8.8 Performance Characteristics Subcommittee

8.8.1 Introduction/Attendance

The Performance Characteristics Subcommittee (PCS) met on Wednesday, March 16, 2005 with 60 members and 26 guests in attendance. 1 of those guests requested membership in PCS. See last page of these minutes for summary of attendance.

8.8.2 Approval of Meeting Minutes

The minutes of the last meeting in Las Vegas were approved as written, except for one very minor change which was corrected.

8.8.3 Chairman's Remarks

8.8.3.1 Administrative Subcommittee Notes

- Next Standards meeting dates and locations are as follows:
  Fall 2005: October 23 –27, Memphis, TN
  Spring 2006: March 19 –23, (Tentative Location - Miami, FL)
  Fall 2006: October 22 –26, Montreal, Canada
  Spring 2007: March 11 –15, (Location – Yet to be selected)
- IEEE PES upcoming meeting: San Francisco, California: June 12 – 16, 2005.
- IEEE T&D Exhibition / Conference: New Orleans, October 9 - 14, 2005. Deadline for submitting papers to this conference is April 11, 2005.
- We are considering the “Loss measurment and tolerances” Guide for Dual IEEE / IEC Logo.

8.8.4 Agenda Changes

None

8.8.5 Working Group and Task Force Reports

8.8.5.1 PCS WG for Continuous Revision to C57.12.90 – Bruce Forsyth, Chairman; Rowland James, Secretary

The PCS Working Group for Revisions to test code C57.12.90 met in Jackson, MS on March 15, 2005. There were 47 persons in attendance, 30 members and 17 guests. 6 guests requested membership in the working group. After introductions, Bruce Forsyth announced his resignation from the Working Group due to work obligations. He introduced Mark Perkins of ABB as the new Working Group chair. Robert Thompson moved, seconded by Subhash Tuli, to accept the minutes as written. They were approved unanimously.

<u>Announcements</u>

- Bruce Forsyth encouraged working group members to register for the Association Management System (AMS).

- Subhash Tuli reported that draft 3 of the revision to C57.12.90 will be sent out for balloting later this year.
- Bruce then reviewed with the Working Group IEEE's Patent Requirements for Standards under development. Two slides provided by the Transformers Committee related to the IEEE's Patent Policy were presented. Inappropriate topics for IEEE Working Group Meetings were identified. An opportunity was provided for WG members to identify or disclose patents that may be essential for the use of this standard. No responses were received.

Old Business

Review of comments from ballot of PC57.12.90/ D2

1. Alan Darwin commented that values for Kj frequencies above 1000 Hz should be positive, not negative. The Audible Sound and Vibration Subcommittee will correct this in the new version of section 13.
2. Lin Pierce commented that C57.91-1995 should not be listed as a reference because it is a guide and including it makes it a requirement. It was suggested that it be retained in the reference list. This will be referred to Bill Chiu for consideration.
3. Lin Pierce also commented that clause 15 (Certified Test Data) should be a sub clause of section 8 of C57.12.00. The working group recommended no change.
4. Marcel Fortin made the following suggestions for Clause 12 (Short Circuit Testing)
   - 4.1. Clause 12.3.1 (note) – suggests ignoring source impedance is unrealistic for category II transformers, and recommends the following rewording: *For Category I, calculate Isc using transformer impedance only; the symmetrical current magnitude shall not exceed the values listed in 7.1.4.1 and table 12 of IEEE Std. C57.12.00-200x. For Categories II, III, and IV, calculate Isc using transformer plus system impedance*.
   - 4.2. Clause 12.5 – recommends adding DGA before and after short-circuit test.
   - 4.3. Clause 12.5.5 – recommends removing LVI tests because it is very difficult to duplicate readings.

   These issues will be referred to the Task Force that will be reviewing the short-circuit test document.
5. Mark Perkins made the following comments
   - 5.1. Clause 5.3.1 (Bridge method): Should be rewritten to update it since modern bridges use the voltmeter-ammeter method and only Wheatstone or Kelvin bridges should be considered bridge methods.
   - 5.2. Clause 5.3.2 (Voltmeter-ammeter method): Recommends rewording to make the voltmeter-ammeter method the preferred method and discourage the bridge method.
   - 5.3. Modernize sentences about commutating machines
   - 5.4. Figure 1 should indicate a DC source, not a battery
   - 5.5. Suggests deflecting ammeters cannot meet the requirements of C57.12.00 and Table 21 should not be allowed.

   Mark will work on revising these clauses.
6. Pierre Riffon offered the following comments and suggestions:
   - 6.1. Clause 5.3.2.e: Questions the use of a potentiometer. Suggests a shunt and voltmeter should only be used when the current is too high. It was recommended to incorporate Mr. Riffon's concerns in Mr. Perkin's revision.
   - 6.2. Clause 12 (Short-circuit Test) – Mr.Riffon had several concerns regarding sections 12.2.1.1, 12.2.2.1, 12.2.3.1, 12.4.2, 12.5.4, 12.5.5.. He suggested that

DGA be added before and after tests. These issues will be addressed by the previously mentioned task force for short-circuit testing.

