# Annex E Transformers and Reactors for HVDC Applications Subcommittee

**March 20, 2023, 4.45 pm local time – Lakeshore B at the Hyatt Regency, Milwaukee, WI**

**Chair:** **Ulf Radbrandt (ulf.radbrandt@ieee.org)**
**Vice Chair:** **Les Recksiedler (lrecksiedler@yahoo.ca) - absent**
**Secretary:** **Klaus Pointner (klaus.pointner@ieee.org)**

## E.1 Introduction / Attendance / Approval of the Agenda / Essential Patent Issues

There was a total of 18 persons in the meeting, 7 members and 11 guests present. No new request for membership was received.

Call for patents (essential patent claim) and IEEE copyright policy have been addressed.

Actual membership prior the Spring 2023 meeting is shown below:

| Last name | First name | Company name |
|---|---|---|
| Caverly | David | Trench Limited |
| *Chiang* | *Solomon* | *The Gund Company* |
| *Davis* | *Eric* | *Burns & McDonnell* |
| Ermakov | Evgenii | Hitachi Energy |
| Falkenburger | Thomas | Coil Innovation USA, Inc. |
| Gaun | Alexander | Coil Innovation GMBH |
| Heinzig | Peter | Weidmann Electrical Technology |
| Hernandez | Giovanni | Virginia Transformer Corp. |
| *Kaineder* | *Kurt* | *Siemens Energy* |
| Ploetner | Christoph | Siemens Energy |
| *Pointner* | *Klaus* | *Trench Austria GmbH* |
| *Radbrandt* | *Ulf* | *Hitachi Energy* |
| Recksiedler | Leslie | Manitoba Hydro |
| Riffon | Pierre | Pierre Riffon Consultant Inc. |
| *Sharp* | *Michael* | *Trench Limited* |
| *Ziomek* | *Waldemar* | *PTI Transformers* |

7 members out of 16 members were present, thus quorum was not met.

The agenda for this meeting, that was distributed via E-mail on March 10, 2023, was presented, no comments received. Approval of the agenda and minutes of meeting of the Charlotte meeting will be done via E-Mail

The list of all attendees of the meeting is shown below:

| First Name | Last Name | Company |
|---|---|---|
| Camilo | Casallas | Trench Limited |
| Solomon | Chiang | The Gund Company |
| Eric | Davis | Burns & McDonnell |
| J. Arturo | Del Rio | Siemens Energy |
| Kurt | Kaineder | Siemens Energy |
| Omar | Mendez | Prolec GE |
| Sylvain | Plante | Hydro-Quebec |
| Klaus | Pointner | Trench Austria GmbH |
| Bertrand | Poulin | Hitachi Energy |
| Ulf | Radbrandt | Hitachi Energy |
| Michael | Sharp | Trench Limited |
| Waldemar | Ziomek | PTI Transformers |
| Hossain | Saif | Trench Limited |
| Duvier | Bedoya | Hitachi Energy |
| Frank | Neder | Trench Germany |
| Nina | Sandsten | Hitachi Energy |
| Vivian | Chan | Hitachi Energy |
| Eunyoung | Cho | Hilo American |

### E.2 Approval of the minutes of the October 2022 Fall meeting in Charlotte

The minutes of the fall meeting as distributed by E-mail on March 10, 2023 have been presented. No comments were given. Approval of the minutes will be obtained by separate E-Mail to the members of the SC HVDC.

### E.3 Brief report on the meeting of the Administrative SC by Ulf Radbrandt

No specific information from the administrative SC beside that already given at the opening session. For detailed information, please see the general meeting MoM.

### E.4 Working Group Reports

The IEEE1277 has been published 2020 (10 years stability until Dec 31, 2030). The dual logo standard IEC/IEEE 60076-57-129 was published 2017 and is good until Dec 31, 2027.
No active working groups.

### E.5 Status of the Entity WG for development of the Guide for vibration testing of oil-immersed HVDC converter transformer.

The SC HVDC will sponsor this Entity WG. Therefore, future work of this WG will be reported to this subcommittee. The actual status of the WG is outlined in the presentation submitted to the WG chair prior to the spring meeting. It is planned that representatives of this WG are present at the Fall 2023 meeting in Kansas City.

