7.5 Performance Characteristics Subcommittee

7.5.1 Introduction/Attendance

The Performance Characteristics Subcommittee (PCS) met on Wednesday, October 26, 2005 with 66 members and 46 guests in attendance. 9 of those guests requested membership in PCS. See last page of these minutes for attendance summary.

7.5.2 Approval of Meeting Minutes

The minutes of the last meeting in Jackson, MS were approved as written.

7.5.3 Chairman's Remarks

7.5.3.1 Administrative Subcommittee Notes

- Next Standards meeting dates and locations are as follows:
  Spring 2006: March 19–23 in Costa Mesa, CA
  Fall 2006: October 22–26, Montreal, Quebec, Canada
  Spring 2007: March 11–15, Phoenix, AZ
- IEEE PSCE (Power Systems Conference & Exhibition) upcoming meeting: Atlanta, GA: October 29 – Novemeber 1, 2006.
- IEEE T&D Exhibition / Conference which was to be held in New Orleans will be held May 21-26, 2006, in Dallas, TX.
- The “Loss measurment and tolerances” Guide C57.123 was approved by the Adminstative SC for submittal to get a Dual IEEE / IEC Logo.
- For getting approval, requests for Par extensions will need to include why the extension is needed and the work plan in the extension period.
- Chairmen of TFs, WGs, and SCs need to update their membership lists.
- The Transformer committee is encouraging Correspondence members.

7.5.4 Agenda Changes

None

7.5.5 Working Group and Task Force Reports

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

The WG met on October 24, 2005 at 9:30 A.M. There were 51 persons in attendance, 28 members and 23 guests. Mark announced he had e-mail problems so the Working Group members did not receive their handouts. Therefore, the handouts at the meeting are reserved for Working Group members only.

After introductions, Mark 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 and 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.

The minutes from the last meeting were then reviewed and approved.

1. Jerry Rosselli presented a proposed draft of section 9.5 “Zero-phase-sequence impedance tests of three-phase transformers”. In this draft, the procedure for measuring zero sequence impedance is described.

   a. Jerry asked the group to review the draft. Equation (23) is independent of what coils are involved.

   b. Subhash Tuli commented that he verified that this equation does work on various types of transformers but it is time consuming and may not be practical in production facilities. Jerry responded that there will be additional testing in order to verify this method.

   c. Mark added that he e-mailed this draft to members of the Working Group this morning. Dennis Marlow asked if the draft sent was the same as the one presented at the meeting. Mark will verify and retransmit if necessary.

2. Subhash Tuli reported that the recirculation ballot of C57.12.90 will go out in the next few weeks.

3. Short-circuit measurements – Comments from Marcel Fortin on the last ballot of C57.12.90 were made regarding the procedures for short-circuit tests. A task force headed by Marcel consisting of 4-5 members will consider these changes and report back to the working group. Other members were Steve Snyder, Gerry Rosselli, Dennis Marlow, and Subhash Tuli.

4. Resistance Measurements, section 5 – A first draft of proposed changes was presented to the group and a Task Force will be established to address this section. Subhash Tuli, Dennis Marlow, Steve Snyder, and Kumar Mani volunteered to serve on this Task Force to review the proposed changes and report back.

   a. Mark identified major proposed changes. He was asked if the one hour wait time described in section 5.1.2 was for directed or non-directed cooling. Mark answered that this is acceptable for both.

   b. The question was asked “where is bottom oil temperature measured?” It was stated that bottom temperature should be defined by the Thermal Performance Working Group.

   c. Mark commented that the Voltmeter / Ammeter method is the preferred method to measure small resistances. It was asked if the current level should be specified. Pierre Riffon responded that in low voltage ranges the current is susceptible to noise. Mark added that several resistance readings should be taken and averaged. Mark recommended adding a note to 5.3.1, c-1 stating that the current should be sufficiently high enough to prevent noise. Loren Wegenaar suggested that the resistance measurement method used be indicated on the certified test report.

   d. Resistance measurement connections were discussed. Pierre recommended that phase-to-neutral measurements should be taken. A comment was made that neutral resistance must be removed. Joe Foldi recommended that for both delta

and wye connections individual winding resistances can be determined mathematically.

e. A section on testing autotransformers is also included in the proposed draft.

f. Comments from James Wilson (9.3.3.4 and 9.5.1) have been resolved in draft 3.

