7.2 Performance Characteristics Subcommittee – Ramsis Girgis, Chairman; Stephen Antosz, Secretary

7.2.1 Introduction/Attendance

The Performance Characteristics Subcommittee (PCS) met on Wednesday, March 22, 2006 with 52 members and 44 guests in attendance. 11 of those guests requested membership in PCS. See last page of these minutes for attendance summary.

7.2.2 Approval of Meeting Minutes

The minutes of the last meeting in Memphis, TN were approved as written.

7.2.3 Chairman's Remarks

7.2.3.1 Administrative Subcommittee Notes

- Next Standards meeting dates and locations are as follows:
  Fall 2006: October 22–26, Montreal, Quebec, Canada
  Spring 2007: March 11–15, Dallas, TX
  Fall 2007: Date TBD, Minniapolis, MN
- IEEE T&D Exhibition / Conference, which was to be held in New Orleans, will be held May 21-26, 2006, in Dallas, TX. Two panel sessions and one Poster session are planned for Tuesday May 23rd.
- IEEE PES Meeting: June 19 – 22, 2 transformer sessions / 10 paper presentations on Wednesday, June 21st.
- Because of some administrative issues at IEC with Dual Logo of IEEE documents, it was suggested that we postpone submitting the “Loss measurment and tolerances” Guide C57.123 for Dual IEEE / IEC Logo.
- Chairmen of TFs, WGs, and SCs need to update their membership lists.
- Those who are not members of the committee are encouraged to seek membership.
- Stephen Antosz was requested to chair the effort on the C57.12.90 revision. He accepted.
- The Administrative Subcommittee is seeking a person to represent the Transformers Committee to the IEEE/PES Standards Board.

7.2.4 Working Group and Task Force Reports

7.2.4.1 PCS WG for Continuous Revision to C57.12.90 – Mark Perkins, Chairman; Rowland James, Secretary

The PCS Working Group for Revisions to test code C57.12.90 met in Costa Mesa, CA on March 20, 2006 at 9:30 A.M. There were 70 persons in attendance, 32 members and 38 guests. Eleven guests requested membership.

Announcements
After introductions, Mark announced that the committee chairman sent an e-mail that gives instruction on viewing the slide presentation concerning patent issues. Mark then asked if there were any patent issues relating to this standard. Being none, this discussion was closed.

The minutes from the last meeting were then reviewed. Gerry Rosselli requested that item #1 of the minutes be reworded as follows.

Gerry Rosselli presented a proposed draft of section 9.5 "Zero-phase-sequence impedance tests of three-phase transformers **with interconnected windings**". In this draft the procedure for measuring zero sequence impedance is described:
Note: The highlighted text was the requested addition. The minutes were approved as amended.

Task Force Reports

1. Marcel Fortin reported on his Task Force's progress on revision of section 11 of C57.12.90, which included a plan to improve the Short Circuit Testing section standard. Marcel made a brief presentation to the working group on the items to be considered by the task force. They plan to conduct the business via email. The plan is to have the revised section surveyed at the WG level before the fall meeting.
2. Gerry Rosselli reported that a survey was conducted on draft 2a of the "Zero-phase-sequence impedance tests" document. There were fourteen responses, ten approved and four approved with comments. The current draft is now 2b. This draft has corrected equations, and will be surveyed with the Performance Characteristics Subcommittee before the next meeting in Montreal.
3. Mark Perkins reported that the task force on resistance measurements (section 5 of C57.12.90) met on the evening of March 19, 2006 to review and consider the recommended changes to the standard. The group prepared recommended changes to Clause 5, which will be distributed to the working group with the minutes. After the working group comments are considered, the proposed changes will be sent to the Performance Characteristics Subcommittee for survey before the fall meeting.

Old Business

1. Review of comments on draft 2 of C57.12.90 continues.
2. Bill Chiu reported that C57.12.00 draft 3 is ready for recirculation.
3. Steve Snyder and Lin Pierce recommended removing clause 15 and place it in C57.12.00.A straw vote was taken and the result was unanimous.
4. Gupta recommended that in sub clause 8.3 "Waveform correction of no-load losses" the term "assigning each a value of 0.5 pu" because "this gives the impression that the total hysterisis and eddy-current losses is one pu which is not the case". Ramsis Girgis recommended that we do not accept this recommendation. After a lengthy discussion the majority voted not to make this change. Steve Snyder will inform Gupta of the decision. See appendix "D" for additional details.
5. Comments from J.W. Wilson on testing a three phase transformer with a single phase source were reviewed. This included suggested revisions to figure 23. It was decided to move this section from this standard to C57.123 "Transformer Loss Measurements". Ed teNyenhuis, who was in attendance, agreed to include this section in the guide.

