IEEE/PES Transformers Committee
Insulation Life Subcommittee
Un-Approved Meeting Minutes

The Insulation Life Subcommittee met in Jackson, MS on March 16, 2005, at 8:00 AM. There were 32 members and 77 guests present, with 9 guests requesting membership in the subcommittee.

The minutes of our meeting in Las Vegas, NV on October 25, 2004 were approved as submitted.

1.1 Chair's Report

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

The Chair reported that reaffirmation of two standards needs to be completed by the end of 2005. They are:

- IEEE 1276-1997, IEEE Guide for the Application of High-Temperature Insulation Materials in Liquid-Immersed Power Transformers
- IEEE 1538, IEEE Guide For Determination Of Maximum Winding Temperature Rise In Liquid Filled Transformers

The Chair also reported that the following standard needs to be dealt with by the end of 2006.

- C57.119, Recommended Practice for Performing Temperature Rise Tests on Oil Immersed Power Transformers at Loads Beyond Nameplate Ratings

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

Don Platts reported that Mike Franchek had resolved the negative comments on this guide. The next step is submitting this guide to the Standards Committee and completing the necessary paperwork.

1.3 Working Group and Task Force Reports

1.3.1 Revision to C57.91 Loading Guide - Tim Raymond

Meeting started at 1:45 pm, Tuesday, March 15, 2005.

There were 22 members present with 3 guests requesting membership to the WG.

The IEEE Patent disclosure requirements were discussed and a request was made for disclosure of any patents that may be related to the work of the WG. There were no responses to the request for disclosure.

Approval of minutes from the October meeting was requested. The minutes were approved.

Chair's Comments:

Not as much accomplished as we had hoped to get done by the last meeting. Glenn Swift who wasn't able to be at this meeting did get quite a bit of work done on Clause 10, which now only includes the Annex G model. This is the recommended temperature calculation from now on.

There is a new Annex for "Simplified Thermal Calculation. Essentially this is the old Clause 7 model for those without bottom oil rises, or for those who wish to use the old model.

Minor cleanups and additions based on comments from those who volunteered to review particular sections (Don Platts, Dave Wallach and Bob Tillman).

The PAR process has officially been started. Should be taken care of at the next NESCOM meeting.

Presentation by T.V. Oommen - Revision of Loading Guide C57.92 Section 7.2 – Bubble Evolution – Why It Should Be Retained.

The presentation will be posted on the website and as an attachment to the minutes.

Effectively, T.V. Oommen's presentation indicates that bubble evolution is a result of a combination of both moisture in paper and Hot Spot Temperature, not simply the Hot Spot temperature alone. Therefore, it is safe to overload dry transformers, however, short term insulation aging would occur.

Comments

Tim Raymond: Moisture content of paper is impossible to determine with great accuracy. In addition, this quantity is changing with loading conditions and is not uniform throughout the winding. Combined with uncertainties in temperature estimation, a precise formula may not yield sufficient conservatism. Prefer to present conservative temperature limits for transformer based upon broad ranges of moisture, with plot illustrating effect of moisture, gas content and static pressure. In addition, provide technical background on the issue to educate users.

Don Platts – As a user, he uses the loading guide to determine future capability or how much damage may have been done to a transformer due to an overload that has been applied. He indicated that they aren't going to know the moisture content of the paper to be able to plug that into the equations.

Tim commented that the moisture content will vary with loading and asked what effect that might have on the equations. TV indicated that the moisture content in the equations is based on an average value.

An attendee commented on a specific example in which there was a transformer that failed where the loading was only such that the hot spot was around 100C but the transformer was about as wet as it could likely ever be. The result of the investigation was that the high moisture even with the lower hot spot generated bubbles that led to failure.

Tim Raymond – Would prefer to see some broad grouping that indicates that if a transformer is dry the hot spot could be up to a certain value, etc.

John Matthews – confused by the estimation of the moisture in the paper.

Comment by an attendee - needs the equation that will provide him with what the risk of operating (what percentage of error exists depending on the moisture in the paper.)

The Chair requested a vote on two proposals:

1. Keep things as they are with the present formulas, but include wording on uncertainties and the need to apply margins of safety.

