

Task Force on Partial Discharge Testing of Class I Power Transformers

Monday, April 26, 2021

Online Meeting 10:45 am – 12:00 pm CDT

**IEEE/PES Transformers Committee
Spring 2021 – Virtual Meeting**

Agenda

- 1. Welcome and call to order**
- 2. Patent announcement**
- 3. Membership and quorum**
- 4. Approval of agenda**
- 5. Approval of minutes.**
- 6. Review of scope and purpose of task force**
- 7. Review of progress to date**
- 8. Open items**
- 9. Determine verbiage & location in standard**
- 10. Last thoughts**
- 11. Approval to adjourn**

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 (35 – Quorum = 18)

(Based on attendance at last two meetings 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

Jose Gamboa

Carlos Gaytan

Zoran Goncin

Jose Gonzalez Ceballos

Detlev Gross

Said Hachichi

Sergio Hernandez Cano

Peter Kleine

Neil Kranich

David Larochele

Victor Mendez

Matthew Mollenkopf

Ali Naderian

Arturo Nunez

Parminder Panesar

Leopoldo Rodriguez

Pugazhenth 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

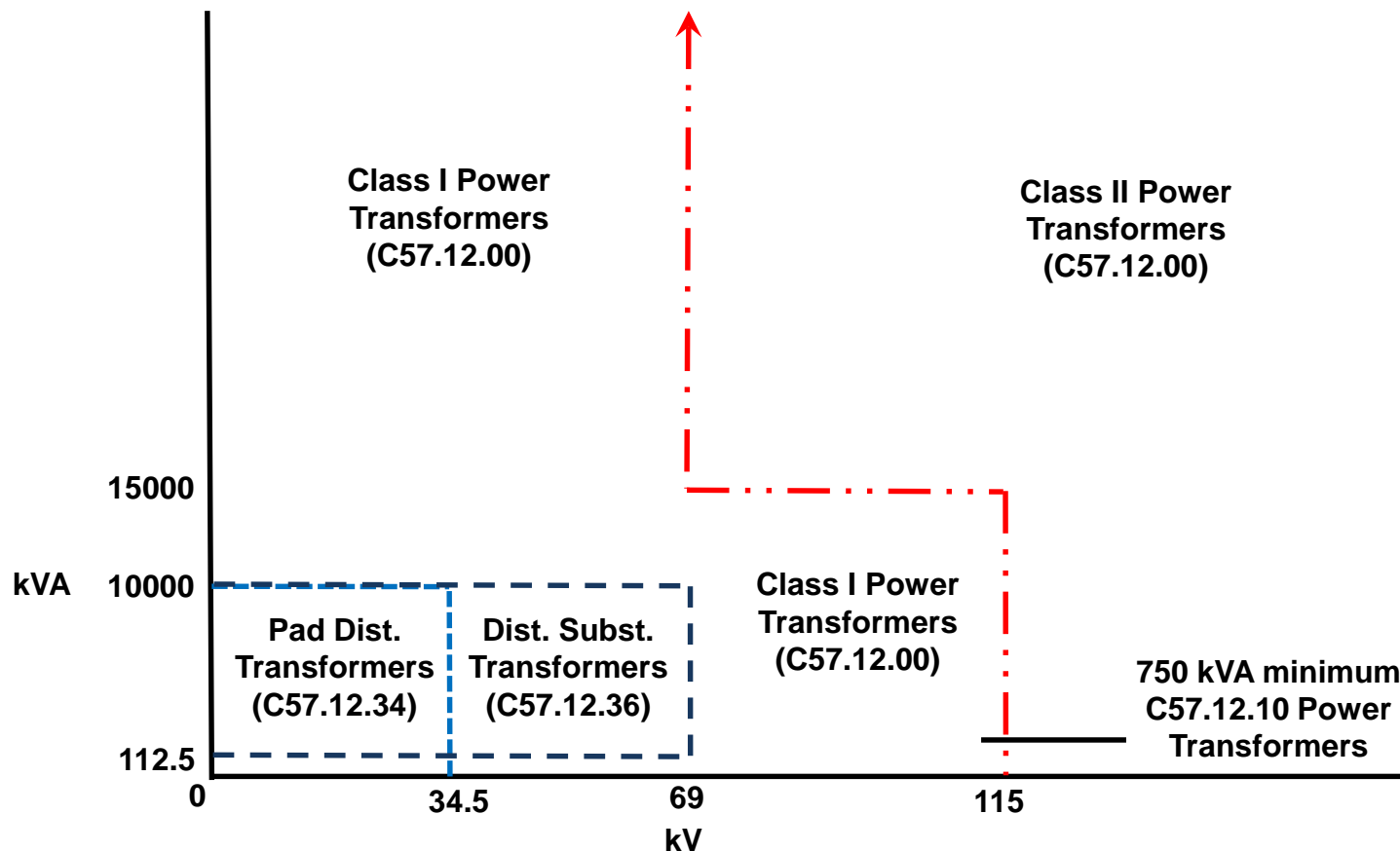
IEEE Std. C57.12.00, 5.10 Insulation Levels