# Guide for Vibration Testing of Oil-immersed High-Voltage Direct Current (HVDC) Converter Transformer (±160 kV to ±1100 kV) PC57.132

**China Southern Power Grid**

**IEEE Power and Energy Society**
**Transformers**

## Content



2

## 1. Working Group

In the early planning stage of this guide, over 60 people expected to be actively involved in the development of this project, and people come from the **8 entities** includes:

(1) China Southern Power Grid;
(2) State Grid Corporation of China;
(3) Electric Power Research Institute;
(4) Hitachi energy;
(5) Siemens energy;
(6) Chongqing University;
(7) Wuhan University;
(8) Tsinghua University.

3

## Content



4

## 2.Planning of the guide

The expected date of submission of draft to the IEEE SA for Initial Standards Committee Ballot is **Dec 2025**, and the projected completion date for submittal to RevCom is **Oct 2026**. Besides, according to the standards development process, the planning of each year is scheduled as:


**2023** **Task 1:** Mobilizing a Working Group ( **holding a meeting**)
**Task 2:** Start to Draft the Guide ( **holding a meeting**)

**2024** **Task:** Draft the Guide ( **holding discussion meeting twice** )

**2025** **Task 1:** Finish the Draft ( **holding discussion meeting twice** )
**Task 2:** Submit Draft for MEC

**2026** **Task 1:** Form balloting group and start balloting
**Task 2:** Modify the draft according to comment from balloting (**holding discussion meeting twice** )
**Task 3:** Submit the draft to RevCom

Mobilizing a Working Group
Draft the Guide
Ballot the Guide
Submit to RevCom

5

## Content



6

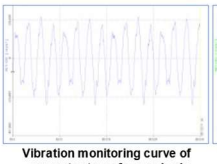
## 3. Relevant research progress

◆ Research on vibration principle of converter transformer –Vibration Sources

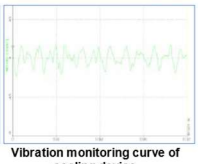
**Source 1-Core vibration**
Mutual attraction between silicon steel sheets under the action of magnetostriction and eddy current

**Source 2-Winding vibration**
Dynamic electromagnetic force caused by load current electrodynamic force and leakage magnetic field

**Source 3-Cooling device vibration**
Vibration caused by rotation of fan and oil pump motor



Vibration monitoring curve of converter transformer body



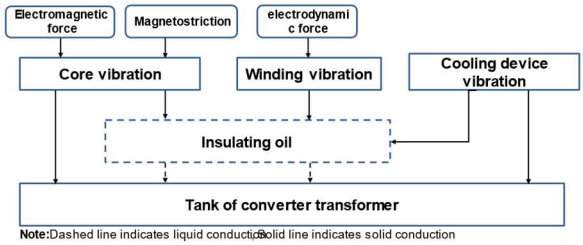
Vibration monitoring curve of cooling device

Three kinds of vibration constitute the vibration of converter transformer, but the **main sources** are **core vibration** and **winding vibration**

7

## 3. Relevant research progress

◆ Research on vibration principle of converter transformer –Vibration transmission path



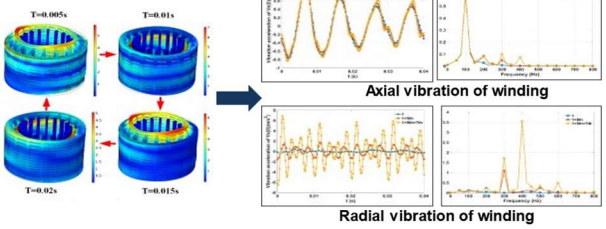

Note:Dashed line indicates liquid conduction;Solid line indicates solid conduction

- The vibration of iron core, winding and cooling device can be transmitted to the oil tank through transmission channels such as transformer oil and solid connectors
- The signals of different transmission paths will overlap each other, so the surface vibration of converter transformer box comes from the common vibration of multiple different vibration sources and is coupled through multiple transmission paths