7. Don Platts commented on procedures and reporting resistance measurements:
   - 7.1. Most manufacturers report resistance as the sum of 3 phases but test data sheets report individual resistances. It was suggested that terminal-to-terminal resistance values be included on the Certified Test Report in addition to over all transformer resistance. The procedure for measuring and reporting converted data should be clearly identified in this clause.
   - 7.2. Some discussion regarding terminal pairs should be added here and possibly in Clause 11 also (e.g. wye, delta, autotransformer windings, etc.)
   - 7.3. There were some discussions on wye-connected windings. Should the measurements be made at the X_0 bushing or at the neutral end of the wye connected windings? Another suggestion was to measure line to neutral and account for the neutral lead resistance for I^2R measurements. The Working Group's opinion is that the resistance measurement procedure shall be specified in C57.12.90.
     - 7.3.1. The first step will be to clarify the connections required for resistance measurements.
     - 7.3.2. The second step should be to specify in the standard the methods to measure resistance. The preceding discussion on resistance measurements concluded at the end of allotted time for this meeting.

Since time ran out, the remaining comments were tabled for review at a later time. The meeting adjourned at 10:45 am.

8.8.5.2 PCS WG for Continuous Revision to C57.12.00 - Steve Snyder, Chairman; Dennis Marlow, Secretary

The Working Group met on Monday, March 14 at 1:45 PM. There were 22 members and 42 guests in attendance, with the following 2 people requesting membership:

Kumar Mani	Progress Energy
Loren Wagenaar	American Electric Power

The addition of the two new members brings the Working Group membership to 62.

Following introductions, the minutes from the October 25, 2004 Las Vegas meeting were approved as submitted. The chairman then reviewed the IEEE patent disclosure requirements. No guests or members present indicated knowledge of any patent activity applicable to our work at this meeting. The Working Group then began discussing the topics of old business, as follows:

WG Item 54: C57.12.00 Table 19 and Section 8.2, request to add winding DC resistance measurements as a requirement for buried tertiary windings.

During the discussion on this topic, it was pointed out that resistance measurements are required on all windings in accordance with the language in the existing document. There is no distinction between "buried" windings or windings with terminals brought out. The WG voted 30 to 1 to not change the present text.

WG Item 55: C57.12.00/D2 April 2002, Table 10, Note 9, Nameplate Information

Suggested change to note 9 – delete the phrase "on the winding assembly, or any tap changer" and replace with "inside the tank or inside the LTC compartment."

The Working Group discussed the proposed editorial change, but with a vote of 16 for and 16 against, the decision was to not change the present wording.

WG Item 56: C57.12.00/D2 April 2002, Table 14, Note the second sentence has incorrect sentence construction, with a possessive inanimate subject. Amend text to read "…limited only by the impedance of the transformer."

This is an editorial change, and the WG expressed no dissent in accepting the proposal. The new sentence will read "Two winding distribution transformers with secondaries rated above 600 V should be designed to withstand short circuits limited only by the impedance of the transformer."

WG Item 57: C57.12.00/D2 April 2002 Section 5.10.2.4 Insulation level of the neutral bushing, request to change the requirement for the neutral bushing to be equal or greater than the neutral end of the winding.

This topic was exhaustively discussed with various views expressed about the origin of the present language. Dennis Marlow indicated in his experience some utilities may require that the neutral be suitable for ungrounded operation or for future grounding via a neutral reactor. The user would have a suitable "spare" bushing available and thus specified a lower BIL bushing be shipped with the transformer. After further discussion and two indecisive votes, the WG finally agreed by a vote of 36 to 2 to accept the revised requirement. The new wording for this section will be as follows:

"The insulation level of the neutral end of a winding may differ from the insulation level of the neutral bushing being furnished or of the bushing for which provision for future installation is made. In any case, the insulation level of the neutral bushing shall be equal or greater than the specified insulation level of the neutral end of the winding."

WG Item 58: C57.12.00/D2 April 2002, Table 19, Routine, design, and other tests for liquid-immersed transformers. The request is to revise and expand this table to specifically spell out the requirements between Class I and Class II power transformers by adding a third set of three columns; the first set staying as it is, the second set headed "501 kVA and above, and Class I power transformers", and the third set headed "Class II power transformers". The routine design and other cells within the last two categories would then indicate the appropriate test on the basis of the present table and the notes. This would eliminate five of the notes and simplify reading of the table.

The Working Group agreed that this would simplify and make the table more understandable. The chairman will accordingly revise the table with changes noted and present this to the WG for comments prior to the next meeting.

WG Item 59: C57.12.00/D2 April 2002, Section 7.1.4.2, request to change the standard to include source impedance in the short-circuit testing of category II transformers. This

product classification is distribution transformers, and since few distribution transformer users or manufacturers were represented in this meeting, it was decided to defer discussion on this item until input was received from the proper audience.

