

Task Force on Partial Discharge Testing of Class I Power Transformers

**Monday, October 19, 2020
Online Meeting 3:30 – 4:45 P.M.**

**IEEE/PES Transformers Committee
Fall 2020 – Virtual Meeting**

Agenda

- 1. Welcome and call to order**
- 2. Patent announcement**
- 3. Membership and quorum**
- 4. Approval of agenda**
- 5. Review of scope and purpose of task force**
- 6. Review of progress to date**
- 7. Special considerations**
- 8. Discussion of bushings to test**
- 9. Discussion on acceptance criteria**
- 10. Determine verbiage & location in standard**
- 11. Approval to adjourn**
- 12. Last thoughts**

Participants have a duty to inform the IEEE of Essential Patent Claims

Participants shall inform the IEEE (or cause the IEEE to be informed) of the identity of each holder of any potential Essential Patent Claims of which they are personally aware if the claims are owned or controlled by the participant or the entity the participant is from, employed by, or otherwise represents

Participants should inform the IEEE (or cause the IEEE to be informed) of the identity of any other holders of potential Essential Patent Claims

Membership Requirements

- 1. Voting membership shall be granted automatically to those participants attending the meeting of a newly chartered Task Force upon their request.**
- 2. Voting membership may be requested and granted after attending two consecutive meetings. Voting membership is granted after the second consecutive meeting.**
- 3. If a voting member misses two consecutive meetings, his or her voting privileges may be revoked. Notification will be sent if voting privileges are revoked.**
- 4. Voting privileges may be reinstated and granted after attending two consecutive meetings.**
- 5. Attendance will be taken of those that are logged into the virtual meeting.**

Voting Membership (36 – Quorum = 18)

(Based on attendance at initial meeting requesting membership)

Mario Alonso

Javier Arteaga

Onome Avanoma

Donald Ayers

Israel Barrientos

David Calitz

Binzhan Chen

Ben Clark

James Cross

Jorge Cruz

Marcos Ferreira

John Foschia

Jitka Fuhr

Jose Gamboa

Carlos Gaytan

Zoran Goncin

Jose Gonzalez Ceballos

Detlev Gross

Said Hachichi

Sergio Hernandez Cano

Peter Kleine

Neil Kranich

David Larochelle

Victor Mendez

Matthew Mollenkopf

Ali Naderian

Arturo Nunez

Parminder Panesar

Leopoldo Rodriguez

Pugazhenthil Selvaraj

Aron Sexton

Kerwin Stretch

Charles Sweetser

Janusz Szczechowski

Ajith Varghese

Pragnesh Vyas

Scope

This task force will define the partial discharge testing procedure of liquid-immersed power transformers, autotransformers and regulating transformers, classified as Class I by IEEE Std. C57.12.00, Clause 5.10

Definition of Class I Power Transformer

IEEE Std. C57.12.00, 5.10 Insulation Levels

... power transformers are separated into two different classes as follows:

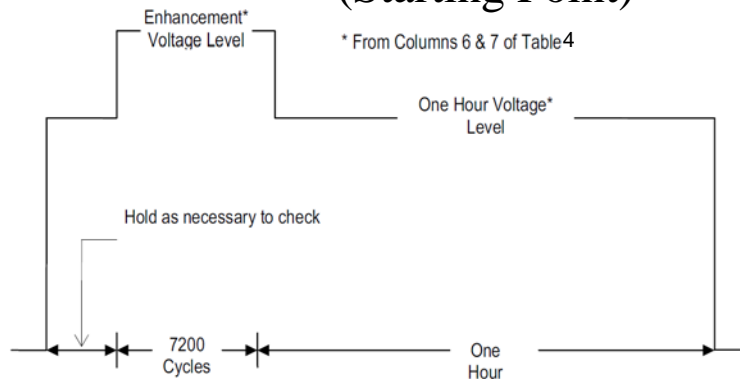
- a) Class I power transformers are any that are not categorized as Class II, described in item b).
- b) Class II power transformers shall include power transformers with high-voltage windings rated for 115 kV nominal system voltage and above, and also power transformers with high-voltage windings rated 69 kV through 115 kV nominal system voltage, having a top nameplate rating of at least 15 000 kVA for three-phase transformers or 10 000 kVA for single-phase transformers.
- c) Scope will not include transformers designated as distribution transformers.