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

The Working Group met on Monday, October 24 at 1:45 PM. There were 23 members and 41 guests in attendance, with the following 2 people requesting membership:

Tim Raymond	Power Delivery Consultants Inc.
Javier Arteaga	Kuhlman Electric

The addition of the 2 new members brings the Working Group membership to 64.

Following introductions, 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 minutes, from the March 14, 2005 Jackson meeting, were approved as submitted. The Working Group then began discussing the topics of old business, as follows:

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. One proposal is to add a third set of three columns which would eliminate several of the notes that supplement the table. The Working Group agreed that this would make the table more understandable. Prior to the meeting, the chairman had emailed a proposed new table to the membership seeking their input, and this will be a working document for future review by this WG. The Chair will also request that this new table be circulated to the Distribution Transformers Subcommittee seeking their input before the next meeting.

WG Item 59 C57.12.00/D2 April 2002 Section 7.1.4.2 is a request to change the standard to include source impedance in the short-circuit testing of category II transformers. This product classification is distribution transformers, so the chairman had solicited and received input from the Distribution Transformers Subcommittee prior to this meeting**.** Quite a number of responses were received, none of them supporting the requested change. The existing wording **will not** be changed.

WG Item 60 C57.12.00/D2 April 2002 Section 5.10.2.5, Neutral not brought out of tank. A request was received to modify the second sentence in this section to recognize that customers sometimes specify the neutral to be left ungrounded. The WG agreed, and the two sentences will be replaced with the following wording:

"Insulation levels shall not be assigned where the neutral end of the winding is not brought out of the tank through a bushing and is solidly grounded to the tank."

WG Item 61 C57.12.00/D2 April 2002 Note 4, "Table 19: Routine, design, and other tests for liquid-immersed transformers". A comment was received that this note should give

guidance as to the cooling conditions at which the sound test is to be performed. It was suggested that as a minimum, one test should be done at minimum rating and one at the maximum rating. There was a great deal of discussion on this topic. Some concern was expressed about whether the Audible Sound and Vibration Subcommittee or the C57.12.90 Working Group should address this item, but in the end we agreed that PCS needs to specify the tests that need to be performed. Following is the consensus statement that will be added as the **third** sentence in this note (note 4):

"As a minimum, one test shall be performed at the cooling stage for the minimum rating and one test at the cooling stage for the maximum rating."

WG Item 62 C57.12.00/D2 April 2002 Section 5.12.2 Table 10: Nameplate information, Note 6. This is an editorial request that the example listed in this note should state kV BIL instead of simply BIL, as is shown presently. The Working Group agreed, and the revised note will read:

High-voltage winding	***450 kV BIL***
High-voltage winding neutral	***110 kV BIL***
High-voltage winding neutral bushing	***95 kV BIL***
Low-voltage winding	***95 kV BIL***

(Note: this was clarified in discussions immediately following the 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 was unclear whether this might conflict with IEEE metrification policy. The Chair will investigate and report at the next meeting. The WG did determine that we should add an item d) to express this statement, which will read as follows (pending a ruling on the IEEE metrification policy):

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

WG Item 64 C57.12.00/D2 April 2002 Table 21: Test system accuracy requirements. A request was received to change the stated test system accuracy for temperature measurement as it relates to loss measurement, from +/- 1.0°C to +/- 1.5°C. The basis for this request is that the accuracy of a calibrated type T thermocouple by itself is +/- 1.0°C, before considering the accuracy of the measuring device. The ramification of the proposal on loss correction due to temperature changes is miniscule. After discussion, the WG agreed by a vote of 36 to 1 to accept the new tolerance.

WG Item 65 C57.12.00/D2 April 2002. A request was received to include a new category of "wind-turbine padmount step-up transformers" into the standard. It was recognized at this meeting that a new task force has been convened to study this proposal. No further action is planned in this WG on this topic at this time.

WG Item 66 C57.12.00/D2 April 2002 Section 5.12.2 Table 10: Nameplate information, note 9. A couple of comments were received stating that the terminology used in this note are inconsistent with the standard for instrument transformers (C57.13) as it relates to the word "potential" transformers. The correct terminology is "voltage" transformers. The Working Group agreed we should make the recommended change to be consistent.