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

The Working Group met on Monday, March 20 at 1:45 PM. There were 24 members and 58 guests in attendance, with the following 3 people requesting membership:

Frank Damic	Tamini Transformers
Robert Tillman	Alabama Power Company
Jim Graham	Alliant Energy

The addition of the 3 new members brings the Working Group membership to 67 .

Following introductions, the minutes from the October 24, 2005 Memphis 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 chairman provided an update on two items of old business carried forward from the autumn meeting :

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 clarify the test requirements for all transformers. This is a work-in-process that is being coordinated with the resolution of several other comments pertaining to Table 19. More will be reported on this at the next meeting.

WG Item 63 C57.12.00/D2 April 2002 Section 5.12.2 Table 10, Nameplate information Note 11
A suggestion was received to use gallons in lieu of cubic-meters as the unit of measurement for liquid volume, as expressed in this note for nameplate data. The working group was in favor of this suggestion, but the chair has been informed that our standards must show a preference for metric units to comply with IEEE metrification policy. However, recent compromises with IEEE have allowed the use of English units as an acceptable alternative. The note will be revised for draft 3 to read as follows :

> d) The volume of insulating liquid, in cubic meters (gallons), and type shall be shown for the main tank and for each liquid-filled compartment.

The Working Group then began discussing the new topics as follows:
WG Item 67 C57.12.00/D2 April 2002 Section 8.2 Table 19

This is a request to make load loss testing and resistance measurements a routine test for distribution transformers. The Distribution Transformers Subcommittee is being solicited for input - topic will be tabled in this WG until their input is received.

WG Item 70 C57.12.00/D2 April 2002 Section 6.5.1 Tank pressure requirements

This proposal is to rewrite clause 6.5.1 to drop the ASME Boiler Code reference and state that tank pressures under rated conditions shall not exceed two atmospheres absolute. Discussion on this matter led to the belief that the statement was probably inserted as a precautionary measure, that if manufacturers exceeded 2 atmospheres pressure then the boiler code would apply. The chair will follow up on this question and discuss the proposal with the commenter, and report on the issue at the next meeting.

WG Item 71 C57.12.00/D2 April 2002 Section 8.2 Routine, design, and other tests for transformers

The request is to change the word usage by deleting "all transformers" from the sentence. The Working Group agreed with the proposal, and the revised sentence will read as follows (in draft 3 revision):

"Routine, design, and other tests *shall be* made in accordance with Table 19."

WG Item 72 C57.12.00/D2 April 2002 Section 8.2.1 Routine tests

The proposal is to change the language of this sentence - the Working Group agreed, and the revised sentence will read as follows (in draft 3 revision) :

"Routine tests *shall be* made on every transformer to verify that the product meets the design specifications."

WG Item 73 C57.12.00/D2 April 2002 Section 8.2.2 Design tests

The proposal is to change the language in this section to emphasize that design tests are mandatory tests. The commenter suggested that the word "are" should be replaced with "shall be" in the first two sentences of this clause. The Working Group approved the first suggestion but felt the word "are" should remain in the second sentence. This change will be incorporated into draft 3.

WG Item 74 C57.12.00/D2 April 2002 Section 8.2 Table 19

This is a request to review and clarify Note 1 of Table 19. Since the note pertains to distribution transformers, the Distribution Transformers Subcommittee is being solicited for input – the topic will be tabled in this WG until their input is received.

WG Item 75 C57.12.00/D2 April 2002 Section 8.2 Table 19

The proposal is to clarify the statement for impedance voltage and load loss testing. The Working Group agreed, and the revised statement will read as follows in draft 3:

"Impedance voltage and load loss at rated current and rated frequency on the rated voltage connection, and at the tap extremes of the first unit of a new design (See NOTE 1 and Note 2. For LTC units, see 8.3.2)"

WG Item 76 C57.12.00/D2 April 2002 Section 8.2 Table 19

The requested change is to add a dot in the "Other Tests" column for the resistance test of transformers 500 kVA and smaller. There was much discussion on this matter but it was not finalized, pending feedback from the Distribution Transformers Subcommittee.

WG Item 77 C57.12.00/D2 April 2002 - Clause 15, of C57.12.90 Certified test data

This proposal is to move section 15, certified test data, from C57.12.90 into C57.12.00, as a new section 8.6. The proposal was discussed in the PCS C57.12.90 WG meeting and unanimously approved. The Working Group agreed that this section, since it dictates requirements for test data, does logically belong in C57.12.00. This change will occur in draft 3.

WG Item 79 C57.12.00/D2 April 2002 Section 5.7.1 Polarity of single-phase transformers

The commenter noted that 200 kVA (one of the parameters for polarity determination) is a nonstandard size, and questions whether this was an intentional selection. No one present seemed to know where this came from, and it has been in place for so long that

there does not seem to be much interest in changing it now. However, the chairman will seek input from the Distribution Transformers Subcommittee and report at next meeting.