Purpose of Task Force

The task force is to establish the methodology, procedures and performance requirements for partial discharge testing on Class I Power Transformers.

Test Procedure for Class II Transformers

(Starting Point)



Enhanced Level – $1.80 \times \text{NSV}$

One-hour Level – $1.58 \times \text{NSV}$

NSV = Nominal system voltage

10.8.2 Test procedure

The voltage shall first be raised to the 1 h level and held for a minimum of 1 min or until a stable partial discharge level is obtained to verify that there are no partial discharge problems. The level of partial discharges shall be recorded just before raising the voltage to the enhancement level. The voltage shall then be raised to the enhancement level and held for 7200 cycles. The voltage shall then be reduced directly to the 1 h level and held for 1 h.

During this 1 h period, partial discharge measurements shall be made at 5 min intervals. Partial discharge acceptance criteria shall be based on each line terminal rated 115 kV and above. These measurements shall be made in accordance with 10.9.

10.8.5 Failure detection (Acceptance)

- The **magnitude** of the partial discharge level **does not exceed 500 pC** during the 1-h test period.
- The **increase** in partial discharge levels **during the 1-h period does not exceed 150 pC**.
- The partial discharge levels during the 1-h period **do not exhibit any steadily rising trend**, and **no sudden sustained increase** in the levels occurs **during the last 20 min** of the test.

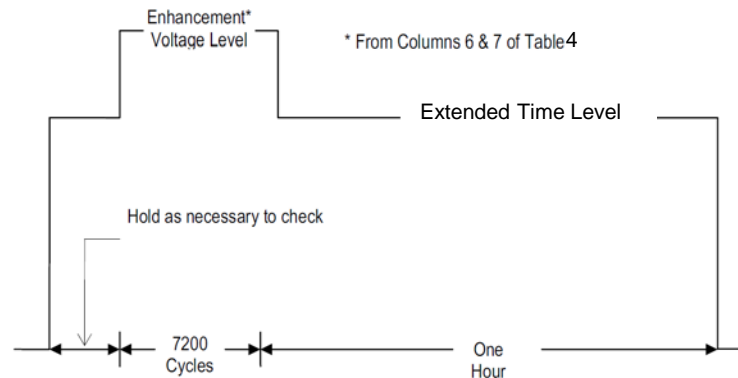
Subjects to Consider

(**Red** indicates agreed to values)

- ✓ Enhanced Voltage Level (**1.8 x NSV**)
- ✓ Voltage Level of Extended Time test (**1.58 x NSV**)
- ✓ Length of Extended Time test (**1 hour**)
- ✓ Voltage Level of first reading (**1.58 x NSV**)
- Special Considerations? Bushings?
- Test all bushings or just highest voltage winding
- Acceptance levels (pC and/or μV)
- Require test or optional?
- Verbiage and location in standards
- Other thoughts

Test Procedure for Class I Transformers

(Accepted Levels Similar to Class II Methodology)



Proposal #	Start Level	Enhanced Level	Extended Time Level	Duration	Acceptance Criteria
1	150% NSV	200% NSV	150% NSV	1/2 hour	500 pC @ 150% NSV
2	158% NSV	200% NSV	158% NSV	1 hour	500 pC @ 158% NSV
3	120% NSV	200% NSV	120% NSV	1 hour	500 pC @ 120% NSV
4	100% NSV	200% NSV	150% NSV	30 sec.	Xxx pC @ 150% NSV pC Free @ 100% NSV
Accepted	158% NSV	180% NSV	158% NSV	1 hour	TBD

Acceptance Levels

Present Standard for Class II Power Transformers

- a) The **magnitude** of the partial discharge level **does not exceed 500 pC** during the **1-h test period**.
- b) The **increase** in partial discharge levels **during the 1-h period does not exceed 150 pC**.
- c) The partial discharge levels during the 1-h period **do not exhibit any steadily rising trend**, and **no sudden sustained increase** in the levels occurs **during the last 20 min** of the test.

C57.12.90 – 2015 Class I Test

10.7 Induced-voltage tests for distribution and Class I power transformers

10.7.1 Test duration

The induced-voltage test shall be applied for 7200 cycles, or 60 s, whichever is shorter.