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

- 23 members and 17 guests attended, with 3 guests (Saurabh Gnosh, Khalin Vladimir, Joseph Cheung) requesting membership.
- Minutes from the Jackson meeting held on Mar 15th, 2005 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 given.
- TF for "Guide of Low Power Factor Power Measurements" – No meeting was held.
- Liability with respect to IEEE patents was discussed as per comment at previous WG meeting. IEEE has disclaimers concerning liability and WG members are indemnified by IEEE insurance. But no litigation has been brought against PES. Thus, there is no concern.
- Frequency Conversion Factors of Transformer Performance Parameters - The wording for C57.12.00 and C57.12.90 was put to a re-survey in PCS and 14 survey responses were reviewed in the WG. Eight of the 14 responses were "Accept With No Comments". From the other responses with comments, below are the resulting changes that were agreed upon by the WG:
  - Change the definition of P_{RI2} to "Calculated I2R losses at rated current from the DC resistance measurement".
  - Keep the separation of eddy & stray loss. For the winding rise current, it was asked what a manufacturer can do if they cannot separate the eddy & stray. It was agreed that all manufacturers have some calculation method (even if it is just a factor and not FEM) for separating the eddy & stray.
  - Change all instances of "eddy" to "winding eddy"
  - It was decided not to add wording in the frequency conversion annex on the frequency tolerance, that applied voltage is measured according to the average voltmeter method or that waveform correction is needed. All this is already described in the 12.00 or 12.90.
  - Specify that sound correction only applies to A-weighted sound level
  - There is no need to say that I2R losses are not converted (they are a DC test). This is already well understood.
  - Revise "Heatrun current" to "Total Losses Run Current"
  - Put in distinct equations for the 60 to 50 Hz conversion. The WG affirmed again the need for such factors.
  - Modify the temperature conversion section so that it is clear that correct losses are fed during the heat run and that the estimated injected current is a guide only
  - There was a request to simplify each of the conversion factors. The WG agreed to keep the factors as derived.
  - The chairman will make the above agreed upon changes and submit the revised wording to the WG members for comments. The wording will then be sent to the PCS chair to carry out approval.
- The variability of the sound level data was re-examined. The data showed a range of +1 to +5 dB and a factor of + 3.6 dB was selected. As was shown, some of the variability is due to the A-weighting at the different spectra. For example, if the 120Hz is dominant, the conversion is close to 3.5 dB. But if the 300 Hz is dominant, then the conversion should only be about +1 dB.

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

The WG was called to order at 8:03 AM on October 26, 2005. There were 71 attendees, 29 members, 1 requesting membership, and 41 guests. The Minutes from the March 15, 2005 meeting in Jackson, MS were approved, and copies of the minutes, Draft 1.7 of the guide, and ballot comments were distributed.

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

2. Bob Degeneff briefly summarized a presentation on this topic that was made at the Moscow Colloquium of the CIGRE SC A2 Transformer group. For interest of the group, he presented several new areas for consideration when examining transformer breaker interactions. Among the items considered were single phase versus three phase representation of the circuit being modeled and the connection of the primary and secondary winding in three configurations. Various switching device pole spans were considered, and results displayed indicated that the resonant frequencies of concern change depending on switching sequence considered. While this subject area is not included in the guide at present, it would be a valuable contribution to future revisions of this guide.

3. A question was raised if anyone has seen a transformer breaker interaction under loaded conditions. There was one response indicating possibly, but it had not been investigated in sufficient detail yet.

4. Next, a brief history of the working group was reviewed, as listed below:
    a. Original topic was considered in 1996
    b. Working Group was formed in 1997
    c. Task force agreed to write Guide in 1997
    d. PAR written and C57.142 assigned in 2001
    e. Asked for assistance of Switchgear Committee, as they have separate WG
    f. Joint tutorial presented in Raleigh, NC - 3/18/03 by Tobin/Hopkinson/Degeneff
    g. PAR extension requested and approved
    h. Draft circulated in 2004 – asked for input/guidance from subcommittee
    i. Ballot held August 2005

5. Results of the ballot, which was open from 8/9/05 to 9/9/05, were reviewed and are as follows:
    a. 145 eligible members in ballot pool
    b. 115 votes received (79% returned)
    c. 85 affirmative votes
    d. 22 negative votes with comments
    e. 2 negative votes without comment
    f. 6 abstentions
    g. 107 countable votes
    h. 85/107=79% affirmative

6. A summary of comments received was presented. There were 438 comments in system, and more than 500 received. Eighty ballots had no comments, and 90% of comments were by 10% of voters.
   The comments were in three major categories, typos and figure number references, editorial (clarity & simplification), and technical/philosophical content.

7. It was proposed that the editorial comments would be addressed by Peter Balma & Bob Degeneff, who will convert the document to the new IEEE template, correct

typo's & figure numbers, and make editorial changes. Furthermore, Pierre Riffon volunteered to re-write the breaker section.