2. Get rid of equations and have generic temperature limits

Overwhelmingly the consensus was to keep the formulas and add some wording describing the variations that could be seen depending on moisture.

Presentation by T.V. Oommen on Aging

Presentation will be placed on the web and as an attachment to the minutes.

Discussed the problems in using the old life plots, end point had been defined as retention of 50% of tensile strength. We now know that 50% tensile strength is far from the end life of the insulation.

In the 1995 revision of C57.91, the end point was specified on the basis of DP.

Comments:

Tim Raymond –

Proposal #1

Apply factors to aging rate to include effects of moisture and oxygen:

$$F_{AA} = e^{\frac{B}{\Theta_o + 273} - \frac{B}{\Theta_{HS} + 273}} \qquad (1)$$

Moisture Content (roughly)	K_H2O
Dry (<0.5%)	1
Moist (0.5-2.5%)	2
Wet (>2.5%)	4+

Oxygen Content	K_O2
Low	1
High	3-5

Proposal #2

	Good	**Moderate**	**Marginal**
Moisture	< 0.5%	0.5%-1.5%	> 1.5%
Oxygen	< 3% TDG	3%-5% TDG	> 5% TDG
Methane	< 120ppm	120-400ppm	> 400ppm
Ethane	< 65ppm	65-100ppm	> 100ppm
Ethylene	<50ppm	50-100ppm	>100ppm

Condition		**Normal**	**LTE (>4hrs)**	**STE (<4hrs)**
GOOD	**Top Oil**	95	105	110
	Hot Spot	120	140	160
	LOL (hrs)	24	-	-

		Normal	LTE (>4hrs)	STE (<4hrs)
MODERATE	**Top Oil**	95	105	105
	Hot Spot	120	130	140
	LOL (hrs)	24	-	-
		Normal	**LTE (>4hrs)**	**STE (<4hrs)**
MARGINAL	**Top Oil**	95	100	100
	Hot Spot	110	120	120
	LOL (hrs)	24	-	-

We ran out of time to have proper discussion on the above proposals, so comments will have to be submitted via email. We will need to work out an effective method for discussion between meetings.

Meeting adjourned at approximately 3:00 pm.

Tim Raymond, Chair

Attachment A
(TV Oommen Presentations)

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

The Subcommittee voted to stop work on this project at the last meeting. The information collected in the course of this project has been gathered and will be given to the Transformer Committee for archiving.

1.3.3 Working Group On Thermal Evaluation Of Power And Distribution Transformers (C57.100) – Roger Wicks

1.3.3.1 Introduction and Rosters

The working group met on Monday, March 14, 2005 at 9:30 AM with 10 members and 34 guests attending.

1.3.3.2 Approval of minutes from October 25, 2004 meeting

The minutes of the October 25, 2004 meeting in Las Vegas were approved as written.

1.3.3.3 Patent Disclosure
The chairman asked if anyone knew of any patents which could pertain to this project. There were none.

1.3.3.4 Discussion of "conventional insulation system" (for both power and distribution transformers)

Chairman Wicks stated that the issue is that we are trying to analyze a “new” insulation system and compare it to a “conventional” insulation system that was used to establish the criteria given in the loading guide.

The chair requested that working group members should propose definitions of a conventional insulation system to him by the end of April.

He suggested that there could be three possible methods:

1) Lockie Test (full scale models)
2) Sealed Tube Test
3) Other test that models power transformers

It was noted that we could be developing different criteria for end of life depending on the insulation component being measured. For example, tensile strength retention for paper and compressibility for spacer material.

Tim Raymond commented that the loading guide is a guide and not a standard. There needs to be a standard that defines the insulation system. That is not included in the loading guide.

1.3.3.5 Discussion of OEM aging studies (distribution and power)

Jerry Corkran presented data from an aging study that Cooper is conducting. The study includes thermally-upgraded kraft paper in a sealed tube aging experiment. The ratio of paper to oil in this study was 24 pounds of fluid per pound of paper. Jerry presented data on both Natural Ester Fluid and Mineral Oil. He presented data on gas generation as well as percent tensile retention. A full copy of his report will be posted on the Working Group site on the Transformers Committee web page.

