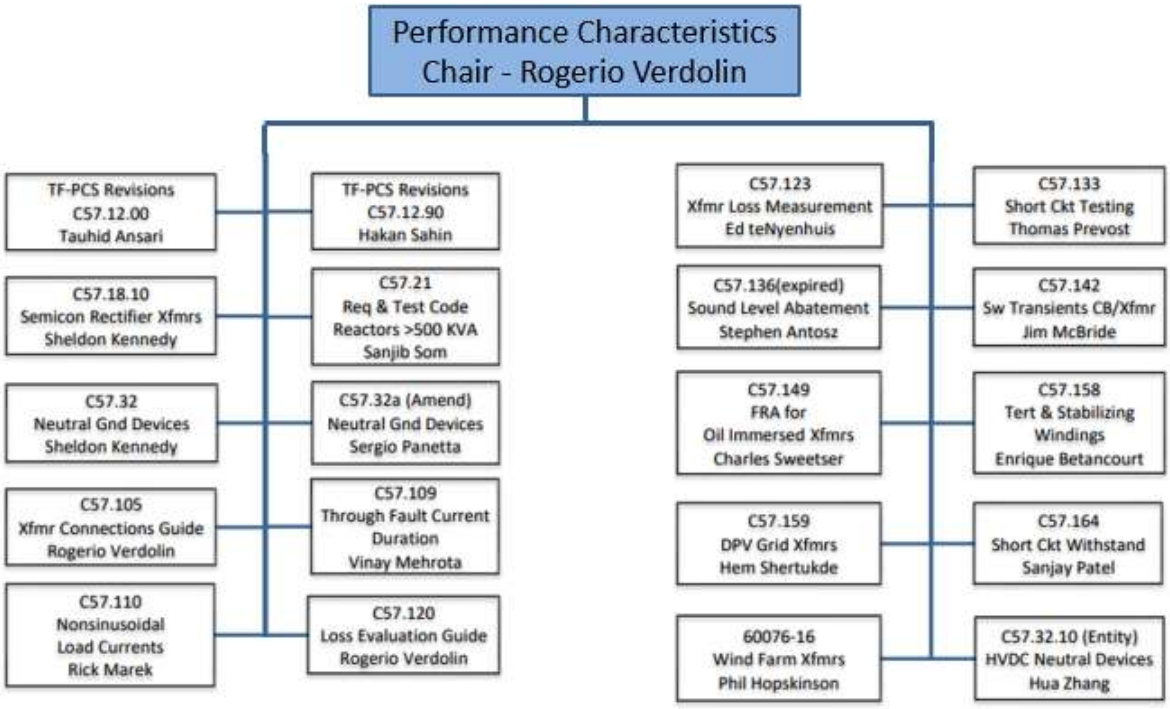
The Vice Chair asked anyone with new business to submit in writing prior to the meeting.

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
- C57.105 – Transformer connections guide – R. Verdolin
- C57.109 – Through Fault Current Duration – V. Mehrotra
- C57.110 – Xfmr 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
- C57.142 – 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-new – Short Circuit Withstand (in development) – S. Patel
- 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 (WG in draft development)
  - C57.149 SFRA Guide (WG in draft development)
- 2023 PAR's
  - C57.142 Transient Guide (In Sponsor Ballot)
- 2024 PAR's
  - C57.105-2019/Cor 1 (New WG)
- 2025 PAR's
  - C57.136 Audible Sound Guide (New WG)
  - C57.141 Entity WG Guide for Detection, Monitoring and Evaluation of Winding Deformation

Status of Standards without active PARs

- C57.32-2015 – Neutral Grounding Devices (2025)
- 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 Sue
- Must track attendance.
- 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 1 Member missed the past 2 meetings and have been moved to "Guest" status:

- None

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

These 7 former Guests requested membership at the Fall 2019 meeting and have attended the past 2 of the last 3 meetings:

- Amitabh Sarkar
- Harry Pepe
- Hakan Sahin
- Michael Sharp

Welcome the New Members: We look forward to your contributions to the Subcommittee

Attendance / Membership – Quorum determination

- Current breakdown of the Subcommittee:
  - 117 Members
  - 59 are needed for a quorum
- Quorum was established.

J.3 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 passed by unanimous consent.

J.4 Approval of Last Meeting Minutes

The Chair presented the minutes of meeting held in the Fall 2022 – November 28th, 2021 and entertained a motion to approve. The minutes had been sent to the members by email several weeks prior to the meeting. The motion passed by unanimous consent.

J.5 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** **C. Sweetser**
- **TF PCS Audible Sound Revision to Test Code** **R. Girgis**
- **TF PCS Continuous Revisions to C57.12.00** **T. Ansari**
- **TF PCS Continuous Revisions to Test Code C57.12.90** **H. Sahin**
- **WG HV & EHV Breaker & Transformer Sw. Transients C57.142** **J. 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

- 32 in attendance, 31 members on the roster, 10 members attended, a quorum was not achieved.
- Revision is completed; grounding, connections, and analysis. Ready for WG straw ballot. PAR expires this year.
- Jim McBride presented on the topic of on-line FRA, a shunt reactor example was presented

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

Meeting Date / Time : March 27th, 2022, @ 3:15PM to 4:30PM

- 75 total attendees, consisting of 33 members and 42 guests. The TF achieved a quorum (33 members required).

Highlights:

- Old Business
  - Inclusion of Core information on Nameplate
    - The proposed addition to row # 25 and 26 in table 6 of C57.12.00 passed with 22 members in favor, 1 opposed, and 10 abstain.
  - Clarification on ±0.5% tolerance of ratio of three-phase transformer
    - The discussion was not conclusive due to no clear understanding of phase-to-phase ratio tolerance
  - A motion was initiated to form a study group (task force) to review the sec 9.1 of C57.12.00 and provide recommendation on phase-to-phase tolerance to this task force by Fall 2022. 14 voted in favor, 9 oppose and 5 abstain. This totaled 28 members. A second quorum check (by raise of hand) was conducted and found ; the quorum was not maintained. Hence the motion did not pass.
  - This discussion will continue in Fall 2022 meeting
  - Meeting adjourned at 4:30PM
  - Motion to vote in Sub committee: Add row # 25 and 26 with Core information in table 6 of C57.12.00

Row	Nameplate A	Nameplate B	Nameplate C
25	-	-	Core Design --Shell or Core form
26	-	-	Core Type -Number of limbs (wound), Shell Type - D type , 7 limbs, or others

- T. Ansari asked that the motion be surveyed among the subcommittee.

3) **WG on Noise Guide C57.136** **S. Antosz**

- The WG met as scheduled. The meeting was attended by 25 members (out of 46), and 35 guests, for a total of 60 persons. There were 5 requests for membership. A quorum was established with 25 / 46 = 54 % attendance. The agenda was unanimously approved as was the unapproved minutes from the previous meeting (Virtual meeting, fall of 2022).
- Chairman Stephen Antosz presided over the meeting with Dr. Ramsis Girgis being the Vice-Chair, and Mats Bernesjo as Secretary.
- The Chair welcomed the audience, reviewed the agenda, and updated about the status of the latest circulated revision of the Guide, Draft 3.
- Dr. Girgis presented new additions to Draft 3. Some of these were in response to previous requests from members and guests, and some were topics that were yet to be added to the Guide.
- The ensuing discussion resulted in several requests for new or additional topics of information to be included in the guide, and these will be implemented as much as possible. Details are in the Minutes.
- There are some final updates and editorial work to be made to the Introduction and Bibliography.
- A new draft will be circulated before the Fall 2022 meeting.
- The document is nearing completion and hopefully will be finalized before the end of 2022, and be able to be open for IEEE-SA ballot.

