PC57.154
Standard for Liquid-Immersed Transformers Designed to Operate at Temperatures Above Conventional Limits Using High-Temperature Insulation Systems

IEEE/PES Transformers Committee
Insulation Systems Subcommittee

March 25, 2019
Anaheim, California, USA

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Working Group Agenda

- **Welcome & chair's remarks**
- **Call for patents**
- Introduction of attendees & roster circulation
- Establish quorum
- Approval of agenda
- Approval of previous meeting minutes
- Suggestions for revision activities
- Adjourn

Participants have a duty to inform the IEEE

- **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**

Early identification of holders of potential Essential Patent Claims is encouraged

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Ways to inform IEEE

- **Cause an LOA to be submitted to the IEEE-SA (patcom@ieee.org); or**
- **Provide the chair of this group with the identity of the holder(s) of any and all such claims as soon as possible; or**
- **Speak up now and respond to this Call for Potentially Essential Patents**

If anyone in this meeting is personally aware of the holder of any patent claims that are potentially essential to implementation of the proposed standard(s) under consideration by this group and that are not already the subject of an Accepted Letter of Assurance, please respond at this time by providing relevant information to the WG Chair

Other guidelines for IEEE WG meetings

- **All IEEE-SA standards meetings shall be conducted in compliance with all applicable laws, including antitrust and competition laws.**
  - **Don't discuss the interpretation, validity, or essentiality of patents/patent claims.**
  - **Don't discuss specific license rates, terms, or conditions.**
    - Relative costs of different technical approaches that include relative costs of patent licensing terms may be discussed in standards development meetings.
      - **Technical considerations remain the primary focus**
  - **Don't discuss or engage in the fixing of product prices, allocation of customers, or division of sales markets.**
  - **Don't discuss the status or substance of ongoing or threatened litigation.**
  - **Don't be silent if inappropriate topics are discussed … do formally object.**

For more details, see *IEEE-SA Standards Board Operations Manual*, clause 5.3.10 and *Antitrust and Competition Policy: What You Need to Know* at http://standards.ieee.org/develop/policies/antitrust.pdf

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Patent-related information

The patent policy and the procedures used to execute that policy are documented in the:

- ***IEEE-SA Standards Board Bylaws***
  (http://standards.ieee.org/develop/policies/bylaws/sect6-7.html#6)
- ***IEEE-SA Standards Board Operations Manual***
  (http://standards.ieee.org/develop/policies/opman/sect6.html#6.3)

Material about the patent policy is available at *http://standards.ieee.org/about/sasb/patcom/materials.html*

If you have questions, contact the IEEE-SA Standards Board Patent Committee Administrator at patcom@ieee.org

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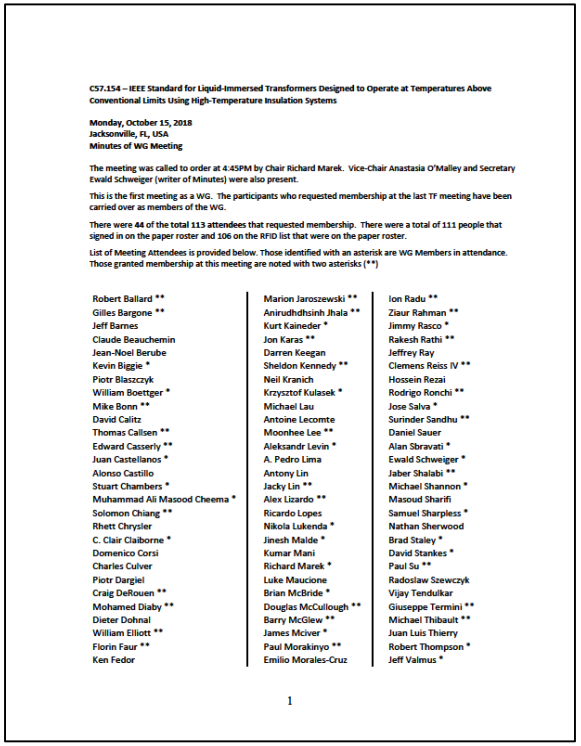

C57.154 – IEEE Standard for Liquid-Immersed Transformers Designed to Operate at Temperatures Above Conventional Limits Using High-Temperature Insulation Systems

Monday, October 15, 2018
Jacksonville, FL, USA
Minutes of WG Meeting

The meeting was called to order at 4:45PM by Chair Richard Marek. Vice-Chair Anastasia O'Malley and Secretary Ewald Schweiger (writer of Minutes) were also present.

