Annex E HVDC Converter Transformers and Reactors Subcommittee

April 13, 2015, 3.15 pm
San Antonio, Texas

Chair: **Michael Sharp**
Vice Chair: **Les Recksiedler**
Secretary: **Ulf Radbrandt**

E.1 Introduction / Attendance

Introductions were made and the attendance list circulated.

There were 12 members and 22 guests present. Two of the guests requested membership

The total membership of the SC is 17. We needed at least a total of 9 members to be present in order to have a quorum. This was achieved.

The agenda for this meeting was approved

E.2 Approval of the minutes of the October 20, 2014 meeting in Washington, DC

The minutes from the Washington meeting (Fall 2014) were approved.

E.3 Brief report on the meeting of the Administrative SC

The classification of 'corresponding member' is not allowed any more. Our five corresponding members have been contacted and they all agreed to be transferred to 'guest members'.

Two previous members have not been attending any of the three last meetings. They have been transferred to guest members.

Four attendees of the previous two meetings in a row have requested membership and been accepted. Those are Paul Jarman, Waldemar Ziomek, Arturo del Rio and Solomon Chiang.

NESCOM has approved the PAR to start a WG for a dual logo standard (together with IEC) for converter transformers. Ulf Radbrandt is the chair of this WG. The PAR expires December 31, 2018.

Our standard for converter transformers (C57.129) will expire in 2018, i.e. within 3.5 years.

Our standard for smoothing reactors (1277) will expire in 2020, i.e. within 5.5 years.

E.4 Working Group Reports

E.4.1 WG IEC/IEEE 60076-57-129 – Ulf Radbrandt (IEEE) and Anders Lindroth (IEC), Co-Chairs

This joint workgroup has had three joint meetings since the last IEEE Transformers Committee Meeting (Washington Fall 2014).

The three meetings are:

- Washington October 23-24 2014 (directly after last IEEE Transformers Committee meeting)
- Nürnberg February 3-5 2015
- San Antonio April 10-11 2015 (directly before this IEEE Transformers Committee meeting)

The Agreements and actions from the Washington meeting were the following:

- Anders Lindroth (convener of IEC MT 61378-2) to ask the members about their opinion on the polarity reversal time.
- The reports on comparisons on load loss measurements with both IEC and IEEE methods were transferred to next meeting.
- Mats Berglund, Pierre Riffon, Frank Trautmann and Sheila Batey should collect available data and prepare presentations regarding double loss measurements.
- Pierre Riffon showed some comparison of Fh factors from measurements made with both IEC and IEEE method. He will calculate and report on the resulting difference in total load losses.
- Pierre Riffon undertook to check for the IEEE requirement for running the pumps during the induced voltage test.
- Eric Davis will check on the general concept of referring to C57.12.00 and/or C57.12.90 in standards.
- Review Table 1 (Routine, Type and Special tests) to make certain that the transformers are tested consistently with the definitions of IEEE Class II.
- We agreed that the rated current should be defined as including the harmonics (The IEEE method).
- IEC is requiring not less than 12 hours for the Load-current test whereas IEEE is specifying 48 hours. What duration should be specified in the dual logo document? Prepare for a discussion and agreement at the next meeting.
- All members should review the completed parts of the document and suggest modifications if required.
- Ulf Radbrandt will ask Chris Ploetner to propose the text for the section on Sound-power level measurements.
- Ulf Radbrandt will suggest the text for the definition on Line side (or AC-side) and Valve side (or DC-side) and included it in the document after the meeting.
- A calculation of the hotspot factor should be included in the document. Anders Lindroth to prepare a proposal.

The Agreements and actions from the Nürnberg meeting were the following:

- Following a suggestion from Ugo Piovan the time duration for the PR test it was agreed to postpone the decision until the next meeting. In the meantime Anders Lindroth will ask Ugo Piovan to circulate the latest draft report from CIGRE JWG A2-D1.41 to the members of the joint WG.
- If the times for the Polarity Reversal test are changed, then the newly revised bushing standard IEC/IEEE 65700-19-03 on Bushings for DC application will also need to be changed as the time for the bushing tests are given the same as the present transformer standard.
- Comparison of loss measurement according to present IEC and IEEE standards was presented by Mats Berglund, Frank Trautmann, Sheila Batey and Pierre Riffon. The results show that the two methods give very similar results with a variation less than +/- 3 % in most cases.
- Zhang Shuqi presented an interesting analysis of the accuracy of the exponents 2 and 0.8 in the IEC loss calculation method. The findings suggested that deeper analysis need to be done. It was agreed that it cannot be done within the timeframe for the preparation of this dual logo standard.