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

- Meeting started at 9:30 am MDT. There were 83 attendees. Quorum was not achieved as we had only 22 members out of 70 listed members; needed 35
- Agenda and previous meeting minutes could not be approved. Meeting proceeded for information purposes, as the agenda was emailed ahead of the meeting.
- Updated the TF on the status of the PCS surveys for the below revisions and the new clauses to C57.12.90. All below clauses had already passed the TF, and were surveyed within the PCS, and passed!
- Revision to the "Ratio Test Methods" under section 7.3
- Revision to the "Ratio tests voltage and frequency" under section 7.1.2
- Revision to the "Number of short circuit tests" under section 12.3.4
- *New* test sections 8.7 & 9.6 for "LTC tests"
- There will be continuous clarifications for some of the above clauses, including online meetings, and the TF will be updated.
- No critical items or motions to be brought up to PCS at this point
- Meeting adjourned at 10:40 am

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

- 53 total attendees, consisting of 21 members and 32 guests. The WG did not achieve a quorum. 25 / 49
- Agenda was approved by those present. The minutes of Fall 2021 meeting will be approved by email
- Draft 10 is under ballot. Ballot closes April 21,2022. Ballot group consists of 179 people. Current response rate is 16% and approval rate is 89% with 28 comments.
- PAR Extension ends December 31, 2023.
- Mitigation Methods Task Force Summary:
    - Resistor-Capacitor Snubbers
    - Increasing Insulation is Key Areas with Additional Test Requirement for Special Terminated Lightning Impulse to Better Test for Field Conditions.

- Increasing Series Capacitance by Installing Shields to Improve Impulse Distribution and Reduce Series Resonance
- Introduce Internal Surge Protection to Limit Over-voltages During Resonant Conditions
- Reignition Mitigation with Controlled Switching
- Using Resistance Load During Switching to Provide Damping During the Event.
- Online Monitoring to Identify Actual Field Interactions and Identify Real World Conditions at the Transformer Terminals and Within the Transformer.

- Meeting concentrated on fourth item (internal surge protection). Presentation by J. Montanha, presented by E. Kirchenmayer. Presentation will be on the website.
- Next Meeting:
  Fall 2022 – Charlotte, NC March 29th, 2022.
- We will be discussing mitigation methods for failures associated with instrument transformers.
- The meeting was Adjourned at 4:30pm.
- P. Hopkinson had a comment about performance of single arresters vs multiple arresters across windings.

7) WG PC57.32.10 Entity Guide for the Selection of Neutral-Grounding Devices for HDVC Converter Transformers

- Email from Zhang Hua received today:
  Hello, I'm ZhangHua, the chairman of the working group of PC57 32.10 , the latest status of the standard is as follows:
  The working group has held three meetings and is currently in the status of revised draft. It is planned to hold the fourth meeting in May 2022 and form a standard draft for approval as early as the end of June.
  In addition, since the follow-up process may still be affected by COVID-19, I apply for permission to extend the implementation period of this standard for one year.
  Thank you.

J.6 Unfinished (Old) Business

- **There was no old business.**

J.7 New Business

- **A quorum check was initiated and it was found that the Subcommittee did have quorum.**
- **D. Sauer made a motion to approve the minutes. Second by W. Binder. The motion was approved by unanimous consent.**
- **D. Sauer made a motion to approve the agenda. Seconded by W. Binder. The motion was approved by unanimous consent.**
- **Discussion was had regarding what business should now be taken up.**
- **T. Ansari made a motion to add core information to nameplate as passed by TF PCS Cont. Rev. C57.12.00. T. Ansari gave background information regarding the WG's prior deliberations regarding. Seconded.**
  - R. Girgis had discussion in support.
  - J. Watson asked if applied to reactors or just power transformers. Just power transformers.
  - Motion passed by show of hands.

J.8 Adjournment

- **The meeting adjourned at 3:51PM.**

J.9 Minutes of Meetings of Working Group (WG) and Task Force (TF) Reports (all unapproved)

J.9.1 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 28, 2022 0930 H
Meeting Location: Denver, Colorado
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 32 total attendees, consisting of 11 members and 21 guests. A quorum was not achieved.
AGENDA
1. Introductions and Attendance Sheets
2. IEEE-SA Standards Board Bylaws on Patents in Standards
3. Approval of Minutes from November 15, 2021 (Virtual)
4. Approval of Agenda
5. Discussions
   a. PAR Status
   b. Present final document to WG for comments regarding submission to PCS SC and the ballot process.

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.
11 members were present at this meeting, so quorum was not achieved.
The agenda and minutes were not approved; the WG will proceed with an email motion to approve the agenda and minutes.
CS noted that the PAR expires this year and so we need to prepare for balloting. Draft 3 is ready for ballot, however the absence of the quorum has redirected our process. We will attempt an email motion. Once successful we will submit Draft 3 to the PCS subcommittee
Noted Discussions:
Revision tasks are wrapping up with the main focus on consolidated failure modes, connection tables, and analysis. The sections are solid and in good shape.
An edit was required in the new connection table. It was associated with Delta primaries. D1 was referenced when it should have been a D11. This was noted and the correction performed.
Some new wording was submitted by and reviewed by Wes Schrom regarding grounding. It is now in Draft 3.
List of meeting participants with membership status at the end of the meeting:
Alexander Kraetge
Amitabh Sarkar

Jim McBride	Member
Rogelio Martinez	
Dan Tournoux	
Tim Rocque	
Ajith M. Varghese	
Mark Lachman	
Juan Alfredo Carrizales	
Mike Spurlock	
Daniel Weyer	Member
Nathan Jacobs	
Evan Knapp	
Rich Frye	
Poorvi Patel	Member
Evgenii Ermakov	
Diego Robalino	Member
Idvarvo Tolcachir	
Kumar Mani	Member
Wes Schrom	Member
Parminder Panesar	Member
Balakrishnan Mani	
Eric Davis	
Steve Jordan	
David Murray	
Jeff Britton	
Tony McGrail	
Adetokunbo Shsanya	
Ed teNyenhuis	
Jason Varnell	Member
Scott Reed	Member
Arup Chakraborty	Member
Charles Sweetser	Member

Respectfully submitted,

Charles Sweetser
Chair
C57.149 WG

J.9.2 TF PCS Continuous Revisions to Test Code C57.12.90

Meeting was called to order at 9:30 AM MST, March, 2029.

1. **Administrative**
    a. IEEE Patent Policy and Call for Patents
        i. No comments from group
    b. IEEE SA Copyright Policy
        i. No comments from group
    c. Introduction of the officers
        i. Chair: Hakan Sahin

ii. Vice-Chair: -
iii. Secretary: Pugal. Selvaraj

d. Update on membership and Quorum
    i. Poll conducted at 9:45 AM did not achieve quorum
e. Approval of Agenda
    i. Not Approved due to lack of Quorum

2. Old Business – "Ratio Test Methods" clause 7.3

Chair provided update on the status of the revisions to "Ratio Test Methods" under section 7.3. He informed the group that the revisions which was approved in our TF was sent to PCS. Below is the new revision to clause 7.3

7.3 Ratio test method

7.3.1 Electronic ratio and phase measurement meters

An electronic meter that determines the transformer turns ratio, polarity and phase angle may be used for the measurement of these parameters

7.3.2 Voltmeter method (This is currently 7.3.1)

(Clause number changes and descriptions stay the same**)**

7.3.3 Comparison method (This is currently 7.3.2)

(Clause number changes and descriptions stay the same**)**

Current 7.3.3 Ratio meter clause (R/R1) to be removed

Above revision was surveyed within 118 PCS members, and passed with below results:

APPROVED	**68**
DISAPPROVED	**1**
ABSTAIN	**5**
TOTAL	**74**
APPROVED WITH COMMENTS	**0**

There were no critical comments, and the new clause is approved to be released in the upcoming C57.12.90 revision.