This is the first meeting as a WG. The participants who requested membership at the last TF meeting have been carried over as members of the WG.

There were 44 of the total 113 attendees that requested membership. There were a total of 111 people that signed in on the paper roster and 106 on the RFID list that were on the paper roster.

List of Meeting Attendees is provided below. Those identified with an asterisk are WG Members in attendance. Those granted membership at this meeting are noted with two asterisks (**)

Robert Ballard **
Gilles Bargone **
Jeff Barnes
Claude Beauchemin
Jean-Noel Berube
Kevin Biggie *
Piotr Blaszczyk
William Boettger *
Mike Bonn **
David Calitz
Thomas Callsen **
Edward Casserly **
Juan Castellanos *
Alonso Castillo
Stuart Chambers *
Muhammad Ali Masood Cheema *
Solomon Chiang **
Rhett Chrysler
C. Clair Claiborne *
Domenico Corsi
Charles Culver
Piotr Dargiel
Craig DeRouen **
Mohamed Diaby **
Dieter Dohnal
William Elliott **
Florin Faur **
Ken Fedor

Marion Jaroszewski **
Anirudhdhsinh Jhala **
Kurt Kaineder *
Jon Karas **
Darren Keegan
Sheldon Kennedy **
Neil Kranich
Krzysztof Kulasek *
Michael Lau
Antoine Lecomte
Moonhee Lee **
Aleksandr Levin *
A. Pedro Lima
Antony Lin
Jacky Lin **
Alex Lizardo **
Ricardo Lopes
Nikola Lukenda *
Jinesh Malde *
Kumar Mani
Richard Marek *
Luke Maucione
Brian McBride *
Douglas McCullough **
Barry McGlew **
James Mciver *
Paul Morakinyo **
Emilio Morales-Cruz

Ion Radu **
Ziaur Rahman **
Jimmy Rasco *
Rakesh Rathi **
Jeffrey Ray
Clemens Reiss IV **
Hossein Rezai
Rodrigo Ronchi **
Jose Salva *
Surinder Sandhu **
Daniel Sauer
Alan Sbravati *
Ewald Schweiger *
Jaber Shalabi **
Michael Shannon *
Masoud Sharifi
Samuel Sharpless *
Nathan Sherwood
Brad Staley *
David Stankes *
Paul Su **
Radoslaw Szewczyk
Vijay Tendulkar
Giuseppe Termini **
Michael Thibault **
Juan Luis Thierry
Robert Thompson *
Jeff Valmus *

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Task Force 1
Thermal Class of Liquids

- Scope:
  - Consider the background and historical applications
  - Consider options to prove (or develop) the temperature limits for transformer liquids
  - Propose tentative test procedure(s)
- Status of the activities after a kick-off meeting and 3 conference calls

Definitions Agreed With the Group

- **Thermal class of a liquid** is the maximum continuous operation temperature leading to a life expectation for the liquid insulation longer than the IEEE unit of life (180,000 hrs.) under normal operating conditions.
- **Thermal limit of a liquid** is the maximum short time temperature it can be exposed to, since crossing this limit may lead to non-acceptable accelerated degradation rate.
- **The thermal limit for any component immersed in the liquid** would be related with the closed-cup flash point of the liquid or the thermal gravimetric analysis (TGA) , or other limiting parameters, as an indication of the temperature were volatile compounds may be formed.

