10.4 Performance Characteristics Subcommittee – Chair: Ed teNyenhuis; Vice-Chair: Craig Stiegemeier; Secretary: Sanjib Som

Introduction / Attendance

The Performance Characteristics Subcommittee (PCS) met on Wednesday, March 20, 2013 at 3pm with 110 people attending. Of these, 60 were members and were 50 guests. Prior to this meeting, the total membership of PCS was 105 members; therefore, quorum was achieved with 60 of the membership in attendance.

There were 7 guests requesting membership.

Chairman's Remarks

A review of the PCS standard expirations and PAR expirations was reviewed; five standards due to expire in 2018 needs attention. These are (C57.21, C57.105, C57.109, C57.110 and C57.136).

The Thursday morning technical presentations were mentioned for information.

Administrative Subcommittee Notes

Upcoming IEEE – PES Meetings

- PES General Meeting: July 2013, Vancouver, BC, Canada.
- Next Transformer Committee meetings:
  - Fall 2013, St. Louis, Missouri; hosted by HJ Enterprises
  - Spring 2014, Savannah, Georgia; hosted by EFACEC

Approval of Last Meeting Minutes

The chairman presented the minutes of the last meeting in **Milwaukee, WI – October 24, 2012.** This was seconded by Dan Sauer. There were no comments from the attendees. The minutes were approved as written.

Unfinished (Old) Business

No old business.

New Business

No new business.

Meeting was adjourned at 4.15 pm.

Working Group (WG) and Task Force (TF) Reports:

10.4.1 PC57.120 LOSS EVALUATION GUIDE FOR DISTRIBUTION AND POWER TRANSFORMERS AND REACTORS

Meeting Minutes (Un-approved) of Fall 2013 Munich, Germany on Tuesday March 19, 2013

Al Traut, Chair, Don Duckett, Vice-Chair, Dave Harris - Secretary

PAR Status: PAR Approved; PAR expiration Date: 12/31/2014; Current Draft Being Worked On: D13

- Attendance
  - 45 Total
  - 8 of 21 Members
  - 31 Guests
  - 6 Guests requesting membership
- The meeting was called to order at 11:00 am on Tuesday, March 19, 2013.
- Attendance of membership was taken and a quorum was not established.

Chair Report

- Al Traut outlined the PAR status and expiration and noted that we need to go to ballot no later than immediately after the Spring 2014 meeting.

Old Business

Updates to Draft 13

- Suggestion from last meeting was to move Annex C in to section 4.2 – Al completed this move
- No changes in definitions
- Comment about LM and L acronym at last meeting - Al modified each to LM for consistency.
- Two stages of cooling in TOC – section 4.1 updated
  - Added B1, AL1 and B2, AL2
  - Jerry (EFACEC) asked question about bank 1, bank 2. Al said might become clear in later section.
- Added Loss Multiplier to equation in 4.1.1 – into determination of A & B factors
  - As long as the LM is taken out of the other equations (Wally)
- Al - trying very hard to keep dollar units out of the document
  - Steve Shull suggested that the word “currency” could be used in place of dollar sign to get around IEEE requirement.
- 4.2 – includes information that was in Annex C, might be some redundant statements as we go through this
  - Include all costs of acquiring the transformer (taxes, engineering work, etc.)
  - Auxiliary Losses – Last sentence - Stage 1 running during stage 2
  - Shunt and Series Reactors came out of Annex C
- 4.3 – Cost Parameters
  - Don brought up the point about system capacity costs at last meeting; suggestion to break costs into three separate costs. Al needs help breaking the non-GC costs into Transmission and Distribution “buckets”.
    - Brian K. and Al T. suggested that the loading factor would be different depending on where the transformer is in the system, but the model would be similar
  - Al will update the specific time references used in this section

  - Wes Knuth – Resource management people were pretty secretive about how much they were spending. Stated he would go back and try to obtain more information.
  - Wally – Identified resource (where?) cost of various technologies – if you don't have generation, there are numbers available for a good estimate. Energy Interface Agency? (Al) Wally will check to see what he sent to Al previously. Wally provided the link below. http://en.openei.org/apps/TCDB which is a Transparent Cost Database which shows the overnight capital costs of various generation technology
  - Tony Reiss provided a copy of report that he believes was the reference mentioned by Wally. Link included below.
    - http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf
  - Avoided Cost of Energy – no change
- Bibliography has to be at the end per IEEE requirements.

Question (Sasha Levin): Does this standard address solar (PV) transformers installations

- This guide should cover it – have all the pieces in the document to cover these installations, customer has to understand how to apply these calculations to this type of transformer
- Generating xfmr when PV operating – Wally
- Jeff mentioned 4 different scenarios customers use
  - Utility at times specifies the transformer being used and customer must conform to the specs of that xfmr
- Brian K. mentioned "green factor" for utility
- Al – don't need to specifically address the PV gen xfmrs

New Business

- None

Next Meeting

- October 2013 St Louis, MO
- Adjourned at 11:45am

10.4.2 Working Group on PCS Revisions to C57.12.90

Mark Perkins, Chairman; Craig Stiegemeier, Secretary

Unapproved minutes: March 18, 2013, 11:00am-12:15pm, Ammersee II, Dolce Hotel, Munich, Germany

1. Attendance

Attendance rosters were circulated for those in attendance to record their presence and confirm their membership or guest status. There were 30 members and 29 guests in attendance.

A roll call vote was taken, and a majority of the 65 active members of the WG were not in attendance, so there was not a quorum.

2. The Fall 2012 Milwaukee minutes were not approved, as there was not a quorum present at the start of the meeting. The plan is to conduct an E-mail approval of the minutes of both the Milwaukee meeting as well as these minute to the membership group.

3. Old Business

The main task of the working group was to review suggested changes to section 9.5 for zero sequence testing. Prior to the meeting an email was sent to working group members and guests with the suggested changes to section 9.5.1 and 9.5.3. A number of members replied to the email with suggested changes. These changes were reviewed in the meeting and the reasons behind the changes were discussed.