New Business

A statement was received from the floor requesting our Working Group to clarify how impedance voltage is stated for transformer taps – is it referenced to the tap voltage or the rated voltage of the transformer? This matter will be considered for future work by the group.

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

- 26 members and 13 guests attended with 2 guests requesting membership (Bruce Forsyth & David Scaquetti)
- 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 given.
- Minutes from the Memphis Meeting held on Oct 25th, 2005 were approved.
- Report from TF for "Guide for Low Power Factor Power Measurements". This meeting was chaired by Ed teNyenhuis in the absence of Eddy So. There was nothing to report on the Low PF Power Factor Guide. The TF reviewed the C57.123 Guide for Loss Measurement for changes. These changes and the persons responsible for review of the Guide were noted in the TF minutes.
- Frequency Conversion Factors of Transformer Performance Parameters - The final wording for C57.12.00 and C57.12.90 was reviewed again by the WG. The WG agreed that with the below changes, the wording could be sent on to Dong Kim (C57.12.00) and Steve Antosz (C57.12.90):
  - Editorial change to No Load Loss example – change "-0.05(1.7-1.4) + 1.33" to "1.33 + 0.05(1.7-1.4)".
  - Chairman to find out if equation numbers are needed. If so, they will be added.
  - Chairman to prepare wording that for frequency spectrum measurement, the linear values would be correct for spectrum measurments. This wording will be confirmed with Ramsis Girgis.
  - Chairman to prepare introduction on the frequency conversion factors to send along with the wording
- C57.123-2002 – Guide for Transformer Loss Measurement – This Guide needs to re-affirmed by Dec 2007 so the WG reviewed for initial changes and assignment of responsibility as per below. The chairman will send a Word copy to everyone so that text can be edited and complied for review at the next meeting.
  - Add reference to the frequency conversion factors that will be added to C57.12.90 annex.
  - Section 3 to be reviewed by Ed teNyenhuis
  - Section 3.5.3 – Bertrand Poulin will review for changes
  - Section 4 will be reviewed by Ernst Hanique
  - Equation 7, 8 – error – the "=" should be "+"
  - Remove 3.7.2 on two wattmeter method but say why it is not recommended.
  - Section 3.7.3 – Strengthen the wording on using the correct voltmeter connections and add further examples (Ed teNyenhuis to prepare this)

- Section 4.5.2 – remove this and add text on why it should not be used
- Section 5, 7 – Reto Fausch will review for changes
- Section 5.3 – Bridge Method – It was decided to keep this section as it is still used for low pf loss measurement in some companies
- Section 6 – Ed teNyenhuis to review for changes
- Section 8 – Vladimir Khalin agreed to review for changes
- All will review the Bibliography for additional references
- Ed teNyenhuis will review previous WG minutes for earlier noted changes

- Figure 23 from C57.12.90 was reviewed for possible addition to the Loss Guide. This was per a request from the WG Revision to Test Code C57.12.90. The WG agreed to add this to the Guide however it will be reviewed again with the other changes to the Guide. Below are the errors in the figure:
  - Add H3, H0
  - Remove CT on H2
  - VT should be connected to H2 (not ground)
  - V connected to ground (remove N, B)

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

Acting Chairman: Phil Hopkinson Acting Secretary: Scott Choinski

The Task Force on Switching Transients Induced by Transformer/Breaker Interaction was called to order at 8:00 AM on March 21, 2006. There were 61 attendees, 22 members, 2 requesting membership and 37 guests. Reviewed the agenda for the meeting, and the IEEE patent policy. The Minutes from the October 26, 2006, meeting in Memphis, Tennessee were approved.

1. Status of C57.142 Document –Revisions proposed by Pierre Riffon

   Mr. Hopkinson discussed his experience with transformer/breaker interaction. Hopkinson noted that the transformer gets in trouble, but the circuit breaker (vacuum or SF_6) causes the problem. It occurs in Delta-connected systems, and switching times in arresters are insufficient to protect the transformer.

   Mr. Fallon updated the status of the document. Liaised with Switchgear committee and some rewrites were completed. Not all of the negatives were addressed and the document is not ready for recirculatioin. Will continue to work with the Switchgear Committee to address all of the negatives.

   Hopkinson noted that the vacuum breaker switchgear makers have indicated that vacuum switchgear does not chop current. He said that this is clearly not an accurate statement and needs to be challenged. Furthermore, a complex interaction between cable resonance from current chopping and Transient Recovery Voltage (TRV) places high frequency voltage reversals across transformer windings and produces destructive winding flashovers and failures.