8.8.5.3 WG on Loss Tolerance and Measurement - Ed teNyenhuis, Chairman; Andy Steineman, Secretary

- 19 members and 16 guests attended, with 3 guests (William Boettger, Bill Griesacker and Kumar Mani) requesting membership.
- Minutes from the Las Vegas meeting held on Oct 26th, 2004 were read and approved.
- IEEE Patent Policy - The policy was reviewed by the WG and an opportunity was provided for WG members to identify, or disclose, patents that the WG member believes may be essential for the use of that standard. No responses were received.
- Report on TF for "Guide of Low Power Factor Power Measurements" was given by Ernst Hanique for Dr. Eddy So. The review of the guide by the National Research Council of Canada (NRC) has been completed. A PAR will now be requested from PSIM/PMS, after which it will be put to a ballot.
- Frequency Conversion Factors of Transformer Performance Parameters - The wording for C57.12.00 and C57.12.90 was put to a survey in PCS and 10 survey responses were reviewed in the WG. Below are the resulting changes that were agreed upon by the WG:
  - Keep the comment in C57.12.00 that the customer should know at "the tender stage" that the frequency conversion factors will be used.
  - Add examples for each of the frequency conversion factors
  - The examples should be revised as follows:
    - Add the voltage to be used to the no load loss conversion factor example
    - State more clearly the separation of the eddy+stray losses in the load loss conversion factor example
  - Change the exciting current conversion factor wording to "there is no conversion factor" since the factor is 1.00
  - Change "can" to "shall' in the C57.12.00 wording in order to strengthen the use of the frequency conversion factors
  - Add a comment in the temperature rise conversion factor that P_0 is measured at 50 Hz and converted to 60 Hz
  - There was a response on the validity of the sound level conversion factor due to the variability of the measurements in the paper. While it is true that the measurements were somewhat variable, there was already strong text put in the wording such as comments on resonant frequency, recognized greater uncertainty, and the final possible request by the customer to measure the sound at the site. Thus, it was agreed to keep the wording as it was.
  - Chairman to check what the liability of IEEE standards is if, for example, the frequency conversion factor for sound level is used and the measured sound level at site were to be greater than the guaranteed value.
  - The location of the text will be moved from the main body of C57.12.90 to a Normative Annex since it will not be used that often and it will unnecessarily add bulk to the main text. The chairman will revise the wording into a normative annex.

- Revise "at the tender stage" in C57.12.00 to "at the tender stage or prior to a contract"
- Add comment in short circuit tests: "For large power transformers, it should be considered that mechanical resonances in the windings in the 120Hz range may impact the measured results"
- Add a comment in C57.12.00: "The purpose of the frequency conversion factors is to have uniformity amongst the manufacturers when such cases arise."
- Change wording in audible sound emissions from "The correction factor for ONAN or No Load Sound level (50 to 60 Hz) shall be + 3.6 dB" to "The corrected sound level for 60 Hz equals the measured ONAN (no load) sound level at 50Hz plus 3.6 dB". Change also "Similarly, the 60 to 50 Hz frequency conversion of sound level shall be the negative value of the above mentioned 50 to 60 Hz value" to "Similarly, the corrected sound level for 50 Hz equals the measured sound level at 60 Hz minus 3.6dB"
- Due to the fact that wording will now be put into a Normative Annex, it was agreed to put the wording out to a PCS survey one more time. The responses will be reviewed at the next WG meeting

- Old Business – The WG reviewed suggested topics for future meetings:
  - Investigate the errors in the temperature rise measured values due to corrections and assumptions – This is being handled by Insulation Life SC.
  - Overload test at different frequencies – It was agreed that this would be handled at another temperature rise test and the same conversion factors would be used
  - Zero sequence impedance – This is being handled already by the WG for C57.12.90.
  - Investigate the total error for load loss in all corrections due to temperature and other factors – This has already been covered in the C57.123 Loss Measurement guide

- New Business –
  - C57.123 will need to be reaffirmed by 2007. The WG should start to review the guide and any required changes in 2006

8.8.5.4 WG on Switching Transients Induced by Transformer / Breaker Interaction, PC57.142,WG - Robert Degeneff, Chairman; Peter Balma, Secretary

The Working Group was called to order at 8:00 AM on March 15, 2005. There were 69 attendees, 32 members, 1 requesting membership, and 36 guests. After introductions, the Minutes from the October 26, 2004 meeting in Las Vegas, Nevada were approved. Copies of the minutes were distributed.

1. IEEE patent policy was reviewed and the group was asked if there were any disclosures. There were none.

2. The Switching Transients Interaction Guide was sent to IEEE editors for review, and comments were received back on March 11, 2005. Most of the comments were minor and will be addressed before the ballot version is distributed.

3. A ballot pool has been requested, however, it was done under the old system. Bill Chiu suggested that the ballot pool be re-established utilizing myBallot™. It was

agreed that this would be done, and all members were asked to reconfirm their participation in the myBallot™ system. It is anticipated that the document will be in the hands of the balloters by mid to late April.

4. Bob Degeneff and Sam Mehta will make a presentation of this group's work to the CIGRE SC A2 Committee at the Colloquium to be held in Moscow in June.

5. Under old business, the group was asked if it should continue its efforts, by investigating back-feed energization of transformers. It was determined that the group should complete its current effort to ballot and publish this guide, and only then, to consider this activity as a new guide or revision to the guide just prepared.

   Ramsis Girgis, asked the group if anyone knew the history of a group that considered back-feed approximately 20 years ago. It appears there was a group which discussed resonances within transformers, but no one was aware of a group that specifically addressed back-feed situations. Ramsis further inquired of the group whether anyone was familiar with examples of difficulties in this area. Two recent events were described indicating problems of this type, and some of the steps taken to mitigate them. A number of such failures have been reported in the literature over the years.

6. Under new business, Mel Smith of the Switchgear Committee asked the working group if any progress had been made in determining the typical resonant frequencies of transformers. The Switchgear Committee would like to utilize this information to determine transient recovery voltages (TRV), and would like to work with values representative of transformers currently in service. The only data available to the switchgear committee has become aged, and needs to be updated.