The following changes (highlighted in red) to Section 9.5.1 were included in the original email:

The excitation voltage and current shall be established as follows:

a) If no delta connection is present on the transformer and the transformer is a three leg core design, there is a risk of excessive tank wall heating due to the return flux from the core going into the tank wall. To avoid this, the applied voltage should be such that the current is no more than 20% of the base rating of the winding being excited. This applies to both open-circuit tests and short-circuits tests as described in section 9.5.3.

If the transformer is a five leg core or a shell form design the zero-sequence impedance is equal to the positive sequence impedance and the zero-sequence test is generally not needed. However, should the test be done, the applied voltage should not exceed 30% of the rated line-to-neutral voltage of the winding being energized for the open-circuit test, and the phase current should not exceed ~~its~~ the base rated value of the winding being excited for the short-circuit test.

b) If a delta connection is present, the applied voltage should be such that the base rated phase current of any delta winding is not exceeded.

The following changes to section 9.5.3 (highlighted in red) were included:

NOTE – Applies also to auto transformers. For wye-wye transformers or autotransformers without a delta tertiary that are 5 leg core form or shell form, Z3 is very large and the zero sequence impedance is equal to the positive sequence impedance. For three leg core form wye-wye transformers, the Z3 value is typically 5-10 times the Z12 measured value due to the "phantom delta" effect of the tank and/or tank wall shielding. The Z3 value should be taken into account in short circuit calculations involving the zero sequence impedance. Measurements may be made at different current levels to establish the non-linear curve for all four different measurements.

Four tests may be made to determine the zero-phase-sequence equivalent network, one of which is redundant.

a) *Test 1*. Apply a single-phase voltage to winding 1 between the shorted line terminals of winding 1 and its neutral. All other windings are open-circuited. The measured zero-phase-sequence impedance is represented by Z_1N_o.

b) *Test 2*. Apply a single-phase voltage to winding 1 between the shorted line terminals of winding 1 and its neutral. Short the line terminals and neutral of winding 2. All other

windings shall be open-circuited. The measured zero-sequence impedance is represented by Z_1N_s.

c) *Test 3*. Apply a single-phase voltage to winding 2 between the shorted line terminals of winding 2 and its neutral. All other windings are open-circuited. The measured zero-phase-sequence impedance is represented by Z_2N_o.

d) *Test 4*. Apply a single-phase voltage to winding 2 between the shorted line terminals of winding 2 and its neutral. Short the line terminals and neutral of winding 1. All other windings shall be open-circuited. The measured zero-phase-sequence impedance is represented by Z_2N_s.

Egon Kirchenmeyer objected to the part in 9.5.1 that indicated that for a 5 leg core or shell form transformer the zero-sequence impedance is equal to the positive sequence impedance. After discussion by the chair with Egon, he presented the following suggested change to the information provided above on section 9.5.1:

If the transformer is a five leg core or shell form design, the zero sequence impedance measured in open-circuit is very high and can be considered as infinity for most short-circuit studies and therefore a measurement is generally not needed. Only the zero-sequence impedance measured in short-circuit, which is nearly equal to the positive sequence impedance is of interest in these cases.

and 9.5.3:

NOTE - For wye-wye transformers or autotransformers without a delta tertiary: For five leg core or shell form transformers Z3 is very large, therefore the zero sequence impedance measured in an open-circuit test is nearly equal to Z3. The zero sequence impedance measured in a short-circuit test is nearly equal to the positive sequence impedance. For three leg core form transformers Z3 is typically 5-10 times the positive sequence impedance due to the "phantom delta" effect of the tank and tank wall shielding. Measurements may be made at different current levels to establish the "low current" section of the non-linear curve of Z3. The zero sequence impedance measured in a short-circuit test is nearly equal to the positive sequence impedance.

V Sankar requested that we add the following information to the note in 9.5.3:

For fault calculations, in Z3 branch one turn should be considered

Shamaun Hakim asked that we clarify whether the 20% current limitation is phase current or the neutral current.

Based on these comments the chair suggested the revisions be modified (as highlighted in blue) as follows on section 9.5.1:

The excitation voltage and current shall be established as follows:

c) If no delta connection is present on the transformer and the transformer is a three leg core design, there is a risk of excessive tank wall heating due to the return flux from the core going into the tank wall. To avoid this, the applied voltage should be such that the phase current is no more than 20% of the base rating of the winding being excited. This applies to both open-circuit tests and short-circuits tests as described in section 9.5.3.

If the transformer is a five leg core or a shell form design the zero-sequence impedance for the short-circuit test is equal to the positive sequence impedance and the open-circuit impedance has such a high value as to be negligible. Therefore, the zero-sequence test is generally not needed. However, should the test be done, the applied voltage should not exceed 30% of the rated line-to-neutral voltage of the winding being energized for the open-circuit test, and the phase current should not exceed ~~its~~ the base rated value of the winding being excited for the short-circuit test.

d) If a delta connection is present, the applied voltage should be such that the base rated phase current of any delta winding is not exceeded.

and 9.5.3:

NOTE – Applies also to auto transformers. For wye-wye transformers or autotransformers without a delta tertiary that are 5 leg core form or shell form, Z3 is so large as to be neglected and the zero sequence impedance is can be assumed as equal to the positive sequence impedance. For three leg core form wye-wye transformers, the Z3 value is typically 5-10 times the Z12 measured value due to the "phantom delta" effect of the tank and/or tank wall shielding. The Z3 value should be taken into account in short circuit calculations involving the zero sequence impedance. Measurements may be made at different current levels to establish the non-linear curve for all four different measurements.

Four tests may be made to determine the zero-phase-sequence equivalent network, one of which is redundant.

a) *Test 1*. Apply a single-phase voltage to winding 1 between the shorted line terminals of winding 1 and its neutral. All other windings are open-circuited. The measured zero-phase-sequence impedance is represented by Z_1N_o.

b) *Test 2*. Apply a single-phase voltage to winding 1 between the shorted line terminals of winding 1 and its neutral. Short the line terminals and neutral of winding 2. All other windings shall be open-circuited. The measured zero-sequence impedance is represented by Z_1N_s.

c) *Test 3*. Apply a single-phase voltage to winding 2 between the shorted line terminals of winding 2 and its neutral. All other windings are open-circuited. The measured zero-phase-sequence impedance is represented by Z_2N_o.

d) *Test 4*. Apply a single-phase voltage to winding 2 between the shorted line terminals of winding 2 and its neutral. Short the line terminals and neutral of winding 1. All other windings shall be open-circuited. The measured zero-phase-sequence impedance is represented by Z_2N_s.