10.7.2 Test frequency

As an induced-voltage test applies greater-than-rated volts per turn to the transformer, the frequency of the impressed voltage shall be high enough to limit the flux density in the core to that permitted by 4.1.6.1 of IEEE Std C57.12.00-2015. The minimum test frequency to meet this condition is given in Equation (27):

$$\text{Minimum test frequency} = \frac{E_t}{1.1 \times E_r} \times \text{rated frequency} \quad (27)$$

where

E_t is the induced voltage across winding (V)

E_r is the rated voltage across winding (V)

C57.12.90 – 2015 Class I Test

10.7.3 Application of voltage

The voltage should be started at one quarter or less of full value and be brought up gradually to full value. After being held for the time specified in 10.7.1, it should be reduced gradually before the circuit is opened.

10.7.4 Grounding of windings

When a transformer has one end of the high-voltage winding grounded, the other windings should be grounded during the induced-voltage test. This ground on each winding may be made at a selected point of the winding itself or of the winding of a step-up transformer that is used to supply the voltage or that is connected for the purpose of furnishing the ground.

10.7.5 Need for additional induced tests

When the induced test on a winding results in a voltage between terminals of other windings in excess of the low-frequency test voltage specified in Table 3 or Table 4, as applicable, of IEEE Std C57.12.00-2015, the other winding may be sectionalized and grounded. Additional induced tests shall then be made to give the required test voltage between terminals of windings that were sectionalized.

10.7.6 Failure detection

Careful attention should be maintained for evidence of possible failure, such as an indication of smoke and bubbles rising in the insulating liquid, an audible sound such as a thump, a sudden increase in test circuit current, or an appreciable increase in partial discharge level. Any such indication should be carefully investigated by observation, by repeating the test, or by other tests to determine whether a failure has occurred.

C57.12.90 – 2015 Class II Test

10.8 Induced-voltage test for Class II power transformers

10.8.1 General

Each Class II power transformer shall receive an induced-voltage test with the required test levels induced in the high-voltage winding. The tap connections shall be chosen, when possible, so that test levels developed in the other windings during the 1 h test are x times their maximum operating voltages, as specified in ANSI C84.1, where x is the ratio of the test voltage on the high-voltage winding to the maximum operating voltage.

10.8.2 Test procedure

The voltage shall first be raised to the 1 h level and held for a minimum of 1 min or until a stable partial discharge level is obtained to verify that there are no partial discharge problems. The level of partial discharges shall be recorded just before raising the voltage to the enhancement level. The voltage shall then be raised to the enhancement level and held for 7200 cycles. The voltage shall then be reduced directly to the 1 h level and held for 1 h.

During this 1 h period, partial discharge measurements shall be made at 5 min intervals. Partial discharge acceptance criteria shall be based on each line terminal rated 115 kV and above. These measurements shall be made in accordance with 10.9.

10.8.3 Connections

The transformer shall be excited exactly as it will be in service. The voltage may be induced from any winding or from special windings or taps provided for test purposes. Single-phase transformers shall be excited from single-phase sources. Three-phase transformers shall be excited from three-phase sources. The neutral terminals and other terminals that are normally grounded in service shall be solidly grounded. This will stress all of the insulation at the same per unit of overstress.

C57.12.90 – 2015 Class II Test

10.8.4 Frequency

The test frequency shall be increased, relative to operating frequency, as required to avoid core saturation. The requirements in 10.7.2 are also applicable in the case of this induced test.

10.8.5 Failure detection

Failure may be indicated by the presence of smoke and bubbles rising in the insulating liquid, an audible sound such as a thump, or a sudden increase in the test current. Any such indication shall be carefully investigated by observation, by repeating the test, and by other diagnostic tests to determine whether a failure has occurred. In terms of interpretation of partial discharge measurements, the results shall be considered acceptable and no further partial discharge tests required under the following conditions:

- a) The magnitude of the partial discharge level does not exceed 500 pC during the 1-h test period.
- b) The increase in partial discharge levels during the 1-h period does not exceed 150 pC.
- c) The partial discharge levels during the 1-h period do not exhibit any steadily rising trend, and no sudden sustained increase in the levels occurs during the last 20 min of the test.

Judgment should be used on the 5-min readings so that momentary excursions of the partial discharge readings caused by cranes or other ambient sources are not recorded. Also, the test may be extended or repeated until acceptable results are obtained.

A failure to meet the partial discharge acceptance criterion shall not warrant immediate rejection, but it shall lead to consultation between purchaser and manufacturer about further investigations.

Discussion notes on Verbiage

Wrap-Up Comments