Minutes of Meeting
IEEE Switchgear Briefing
IEEE/PES Transformers Committee
Dry Type Transformers Subcommittee
WG for Revision of IEEE C57.16- 2011

Burlington, Vermont
Tuesday, April 30, 2019
2:00 PM – 3:45 PM
Lake Champlain Salon

Chair: Victor Hermosillo
Vice Chair: David Caverly

IEEE C57.16- 2011, IEEE Standard for Requirements, Terminology and Test Code for Dry-Type Air-Core Series Connected Reactors

Agenda

1. Welcome
2. Introductions and Circulation of Attendance Sheet
3. IEEE Patent Policy
4. Purpose of this Meeting and Agenda Review
5. PC57.16 Members, Guests and Timeline
6. Brief Overview of IEEE C57.16
7. Scope and Content
8. Annex B: Shunt Capacitor Reactors – content and issues with present version
9. Open Discussion on the best way forward
10. Next Actions
11. New Business
12. Next Meetings: Transformers, Columbus, October 27th-31st, 2019; Switchgear, San Diego, October 6th-10th, 2019
13. Adjournment

1. Call to order

Chair called to order and presented agenda

2. Introduction of Members & Guests, Circulation of Sign-in Sheet

3. IEEE-SA Patent Policy and Copyright Compliance

Vicechair: patent and copyright policy presented. No Patent claims identified.

4. Scope and Content of C57.16 -2011

Vice Chair presented an overview of IEEE C57.16- 2011, IEEE Standard for Requirements, Terminology and Test Code for Dry-Type Air-Core Series Connected Reactors along with a summary

This standard is currently under revision by a WG with 12 members. This is a product standard, not an applications guide.

Annex B covers dry-type series connected reactors for shunt capacitor bank switching.

Annex F includes some basic guidance and cautions regarding potential impact of series reactors on CB TRV duty (though it principally refers to fault current limiting reactors rather than inrush/outrush reactors).

Issues with C57.16 -2011

The initial draft of the current 2011 version of the standard contained much more information on application aspects and potential effect of series reactors on CB TRV. A significant number of negative comments were received from the Switchgear Committee and as a result much of this material was removed in the final 2011 version.

Current Issues: Overall the situation for Users is very confusing.

Users approach reactor manufacturers regarding what values to use for rating and specifying inrush and outrush limiting reactors as there is little to no guidance provided in C57.16:

- no guidance re inductance definition/selection (nor any explanation of what is behind it; peak current, Ixf, frequency)
- No explanation as to how to arrive at short term current ratings (combination of fault current and inrush/outrush currents)
- does not even mention TRV within Annex B (though it is addressed in Annex F (principally in the context of CLR's))
- provides only a couple of examples of typical arrangements (does not show neutral side reactors option)

- the relevant IEEE Switchgear documents are referenced in general terms within C57.16 however these documents also do not fully address the reactor ratings and to some extent are not fully consistent with each other, partly due to having been published at different times in an evolving environment. Also, some examples in C37.012- 2014 (see section 9.11.2.3) do not match the corresponding text in C37.06-2009 sub point (3) in respect of the importance of frequency.

Relevant and Referenced Standards and Documents:

- **IEEE C 37.06 – 2009:** Standard for AC high-voltage circuit breakers rated on a symmetrical current basis-Preferred ratings and related required capabilities for voltages above 1000V
    - this document defines the breaker capabilities
    - does not specifically address reactors for cap banks
    - based on Ixf for inrush
    - revises outrush for C1/C2 to close and latch instead of Ixf

- **IEEE C 37.012 – 2014** (referenced version is 2005) IEEE Guide for the Application of Capacitance Current Switching for AC High-Voltage Circuit Breakers Above 1000 V (see also 2016 correction)
    - recent version (2014) indicates inrush and outrush are "under review"
    - mentions use of reactors to limit I peak and f in back to back
    - formulas given for back to back of n+1 banks and for outrush
    - example calculations for a given configuration but uses peak frequency as limit
- **IEEE 1036 – 2010 :** Guide for application of shunt power capacitors
    - mentions use of reactors for inrush outrush limiting but no detailed guidance on sizing. Indicates that sometimes Ixf is too restrictive
- **Technical Report PES- TR16 Nov 2014**: Transient Limiting Inductors in Shunt Capacitor Banks
    - clarifies much of the confusion regarding capacitor switching and sizing of inrush and outrush limiting reactors, as well as other mitigation methods
    - clearly hi-lites the potential TRV issue (though not exhaustive regarding solutions)
    - not referenced by C57.16- 2011 as TR-2014 as published later

Discussion:

Following is a brief summary of various points which were raised by meeting participants during the discussion period:

Additional nameplate information would be very beneficial. High frequency model to be included in nameplate data.