The following comments were made during a review of the suggested text changes:

- Bertrand Poulin noted that in a recent test on a three-leg core form transformer without a delta winding, when 20% of the rated phase current was supplied for the open-circuit zero-sequence impedance measurement, the measured loss was five times the positive sequence load loss at rated current. This high loss is caused by tank wall heating.

- Joe Foldi commented that during a single line to ground fault, the impedance would be different than what's measured during the test – especially if a strong system is present to

support the fault current. He suggested that it be stated in the standard that the impedance at full voltage is different. Joe will E-mail Mark with the comment and a suggestion to users

The following notes were taken during a review of the procedure and suggested comments:

- The suggestion for measurements at different current levels to better estimate the zero sequence impedance at full voltage levels.
- Don Ayers suggested that consideration of the watts loss be measured, reported and limited to some value.
- Bertrand Poulin commented that this was a good suggestion, as the measuring system typically in place can record and report this information.
- In general, those in attendance thought this was a good suggestion, and it will be considered as a new business item for the next meeting.

Since we did not have a quorum at the meeting, the minutes of both the Fall 2012 meeting and the Spring 2013 meeting will be emailed to working group. The members will be asked to respond to the email to:

(a) Approved the minutes of the Fall meeting

(b) Review the business items and proposed changes to 9.5.1 and 9.5.3 and to respond to the email whether they approve, approve with comments or reject with reasons.

4. New Business - There was no new business

5. Attendance roll call – Before the meeting, the Working Group had 368 members & guests, broken down as the following:

65 Members

2 Corresponding Members

301 Guests

After a review of the attendance rosters and the tallying of those attending, along with a change in membership from “Member” to “Guest” of those who have not attended the past 3 meetings and removal of either “Terminated” membership or participation status, the following is the composition of the Working Group:

67 Members – 38 attending the meeting (57% - a quorum)

2 Corresponding Members

311 Guests – 51 attending the meeting

6. Adjournment - Meeting adjourned at12:15 pm

10.4.3 PCS WG on “General Requirements C57.12.00” – Steve Snyder, Chairman; Enrique Betancourt, Secretary

March 18, 2013 3:15 PM; Dolce Munich Unterschleissham Hotel; Munich, Germany

The Group met at 3:15 PM on Monday, March 18, 2013, with **26 out of 69** members, and **20** guests present. **Three (3)** guests requested membership. The meeting was chaired by the Group's Secretary, E. Betancourt, on behalf of the Chairman Steve Snyder, who was unable to attend. Scott Digby took notes as Acting Secretary.

The statement of purpose of the WG was explained. As we did not have a Quorum, the minutes from the Milwaukee Meeting were not approved; the chairman of the WG will perform a survey among the Group's membership for approval.

Following guests requested membership to the Group:

David Ostrander	Ameren
Pontus Sundqvist	ABB
Scott Digby	Progress Energy

1. Old Business.

The Acting Chairman reported that the minutes of the Spring 2012 Nashville meeting were approved by an email survey on November 20, 2012.

One old business for this WG, Item 87 "Table 15 Short-Circuit Apparent Power of the System", was shifted for the next autumn meeting, after a final survey for the last proposed version of the Table can be carried out.

Next, four Agenda Items were discussed within this meeting

A. WG Item 96, Table 18 "Resistance Measurements for All Taps on Power Transformers".

Change Requested by : Joe Foldi – 2009 Ballot Comment.

Requested Change: Resistance measurements should be done on all taps for Power Transformers, as a very important quality verification.

This item has already been discussed in the last two meetings, including a survey which was performed among members of the WG and the PC SC. In response to the negative comments, Joe Foldi provided this time new inputs to substantiate his request. A practical example on how a smooth resistance profile would be expected for a transformer with all connections in good condition was explained in detail by Joe to the meeting attendance. Besides that, it was clarified that his proposal is applicable for Class II power transformers.

The relevance of capturing problems with LTC connections before factory testing and before the field energization of the transformer was stressed through description of real cases from experience of several participants to the meeting.

After a lengthy discussion, the Acting Chairman concluded the discussion as being reduced to following items, some of them still carried from previous discussions:

Need to propose pass/fail criteria for interpretation of measurement results

Recommendation to investigate feasibility of a fast testing procedure

Need to investigate on repeatability of test results in the field

Demonstrate ability of the test to capture bad connections

Evaluate if a faster and apparently simpler 120% overload test would capture connection issues

With these inputs, a new text will be prepared for this proposal, for a new survey within the WG and PC SC Groups.

Next the second agenda item was discussed by the Group.

B. WG Item 97, Table 18 "Operational Tests of LTC Equipment"
Change Requested by: Joe Foldi – 2009 Ballot Comment

Requested Change: Establish here (on Table 18) requirements for operational tests on the LTC equipment under full voltage (during No-Load test) and under full current (during Load loss test). The details of the LTC operational test should be described in C57.12.90.

As for the previous case, an intensive discussion followed Joe's explanation of technical background for this proposal, specifically for the load test, with questions being reduced to following items:

Need to define pass/fail criteria: gas levels, noise, current magnitude?

Investigate practicality of the test for large power transformers, which would require frequent adjustment of capacitor banks.

Investigate the possibility to substitute the load test with the simpler method of the "light bulb test".

It was clarified that the no-load operational test cannot be devised as a substitute for the load test, and that the proposed tests should be mainly applicable to Class II transformers, where test time is less critical than for the case of smaller transformers.

As for the previous item, a new text will be prepared for this proposal, for a new survey within the WG and PC SC Groups.

C. WG Item 99. Clarification Requested by Mark Perkins, Chair of C57.12.90 WG.

Requested Clarification: Discussions in the C57.12.90 Continuous Revisions WG concerning the ratio and polarity test. It was raised the question whether the ratio required by standard C57.12.00 is based upon voltage ratio or turns ratio.