8. There was considerable discussion and suggestions as to how to proceed with resolving technical comments, particularly those associated with the breaker section. The general consensus was that the Switchgear Committee should be contacted, so that their concerns could be addressed in a constructive exchange of ideas.

9. Angela Ortiz, Program manager from IEEE indicated that the proposals discussed were ok, but suggested working with Marcel Fortin (of the Switchgear Committee) and a small group (a ballot resolution committee) to get resolution of the Switchgear Committee's concerns. She also indicated that IEEE would look at coordinating or developing liaisons between the Transformer and Switchgear committees. Don Fallon added that the group was headed in the right direction, and asked that Ramsis Girgis contact the Switchgear Committee to begin additional dialogue.

10. A motion was made by Marcel Fortin and seconded, that the chairman's proposal to have Dr. Pierre Riffon and a group of Switchgear Committee members to review and re-write the breaker section of the guide. A vote on this motion indicated that the majority of the working group agreed with the motion, there were no negative votes, and the motion passed.

11. Next steps are to develop all revisions within the next 3 months, communicate with all negative balloter's, and to prepare for a re-circulation ballot prior to the next meeting.

12. There was no new or old business brought up before the Work Group.

7.5.5.5 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 on Oct. 24, 2005 from 11:00 a.m. to 12:15 p.m. There were 13 members and 11 guests present. The following are highlights.

1. The minutes of the W.G. meeting in Jackson, Mississippi were approved.
   NOTE: The minutes of the Memphis W.G. meeting will not be formally approved until the W.G. meeting in Costa Mesa, California.

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

   (i) The major subject of discussion was the audible sound test. Since the majority of the meeting was devoted to this discussion W.G. members were asked to provide input regarding other revisions in D # 4 via e-mail.

   (ii) There was a great deal of discussion as to whether the audible sound test should be performed at nominal / rated voltage or at maximum voltage.

   (iii) There is consensus that the audible sound type test should be carried out at rated temperature. In the case of oil-immersed shunt reactors, where a

routine audible sound test is required, it can be carried out with the SR "cold" provided a reference audible sound test is carried out at the beginning of the audible sound type test with the SR cold.

(iv) There is some advantage to conducting the audible sound type test as part of the temperature rise type test.

(v) The audible sound test is required to assess environmental impact and also as a quality check. If sound level guarantees are related to environmental impact then it may be more appropriate to carry out the audible sound test at nominal/rated voltage vs. maximum voltage. However this is based on the assumption that SRs are employed to bring high system operating voltages, due to light loads, down to nominal values. In the case of using the audible sound test as a quality check then it may be more appropriate to carry out the test at maximum operating voltage.

(vi) How should historic databases of audible sound test results be handled and correlated with new audible sound tests as test parameters may vary; cold vs. operating temperature, maximum vs. rated system voltage?

(vii) Should it be left to the customer to specify the voltage level at which the audible sound test is carried out? The rationale for carrying out the audible sound test should be described in the standard; environmental, quality check, SR construction etc.

(viii) In the IEC reactor standard the audible sound test on SRs is carried out at rated voltage. It should be noted that for SRs manufactured to the IEC standard maximum and rated voltage are often the same.

(ix) The Chairman agreed to redraft the sections of C57.21 covering the audible sound test, taking the above into consideration, and e-mail the drafts to W.G. members for comment. This will be done as soon as possible as the Chairman would like to issue Draft # 5 prior to the Costa Mesa meeting in a ready to ballot condition.

Following the Costa Mesa meeting, it is the Chairman's objective to go out for ballot. To meet this objective all W.G. members are requested to provide input re D#4 as soon as possible so that the Chairman can issue D#5 well in advance of the Costa Mesa W.G. meeting.

7.5.5.6 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 meeting opened with introductions at 1:45 PM. There were 12 members and 15 guests present. 4 attendees requested membership on the WG.

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 WG. There was no response to the request for disclosure. The minutes from the Jackson meeting were approved as submitted to the SC Chair.

Ramsis Girgis was requested to report on rewording the Abstract and Introduction, but the work is not yet complete. The additional wording on neutral heating due to 3rd harmonics also was not available due to the absence of the Phil Hopkinson.

The Chair asked the membership if the WG should harmonize the C57.110 symbols with C57.18.10. The most important symbols would be the harmonic loss factors for eddy loss and other stray loss. One concern was the potential impact on the industry, since the document has been in use for a number of years. After some discussion, it was agreed that the two documents have sufficiently different audiences, and the differences would not be a problem. The two documents will be revised with the current symbols.