- All members should check if the last paragraph (regarding 3-ph transformers) in section 6.4 (Load loss under service conditions) marked in red font can be removed. If not references to IEEE documents should be included. Prepare for discussion at next meeting.
- We agreed to use the IEC loss method with two frequencies measurement as the loss measurement method in the document.
- An additional special induced test with the pumps running, in units with OD cooling, was introduced.
- It was agreed that the document would be better structured if the present sections on "Insulation levels" and "Testing" were brought together into one section "Test requirements". Part of the present Testing section also specifies how the test shall be made. That part should be given a new section name "Tests". The present draft also has a lot of normative information in the notes to table 1. The normative information in the notes should be moved to the clauses describing the different tests in the new Tests section. Sheila Batey will prepare a proposal to be circulated before the next meeting.
- A new section on tank temperature rise should be included. Mats Berglund will prepare a proposal and circulate before the next meeting.
- The duration of the load current test was discussed. Ulf Radbrandt will ask IEEE HVDC SC members for the background to the requirement for the 48 hours test duration.
- The text provided by Chris Ploetner for the sound level section was considered too extensive and it was agreed that some parts will be moved to an informative Annex. Ulf Radbrandt will prepare a proposal based on our discussions.
- The calculation of the hotspot factor was not considered necessary for this document but we will ask for it to be introduced in HVDC transformer section in the IEC loading guide. Anders Lindroth will ask Dejan Susa to include this in the IEC loading guide.
- The field testing section was copied from the present IEEE standard. Eric Davis will search for the background information to the figures given.
- Eric Davis will check if the requirements on the oil is covered in other IEEE standards.
- Agreed to include an Annex giving information on what is required in the transformer specification. Ulf Radbrandt to prepare a proposal to be circulated before next meeting.

The Agreements and actions from the San Antonio meeting were the following:

- The CIGRE JWG A2-D1.41 has not yet prepared their document to the stage where they are prepared to share it. Discussion on PR test has to be postponed until next meeting.
- Decide on the minimum temperature for the DC tests after studying the CIGRE report.
  During d.c. withstand voltage tests the temperature of the oil shall be (20 ± 10) ^{0}C. The proposal is to only have the minimum temperature since the maximum temperature can be difficult to accomplish if the test is performed after the temperature rise test and the oil is still warm.
- Agreed to delete the last paragraph in section 6.4 (Load loss under service conditions) on special consideration for three winding transformers
  In the case of three-winding transformers, the winding arrangement shall be considered for the calculation of the eddy current losses in windings and of the stray losses in structural parts
- Added some more details in section 8.2.1 on how the load loss measurements should be made.
- Impedance measurement included in section 8.2, Title changed to "Load-loss and impedance measurements"
- Fred Eliot mentioned that an overvoltage test at 110% of maximum voltage with fundamental frequency for 2 hours is sometimes asked for. Should this be included as a special test? How

often is it asked for? A question regarding the frequency of the requirement will be raised at the IEEE SC meeting.

- Chris Ploetner will review Sections 8.14, 10 and the new Annex on Audible sound and suggest modifications to be circulated before next meeting.
- Since the IEC loss measurement method is used the Annexes on Determination of loss adjustment factors and Laboratory power testing concepts could be removed
- Ulf Radbrandt will review the test in the overloading Annex to make certain that the correct formulas are used based on the IEC method.
- Ulf Radbrandt will add a section in Annex B (HVDC converter transformers for use with voltage source converters) on the asymmetric configuration. This is needed because this standard is intended to be used for asymmetric configurations where the valve side windings are subjected to d.c. voltage.
- Eric Davis will review Annex C (Design Review) and prepare a suggestion for the text.
- A question regarding the background to the statement on 2000 pC sporadic pulses during the AC Induced test will be brought up during the IEEE SC meeting.
- The list of variables will be brought into alphabetical order by Sheila Batey.
- The field testing section was first copied from the present IEEE standard. Eric Davis has searched for the background information to the figures given.

  Comments by Peter Heinzig and Les Recksiedler pointed out that:
  Field tests on converter transformers are normally well prepared and observed by all parties. The limits currently presented in the IEEE standard should be deleted because they depend on the available equipment and boundary conditions. A proposal was made to write something general like “Dielectric field tests shall be agreed between manufacturer and purchaser during the order process”. We should not limit this to AC and DC tests because impulse test in field is possible today and required by customers especially after on site repair.

  The section was modified with the title “Dielectric tests on transformers that have been in service” to also cover tests after factory repair.
- The duration of the load current test was discussed. Ulf Radbrandt had asked IEEE SC members for the background to the requirement for the 48 hours test duration in the Extended load run test with overload in the IEEE document.