The group discussed pros and cons of having the voltage ratios described on nameplate as true turns ratios, when the voltage ratio would be off by more than 0.5%.

The case of error introduced by bridging position of tap changer reactors was newly brought up. It was mentioned as a practice to shift the transformation error over a wider range along the table of voltages on the nameplate.

Raj Ahuja mentioned that he has been studying the case to make a recommendation, although he is not ready yet with his conclusions.

Discussion on this Item will be continued in the next WG meeting.

Last item discussed:

D. WG Item 100, Table 7 “Nameplate Information in C57.12.00”.

Change Requested by: Bipin Patel – April 21, 2011 email communication.

Requested Change: To consider inclusion of Core Type description to the nameplate requirements for large power (Class II as a starting point) transformers. Core or Shell type, and for the three phase core type, if it three, five or seven legs; which should be considered as a minimum to be added.

Fundamentals for the request are new potential problems, as those coming from Geomagnetic Disturbances (GMD), where the core type plays an important role on the equipment response and robustness. Core type information may be requested during technical reviews but might get lost through the years, while the nameplate stays with the transformer.

It was mentioned that in some other places of the world users already specify this as a particular request. Besides that, it was mentioned that the core type has influence on zero sequence performance of the transformer, and from that perspective can be useful information too. In a straw ballot within the meeting attendance, 19 participants were in favor of including this information within the nameplate.

No new business was discussed and the meeting was adjourned at 4:30 PM.

10.4.4 WG for IEEE Standard Requirements, Terminology, and Test Procedures; for Neutral Grounding Devices, PC57.32;

Chair: Sheldon P. Kennedy; Vice Chair: Tom Melle; WG Secretary: Fred Elliott

The Neutral Grounding Devices working group was called to order at 3:15 PM on March 19, 2013. There were 11 attendees present.

1. Quorum was established from new membership survey - 7 working group members were present with 4 guests.

2. Minutes from last meeting approved

3 A new draft 11.1 has been prepared by copying the information from draft 11 from July 2011 into a new IEEE Template copy. In the process, the revision marks were lost. A master of the new draft must be kept in Word 2003 format in order not to lose the macros.

4. Comments for the Reactor section have been submitted by Mike Sharp. The comments will be inserted into the existing draft.

5. Klaus Pointner has the IEC section on Ground Fault Neutralizers to submit. We have permission from IEC to use the information.

6. The grounding transformer section was discussed. The existing IEC and IEEE calculation methods give different results for the same requirement. The IEC method is straight forward based on physics. The IEEE method contains constants and factors that are not documented as to meaning or source. Adoption of the IEC method was discussed as a way to deal with the undocumented parts of the existing IEEE method.

6. Development of the new PC57.32 needs to move quickly because of the December 31, 2015 deadline for completion.

8. Sergio Panetta is preparing the Grounding Resistor and Combined Devices sections.

9. Guidelines for development of PC57.32 discussed in the Milwaukee meeting were reviewed:

   a. Referencing definitions and general information that is not critical to the devices being specified.

   b. Consolidating information about the different types of devices in separate sections.

   c. Minimizing the use of large tables covering all devices.

10. Tom Melle will circulate the comment list that was used in the preparation of Draft 11.

11. Current Volunteers to work on the various sections of the document are:

   a. Reactors – Mike Sharp (with possible assistance from Richard Dudley).

   b. Ground fault neutralizers – Klaus Pointner (with possible assistance from Klaus Papp)

   c. Grounding Transformers - Don Ayers, Sheldon Kennedy, Fred Elliott

   d. Resistors – Sergio Panetta, Peter Balma

   e. Combination Devices – Sergio Panetta, Peter Balma

   Additional Volunteers were requested. Contact Tom Melle or Sheldon Kennedy if interested or if you know someone who is interested.

12. Two new members were added to the working group: Larry Kirchner and Ulf Radbrandt.

The meeting adjourned at 4:25 pm.

10.4.5 WG on Tertiary/Stabilization Windings PC57.158 – Enrique Betancourt, Chairman; Steve Snyder, Secretary

March 18, 2013 9:30 AM; Dolce Munich Unterschleissheim Hotel; Munich, Germany

The Chair called the WG meeting to order at 9:30 am on March 18, 2013 and stated the Working Group's purpose for preparing this Guide for publication. Brian Penny started service as Secretary for the WG.

As of this meeting the Working Group consists of **39** regular members and **2** corresponding members. **20** Members were counted in attendance thus a quorum was attained. Additionally there were **34** guests with **9** of them requesting membership in the Working Group.

Baitun Yang	Pennsylvania Transformers
Dharam Vir	SPX Transformers Solutions
Frank Damico	TAMINI Transformers
Jerry Reeves	EFACEC
Jinho Kang	Hyundai Heavy Industries
Ken Fedor	SMIT USA
Lakhiani Virendra	Transformers and Rectifiers
Scott Digby	Progress Energy
Vijay Tendulkar	ONYX Power

The minutes from the Milwaukee meeting were approved as submitted.

1. **Old Business**

There was a general call to the Working Group for active participation and support in collecting and reviewing the materials required for this Guide's creation and for volunteers needed in the development and writing of the chapters.

The guide development process and the "key questions to be answered by our Guide", which were provided to the Working Group before the meeting, were reviewed and discussed in detail during the meeting.

Another document, distributed to the Working Group before this meeting, with preliminary descriptions and proposed responses to questions to be answered in each chapter of this Guide was reviewed and discussed. Following questions were part of the discussion:

How the BIL level of a stabilizing winding will be established.

Testing recommended for a buried stabilizing winding.

Application and effect of current limiting reactors.

Recommendation to prioritize and document the information to be presented, as for example to first describe what functions the users may want to be provided by the

stabilizing winding, followed later in the document by how it is provided and the effects it has on the transformer design by the manufacturer

Another question brought up was if core flux density can affect the requirement for a stabilizing winding since low flux density generates smaller 3rd harmonics. It was noted that modern core materials have negated most of this issue.

It was noted that a stabilizing winding does not automatically provide low zero sequence impedance such as when users specify short circuit withstand requirements.