There being no further old business, the chair introduced Alvin Kopp who made a presentation on the application of a solid state AC power source. Since this programmable device is capable of injecting a complex wave shape, it may be possible to perform a heat run with a current that simulates the harmonic components described in this document. The presentation was well received with a number of questions.

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 chair also noted that draft 1 will be transferred to the new template described at the Standards Development Lunch. The new template with its automatic links and macros should reduce the formatting time that will be substantial due the large number of bibliography references, formulas and tables. There were no comments on the draft that was provided to the members and guests in advance of the meeting. All members and guests were reminded to continue to identify any technical papers or books that would be appropriate for addition to the Bibliography.

A revised set of tables was also presented to the WG along with a summary of the rules on significant figures that were used to reduce the number of significant figures to 2 or 3. It was agreed that this change makes the document easier to read and is more reasonable considering the approximate nature of the calculations. Chuck Johnson will review the document to make sure the reader is properly advised that although there are many complex formulas in the document, the conceptual approach still results in an approximate answer.

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

The Working Group met on Monday, March 24, 2005 at 3:15 PM with 13 members and 11 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 Jackson, Mississiippi were approved.

The Chair announced that we were beginning 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 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, ... 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 from the conversion into PDF which performed an automatic renumbering of tables.

We were fortunate to have both Angela Ortiz and Jennie Steinhagen from IEEE in attendance at our meeting to hear these comments. Several possible resolutions were discussed. Tables A.1, A.2, A.3 and A.4 must be corrected. We could leave Tables 5 through 9 as they are shown in the PDF, or correct them back to Tables 5 through 7, as they were in the hard copy. If we leave them as they are, C34.2, the rectifier standard that uses these same tables, may also need to be changed. But, it may be preferable due to the way the programs perform automatic numbering. Angela and Jennie said they would look into this and see what IEEE would advise us to do. The Chair will make whatever necessary changes are needed in the Amendment.

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.

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

The Working Group met on Tuesday, October 25 at 9:30 AM. There were 12 members in attendance. The chairman, Steve Schappell could not attend the meeting and H. Jin Sim conducted the meeting for him.

Richard Dudley reported that a sufficient amount of information on Grounding Resistors and Arc Suppressing Coils from IEC have been made available for us to utilize in our document. We will need to rework the information to suit the IEEE format.

We discussed the need for including test codes for each devices covered by this standard. Although there are some benefits for having one document that contains complete information, the WG decided to include only the exceptions for individual devices and reference other documents to ensure that maintenance of the document is manageable.

Peter Balma volunteered to work with the Chairman to complete the grounding resistor part of the document.

After these items are completed, a new draft will be circulated to the Working Group members before the next meeting.

7.5.5.9 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 Frequency Response Analysis (FRA) on October 25, 2005 at 8:00 A.M. There were 42 persons in attendance, 20 members and 22 guests of which 4 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. This meeting focused on two out of the six sections, Section 1: Scope and Application and Section 5: Analysis and Interpretation. Each of these sections was then discussed.

- **Section 1: Scope and Application** – The work on Section 1 is almost complete. However, the Working Group was not satisfied with one particular term, and that was the use of the term Self-Admittance to describe various test types. The Working Group provided alternative suggestions which included: Terminal Transfer Admittance and Terminal Transfer Response. This is still an unresolved issue. As a request from the previous meeting in Jackson, Jeff Britton submitted a new definition for FRA Frequency Response and two new test configuration diagrams. Jeff's contributions will be added to the guide and commented on at the next meeting. Saurabh Ghosh, Ernst Hanique, and Roger Verdolin volunteered to review Section 1 for the next meeting.

- **Section 5: Analysis and Interpretation** – Prior to this meeting, no work has been completed on Section 5. The WG Chair provided a new outline and a first draft attempt for review. The outline included topics such as Trace Characteristic, Trace Comparison, Relation to Other Diagnostic Tests, Failure Modes, and Modeling. Only Trace Characteristic, Trace Comparison, and Relation to Other Diagnostic Tests received a first draft attempt:

    1. The subtopics for Trace Characteristic will investigate inherit diverse properties and expected characteristics influenced by the winding and core configuration, test type, and other design differences. These expectations can be used to identify basic problems that may exist within a transformer.

    2. The Trace Comparison section provides an analysis strategy for comparing traces. Various methods were discussed which included manual comparisons of the test results and the use of advanced algorithms.