Proposed “Screening Test”

- A sealed vessel test methodology was proposed.
- Differently from the IEEE C57.100, the vessels should contain only the insulating liquid, without other materials
- Proposal is to run 4 weeks of accelerated aging, having one vessel at the “proposed thermal class”, as a baseline, and two others at steps of +25°C
- After one week inside the oven, on of the bottles would be removed and let cooling down. All the liquid would be used for the laboratorial analysis.
- DGA will not be included in this screening test

Preliminary Estimate Of Times And Temperatures

For mineral oil

	105 °C	130 °C	155 °C
Cell #	0	0	0
1	168 hrs	168 hrs	168 hrs
2	336 hrs	336 hrs	336 hrs
3	672 hrs	672 hrs	672 hrs
4	1344 hrs	1344 hrs	1344 hrs

For natural and synthetic esters

	130 °C	155 °C	180 °C
Cell #	0	0	0
1	168 hrs	168 hrs	168 hrs
2	336 hrs	336 hrs	336 hrs
3	672 hrs	672 hrs	672 hrs
4	1344 hrs	1344 hrs	1344 hrs

Proposed Tests to be Performed

For mineral oil

- Color: ASTM D1500-98
- Dissipation Factor (power factor): ASTM D924-92, at 100°C [%]
- Neutralization Number (acidity): ASTM D974-97, [mg KOH/g]
- Interfacial Tension: ASTM D971-99 [mN/m]
- Breakdown Voltage: ASTM D1816 [kV]

For natural esters

- Color: ASTM D1500-98,
- Dissipation Factor (power factor): ASTM D924-92, at 25°C [%]
- Neutralization Number (acidity): ASTM D974-97, [mg KOH/g]
- Kinematic viscosity: ASTM D445, at 40°C, [mm2/s (cSt)]
- Breakdown Voltage: ASTM D1816 [kV]

For synthetic esters

- Color: ASTM D1500-98
- Dissipation Factor (power factor): ASTM D924-92, at 100°C [%]
- Neutralization Number (acidity): ASTM D974-97, [mg KOH/g]
- DC resistivity at 90°C – IEC 60247 (GΩ x m)
- Breakdown Voltage: ASTM D1816 [kV]

IEEE C57.154 Definition Review

- Objective:
  - Compare definitions in IEEE C57.154 with those in C57.12.80 (also under revision).
  - Determine if there are any conflicts.
- Volunteers:
  - Dave Stankes
  - Jose Silva

IEEE C57.154 Definition Review

- Nine definitions found in C57.154
- Eight definitions are only found in C57.154.
- No conflict noted.
- The definitions include:
- **conventional**
- **conventional insulation system**
- **full hybrid insulation winding**
- **high-temperature**
- **high-temperature insulation system**
- **high-temperature insulation winding**
- **hybrid insulation system**
- **mixed hybrid insulation winding**

IEEE C57.154 Definition Review

- Results: One definition is found in both documents: **reference temperature**

C57.154 "reference temperature"	C57.12.80 "reference temperature"
The standard temperature to which calculations and measurement are referred shall be defined as 20 °C plus the base rated average winding rise. For multiple winding transformers that have more than one base rated average winding rise, the highest average winding rise shall be used to determine the reference temperature.	Unless otherwise stated, the reference temperature shall be defined as 20ºC plus the rated average winding rise. For multiple winding transformers that have more than one base rated average winding rise, the highest average winding rise shall be used to determine the reference temperature.

