IEEE/PES Transformers Committee
Insulation Life Subcommittee

The Insulation Life Subcommittee met in Las Vegas NV. on October 25, 2004, at 8:00 AM. There were 29 members and 72 guests present, with 2 guests requesting membership in the subcommittee.

The minutes of our meeting in San Diego, CA on March 10,2004 were approved as submitted.

1.1 Chair's Report

The chair reported on the patent issues that have been reviewed at each meeting during the week. This process will be continued at future meetings to ensure that any effected patents are disclosed. The meeting minutes shall note that a request was made for disclosure of any patents that may be related to our work, and the response to that request.

The chair reminded participants that we need to continue to promote membership in the committee. He reviewed the balance of users, producers and general interest, and the requirements to qualify for membership. The requirements are active participation for a year, and that a prospective member needs the sponsorship of 3 working group or subcommittee chairs.

The 2005 meetings will be held in Jackson, MS in spring and Memphis, TN in fall.

A request was made for disclosure of any patents related to the work of the subcommittee. None were reported.

1.2 Project Status Reports

1.2.1 Reaffirmation Ballot 1276-1997 IEEE Guide for the Application of High-Temperature Insulation Materials in Liquid-Immersed Power Transformers Mike Franchek
Mike reported that he has resolved the negatives, and that he should be able to proceed with the reaffirmation. He has suggested that based on comments received and additional data that has been collected since the guide was published, that a new task force should be formed to update the document.
Since the PAR will expire at the end of the year, we need to move forward with this document. We will consider a revision after some other projects are completed.

1.2 Working Group and Task Force Reports

1.3.1 Revision to C57.91 Loading Guide - Tim Raymond

Meeting started at 1:45 PM, Tuesday, October 26, 2004.

There were 22 members present and 38 guests with 7 guests requesting membership to the WG.

The chair raised the following question: Do we feel that combining distribution and power transformers into single document still good idea?

There was discussion about the different risk profiles between distribution and power transformers. The problem with not having them combined is that with two documents, areas that should be the same ended up being out of sync.

One comment from Glenn was that these were at one time two documents and then combined. He indicated that we should be very careful when thinking about splitting the document back up again. It will take time and effort to do this.

Loss of life equations: Should we include some qualification of the effects of moisture and oxygen? Presented a formula from Lundgaard, Emsley, CIGRE. Problems: Moisture content within winding insulation is difficult, if not impossible to quantify. Can we create two or three categories to pigeon-hole a specific transformer (dry, aged, wet)?

Comment: Loading Guide should consider the condition of the transformer. A clear statement of expected tolerances and to use the guide with some caution.

Comment: If you indicate categories of dry, moderately dry, wet, how do you identify what is dry etc? The problem is that you don't always know this condition.

Comment: Another option would be to leave equations as is, add note that moisture content and oxygen affect the loss of life and provide some examples to provide a feel for how much they affect the aging of the transformer. This would let the user recognize that if they have a wetter transformer, that they would need to be more conservative.

Bubble Evolution:

- 1995 guide partially included detailed model by McNutt, Rouse, et al.
- Early drafts of revision replaced old material with an equation by TV Oommen.
- Bubble evolution relies heavily on moisture content of paper. This is difficult, if not impossible, to determine with sufficient accuracy for predicting bubble evolution.
- Propose removing mathematical models and give guidance on hot spot limit to avoid bubble evolution. Why it is important, what happens when you have pockets of bubble formation. Put in a limit of 140C. If you want to load above that, you are taking a chance that you will have bubble evolution.

Comment: Has anyone documented a failure of a transformer during overload? There was a response that this had occurred on a transformer loaded up to 170%.

Comment: Overload is not the only problem. The rate of temperature rise is also a problem and can cause generation of bubbles.

Comment: Equation is complicated, perhaps it could be converted into a graph for illustrative purposes only.

Comment: Add wording that you can go above 140C, but have discussion of the potential risks in doing so.

Thermal Model: After much discussion and study, we have come to the following:

- Move Annex G (Pierce) model to main body of guide.
- Move Clause 7 to Annex to provide continuity and alternative for older and distribution transformers. May add resistance and viscosity corrections.