2. Recent Tests and analysis by Phil Hopkinson
   Reviewed Mr. Hokinson's presentation "Transformer Switching Events – A Case For Change" originally presented March 17, 2003, in Raleigh.
   Reviewed Mr. Hopkinson's presention "Ping Test". This presentation is posted under the Performance Characteristics Subcommittee site. Hopkinson

indicated that he and Bob Degeneff will conduct a seminar with the same materials at the April 13 meeting of Doble in Boston.

3. Switching Events
Responsibility for correcting the transformer/breaker interaction needs to be addressed. This will require negotiations between Transformers, Switchgear and Applications Committees to develop a charter between the Power Engineering groups in IEEE. It was noted that some SF_6 switchgear actually have vacuum contactors and are insulated by SF_6

7.2.4.5 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 Balboa I Meeting Room of the Costa Mesa Hilton Hotel in Costa Mesa, California on Mar. 20, 2006 from 11:00 a.m. to 12:15 p.m. There were 9 members and 16 guests present. The following are the highlights.

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

   NOTE: The minutes of the Costa Mesa meeting will not be formally approved until the W.G. meets in Montreal, Quebec.

2. IEEE patent policy was reviewed as it applies to the revision of this standard. No patent issues were noted. Attendees were directed to the IEEE Transformers Committee website for more details on IEEE patent policy.

3. Draft #5, of the revision of IEEE C57.21 prepared by the Chairman, was discussed. The following are the highlights and, except as noted are related to comments provided by Ramon Garcia.

   (i) IEEE C57.12.80 and IEEE C57.12.00 will be consulted re definitions for rated voltage, maximum system voltage, maximum operating voltage. Maximum operating voltage is generic to SRs. The current definition for maximum system voltage in D#5 is a good definition of maximum operating voltage.
   (ii) Consensus is that the preferred condition for carrying out the audible sound test is at maximum voltage.
   (iii) Are definitions of voltage consistent for “delta” connected SRs as well as “Y” connected SRs?
   (iv) Re “terms in which rating is expressed” it was decided that the “end user” should define desired magnetic characteristics and that the standard should not define these characteristics. A NOTE will be added to Clause 5.2 stating that “magnetic linearity may be important re switching considerations”.
   (v) The Insulation Class for oil-immersed SRs is not indicated in Table 3. Is it 120°C? The transformer standards will be consulted as well as the Chairmen responsible for revision; Subhash Tuli etc.
   (vi) An enhancement of 170% will be kept for the Low Frequency Overvoltage Test. This was the consensus of utility W.G. members; AEP, APS, HQ, BCH. An enhancement of 170% is also in line with the IEC reactor standard.
   (vii) Clause 10.6.3.4 will be corrected; “where specified sound level tests shall be conducted at a specific voltage other than maximum voltage”.

(viii) Dong Kim of S. Cal Edison suggested that p.d. tests on oil-immersed SRs should be consistent with the methodology for power transformers. More input is requested from Dong Kim.

The Chairman stated that he had only received 3 comments to-date from his survey of the PC S.C. re D#5. More input is required. The Chairman also asked for volunteers from the W.G. to review D#5 in detail re editorials etc. Once these 2 processes are complete the Chairman will produce D#6 which should be suitable for formal IEEE ballot.

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

The working group chair opened the meeting with introductions at 1:45 on Tuesday March 21, 2006. There were 16 members and 10 guests present.

The IEEE Patent disclosure requirements were addressed. A request was made for disclosure of any patents that may be related to the work of the working group. There was no response to the request for disclosure. The minutes from the Memphis meeting were approved as submitted to the SC Chair.

Old Business
The chair thanked Ramsis Girgis for editing the abstract, key words and introduction. The introduction was reduced in length by removing descriptions of the changes that were made in the last revision, since the comments were no longer appropriate to the current revision. These changes will be added to draft 3 for review by the working group.

The chair reminded the working group of a reaffirmation ballot comment made by Ed Bertolini concerning a lack of information on neutral heating due to third harmonics. Ed felt the document did not provide sufficient information on the topic. A second ballot comment by Ajit Hiranandani suggested additional words of clarification in this clause. He also suggested a bibliography reference to his paper about sizing line and neutral conductors in the presence of harmonics. A question was raised whether sizing conductors was included in the document scope. The chair stated that while the topic was not, a reference to the methods and the paper were probably useful. The suggestion would be included in draft 3 for review by the group.

New Business
The chair thanked Ramsis for providing a marked up copy of draft 2 with suggestions for revisions and corrections. The working group members were urged to do the same after closely reading the document, since many changes were made during the process of reformatting the document. The many formulas and the associated variables should also be reviewed very carefully, since all were modified to meet the new format requirements.

The chair then noted a number of items that should be considered by the working group during review of the document:

- All tables have been numbered and titled, but a review and suggestions are requested
- All table data and calculations have been revised following consistent rules of precision and rounding
- The chair decided to retain the two table format in draft 2 for the example calculations since it more clearly separates the input data from the calculated information. All were requested to review and compare to the single table format in Annex B.

