

**IEEE TRANSFORMERS COMMITTEE
TEMPERATURE RISE TEST PROCEDURE
C57.12.90 SECTION 11.0
INSULATION LIFE SUBCOMMITTEE**

**March 18, 2008
Charlotte Westin Hotel
Charlotte, North Carolina USA**

Grand Ballroom C

11:00am – 12:15pm

Agenda

** Note: These items are posted for *C57.12.90 Sect 11.0 Temperature Rise* on the Insulation Life Subcommittee webpage of the [Transformers Committee](#).

1. Introductions
2. Membership
3. Patent Disclosures
4. Approval of Minutes**
5. Presentation by Marcel Fortin**
6. Projects:
 - a. Hot Resistance Measurement (*comments from straw vote attached*)
7. Old Business
8. New Business
9. Adjournment

Paulette Payne Powell
papayne@ieee.org

IEEE C57.12.90-2006	WG Proposal 10/16/2007	For WG Consideration 3/18/08
<p>a) The time from instant of shutdown shall be recorded for each resistance measurement</p> <p>b) At least one resistance measurement shall be taken on all terminal pairs within 4 min after shutdown.</p>	<p>a) The time from instant of shutdown shall be recorded for each resistance measurement. Juan Castellanos – approved w/comment - The time from instant of shutdown shall be recorded for each <u>hot</u> resistance measurement.</p> <p>b) A hot resistance measurement shall be made on each winding under test, and all windings shall be tested. <i>Steve Synder: I am unconvinced that it is necessary to measure all windings, or that we'll ever reach a consensus to require it. Under George Henry's WG this matter was battled to almost an even 50/50 split between those that wanted it and those that did not. While it might make sense as a mandatory measure for a large transformer representing a big capital investment, I don't think this is true for the rest of the industry. I disapprove.</i> Jerry Corkran - Disapproved - My vote will change to approved when "and all windings shall be tested" is deleted. The purpose of standard C57.12.90 is to specify how tests are conducted. The purpose of standard C57.12.00 is to specify what tests are conducted. Alan Darwin – approved w/comments - I think there might be need for a clarification concerning "and all windings shall be tested". What does this phrase really mean? What about unloaded tertiary windings; surely these do not require testing. Maybe the term "loaded winding" should be used. In addition, does "each winding under test" include each phase of a tested winding (for a 3-phase transformer of course) and if so, how are delta windings and wye windings without a star-point brought out to be dealt with? Juan Castellanos – approved w/comment - A <u>series of</u> hot resistance <u>measurements</u> shall be made on each winding under test, and all windings <u>of one phase</u> shall be tested. Lin Pierce - Specifically, the current standard requires resistance measurements on all terminal pairs for a three-phase transformer. The proposal requires an interpretation of what "winding" means. For example, a manufacturer may only test one terminal pair and state that this was a test of a "winding". A customer inspector may interpret this as requiring cooling curves on all terminal pairs in order to test all the windings. That is for a three phase transformer, six cooling curves, three on the HV and three on the LV. I prefer the term "terminal pairs"¹ to "windings".</p>	<p>a) The time from instant of shutdown shall be recorded for each <i>hot</i> resistance measurement.</p> <p>b) A <i>series of</i> hot resistance measurements shall be made on each <i>terminal pair</i> under test, and all <i>terminal pairs</i> shall be tested.</p> <p>Comments: 1. WG – Temperature Rise Test Procedures C57.12.90 Section 11 Meeting Minutes: The Task Force met March 21, 2006 at 8:00am in the Emerald 1 Room of the Costa Mesa Hotel in Costa, Mesa California ... 11.2.2 - Mr. Bob Ganser presented a proposal for a cooling standard curve format requiring a 10 minute data collection interval starting at time zero (when the power is taken off the system) with data points taken every 15 seconds up to 4 minutes, then every 30 seconds from the 4 to the 10 minute mark. This would generally result in 20 – 24 data points. Discussion ensued regarding the 15 second interval and if the shutdowns and data collection should be done for all three phases. Mr. Ganser suggested at least one measurement be made on all windings within 4 minutes of shutdown and that a minimum of 4 measurements be made on all windings as B-phase may not necessarily give the highest temperature rise. 2. Is there a need for a different requirement for distribution transformers?</p>

¹ IEEE 100 defines terminal pair (networks) - An associated pair of accessible terminals, such as input pair, output pair, and the like.

c) A series of at least four resistance measurements shall be made on one terminal pair corresponding to a phase of a winding.

c) The first resistance data point used to determine the resistance of the winding shall be taken as quickly as possible after shutdown and after core saturation and in any case, no later than 4 minutes after shutdown.

