10.0 Reports of liaison representatives

10.1 EPRI – B. Ward

Memorandum

October, 2001

TO: Mr. Ken Hanus
Secretary, IEEE Transformers Committee
TXU Electric & Gas
PO Box 970
Fort Worth, TX 76101

FROM: Barry Ward, Manager, Power Transformers

SUBJECT: **EPRI LIAISON REPORT**

The following report is for inclusion in your minutes for the October, 2001 meeting in Orlando:

1. Moisture Dynamics:

Very rapid load changes can cause bubble formation under some conditions and reduce low frequency and impulse dielectric strength by 40%. This has been demonstrated in models with rapid/high overload.

Additional work has been completed to experimentally study moisture dynamics associated with rapid overloads and cool-down cycles plus detect inception of partial discharges caused by bubble evolution. Moisture moves away from the hot conductor fast and returns very slowly after cool-down. Distribution of moisture in the solid insulation was found to be very uneven and time to dissolve free water is very long. TR-113390, *Power Transformer Behavior During Overload - Phase I: Dynamic Behavior of Moisture,* is now published. Phase II has been completed to study the correlation between moisture-in-oil with moisture-in-paper for a range of conditions and temperature cycles using winding models with moisture contents ranging from 0.5% to 7.0% in paper and pressboard. Phase III started 1/99

to broaden the experimental work and include prototype field applications of a dynamic moisture assessment method on operating conservator-type core-form transformers. TR-114075, *Transformer Moisture-In-Paper Assessment Method – Field trial,* is published. An algorithm has now been developed and is described in report number 1000724, *Green-Yellow-Red Diagnostic Method: Transformer H2O Assessment Method* It describes the Transformer Moisture Monitor, a stand-alone software application for the assessment of moisture conditions in the insulation system of a core-form conservator power transformer. Further experimental work covering nitrogen-blanketed and shell-form transformers are in process. Field trials are underway at three utilities. Two involve long-term on-line continuous assessment; the third is a dry-out experiment.

2. High Voltage Instrument Transformers & Bushings

EPRI sponsored a workshop 9/90 to provide a forum to compare and categorize failure information, failure modes and potential mitigation measures. This was an outgrowth of the Transformers Committee roundtable in Washington, DC, 4/88. Proceedings, TR 100205, were published. A Project was completed to study fast disconnect switching transient effects on HVCTs. Mathematical modeling was checked experimentally through laboratory tests and switching tests in a 500 kV substation with very high speed instrumentation. Effects of switching resistors during disconnect switching has been studied and found to reduce bus transients and stresses by up to 80%. A final report is published, TR-104961.

A project has been completed to monitor a large number of HVCTs and bushings in laboratories and in service, including on-line tan delta, partial discharge (pd) and other available monitoring methods. Units are being tested to failure to evaluate failure modes, sensitivity of monitoring and to develop "end-of-life" criteria for interpretation of field monitoring data.

A Symposium: *HVCTs & Bushings – Failure Prediction & Prevention,* was held September 22-24, 1999 in Portland, Oregon. Proceedings, TR-113649, are published. At this time, three different failure detection methods are being tried at three different utility sites. These are: an electrical pd method for detecting internal pd, on-line and without taking an outage, an acoustic pd system for measurements in the field, and an on-line tan delta system being evaluated under field conditions but with accelerated aging.

3. Power Transformer Loading Software PTLOAD

EPRI's Power Transformer Loading program (PTLOAD 5.1) calculates transformer oil and winding temperatures, thermal ratings, insulation loss-of-life, and the likelihood of gas bubble formation. The calculation methods, which incorporate user-specified load and air temperature, are based on the IEEE C57.91-1995, "Guide for Loading Mineral-Oil-Immersed Transformers" as well as the IEC Standard 354, "Loading Guide for Oil-Immersed Power Transformers." It provides a convenient way

for substation engineers to plan a full, yet safe, loading of power transformers under a wide variety of operating conditions. PTLOAD Version 6.0 is under development. It will expanded functionality to include a means of generating 24-hour load and temperature files by a probabilistic derivation from actual measured data over a long period of time (e.g., a month). This will give the code a more accurate basis on which to calculate ratings. Version 6.0 will also include a three-winding (dual secondary) transformer model. The software is currently in beta test.

4. Dynamic Thermal Circuit Ratings - DCTR

This project involves all transmission components including power transformers regarding software development and a field test involving two substations on a utility system. The field test has been completed. A final report is published, TR-105421. An IEEE paper, 94 SM 473-9 PWRD, was presented at the IEEE/PES 1994 Summer Meeting in San Francisco. A second paper, "Field Application of a Dynamic Thermal Circuit Rating Method", was presented at the IEEE/PES 1996 Winter Meeting in Baltimore. The method has been extended to include transmission lines. DTCR 2.0 is available to EPRI Substations Asset Utilization, Overhead Transmission, and Underground Transmission Target members. DTCR 2.1 is being developed to add the IEC transformer thermal model and other refinements. It uses the PTLOAD engine and future enhancements to PTLOAD will be included in DTCR.