- Additional words added to the examples to explain some of the intermediate calculations should be reviewed for content and consistency.
- All reaffirmation ballot suggestions and corrections should have been incorporated in draft 2, but should be crosschecked.
- Annex D should be reviewed for upgrades. Hasse Nordman suggested that some of the graphics from IEC 61378-3 could be added to this annex. The chair will review and request permission from IEC.
- If there is a need for additional examples or if an example should be changed, the suggested revision should be sent to the chair for inclusion in the next draft so that all members may review the change.
- All papers, articles or book references that have been published since the last revision should be submitted for addition to the bibliography

The Chair asked manufacturers to review Annex C which details methods of temperature rise testing and suggested that it be updated to include the new equipment that is now available. Chuck Johnson noted that it is now possible to simply dial in the harmonics to generate a composite wave. Dhiru Patel also indicated that they have equipment that allows direct harmonic load testing and that they had tested a large range of units. Chuck and Dhiru agreed to review Annex C for appropriate upgrades. One member expressed concern that a test could become mandatory, but the chair stressed that this was the reason that testing information appears in an informative annex. He also noted that the document is a recommended practice and therefore was not mandatory.

Ramsis Girgis questioned whether the 0.8 exponent used in the equations for the Harmonic Loss Factor for other stray losses was sufficiently accurate considering more recent investigations. He noted exponents as high as 1.55. Sheldon Kennedy reminded all that the number was taken from IEC documents that were also under development at the same time the last draft was completed. Hasse Nordman related details of the testing that was the source of the IEC exponent. This testing resulted in an exponent of about 0.6, but that 0.8 was used to be conservative. The chair noted that he felt 0.8 was appropriate considering the approximate nature of the whole document. All agreed.

Hassan Zarmandily asked if the document would address core losses due to harmonics. This resulted in a lengthy discussion by a number of members and guests. Ramsis Girgis pointed out that the result could actually be a reduction in the core flux. Ramsis suggested that this was a very complex subject and that we might want to let this issue be addressed in a future standard or discussion. The chair noted that historically the document has specifically excluded voltage harmonics. However, if someone feels it should be addressed, they should provide at least the start of a paragraph that may be added to the next draft for all to consider.

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

The Working Group met on Tuesday, March 21, 2006 at 3:15 PM with 9 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 March 14, 2005 meeting in Memphis, Tennessee were approved, after noting one error. The meeting minutes stated that the meeting occurred on March

24, 2005 when it was October 24, 2005. This was an error in updating the minutes from the previous meeting.

The Chair announced that we were near finishing work on the Amendment to C57.18.10, which had been approved as a PAR by IEEE. 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 submitted proposed definitions to the working group for the terms E_z, P_a, P_b, and P_c. These were discussed and accepted.

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. These problems appear to be a problem with the conversion into a PDF which performed an automatic renumbering of the tables.

We were fortunate to have both Angela Ortiz and Jennie Steinhagen from IEEE in attendance at our previous meeting in Memphis to hear these comments. Angela and Jennie agreed to work with the Chair on the Errata to correct this problem. This was published by IEEE on January 27, 2006. The errant tables and figures were corrected and done in the same manner as they were in the original printed standard. Leaving them as they are allows C34.2, the rectifier standard that uses these same tables, to not need to be changed.

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

Subhas Sarkar brought up a new item for possible inclusion in our next revision. Some drives suppliers are specifying high impedance transformers on the order of 15 % to 25 % impedance. He feels we should have some discussion on the impact that has on the rectifier transformer.

Issues that are being discussed in the C57.110 revision were also discussed. Better agreement between the terms used in the two standards was discussed. Difficulties with the new requirements from the IEEE Styles Manual will also make the large tables in C57.18.10 difficult to manage. We may need to seek advice from IEEE staff at that time.

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

No formal meeting was held in Costa Mesa but Richard Dudley (W.G. member) met, on Wed. Mar. 22 at 9:30 a.m., with Douglas McCullough, who is a Manufacturers Representative for Post Glover Resistors, re obtaining input for the neutral grounding resistors section of IEEE C57.32. The background and objectives of this standard were presented to Doug by RFD. Doug commented that Post Glover was committed to participating in the revision of this standard.

Subsequent to this informal meeting Doug requested membership in the W.G. He stated that he would receive technical back-up from Post Glover engineers as required. In fact he promised that he would co-ordinate the drafting of the section on neutral grounding resistors. RFD promised to provide the latest draft of the revision of IEEE C57.32. RFD suggested that the completed section on neutral grounding reactors be used as a template for the neutral grounding resistors section.