Tom Prevost suggested that with the posting of sealed tube data it is important that the authors give quantities of all materials used in the sealed tube as well as whether it had air or an inert gas.

Peter Heinzig presented information that Siemens presented in last year’s CIGRE session in Paris. The presentation will be posted on the working group web site. The summary of the presentation were:

• Humidity in the solid material and contact of Oil to the Air accelerates the ageing process
• The primary moisture content determines the slope of aging (especially the initial slope)
• Thermally Stabilized Paper shows a better aging behavior than Kraft Paper under the influence of Humidity and/or Air

• The influence of primary Humidity inside Paper is lower in Ester-Fluids than in Mineral Oil due to the better moisture absorbing behavior of the Ester-Fluid
• Inhibited Oil shows lower ageing of the solid insulation under the influence of air than non-inhibited oil

Further information see report of
CIGRE Task-Force TF D1.01.10 - Paper Ageing
Paris Session 2004
Convener: Lars Lundgaard

Roger Wicks presented work that DuPont has done on aging of solid/liquid insulation systems. This study used a dual temperature aging test that models hot spot and bulk oil. The test results on kraft paper was very close to the loading guide curve for kraft paper which verified the test results. A copy of this presentation will be posted on the WG site as well. The dual temperature concept as been adopted by the IEC (see below).

1.3.3.6 Discussion IEC – 62332 – Electrical Insulation Systems (EIS) Thermal Evaluation of Combined Liquid and Solid Components

Bill Simpson gave a summary of the work that is being done by the IEC. He presented a sketch of the aging cell that is being proposed. This aging cell is similar to the cell developed by DuPont which can test different materials at different temperatures modeling insulation at the hot spot and in the bulk oil. The IEC document is currently being balloted. At this time the working group does not have permission to circulate this document, but this will be circulated when it is approved and available for circulation.

1.3.3.7 Adjournment
The meeting adjourned at 10:40 AM.

1.3.4 Task Force on Winding Temperature Indicators - Phil McClure

The meeting was called to order at 8:00 am on Monday, March 14, 2005. There were 9 members and 26 guests present.

The first order of business was to display the slides which covered potential patent infringement and inappropriate discussion topics and to request disclosure of knowledge of patent applicability to the groups work. There was negative response to the disclosure request.

The next order of business was the introduction of members and guests. This was followed by welcoming of two new members to the group.

The minutes of the October 25, 2004 meeting in Las Vegas were then approved.

Old Business

It was announced to the group that a second new transformer had been identified as a potential candidate for a production heat run, some time in November 2005.

New Business

A considerable amount of work was done in the four weeks before the meeting, and it was planned to discuss as much as possible during the meeting. The sections which had been added or massively rewritten were 1.2, "Sensors for Indirect Measurement", 1.5, "Support of National Standards" and 7, Glossary.

We began with the glossary because the definitions were written, commented and edited prior to the meeting and it was expected that the discussion would be brief. As it turns out there was a great deal of discussion and many good points were made. Ultimately the remainder of the meeting was spent completing half of the glossary. It was decided to complete the remainder of the glossary through recirculation for further comment and voting.

In the closing minutes of the meeting it was decided that sections 1.2 and 1.5, which had not been previously circulated, would be sent to the members for comment as soon as possible. The members were also asked to consider whether section 3.6 "Calibration and Preparation for Delivery" should be included in the paper.

The group was also asked for authors and editors for sections 4.5, "Winding Temperature Indicator Ownership" and section 5.2, "Far Future Solutions".

The meeting was adjourned at 9:15 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 March 14, 2005 at 11:00 am in room Amphitheatre 2 at the Hilton Hotel in Jackson, Mississippi. Thang Hochanh led the meeting for Paulette Payne, who could not attend. Allen Mitchell had resigned as the secretary before the Fall 2004 meeting. Marnie Roussell filled in as secretary for this meeting.

There were 49 attendees; 12 members and 37 guests of which 8 requested memberships. Two new members, Alan Darwin and TV Oommen, joined the Working Group at the last meeting.

