9.7 Insulation Life Subcommittee - D.W. Platts

The Insulation Life Subcommittee met at 8:00 AM Wednesday, October 17, 2001 in Orlando.. Attendance was 37 members and 72 guests. The minutes of the April 11, 2001 meeting in Amsterdam, The Netherlands were approved.

9.7.1 Chair's Announcements

9.7.1.1 ADCOM meeting on Sunday. All future ballots will be done as electronic ballots. Please make sure that the Standards Association has a viable email address for you.

We discussed future meetings, the budgets for them and a request from IEEE that we coordinate our meetings with the annual PES meeting. Details will be discussed at the main committee meeting. Our next subcommittee meeting will be in Vancouver, BC, Canada on April 17, 2002.

The Chair responded to a request for interpretation regarding Note 'a' of Table 8 of C57.91. The requestor had identified an error that is being corrected in the corrigenda to be balloted soon. No further action is required.

9.7.1.2 Review of Subcommittee Survey for new activities

Between meetings the chair conducted a survey of the subcommittee to determine the level of interest in the four proposals for new projects presented at the Amsterdam meeting. The question asked was - should we pursue these topics?

There were only 24 responses. A summary of them follows:

1. Change rated average winding rise to 70C for ODAF transformers
   Yes- 14 No 7
2. Average the winding temperature rises for split LV windings located one above the other.
   Yes- 14 No 8
3. Standardize calculations for the temperature rise tests.
   Yes- 19 No 3
4. Summarize the experience using c57.119, the overload heat run guide.
   Yes- 20 No 0

Dennis Marlow has begun work on the first two topics. The others will be addressed in new business.

9.7.2 Status Reports for active projects:

Subhash Tuli reported PC57.119; "Recommended Practice for Performing Temperature Rise Tests on Oil-Immersed Transformers at Loads beyond Nameplate Rating" has been approved.

9.7.3 Working Group reports were as follows:

9.7.3.1 Working Group on Loading of Liquid Immersed Transformer - Linden Pierce, Chair.

The Working Group met from 9:30 am to 12:00 Monday, Oct. 15, 2001 with 26 members and 51 guests in attendance. The minutes of the Oct. 16, 2000 meeting in Niagara Falls, Canada were approved.

Draft 1 of a revision of C57.91, "Guide for Loading of Liquid Immersed Transformers and Voltage Regulators" was sent to the Working Group and the Insulation Life SC members by E-mail in early September. The results of the Working Group Survey were as follows:

Approve or Approve with comments	15
Negative	1
Comments only	1
No response	21
Wrong E mail	3
Chair, no vote	1
Total	42

Conversations with the "no responses" indicated that the 4 week time period was not sufficient to review the document which was in excess of 140 pages.

The technical comments from George Henry, Jin Sim, Glenn Swift, Jerry Corkran, and Don Platts were reviewed. A summary of the major issues is as follows:

Scope

The scope will be revised as follows to better accommodate transformers with different temperature rise ratings:

"This guide provides recommendations for loading liquid-immersed transformers and voltage regulators with insulation systems rated for a 110 °C winding hottest spot temperature at rated load. This guide applies to transformers manufactured in accordance with IEEE C57.12.00 and tested in accordance with IEEE C57.12.90, and voltage regulators manufactured and tested in accordance with C57.15.

Because a substantial population of transformers and voltage regulators with insulation systems rated for 95 °C winding hottest spot temperature at rated load are still in service, recommendations that are specific to this equipment are also included."

Computer Code

When the present BASIC language code was developed in 1992, all PC's could run BASIC language programs under DOS. Present personal computers do not have this capability. The possibility of using a modern structural language such as Microsoft Visual Basic was discussed. IEEE has been contacted for examples of how other standards handle computer program documentation. The preliminary response that it is best to use a generic product and not refer to Microsoft. This issue is open. Alternatives will be reviewed after review of other IEEE standards.

Exponents

A statement will be included that if exponents are known from testing they may be used in the program. IEEE C57.119 will be referenced.

The exponents which appear in C57.12.90 are not affected since the Loading Guide is not referenced. The draft of P1524, Thermal Duplicate should be revised to give the exponents in the document and not refer to the loading guide. No Loading guide exponents are given in C57.100.

An amendment to IEEE C57.119 should be issued to show the calculation procedure for the x, y, and z exponents. The test method is satisfactory and the data taken is adequate.

Effect of LTC Taps on winding hottest spot.