3. Old Business - "Ratio tests voltage and frequency" under section 7.1.2

Chair provided update on the survey results and the responses received from PCS members. The revision to clause 7.1.2 had already been revised twice within the TF and the final version was approved (Refer to previous meeting minutes). Below is the revised clause which was surveyed within PCS

Ratio test Voltage and Frequency

CURRENT:

7.1.2 Voltage and frequency

- The ratio test shall be made at rated or lower voltage and rated ~~or higher~~ frequency.

NEW PROPOSAL:

7.1.2 Voltage and frequency

- The ratio test shall be made at rated or lower voltage and be such that the ratio of test voltage to test frequency is less than or equal to the ratio of rated voltage to rated frequency.

Results of the PCS survey was:

APPROVED	64
DISAPPROVED	7
ABSTAIN	4
TOTAL	75
APPROVED WITH COMMENTS	0

Chair shared some of the PCS survey comments during the meeting and below were some of the discussions:

- Ajith Varghse Commented that lower and upper limit is required for frequency
- Jeff Rifton commented to limit the upper frequency limit to 100%
- Tauhid Ansari commented that current electronic ratio measuring systems allows voltage measurements ranges from 10V to 100V. At this low voltage measuring range frequency variance may not have impact
- Sanjib Som commented that voltage ratio methods are conducted at 100V or below range for safety reasons
- Steve Antosz made a motion to revisit the section 7.1.2 as new business and Sanjib Som seconded it.
- Chair commented that, since the new revision was already approved within PCS, we will survey the motion within the TF

4. Old Business – "Number of short circuit tests" under section 12.3.4

Chair presented the proposed revisions to the "Number of short circuit tests" under section 12.3.4 along with the survey results & comments to the members. Below revision was approved within the TF and sent to PCS to be surveyed.

Current Version:

12.3.4 Number of tests

Each phase of the transformer shall be subjected to a total of six tests satisfying the symmetrical current requirement specified in 12.3.1 or 12.3.2, as applicable. Two of these tests on each phase shall also satisfy the asymmetrical current requirements specified in 12.3.3.

Proposed Version

12.3.4 Number of tests

- When a three-phase transformer is tested in a three-phase test circuit or in a single-phase test circuit as given in Annex C, each phase of the transformer shall be subjected to three tests satisfying the asymmetrical current requirements specified in 12.3.3. The tests shall be performed on one of the outer phases with the tap-changer in the maximum position, on the other outer phase with the tap-changer in the minimum position and on the middle phase with the tap-changer in the principal position
- When a single-phase transformer is tested in a single-phase test circuit the transformer shall be subjected to three tests satisfying the asymmetrical current requirements specified in 12.3.3. The three tests shall be performed one each, with the tap-changer in the maximum, minimum and principal position.

Chair shared the feedback comments received to the PCS survey responses. There were some discussions, which were all similar discussions made for several years. Chair commented that he will setup an online meeting with end users and subject matter experts. However, as of Spring-22 meeting, this revision is approved by the TF and also PCS to be released in the upcoming release of C57.12.90

5. Old Business - N*ew* proposed test sections 8.7 & 9.6 for OLTC tests

Chair Presented the new proposed test sections for OLTC tests under section 8.7 and 9.6. These sections have been worked on for 8 years and were approved by TF members and were sent to PCS for survey.

8.7 On Load Tap Changer Voltage Test

8.7.1 General

In order to verify the performance of a transformer that has an on load tap changer (OLTC), the OLTC shall be operated through one end-to-end-to-end sequence (from one tap extreme to the other tap extreme and back again) with the transformer energized at rated voltage.

8.7.2 Control voltage

Control voltage for the OLTC motor during the test shall be as near to rated voltage as possible, with a minimum of 85%.

8.7.3 Preparation for the test

The OLTC shall be fitted with all included equipment. It shall be connected as it will be in service, including protective devices.

8.7.4 Procedure

Either the high or low voltage winding of the transformer under test shall be energized at rated voltage and frequency, unless otherwise specified. The OLTC shall be operated using the motor drive but not manual rotation. The OLTC shall be operated through all tap positions twice, starting at one tap extreme and progressing to the other tap extreme, and then return back again to the original tap position.

The test may be performed at intervals, if necessary, such as to adjust the test circuit for the applied voltage to be adjusted to the rated voltage of the tap position, but it is a requirement that the transformer be energized at no less than rated voltage corresponding to each tap to be changed.

8.7.5 Observations and Analysis

8.7.5.1 Audible Sound

The transformer shall be observed during this test and the operator shall identify that the sound during the tap changing operations was either normal or abnormal. With some types of tap changers, there will be abnormally loud sounds if components are not assembled properly. Note that during operation of the change-over selector (reversing switch or coarse-tap selector) the sound can be slightly different.

8.7.5.2 Supply Test Circuit

The test control system shall be monitored for any trip of the test circuit that automatically stops the circuit from keeping the transformer energized.

8.7.5.3 Dissolved Gas-in-Oil Analysis

Oil samples shall be taken from the LTC compartment of vacuum type tap-changers before and after the test and analyzed for dissolved gasses. Results of the analysis may show some increase of dissolved gases due to current commutation, resistor heating and / or stray-gassing of the oil.

8.7.6 Failure Detection and Acceptance Criteria

The transformer will have passed this OLTC Voltage test if:

- The tap changer operates normally with no abnormal sound
- The transformer stays energized without a trip in the supply test circuit
- For mineral oil filled vacuum OLTCs, the increase of the sum of H2, CH4, C2H6, C2H4 and C2H2 should not exceed 12 ppm for in-tank type OLTCs and 6 ppm for compartment type LTCs.
- For non-vacuum type OLTCs, or OLTCs filled with a liquid other than mineral oil, the determination of acceptance criteria is through sound only and there is not a limit for increase in gases.

9.6 On Load Tap Changer Current Test

9.6.1 General

In order to verify the performance of a transformer that has an on load tap changer (OLTC), the OLTC shall be operated through one end-to-end-to-end sequence (from one tap extreme to the other tap extreme and back again) with the transformer current flowing through the windings, corresponding to the top nameplate MVA rating.

9.6.2 Control voltage

Control voltage for the OLTC motor during the test shall be as near to rated voltage as possible, with a minimum of 85%.

9.6.3 Preparation for the test

The OLTC shall be fitted with all included equipment. It shall be connected as it will be in service, including protective devices.

9.6.4 Procedure

The test shall be performed by applying a short circuit either the high-voltage winding or the low-voltage winding and applying sufficient voltage across the other winding to cause a specific current to flow in the windings. The OLTC shall be operated using the motor drive but not manual rotation. The OLTC shall be operated through all tap positions twice, starting at one tap extreme and progressing to the other tap extreme, and then return back again to the original tap position.

The test may be performed at intervals, if necessary, such as to adjust the test circuit for the applied voltage to be adjusted to the required current of the tap position, but it is a requirement that the transformer be energized at no less than 80% of the top MVA nameplate current value for each tap change.

9.6.5.3 Dissolved Gas-in-Oil Analysis

Oil samples shall be taken from the LTC compartment of vacuum type tap-changers before and after the test and analyzed for dissolved gasses. Results of the analysis may show some increase of dissolved gases due to current commutation, resistor heating and / or stray-gassing of the oil.