There is a section within C57.16 on harmonic filters (Annex A). Manufacturers deliver a product (filter reactor) but not the filter combination. Who is responsible for integration? Ans: Usually the companies providing the system solution – eg,. - for FACTS, HVDC applications – the FACTs or HVDC system supplier. Industrial customers usually obtain the advice from EPC. With EPC there is often less experience compared to FACTs and HVDC suppliers (and so they rely more on the standards to dictate how to integrate several products.)

Within utilities, transformer engineers (as opposed to circuit breaker engineers) are often the ones involved in procurement of reactors used with cap banks. Hence, they may not be aware of the details of circuit breakers, circuit breaker standards and so on. Therefore, good guidance in standards is important.

Current ratings discussion: Need to provide guidance on deriving the reactor current ratings. The continuous current rating is explained in the existing standard and is derived from the bank current with factors for overvoltage, harmonics and cap tolerance. Thermal withstand current as well as peak current (associated with electromechanical stresses) is not well explained at all. (Thermal effect of inrush current is not significant because of the short duration.)
For faults involving the banks and the system, worst case peak current (mechanical) is in between voltage peak and zero (ie. in between maximum asymmetry and max voltage on capacitor bank). Conservative calculations can be made by adding the short-circuit current peak to the inrush current peak.

One possible approach which was discussed is to add an informative annex to be included in C57.16 with more application information. Informative annex could direct to switchgear documents that are evolving. However, this approach may add too much time to the work package and thereby result in not meeting the standard expiry date – which is an outcome which we wish to avoid.

Annex F cautions that the introduction of a series current limiting reactor will impact the TRV experienced by the adjacent circuit breaker.

There is some material in C37.011 “TRV application guide” which could be used in C57.16.

There was discussion about the best way forward and whether the participants felt that it would worthwhile to form a Task Force within Switchgear to support the IEEE Transformers WG in updating C57.16.

Motion to create a Task Force to support the preparation of the new revision of C57.16
First: Roy Alexander
Second: Michael Skidmore

Motion was carried.

Recommend that Task Force to have circuit breaker and systems studies participants.

Roy Alexander (RWA Engineering) offers to participate.
Craig Polchinski (MEPPI) may join.

Next Meeting.
Switchgear Committee: October 6-10, 2019 San Diego, CA
Transformer Committee: October 27-31, 2019 Columbus, OH

Adjourn
First: Roy Alexander
Meeting adjourned

Reported by:
David Caverly
Ad Hoc Group Vicechair
Liaison Task Force Chair

April 30, 2019 Attendance:

All the individuals listed below attended the April 30, 2019 meeting in Burlington, VT. Any of these may become Members by sending an email to david.caverly@trench-group.com.

ADSCOM C57.16

Last	First	Company	Role
Alexander	Roy	RWA Engineering	Guest
Boulus	Michael	PSE&G	Guest
Caverly	David	Trench Ltd.	Chair
Collette	Lucas	Duquesne Light	Secretary
Hall	John	Tennessee Valley Authority	Guest
Hermosillo	Victor	GE Grid Solutions	Guest
Hester	Edward	Entergy	Guest
Hutchins	Roy	Southern Company Services	Guest
Peterson	Alan	Utility Service Corporation	Guest
Polchinski	Craig	MEPPI	Guest
Skidmore	Michael	AEP	Guest
Sullivan	Dustin	Hubbell Power Systems	Guest
Weisker	Jan	Siemens AG	Guest
York	Richard	Mitsubishi Electric Power Products Inc.	Guest
Yu	Li	Eaton Corporation	Guest