One area of particular interest to the Switchgear Committee is the application which requires a breaker located close to a transformer to clear a fault on the line close in to the transformer.

Ramsis Girgis suggested two presentations be made at a future meeting (possibly New Orleans T&D meeting) to facilitate understanding of the data required. The first should be a discussion by the Switchgear Committee of the data they need and the recovery voltage they are calculating, and the second, should be a discussion of resonances within transformers.

8.8.5.5 WG on Revision of C57.21- Standard Requirements, Terminology, and Test Code for Shunt Reactors over 500 KVA – Richard Dudley, Chairman

The W.G. met in the Amphitheater 1 Meeting Room of the Hilton Jackson Hotel in Jackson, Mississippi on March 14, 2005 from 11:00 a.m. to 12:15 p.m. There were 10 members and 7 guests present. The following are highlights.

1. The minutes of the W.G. meeting in Las Vegas were approved.

   NOTE: The minutes of the Jackson W.G. meeting will not be formally approved until the W.G. meeting in Memphis, Tennessee.

2. IEEE patent policy as related to standards development was reviewed; details can be found on the IEEE Transformers Committee website. Attendees were asked if

they knew of any patents that would impact the implementation of the revision of IEEE C57.21. None were noted.

3. Draft #3, prepared by the Chairman, of the revision of IEEE C57.21 was discussed. The following are the highlights:

   (i) It was decided to use, in Table 5 and throughout the document, "rated/nominal" voltage and "maximum voltage".

   (ii) Other changes to Table 5 were agreed to. The maximum system voltage for nominal/rated 500 kV systems is 550 kV (10% of nominal/rated). For tertiary-connected SRs 69 kV and below the maximum tertiary voltage should be 5% of nominal/rated or should be specified. Note the tertiary voltage, although at distribution voltage levels, is a function of the transmission system voltage and transformer characteristics. The notes associated with Table 5 should reference the specific columns in Table 5.

   (iii) In the revision of IEEE C57.21, it was agreed that the audible sound test will be performed at maximum voltage at the end of the temperature rise design test versus at nominal/rated voltage per IEC 60076-6 (revision in process). A NOTE will be added to stress that if the audible sound design test cannot be performed at maximum voltage due to test lab limitations, the manufacturer must inform the end user at the bid stage.

   (iv) Note 7 of Table 5 should be modified. If the induced test level enhancement of 1.7 cannot be met due to test lab limitations then the "end user" should be informed by the manufacturer at bid stage. This test should be carried out at as high a level of enhancement as possible.

   (v) Clause 10.3.9.4.2.2 defining the switching impulse across the SR should be modified. If the specified waveshape cannot be achieved then the manufacturer should inform the "end user" the waveshape possible at the design review or final electrical design stage.

   (vi) Current IEEE designations will be used for the methods of cooling of oil-immersed SRs. Pierre Riffon will provide a draft.

   (vii) Clause 7.1.2 which describes loss limits will be revised based on the text in IEEE C57.16. Commercial versus technical issues will be defined. If losses exceed the guaranteed value the main technical issue to be assessed is the impact on expected temperature rise versus temperature rise limits. The Chairman will redraft this clause.

   (viii) Clause 9.1.3.1 will be redrafted by Pierre Riffon to make it consistent with the combining of Tables 5A and 5B in the current version of IEEE C57.21 into one table in the current revision; Table 5.

   (ix) It was agreed to keep determination of magnetic characteristics (linearity) as "other test" in Table 4A.

(x) The audible sound test should be performed at "close to operating temperature" versus the current wording "at operating temperature". Table 4A and text should be so modified.

The Chairman agreed to produce Draft #4 well in advance of the Memphis meeting.

8.8.5.6 WG for Revision of C57.110 – IEEE Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer **Capability When Supplying Non-Sinusoidal Load Currents – Rick Marek, Chair; Kent Haggerty, Co-Chair**

The meeting opened with introductions at 1:45 PM. There were 16 members and 7 guests present. 4 attendees requested membership on the WG.

The group was referred to the IEEE patent information and the group was requested to identify or disclose any patents. There was no response. The minutes from the Las Vegas meeting were approved with one minor correction that will be submitted to the SC Chair.

The group was informed that on November 18, 2004, the IEEE-SA Standards Board approved the PAR, until December 31, 2008. An objection to the PAR was resolved by adding the phrase "Liquid-Filled and Dry-Type Distribution and Power" before the word "Transformer" in the title.

Access to the new C57.110 website was demonstrated and the posted files were discussed. The group was encouraged to download the files of interest since the posting will be for only a limited time. Space on a second password protected website has been assigned by IEEE, specifically for C57.110 activities. The chair will evaluate this second site to determine how the group can take best advantage of the two.

The chair noted that draft 1 is progressing very slowly and that the whole document requires re-formatting to match the latest Styles Manual. The formulas will require the most work and there are many formulas in this document. One or two volunteers were also requested to assist in editing. They would be called on only if necessary. Anyone interested is requested to contact the chair directly.