Comment: Bottom oil gives a stable reference point. By moving the Annex G model to the main body, it gets away from the impression that it is experimental. The other method would still be available.

Comment: Design data is required to use the model from Annex G and will be difficult for users to implement use of this model.

Response: The old model is still planned to be there, newer transformers are required to have this information and it may be available for older transformers. We want to give the impression that both models are available and can be used.

Without serious objections, we plan to move ahead with this proposal. None were brought forth.

Volunteers:

5.0 Effect of loading beyond nameplate rating – *Bob Tillman and James Cross volunteered to help with this clause.*

- 5.1 General
- 5.2 Voltage, core excitation, and frequency considerations
- 5.3 Non-sinusoidal load currents *(keep? No, will mention reference to other guide that deals with this issue)*
- 5.4 Supplemental cooling of existing self-cooled transformers (?)

6.0 Transformer Insulation Life – *TV Oommen volunteered to help with this clause.*

- 6.1 General
- 6.2 Aging equations
- 6.3 Life expectancy
- 6.4 Percent loss of life

7.0 Thermal Evolution of Gas from Transformer Insulation – *TV Oommen volunteered to help with this clause.*

8.0 Ambient temperature and its influence on loading – *Don Platts and Jim? Thompson volunteered to help with this clause.*

- 8.1 General
- 8.2 Approximating ambient temperatures for air-cooled transformers
- 8.3 Approximating ambient temperatures for water-cooled transformers
- 8.4 Influence of ambient on loading for normal life expectancy.

9.0 Information for loading calculations– *Tim Raymond, Glenn Swift and Gary Hoffman volunteered to help with this clause.*

11. Loading of distribution transformers and voltage regulators - *Craig Colopy*

12. Loading of power transformers – *Sue McNelly will provide Xcel Energy's loading guide for informational purposes, David Wallach.*

13. Effect of loading Transformers above nameplate rating on bushings, tap-changers, and other auxiliary components - *Tim Huff*

14. Operation with part or all of the cooling out of service – *no volunteers*

15. Operation at altitudes above 1000m – *Sue McNelly may be able to provide information from its Denver area on this.*

Schedule:

Need comments back by Jan 31st, 2005.

Produce working, complete draft by Feb 28, 2005.

Will arrange e-mail list and web facilities to enable work to proceed between this meeting and next.

Send draft to all members for comment prior to Spring 05 meeting.

Discuss comments at Spring 05 meeting

Send document out for ballot Fall 05.

Meeting adjourned at 3:00 PM.

Tim Raymond, Chair
Glenn Swift, Vice-Chair

Attachment A
(PPT Presentation)

1.3.2 WORKING GROUP ON THERMAL EVALUATION OF POWER AND DISTRIBUTION TRANSFORMERS (C57.100) – Roger Wicks

1.0 Introduction and Rosters
The working group met on Monday, October 25, 2004 at 9:30 AM with 17 members and 21 guests attending. Two requested membership bringing the total number of members to 46.

Prior to the introduction of members and guests Chairman Wicks requested that all working group members should sign up for the Transformer Committee AM. The information can be found on the transformer committee web site. Don Platts reviewed the patent documents for our meeting, and no patent related issues were noted for the work of this working group.

2.0 Approval of minutes from March 8, 2004 meeting
The minutes of the March 8, 2004 meeting in San Diego were approved as written.

3.0 Review of scope

The chair reviewed the scope of the working group. This has been incorporated into the PAR which has been submitted to the Standards Board. The scope is:

Scope - This standard provides test procedures to evaluate the thermal aging characteristics of insulation systems used in liquid-immersed distribution or power transformers. The dielectric liquid is part of the insulation system. The test procedure shall simulate practical service conditions of the insulation system, with the main emphasis on the thermal aging of materials in the candidate insulation system as compared to a conventional insulation system.

4.0 Discussion of "conventional insulation system" (for both power and distribution transformers)
The curves that we have today are based on testing of thermally upgraded paper in mineral oil. It was recommended that we need to extend the definition beyond conductor wrap. For example, some manufacturers are using netted CTC conductor which has no cellulose paper. In this case we need to consider the stress on the spacer material.