5. On-Line Transformer Condition Assessment – Green / Yellow / Red

This project is a continuation of earlier EPRI efforts to develop an on-line low cost gas analyzer that were abandoned because of baseline drift of the sensors. A "key gas" analyzer uses metal-insulated-semiconductor (MIS) sensors to monitor individual ppm for hydrogen, acetylene, ethylene and carbon monoxide. A field demonstration program that involved 40 prototypes, starting October 1993, was completed in 1996. An EPRI/Micromonitors/Sandia National Labs collaborative project was initiated 2/99 to solve technical problems that have delayed commercial production of the MIS sensors. An alternative 8-gas analyzer for nitrogen-blanketed transformers has been developed and is now commercially available. A prototype version suitable for conservator-type transformers began a successful field trial May, 2000, and is now commercially available. Current work at Sandia National Labs will first concentrate on producing a complete model for a hydrogen only sensor with lab verification. The feasibility of an acetylene sensor will also be studied.

Experimental work is in process to identify the dynamic behavior of gases and other byproducts associated with loading and internal problems. Early results show that gases are developed in the form of tiny bubbles that *are not* quickly absorbed into the oil, including gases with high solubility such as acetylene. Knowledge developed will be used in the development of fuzzy logic expert system modules that can provide Green-Yellow-Red indication of transformer operating condition. Report number 1000726, *Dynamic Behavior of Gases and Chemicals & On-Line Monitoring of In-Service Transformer: Laboratory Transformer Simulation Experiments & Field Trials* was published December, 2000. Further field trials are underway.

6. Power Transformer Remaining Life Prediction & Extension

Furaldehydes in Transformer Oil

A project has been in place since 1994 to develop a correlation between furaldehydes in oil samples with degree of polymerization (DP) found in paper insulation samples taken from a significant number of transformers in service. Additional laboratory experimental work has identified trace chemicals that are an early indication of insulation degradation and could be sensed through on-line monitoring. A report is being written.

Frequency Response Analysis (FRA)

A project has been in place since 1994 to develop a correlation between existing winding conditions and FRA tests before and after internal inspection and reclamping of the same transformers. The objective was to develop noninvasive field test methods and criteria that can be used to predict winding condition in the broad variety of existing power transformers without entering the transformer. Over 40 transformers have had the initial FRA and internal inspection, and over 20 have had the follow-up FRA test. Results have been applied to assess the condition of a number of core-form and shell-form transformers. Recent co-sponsored experiments on a retired 345kV auto-transformer comparing the swept-frequency method and the impulse method were presented at the EPRI Substation Equipment Diagnostics Conference VIII held in New Orleans, February 21-23, 2000 (*Proceedings: Substation Equipment Diagnostics Conference*, EPRI 1000124, June 2000). A variety of problems were introduced individually. In general the study showed that both methods, properly applied, are effective and give similar results. Current work includes the field assessment of the in-situ, on-line impulse technique and the off-line swept frequency method to determine the feasibility of comparing signatures from one technique with signatures from the other, for the assessment of winding movement. Additional field tests were performed in August, 2001 and a report will be available at the end of the year.

7. Transformer Expert System - XVISOR

Objective of this project is to capture the knowledge of transformer experts and make it usable in an off-line software tool for evaluation of transformer design questions, condition assessment, problem diagnosis, and identification of maintenance needs. XVISOR Version 1.0 is available to EPRI Substations O&M members. An LTC module for this software has been developed and has just completed beta test. The software has been submitted for EPRI software quality testing and will be available by the end of November, 2001.

8. Guidelines for Life Extension of Substations

These guidelines, now published in Final Report TR-105070 dated April 1995, include a large section on transformer inspection, condition assessment, testing, and

maintenance practices. An extensive update and extension, *Guidelines for the Life Extension of Substations (CD-ROM Version)*, EPRI 1000032 is now available to O&M members.

9. Low Maintenance LTC

Work is completed to identify and categorize specific LTC problems, causes and populations involved; evaluate existing mitigation measures; and identify R&D needed to achieve substantial reduction in LTC maintenance requirements. A workshop was held November 1996 in Tampa, FL. to provide a forum for discussion of LTC problems / maintenance / and ways to improve reliability and reduce maintenance. Proceedings were published in TR-108398 dated June 1997. Two EPRI projects to improve understanding of contact coking, oil filtration effectiveness and monitoring concepts were recently completed. Further work is on going regarding coking, filtration, contact material effectiveness, the development of oil characteristic signatures for normal and abnormal operation, and novel methods for on-line monitoring. Two reports are being written and will be available at the end of the year.