System designers need to provide the zero sequence system requirements, such as for relay settings, so decision or recommendation can be made by the manufacturer as if a stabilizing winding is necessary and how it can be properly specified and designed.

Sanjay Patel mentioned that there are already standards that handle the subject of unbalance transformer operation and he agreed to provide information and references to the WG.

Reference values for expected zero sequence impedance with 3 leg construction without a stabilizing winding should be given within the Guide, as it was clarified that this construction has a significantly higher zero sequence impedance than with a nested stabilizing winding.

It was reiterated that the scope of this document applies only to wye-wye transformers when questions about other (specialty) applications were brought up for consideration of the WG. This particular subject will be discussed again later, in the next WG meeting.

Further discussion on the chapters was curtailed due to time.

The Chair requested draft documentation to be submitted within the next couple of months in order to prepare items for discussion at the fall 2013 meeting in St. Louis, where a first draft will be assembled and discussed in overall format, as well as a Time table for development of the Guide.

Several references on stabilizing windings were distributed to the Working Group prior to the meeting and recommended for review as material relevant to the Guide.

No new business was presented before the working group.

The meeting was adjourned at 10:45 am.

10.4.6 TF on Revision of Section 13 of C57.12.90, Sound Level Measurement:

The TF met at 1:45 PM on Monday, March 18, 2013 with a total of 55 in attendance. Of those, there were 16 Members, 3 Corresponding Members, and 36 Guests. Prior to the meeting, the membership had been adjusted with the number of active members set at 28 members. A quorum has been established after reviewing the signup rosters.

At the meeting, an agenda was presented and corrections to the unapproved minutes of the fall 2012 Milwaukee meeting were requested. Prior to the meeting, these minutes were

circulated to all members and corresponding members for review. Since no corrections were requested, the fall 2012 meeting minutes stand as Approved minutes.

After the introductions, the next agenda item was presenting a summary review of the prior agreements of the TF. This review helps the membership stay in tune with the activities of the group without any regression of topics and helps maintain focus on the yet to be resolved topics that must be addressed. The review highlighted the following agreements:

- Making the wall sound reflection correction per IEC equation
  - But limiting the correction to 4 dB and limiting the number of test room cases to 4; instead of 7 dB and 7 cases in IEC.
- Using the “Sound Intensity Method” as an alternate sound measuring method to the “Sound Pressure Method”
  - With corrections of 1 and 2 dB to be applied to the measured level using the “Sound Intensity method” if $4 < (Lp - Li) \leq 6$ dB.
  - When the $(Lp - Li) > 6$ dB, the “Sound Pressure Method” is to be used and the corresponding corrections for near – field, wall reflections, and ambient noise are to be applied.
- Measuring Load Noise when requested by the customer.
  - This will be valid over a range of 60 % to 130 % of rated current and corrected per the IEC equation.
- Keep the ONAN Sound Measuring contour at 1/3 m all around the transformer but change the ONAF measuring contour to be 2 meters all around the transformer; the same as IEC.
- Total Noise Level is to be obtained by logarithmically adding the sound power levels of no load and load noise and then converting back to a Sound Pressure Level.

The next agenda item was an update by Dr. Chris Ploetner on the latest work of the IEC WG on the IEC noise measuring Standard and Guide.

- Work is underway on revision of both the 60076 – 10 (Standard) and the 60076010 – 1 (Application Guide) simultaneously.
  - Since both documents go hand in hand, it makes sense to revise them at the same time.
- Clear rules for application and simplification of the documents without losing accuracy.
  - The reduction in volume of pages is achieved by eliminating duplication of information in different parts of the documents.
- Harmonization with IEEE.
- The transformer height to be used is measured from the bottom of the transformer not from the floor.
- The formula for the surface area of the sound measuring contour 'S' is unified and the Sound reflection correction “K” is clarified.
- The standard measuring bandwidth will be the 1/3 Octave.
- The walk – around measuring procedure is to be used as the standard.
- A new template for reporting the sound measurements is included.

- In the Application Guide, the topics presented are Basic physics, Sources, components and characteristics of transformer noise, Measuring principles, Practical aspects of making sound measurements, and difference between Factory and Field sound level measurements.

The next item on the agenda was addressing proposed additions / changes to the text of clause 13 as agreed upon in the spring 2012 TF meeting. These are:

- The "Sound Pressure Method" had a comment regarding the "environmental corrections to be agreed upon between the manufacturer and the purchaser of the transformer". A decision was made, based on Pierre Riffon's suggestion and agreed upon by the attendees, to remove the agreement statement and to have "the final test report data include the measured noise levels along with the corrections used in determining the final value". All agreed and the text was adjusted accordingly.
- The Near – Field Correction was suggested in order to compensate for the measuring error caused by the near – field reactive sound power around the transformer; which does not propagate beyond the transformer. The chairman originally suggested a 1.5 dB correction for the ONAN measurements and 0.5 dB for the ONAF measurements. Pierre Riffon suggested no correction for the ONAF measurements and using 1.0 dB for the ONAN measurements. All agreed and the text was adjusted accordingly. Also, in this meeting, a statement saying "No correction is to be made of the ONAF measurements" was requested and agreed upon. The statement will be added.
- A request was made earlier by Jeewan Puri to provide some direction to manufacturers as what possible solutions to environmental conditions causing an (Lp - Li) > 6 dB; when using the "Sound Intensity method" other than using the "Sound Pressure Method" and making the corresponding corrections per the Standard. In response, the following statement was added and was presented in the meeting: "*Above environmental conditions are typically caused by high ambient noise and / or High sound wall reflections. In this case, the transformer manufacturer could attempt to reduce the ambient noise and / or move the transformer into a larger test area / room, if feasible*".
- Reference to the statement in the Standard to "Measure no load noise of the transformer with the Tap changer in the principal Tap", a request was made earlier by Dennis Marlow to add measuring no load noise with the transformer at a bridging position when the transformer has a Preventive Auto (PA). This is in spite of the fact that, in section 13.3.4 Tap changer, a statement reads "When the transformer is equipped with a tap changer, the transformer may, on certain tap changer positions, produce sound levels that are greater than the levels at the principal tap position. Sound measurements should be made with the transformer on the principal tap, unless otherwise specified". This item was discussed in great detail in the TF meeting with a number of very good inputs from many in attendance. Steve Antosz made a motion to require measurement to be made at the highest noise producing tap in addition to the rated position. This motion was approved by a 16 to 1 vote of the membership. However, this discussion brought a number of important and relevant issues:
    - Who and how to determine what the highest noise producing tap is?