9.6.6 Failure Detection and Acceptance Criteria

The transformer will have passed this OLTC Current test if:

- The tap changer operates normally with no abnormal sound
- The transformer stays energized without a trip in the supply test circuit
- For mineral oil filled vacuum OLTCs, the increase of the sum of H2, CH4, C2H6, C2H4 and C2H2 should not exceed 12 ppm for in-tank type OLTCs and 6 ppm for compartment type LTCs.
- For non-vacuum type OLTCs, or OLTCs filled with a liquid other than mineral oil, the determination of acceptance criteria is through sound only and there is not a limit for increase in gases.

9.6.5 Observations and Analysis

9.6.5.1 Audible Sound

The transformer shall be observed during this test and the operator shall identify that the sound during the tap changing operations was either normal or abnormal. With some types of tap changers, there will be abnormally loud sounds if components are not assembled properly. Note that during operation of the change-over selector (reversing switch or coarse-tap selector) the sound can be slightly different.

9.6.5.2 Supply Test Circuit

The test control system shall be monitored for any trip of the test circuit that automatically stops the circuit from keeping the transformer energized.

New sections were sent to 188 PCS members for survey, and the results as:

APPROVED	**56**
DISAPPROVED	**9**
ABSTAIN	**5**
TOTAL	**70**
APPROVED WITH COMMENTS	**0**

Survey was sent to 118 members of the PCS

Even though the new sections were approved by PCS as well, Chair presented 4 slides prepared by Alexander Winter from HighVolt and Rainer Frotshcer from Reinhausen. These slides were focusing on the amount of time it would take to perform the test under load due to capacitor bank adjustments. Alex and Rainer proposed to add a foot note at the bottom of the new section 9.6 to allow the end user and the manufacturer to agree on reducing the number of cycles under load if necessary to reduce the amount of test time. There were discussions on IEEE standards to focus on the standard tests, but not necessarily the concern of the duration of the test. Chair commented that he will discuss this request with other experts, but as of Spring-22 meeting, these new sections are considered to be approved by PCS as well and to be released in the upcoming C57.12.90.

6. **New Business -** No additional new business was brought up during the meeting.

7. Next meeting: Fall 2022 Transformer Committee Meeting Scheduled at Charlotte
8. Close of meeting
    a. Meeting adjourned at 10:40 AM MST

9. Attendee's list is provided in Annexure - A

Submitted by: Hakan Sahin Date: 4/19/22

Annexure – A Meeting Attendance:

Last	First	Last	First	Last	First	Last	First	Last	First
Adams	Keyland	Diaz	Cesar	Jenson	Nicholas	Ramadon	Issack	Winter	Alexander
Alahmed	Alex	Digby	Scott	Joshy	Akash	Reto	Fausch	Wright	Jeffrey
Albert	Sanchez	Dillon	Nikalaus	King	Gary	Sahin	Hakan	Zemanov	Kyle
Almedia	Nabi	Dolloff	Paul	Kraemer	Axel	Sankarakurup	Dinesh		
Ansari	Tauhid	Door	Jeff	Kraetge	Alexander	Sarkar	Amitabh		
Anton	Koshhel	Elliot	William	Kyle	Stechschuttle	Schwatrz	Dan		
Antosz	Steve	Ermakov	Evgenii	Lachman	Mark	Sebastin	Rehoff		
Arnold	Elise	Faherty	Joe	Larrison	Andrew	Selvaraj	Pugal		
Arteaga	Javier	Faur	Florin	Leigl	Angela	Snyder	Steve		
Ayers	Don	Flores	Hugo	Li	Weijun	Som	Sanjib		
Bernesjo	Mats	Frye	Rich	Lucas	Tiffany	Steineman	Andy		
Betancourt	Enrique	Garcia	Eduardo	Mani	Kumar	Sullivan	Liz		
Boettger	William	Girgis	Ramsis	Montpool	Rhea	Taylor	Marc		
Britton	Jeff	Hakim	Shammaun	Morgan	Tyler	Theisen	Eric		
Brown	Darren	Hampton	Steele	Murray	David	Valentin	Reinaldo		
Chakraborty	Arup	Herron	John	Parkinson	Dwight	Vantol	Robert		
Chrysler	Rhett	Hoffman	Saramma	Patel	Nitish	Varghese	Ajith		
Cruzvaldes	Juan Carlos	Hopkinson	Phil	Patel	Sanjay	Varnell	Jason		
Dauzat	Thomas	Hutchinson	Zachary	Poureh	Davoudi	Veerdal	Joshua		
Debass	Samson	Jason	Beaudin	Prince	Jarrod	Watters	Shelby		

J.9.3 WG PC57.136 Noise Guide

Unapproved Minutes of Fall 2021 TF PCS IEEE PC57.136, "Guide for Audible Sound of Liquid-Immersed Power Transformers"

The task force met at 1:45 PM, on Monday, March 28, 2022, as part of the TF PCS Guide for Audible Sound of Liquid-immersed Power Transformers. Chairman Steve Antosz presided over the meeting with Dr. Ramsis Girgis being the Vice-Chair, and Mats Bernesjo acted as Secretary.

The meeting was attended by 25 members (out of 46), 35 guests, for a total membership meeting attendance of 60 persons, including 5 requests for membership at this meeting. A quorum was established with 25 / 46 = 54 % attendance. The agenda was unanimously approved as was the unapproved minutes from the previous meeting (Virtual meeting, fall of 2022).

First, the Chairman welcomed the audience to this meeting, reviewed the agenda, and commented on the latest circulated revision of the Guide.
Dr. Girgis then presented new additions to the Guide since last meeting. Some of these were parts in response to previous requests from power Transformer users and some were parts that were yet to be added to the Guide. The sections of the Guide where text was added are as follows:

- Chapter 3: Basic and Standards of Transformer Noise
  - Chapter 3.2.1.5 Impact of load and load power factor
  - 3.2.5 Relative magnitudes of core noise versus load noise

    - 3.3.1 IEEE Standards
- Chapter 5: Transformer Noise Reduction in the Design Stage and Factory
    - 5.4.3 External sound panels
    - 5.4.4 Sound enclosures
- Chapter 6: Methods to Mitigate Transformer Noise on Site
    - 6.1 Sound Walls and Sound Barriers
    - 6.2 Other previously used field installed techniques
- Chapter 7
    - 7.2 Determination of appropriate sound level of a transformer on-site

Comments from attendees

Stefan Siebert of Brockhaus stated that as the guide is focusing on lowering noise of power transformers, the magnetostriction properties of core steel should be considered. Most recent method of measuring magnetostriction indicates that this measurement can be made with about 5 % uncertainty. Dr. Girgis responded that the Guide discusses core noise in detail including impact of core material. However, he agreed to consider adding a statement or two related to magnetostriction.

Ajith Varghese (SPX Transformer Solutions, Inc.) asked whether external sound mitigation is causing an impact on the cooling capacity of the transformer. Dr. Girgis responded that, in general, cooling from tank surfaces is typically < 10 % of the total cooling of the transformer so reduction of cooling from covered up walls would not be significant. Sanjay Patel (SMIT) indicated that most manufacturers take this into consideration when designing for sound panels, or for retrofit of sound panels. Dan Blaydon (BG&E) also indicated that they do not de-rate a transformer when using external sound mitigation methods. However, he could see that there could be a confusion on how panels could theoretically choke the thermal performance of the transformer. Another question was brought up by John Sen (Duke Energy) whether the Guide would also specify sound panel materials. Dr. Girgis responded that this is the expertise of the sound panels and sound enclosure manufacturers. He agreed that there may be a need to add some text on impact of Sound panels and sound enclosures on cooling. Sanjay Patel (SMIT) promised to provide a photograph of a transformer with sound panels on the tank wall and tank cover (Figure 9 in the draft of the Noise Guide).