The Minutes of the Las Vegas Meeting were approved as written.

Proposed revisions to Clause 11.2.2 of PC57.12.90 D2 April 2002 were discussed. Explanation was initiated by Bob Ganser on the last sentence of the first paragraph which states, *"To minimize inductive effects when transferring measuring instrument leads from one terminal-pair to another, the same relative polarity should be maintained between measuring leads and transformer terminals"*. The Working Group agreed the original wording of the sub clause conveyed the intention to maintain the same polarity.

The following sub clauses of Clause 11.2.2 of PC57.12.90 D2 April 2002 were discussed:

Item a

The Working Group confirmed the original wording. ``*The time from instant of shutdown shall be recorded for each resistance measurement, and"*

Item b

This item was explained and it was agreed to maintain the original wording. ``*At least one resistance measurement shall be taken on all terminal pairs within 4 min after shutdown, and"*

Item c, c2, and d

The time duration of the data collection was discussed. Some members mentioned a duration of 10, 12 minutes. Steve Snyder pointed out that this clause applied to all transformers small and large. Bob suggested that this sub clause may have been a carry over from the watts per pound method and should be segregated by KVA. Vasanth Vailoor suggested to non-dimensionalize it utilizing multiple time constant duration. It was proposed to include c2 in sub clause d. The proposed addition of item c2 was explained and discussed. Item c2 stated that *"If the 4 minutes limit cannot be achieved or another terminal pair needs to be measured, the time to re-energize should be less than 1 hour"*. The intention was to minimize the time the unit remained de-energized. Thang pointed out that no time limit is currently specified in the standard. The Working Group indicated the proposed c2 wording could be misused. The Working Group agreed to maintain the original wording of sub clauses c and d. A motion was made to re-word item c2 for presentation at the next meeting.

Item e

The Working Group discussed the method of obtaining the hot resistance measurement from the collected data. Various methods were mentioned. A

motion was made that Thang Hochanh will provide an equation at the next meeting.

Item f

The Working Group initiated the discussion on usual practice of how to report temperature rise on one phase of a three phase transformer as the winding rise for the transformer. A motion was made to re-write this section.

The meeting was adjourned at 12:15pm.

Marnie Roussell, March 16, 2005-03-16
Thang Hochanh for Paulette Payne

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

The task force met on Tuesday, March 15, 2005 at 11:00 am. There were 4 members and 12 guests in attendance.

The task force did not meet in Las Vegas. The minutes from the San Diego meeting had been included in the Subcommittee minutes and were not distributed or approved at this meeting.

The task force was formed to make recommendations to the Insulation Life SC concerning proposals for temperature rise changes to C57.12.00 Clause 5, submitted by Dennis Marlow at the Amsterdam meeting in April 2001.

The Chair reviewed the IEEE patent disclosure requirements. No guests or members present indicated knowledge of any patent applicable to our work at this meeting.

The Chair indicated that this task force had been reconvened to resolve and/or make recommendations to resolve any negatives from the recent Insulation Life SC survey concerning the two proposals.

The results of the survey were as follows:

Surveys Sent Out: 65
Responses: 22

Proposal #1 – 70°C Average winding rise for ODAF transformers
In Favor: 14 (66.7%)
Against: 7
Abstain: 1

Proposal #2 – Stacked Windings 65°C average temperature rise
In Favor: 16 (76.9%)

Against: 5
Abstain: 1

Proposal #1 - 70°C ODAF Cooling

The task force discussed the individual comments received from the survey results using the initial observations/comments made by the task force Chair. The Chair will respond to the comments by e-mail to each of the individuals who voted not in favor of Proposal 1 thanking them for their participation in the survey and advising them of the following action of the task force.

The task force decided, based on the large number of negatives and the limited applications for the proposal, to not recommend its inclusion in C57.12.00 at this time. The proposal will be archived for possible inclusion in other standards in the near future.

Proposal #2 – Stacked Windings

The task force discussed the individual comments received from the survey results using the initial observations and comments made by the Chair. The Chair will respond to each of the individuals voting negative in order that they may now want to reconsider their vote. The task force believes the negatives can be resolved and that this proposal should proceed, possibly with a different wording and/or inclusion in a different section or standard. The task force may need to meet again in Memphis to resolve any outstanding issues.