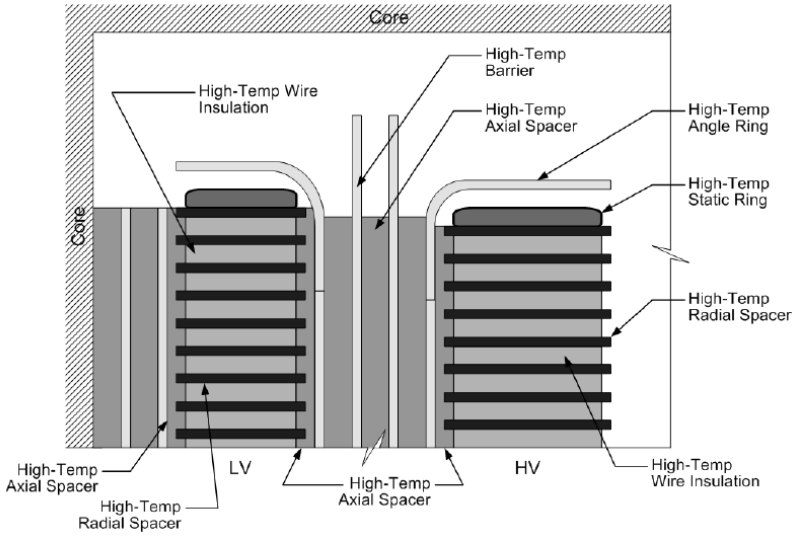
- Discussion:

  Both definitions are technically similar, although 12.80 gives ability to use a reference temperature other than 20C by including the "unless otherwise stated" statement. Should C57.154 definition be updated to match definition found in C57.12.80?

Precision Needed for High Temperature Insulation System Description

4.2.4 High-temperature insulation winding

This winding style shall use high-temperature insulation material throughout the winding such as conductor insulation, radial and axial spacers separating the coil sections, barrier cylinders and angle rings. See Figure 3 for an illustration of this winding style.



Note "b" under Table 2, as of today:

"Some conventional insulation is acceptable in locations where conventional temperatures are maintained."

Note "c" under Table 4 as of today:

"The high-temperature insulation may include different temperature classes, all above conventional."

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Precision Needed for High Temperature Insulation System Description

In reality, if top liquid rise in high temperature system is not 90 K but 80 K or less, the temperature to which barriers or angle rings are exposed, may not exceed normal allowance for cellulose temperature (80 K hot spot rise allowed for cellulose).

It is suggested:

1. To unify the notes identified on the previous slide.
2. To add a clarification for such case in the document, in section 4.2.4:

"If liquid temperature does not exceed temperature allowed for conventional insulation, components exposed only to the liquid temperature can be made of conventional insulation. This makes the design similar to hybrid insulation system.

It shall be ensured that the conventional insulation components are not exposed to hot liquid stream from winding cooling ducts, which may exceed the top liquid temperature. Also, the conventional insulation shall not be exposed to excessive temperatures of other hot parts."

Proposal for Informative Annex ”Guidance on High Temperature Transformer Applications”

IEEE Std. C57.154 Purpose:

This standard provides specific requirements and guidance in the design, testing, and application of the transformers covered within its scope.

Today, there is no guidance on high temp transformer applications in C57.154.

Some minimal guidance is included in IEEE 1276, but that document shall rather focus on high temperature insulation materials and insulation systems, not on transformers. C57.154 is the right place for that guidance.

An Informative Annex is proposed.

Proposed Contents for Informative Annex ”Guidance on High Temperature Transformer Applications” (draft has ca. 10 pages)

1. Description of high-temperature transformers

2. Characteristics and applications of transformers with hybrid insulation systems

   2.1 Power transformers

   2.2 Mobile transformers *(including applications, typical specification requirements, typical design aspects, like: forced ODAF cooling, switches, short circuit forces, auxiliary power supply, trailer and accessories, etc.)*

   2.3 Distribution transformers

3. Characteristics and applications of transformers with high temperature insulation systems

   3.1 Power transformers

   3.2 Distribution transformers

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On-Load Tap-Changers

- Technical comments have been transmitted for Ballot of P1276.
  Some of these comments would also be appropriate for C57.154.
  ⇨ Alignment P1276 – C57.154 ?

Further questions to be answered:

- Which temperature profiles can be defined for transformers in HT applications ?
- What is the estimated lifetime of a HT transformer ?
  Is it also 30+ years – or shorter ?
  - Same as conventional transformers
  - 180, 000 hours
  - or…?
- Is it possible to estimate a figure for the requested number of LTC operations during the lifetime of a HT transformer ?
- Which temperature rise of contacts can be allowed in ester liquids, at top-liquid temperatures of 140°C max ?

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