Hasse Nordmann – approved w/comment - We are just now struggling with the same issue within IEC, and our suggestion included in an Informative Annex can in your template be formulated as follows:

"c) The first resistance data point used to determine the resistance of the winding shall be taken

- within 2 minutes for transformers < 33 MVA/phase

- within 3 minutes for HV-windings of transformers equal or larger than 33 MVA/phase

- within 4 minutes for LV-windings of transformers equal of larger than 33 MVA/phase"

These times are the limits I would set, when I study our test room records.

This comment here is intended only as a hint when the work on this sub-clause is re-started after a number of years.

Juan Castellanos – approved w/comment - The first hot resistance data point used to determine the time zero hot resistance of the winding shall be taken as quickly as possible after shutdown and after core saturation and in any case, no later than 4 minutes after shutdown.

Lin Pierce – (1) My opinion is that the most important thing for a three phase transformer is to get the first readings quickly. It is entirely feasible to get the first reading within two minutes and all three within about 2 and one-half minutes.

(2) The proposal uses the term "and after core saturation". It appears that this requires that the core must be saturated by the test equipment. Apparently a word needs to be added, perhaps it should read,. "...after core saturation² disappears".

(3) As a technical issue, I question whether the term "core saturation" is accurate. I recall that the previous standards used the term "inductance³ effect". Now is not the resistance test equipment supplying a DC current? I (a Mechanical Engineer) remember an electrical circuit from elementary circuit classes consisting of a battery, a switch, an inductance L, and a resistance R. After the switch is thrown, a current flows, which decays to a constant value determined by the resistance. I seem to remember some differential equation with a term L dI/dt. What if you have an iron core? Does core saturation occur? I could be wrong on this and perhaps someone in the WG could clarify it.

c) The first hot resistance data point used to determine the time zero hot resistance of the winding shall be taken as quickly as possible after shutdown and after core saturation *disappears* and in any case, no later than 4 minutes after shutdown.

Or

c) The first hot resistance data point used to determine the time zero hot resistance of the winding shall be taken as quickly as possible after shutdown and *after the inductance effect disappears* and in any case, no later than 4 minutes after shutdown.

² IEEE 100 defines saturation - **(1) (signal-transmission system)** A natural phenomenon or condition in which any further change of input no longer results in appreciable change of output.

³ IEEE 100 defines inductance - (1) The property of an electric circuit by virtue of which a varying current induces an electromotive force in that circuit or in a neighboring circuit. (2) A force that resists the sudden buildup of electric current.

d) Resistance-time measurements in accordance with item c) shall be made on all windings.

d) The resistance versus time data shall be used as the basis for correction to time zero. The cooling curve format shall consist of a series of measured resistance points beginning with the first resistance data point in accordance with c) and ending with a resistance data point taken no sooner than 10 minutes from shutdown. All resistance data points taken within the 10-minute period after shutdown shall be recorded at no longer than 15-second intervals.

Steve Synder - I disagree with the requirement to measure resistance at 15 sec intervals for 10 minutes. While this requirement may work well for transformers of large mass, 10 minutes is much too long for small transformers. I would accept this statement : "Measurements shall be taken during 10 - 30 sec intervals to accumulate a minimum of 10 points."

Subhash Tuli - **Disapproved** for item # **d** with following comments: I will change my ballot to **Approve** if last three lines of item # d are changed to read as follows: " **All resistance data points taken within the 10 minutes period after shut down shall be recorded at no longer than 30- seconds interval.**" In changing this period from 30 seconds to 15 seconds as proposed will not provide any added value to the above Hot resistance measurements and will be aggressive. It will also not provide better curve as the duration of 10 minutes is fixed.

Jerry Corkran - **Disapproved - My vote will change to approved when the statement "shall be recorded at no longer than 15-second intervals" is deleted and also the 10 minute measurement requirement is deleted with the following added " Measurements shall be taken during 15 to 30 second interals to accumulate a minimum of 16 data points". CPS's heat run equipment is some of the newest and best available. It requires approximately 30 seconds to settle in to a good reading. Taking measurements at 15 second intervals results in less accurate data than at 30 second intervals.**

Waldemar Ziomek - The proposal looks fine, but we would oppose to 15 second intervals. For large transformers it is not realistic (due to saturation time). 30 second intervals would be no problem.

Marcel Fortin – approved w/comment - My only comment is that for distribution and category I transformers, the 10 minutes can be reduced to 5 minutes.