Glen Swift reported that a device made by his company indicated a 20 C difference in hot spot at the same current through different LTC tap connections. Present draft states in Clause 9.5 states, "Calculating the effect of load tap changer operation into the loading predictions is an extremely complicated and controversial subject and the effect may vary with the manufacturer". Since no alternative guidance can be provided, the present wording in this clause will be retained.

Complexity of Loading Equations

Less complex loading equations are desired by Jerry Corkran for distribution transformers. Don Platts wishes to include the 1995 Guide Clause 7 equations since many utility computer programs use them.

However, simple equations will not cover complex load cycles in Specifications by some utilities. The clause 7 equations also do not consider the winding duct oil rise during high short time overloads.

The next draft will probably include simplified equations which may be used for simple loading situations, that is a two step overload in a constant ambient. It is the intent that the simple equations will be for a hand calculator use. It is not the intent that simple equations be computerized for complex loading situations. If equations are computerized, then the most accurate form should be used.

References for cold start up and low ambient temperature operation

Eastgate in 1967 and Aubin and Langhame in 1989 investigated start up under low ambients and overloading under low ambients. Results were for mineral oil. Both discovered that the winding duct oil is a factor in causing the winding hot spot to be higher than the 1995 Guide Clause 7 equations predict. The phenomena for start up or for overloading is the same. The references will be retained. References to other investigations by Northrup and Thompson and Lampe will be reviewed to determine if they are really useful.

Cold load pick up

The statement, "If prior loading cannot be controlled by demand or rate of increase, the windings may experience localized hot spots and accelerated aging of conductor insulation during cold weather ambients", will be changed to, "Loading should be controlled by demand or rate of increase to limit the winding hottest spot temperature to acceptable values". A reference to use the temperature equations for transient temperature predictions and Table 4 for constant load, constant ambient will be added.

Use bottom tank wall temperature instead of bottom oil for distribution transformers

A future revision of the test code C57.12.90 will cover a test method which will allow measurement of the tank wall temperature with a correction to give the bottom oil temperature. No modification of draft 1 is required.

Ambient Temperature

Clause 8 about ambient temperature will be rewritten to reflect modern practice. Margins will be removed. Margins should be applied to the final answer, not to the individual components.

Over and under excitation and frequency effects.

Clause 5.2.1 will be expanded to cover rating information in C57.12.00. Presently "load" is not defined. It can be either KVA or Current per C57.12.80. It is current that causes winding heating and maximum currents are given on the nameplate. To stay within the manufacturers ratings, both KVA or maximum current must not be exceeded. The next draft will replace "load" with "load current" or similar wording.

Thermal evolution of gas from transformer insulation

Clause 7 will be expanded to provide information on how to obtain the information to use the equation given.

Loading increase due to lower tested average winding rise

Margin will be removed. It will be assumed that the data provided by the manufacturer is correct. Any margin should be applied to the final answer.

Information needed for Bushing Loading Calculations

A statement will be added to contact the transformer or bushing manufacturer to obtain the bushing constants needed for the bushing loading calculations. It was reported that it is difficult to obtain the information.

Operation of directed flow transformers without pumps in operation

Clause H4.2 in C57.91-1995 was not retained in the present draft. The major reason is that operation of directed flow FOA units without the pumps is a very risky situation. The calculation procedure omitted contains many approximations which may not be valid for all transformers. Without the pumps in operation, the transformer operates in a natural convection cooling mode. Restrictions within the forced oil heat exchanger, and by the pump impeller may prevent natural convection flow. The winding duct oil temperature may reach a very high value in this situation.

It is the conclusion that only the transformer manufacturer has the detailed information required to perform any calculation for this condition. The manufacturer should be contacted for this information.

Additional caution and explanations will be provided in the next draft.

Submitted by,

Linden W. Pierce, Chair

9.7.3.2 Working Group on Definition of Thermal Duplicate - Barry Beaster, Chair.

The Working Group met on Monday, October 15, 2001 at 1:45 p.m. There were 8 members and 18 guests in attendance. One request for membership was received by Scott Digby of Waukesha Electric Systems. The minutes of the spring 2001 meeting were read and approved.

Agenda items from discussion generated at the spring 2001 meeting were included in Old Business for this meeting. The first of these topics was the improvement of definitions of terms and exponents used in the guide. The second discussion topic was the standardization of SI units throughout the guide. The third item on the agenda was the underlying assumptions about making comparisons between a new 'thermal duplicate' and a tested unit. The last Old Business topic was conditions when non-identical types, as presently defined in the guide, could be used as thermal duplicates.

