IEC and IEEE Standards for High-Voltage Switchgear and Controlgear Present Situation and Future Evolution

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Introduction to IEC Technical Committee 17 (TC17) for Switchgear & Controlgear
Organization of IEC TC17

TC 17 „Switchgear and Controlgear“
Chairman: D. Dufournet
Secretary: A. Bosma

SC 17A „High Voltage Switchgear and Controlgear“
Chairman: D. Dufournet
Secretary: A. Bosma

SC 17C „High Voltage Switchgear and Controlgear Assemblies“
Chairman: S. Theoleyre
Secretary: H. Koch

SC 17B „Low Voltage Switchgear and Controlgear“
Chairman: S. Kjellnas
Secretary: J. Briant

SC 17D „Low Voltage Switchgear and Controlgear Assemblies“
Chairman: D. Hier
Secretary: G. von Trentini
Scope of IEC SC17A and SC17C

Scope of SC17A

To prepare international standards regarding specifications for high-voltage switchgear and controlgear rated above 1 kV a.c. or above 1.5 kV d.c.

Scope of SC17C

To prepare international standards covering prefabricated assemblies which are combination of one or more parts of switchgear and controlgear exceeding 1 kV a.c., together with associated control and power equipment, measuring, signaling, protective, regulating equipment etc.
Membership of IEC SC17A & SC17C

**SC 17A**
- Participating countries: 26
- Observer countries: 19

**SC 17C**
- Participating countries: 27
- Observer countries: 17

India is a full member of SC17A and SC17C
Meetings of IEC SC17A & SC17C

IEC SC17A & 17C have plenary meetings every 18 months.

The more recent one was organized in New Delhi, in April 2007, at the invitation of the Indian Bureau of Standards, with support from IEEMA, Power Grid Co and Indian manufacturers.
IEC Standards for High-Voltage Switchgear & Controlgear
General on SC17A-SC17C standards

- **Market relevance**
  - Proven by large participation of experts

- **World-wide acceptance**
  - IEEE standards for HV Switchgear are currently harmonized with IEC

- **Emerging technologies**
  - Revision of standards for vacuum switching devices
  - New standards for disconnecting circuit-breakers, by-pass switches, controlled switching
  - UHV and impact of distributed generation: under consideration at CIGRE, revision of standards are planned.
IEC Standards for Switchgear & Controlgear

Numbering system for switchgear standards

A common numbering system has been established for High-voltage switchgear. IEC 62271 is the basis of the standards of SC17A (High-voltage Switchgear) and SC17C (High-voltage Switchgear Assemblies).

The following rule is applied to the numbering of the standards:

- Common standards prepared by SC 17A and SC 17C start with IEC 62271-1;
- Standards of SC 17A start with IEC 62271-100;
- Standards of SC 17C start with IEC 62271-200;
- Guides prepared by SC 17A and SC 17C start with IEC 62271-300.
IEC Standards for Switchgear & Controlgear

Main standards from SC17A

- 60265-1 Switches < 52 kV (1998) under revision (62271-103)
- 60265-2 Switches ≥ 52 kV (1998) under revision (62271-104)
- 60470 Contactors & contactor-based motor-starters (2000) under revision (62271-106)
- 61634 Use and handling of SF₆, under revision (62271-303)
- 62271-1 Common specifications, published 2007-10
- 62271-100 HV circuit breakers Ed 1.2 (2006-10), under revision
- 62271-101 Synthetic testing Ed.1.0 (2006-05) under revision
- 62271-102 Disconnectors & earthing switches (2003-08) under revision
- 62271-105 Switch-fuse combinations (2002)
Main standards from SC17A

- 62271-107 Fused circuit-switchers (2005-09)
- 62271-108 Disconnecting circuit breakers (2005-10)
- 62271-109 Series capacitors by-pass switches (2006-08)
- 62271-110 Inductive load switching (2005-06), under revision