10. Continuous On-Line Oil Filtration

The objective is to develop or adopt technologies for a passive on-line filter for mounting on transformers to continuously remove moisture, oxygen, and oil degradation products to keep oil in pristine condition and thus retard the aging of the cellulose insulation. Laboratory experimental work has been completed. Full-scale simulation tests are in process, and a field demonstration is underway. A patent for a special purpose filter designed for the removal of moisture, oxygen, and certain other chemicals has been allowed and will be issued soon. The next step will be commercialization.

11. Environmentally Acceptable Transformer Oils

Objectives are to 1) review the state-of-the-art of dielectric fluids, 2) perform laboratory tests & simulations on available candidate fluids for transformer application, and 3) demonstrate promising fluids in operating transformers. Laboratory tests & simulations have been completed on 12 candidate fluids. Report number 1000438, *Environmentally Acceptable Transformer Fluids: Phase I State-of-the-Art Review; Phase II Laboratory Testing of Fluids* was published December, 2000

10.2 SCC4 - P. A. Payne

No report was provided for the minutes.

10.3 TC 14 TAG - P. J. Hopkinson

TECHNICAL ADVISORY GROUP

ON TC14 (Power Transformers)

Place of Meeting:	Rosen Centre Hotel Orlando, Florida
Date & Time:	Tuesday, 16 October 2001 8:00 AM

INTRODUCTIONS

Members Present

C. Colopy	Cooper Power Systems
J. Foldi	ABB Inc, (Canada) Liaison
J. Gauthier	NEMA
B. Henning	Waukesha Electric Systems
P. Hopkinson	Square D Company
R. Nordman	Waukesha Electric Systems
W. Patterson	ABB T & D

Members Absent

C. Bush	PEMCO
J. Cockran	Cooper Power Systems
R. Del Vecchio	North American Transformer
D. Foster	Olsun Electrics Corp
R. Girgis	ABB
S. Kennedy	Niagara Transformers
G. Morehart	Acme Electric
R. Marek	Dupont Advanced Fibers Systems
P. Payne	PEPCO
J. Puri	Consultant
M. Rajadhyaksha	Ciba-Energy
H. Jin Sim	Waukesha Electric
J. Smith	Khulman Electric Corp
L. Wagenaar	Amer Electric Power Co

Others Present

B. Darvony	VA Tech Farrenti-Packard
J. Lackey	Ontario Power
D. Marlow	PORLEC-GE
B. Patel	Southern Company Services
S. Snyder	Khulman Electric
C. Steigemeier	ABB
G. Swift	APT Power Technologies

PRESIDING OFFICER: P. Hopkinson, Technical Advisor

I. APPROVAL OF PREVIOUS MINUTES

The minutes for the meeting held 10 April 2001, were approved as submitted.

APPROVAL OF THE AGENDA

The agenda was accepted as circulated.

MEMBERSHIP

The chairman reviewed the criteria for membership and the status of TAG membership.

OLD BUSINESS

The Chairman noted that activity in IEC TC14 has been noticeably lower this year (2001) than in previous recent years. While the WGs have met, the meetings have not been as frequent as in the past. He noted that there are a number of issues that remain to be addressed.

Revision of IEC 60076-5 (Ability to withstand short-circuit)

The chairman reported that there has been little additional new work on this document. It was noted that work is underway in CIGRE to address accepting short-circuit testing by calculation, noting that if a manufacturer proved a short-circuit capability by using the CIGRE calculation method, it probably will be accepted.

Revision of IEC 60076-3 (Insulation levels and dielectric tests)

The chairman reported that work continues at a slower pace on this standard, with little new information being available.

Revision of IEC 60378-2 (Converter Transformers: for HVDC applications)

The chairman noted that work continues in TC14 on converter transformers but the only US expert does not have his company's support to participate. There is little activity in the US on this subject matter.

The chairman requested member support to identify a candidate who can provide US participation in this activity. He noted that the candidate should be prepared to address the cost for USNC membership.

Revision of IEC 60214 (Tap Changers)

It was noted that the WG held its last meeting in June 2001. Two documents have been the subject of interest and circulated to national committees. Document 14/314/CDV was approved in August.

Work is underway in developing an application guide for reactive tap changers. It is still in the preliminary stages. It was noted there appears to be support for the continuation of the project and to harmonize with IEEE C57.131standards. While the document is progressing, the chairman expressed disappointment that the WG has not addressed

the functional life test for de-energized tap-changers. Based on the testing work that some members have done, the European working group members are increasingly motivated to doing their own tests. The chairman expressed optimism that a functional requirements test would be included in the IEC document, with some persistence on the US part, in the near future. He briefly reviewed why it is necessary to include such a test in the IEC standard

The chairman noted that there is a need to develop the necessary technical paper that would be the basis for supporting (validating) the need to include a test in the standard. He noted that a paper has been developed and that additional co-authors were needed to enhance its fundamental conclusions to support tests – directly or indirectly (through adoption of the US proposal and putting in place practices to exercise contacts on a regular basis and thereby achieving the same end.)