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

WG PC57.149 met for the development of a guide for (FRA) in Costa Mesa, California on March 22, 2005 at 11:00 A.M. There were 31 persons in attendance, 15 members and 16 guests of which 8 guests requested membership.

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 newly formatted Draft was introduced, and it was labeled D1. All six sections were discussed.

- **Section 1: Scope and Application** – The group decided to review the following components.

  Definitions – The 20 definitions in place are too descriptive and will be reviewed and edited for length and content. Reference links will be added when necessary.

  Test Names – Terms such as Self-Admittance will be removed from the test names. The IEEE FRA and CIGRE Group collaborate on a set of common names.

- **Section 3:** MAKING A FRA MEASUREMENT – The group decided on reformatting the connection tables. The connections will be referenced by phase and not by terminal designation. Special formatting will be used to distinguish between recommended and optional tests.

- **Section 4:** Test Records – Bertrand Poulin offered to review and edit this section. All of the information is present, however it needs better presentation.

- **Section 5: Analysis and Interpretation** – The group agreed on the basic components for this section Trace Characteristic, Trace Comparison, Relation to

Other Diagnostic Tests, Failure Modes, and Modeling. It was recommended that we add a component that would address test error issues.

- **Section 6: Appendix FRA Theory** – Alan Darwin agreed to review and edit this section for length and content.

Alan Darwin made a short presentation regarding modeling. This presentation focused on the modeling work done by Dr.Zhongdong Wang from the University of Manchester. We are hoping to include some of this work in our modeling section.

Richard Breytenbach presented a CIGRE Update, which included the last meeting held in London, UK last week. The subjects from the CIGRE meeting included:

- Effects of grounding and contact resistance.
- A round table of test data interpretation experience.

The PC57.149 FRA WG plans to have an updated draft D2 at the next meeting.

7.2.4.10 TF on Core Overexcitation – Craig Steigemeier, Chairman

The fifth meeting of the Core Over-Excitation Task Force authorized by the Performance Characteristics Subcommittee took place at 3:15pm on March 20, 2006. 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 68 total attendees, of which 24 were members and 44 guests. Thirty (30) of the 68 attendees were first time attendees to this task force meeting. Four (4) attendees requested membership and will be added to the Task Force member roster. Tim Raymond volunteered to assist the chairman in the collection of comments to support the development of these minutes.

The following agenda for the meeting was reviewed with the attendees.

- Participant introductions
- Patent reminder
- Approve Minutes of Memphis Meeting
- Task Force Charter & Scope: Charter – Performance Characteristics Subcommittee; Scope – The impact of excitation overvoltage on the core
- Review Suggested Modifications to Standards based on discussion at the Memphis meeting

At the beginning of the meeting, attendees were reminded 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. No one offered the chairman suggestions during or after the meeting of patentable work or identified any inappropriate topics covered during the meeting.

A discussion was opened to review the minutes from the Memphis meeting published on the Committee website. A vote was taken and the minutes were approved.

The 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) suggested at the Memphis (Fall 2005) meeting were reviewed in detail. The following suggestion was made for the re-write of C57.12.00, with the text in blue being additions to the standard suggested at the Memphis meeting:

4.1.6 Operation above rated voltage or below rated frequency
4.1.6.1 Capability
Transformers shall be capable of:

a) Operating continuously above rated voltage or below rated frequency, at maximum rated kVA for any tap, without exceeding the limits of observable temperature rise in accordance with 5.11.1 when all of the following conditions prevail:
1) For distribution transformers:
1a) Secondary voltage and volts per hertz do not exceed 105% of rated values.
1b) Load power factor is 80% or higher.
2) For generator step-up transformers, the primary voltage is equal to the highest generator voltage at full load as specified by the user.
3) For system tie transformers, the primary and secondary voltages are equal to the highest levels specified by the user.
4) Frequency is at least 95% of rated value.
b) Operating continuously above rated voltage or below rated frequency, on any tap at no load, without exceeding limits of observable temperature rise in accordance with 5.11.1, when neither the voltage nor volts per hertz exceed 110% of rated values.
In the case of multiwinding transformers or autotransformers, 4.1.6.1 applies only to the specific loading conditions used as the basis of design. These loading conditions involve simultaneous coordination of kVA input and output, load power factors, and winding voltage combinations [see item j) of 4.3.3]. Differences in loading and voltage regulation for various output windings may prevent simultaneous achievement of 105% voltage on all output terminals. In no case shall the kVA outputs specified for any loading condition require continuous loading of any input winding in excess of its rating.
4.1.6.2 Maximum continuous transformer operating voltage (unchanged)
4.1.6.3 Core hotspot temperature limit
To avoid the generation of gasses in the core, the core hot spot temperature should be limited to 130ºC for the condition of highest core over-excitation, full load, and the highest ambient temperature for transformers filled with mineral oil. It should be noted that the calculation for the hotspot is unique and different from the core surface temperature. The location of the core hotspot is typically in the center, or between cooling ducts, of the upper part of the core. Gas generation in this area is caused by overheating of a thin film of mineral oil.