- 62271-111 Overhead, pad-mounted, dry vault, and submersible automatic circuit reclosers and fault interrupters for systems up to 38 kV (2005-11)
  IEC-IEEE Dual Logo standard, under revision

- 62271-300 Seismic qualification (2006-11)
- 62271-310 Electrical endurance c.b. ≥ 72.5 kV (2004-04)
  revision approved in 2007-10
Main standards from SC 17C

- IEC 60932 Additional requirements for enclosed switchgear ≤72.5 kV in severe climatic conditions (1988), under revision (future 62271-304)
- IEC 61639 Direct connection between transformer-GIS (1996)
- IEC 61640 Gas insulated transmission lines (1998-07)
- IEC 62271-3 Digital interfaces based on IEC 61850 (2006-06)
- IEC 62271-200 Metal-enclosed switchgear and controlgear ≤ 52 kV (2003-11), under revision
Main standards from SC 17C

- 62271-201 AC insulation-enclosed switchgear and controlgear (2006-6)
- 62271-203 Gas-insulated metal-enclosed switchgear above 52 kV (2003-11), under revision
- 62271-205 Compact switchgear assemblies for rated voltages higher than 52 kV (2008-01)
- 62271-207 Seismic qualification (2007-08)
- 62271-209 Cable connections for GIS > 52 kV (2007-08)
Standardization of UHV level
Standardization of the Ultra-High Voltage level (> 800 kV a.c.)

A symposium on UHV was organized in Beijing 18-21 July 2007, by IEC-CIGRE-SAC-SGCC (State Grid Company of China). It concluded the technology is mature enough so that standardization can be done urgently to coincide with starting projects in China and India.
Standardization of the Ultra-High Voltage level (> 800 kV a.c.)

- The first step is the definition of rated voltage(s) and insulation levels by TC28 and TC8.
- Concerning high-voltage switchgear, IEC SC17A asked CIGRE SC A3 to set up a new working group to study technical requirements for UHV equipment.
- CIGRE WG A3-22 has started its work in January 2007, a final report is expected end of 2008.
- Similar work is done for UHV with D.C.
- Since November 2007, the work in IEC and CIGRE on UHV is coordinated by a Joint IEC-CIGRE Coordination Group.
- Deadline for standardization: end of 2010 or 2011
Some topics currently studied by CIGRE WGA3-22

- **Insulation level** (work also in progress in IEC TC 28)

- **Circuit breakers**
  - Terminal fault TRV (First pole to clear factor: 1.3 or 1.2)
  - DC time constant (120 ms)
  - Short-line fault (Line surge impedance)
  - Capacitive current switching (current, voltage factor)
  - Shunt reactor switching (controlled switching)

- **Disconnectors & Earthing switches**
  - Bus-charging and bus-transfer current switching

- **Secondary-arc extinction**
Standardization of UHV

Some topics studied by CIGRE WG A3-22

- DC time constant

<table>
<thead>
<tr>
<th>DC time constant (ms)</th>
<th>Third peak (p.u.)*</th>
<th>Third peak (relative value)</th>
<th>Peak 3rd loop x Duration (relative value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>1.33</td>
<td>82.6 %</td>
<td>70.9 %</td>
</tr>
<tr>
<td>100</td>
<td>1.61</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>120</td>
<td>1.66</td>
<td>103.3 %</td>
<td>108.1 %</td>
</tr>
<tr>
<td>150</td>
<td>1.72</td>
<td>106.9 %</td>
<td>114.1 %</td>
</tr>
</tbody>
</table>
Some topics studied by CIGRE WG A3-22

- Surge impedance for SLF

Quadruple conductors with 810mm$^2$ in cross-section carrying 30-50 kA collided at 100-200ms.

UHV lines have a high number of conductors with a large cross section.

For UHV lines with 6-8 bundle conductors, bundle contraction is not completed when the fault current is interrupted, between 50-80ms after a fault initiation.