- There are other applications, such as variable flux designs, SVC transformers with capacitive loads, etc. where measurements need to be made at levels different than the rated voltage and tap position.
- Which measurement to use for the guarantee?

Dr. Christopher Ploetner brought up the section of the IEC Standard that refers to this matter. Upon reading this section, it was recognized that it is a very good write – up that can be used in the IEEE Standard and would help settling this issue. Steve Antosz suggested that this section, from the IEC Standard, is circulated for additional review by the TF membership. This section will be forwarded to the attendees of the TF meeting along with the minutes of the meeting in order to get consensus on the desired wording with some harmonization with IEC.

Two items brought up subsequent to the TF meeting are:

- Whether such a determination should be included in C57.12.90 or C57.12.00.
- Different LTC tap positions are typically associated with corresponding voltage levels that result in rated flux density in the core. It is only when the transformer is on a bridging position that the PA noise is included in the main transformer noise.

The Chairman then presented responses to 3 questions received from Jeewan Puri after the Nashville meeting. He will send Jeewan the answers after this meeting.

Next, the Chairman presented factory and field measurements that support the revisions being made to sections 13;

- One showing that the change made in the ONAF contour makes a difference of 0.1 dB in the measured noise level.
- One showing that measuring the transformer noise level using the “Sound Intensity Measuring Method” provides measured noise levels at the factory that are almost identical to those measured in the field; without the errors associated with the “Sound Pressure Measuring Method”; namely ambient noise, wall reflections, and near – field effects.
- In the absence of ambient noise, noise levels measured in the field; using both the “Sound Pressure Method” and the “Sound Intensity method”, are about 2 dB apart at the 1/3 m contour from the transformer due to the Near – Field error associated with the “Sound Pressure method”. They become about the same within 2 – 4 m from the transformer where near – field effects are minimal. This represents the true noise level of the transformer as propagated from the transformer to the far field and into the community nearby the transformer.

The next main item on the Agenda was the “Determination of the Total Sound level of a transformer“. The Chairman presented the proposed methodology and text. He also included a numerical example of this calculation. He asked whether including such an example is needed. The answer by the TF attendants was in support of including the example.

Nearing the close of the TF meeting, the Chairman presented a topic to be discussed in greater detail in the TF fall meeting. That was the need for Reference Load noise levels

corresponding to the NEMA levels for No – Load noise of transformers. First, he presented how much Load noise can affect the total noise of a transformer. He showed data vs. MVA for transformers that have high, medium, and low levels of no load noise. Those figures showed that Load noise can add 3 – 10 dB to the total noise of low and ultra low no load noise transformers. He then presented how tested Load noise levels of transformers of 20 – 400 MVA power ratings compared with values calculated using the Reiplinger equation. It showed that the Reiplinger's curve represents an average value for load noise with about ± 7 dB deviations. One transformer tested 12 dB > Reiplinger's value. The Chairman suggested that one possibility for reference load noise levels could be obtained by adding 10 dB to values obtained by the Reiplinger equation. The Chairman then showed a comparison between the suggested Reference Load Noise levels vs. the NEMA TR1 table values, NEMA – 10 dB, and NEMA – 20 dB. The suggested load noise reference values were within ± 2 dB of the NEMA - 10 dB values for the transformers ≥ 100 MVA. Transformers < 100 MVA would have Load noise levels several dB (s) below NEMA – 10 dB No Load noise levels. The Chairman asked other manufacturers to submit their Load noise measurements vs. Reiplinger's values.

The Meeting adjourned at 3:00 PM.

10.4.7 WG P60076-16 Standard Requirements for Wind Power Generator Transformers

Chairman: David Buckmaster, Vice Chair: Phil Hopkinson, Secretary: Steve Griffith

The Working Group on Wind Power Transformers was called to order at 8:00 AM on Tuesday March 19, 2013. There were 86 attendees, 35 members present of a membership of 96 and 51 guests. A quorum was not present. Two members (Paul Jarmin and Frank Damico) requested membership.

1. The chairman opened the meeting and introduced the officers:
   Chairman: Dave Buckmaster; Vice-chairman: Phil Hopkinson; Secretary: Donald Ayers for Steve Griffith.

   It was verified that this was to be a joint standard with the IEC document.

2. The minutes from the fall 2012 meeting could not be approved due to lack of a quorum.

3. Phil Hopkinson made a presentation and identified five issue areas that he supported including in the final document.
   a. Generation of high hydrogen gas – most probable cause due to lamination arcing within wound core designs. Recommended corrective action would be the addition of a shield over outer high voltage coil. P. Hopkinson agreed to provide information for document annex.
   b. High voltage winding failures due to vacuum switching - Recommended corrective action would be the addition of snubbers to reduce current chopping transients.
   c. Safety in using Load Break Switches – Existing designs require the LV compartment door be opened before HV door can open to operate LB Switches

allowing possible exposure to arc blast incidents. Recommended corrective action would be adding third door for access only to gauges and LB switches to prevent arc blast exposure. D. Buckmaster agreed to provide information for document annex.

d. Switch and DETC contact carbonization and thermal runaway – Another working group is developing recommendations for design and test for contact stability.
e. Low Oil Level – Exposure of LB switches, DETCs or fuses due to low oil levels – Possible most probable causes are due to filling when element is still hot, light loadings and low ambients. Recommendation to refer to Distribution Subcommittee for comments and recommendations.

4. Comments on first draft of Section 1, “Scope”
   a. Add word “step-up” to description in scope
   b. Add static converter type transformers to scope
   c. Make tie-in to Photo-Voltaic transformer standard?
   d. Should reference to both AC & DC type wind generators be made
   e. How best to address requirements for both IEC and IEEE requirements.
   f. Should scope include units higher than 36 kV – Possibly to 69 kV?