8

## 3. Relevant research progress

◆ Research on vibration principle of converter transformer –Simulation research




Axial vibration of winding

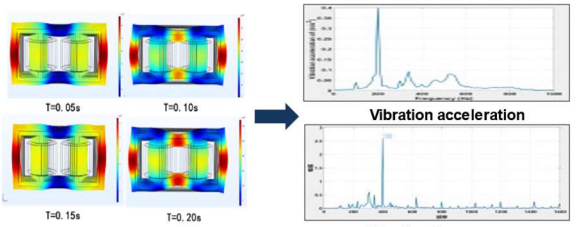
Radial vibration of winding

- Through simulation and analysis of winding vibration characteristics under harmonics, it is found that the main frequency of axial vibration of winding under fundamental, 5th and 7th harmonics is still 100Hz, and the spectrum has 200-400Hz components. However, the dominant frequency of radial vibration is shifted to 400Hz. And the radial vibration contribution of the winding exceeds the axial vibration .

9

## 3. Relevant research progress

◆ Research on vibration principle of converter transformer –Simulation research




Vibration acceleration

Vibration frequency

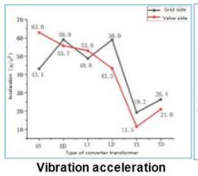
- Through simulation and analysis of core vibration characteristics under harmonics, it is found that the main frequency of core vibration will also shift from 100Hz to 400Hz, and the spectrum range will become wider, and the high-frequency component will increase.

10

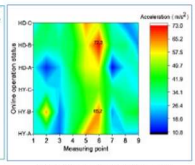
## 3. Relevant research progress

◆ Actual measurement and analysis

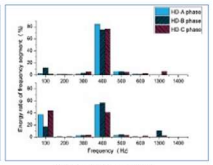
We have carried out vibration test for the actual converter transformer and made a preliminary analysis of the data.



Vibration acceleration



Vibration acceleration and distribution nephogram of measuring points



Vibration energy characteristics

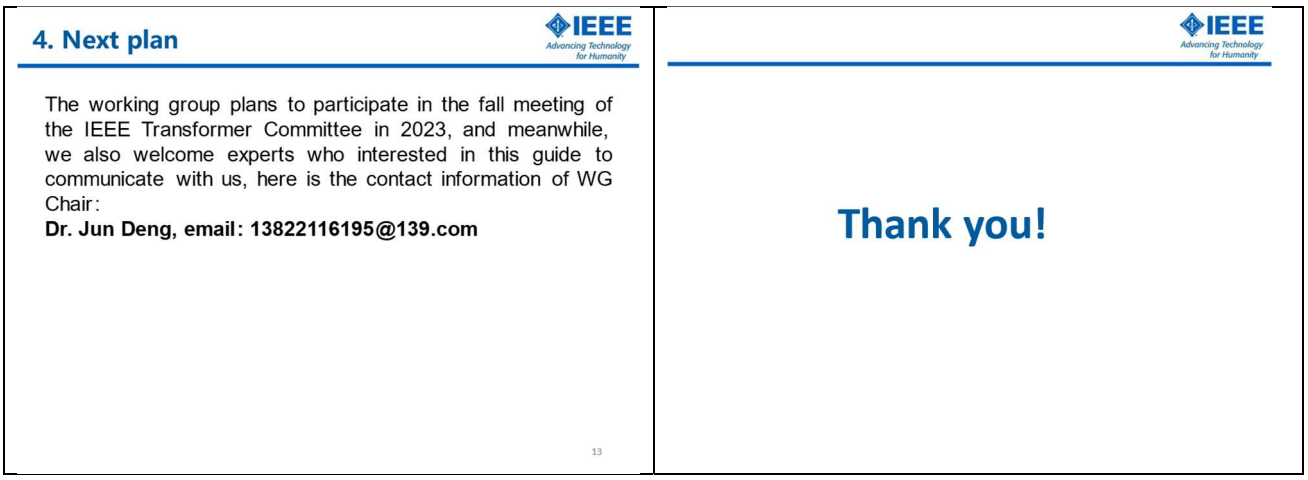
- The frequency spectrum of converter vibration is mainly concentrated in 0~2000Hz, with obvious main frequency (mainly distributed in 300Hz~500Hz) and maximum amplitude >3.6g (traditional transformer vibration main frequency 100Hz, maximum amplitude 0.5g). The frequency complexity is large, and the vibration spectrum energy is more dispersed.

11

## Content



12




A discussion took place how this SC can influence the work of this WG. Mike Sharp asked about the purpose and scope of this WG and which lever we have to influence this. It is not clear to the SC if the PAR is already approved or not.