It was noted that transformers have been built for more than one hundred years and that this insulation system should be considered as the basis for conventional insulation system.

There was considerable discussion regarding the sealed tube aging test. In recent work done by Cigre WG 15.01.10 there were several papers presented which compared the aging of non thermally upgraded and thermally upgraded paper with respect to moisture content of the mineral oil. The sealed tube test does not represent free breathing transformers. More study needs to be done in this regard. The chair requested that any member should have access to any papers relating to aging studies that they forward them to the chair for circulation. The chair will see if he can get a place in the transformer committee web page to post these papers.

Jerry Corkran has volunteered to present a definition for a conventional insulation system for liquid-filled distribution transformers. He will have a draft of a definition for the next WG meeting.

Gustav Preininger and Steven Schappell will develop a similar definition for power transformers for the next meeting as well.

5.0 Distribution Transformer Aging
Jerry Corkran will send the chair sealed tube aging data that Cooper has as well as testing on complete distribution transformers (Lockie Test). He asked that this be circulated with the meeting minutes.

6.0 Power Transformer Aging
Tom Prevost indicated that he wrote a paper for Doble last year which gives a single point aging test to verify that material meets the criteria in the present C57.100. This will be circulated as well.

In regards to Power Transformer model aging the chair asked the membership to submit current and past literature dealing with this subject. These will be circulated to the working group for review. It was noted that Cigre WG 15.01.10 has information on this subject. Members of the WG who have access to Cigre should try to get this information to share with the WG.

IEEE 99 "IEEE Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment" should be reviewed to determine if there is anything included in that document which can be used to define the power transformer aging model. Tom Prevost will send the Chair a copy of IEEE 99 for circulation to the WG.

7.0 Sealed Tube Aging

There was discussion about whether the Sealed Tube Aging test should be in an Annex (as it is in the current document) or in the main body of the document. The consensus was that it should be in the main body. However Patrick McShane indicated that doing so would require a revision of the scope because the sealed tube test does not qualify as simulating practical service conditions of the insulation system.

Peter Heinzig from Siemens volunteered to give a short presentation on some aging tests which his company has performed. The chair asked for additional information regarding aging tests that could be shared with the WG.

8.0 Adjournment

The meeting adjourned at 10:34 AM.
Roger Wicks, Chairman
Tom Prevost, Secretary

1.3.3 WG on Definition of Thermal Duplicate – PC57.145 - Barry Beaster

The working group met on Tuesday, October 26, 2004 with ten members and 23 guests in attendance. An agenda, a copy of the Spring 2004 meeting minutes, an example of possible variations in hot spot reporting, and draft eight of the guide were electronically distributed to the working group prior to the meeting. Additional paper copies were available for guests. Prior to working group discussions, Don Platts, the Insulation Life Subcommittee Chairman, asked for patent disclosure concerns regarding the working groups' activities. This was an IEEE mandatory meeting requirement. No concerns were raised.

After introductions, the Spring 2004 meeting minutes were approved. A correction to the membership roster was noted during review of the Spring 2004 meeting attendance roster. A request for new membership was noted. The membership roster now includes Ron Daubert of Finley Engineering and Saurabh Ghosh of Pauwels.

The PAR for this working group expires at the end of 2004. The question addressed to the working group is whether work should continue on this guide, or has the state of our standards moved to make the guide unnecessary?

An example of a set of thermal computations, with hot spot, was presented to illustrate that it is possible to perform detailed analysis beyond the methods presently in the guide. It was also shown that it is important to properly adjust these results with the proper loss calculation techniques. Cautions were mentioned in how the final analysis might be made in arriving at the final hot spot temperature. There were no additional comments on this example. In an effort to recognize that the methods in the guide might not be suitable for every installation across the scope of the guide, additional statements were added into the purpose clause. A proposed 'limitations and caveats' clause was also proposed. The proposed wording referenced a large population of transformers not requiring detailed analysis. Mark Perkins suggested being specific and restate the large population be clarified as distribution transformers, which was the original intent of the statement.

