

WG C57.12.90 Sect. 11 – Temperature Rise Tests (Insulation Life SC)
Ballot Survey 11.2.2 Summary - July 6, 2011

The survey was conducted via email of the 129 active members of the C57.12.90 Section 11.0 Working Group, Insulation Life Subcommittee and Distribution Transformer Subcommittee. There is overlap of the membership among the entities:

- 2% are members of the Working Group and both Subcommittees
- 5% are members of both Subcommittees
- 2% are members of the Working Group and Distribution Transformer Subcommittee
- 7% are members of the Working Group and Insulation Life Subcommittee.

There were 79 respondents to the survey satisfying the quorum requirement with a majority of the respondents approving the proposed modification:

- 51 approved
- 9 approved with comment
- 9 disapproved
- 10 abstained
- Approval ratio = 60/69 = 87%.

Following is the Ballot Survey which was restricted specifically to modifications (*highlighted in yellow*) which would amend the approved proposal dated February 4, 2009.

BALLOT SURVEY – WG C57.12.90 Section 11

11.2.2 Hot-resistance measurements

a) The time from the instant of shutdown, i.e. time zero, shall be recorded for each hot resistance measurement.

b) For *distribution transformers*, a hot resistance measurement shall be made on each terminal pair, and a series of hot resistance measurements shall be made on at least one terminal pair under test. For *power transformers*, a series of hot resistance measurements shall be made on each terminal pair under test, and all terminal pairs shall be tested.

c) For *distribution transformers*, at least one resistance measurement shall be taken on all terminal pairs within a time less than half the coils shortest time constant after shutdown.

For *power transformers*, 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 inductive effects disappear and in any case, no later than 4 minutes after shutdown. In order to achieve core saturation in a short time period, the DC power supply voltage should be large enough to saturate the cores in a short time.

The DC source should be selected such that it can also provide sufficient current to keep the core saturated without causing excessive heating of windings. A series resistor added to the circuit will decrease time to stabilization.

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When a transformer has a winding connected in delta, all involved core legs shall be saturated unless the delta is open during shutdown, for stable and accurate readings. When performing winding resistance measurements on a transformer that utilizes series transformers for load tap changing, care is required to ensure that the whole circuit, consisting of the main and series transformer windings, is saturated before stable readings of the combined winding resistances can be obtained.

d) 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).

For distribution transformers, at least 10 resistance measurements shall be made on one terminal pair corresponding to a phase of a winding. All resistance data points shall be recorded at no longer than 30 second intervals and no less than 10 second intervals.

For power transformers, the ending hot resistance data point shall be 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.

e) The hot resistance-time data collected in d) shall be extrapolated to the instant of shutdown using a computerized curve fitting program to determine the hot resistance-time cooling curve. The hot resistance-time data collected shall be fitted to an exponential decay curve using the method of least squares.

NOTE 1 - Comparative to large power transformers, the time constant of small distribution transformers may be short due to transformer thermal characteristics and measuring equipment which may affect the appropriateness of an exponential decay curve.

NOTE 2 - The mean oil temperature surrounding the winding and the actual location of the winding may result in top and bottom oil temperatures not giving the intended average winding oil temperature which could affect the appropriateness of the exponential decay curve.

NOTE 3 -The Working Group is initiating an investigation to define appropriate curves concerning notes 1 and 2 for a future modification to this clause.

f) When the series of hot resistance measurements on a *distribution transformer* is made on only one terminal pair under test, 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 a time less than half the coils shortest time constant after shutdown.

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Balloters approving with comments:

Jim Graham – After reviewing the proposed comment, I approve the proposed changes with two comments highlighted in red.

“ c) For *distribution transformers*, at least one resistance measurement shall be taken on all terminal pairs within a time less than half the ~~coils~~ **coil's** shortest time constant after shutdown. “

“f) Whenthe series of hot resistance measurements on a *distribution transformer* is made ... provided the first measurement of each of the other phases has been taken within a time less than half the ~~coils~~ **coil's** shortest time constant after shutdown.”

Jerry Murphy – As a user these are good benchmarks and an improvement over the previous lacking information. My only thought would be a reference to where one will find how to calculate or obtain the transformer coil time constant. Minor editorial on the first highlighted sentence there needs to be an apostrophe in coil's as this is a possessive use of the word in this case.