The meeting adjourned at 12:00.

Respectfully Submitted,

Dennis Marlow
Task Force Chair

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

Chairman's notes:

- *The final draft of the addition to clause 5 was approved at the Insulation Life Subcommittee meeting on March 16, 2005.*
- *These draft minutes were created from discussion with some members, since no one acknowledges having detailed notes of the proceedings, or of the actual wording of our approved final draft.*

The Task Force met on Tuesday, March 15, 2005 at 8:00. The meeting began with introductions and circulation of the rosters. Attendance was 7 members and 50 guests.

The IEEE patent issues were reviewed with no concerns noted.

The minutes of the October 26, 2004 meeting in Las Vegas, NV were approved as submitted.

Don Platts, the chair, reviewed the status of our work. We have proposed that the minimum life expectancy for a transformer insulation system must be a requirement in C57.12.00. Draft #4 had been circulated for review by the task force and the subcommittee. The meeting was devoted to review of the comments from those surveys.

The task force reviewed the wording in Draft #5 which incorporated the editorial changes from the surveys. The primary topic of discussion was a comment form Mark Perkins that we needed to be more specific about the insulation components that need to be thermally upgraded, so that it will cover all types of transformers.

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 all of the insulation components that determine the minimum life expectancy." The statement in red would replace the prior wording of – "This requirement applies to the insulation components that determine the minimum life expectancy, such as: winding insulation, layer to layer insulation, lead insulation, and other components."

This was accepted with the recommendation to present it to the Insulation Life Subcommittee for their approval. When approved, that would complete the work of the task force.

Donald W. Platts
Chair Task Force - Definition of Thermally Upgraded Insulation

1.4 Old Business:

Don Platts reminded the Subcommittee that most recent survey of C57.12.00 and C57.12.90 generated many comments. The files with the comments for the Insulation Life SC have been misplaced. Once they are located, Barry Beaster will review them and recommend/take the appropriate action. Anyone interested in helping with this process should contact Barry Beaster.

1.5 New Business:

Jin Sim requested the Subcommittee consider creating a task force or a guide on the determination of moisture in an operating transformer. The Chair asked T.V. Oommen and Jin Sim to present a short proposal to the Subcommittee at the next meeting.

Jerry Corkran requested the Subcommittee create a task force to review the coordination between C57.91, the Loading Guide, and C57.104, the DGA Guide. He presented data on gas generation from an aging study that Cooper is conducting. The results of this experiment show that for some transformers loaded in accordance with C57.91 (lightly loaded transformers) the DGA results will indicate that there is a problem when all other tests and examinations show that the transformer is operating correctly.

The study was conducted using sealed tubes and small transformers with thermally-upgraded kraft paper. The temperature was held at 137°C to accelerate the aging of the insulation. The transformers had initial gas levels above zero due to heat run tests used to establish identical heating for the two insulating fluids.

The results were similar for both natural ester fluid and mineral oil. Testing has not been completed on the furan levels, degree of polymerization and tensile strength. A full copy of his report will be posted on the Subcommittee site on the Transformers Committee web page.

The Subcommittee members raised several points during the discussion.

Oil Volume

A small rectangular core transformer has 50% of the oil volume of a round core transformer. As a result, the same amount of gas will produce a higher concentration of gasses in the rectangular transformers.

The DGA guidelines were established for medium and large power transformers. It was suggested that the acceptable limits in the guide should be multiplied by the ratio 5000 gallons of oil (the oil contained in a medium sized transformer) to the oil in the small transformer to determine appropriate gas concentrations in the small transformer.

Gas Generation

Since the DGA guidelines were establish for a temperature of 110°C, is it a valid comparison with gasses generated at 137°C? An article was referenced that provided an equation for calculating the amount of gas generated at a given temperature. This equation showed that a higher volume of gas would be generated at the higher temperature.

1.6 The meeting adjourned at 9:15 AM

Don Platts
Chair, Insulation Life Subcommittee

Eric Davis
Secretary