    3. With regards to Relation to Other Diagnostic Tests, the FRA results depending on the test connections can be used to confirm the results of other diagnostic tests.

These tests include, Single Phase Exciting Current, Turns Ratio, Short Circuit Impedance (Leakage Reactance), DC Winding Resistance. Several FRA plots were presented illustrating where these relationships can be found.

4. It was the recommendation of Bertrand Poulin that we need to proceed with the modeling subject cautiously. Bertrand indicated that modeling requires a true admittance measurement and that the current must be measured at the input of the test specimen. The test configuration for a true admittance measurement will be added to the modeling section but it will not be part of the primary test types used for determining mechanical problems in transformers. Alan Darwin indicated that he was aware of some addition modeling research conducted by CIGRE. Alan agreed to provide the Working Group with an update on the work.

The PC57.149 FRA Working Group plans to have a complete draft at the next meeting.

7.5.5.10 TF on Core Overexcitation – Craig Steigemeier, Chairman

The fourth meeting of the Core Over-Excitation Task Force took place at 8:00am on October 24, 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 83 attendees, of which 43 were members and 40 guests. Thirty-one (31) of the 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.

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 and Committee'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, Section 4.1.6 (Operation above rated voltage or below rated frequency) covered previously were reviewed, with the intent being to pass these recommendations on to the appropriate working groups for action.

Detailed discussions were held concerning the suggestions made during the spring (Jackson, MS) meeting. The following were the suggestions for changes to C57.12.00, with deletions shown struck out and additions underlined:

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) Secondary voltage and volts per hertz do not exceed 105% of rated values.~~

~~2) Load power factor is 80% or higher.~~

1a) For generator step-up transformers, the primary voltage is equal to the highest generator voltage at full load as specified by the user.

1b) For system tie transformers, the primary and secondary voltages are equal to the highest levels specified by the user.

~~3)~~ 2) Frequency is at least 95% of rated value.

Additionally, at previous meeting it was decided to use 130°C as the core hottest spot limit rather than the 90°C rise over the 40°C ambient for clarity. The following additional clause was presented that addresses the core hottest spot:

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 130°C for the condition of highest core over-excitation, full load, and the highest ambient temperature. It should be noted that the calculation for the hotspot is unique and different from the core surface temperature. The core hotspot 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 cellulose.

At previous meetings, it was agreed to add the second and third sentences to proposed clause 4.1.6.3 to emphasize that the calculation for the hotspot is unique and different from the core surface temperature and to clearly state that the core hotspot occurs in an area where there is only a thin film of oil.

Discussion of the proposed changes was conducted with the following significant comments made:

- In general, the 130°C hotspot limit was well accepted during the meeting, although the attendees felt that the limit should be acknowledged as a limitation of the core hot spot when exposed to mineral oil.
- A point was made that C57.12.00 covers both distribution, and power transformers. Thus, it was decided to leave the volts/hertz and power factor clauses in the document, and add the information suggested in 1a) and 1b) above to aid in achieving a clear understanding of the actual required capacity of the transformer for generator step-up applications.
- To clearly demonstrate the capacity of the transformer, the nameplate must adequately identify the actual capacity to which the transformer was originally designed. While standards may specify an overvoltage, 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.
- Data was presented by AEP showing the power factor values for 8 transformers over the past few years. The power factor varied as follows:
    - The power factor for two transformers never went below 0.95
    - The power factor for two transformers never went below 0.90
    - The power factor for two transformers never went below 0.85
    - The power factor for one transformer never went below 0.80
    - The power factor for the remaining transformer never went below 0.50

This example illustrates that many GSU transformers may operate at a power factor near unity, but the user must define applications where unusually low power factor operation is required.

- It was noted that recommendations for changes to C57.12.00 should be coordinated with C57.116, the IEEE Guide for Transformers Directly Connected to Generators. For reference, the overexcitation clause in this standard follows:

    5.3.7 Overexcitation

    It is not likely that one high-voltage tap will allow full generator utilization over the full range of expected system voltages during the life of the UT. It is likely

that more than one tap will be found desirable, as shown in Fig 9. A lower rated tap will allow the generator to absorb VARs for a lightly loaded system, while a higher rated tap will allow the generator to produce VARs for a mature, heavily loaded system. Use of a particular tap may change as the system grows or changes significantly.