5. Comments on first draft of Section 2, “Normative References”
   a. Documents shown in Normative Reference section must have direct reference within the standard.
   b. Other references should only be included in a Bibliography.

Meeting broke at 9:15 AM for break. Meeting was reconvened at 9:30 AM.

6. Comments on first draft of Section 3, “Terms and Definitions”
   a. Formatting must conform to IEC writing standards
   b. Substituting definition for word should not change emphasis or meaning of sentence.

7. Comments on first draft of Section 4, “Service Conditions”
   a. Document must address specific requirements of both IEC and IEEE reference documents
   b. Document should maintain existing IEC wording and where needed, separate paragraphs shall be added for specific IEEE needs.
   c. Recommended utilizing IEC temperature nomenclature of “C” for absolute temperatures and “K” for temperature differences.
   d. Restore reference to temperature limits. Suggestion made to just make reference to the appropriate IEC or IEEE document rather than trying to incorporate all variations in this document.
   e. Section 4.7 – add reference to C57.12.94 to better define ventilated dry type application. Delete last sentence in section.
   f. Maintain dry type impulse wave polarity requirements from both organizations.

g. Section 4.8 – Change emphasis of wording to state reduced air strength may allow onset of PD, not vice versa. Add appropriate reference to IEC and IEEE.
h. Section 4.3 – insert after word increase "transformer ambient temperature and in consequence" ... Separate ambient requirements with references to the appropriate organization shall be maintained.

8. General Comments
   a. Start with existing IEC document; add only necessary sections or subsections to cover IEEE specific requirements.
   b. Comments on early draft will be distributed to the individual task force groups to be integrated into a draft of the standard. – All changes should start with clean draft of IEC P60076-16 with tracking turned on. New modified drafts of each section shall be completed within 30 days and sent to the Chairman who will distribute to the full working group.
   c. The five areas discussed above in 3. should be added to the IEC document as individual Technical Annexes to document the identified problems.
   d. One suggestion was that items that are unique to IEEE or North American market should only be added to the document as an annex.

9. Rick Marek volunteered to head up a task force to create the Bibliography and expand Annex A covering cooling and harmonics. Sheldon Kennedy agreed to assist on expanding the harmonics section.

10. Next Meeting
    The next in person meeting will be held at the Fall IEEE Transformer Committee meeting in St. Louis, Missouri during the week of October 20-24, 2013.

11. Adjournment
    The meeting was adjourned at 10:45 AM.

10.4.8 – WG on "Distributed Photo Voltaic (DPV) Grid Transformers" PC57.159, Chairman Hemchandra Shertukde; Vice Chairman: Mathieu Sauzay; Secretary: Sasha Levin

Munich, Germany Tuesday, March 19, 2013

AGENDA

Introduction

Roster and Quorum Verification

Approval of the Milwaukee Meeting Minutes

Action Items Review

Presentation / Tutorial "Transformers for Application in Distributed Photovoltaic (DPV) Power Generation Systems" by C. Jordaan

Presentation / Tutorial by E. Betancourt

Discussion on the Chapters of the Guide: Chapter Leaders Report (please provide and review already collected and collated materials)

Recruitment of New Participants to the WG

Plan for the Next Steps on Writing the IEEE Guide

New Business

The Working Group met in the Ammersee I room of the Dolce Munich Hotel. This is a second meeting of the WG.

The meeting was called to order at 8:00 am by Chairman Hemchandra Shertukde.

The meeting was convened with 22 participants present, 12 of them are members (which constitute a quorum out of 23 current members in the roster), 4 participants requested a membership.

<u>Old Business</u>

Milwaukee Meeting Minutes were approved.

<u>New business</u>

1. C. Jordaan provided a very thorough and thoughtful presentation on the power converting system of the solar power generation, including the interface between inverters, transformer and a power grid.

The following issues were highlighted as of interest to be addressed in the IEEE Guide:

- Definition of a "Step-Up Transformer" for DPV PGS
- Recommendation for efficiency for DPV PGS transformers (e.g. CEC efficiency)
- Transformer overload capability at reduced ambient temperatures
- Impact of short circuit current of inverters (differences between inverts and rotating machines)
- Advantages and disadvantages of different winding and core designs
- Recommendation for useful warning signs
- Effect of daily energizing operation (power savings during night)
- Impact of solar irradiation

Christoph is going to provide the presentation that will be placed on the protected WG C57.159 web-site (**ACTION**).

The presentation was followed with the discussion:

- S. Sarkar – in case of the load difference between inverters, there are can be non-symmetry problems in a transformer; the limits of the non-symmetrical load shall be defined

- S. Som – short circuit and other fault of the inverters are effecting transformers, our WG would like to have an information on the frequency of this potential events

C. Jordaan – IGBT thyristors have own protection system, but fault can happen; depending on the nature of the fault, the impact on the transformer can be different. Christoph has recommendations in this regard and can provide them to the WG (**ACTION**).

- J. Yu - are there some other transformers in the system in addition to the step-up transformer?

C. Jordaan – yes, some systems have special auxiliary transformers on the secondary side of the transformer which is used for power supply to the inverter and other auxiliary needs.

- J. Roach – in reality, there are multiple inverters and transformers on the system of the solar plant that collect power and then supply it to the grid through a collector transformer.

J. Schneider – the solar power plant has a string of inverters and transformers; the operation of protection system with arresters, etc. and the influence of this operation on the transformers can be pretty complicated. Also, the connection of other users (heating, etc.) to the same system can create a complex power flow.

C. Jordaan – you also need to understand that solar power generation system generates 30-50% more power than power converted to the system.

As Christoph ran out of his business cards, he permitted to distribute his coordinates to the WG (**ACTION**).

2. E. Betancourt continued the presentation / tutorial.

Enrique reviewed transformer specifications from different customers summarizing differences and topics of interest:

- some customers specify more than 5% harmonic content

- unusual connection when several inverters connected in parallel to one transformer winding

- shields are used to de-couple HV side from LV side to isolate LV side from HV side commutations

- generally, there isn’t enough information on grounding

- arc flash protection is a very important aspect of transformer protection

- as a rule, transformer OEM does not participate in the analysis of the system in order to make an input in the configuration and parameters of the transformer; we can make an input by writing the Guide.