... 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.

Definitions

(Corrected 4/28/2021)



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.

Subjects to Consider

- Enhanced Voltage Level
- Voltage Level of Extended Time test
- Length of Extended Time test
- Voltage Level of first reading
- Special Considerations? Bushings?
- Test all bushings or only highest voltage
- Acceptance levels (pC and/or μV)
- Required test or optional?
- Verbiage and location in standards
- Other thoughts

Progress to Date

Motions voted on to date

1. Enhanced voltage test to be set at 200%. Motion failed (3+/22-).
2. Enhanced voltage test to be set same as Class II level. Motion passed (All +).
3. Extended time test voltage to be set at 1.58 NSV. Motion passed (All +).
4. Extended time test length to be set at 1 hour. Motion passed (All +).
5. Level of 1st PD measurement to be at 1 hour level – 1.58 NSV (All +).
6. When PD testing is specified for Class I power transformers, this test should be carried out as defined by C57.12.00-2015, and the PD limit shall be as stated in C57.12.90-2015. Motion passed (16+, 2-, 7 abstain).
(Note: pC57.12.90-2021 Draft 4 reduces passing criteria from maximum of 500 pC to 250 pC and the maximum increase from 150 pC to 50 pC)
6. Measure PD only on the terminals with the highest voltage rating. Motion passed (16+, 1-, 6 abstain).

Subjects to Consider

(**Red** indicates agreed to actions)

- ✓ 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 only highest voltage (**Highest only**)
- ✓ Acceptance levels (pC and/or μV) (**Same as Class II**)
- Required test or optional?
- Verbiage and location in standards
- Other thoughts

Acceptance Levels

Present Standard for Class II Power Transformers
voted to be the same for Class I Power Transformers

- a) The **magnitude** of the partial discharge level **does not exceed 500 pC (250 pc)** during the **1-h test period**.
- b) The **increase** in partial discharge levels **during the 1-h period does not exceed 150 pC (50 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.

Blue notation are proposed limits in pC57.12.90-2021
Draft 4

Comparison of Test Voltages

IEEE C57.12.00-2015		Table 3 Col 6	----- Table 4 ----- Col 6	Col 7
Maximum System Voltage kV	Nominal System Voltage kV	Class I Induced Test ----- 2.0 x NSV	Class II Induced Test Phase to Ground kV ----- 1.8 x NSV	Class II One- Hour Test ----- 1.58 x NSV
1.5	1.2	1.5	1.3	1.1
3.5	2.5	2.9	2.6	2.3
6.9	5	5.8	5.2	4.6
11	8.7	10	9	7.9
17	15	17	16	14
26	25	29	26	23
36	34.5	40	36	32
48	46	53	48	42
73	69	80	72	63
121	115	133	120	105

***** Figures do not presently exist in the tables**

Discussion Items

1. Required test or optional?
2. Special Considerations? Bushings?

Note: The voltage rating of the highest voltage bushing should be evaluated in determining the capability of the Class I transformer to pass a partial discharge test. (Place at end of clause

Note: For highest voltage bushings on a unit rated below 69 kV will generally require the equivalent of a coupling capacitor connected to the appropriate bushing to properly measure partial discharges during a test.