Overexcitation can occur when the UT is operating on one of the lower taps and the system voltage increases beyond 105% of that tap's rating. For instance, assume the transformer in Fig 9 is operating on the 23 kV–336.4 kV or 24 kV–351 kV tap and the transmission system is operating in the 345 kV to 353 kV range. Now assume that for some reason the transmission system voltage increases to 360 kV. It can be seen that the transformer secondary now has 107% voltage, which is 2% overexcitation.

Methods for achieving suitable overexcitation characteristics for the transformer system should be evaluated economically.

This definition is clear and stands alone. It does not appear to be in conflict with the proposed suggestions being made for C57.12.00.

- The duration of an overvoltage should be stated, since very short overvoltages will not produce gassing, but long duration overexcitation will have the most impact.
- Attendees suggested that a clear limitation of the core surface temperature would be desirable. While this task force has made a recommendation of a limitation for the core hottest-spot, a limit for the core surface temperature would aid in a clear understanding of the accepted performance characteristic. The following excerpt in C57.12.00 is the only limit of the "other" metallic parts of the core:

  5.11.1.3 Rises of metallic parts other than windings

  Metallic parts in contact with current-carrying conductor insulation shall not attain a temperature rise in excess of the winding hottest-spot temperature rise.

  Metallic parts other than those described above shall not attain excessive temperature rises at maximum rated load.

In general, those attending desired to include modifications to address concerns over the adequate understanding of overexcitation situations. Suggestions from the meeting will be used to come up with another round of suggested changes. These changes will be reviewed with a volunteer group including representatives from the following 4 manufacturers and 10 utility/consultants prior to the spring meeting:

Peter Balma – Public Service Electric and Gas Company
Stephen Beckman – Fort Pierce utilities Authority
Enrique Betancourt – GE Prolec (volunteered after meeting)
Donald Chu – ConEd
Peter Heinzig – Siemens
Rowland James – Entergy
Bipin Patel – Southern Company
Ed teNyenhuis – ABB
Ramsis Girgis - ABB
Harold Moore - Consultant
Miguel Oliva - ABB
Gustav Preininger - Consultant
Bob Tillman – Alabama Power Company
Subhash Tuli – Waukesha Electric Systems
Loren Wagenaar – AEP
Dieter Wagner – Hydro One
Peter Zhao – Hydro One

7.5.6 PCS Standards Update

7.5.6.1 Status of PCS Standards

This status will be updated at the Costa Mesa spring 2006 SC meeting.

7.5.6.2 Responsibility Matrix of Performance Characteristics Subcommittee (PCS):

C57.12.00			C57.12.90	
12.00 Clause	**Description**	**Responsible SubComm**	**12.90 Clause**	**Description**
4	Service conditions	PCS	4.4	Instrumentation
4.1	Usual service conditions	PCS	6	Polarity and phase-relation tests
4.3	Unusual service conditions	PCS	6.1	Subtractive and additive polarity
5	Rating data	PCS	6.2	Polarity tests: single-phase
5.1	Cooling classes of transformers	PCS	6.3	Polarity and phase-relation tests
5.2	Frequency	PCS	7	Ratio tests
5.3	Phases	PCS	7.1	General
5.4	Rated kilovoltamperes	PCS	7.2	Tolerances for ratio
5.6	Connections	PCS	7.3	Ratio test methods
5.7	Polarity, angular displacement …	PCS	8	No-load losses and excitation current
5.8	Impedance	PCS	8.1	General
5.9	Total losses	PCS	8.2	No-load loss test
5.12	Nameplates	PCS	8.3	Waveform correction of no-load losses
6.7	Grounding	PCS	8.4	Temperature correction of no-load loss
7	Short-circuit characteristics	PCS	8.5	Determination of excitation current
7.1	Requirements	PCS	9	Load losses and impedance voltage
7.2	Components	PCS	9.1	General
7.3	Base kilovoltamperes	PCS	9.2	Factors affecting load loss & impedanc
9	Tolerances	PCS	9.3	Measuring load loss and impedance
9.1	Tolerances for ratio	PCS	9.4	Calculation of load loss and impedance
9.2	Tolerances for impedance	PCS	9.5	Zero-phase-sequence impedance
9.3	Tolerances for losses	PCS	12	Short-circuit tests
9.4	Accuracies for measuring loss	PCS	12.1	General
10	Connection for shipment	PCS	12.2	Test connections
		PCS	12.3	Test requirements
		PCS	12.4	Test procedure
		PCS	12.5	Proof of satisfactory performance
		PCS	14	Calculated data
		PCS	14.1	Reference temperature
		PCS	14.2	Losses and excitation current
		PCS	14.3	Efficiency
		PCS	14.4	Voltage regulation…
		PCS	15	Certified test data

7.5.7 Old Business

7.5.7.1 A Par has been approved to update the SC Guide. The Par duration is until 12 /09. A Chairman for the WG to clean up this Guide is being sought.