Discussion was heard on the aforementioned topics and the following comments and concerns were raised.
When does the guide apply? Tom Holifield, Mark Perkins, and Don Platts commented on this question. As written in the present draft, the guide only applies when a specification statement clearly requests, "Perform a thermal test in accordance with C57.12.90 unless the manufacturer has thermal test data from a thermal duplicate transformer".
Carlo Arpino requested the guide require thermal data from the tested transformer be provided in addition to the calculated results from the method in the guide.
Sanjay Patel questioned the validity of using the thermal results of a duplicate design being manufactured in two different facilities.
Juergen Gerth stated his concern that manufacturers should work to establish a base to use and not set individual limits.
Barry Beaster stated the present method requires a recalculation of the test data into thermal variables and used those to determine the proposed values for the new transformer. The question was raised if the improved methods and models allow pure computation without specific reference to a single test. This method uses its historical adjustment of all thermal tests.
Sanjay Patel expressed concern that thermal duplicate analysis may not offer any quality control.

Discussion was halted to determine what recommendations should be made to the Insulation Life Subcommittee regarding our original question on continuing work per the original PAR, or propose a new PAR be written. Mark Perkins proposed adding an alternative method to the document allowing those manufacturers, who have detailed thermal models and historical test data, to apply a statistical margin to compute results. A hand ballot indicated three persons approved, two persons disapproved this proposal. Marion Jaroszewski proposed to keep the tolerances in Table 2 of the guide, but drop the method to permit the manufacture to apply other methods. This might be to adjust parameters in a program to match the tested results and apply those adjustments to the computations of the new unit. A hand ballot showed four persons approved, three persons opposed this proposal.

Time had expired and the meeting had to be adjourned. The conclusion perhaps from these results is that consensus from the working group is still a long way off.

Respectively Submitted,

Barry Beaster
Chairman

1.3.3.1 Discussion During the Subcommittee Meeting:

Barry reiterated the problem that the PAR is due to expire at the end of 2004, and the working group still has a lot of work to do before we can hope to reach a consensus on this draft document. He noted that some have questioned the need for the document considering the changes in the standard during the extended life of this project. Now that detailed thermal models are required by C57.12.00 is there still a need for this? The subcommittee chair has supported the idea that the document is no longer needed, and posed a question to the attendees. Does anyone deal with the question of having a "thermal duplicate" for a new transformer in his day to day work? No one responded that it is an issue that they must deal with.
A proposal was made to archive the existing work on this project, discontinue the project, and allow the Par to expire. A show of hands vote gave overwhelming support to this proposal.

Barry was asked to determine the best method of preserving the work either in a formal paper or as a document to be preserved on our website, etc. then to oversee that task.

1.3.4 Task Force on Winding Temperature Indicators - Phil McClure

Monday, October 26, 2004 Las Vegas, NV.

The meeting convened at 8:00 am with eleven of the fourteen members and forty one guests attending. The members and guests introduced themselves. There were six more persons requesting membership in the task force.

The group was instructed that existing and pending patents may not be used in standards, or other work the group may produce, without the written permission of the patent holder or patent applicant. The group was asked if anyone present knew of any patents that may be affected by the work being performed, and there were no affirmative responses.

The minutes of the Spring meeting in San Diego were read, then approved as written.

Old Business

The group was asked if there were any new comments regarding the stepped load heat run test plan that was emailed to several interested parties. The test is intended to establish the response time of various types of WTI, to winding temperature changes, which are the result of abrupt load increases. No comments were voiced.

The group was directed to refer to newly added figure 2 in the technical paper. This figure is a graph of data that was taken during a heat run, which was conducted according to the load profile contained in the test plan. It was disclosed that figure 2 was presented in this draft revision as an example of the results which are sought, but due to data irregularities, it would not appear in the final paper. The chair felt that several anomalies that occurred during the test may have been partially the result of a lack of scrupulous plan detail, and resolved to rewrite the proposed plan, with help from the other WTI manufacturers in the group and comments from transformer owners and manufacturers.

A second test plan also needs to be written to describe a survey test which is proposed to be conducted on installed transformers, under normal loading patterns.

New Business

Draft seven of the technical paper was made available to the group, and eight added, edited and / or expanded sections were briefly discussed.