Revision of IEC 60551 (Audible sound)

It was noted that work is ongoing in the committee on this subject, but the WG has not supported US expert proposals for sound level tables for specific equipment.

The chairman briefly discussed the need for maintaining a reference base and the reasons for NEMA's revival and re-issuance of its audible sound standard TR-1. It was noted that the European position is to leave specific sound levels as a negotiating point between buyer and seller.

A brief discussion ensued on the utility and value of audible sound tables. It was proposed

Review activities of TC 106 (EMF)

The chairman noted that some in the industry have indicated that transformers neither produce nor are affected by EMF. The chairman also noted that EMF is a maximum at the transformer enclosure and that it drops off quickly with distance. He noted that the field varies according to the type of transformer and its encasement. He reported that some individuals in Europe are seeking to establish the limits for field intensities in the 5-milligauss range. The chairman briefly reviewed the environments for exposure and consequence.

He noted that TC106 is seeking to identify means for measuring magnetic fields. IEEE SCC28, SC3 (0-3kHZ) has done work on exposure levels that can be met around most electrical apparatus. It was noted that establishing an exposure level of 5 milligauss would be nearly impossible to meet and apparently unnecessary.

Discussion of new document 14/397A/NP

The chairman noted that the guide for the application of high temperature insulation materials in liquid immersed power transformers has been proposed. There appears to be support in TC14 for continuing the work. He expects the issue to be discussed at the next meeting of TC14 in 2002. In late breaking news, as of November 26, the work was approved:

14/405/WG announced the formation of **Working Group 29** to establish a document on **High Temperature Insulation Systems.** The convenor will be Rick Marek of Dupont, USA.

The chairman briefly discussed differences in the contents of IEC and IEEE standards; the latter seem less complete and less detailed than the former. He noted also that people who work on standards should understand that harmonization does not mean that standard document should be identical in language and text, but that they do not conflict.

Members briefly discussed how national and regional differences are reconciled in IEC standards. It was noted that the "in some country" clause is a vehicle for addressing this and regional acceptance (i.e., North American practices). Members urged that the Mexico National Committee be encouraged to participate in TC14 activities. The chairman agreed to identify the individual or organization to be contacted.

ACTION: P. Hopkinson provide information on individual or organization in Mexico for liaison activities.

It was noted that work on the loading guide in the IEC committee has been encumbered on the harmonization issue and has not moved as smoothly or as quickly as expected. It was noted that a draft document will be released in November for national committee review. It was noted that this matter will likely be discussed at the 2002 meeting of TC14 and it was important that the key people in the US and Canada review the document and provide comment as appropriate.

ACTION: P. Hopkinson circulate any proposal as soon as it is received.

Revision of IE 60076-11 (Dry-type power transformers)

The chairman briefly described a test requiring the immersion of the transformer in highly flammable liquid. It was noted that US had expressed interest in flame-resistance and evaluation technique. It was agreed that

New Work Item on Distribution Transformer Efficiency

The chairman presented a brief review of US activities relating to energy efficiency of distribution transformers, 2500 kVA and below. He inquired about member interest for submitting a new work proposal to the IEC. J. Foldi requested that a proposal be sent to the CNC subcommittee 14 for consideration.

Members engaged in a brief discussion. It was noted that such a document would define some of the economic parameters (TOC and payback period) for evaluating efficiency. Members agreed that the presentation of such a proposal would be useful. The chairman agreed to develop a proposal for review.

ACTION: P. Hopkinson prepare a proposal for TAG review.

NEW BUSINESS

There were no new business items identified. However, as of November 26, there were several new items of work that deserve a report:

14/399/WG announced the formation of **Working Group 28** to develop a document on **Transformers with internal protection.** The task will be to produce a standard for immersed distribution transformers with protection and current breaking device. The convenor will be Michel Sacotte of Schneider Electric, France.

14/402/MCR announced a **maintenance cycle report** on **IEC 60076-7** Power transformers-Part 7**: Loading guide for oil-immersed power transformers.** The convenor is Hasse Nordman of ABB, Norway.

14/403/CD is the revision of loading guide IEC 60354, announced in 14/402/MCR.

TIME AND PLACE OF NEXT MEETING

Members agreed to meet in conjunction with the IEEE Transformer Committee meetings in Vancouver, British Columbia in April 2002

ADJOURNMENT

There was no additional business. The meeting was adjourned at 9:25 AM

REPORTED BY
John A. Gauthier
TAG Administrator
16 October 2001