Bruce Forsyth – I question the use of “coils shortest time constant” since the time constant is not truly known until after the temperature rise test is complete.

Yunxiang Chen – Is the “coils shortest time constant” required to be displayed in the name plate?

Al Traut – In d), the requirement of 10 hot resistance measurements is excessive and does not substantially improve the accuracy of the test. A minimum of 5 hot resistance readings is adequate.

Steve Shull – In subclause 11.2.2.d, the requirement of 10 hot resistance measurements appears to me to be too large. I believe that this is overkill. I would like to see this reduce to ½ as many. I believe that 5 should be enough to insure accuracy of the test. Since time is money I believe 10 may raise the cost of the unit over the long haul when you consider the number of units produced for this type of transformer.

Phil Hopkinson – For manufacturers with data logging equipment the appropriate recording should readily be possible and a good thing to do. For manufacturers who do not possess data logging equipment the measurements will be difficult. It is still a good thing to do and will lead to better and more repeatable results.

Hemchandra Shertudke – I approve this change subject to providing sample curves for representative transformers in these classes for points 'd' and 'e' respectively. Please ask Manufacturers to provide some to illustrate the wording in pictorial form.

Don Duckett – I guess my only thought is the references to “distribution” and “power” transformer classifications ... should this be “rectangular wound” coils vs. circular or disk wound or Pancake types?

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Balloters Disapproving Survey

Don Ayers – I vote NO to the increase in the number of resistance readings necessary for a temperature rise test. This may be easy to do for those manufacturers that have sophisticated equipment that can take multiple phase readings simultaneous but for distribution transformer with short time constants, trying to obtain all of the resistance readings in the time frame is very difficult. I don't believe that all the additional readings will add anything to the accuracy or to the state of knowledge in temperature testing.

Jerry Corkran – I disapprove of the changes listed below for the similar reasons as listed below from my comments on the previous negative ballot on the same subject:

11.2.2.c – Negative about the procedure calling for resistance measurements all terminal pairs. One terminal pair is adequate as the other terminals are thermal duplicates.

11.2.2.d – Negative regarding requirement for a minimum of 10 data points; a minimum of 8 data points provides accurate results. The existing standard has only required 4 data points for many years. Going from 4 to 8 is a significant change. Going to 10 data points adds no accuracy to the tests and is not required.

Negative regarding the allowed 10 seconds spacing of resistance measurements. Recommend at least 20 sec minimum spacing between resistance measurements. The required time depends on size of unit and inductance; for some units, the max time has to be up to 45-50 sec.

My vote will change to positive if for distribution transformers measurements are made on one terminal pair, taking at least 8 measurements. For all transformer use between 20 and 40 seconds between resistance measurements.

The longer time between resistance readings is needed in some instances to assure that duplicate readings do not result in the same resistance values.

Tom Holifield – I vote to DISAPPROVE. I appreciate the concept of attempting to obtain measurements within limit that is based on the coil time constant; however, practically, at this time, I'm concerned that different testers and observer will use different and inconsistent methods to arrive at the time constant value. I would approve the following [*changes*]:

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 inductive effects disappear and in any case, no later 4 minutes after shutdown. In order to achieve core saturation in a short itme period, the DC power supply voltage should be large enough to saturate the cores in a short time.”

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[Note: This revision deletes the first sentence of the proposed (item C) which states with “For distribution transformers” and deletes the first three words of the next sentence “For power transformers.” Basically everything in yellow is deleted.]

d)

“For *distribution transformers*, at least 10 resistance measurements shall be made on one terminal pair corresponding to a phase of a winding. At least 10 resistance measurements shall be recorded at no longer than 30 second intervals and no less than 10 second intervals. However, any additional resistance measurements may be recorded.”

e)

“The hot resistance-time data collected in d) shall be extrapolated to the instant of shutdown using a computerized curve fitting program to determine the hot resistance-time cooling curve. The hot resistance-time data collected shall be fitted to an exponential decay curve using the method of least squares. For distribution transformers the measurements used for this extrapolation shall be a minimum of 10 recorded at no longer than 30 second intervals, and no less than 10 second intervals. However, any additional resistance measurements may be recorded.”

f) “When the series of hot resistance measurements on a *distribution transformer* is made on only one terminal pair under test, 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 minutes after shutdown.”