During the discussion of the response of WTI to step load increase, Sankar Vallamkanda explained his concern, which was largely responsible for formation of the group. His concern regarded the response of a simulating WTI to a sudden, unplanned load shift from two load sharing transformers to only one of them, in the event of a failure in the other. The transformers were ODAN types, and the specific concern was that at a time when the shifted load would result in a rapid increase in winding temperature, the inactive pumps would restrict oil circulation, and the slow response of the simulating WTI would not call on the pumps in time to forestall thermal runaway. The chair responded that the

group would like to include a transformer with OD cooling in its testing, but if one was not available, the testing would otherwise proceed without an OD subject.

During discussion of possible improvements to the paper's structure, two suggestions were made which would make the paper more readable; the addition of a glossary of terms and illustrations of typical connections of the various WTI types. Both of these suggestions were well received and will be implemented in draft eight.

A brief discussion of terminology was had, regarding the concept of loading transformers at higher or lower magnitudes, depending upon the temperature of the ambient air mass available for cooling, and possibly the health of the cooling auxiliaries themselves. This has been referred to variously as load forecasting, predictive loading, dynamic rating and dynamic loading. It was decided to use the term dynamic loading in the paper. It was also decided to discuss the difference between dynamic loading and seasonal setback in the paper, because of their seemingly similar, but completely different reasons for existence.

Section 1.5 "Support of National Standards" was split out from section 3.6 to provide a venue for de-mystifying the degree of compliance of calculating and virtual WTI to IEEE and IEC loading guides. It was decided that the WTI manufacturers should meet separately to discuss this issue.

It is anticipated that the main body of the paper, minus the transformer heat run and survey tests and conclusions sections, will be completed by the next meeting.

A motion to adjourn was made and seconded, and the meeting adjourned at 9:20 am.

Respectfully Submitted

Phil McClure,
Chair

1.3.5 Task Force for Temperature Rise Test Procedures Section 11 of C57.12.90 - Paulette Payne

The meeting of the Working Group was held October 25, 2004 at 11:00 AM in room Estancia E at the Green Valley Resort Hotel in Las Vegas, Nevada. Don Platts lead the meeting for Paulette, who could not attend. Allen Mitchell has resigned as the secretary; Steve Snyder filled in for this meeting.

There were 51 attendees; 17 members and 34 guests of which 7 requested membership.

The IEEE patent issues were reviewed with no concerns noted.

The Minutes of the San Diego Meeting were approved as written.

1 Don Platts reviewed the previous work by a Task force chaired by George Henry in the 1990's. That working group completely rewrote clause 11. It was submitted to the Standards Subcommittee after the fall 1999 meeting. Although it was part of the draft balloted in 2002, this previous work has not yet been published. As a result of this discovery, we found that the new working group has been working based on the latest approved revision of the standard, but not from the latest approved work of our subcommittee. He will provide the wording in that draft to the group for review, and to serve as the basis of all future work.

2 We discussed the correction of No Load Losses to a standard reference temperature to be used in the Total Losses for the temperature rise test. The working group agreed to accept the wording in the latest draft ballot of C57.12.90/D2-2002. We will not make further changes.

3 Thang Hochanh raised the question about the necessity of performing the temperature rise test on the tap with the highest losses, even if it is only slightly different from the tap that produces the highest winding rise. The working group discussed and agreed that the present wording in the standard is acceptable. Thang was offered the opportunity to prepare a proposed wording that would address his concerns, and submit it to the working group for future consideration.

4 Time for Resistance Measurements After Shutdown
We discussed the change proposed in previous meetings, and surveyed prior to this meeting. It would have changed the maximum time allowed from 4 minutes to 2 minutes. The conclusion was that although it would be very practical for tests of some transformers, it is not possible for the larger units. We concluded not to change the standard.

5 Discussion on Standardizing Cooling Curve Methodology
Don Platts reviewed the history of the request and our plan to develop a standardized methodology to become a part of the standard. He suggested that each of the manufacturers and other interested parties submit their methodology to Paulette for consideration at future meetings.

The meeting was adjourned at 12:05 PM

Steve Snyder Oct. 25, 2004
Don Platts; For Paulette Payne

1.3.6 Task Force Definition of Thermally Upgraded Insulation. – Don Platts

The Task Force met on Tuesday, October 26, 2004 at 8:00. The meeting began with introductions and circulation of the rosters. Attendance was 5 members and 37 guests.