Juan Castellanos – approved w/comment - The hot resistance versus time data shall be used as the basis for correction to time zero. The cooling curve format shall consist of a series of measured hot resistance points beginning with the first hot resistance data point in accordance with c) and ending with a hot resistance data point taken no sooner than 10 minutes from shutdown. All hot resistance data points taken within the 10-minute period after shutdown shall be recorded at no longer than 15-second intervals.

d) The resistance versus time data shall be used as the basis for correction to time zero. The cooling curve format shall consist of a series of measured resistance points beginning with the first resistance data point in accordance with c) and ending with a resistance data point taken no sooner than 10 minutes from shutdown. All resistance data points taken within the 10-minute period after shutdown shall be recorded at no longer than *30-second intervals*.

Or

d) The resistance versus time data shall be used as the basis for correction to time zero. The cooling curve format shall consist of a series of *X measured resistance points for power transformers and Y measured resistance points for distribution transformers* beginning with the first resistance data point in accordance with c). All resistance data points taken within the *time period* after shutdown shall be recorded at no longer than *30-second intervals*.

e) The resistance-time data collected in item c) shall be corrected to the instant of shutdown using a resistance-time cooling curve determined by plotting data on suitable coordinate paper, or by using a curve fitting program.

e) The resistance-time data collected in d) shall be corrected to the instant of shutdown using a resistance-time cooling curve determined by plotting the data on suitable coordinate paper, or by using a computerized curve fitting program.

Don Platts - I can not agree to retaining the wording in e). Plotting the data on paper and drawing a curve is not acceptable. I believe that we need to standardize this portion of the test procedure to ensure that every test lab will produce the same resistance at the instant of shutdown, (and therefore, the same temperature), when given the same set of resistance data points.

Jerry Corkran - Add - A minimum of 16 data points are required to support the cool down curve which is created.

Juan Castellanos – approved w/comment - The hot resistance-time data collected in d) shall be extrapolated to the instant of shutdown using a resistance-time cooling fitting curve determined by plotting the data on suitable coordinate paper, or by using a computerized curve fitting program.

e) The *hot* resistance-time data collected in d) shall be *extrapolated* to the instant of shutdown using a resistance-time cooling curve determined by plotting the data on suitable coordinate paper, or by using a computerized curve fitting program. *The minimal least squares of the fitted cooling curve to the data collected in d) shall define the best statistical fitting curve.*

f) The resistance-time data obtained on one phase of a winding shall be used to determine the correction to shutdown for the other phases of the same winding, provided the first measurement of each of the other phases has been taken within 4 min after shutdown.

f) The resistance-time data obtained on one phase of a winding shall be used to determine the correction to shutdown for the other phases of the same winding, provided the first measurement of each of the other phases has been taken within 4 min after shutdown.

Steve Snyder - Ultimately I think we made need one set of criteria for distribution transformers, and another set for power.

Jerry Corkran - Due to scheduling conflicts, it is difficult for most of the Distribution Transformer Committee members to attend the WG sessions. Request that this survey be sent to the Distribution Transformer Committee to obtain their input.

Lin Pierce - Please consider me a non-voting corresponding member if there is such a category. Although the new proposal requires more frequent resistance measurements, the new language is less specific than the current standard in other areas. It would be very interesting if the members of the working group representing manufacturers would state for the record (that is, to be recorded in the minutes) exactly their sequence of measurements for the test. For example, at my previous employer, the sequence for a three-phase transformer was as follows (as best I can remember):

1. Cold resistance was made on all terminal pairs prior to the test. Oil temperatures and ambient temperatures recorded.
2. Heat run started.
3. When oil temperature rise over ambient reached the tolerance specified in the test code, oil and ambient temperatures were recorded.
4. The heat run was shut down and the resistance measuring equipment time was started. That is time equals zero.
5. The test personnel removed the short from the LV, the power leads, and attached the resistance leads to all three terminals of either the LV or HV.
6. Resistance measurements were made on one terminal pair (after the inductance effect disappeared)
7. The resistance bridge had a switch, and then resistance measurements were made on the other two terminal pairs. The only time limitation was the inductance effect.
8. The resistance bridge was switched back to the first terminal pair in Step 6. The resistance was then recorded continuously. (Thus the 15 second requirement was easily met.)
9. The resistance time data for the terminal pair with the cooling curve was fitted using a computer program and the resistance at time zero was computed for the other two terminal pairs using the data from the cooling curve.
10. The heat run was resumed and held for a minimum of one hour and the steps repeated for whichever of the HV or Lv was not tested previously.

Please forward my comments to others in the Working Group. Look forward to reading the minutes of the meeting.