Another delegate from Trench commented on that the guide is mostly dealing with sound pressure whereas he would like the guide to also deal with sound power as this is most important to his company. Dr. Girgis replied that sound pressure is what is always measured whereas sound power is calculated and used in theoretical sound modelling of substations. Also, Sound Pressure is what the human ear hears.

Additionally, upon the request by Mr. Onome Avanoma, a comment will be added to the guide on when to perform core noise measurements, before or after dielectrics test.

A solicitation of those in attendance was initiated to request membership in the Noise Guide. A total of five requests were received. The following names and company affiliation are included in this following table.

Alex AlAhmed / Evergy Wolf Creek
Javier Arteaga / Hitachi Energy
Jerzy Kazmierczak / Hitachi Energy
Onome Avanoma / MJ Consulting
Juan Carlos Cruz Valdes / Prolec GE

Finally, the Chairman announced that text to respond to items brought up in this meeting will be added to the present draft of the Guide and Annex – A: Bibliography will be reviewed and updated. The new draft will be emailed to the WG members and guests. A request was made to all attendees to review the new

draft and provide feedback. It is the hope of the chairman that the new Draft, which will be posted on the committee website in the C57.136 section under Performance Characteristics Sub Committee, will be balloted on before the fall 2022 meeting in Charlotte.

With no new business raised, the meeting was unanimously approved to be adjourned.

Respectfully submitted,

Mats Bernesjo, WG Secretary

Spring 2022 WG Meeting Attendance and Affiliation is as follows:

Last name	First name	Company name	Role
Adams	Kayland	SPX Transformer Solutions, Inc	Member
Adetekumbo	Shosanya	XCEL Energy	Guest
AlAhmed	Alex	Evergy Wolf Creek	Guest
Antosz	Stephen	Stephen Antosz & Associates, Inc	Member
Arnold	Elise	SGB	Member
Arteaga	Javier	Hitachi Energy	Guest
Avanoma	Onome	MJ Consulting	Guest
Beaster	Barry	H-J Family of Companies	Guest
Bernesjo	Mats	Hitachi Energy	Member
Blaydon	Daniel	Baltimore Gas & Electric	Guest
Boettger	William	Boettger Transformer Consulting LLC	Member
Brown	Darren	Howard Industries	Guest
Byrnes	Ryan P.	HICO America	Guest
Cruz Valdes	Juan Carlos	Prolec GE	Guest
Digby	Scott	Duke Energy	Member
Dolloff	Paul	East Kentucky Power	Guest
Ebbeny	Alexander	HICO	Guest
Enrique	Betancourt	Prolec GE	Member
Flores	Hugo	Hitachi Energy	Member
Gamboa	Joe	H-J Family of Companies	Guest
Garcia Wild	Eduardo	Siemens Energy	Member
Girgis	Ramsis	Hitachi Energy	Member
Jensen	Nicholas	Delta Star Inc.	Member
Joshi	Akash	Black & Veatch	Member
Kazmierczak	Jerzy	Hitachi Energy	Guest
Kirchenmayer	Egon	Siemens Energy	Guest
Kostel	Anton	Delta Star Inc.	Guest
Lackman	Mark	Doble	Guest
Lawless	Andrew	Potencia Partners	Guest
Mbouombouo	Mama	Hitachi Energy	Guest
Nesvold	Brody	XCEL Energy	Guest
Nims	Joe	Allen & Hoshall	Guest

Pandza	Tihomir	Siemens Energy	Guest
Patel	Nitesh	Hyundai Power Transformers USA	Member
Patel	Sanjay	SMIT Transformer	Member
Plisic	Goran	Siemens Energy	Guest
Pointner	Klaus	Trench Austria GmbH	Member
Pouneh	Davoudi	Delta Star Inc.	Guest
Radbrandt	Ulf	Hitachi Energy	Guest
Riggins	Benjamin	XCEL Energy	Guest
Rocque	Tim	Prolec-GE Waukesha	Guest
Roussell	Marnie	Entergy	Guest
Sankarakarup	Dinesh	Duke Energy	Member
Sarkar	Amitabh	Virginia Transformer	Member
Sauer	Daniel	EATON Corporation	Member
Schappeu	Steven	Prolec-GE Waukesha	Guest
Sen	John	Duke Energy	Member
Sharp	Michael	Trench Ltd. Canada	Guest
Siegbert	Stefan	Brockhaus	Guest
Simons	Andre	JFE Shoji	Member
Sinclair	Jonathan	PPL Electric	Guest
Som	Sanjib	Pennsylvania Transformer	Member
Steineman	Audy	Delta Star Inc.	Guest
Taylor	Marc	JFE Shoji Power Canada Inc.	Member
Thompson	Ryan	Burns & McDonnell	Guest
Varghese	Ajith	SPX Transformer Solutions, Inc	Member
Varnell	Jason	Doble Engineering Co.	Member
Wallach	David	Duke Energy	Member
Wright	Jeffrey	Duquesne Light	Guest
Zibert	Kris	Allgeier Martin	Guest

J.9.4 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 28, 2022
Denver, Colorado (USA)

UNAPPROVED MINUTES

The PCS Task Force on General Requirements for C57.12.00 met at 3:15 PM on Monday, March 28, 2022. 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 statement from IEEE was 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 33 members (out of 65), 42 guests, for a total meeting attendance of 75 persons, including 6 requests for membership at this meeting. A quorum was established with 33 / 65 = 51 % attendance.
The agenda was unanimously approved (1st Dan Sauer, 2nd David Wallach) as was the unapproved minutes (1st David Wallach, 2nd Dan Sauer) from the previous meeting (Virtual meeting, fall of 2021).

The following **6** guests requested membership:

Sanjib Som	Pennsylvania Transformers
Ryan Hogg	Bureau of Reclamation
Nick Jensen	Delta Star Inc.
Alexander Kraetge	Highvolt
Amitabh Sarkar	Virginia Transformers
Dr. Alexander Winter	

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.

1. OLD BUSINESS
   - **A. Inclusion of Core information on Nameplate**

     This request had originally been brought up by Bipin Patel, expecting to simplify GIC evaluation of power transformers (type C Nameplate). In course of discussion with subject matter experts, it turned out that much more information would be required for a proper evaluation. However, a second group of participants saw value on having core type information on nameplate and the topic came back within Group's business agenda.
     With support of a TF of WG Members, the Chair developed new proposed text to include on Table 6 of C5.12.00 standard. WG Member Dr. Ramsis Girgis provided detailed description of core type options currently applied in industry. The Chair presented additional material, as a courtesy to the TF, showing simplified drawings (core & coils) of the 8 different core types for Shell and Core form transformers typically used by the Industry and opened the floor for discussion.

     A lengthy and informative discussion was held discussing:

     i. Different core types for Shell form and Core form transformers and its particular configurations, whether to add reference to the simplified drawings presented (Chair's note: not part of the scope of this TF).
     ii. the proposed additions to Rows 25 and 26 and interpretation of # of limbs (wound).
     iii. Other ways of defining # of limbs and wound limbs inside the transformer

Row	Nameplate A	Nameplate B	Nameplate C
25	-	-	Core Design --Shell or Core form

26	-	-	Core Type -Number of limbs (wound), Shell Type - D type , 7 limbs, or others

After discussing the above, Dan Sauer motioned to end the debate (seconded by Chris). The motion to end the debate was approved unanimously.

A motion to vote on whether to include the table on the nameplate was proposed (1 opposed). 22 members voted in favor and 1 member opposed the vote. As the motion passed, this nameplate requirement is sent to the PCS.