Three members submitted comments to a request for a complete document review at the last meeting. Discussion on a suggestion made by Subhash Sarkar was delayed until the next meeting, since he was not present. John Sullivan's list of editorial comments was accepted as submitted, except for two items. The first was a request for clarification to paragraph 5.3, titled "Power Factor Correction Equipment", since capacitors are never mentioned. After some discussion, it was agreed that the paragraph should be re-written to include power factor correction capacitors.

The second item of discussion concerned note 7 of the document and whether the wording was sufficient, since utilities are exempt from NEC and local codes. The chair agreed to review the note with John's assistance, if necessary.

Mahesh Sampat presented an analysis of the effects of current harmonics on core loss. The analysis referred to the testing of several units comparing identical coils using silicon and amorphous core steel, concluding that there was a significant effect. Ramsis Girgis, having previewed the analysis, presented an explanation of what appeared to be higher

core losses. This was followed by a discussion and the conclusion that additional equations should be added to the document. However, the complexity of these equations will be determined as the revision progresses.

Don Duckett asked if frequency response analysis had been used to determine a transformer response to harmonics. He referenced a study that included the testing of a number of transformers. Don was requested to provide the chair with contact information to see if any additional information could be provided to the WG.

All members and guests were reminded to continue to identify any technical papers or books that would be appropriate for addition to the Bibliography. The group was also reminded to provide document review comments, updates on the abstract and introduction, and additional wording on neutral heating due to third harmonics.

8.8.5.7 TF on Semi-Conductor Rectifier Transformers, C57.18.10 – Sheldon Kennedy, Chairman

The Task Force met on Monday, March 14, 2005 at 3:15 PM with 14 members and 6 guests present. Sheldon Kennedy chaired the meeting.

The IEEE disclosure statement was read. There were no patents pertaining to this standards work for which any members had awareness.

The minutes of the October 2004 meeting in Las Vegas, NV were approved.

The Chair announced that the PAR had been approved, but as an Amendment PAR, not a Corrigendum PAR, as originally submitted. Due to the fact we were adding some definitions that were missing; we could no longer do the work under a corrigendum, even though we were correcting some other errors.

Comments received during the reaffirmation of C57.18.10 required action to resolve the negative votes received. We are correcting the errors and missing or undefined terms. Technical comments will be worked on during a full revision process following the amendment revision.

Items from the comments for editorial corrections received during the reaffirmation were reviewed. The Chair volunteered to make all of the editorial corrections that were noted, including the missing or erroneously labeled technical terms. Rick Marek volunteered to submit proposed definitions to the working group for the terms E_z, P_a, P_b, and P_c.

During the working group review it was noted that the comments received were from the PDF copy of the standard. When the chair was reviewing this with the hard copy it was found that there were differences in the two. One reviewer had commented that the standard lists Figures 4 through 7 for circuit diagrams; while in reality the Figures were numbered 4 through 9. Somehow, the PDF copy differed from the hard copy, which was correct. There were two pages of Figure 5 and Figure 5 Continued, as well as Figure 6 and Figure 6 Continued. These were renumbered to Figures 5, 6, 7 and 8 by someone in IEEE. Then the preceding Table 7 was renumbered to Table 9 by IEEE. Figures 5 and 6 are long and show as continued purposely as they group types of circuits together. This

is the same as it was for the preceding standard for mercury arc rectifier transformers, ANSI/IEEE C57.18, which was replaced by this standard.

Similarly, it was noted that Annex A has Tables A.1, A.2, A.3, A.4, and so on. In the hard copy there is an error in that Table A.1 is labeled Table A.11, even though there is another Table A.11 later in the Annex. Perplexing is that the PDF copy also labels Table A.1 as Table A.11; and additionally labels Table A.2 as Table A.12, and Table A.3 as Table A.13. Again the PDF and hard copy are different.

It was suggested that the Chair request guidance from the Subcommittee Chair and other Committee officers on how to proceed with this. As the document is in an amendment revision it is assumed we will make these corrections along with the others. Rick Marek had suggested that when he found differences in C57.110 between the hard copy and PDF, that IEEE made the corrections on their own, without it being done in his corrigendum revision. The Chair will seek guidance on this.

This concluded all of the comments that were included in the amendment revision. The corrections and additions will be circulated to the working group as a survey. If this is successful, the Subcommittee will be surveyed.

New technical comments were received and discussed, but these will be tabled until the full revision process. These were by Ray Nicholas on the correctness of having Table 11 in the standard which gives a conservative default harmonic spectrum table which may be proposed to a user if he has no information. Ray felt it was too conservative, as did others, but it is meant to be conservative. This will be revisited at the time of the full PAR. Ray also had some comments on thermal testing that will be discussed in more detail when we do the full revision PAR.

There were no further comments.

8.8.5.8 WG on Neutral Grounding Devices, PC57.32 – Steve Schappell, Chairman

The working group met at 9:30 a.m. on Tuesday, March 15, 2005, with 16 in attendance. There were 7 members in attendance and 9 guests. One of the guests requested membership and will be added.

The roster was handed out and introductions made. The group was asked if there was any knowledge of any patents that may be essential to the implementation of the Standard. There were no responses regarding this issue.

The current status of the document was discussed and it was noted that the PAR expires in December 2006. A ballotable draft of the Standard is needed by fall 2005.