With respect to definitions in the guide, it was agreed to include the complete definition of exponent's-m, n, and Z as shown in C57.91 rather than as a reference to this guide. The definition of 'cooling flow path' in section 4.1.3 was proposed in a format closer to the IEC cooling designations. After discussion it was agreed to either make these definitions identical to the IEC wording or to better remove the terms and reference the IEC terms and add descriptive text to supplement special cases such as natural thermosiphon flow with guided oil flow within the windings.

Discussion on the use of SI units within the guide concluded with a majority of the attendees feeling the generic term 'watts per unit area' was better that selecting specific units that would only be used for comparison purposes.

The next topic discussed was the choice of the comparison of the thermal characteristics between a new unit and the tested results of the original unit, versus the comparison between the calculated designs of the new and tested units. It was apparent that those manufacturers of high volume, smaller size transformers and those doing repair of transformers from other manufacturers typically do not have the resources or information to perform a detailed analysis that is normally necessary for larger transformers. It was also noted that improvements in eddy loss analysis with field analysis programs would almost necessitate recalculation of the old design for proper one-to-one comparison. It was agreed that with some additional editorial information, the comparison would continue with the comparison of the new transformer with the tested results of the first unit.

The last agenda item was the comparison of the transformers that are thermally the same with some construction differences. In summary, it is proposed that if a new design has an on-load tap-changer, the thermal duplicate must also have an on-load tap-changer. Both of these units would have to be rated as either reduced or full capacity. Another case is if the new unit has no regulation winding, the thermal duplicate may or may not have a regulating winding. The unit with the regulating winding would have to have a reduced capacity rating.

These changes will be incorporated and a survey of both the Working Group and the Subcommittee will be completed prior the end of the year.

Respectfully Submitted,

Barry Beaster Chairman

9.7.3.3 **Task Force on Winding Temperature Indicators - Phil McClure, Chair**

The meeting convened at 1:55 PM on October 16, 2001. Five members and 18 guests were present. Mike Barnes, former Chair of the task force, had asked to be relieved of his duties citing additional responsibilities at his company, and Phil McClure introduced himself as the new Chair.

The members and guests introduced themselves and the minutes of the spring meeting in Amsterdam were approved.

A brief history was related to the group, followed by a discussion of the evolution of the task force's objectives. Progress has been slow to date, and reaffirmation of the group's interest in the objective established in April 1999 was sought. The objective was to write a technical paper describing the problems involved with making accurate winding temperature measurements from the manufacturer's and user's perspectives, and to present current and future technologies which may offer solutions. A vote was held and it was agreed that the objective should not be changed.

A rough outline of the proposed paper was made available to the group. The outline comprises the blueprint presented by Barry Ward in April 1999 with all text written since that time merged into one document.

Concern was expressed that the lack of participation was seen as a lack of interest and that the future of the task force would depend upon the sharing of experiences and knowledge of the members.

Discussion was had regarding the collection of heat run data for presentation with the paper. The data is intended to be incorporated as a graphical representation of the effect which step changes have on time constants of winding temperature indicators. Data taken using fiber sensing elements versus simulating or calculating winding temperature indicators was desired. It was suggested that a survey should be sent to transformer manufacturers requesting any available data. It was also suggested that proprietary issues would be mitigated by removing brand name information prior to submission of the data.

A call for volunteers to help write the paper was made, but no new members responded during the open session. After the meeting adjourned several persons did volunteer to provide some thermal data and help with editing.

In discussions immediately after adjournment it was expressed that interest in the subject may have waned due to the fact that some solutions have caught up with the problem as originally stated.

The meeting adjourned at 3:10 PM.

Respectfully,

Phil McClure
Chair

9.7.3.4 Task Force on Temperature Rise Clause 5 C57.12.00- Dennis Marlow, Chair

The Task Force met on Tuesday, October 16 at 11:00 AM. All the 27 participants to this inaugural meeting are welcomed into the Working Group as members.

There were no previous minutes as this is a new Task Force.

The task force was formed to make recommendations to the Insulation Life SC concerning the 2 proposals for temperature rise changes to C57.12.00 clause 5, submitted by Dennis Marlow at the Amsterdam meeting in April 2001. The SC was polled after that meeting and responses indicated that we should proceed with further discussions on those two proposals.

The following items were discussed:

1) **Proposal 1** dealt with changes to the average temperature rise for ODAF cooling from 65°C to 70°C. 15 members of the SC survey were in favor of pursuing this proposal while 4 did not favor further investigation

2) **Proposal 2 dealt with changes to the average temperature rise of two windings that were located one above the each other.** 16 members of the SC survey were in favor of pursuing this proposal while 4 did not favor further investigation.