B. NEW BUSINESS

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

Ryan Musgrove brought up a concern regarding ratio tolerance on 3-phase power transformers. The concern is with a tolerance between phases of a 3-phase transformer. As the standard is written now, there could be a 1% difference between one phase and another. Example, A-phase is -.49 % and C-phase is +.49 percent. Technically both are within 0.5% of nameplate voltage. Mr. Musgrove would like to see additional clarifications for three phase transformers

Again, a lengthy and informative discussion was held discussing:

- What should be the difference in the Standard (Tauhid Ansari) and is the difference specified in the Standard sufficiently accurate? It appears that the specified limit is ok (Ajith Varghese, Dan Blaydon, Dan Sauer) but having the smallest % difference between the phases would be preferred as a slightly higher % difference could indicate a quality problem with the manufacturer. Shamaun Hakim proposed to at least measure the ratio between two phases and to limit the % difference to no more than 0.5 % for two phases.
- Difference due to half-turn in Autotransformers (Sanjay Patel, Ajith Varghese)
- Complexity of a possible repair if % difference is too high
- Consequences and impact of the % difference and at what tap positions should this % difference be maintained

Towards the end of the meeting, due to time constraints, the TF would not be able to settle on an agreeable difference during this meeting and a motion to establish a TF was raised. The question whether a TF would be needed or whether a Study group would be sufficient was raised by Dan Blaydon. Bruce Forsyth indicated that they are the same, but it would be good to have a shorter time frame for this study.

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

No new business was proposed.

Meeting was adjourned at 4:30 PM (Motion Sanjay Patel, Second Sanjib Som)

Respectfully submitted,

Tauhid Ansari	Enrique Betancourt	Mats Bernesjo
WG Chair	Co-Chair	Acting Secretary

Attendance Fall 2022 Spring Meeting – PCS TF on General Requirements C57.12.00

Last name	First name		Last name	First name
Alahmed	Alex		Kraetge	Alexander
Andre	Simons		Lachman	Mark
Ansari	Tauhid		Leigl	Angela
Antosz	Stephen		McCullough	Doug
Arteaga	Javier		Murray	David
Ayers	Donald		Musgrove	Ryan
Beaudoin	Jasou		Nambi	Shankar
Benzler	Olle		Nesvold	Brady
Bernesjo	Mats		Nims	Joe
Betancourt	Enrique		Parkinson	Dwright
Blaydon	Daniel		Patel	Nitesh
Boettger	William		Patel	Sanjay
Britton	Jeffrey		Pepe	Harry
Brown	Darren		Prince	Jarrod
Chakraborty	Arup		Radbrandt	Ulf
Davoudi	Pouneh		Rechkopl	Sebastian
Debass	Samson		Rocque	Tim
Digby	Scott		Roussell	Marnie
Dillon	Nikolaus		Sahin	Hakan
Elliott	William		Sankarakurup	Dinesh
Flores	Hugo		Sarkar	Amitabh
Forsyth	Bruce		Sauer	Daniel
Garcia Wild	Eduardo		Selvarat	Dugal
Girgis	Ramsis		Sen	Cihangir
Gomez Hennig	Eduardo		Snyder	Steven
Gragert	Jeffrey		Som	Sanjib
Hakin	Shamaun		Stretch	Kerwin
Herron	John		Taylor	Marc
Hoffman	Saramma		teNyenhuis	Ed
Hogg	Ryan		vanTol	Robert
Hopkinson	Phil		Varghese	Ajith
Jensen	Nick		Varnell	Jason
Jordan	Steven		von Gemmingen	Richard
Joshi	Akash		Wallach	David
Kazmierczak	Jerzy		Winter	Dr. Alexander
Kiparizoski	Zan		Zemanovic	Kyle

Knapp	Evan		Zibert	Kris
Koshel	Anton			

J.9.5 WG HV & EHV Breaker & Transformer Sw. Transients C57.142

MEETING NOTES
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
Denver, CO
Tuesday, March 29th , 2022
3:15 PM – 4:30 PM Mountain Time Zone - USA
Chairman – Jim McBride
Vice Chair – Xose Lopez-Fernandez
Secretary – Tom Melle

1) Meeting called to order at 3:15 PM Central Time.
   Welcome and Chair's Remarks
2) 53 Attendees were present (32 Guests) 21 of 49 Members present
   Quorum was not achieved.
3) IEEE Patent Policy Slides and Copyrights slides (NO essential patent claims or copyright issues)
4) Approval of Agenda and Minutes from Last Meeting.
   Quorum was not achieved. Therefore, the Minutes will be sent by e-mail for approval.
5) SA Ballot– Jim McBride

C57.142 Draft 10 is now under ballot. Only the slight editorial changes and mandatory changes requested by MEC were made between Draft 10 and the Draft 9B which was approved by the WG.

6) Switchgear Liaison Update
No new business from the Switchgear group. The Spring Switchgear Committee meeting will be held in Orlando, FL from April 10th – 14th 2022. We will encourage voting on the ballot at the meeting.

The WG focus now will be on Mitigation Methods until balloting begins.

7) Mitigation Methods Task Force Update – Jim McBride / Phil Hopkinson
The membership of task force was shown. Several of the suggested mitigation methods follow:
- Resistor-Capacitor Snubbers
- Increasing Insulation in Key Areas with Additional Test Requirement for Special Terminated Lightning Impulse to Better Test for Field Conditions.
- Using Shielding to increase Series Capacitance and reduce capacitance to ground in order to Improve Impulse Distribution and Reduce Series Resonance
- Introduce Internal Surge Protection to Limit Over-voltages During Resonant Conditions
- Reignition Mitigation with Controlled Switching
- Using Resistance Load During Switching to Provide Damping During the Event
- Online Monitoring to Identify Actual Field Interactions and Identify Real World Conditions at the Transformer Terminals and Within the Transformer.

8) Presentation: *Mitigation of internal over-voltages with MOV's* - Juliano Montanha, Egon Kirchenmayer. The presentation will be available on the working group website.

Following the presentation several questions were fielded by Mr. Kirchenmayer and the Chair regarding Zn0 varistors in practical use by manufacturers and about preliminary quality checks and testing of MOV's. There is an IEC standard for surge arrester testing used as a reference for MOV test procedures. The chair also discussed the effect of temperature on losses.

9) Preview of Presentation: Mitigation of Failure using online monitoring – Jim McBride (to be presented next meeting)

The Chair provided a brief summary about the mitigation methods discussed in previous meetings.

10) New Business – During the Fall 2021 (virtual) meeting, Deepak Kumaria suggested the possibility of including the study of transients on instrument transformers in the WG. This topic will be investigated during the next meeting.

11) Next Meeting - Fall 2022 – Charlotte, NC USA (TBD) October 16th – 20th, 2022

12) Motion to Adjournment made by the Chair at 4:30 PM with no objection.