Lee Matthews – I would vote to disapprove the proposed modifications to Sub-clause 11.2.2 and propose the following revisions:

c) For distribution transformers, the resistance measurements for each terminal pair which does not receive a series of hot resistance measurements shall be taken during a time period after shutdown not exceeding the time required for the cooling curve resistance measurements in accordance with d).

e) The hot resistance-time data collected in d) shall be extrapolated to the instant of shutdown using a computerized curve fitting program to determine the hot resistance-time cooling curve.

Remove NOTES 1&2.

New NOTE 1 – The Working Group is initiating an investigation to define an appropriate cooling curve method for future modification to this clause.

f) When the series of hot resistance measurements on a distribution transformer is made on only one terminal pair under test, 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, provide the resistance measurement of each of the other phases has been taken as noted in c).

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Kevin dela Houssaye – I would vote to disapprove the proposed modifications to Sub-clause 11.2.2 and propose the following revisions:

c) For distribution transformers, the resistance measurements for each terminal pair which does not receive a series of hot resistance measurements shall be taken during a time period after shutdown not exceeding the time required for the cooling curve resistance measurements in accordance with d).

e) The hot resistance-time data collected in d) shall be extrapolated to the instant of shutdown using a computerized curve fitting program to determine the hot resistance-time cooling curve.

Remove NOTES 1&2.

New NOTE 1 – The Working Group is initiating an investigation to define an appropriate cooling curve method for future modification to this clause.

f) When the series of hot resistance measurements on a distribution transformer is made on only one terminal pair under test, 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, provide the resistance measurement of each of the other phases has been taken as noted in c).

Gary King – I vote to disapprove the proposed modifications to Sub-clause 11.2.2. My disapproval of these changes is due to the coil time constant restriction.

~~c) For *distribution transformers*, at least one resistance measurement shall be taken on all terminal pairs within a time less than half the coil's shortest time constant after shutdown.~~

~~For *power transformers*, 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 inductive effects disappear and in any case, no later than 4 minutes after shutdown. In order to achieve core saturation in a short time period, the DC power supply voltage should be large enough to saturate the cores in a short time.~~

~~f) When the series of hot resistance measurements on a *distribution transformer* is made on only one terminal pair under test, 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 a time less than half the coils shortest time constant 4 minutes after shutdown.~~

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Said Hachchi – Please see my responses in blue.

c)

For power transformers, 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 inductive effects disappear and in any case, no later than 4 minutes after shutdown. In order to achieve core saturation in a short time period, the DC power supply voltage should be large enough to saturate the cores in a short time. **Disapprove – revision add: For power or distribution transformers**

d)

For *distribution transformers*, at least 10 resistance measurements shall be made on one terminal pair corresponding to a phase of a winding. All resistance data points shall be recorded at no longer than 30 second intervals and no less than 10 second intervals. **Approve with comment: this should be done for all terminal pairs.**

Sanjib Som –

c) For *distribution transformers*, at least one resistance measurement shall be taken on all terminal pairs within a time less than half the coil's shortest time constant after shutdown.

We are writing a standard. This statement does not define a method of computing “coil time constant” as required by this test. Thus it will depend on the manufacturers’ calculation which will be different for each manufacturer and hence not a standard approach. Further the ‘coil time constant’ can be computed after the test. Does this imply that if after test it is determined that the measurements do not meet this standard then the test is to be repeated; then what if the time constant changes due to variation of measurement from one measurement to the next measurement? Will we be chasing a moving target by a statement in an international standard? I am voting against this unless this clause also specifies a standard formula for computing ‘coil time constant.’

f) We are stating requirement of ‘coil time constant’ without defining a standard method of calculating it. I am rejecting this proposal. I propose that the originator please provide a method to compute the ‘coil time constant’ for this standard – else we will either chase a moving target (as explained in (c) above) or use non-standardized practice to implement a standard.

Juan Castellanos – I keep my negative vote to the proposal. As I mentioned previously, because there is a lack of standard method to calculate the thermal time constants of windings. Every manufacturer/tester would have their own set of equations, and that is what we are trying to solve with this revision. A possible solution would be to reduce the time to the first hot resistance measurement, (i.e. 2 or 3 minutes according to industry average), but keeping the use of a constant time value.