  Comments from Gene Wolf, Pierre Riffon, Waldemar Ziomek and Les Recksiedler pointed out that:
  The duration shall be long enough to get a valuable detection of dissolved gas-in-oil. HQ always ask for a 24 hours test if there is no overload test required in addition to the standardized heat run test.
  Because of the large amounts of insulation in converter transformers it takes a lot longer for the gasses to get into the oil. A converter transformer in the factory which was at the limit of DGA acceptance in a 12 hour load run test, was tested for 48 hours and it failed the DGA. Another converter transformer passed the 12 hour factory DGA test but was gassing badly in the field. It failed the 48 hour DGA load run test in the factory. The converter transformer standard now at Manitoba Hydro is 48 hours for that test.

  The decision was to not include a time of 48 or 24 hours at this stage. We considered that utilities can use the existing Load-current test (see below) with their desired test times. This should be discussed at the IEEE SC meeting.

- A new Annex, based on and referring to the Electra paper, “HVDC converter transformer specifications—A review of specification content,” Report, CIGRÉ JWG 12/14.10, ELECTRA, no. 141, pp. 35–49, Apr. 1992, has been created.
- Plan for the future joint WG work
  - The document should be circulated to the IEEE HVDC SC members for comments, after some editorial changes by Anders Lindroth. This should be proposed at the IEEE SC meeting.
  - Joint meeting in Milan Italy in September 2015
  - Document to CD within IEC and to Ballot within IEEE

E.5 Discussions and agreements regarding the work for a Dual Logo standard for converter transformers

Ulf Radbrandt made a presentation of the progress of the joint IEC/IEEE WG meetings (according to clause E.4 above). The discussions and agreements during and after the presentation were as follows:

- Winding arrangement considerations for the calculation of the eddy current losses and the stray losses in structural parts for three-winding transformers.

  This is only valid for three-phase, three-winding transformers, i.e. transformers with axial split. This is only to be considered in the transformer design. Instead of the deleted text we should add a note such as, “For transformers having axial split, the designer shall present that considerations to eddy current losses and stray losses in structural parts, due to that winding arrangement, have been taken into account”.
  For this type of transformer all three combinations (only one transformer function, the other and both) of loss measurement are performed in the same way as for normal transformers and does not have to be explained in our document.

- Special induced test with the pumps running, in units with OD cooling.

  Apparently there are different routines in different factories. Some manufacturers always do this test for OD-transformers but some never perform this test. All SC members with experience are encouraged to give comments on commonly used routines and background for this test.

- Calculation of hotspot factors

  Pierre Riffon disagreed with the decision to not include that in the document. The hotspot factors are normally too conservatively calculated based on all worst conditions in not consistent cases. That leads to too high hotspot factors, too conservative design and false alarms during operation. The hotspot factors should be based on realistic operation conditions. Pierre Riffon volunteered to give a proposal.

- Oil temperature limits during the DC withstand voltage test

  Pierre Riffon explained that this has been discussed earlier within IEEE. First it was considered that it was relevant to perform the DC test with oil of both room temperature and high temperature. Later the applied AC voltage test was introduced and that test was considered to cover for the DC test with high temperature. The recommendation is therefore to keep the existing temperature range.

- Overvoltage test at 110% of maximum voltage with fundamental frequency

  The test is to check the magnetic circuit, e.g. core joints.
  This test is sometimes required to be performed at up to 12 hours.
  The time should be long enough to get the oil temperature high enough to simulate full load.

It has been required for both converter transformers and normal transformers.
This test is not more relevant for converter transformers than for normal transformers.
Nobody at the meeting knew of any standard where this test is described. It was suggested that we shouldn't introduce a test in our standard before it is introduced in the general transformer standard.
If the test is introduced then it should be a special test.
SC members are encouraged to give more input regarding this. If someone insists that we should introduce this test then he/she should give a proposal to text including passing criteria.

- Background to the statement on 2000 pC sporadic pulses during the AC Induced test

  Pierre Riffon explained that these pulses are easy to see on the oscilloscope and that these pulses can destroy the test. The recommendation to energize the transformers at 1.1 p.u. for a few hours prior to the test, to remove trapped charges, should also be kept in the document. This is only recommendation and is suitable for a note.

- A motion was put forward by Pierre Riffon and seconded by Paul Jarman to circulate the Draft Dual Logo document within the IEEE SC members for comments.
  Ulf Radbrandt will send out the document for review to all SC members when Anders Lindroth has completed the editorial updates. All SC members should review the document thoroughly at this stage and give their comments. The joint WG will then have the possibility to consider the comments at next meeting and prior to official balloting. This will minimize the risk for negative votes by SC members at that time.

E.6 Old Business

None.

E.7 New Business

E.7.1 Revision of IEEE Std 1277

The chair (Michael Sharp) asked for volunteers to chair and participate on a working group to review and update IEEE Standard General Requirements and Test Code for Dry-Type and Oil-Immersed Smoothing Reactors for DC Power Transmission, IEEE Std 1277.

E.8 Adjournment

The meeting was adjourned at 4.26 pm.