Enrique will provide the presentation for the distribution to WG (**ACTION**).

3. Discussion on the Chapters of the Guide.

- A. Levin commented that numerous topics of WG's interest have been identified in the Task Force Position Paper, Chapter-topic matrix and during the described above tutorials.

WG shall start addressing those topics and include them in the Chapters of the Guide. Some of the topics of interest have been reviewed.

- E. Betancourt commented that we need to concentrate on the current status of the DPV PGS and on the fact that, ultimately, we need to harmonize approaches and interests of different parties (transformer OEM, inverter OEM, developer and end user).

- S. Kennedy informed that he continues work on the Transformer Design and Construction section of the Guide; one of the aspects that he will be addressing is high-frequency disturbance and shield functions, design and effect on the transformer's parameters (impedance, harmonics, etc.) (**ACTION**).

- E. Betancourt and H. Shertukde will be working on the section discussing advantages and disadvantages of different winding and core configurations (**ACTION**).

- S. Sarkar commented that we need input from developers and end users on the recommendations on efficiency of DPV PGS transformers. J. Yu will try to contact a developer in order to ask for the input (**ACTION**).

- S. Sarkar will be working on the topic discussing impedance requirements and optimal ways of achieving the required impedances in the multi-winding transformers (**ACTION**).

- J. Schneider will work on the over-current protection recommendations.

- J. Yu commented that DGA diagnostic needs, probably, to be specified for these transformers. C. Stiegemeier noted that correctly designed transformer may not need this type of continuous diagnostics. S. Levin commented that the complex loading, switching operation and protection of this type of transformers may warranty the DGA anyway. J. Roach confirmed that he continues working on the "Transformer Maintenance and Diagnostics" Chapter of the Guide (**ACTION**).

- S. Levin will be sending proposals on other topics of the Guide for the WG discussion.

With no new business the Meeting adjourned at 9:15 AM.

10.4.9 TF to Investigate the Interaction between Substation Transients And Transformers in HV and EHV Applications Chairman Jim McBride

Task Force Meeting took place on Tuesday at 3.15pm

47 people in attendance
15 members present

The chair opened the meeting opened with introductions of members and guests.

The below goals for the group were reviewed for those not present in Milwuakee.

Goal: Prepare a TF report on the need to revise the C57.142 guide to extend to HV and EHV applications.

Deliverables: TF report and recommendation on forming a WG to revise the guide (or not)

TF Objectives

- Establish the present target voltage class range of the C57.142 guide
- Gather field data, reports and literature on HV and EHV failures related to substation transients and transformer interaction
- Get input from the other technical committees concerning the interactions between substation transients and transformers at HV and EHV applications
- Review IEC and CIGRE standards
- Recommend if there is sufficient need to revise the guide and if WG should be formed.
- Recommend high level changes to the guide (if it should be revised)
- Prepare final report to the SC and present work in SC or tutorial session

The group looked at the first objective to establishing the target voltage range of C57.142

1) Present C57.142 guide does not state a target voltage range. Present intro states that the phenomenon primarily occurs at 38 kV and below, but may occur at any voltage.
2) Present guide excludes inductively loaded transformers and solid state devices.
3) Examples in present guide are directed toward lower voltage cases.

Phil Hopkinson stated that additional experience gained from actual cases should allow for extension of the guide to wider voltage range.

Bertrand Poulin suggested specifically investigating Generator Transformers operating in back feed mode, citing many failures of these types of transformers operating under back feed conditions.

Chair suggested requesting input from other IEEE apparatus committees (Switchgear)

Chair suggested doing a review of existing IEC and CIGRE material.

Quorum count was taken, and a quorum was achieved.

Minutes from Milwaukee meeting were approved.

A survey is being prepared to send to utilities to request input on failures associated with transients and HV and EHV systems. The intro wording of this potential survey was displayed for review by the group.

Pierre Riffon suggested including adding Reactors to the scope, in addition to Transformers. Phil Hopkinson agreed this would be a good idea. The chair stated that the present guide covers Transformers only, not Reactors.

A comment was made that some manufacturers are already offering snubber products, and questioned whether these products reference the guide, or vice versa. Same commenter requested whether there was a possibility to better identify which transformers are at risk, by doing a low voltage “ping” test to look for dangerous resonance frequencies.

Phil Hopkinson commented on a 46 kV - 13 kV transformer with an SF6 breaker, and a 200 Ft permanently connected cable from the secondary terminals to the load. The transformer failed when the SF6 primary breaker operated, without any switching taking place on the secondary side. Phil stated that most failures he has seen involve a coaxial HV cable connected to the transformer. In another case, installing an electrostatic shield on the transformer winding would prevent the transformer failure. Inductive load makes the problem worse.

Bertrand Poulin stated that better models for the transformers and their surrounding circuitry in the substation are needed in order to analyze the effect of the transient inside the transformer. An FRA characterization only predicts terminal characteristics, and not whether the transformers can internally withstand the voltage internally.

Phil Hopkinson made a request to the group for utility members to contribute data from actual failure cases, and not to be “embarrassed” to share the data.

The individual questions of the potential survey were displayed for review by the group.

Target recipients of the survey are intended to be key selected transformer users who have experience with transformer failures where switching interaction is suspected as the source of the transient.

Phil suggested that in some failures, the transformer winding may be withstanding the transients, and that the failure location may be in the bushing.

The chair showed an example of an energization transient recorded on a 230 kV / 20 kV 60 MVA transformer and an S&C Mark 4 Circuit Switcher.

Bertrand Poulin stated that the real danger to the transformer takes place when re-strikes are close enough together that the transient ringing from successive restrikes overlap in time, and the stress combines at points within the transformer.

Phil Hopkinson mentioned that cable reflections on short cables also combine to cause superposition of stresses at the transformer terminal.

The chair asked for volunteers from the TF to work on specific TF objectives.

The meeting was adjourned at 4:25 pm.