7.5.7.2 The Chairman is also in the process of recruiting George Reiter to lead the effort of reaffirming C57.105 (Transformer Connections) & C57.109 (Thru – Fault Current Duration) documents since these need to be sent for affirmation this year.

7.5.8 New Business

7.5.8.1 A request has been submitted by Mr. VSN Sankar for the IEEE Standards to provide recommendation on parallel operation of transformers. The Chairman will look into this issue and present it in the spring meeting.

7.5.8.2 There was some discussion, brought forth by Mark Perkins, pertaining to C57.12.90 about how to simplify the Test Code and speed up the Standards process. C57.12.90 is becoming a lengthy document, and maybe some of the excess information should go in a separate Guide or an Annex to 12.90. Some discussion points are: cover the simple issues in 12.90 and more complex ones in a Guide; Can create timing problems with publication dates of 12.00, 12.90, and various Guides; Guides cannot contain requirements; Put requirements in 12.00 & 12.90 and refer to a Guide; but does the Guide then become “Required”? This same topic was discussed in the Dielectric Test SC meeting and will be tabled for future consideration.

Attendance at this Memphis Meeting

MEMBERS

1. Raj Ahuja
2. Jerry Allen
3. Stephen Antosz
4. Javier Arteaga
5. Peter Balma
6. Dave Barnard
7. Israel Barrientos
8. Barry Beaster
9. Enrique Betancort
10. William Boettger
11. Jeffrey Britton
12. Bill Chiu
13. Donald Chu
14. Larry Coffeen
15. Robert Degeneff
16. Dan de la Cruz
17. Charles Drexler
18. Richard Dudley
19. Don Fallon
20. Joe Foldi
21. Bob Ganser
22. Eduardo Garcia
23. Saurabh Ghosh
24. Ramsis Girgis
25. E. Gomez-Hennig
26. Myron Gruber
27. Ernst Hanique
28. Roger Hayes
29. Peter Heinzig
30. Bill Henning
31. Philip Hopkinson
32. Rowland James
33. David Keithly
34. Sheldon Kennedy
35. Vladimar Khalin
36. John Lackey
37. Tamyres Machado
38. Richard Marek
39. Dennis Marlow
40. John Matthews
41. Harold Moore
42. Van Nhi Nguyen
43. Samuel Oriti
44. Klaus Papp
45. Bipin Patel
46. Don Platts
47. Christoph Ploetner
48. Bertrand Poulin
49. Paulette Powell
50. Jean-Chris Riboud
51. Ewald Schweiger
52. Devki Sharma
53. H. Jin Sim
54. Steve Snyder
55. Andy Speegle
56. Andy Steineman
57. Craig Stiegemeier
58. Charles Sweetser
59. Craig Swinderman
60. Ed teNyenhuis
61. Robert Thompson
62. Robert Tillman
63. George Tolbbert
64. Subhash Tuli
65. Roger Verdolin
66. Peter Zhao

GUESTS

1. Pierre Riffon
2. Marcel Fortin
3. Pritpal Singh
4. Alvaro Cancino
5. Sergiy Razuvayev
6. Girolamo Rosselli*
7. Jim McBride
8. Nick Abi-Samra*
9. Shor Andre
10. Jose Salva
11. Jim Zhang*
12. Alex Uraemer
13. Brett Todd
14. Sam Mehta
15. Richard Tellez
16. Randy Rensi
17. Shuzhen Xu*
18. Laszlo Kadar
19. Martin Navarro*
20. Bill Griesacker*
21. Arthur Molden
22. Greg Troxell*
23. Randall Kyle
24. Hasse Nordman
25. Dick Sullivan
26. Gary McCulla*
27. Surinder Sandhu
28. Dick Amos
29. Ulf Radbrandt
30. Don Dorris
31. Bruce Fairris
32. Wayne Johnson
33. Mary Foster
34. Herman Vogel
35. Christoph Schuette
36. Frank Bray
37. Charles Garner
38. E. Tom Jauch
39. Joe Garza
40. Moo Geun Park
41. Dwight Parkinson
42. C.J. Kalra
43. Jim McIver*
44. Martin Heathcote
45. Ramon Garcia
46. Geoffrey Gill

* Guests requesting Membership.