The following comments were made during the discussion of the suggested text:
Devki Sharma – For Item 3 of revised clause 4.1.6.1, include standard values (e.g. 105%) in the event users do not explicitly specify max. voltages. TF members agreed.
Juergen Gerth – (Regarding 4.1.6.3) Is it clear what ambient temperature applies?
Craig: Rated ambients of 30ºC avg., 40ºC max. apply.
Harold Moore – Should we also have a core surface temperature limit, since core surface is often in contact with insulation materials? Craig: Correct, addressed in next slides.
Arnold Carlos – How do we verify core temperature limit? Craig: Each manufacturer must develop own method and justify to customer.
(Unknown) – suggest 120ºC in contact with insulation, 130ºC internal core
Harold Moore – Pressboard is not thermally upgraded, temperature limit should be 95ºC.
Craig – It was suggested at the Memphis meeting to set induction limits for the core. One proposal was to limit the induction at the maximum defined voltage on the system to 1.93 Tesla for step lap cores and 1.90 Tesla for non step-lap cores. Another suggestion was 1.95 Tesla for HI-B material and 1.93 Tesla for RGO material.
It was suggested by the Chairman that this may well be a design parameter that is best left to the manufacturer to decide upon depending on the customer requirements, core

design and the core material. The Chairman opened up the topic to discussion by the attendees. Following are the significant comments from that discussion:
Arnold Carlos – Wouldn't temperature or noise limits set induction level?
(Unknown) – Would it be useful to set time limits for various overvoltages.
Craig – Is it OK to abandon set induction limits?
Juergen Guerth – Stated that it is not appropriate to limit flux density. Flux density and heating not directly connected (ie. cooling duct configuration)
Dennis Marlow – Agree with Juergen.
Harold Moore – Consider induction limits, since it is difficult to explicitly define conditions for temperature limit and there is not a widely accepted method for calculating core temperatures. Use induction limits as "stop gap".
Ramsis Girgis – Should make clear voltage conditions that apply to temperature limits.
VOTE: Should there be an explicit induction limit? 6 No, Majority (>30) Yes.
The Chairman noted that it was suggested at the Memphis meeting that a core hot spot temperature calculation be part of C57.12.00? The following general guideline for core hot spot temperature calculations was reviewed with the attendees:

> 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 at full Load
>
> 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

Ramsis Girgis: This is not a real core hot spot temperature calculation, but sets specific conditions for calculation.
Gary Walters: Use wording similar to winding hot spot clause.
Ramsis: This is exactly what Craig has shown in the slide. This is equivalent clause.
VOTE: Forward core hot spot "definition" to C57.12.00 WG? 16 Yes, 0 No.
Craig: Should we add limit for core surface temperature? It was suggested in Memphis that a limit on the maximum allowed core surface temperature should be added to the standard. The following suggestion for the Surface Temperature Rise of Cores was presented to the attendees:

> The surface temperature rise of the core will not exceed 125ºC at rated load and at the rated MVA of the transformer and with 105 % voltage on the loaded windings at the defined load power factor. The hot spot temperature shall not exceed 130ºC.
>
> The material used to maintain cooling ducts in the core should be capable of operating continuously at 125ºC.

The Chairman suggested that the temperature limits of the core should be part of the Loading Guide, C57.91 and that this is outside the scope of this task force.
Tim Raymond: He would not add to loading guide since there is no way to evaluate core temperature from users standpoint.
Ramsis: There are already limits for metallic temperatures in contact with insulation.
Juergen: Should differentiate use of insulation materials (as electrical insulation or mechanical spacing).
Ramsis: Need to differentiate two components to core temperature: main flux and leakage flux. Ramsis volunteered to make a first pass at wording for the surface temperature limit..