Mike Sharp and Klaus Pointner mentioned that the Switchgear Committee can be a role model for the work with entity PAR's.

All agreed that it is important to learn more about this entity PAR's and how to influence their work to avoid losing control of standardization work, pushing it away from the regular process towards entity work, with subsequent limited rights to vote (only entities are allowed to vote for such a standard).

### E.6 Dual logo standard IEC/IEEE 60076-57-129

The dual logo standard for HVDC transformers, IEC/IEEE 60076-57-129 is valid until 2027 for IEEE. For IEC there is a stability date of 2024, but that can easily be extended to match IEEE.

Discussion between Chris Plötner (chairman of IEC TC14) and Ulf Radbrandt prior to this meeting resulted in a preliminary agreement to apply for a PAR (IEEE) and RR (IEC) for revision of the standard in the Fall 2023 so joint WG work can start in 2024. Request for approval of this PAR will be done via E-mail.

#### E.6.1 Experience of the usage of the dual logo standard for HVDC transformers, IEC/IEEE 60076-57-129

Continued discussion from the Fall 2022 meeting (for details - see minutes of the previous meeting)

- IEC editorial review (last time) removed the last paragraph below.

  **2.1 Use of normative references**

  This standard can be used with either the IEC or IEEE normative references but, other than for IEC/IEEE dual-logo document references, the references shall not be mixed. The purchaser should include in the enquiry and order which normative references are to be used. If the choice of normative references is not specified, then IEC standards shall be used except for HVDC converter transformers intended for installation in North America where IEEE standards shall be used.

  If only one alternative is given in a certain part of the document, i.e. only IEC reference(s) or only IEEE reference(s), then that/these reference(s) is/are valid independent of the choice of normative references.

It could not be corrected. There are single references that should be valid independent on selection of IEC or IEEE – see the following examples.

**9.6.5 Acceptance criteria**

The test is considered accepted if there is no disruptive discharge and if the measured partial discharges are within the limits given below.

Partial discharges shall be measured with a method according to IEC 60270.

**9.16 Insulation power-factor test**

Insulation power factor (tan δ) procedures for tests are described in IEEE Std C57.12.90. The voltage should not be above 10 kV.

Perhaps we should try to get the removed paragraph back?

- The high rate of change of currents is only applicable to LCC.

**13.2 Current wave shape**

The rate of change of currents in the tap-changer is higher in service on transformers with delta-connected valve windings compared to the corresponding sinusoidal current at fundamental frequency. The purchaser shall specify di/dt for the actual current wave shape.

NOTE Additional information can be found in IEC 60214-2.

Perhaps that should be mentioned.

- Consecutive operation of tap-changers

**13.3 Consecutive operation of tap-changers**

Unless otherwise specified, the tap-changers shall be capable of continuous uninterrupted tapping from the principal tap to the maximum positive tap and back to the principal tap without exceeding the temperature limits of the transition resistor and other parts of the tap-changer.

This requirement can often be dimensioning for the tap changer and it is often not related to real operation needs.
For LCC it is often relevant to be able to utilize more or less the whole range to lower the secondary side voltage after restart after a DC line ground fault. That is to start again in reduced DC voltage operation. Perhaps should the requirement be changed to “maximum negative to maximum positive” or just let it be chosen by the purchaser.

### E.6.2 Call for a chairman of the upcoming WG

The SC chair made a call for the chairman for the upcoming joint WG to work on this standard and to prepare the PAR together with a review of the scope and the purpose.

The SC chair proposed Waldemar Ziomek – SC HVDC long term member to become the chairman of this WG. All present SC members were in favor and Waldemar confirmed interest to act as the chairman.

As there was no quorum at the meeting. The proposal will be sent by E-Mail to the SC members to get a motion to confirm Waldemar as the future WG chair.

## E.1 Future Work

The SC is planning to have a presentation on conditional monitoring for converter and smoothing reactors at the Fall 2023 meeting in Kansas City to be prepared by Alexander Gaun and Klaus Pointner.

There could be sections of conditioning monitoring introduced in our standards later.

## E.2 Old Business

There was no old business

## E.3 New Business

There is no new business

## E.4 Adjournment

The meeting was adjourned at 5:30pm.