An email from Richard Dudley addressing changes that needed to be made to Table 1 (Limits of Temperature Rise for Neutral Grounding Devices) of the Standard, with reference to previous work on related IEEE documents (C57.16 and C57.32), was reviewed with the group. There was a discussion regarding these possible changes. It was stated that based on the duty requirements for neutral grounding devices that it may be appropriate to increase the average temperatures as stated in Table 1. There was discussion that much higher temperatures than Table 1 are typically acceptable for

resistors due to the materials used for their construction. It was agreed that Table 1 should include temperature ratings applicable to three separate items: Item 1 – Dry Type, Item 2 – Oil-filled, and Item 3 – Resistors. Richard Dudley volunteered to work on a revised draft of Table 1 to be submitted to the working group for review. It was indicated that efforts made by both Peter Balma and Steve Schappell to solicit input from several resistor manufacturers had thus far been unsuccessful. Peter and Steve indicated that they would continue these efforts, particularly with respect to the temperature ratings to be included in the revised Table 1.

A handout of an excerpt from IEC 60076 dealing with Earthing Transformers was supplied by Richard Dudley and Christoph Ploetner as reference material for revising this IEEE Standard. Input was received regarding how to appropriately acknowledge in the Standard that we were permitted by IEC to use the material for reference purposes as well how to appropriately incorporate information from the IEC document. It was noted that there is also an annex to this document relating to resistors that may be reviewed as well. It was also noted that the IEEE document would continue to use the term grounding transformer rather than earthing transformer as used in the IEC document.

The question was raised as to whether there were cases where dry-type grounding transformers were manufactured for indoor applications. The response was affirmative.

There was some discussion as to the use of resistors or reactors in the neutral of a grounding transformer, either inside the tank or mounted on/adjacent to the tank. The appropriate approach by which to assign a nameplate rating for such a case was discussed. This discussion included differences in the definition of rated impedance between IEEE and IEC documents for such a case, specifically that for certain cases based on IEC definitions a combined rated impedance could be used where a grounding transformer and resistor or reactor were supplied together. The suggestion was made that to be consistent with typical practice among US suppliers and users the basic definition for rated impedance should use the definitions as currently stated in the IEEE Standard for each device separately and to nameplate the device or devices as such, not as a combined quantity. The suggestion was also made that additional tutorial-type information may be needed regarding how ratings are defined and what kind of system related information should be considered when selecting a rating.

8.8.5.9 PC57.149 – Guide for the Application and Interpretation of Frequency Response Analysis for Oil Immersed Transformers – Chairman; Charles Sweetser

WG PC57.149 met for the development of a guide for Frequency Response Analysis (FRA) in Jackson, Mississippi on March 15, 2005 at 3:15 P.M. There were 35 persons in attendance, 17 members and 18 guests of which 4 guests requested membership.

The FRA Working Group meeting was called to order at 3:15 PM.

The first order of business was to show the two slides regarding patents and inappropriate behavior.

The minutes from the last meeting were presented and approved without comment.

The Working Group chair presented a brief report on what had been done in the last six months. The latest contributions were identified and discussed. The major contributors were Mark Perkins, Roger Verdolin, and Charles Sweetser. This meeting focused on

three out of the six sections, Section 1: Scope and Application, Section 3: Making an FRA Measurement, and Section 5: Analysis and Interpretation. Each of these sections was then discussed.

- **Section 1: Scope and Application** – Mark Perkins and Roger Verdolin provided the first draft of roughly 20 definitions. The FRA Working Group reviewed this work. It was recommended that the definition for the impulse voltage method be shortened and any additional descriptions be moved to Section 3. Any references to voltage or current as measured signals needs to be replaced by "reference" and "measure", so not to create confusion among various test methods. Definitions 1.2.6 to 1.2.9, regarding test configurations and measurement type, produced some confusion within the FRA Working Group. It was agreed upon that these items need to be better defined. These four definitions will be edited by the original authors.

- **Section 3: Making an FRA Measurement** - The Working Group Chair proposed questions for a general consensus. The results are as follows:

    1. Recommendations for LTC Position: The Working Group agreed the LTC recommendation will be on one tap position, Extreme Raise. However, text will be added recommending additional tap positions for unique circumstances.

    2. Recommendations for DETC Position: The recommendation is the nominal tap position unless otherwise specified by the end user.

    3. The four measurement types, Open Circuit Self-Admittance, Short Circuit Self-Admittance, Inter-Winding, and Transfer Voltage were presented. These four measurement types cover all known test applications. No other additional measurement types have been brought to the FRA WG's attention. Richard Breytenbach and Jeff Britton offered to provide connection diagram for each of these types.

    4. The test connection table will have the terminal designations replaced with phase designations. Example: H1-H3 will be replaced with HV PHASE A. A caution note on phase polarity will be added. The end user needs to establish a polarity convention since reversed polarity connections produce different results.

- **Section 5: Analysis and Interpretation** - The FRA WG agreed that this section is in poor condition. Charles Sweetser provided a new outline for review. The outline included topics such as analysis strategies, relation to other diagnostic tests, failure modes, and modeling. The FRA WG would like to see work done in the area of computer modeling analysis. This analysis should be applied to various transformer designs to see how the results compare to actual measurements. Ramsis Girgis and Bob Degeneff expressed interest in this subject.