The Chairman noted that attendees in Memphis had suggested that the standard include a statement that nameplate must adequately identify the actual capacity to which the transformer was originally designed. If the transformer is capable of a greater or lesser overvoltage than that expected from the general clause of 4.1.6.1 due to the actual capacity of the generator to which it was originally connected, this must be clearly shown on the nameplate. It was also noted that the duration of the overvoltage should be included, since the impact of time will influence the development of gas
Ramsis: Every customer has different "short-term" overexcitation requirements. Should consider requirements discussed here as continuous performance requirement.
VOTE: Should consider requirements as continuous overexcitation requirements (as opposed to short-term overexcitation). 25 Yes, 6 No
Loren Wagenaar: Prevalence of short-term overexcitation in users specs indicates need for guidance.
Harold Moore: We don't know users specific needs.
Loren Wagenaar: AEP used average of other users specs. Put in simply to raise issue. Would like continuous curve. About 15 points in AEPs spec.
Ramsis: Hydrogen starts to generate at approx. 110C. Suggested 130C for worst case loading, ambient, overexcitation, then normal conditions would result in low H2 generation. We can develop curve, but is it necessary. Reason for requirement is to limit H2. This is a separate subject than short-term overexcitation.
The Chairman noted that the development of an acceptable short-term overexcitation is out of current scope of the Task Force.
Harold Moore: Suggested that the Task Force finish the current work, and the the PCS SC can set-up new Task Force to develop short-term overexcitation limits.
A significant amount of discussion took place, which in the majority was in agreement with the decision to defer short-term overexcitaiton limits to a future Task Force.
The chairman noted that it was suggested to add wording to C57.104 to address H_2/CH_4 generation. The following was suggested:
Add wording about the mechanism where H_2 and CH_4 is produced at low ppm per day with a 6-8 ratio. This is caused by moderate core overheating and it is not harmful to the transformer.
All in attendance agreed that the TF should refer this to Insulating Fluids Subcommittee responsible for revising C57.104.
Don Platts: Suggested that we should make sure that the definitions for distribution, GSU & system tie transformers are consistent with other documents. There are holes for other types of transformers. The Chairman agreed to do some research and make necessary modifications before the Montreal meeting.

7.2.5 Old Business

None

7.2.6 New Business

7.2.6.1 New Project - Short Circuit Test Guide, PC57.133, Tom Prevost

The Guide for Short-Circuit Testing was Part 2 of C57.12.90-1995. The IEEE Style Manual did not allow two parts to a Standard, so the plan was to separate it then get published under its own Standard. A new Par was issued. There were problems with the graphics that was not resolved. The document was reviewed by several members of the committee, and it was decided that the section using LVI technique will be removed. It will be cleaned up and balloted. Then the plan is to open up a new revision project to

include other current diagnostic techniques such as FRA. Marcel Fortin volunteered to adopt this task into his group's work on Clause 12 of C57.12.90.

Attendance at this Costa Mesa Meeting

MEMBERS

1. David Aho
2. Jerry Allen
3. Stephen Antosz
4. Jim Antweiler
5. Javier Arteaga
6. Ron Barker
7. Barry Beaster
8. Stephen Beckman
9. William Boettger
10. Carl Bush
11. Jerry Corkran
12. Alan Darwin
13. Richard Dudley
14. Fred Elliott
15. Don Fallon
16. Reto Fausch
17. Bruce Forsyth
18. Derek Foster
19. Ramsis Girgis
20. Bill Griesacker
21. Myron Gruber
22. Ernst Hanique
23. Roger Hayes
24. Bill Henning
25. Philip Hopkinson
26. Virendra Jhonsa
27. David Keithly
28. Sheldon Kennedy
29. John Lackey
30. Boyd Leuenberger
31. Richard Marek
32. John Matthews
33. Van Nhi Nguyen
34. Klaus Papp
35. Mark Perkins
36. Don Platts
37. Bertrand Poulin
38. Paulette Powell
39. Jean-Chris Riboud
40. Girolamo Rosselli
41. Ewald Schweiger
42. Devki Sharma
43. Hem Shertukde
44. Steve Snyder
45. Andy Steineman
46. Craig Stiegemeier
47. Charles Sweetser
48. Robert Tillman
49. Subhash Tuli
50. Loren Wagenaar
51. Jim Zhang
52. Peter Zhao

GUESTS

1. Tom Prevost **
2. Ramon Garcia
3. Jermel Miller
4. Prem Patni
5. Wolfgang Vinorr
6. C.J. Kalra
7. Gylfi Olafsson **
8. Stan Hatch **
9. Laszlo Kadar **
10. Doug McCullough*
11. Mike Craven
12. Randall Kyle
13. Charlie Garner
14. Shawn Luo
15. Alan Kasanew
16. Dieter Dohnal **
17. Dwight Parkinson
18. Fran Huguet
19. Arnold Carlos **
20. Sam Mehta
21. Dong Kim
22. Marcel Fortin **
23. Michael Spurlock
24. Larry Davis
25. Michael Lamb **
26. Bruce Fairris
27. Alan Traut
28. Vinay Memrotra
29. Sergiy Razuvayev
30. Frank Bray
31. Kent W. Brown
32. David Stinson
33. Ryland Revelle **
34. J. David McCarthy
35. Dennis Lee
36. Geoffrey Gill
37. Edward Moe
38. Gregory Anderson
39. Chris Ten Haagen
40. Lewis Powell
41. Dharam Vir **
42. Hasse Nordman
43. Art Molden
44. Rick Cantrelli

** Guests requesting Membership.