The IEEE patent issues were reviewed with no concerns noted.

The minutes of the previous meeting in San Diego were approved as submitted.

Don Platts, the chair, reviewed the status of our work. We have established a definition of thermally upgraded insulation. To resolve issues with the definition, and the content of C57.100, we have proposed that the minimum life expectancy for a transformer insulation system must be a requirement in C57.12.00, not merely listed in the loading guide, C57.91, and in the Standard Test Procedures for Thermal Evaluation of Liquid immersed transformers, C57.100.

Draft #3 is the latest work to develop the basis of temperature limits and thermal aging performance requirements. The attendees were given time to read the background information and the draft.

We spent a considerable amount of time reviewing the wording in the draft, particularly related to the use of the phrase “high thermal stress”, and the idea that some insulation components in a transformer do not need to be thermally upgraded. The phrase “high thermal stress” was used in draft 3 to distinguish

insulation that needed to be thermally upgraded from other insulation components. The draft also said that insulation for structural components did not need to be upgraded. Joe Foldi suggested -- leaving out the reference to structural components as they may also get hot. The statement implies that structural parts do not get hot. This should state insulation components that are not exposed to high thermal stress are exempt from upgraded insulation. We don't need to single out the structural insulation from others.--

Roger Wicks pointed out that we should define "high thermal stress". Does "high thermal stress' have a different value for other insulation materials?

Joe Foldi noted that CSA allows a 100ºC rise for other insulation (not windings)

C57.12.00 clause 5.11.1.3 discusses rises of metallic parts other than windings shall not attain excessive temp rises

Joe Foldi questioned the 'other insulation' Failures have been observed in leads, not just windings. Lead temp rise must meet the winding rise requirements, should this be added?

Someone proposed using the words "Match material used in other places to its loading condition and temperature." This was not supported.

Don Platts offered a proposal to shorten the paragraph and simplify it by saying:
"Transformers that meet the Temperature and Loading Conditions in this standard shall be built using Thermally Upgraded Paper or an alternative insulation system that has been proven to possess minimum aging characteristics that either match or exceed those of Thermally Upgraded Paper. This requirement applies to winding, insulation, layer to layer insulation, lead insulation, and other insulation components that determine the minimum life expectancy."

This was accepted. The new Draft #4 will be sent to the Insulation Life Subcommittee for a survey before the next meeting.

The meeting adjourned at 9:20.

Donald W. Platts — Barry Beaster
Chair Task Force - Definition of Thermally Upgraded Insulation — As Secretary

1.3.7 Task Force for Revision to Temp Ratings in C57.12.00 – Dennis Marlow

This group did not meet. Their work has been completed and submitted to the subcommittee for a survey. Due to problems with our mailing list, and since the secretary was not available to work on this, the survey has not been done. It will be sent out shortly, in time for Dennis to review the results before the next meeting.

1.4 Old Business:

Dennis Marlow reminded the subcommittee that he is serving as our representative on the working group that is updating C57.12.80, Standard Terminology For Power And Distribution Transformers. He requested that any new definitions from our working groups be forwarded to him promptly to ensure that the are included in the next draft.

The chair reminded the group that our subcommittee is facing a leadership crisis. We have had at least 1 working group or task force chair miss each of the recent meetings. We have also had some resignations. Our subcommittee secretary has missed the past 2 meetings and has not contributed since the last meeting. Most of our groups do not have a vice-chair or secretary to assist the chair, and to fill in if he/she cannot attend a meeting. He urged everyone to become more actively involved in supporting the process, and has asked for each WG and TF as well as the subcommittee to fill all 3 leadership positions.

1.5 **New Business**

Our Guide For Determination Of Maximum Winding Temperature Rise In Liquid Filled Transformers, IEEE 1538, will reach the end of its 5-year life in 2005, and must be revised or re-affirmed. Don Platts requested that attendees provide any suggested changes or updates to the document. None were offered and he will survey the subcommittee to determine if a reaffirmation of the existing document is adequate for this update.

1.6 The meeting adjourned at 9:05 AM

Don Platts
Chair, Insulation Life Subcommittee