3. Verbiage and location in standards
See following suggestion

Suggested Amended Wording of IEEE C57.12.00

(Red are suggested changes)

5.10.5.5 Induced-voltage test for Class II, and when specified each Class I, power transformers

With the transformer connected and excited as it will be in service, an induced-voltage test shall be performed as indicated in Figure 2, at voltage levels indicated in Columns 6 and 7 of Table 4. Minimum line-to-ground induced test levels for Class II power transformers shall be a multiple of corresponding line-to-ground nominal system voltage as follows: 1.58 times for one hour tests and 1.8 times for 7200 cycles enhancement level tests.

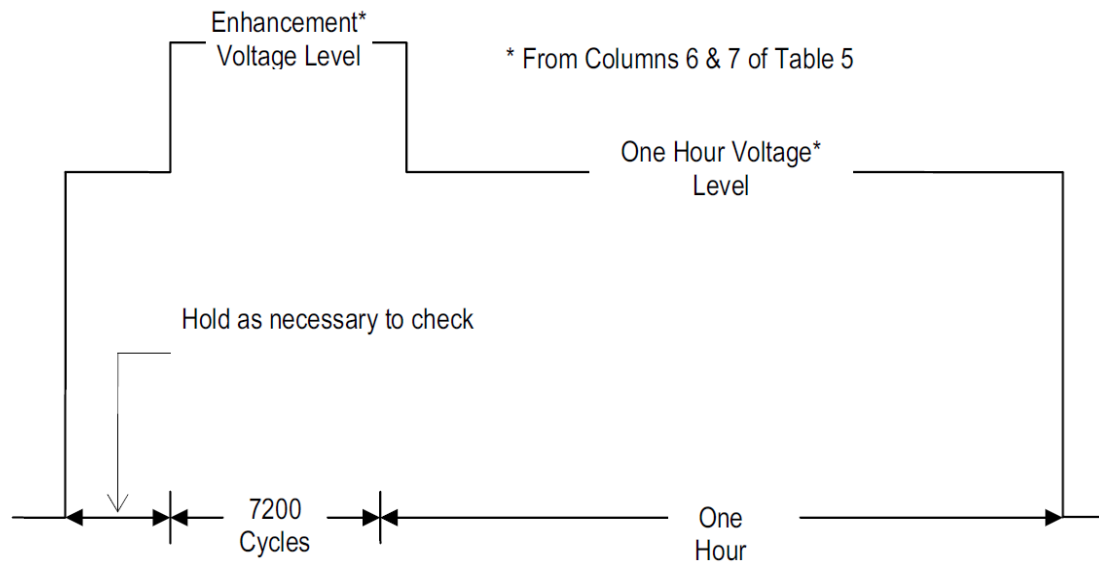


Figure 2 —Induced voltage test for Class II power transformers

Suggested Amended Wording of IEEE C57.12.90 (1)

(**Red** are suggested changes)

10.8 Induced-voltage test for Class II, **and when specified Class I**, power transformers

10.8.1 General

Each Class II, **and when specified each Class I**, 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.

Suggested Wording to IEEE C57.12.90 (2)

During this 1 h period, partial discharge measurements shall be made at 5 min intervals. For Class II power transformers partial discharge acceptance criteria shall be based on each line terminal rated 115 kV and above. For Class I power transformers the partial discharge acceptance criteria shall be based on the terminals with the highest rated voltage. 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.

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.

Suggested Wording to IEEE C57.12.90 (3)

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.
- a) The increase in partial discharge levels during the 1-h period does not exceed 150 pC.
- a) 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.

Final Thoughts

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**Thank you for your participation
in this Task Force. Your
contributions were much needed
and appreciated.**