The topic of transformer natural frequencies was raised. This discussion was a continuation from comments made in the Switch Transients Induced by Transformer/Breaker Interaction Working Group PC57.142 meeting. Mel Smith of the Switch Gear Committee attended both meetings, Switching Transients and FRA. He asked if the FRA measurement could be applied to determine major resonances. However, his request requires a unique test procedure that has not been done on a routine basis. Mel Smith and Charles Sweetser agreed to collect data and report any findings to Working Group PC57.142 and Working Group PC57.149

Charles Sweetser provided a few comments regarding the status of the CIGRE FRA Working Group A2.26. The CIGRE FRA Working Group A2.26 guide will consist of two sections, Introduction to FRA for New Users and Guide to Interpretation of FRA Results.

The general deliverables and time schedule of CIGRE FRA Working Group A2.26 are:

- Intermediate report for circulation within SC A2 - May 2005
- Final report as CIGRE report or Brochure - December 2006

8.8.5.10 Core Overexcitation TF – Craig Steigemeier, Chairman

The third meeting of the Core Over-Excitation Task Force took place at 8:00am on March 14th, 2005. This Task Force is charged with the identification of limits for core over-excitation and coming up with suggestions for modification of appropriate standards. There were 61 total attendees, of which 37 were members and 24 guests. Nine (9) attendees requested membership and will be added to the TF member roster.

At the beginning of the meeting, the reminder of the need to adhere to the IEEE patent policy was stressed and the chair asked for anyone aware of patentable situations to bring it before the group. Also, the hotel's WiFi capabilities were noted. No one offered the chairman suggestions during or after the meeting of patentable work or identified any inappropriate topics covered during the meeting.

The suggested changes to C57.12.00 (IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers), Section 4.1.6 (Operation above rated voltage or below rated frequency) covered previously were briefly reviewed for the benefit of the 24 attendees that had not attended previous meetings of the TF.

Detailed discussions were held concerning the suggestions made during the fall (Las Vegas) meeting. The following are those suggestions, and the comments & recommendations made during this meeting:

- Instead of using 130°C, use the 90°C rise over the 40°C ambient for clarity
  - The issue related to gas generation due to core heating is related to the absolute temperatue of the core hot spot. Hence, the absolute temperature limit will have to be used
  - It was agreed that an explanation should be included that notes that the calculation for the hot spot is unique and different from the core surface temperature. The core hot spot occurs in an area where there is only a thin film of oil while the surface heating is more typical of metallic heating in the vicinity of bulk oil and solid insulation material.
- Address core hot spot when overexcitation occurs in lightly loaded situations
  - It was noted that the core hot spot temperature is much lower at lighter load, since the oil bath temperature is low.
  - The design will always be limited by the core hot spot when the transformer is under full load.
  - It was decided that it is not necessary to address hot spot at light load.
- Consider the core formula in IEC standards
  - We could not determine the basis of this comment.
  - IEC limits overvoltage on the primary side of the transformer while IEEE/ANSI defines overvoltage on the secondary.
  - The overvoltage conditions covered under this TF's recommendations will be consistent with IEEE/ANSI standards.
- Refer to C57.116 for consistency – both in terminology and details like power factor

- Relevant terms in C57.116 will be used in the final recommendation to the Performance Characteristics Subcommittee.

- Consider using a curve for temperature/overexcitation (attendees will send Chairman examples/suggestions)
  - It was decided that since the temperature/overexcitation curve is specific for a given design, it would not be appropriate to utilize a curve in a standard. If a guide is developed, then a sample curve could be appropriate.
- In addition to the GSU and system tie transformers, consider adding a third category for "other" transformers that are designed only for step-down operation
  - Stepdown and autotransformers should be the same as all that's required is the maximum voltage impressed on the transformer. Thus, there is no need for a separate category.
- Ensure consistency in the use of rises versus absolute temperatures
  - As the first point noted, the need for consistency and a clear understanding of the gas generation mechanism drives the decision to stay with an absolute temperature limit to be observed that will lessen the opportunity for gassing.
- Address boundary conditions - such as number of fans in operation and material
  - It was noted that boundary conditions determine the value of the temperature rise of the oil for a specific design
  - Transformer manufacturers must take all design and operation parameters of the transformer into account when making the core temperature calculations
  - Users must clearly identify the boundary conditions related to site and system parameters
  - The assessment of detailed boundary conditions will be avoided in the wording as these conditions are too varied to be covered in specific detail in a general standard.
- Develop and include a core hot spot calculation similar to the winding hot spot calculation
  - It was agreed that a definition of the core hot spot temperature was needed.
  - The definition offered was: Maximum Core Hot Spot Temperature = Maximum Ambient temperature + Temperature Rise of oil around the region of the core Hot spot at full Load + Core Temperature Rise at maximum core excitation and full load.
  - The temperature rise calculation would need to vary by the specific type of construction. For example:
    - For three phase, three limb, Core Form Transformers, the suggested method of calculation of Temperature Rise of oil around the region of the core Hot spot is as follows: Temperature Rise of ambient oil = 7/8 * TOP OIL RISE + 1/8 * BOTTOM OIL RISE.
    - For cores where the core hot spot is located at the top of a wound limb, the temperature rise of the ambient oil will need to be equal to that used in the calculation of the winding hot spot temperature.
    - For Shell Form transformers, the temperature rise of the ambient oil will need to be calculated for the oil at the inside of the phases at the top of the core
- It was decided that the loss of life table in C57.91 should not be modified to include a line addressing core overexcitation.
  - The table primarily addresses loss of life.
  - There is a need to note that the generation of hydrogen should be avoided.
  - A clarification sentence is needed to differentiate between core hot spot temperatures and the limitations of core surface temperatures.