Meeting Attendance

Role	Last Name	First Name	Company	City	State	Present 3/29/22
Chair	McBride	James	JMX High Voltage	Fayetteville	GA	X
Sec.	Melle	Thomas	HIGHVOLT	Holly Springs	NC	X
Member	Betancourt	Enrique	Prolec GE	Apodaca	Other	X
Member	Boettger	William	Boettger Transformer Consulting LLC	Danville	CA	X
Member	Britton	Jeffrey	Phenix Technologies, Inc.	Accident	MD	X
Member	Dinh	Huan	Hitachi Energy	Lexington	KY	X
Member	Garcia Wild	Eduardo	Siemens Energy	Guanajuato	Other	X
Member	Heiden	Kyle	EATON Corporation	Milwaukee	WI	X
Member	Hopkinson	Philip	HVOLT Inc.	Charlotte	NC	X
Member	Joshi	Akash	Black & Veatch	Cary	NC	X
Member	Kirchenmayer	Egon	Siemens Energy	Nuremberg	Other	X
Member	Li	Weijun	Braintree Electric Light Dept.	Braintree	MA	X
Member	Pepe	Harry	Phenix Technologies, Inc.	Accident	MD	X
Member	Pointner	Klaus	Trench Austria GmbH	Leonding	Other	X
Member	Radbrandt	Ulf	Hitachi Energy	Ludvika	Other	X
Member	Roussell	Marnie	Entergy	New Orleans	LA	X
Member	Sarkar	Amitabh	Virginia Transformer Corp.	Roanoke	VA	X
Member	Sharp	Michael	Trench Limited	Scarborough	ON	X
Member	Sizemore	Thomas	ABB Inc.	Greenville	NC	X

Member	Snyder	Steven	Hitachi Energy	Versailles	KY	X
Member	Spurlock	Mike	Spurlock Engineering Services	Columbus	OH	X
						X
Guest	Ayers	Donald	Ayers Transformer Consulting	Waxhaw	NC	X
Guest	Craven	Michael	Phoenix Engineering Services	Atlanta	GA	X
Guest	Gamboa	Jose	H-J Family of Companies	High Ridge	MO	X
Guest	Harley	John	FirstPower Group LLC	Peninsula	OH	X
Guest	Jordan	Stephen	Tennessee Valley Authority	Chattanooga	TN	X
Guest	Leigl	Angela	EATON Corporation	Waukesha	WI	X
Guest	Parkinson	Dwight	EATON Corporation	Waukesha	WI	X
Guest	Patel	Nitesh	Hyundai Power Transformers USA	Montgomery	AL	X
Guest	Roman	Zoltan	GE Grid Solutions	Charleroi	PA	X
Guest	Sanchez	Albert	Knoxville Utilities Board	Knoxville	TN	X
Guest	teNyenhuis	Ed	Hitachi Energy	Stoney Creek	ON	X
Guest	Varghese	Ajith	SPX Transformer Solutions, Inc.	Hartland	WI	X
Guest	vonGemmingen	Richard	Dominion Energy	Mechanicsville	VA	X
Guest	Zaman	Malia	IEEE	Piscataway	NJ	X
Guest	Ziger	Igor	KONCAR - Instrument Transformers	Zagreb	Other	X
Guest	Rocque	Tim	Prolec GE Waukesha	Waukesha	WI	X
Guest	Posadas	Daniel	Prolec SA de CV	Mty, NL, MX	Other	X
Guest	Oliveira	Jonas	Hitachi Energy	Crystal Sprtings	MS	X
Guest	Al Ahmed	Alex	Evergy Wolf Creek	Kansas City	MO	X
Guest	Pandza	Tihomir	Siemens Energy	Zagreb	Other	X
Guest	Gaziloda	Dora	KONCAR - Instrument Transformers	Zagreb	Other	X
Guest	Kotuna	John	Dominion Energy	Richmond	VA	X
Guest	Plisic	Goran	Siemens Energy	Zagreb	Other	X
Guest	Dillon	Nikolaus	Dominion Energy	Richmond	VA	X
Guest	Dolloff	Paul	East Kentucky Power	Winchester	KY	X
Guest	Door	Jeffrey	H-J Family of Companies	Hill Ridge	MO	X
Guest	Shosanya	Adetokunbo	XCEL Energy	Amarillo	TX	X
Guest	Avanoma	Onome	MJC	Winnipeg	Canada	X
Guest	Salmon	Tommy	GE Grid Solutions	Chesterfield	VA	X
Guest	Deverick	Jonathan	Dominion Energy	Richmond	VA	X
Guest	Zhery	Rigi	HICO	Memphis	TN	X
Guest	Debass	Samson	EPRI	Charlotte	NC	X

J.10 Performance Characteristics Subcommittee Attendance List

First Name	Last Name	Email
Tauhid Haque	Ansari	tauhid.ansari@hitachienergy.com
Stephen	Antosz	santosz@ieee.org
Elise	Arnold	elise.arnold@sgb-smit.group
Javier	Arteaga	javier.arteaga@ieee.org
Onome	Avanoma	o.avanoma@outlook.com
Donald	Ayers	donald.ayers@ieee.org
Gilles	Bargone	gilles.bargone@gmail.com
Barry	Beaster	blbeaster@ieee.org
Olle	Benzler	olle.benzler@megger.com
Enrique	Betancourt	ebetanco@ieee.org
Wallace	Binder	wbbinder@ieee.org
Wallace	Binder	wbbinder@ieee.org
Daniel	Blaydon	dblaydon@ieee.org
William	Boettger	weboettger@aol.com
Jeffrey	Britton	jbritton@doble.com
Arup	Chakraborty	arup.chakraborty@deltastar.com
Rhett	Chrysler	rhettchrysler@ieee.org
Michael	Craven	mpcraven@bellsouth.net
Juan Carlos	Cruz Valdes	juancarlos.cruz@prolecge.com
J. Arturo	Del Rio	a.delrio@ieee.org
Nikolaus	Dillon	nikolaus.n.dillon@dominionenergy.com
Huan	Dinh	huan.m.dinh@hitachienergy.com
Daniela	Ember Baciu	emberbaciu.daniela@hydro.qc.ca
Marco	Espindola	marco.a.espindola@hitachienergy.com
Reto	Fausch	retofausch@ieee.org
Hugo	Flores	hafg@dusty.tamiu.edu
Jose	Gamboa	joseg@h-j.com
Eduardo	Garcia Wild	eduardo.garcia@ieee.org
Ramsis	Girgis	ramsis.girgis@hitachienergy.com
Bill	Griesacker	bgriesacker@verizon.net
Kyle	Heiden	kylejheiden@eaton.com
Sergio	Hernandez Cano	shernan@hammondpowersolutions.com
John	Herron	herronjph@aol.com
Gary	Hoffman	grhoffman@advpowertech.com
Saramma	Hoffman	shoffman@pplweb.com
Ryan	Hogg	rhogg@ieee.org
Philip	Hopkinson	phopkinson@ieee.org
Ramadan	Issack	raissack@aep.com

Nicholas	Jensen	nbjensen89@gmail.com
Stephen	Jordan	shjordan@tva.gov
Kevin	Juchem	kevin.juchem@de.abb.com
Egon	Kirchenmayer	egon.kirchenmayer@siemens-energy.com
Anton	Koshel	akoshel@deltastar.com
Alexander	Kraetge	kraetge@web.de
Krzysztof	Kulasek	krzysztof.h.kulasek@hitachienergy.com
Aleksandr	Levin	aleksandr.levin@weidmann-group.com
Weijun	Li	wli@beld.com
Colby	Lovins	colby.lovins@ieee.org
Tim-Felix	Mai	tim-felix.mai@siemens-energy.com
Kumar	Mani	kumar.mani@duke-energy.com
James	McBride	jim@jmxhv.com
Thomas	Melle	tom.melle.us@ieee.org
Emilio	Morales-Cruz	emorales@qualitrolcorp.com
David	Murray	dbmurray@tva.gov
Ryan	Musgrove	ryan.musgrove@ieee.org
Shankar	Nambi	snambi@bechtel.com
Aniruddha	Narawane	anarawane@ieee.org
Poorvi	Patel	poorvi.patel@hotmail.com
Nitesh	Patel	nrpatel@hhiamerica.com
Harry	Pepe	hpepe@doble.com
Klaus	Pointner	klaus.pointner@trench-group.com
Jarrod	Prince	jarrod.prince@ermco-eci.com
Ulf	Radbrandt	ulf.radbrandt@ieee.org
Adnan	Rashid	adnan.rashid@canada.ca
Diego	Robalino	diego.robalino@megger.com
Tim	Rocque	tim.rocque@spx.com
Zoltan	Roman	zoltan.roman@ge.com
Marnie	Roussell	mrouss1@entergy.com
Hakan	Sahin	hakanshaun@gmail.com
Albert	Sanchez	albert.sanchez@kub.org
Dinesh	Sankarakurup	dinesh.sankarakurup@duke-energy.com
Daniel	Sauer	dmsauer@mtu.edu
Steven	Schappell	schappell@ieee.org
Markus	Schiessl	markus.schiessl@sgb-smit.group
Alfons	Schrammel	alfons.schrammel@siemens-energy.com
Ewald	Schweiger	ewald.schweiger@ieee.org
Pugal	Selvaraj	pugal_selvaraj@vatransformer.com
Cihangir	Sen	cihangir.sen@duke-energy.com
Michael	Sharp	sharp.michael@siemens-energy.com