3) Copies of the technical supporting and background data that was sent to all SC members as part of the survey was distributed to all attendees. Copies are attached to these minutes.

4) **Proposal 1 Discussion**.

- The Chair explained that the 4 negative survey responses were returned from final users who may not have fully understood the potential cost benefits of this proposal. They seem to be concerned about the loss of potential overload capabilities.
- Several responses and comments were received concerning the calculation and verification of the actual hotspot limit of 80°C if the average temperature rise was allowed to increase to 70°C for ODAF cooling.
- Most of the SC members surveyed had no or limited experience with ODAF transformers operating at 70°C average temperature rise
- Various attendees indicated that there is a potential cooling cost reduction of 15% to 25% if the average temperature rise is increased to 70°C. The 80°C limit for the hot spot temperature rise does not change
- In order to determine if 70°C average temperature rise is indeed a normal practice, it was agreed that the SC Chair, **Don Platts will survey other users and other suppliers of ODAF transformers to verify the normal practice of others outside the poll of the SC.**

5) Proposal 2 Discussion

- VSN Sankar noted that the core, tie plate and conductor heating needs to be verified for the condition where there is load only on the upper LV winding.
- It is also noted that the short circuit force calculations need special considerations for this type of dual LV winding arrangement.
- Further discussion will be circulated within the TF membership by e-mail prior to the next meeting in Vancouver April 2002

There was no new business. The meeting adjourned at 12:00 noon

Respectfully submitted,

J. Dennis Marlow Task Force Chair,

9.7.4 Old Business

The loading guide C57.91 has reached the end of its 5 year life. Linden Pierce will be sending the document for reaffirmation. He has also prepared a corrigenda covering several errors that have been found in the printed document. It will also be balloted by the end of the year.

IEEE Guide for the Application of High Temperature Insulation Materials in Liquid-Immersed Power Transformers, IEEE 1276, will also reach its 5 year life in 2002. Mike Franchek has agreed to review the document and either recommend revision, or begin the reaffirmation process.

9.7.5 New Business

The chair continued discussion of the survey of the subcommittee to determine the interest in starting new projects. The remining two items were regarding temperature rise tests, to summarize the industry experience with the overload heat run guide, and to provide a standardized method for evaluating the results of the heat run test. Both were recommended by a clear majority of the responses.

The suggestion to summarize the experience with the overload heat run test will be pursued, but we will not start it until some of the other projects are completed.

The suggestion to standardize the procedures for calculations of the heat run data was discussed. Some of that work was attempted during work by the Working Group to revise the Temperature test code, but was abandoned.

The chair read the heat run test procedures from C57.12.90 and asked if anyone could agree that the wording was specific enough to define the test performed to demonstrate compliance with the 65°C average winding temperature rise guarantee. (It says that the tester should use a curve fitting program or draw a smooth curve through the data points). During discussion it was mentioned that Microsoft Excel spreadsheets contain several different curve fitting techniques that could be used to find the resistance at time zero and each produces a different result. Other curve fitting programs would be expected to produce additional different answers.

After the discussion, the chair agreed to survey the manufacturers in the subcommittee asking them to evaluate cooling curve data, and report the resistance at time zero that would result from using their standard techniques. The results of that survey will help to identify the extent of the variations between various factory procedures. George Henry has agreed to resume work on the test code to incorporate additional changes as needed.

The meeting adjourned at 9:20 AM.

Respectfully submitted by:
Donald W. Platts, Chair Insulation Life Subcommittee

Copy of response letter to Request for Interpretation

September 12, 2001

Mr. Jon G. Calkins
Nuclear Management Company, LLC
Prairie Island Nuclear Generating Plant
1717 Wakonada Dr.
East Welch MN 55089

Dear Mr. Calkins:

I have reviewed your request for interpretation of C57.91-1995, IEEE Guide for Loading Mineral-Oil-Immersed Transformers.

As you have pointed out, there is an error in Note a of Table 8.

IEEE has recently sent out an Invitation to Ballot for a corrigenda to C57.12.91. It includes corrections to several portions of the document. When the corrigenda is approved, Note a of Table 8 will be corrected to say 110°C, rather than the 100°C.

To address your specific question which was - "Now, is the allowed continuous temperature 110°C or is it 100°C?" Clause 9.3.1 explains that the requirements for loading are in C57.12.00. It also states that the continuous operation limit for the hottest-spot temperature is 110°C.

Donald W. Platts
Chair, Insulation Life Subcommittee