- The differences between thin oil film trapped between laminations and bulk oil available at the surface of the core must be made clear to the standards user.

- The use of "over excitation" should be reviewed
  - The Task Force felt that excitation values within the range of normal limits should not be termed "over excitation."
  - The term "maximum excitation" may be useful in defining excitation that is at the upper limit of the normal range of core excitation.
- Consider setting induction limits, but must consider core material and construction
  - The meeting attendees agreed that this is outside the scope of the core overexcitation task force, but that it is an important topic that should be considered
  - This will be noted for Performance Characteristics Subcommittee consideration.
- The DGA Guide (C57.104) does not presently address the mechanism of H2/CH4 gas generation due to core overheating
  - It was suggested that wording should be included to address the mechanism of production of H_2 and CH_4 that is produced at low rates per day with ~ 7:1 ratio.
  - This characteristic would likely be the result of moderate core overheating that would not be harmful to the unit, but which may confound or confuse the analysis of future gas samples and diagnosis of unrelated problems.

In general, most attending seemed to prefer to keep the modifications as simple as possible, while coming up with something adequate to address concerns over the adequate handling of overexcitation situations.

After incorporating suggestions from this meeting, the Chairman will set up a web meeting and review the suggested text with a volunteer group including representatives from the following 4 manufacturers and 10 utility/consultants:

Peter Balma – Public Service Electric and Gas Company
Stephen Beckman – Fort Pierce utilities Authority
Enrique Betancourt – GE Prolec (volunteered after meeting)

Donald Chu – ConEd	Ramsis Girgis - ABB
Peter Heinzig – Siemens	Harold Moore - Consultant
Rowland James – Entergy	Miguel Oliva - ABB
Bipin Patel – Consultant	Gustav Preininger - Consultant
Ed teNyenhuis – ABB	Bob Tillman – Alabama Power Company
Subhash Tuli – Waukesha Electric Sys	Loren Wagenaar – AEP
Dieter Wagner – Hydro One	Peter Zhao – Hydro One

8.8.6 Project Reports

8.8.6.1 Measurment of "Zero Sequence Impedance" for transformers with interconnected windings – Ramsis Girgis

A group of six PCS members met to review and confirm accuracy of the method suggested by Gerry Roselli and develop appropriate text to describe the test for implementation in C57.12.90. This text will be finalized in the fall meeting of the WG. Mark Perkins, who is now the leader of the C57.12.90 WG, will have the responsibility for this group.

8.8.7 Old Business

None

8.8.8 New Business

The Chairman will recruit the original leaders of the groups that developed C57.105 (Transformer Connections) & C57.109 (Thru – Fault Current Duration) to lead the effort of reaffirming these two documents, since these need to be sent for affirmation this year.

Attendance at this Jackson Meeting

MEMBERS

1. David Aho
2. Stephen Antosz
3. Jim Antweiler
4. Javier Arteaga
5. Peter Balma
6. Barry Beaster
7. Steve Beckman
8. Enrique Betancort
9. William Boettger
10. Jeffrey Britton
11. Bill Chiu
12. Craig Colopy
13. Jerry Corkran
14. Alan Darwin
15. Ron Daubert
16. Robert Degeneff
17. Richard Dudley
18. Fred Elliott
19. Bruce Forsythe
20. Bob Ganser
21. Eduardo Garcia
22. A. Garnitschnig
23. Harry Gianakoros
24. Ramsis Girgis
25. E. Gomez-Hennig
26. Robert Grunert
27. Ernst Hanique
28. Roger Hayes
29. Peter Heinzig
30. Thang Hochanh
31. Philip Hopkinson
32. M. Jaroszewski
33. Virenda Jhonsa
34. David Keithly
35. Sheldon Kennedy
36. Boyd Leuenberger
37. Richard Marek
38. John Matthews
39. Guy Morrissette
40. Michael Oliva
41. Mark Perkins
42. Don Platts
43. Christoph Ploetner
44. Bertrand Poulin
45. Jean-Chris Riboud
46. Marnie Roussell
47. Mahesh Sampat
48. Steven Schappel
49. Ibrahim Shteyh
50. H. Jin Sim
51. Steve Snyder
52. Andy Speegle
53. Andy Steineman
54. Craig Stiegemeier
55. Charles Sweetser
56. Craig Swinderman
57. Subhash Tuli
58. Loren Wagenaar
59. Peter Zhao
60. Waldemar Ziomek

GUESTS

1. Marcel Fortin
2. Jeff Serzan
3. Jose Grijuela
4. Dong Kim
5. Larry Davis
6. Brett Todd
7. Wayne Johnson
8. Pierre Riffon
9. Lars-Erik Juhli
10. Sten Andersson
11. Joe Melanson
12. George Tolbert
13. Paul Mushill
14. Jane Verner
15. Dick Amos
16. Jim Wiseman
17. Steven Brown
18. Rip Psyck
19. John Haufler
20. Scott Digby
21. Clayton Burns
22. Dennis Lee
23. Jim Y. Cai
24. Christoph Schuette
25. T. Machado *
26. David Scaquetti

* Guests requesting Membership.