Stephen	Shull	sshull@ckt.net
Thomas	Sizemore	thomas.sizemore.us@ieee.org
Kenneth	Skinger	krskinger@scituateconsulting.com
Steven	Snyder	slsnyder@ieee.org
Mike	Spurlock	mspurlock@ieee.org
Brad	Staley	brad.staley@srpnet.com
Markus	Stank	m.stank@reinhausen.com
Kyle	Stechschulte	kdstechschulte@aep.com
Andrew	Steineman	asteineman@deltastar.com
Charles	Sweetser	charles.sweetser@omicronenergy.com
Janusz	Szczechowski	j.szczechowski@reinhausen.com
Troy	Tanaka	ttanaka@burnsmcd.com
Marc	Taylor	marc.taylor@jfeshojipower.com
Ed	teNyenhuis	edt@ieee.org
Alan	Traut	atraut@ieee.org
Olivier	Uhlmann	o.uhlmann@ca.reinhausen.com
Alwyn	Van Der Walt	alwyn.vanderwalt@eciusa.com
Ajith	Varghese	ajith.varghese@prolec.energy
Joshua	Verdell	josh.verdell@ermco-eci.com
Richard	vonGemmingen	rgemmingen@aol.com
Pragnesh	Vyas	pvyas@solomoncorp.com
David	Wallach	david.wallach@duke-energy.com
Alan	Washburn	awashburn@burnsmcd.com
Joe	Watson	joe_watson@ieee.org
Bruce	Webb	bruce.webb@kub.org
Dr. Alexander	Winter	winter@highvolt.de
Jeffrey	Wright	jwright@duqlight.com
Malia	Zaman	m.zaman@ieee.org
Kent	Miller	kent.miller@trelectric.com
Jason	Beaudoin	jason.beaudoin@weidmann-group.com
Kyle	Zemanovic	kylezemanovic@eaton.com
Thomas	Dauzat	thomas.dauzat@prolec.energy
Evan	Knapp	evanhknapp@eaton.com
Tom	Matson	tom.matson@xcelenergy.com
Dennis	Carr	deniss.car@ge.com
Cesar	Diaz	cesardiaz@eaton.com
Andrew	Larison	andrew.t.larison@hitachienergy.com
Alex	Alahmed	alahmedalex@gmail.com
Samson	Debass	sdebass@epri.com
Eduardo	Gomez Hennig	eduardo.gomez_h@siemens-energy.com
Asfnoo	Novet	

Jerry	Kazmierczak	jerrykazmierczak@hitachienergy.com
Mama	Mbouombouo	mama.mbuoumbouo@hitachienergy.com
Heston	de Oliveria Filho	heston.deoliveirafilho@pseg.com
Donnie	Pollaro	dpollaro@nassusa.com
Robert	Vanto	robert.vantol@caiengr.com
Richard	Foye	richardfoye@eaton.com
First Name	Last Name	Email
Tauhid Haque	Ansari	tauhid.ansari@hitachienergy.com
Stephen	Antosz	santosz@ieee.org
Elise	Arnold	elise.arnold@sgb-smit.group
Javier	Arteaga	javier.arteaga@ieee.org
Onome	Avanoma	o.avanoma@outlook.com
Donald	Ayers	donald.ayers@ieee.org
Gilles	Bargone	gilles.bargone@gmail.com
Barry	Beaster	blbeaster@ieee.org
Olle	Benzler	olle.benzler@megger.com
Enrique	Betancourt	ebetanco@ieee.org
Wallace	Binder	wbbinder@ieee.org
Wallace	Binder	wbbinder@ieee.org
Daniel	Blaydon	dblaydon@ieee.org
William	Boettger	weboettger@aol.com
Jeffrey	Britton	jbritton@doble.com
Arup	Chakraborty	arup.chakraborty@deltastar.com
Rhett	Chrysler	rhettchrysler@ieee.org
Michael	Craven	mpcraven@bellsouth.net
Juan Carlos	Cruz Valdes	juancarlos.cruz@prolecge.com
J. Arturo	Del Rio	a.delrio@ieee.org
Nikolaus	Dillon	nikolaus.n.dillon@dominionenergy.com
Huan	Dinh	huan.m.dinh@hitachienergy.com
Daniela	Ember Baciu	emberbaciu.daniela@hydro.qc.ca
Marco	Espindola	marco.a.espindola@hitachienergy.com
Reto	Fausch	retofausch@ieee.org
Hugo	Flores	hafg@dusty.tamiu.edu
Jose	Gamboa	joseg@h-j.com
Eduardo	Garcia Wild	eduardo.garcia@ieee.org
Ramsis	Girgis	ramsis.girgis@hitachienergy.com
Bill	Griesacker	bgriesacker@verizon.net
Kyle	Heiden	kylejheiden@eaton.com
Sergio	Hernandez Cano	shernan@hammondpowersolutions.com
John	Herron	herronjph@aol.com

Gary	Hoffman	grhoffman@advpowertech.com
Saramma	Hoffman	shoffman@pplweb.com
Ryan	Hogg	rhogg@ieee.org
Philip	Hopkinson	phopkinson@ieee.org
Ramadan	Issack	raissack@aep.com
Nicholas	Jensen	nbjensen89@gmail.com
Stephen	Jordan	shjordan@tva.gov
Kevin	Juchem	kevin.juchem@de.abb.com
Egon	Kirchenmayer	egon.kirchenmayer@siemens-energy.com
Anton	Koshel	akoshel@deltastar.com
Alexander	Kraetge	kraetge@web.de
Krzysztof	Kulasek	krzysztof.h.kulasek@hitachienergy.com
Aleksandr	Levin	aleksandr.levin@weidmann-group.com
Weijun	Li	wli@beld.com
Colby	Lovins	colby.lovins@ieee.org
Tim-Felix	Mai	tim-felix.mai@siemens-energy.com
Kumar	Mani	kumar.mani@duke-energy.com
James	McBride	jim@jmxhv.com
Thomas	Melle	tom.melle.us@ieee.org
Emilio	Morales-Cruz	emorales@qualitrolcorp.com
David	Murray	dbmurray@tva.gov
Ryan	Musgrove	ryan.musgrove@ieee.org
Shankar	Nambi	snambi@bechtel.com
Aniruddha	Narawane	anarawane@ieee.org
Poorvi	Patel	poorvi.patel@hotmail.com
Sanjib	Som	ssom@patransformer.com
Kris	Zibert	Kris.zibert@amce.com