It follows that a surge impedance of 360 ohm may be sufficient.
Harmonization of IEC & IEEE Standards for High voltage Switchgear & Controlgear
Harmonization of IEC-IEEE Standards

Introduction

- Major advances have been made over the past 12 years towards the harmonization of IEC and ANSI/IEEE standards for high-voltage circuit-breakers, especially for capacitive current switching and short-circuit breaking tests.

- Since 1995, three main actions were undertaken
  - Harmonization of ratings and test requirements for capacitive current switching,
  - Harmonization of TRVs for breaking tests of circuit-breakers rated 100 kV and higher,
  - Harmonization of TRVs for breaking tests of circuit-breakers rated less than 100 kV.
Harmonization of IEC-IEEE Standards

- Capacitive current switching
  - Revision prepared by a common IEC-IEEE Task Force
  - Introduction of class C1 (low probability of restrike) and class C2 (very low probability of restrike) and new test requirements.
  - Implemented by IEC SC17A in the first edition of IEC 62271-100 (2001-05)
  - Implemented by the IEEE Switchgear Committee in IEEE C37.04a (2003-07) and C37.09a (2005-09)
Harmonization of TRVs, Ur < 100 kV

Using the input from several working groups of CIGRE SC A3, IEC SC 17A started in 2002 the revision of TRV requirements for circuit-breakers of rated voltages higher than 1 kV and less than 100 kV.

Aim: to cover cases not yet covered in edition 1.1 of IEC 62271-100, mainly

- Breaking terminal fault currents in systems with low capacitance on the supply side of circuit-breakers;
- Breaking short-line fault currents in the case of direct connection of the circuit breaker to an overhead line and with rated voltages \( \geq 15 \text{ kV and } < 52 \text{ kV} \)
Harmonization of TRVs, $U_r < 100 \text{ kV}$

Cable systems and line-systems

The rate of rise of recovery voltage (RRRV) for line systems is approximately twice the value for cable systems.

$U_c$
Harmonization of TRVs, Ur < 100 kV

Harmonization of TRVs between IEC and IEEE

- IEC TRV Table 1a
- ANSI TRV Outdoor c.b.
- ANSI TRV Indoor c.b.
- COMMON TRV
- TRV Cable-systems
- TRV Line-systems

\[ U_c \]
\[ t_3 \]
Harmonization of TRVs, Ur < 100 kV

Classes of Circuit breakers

- Class S1
  - SLF?
  - Cable-system
  - No

- Class S2
  - Direct connection to OH line
  - Yes
  - Line-system
  - Yes
  - Class S2

Short-line fault breaking performance is required for class S2
Harmonization of TRVs, Ur ≥ 100 kV

The harmonization of TRVs for circuit-breakers of rated voltages equal or higher than 100 kV was prepared by IEC Working Group 23 with active participation from members of the IEEE Switchgear Committee.

The most significant change proposed was the adoption by IEEE of the two-parameter and four-parameter description of TRVs that is used in IEC.

It was also proposed that IEC changes some values of TRV parameters and adopts a two-parameter TRV for test duty T30 (at 30% of rated short-circuit breaking current).
Harmonization of TRVs, Ur ≥ 100 kV

Exponential-Cosine TRV envelope from ANSI/IEEE and new 4-parameter TRV harmonized with IEC
Harmonization of TRVs, $U_r \geq 100$ kV

- The recommendations from the WG were approved by IEC and lead to amendment 1 to IEC 62271-100 published in May 2002.

- The adoption of harmonized TRVs is still in progress in IEEE, there are few deviations from the values already adopted by IEC.
Harmonization of IEC-IEEE Standards

Conclusion

- **Major advances** have been made during the past twelve years towards the harmonization of IEC and ANSI/IEEE standards for high-voltage circuit-breakers, especially for capacitive current switching and short-circuit making and breaking tests.

- It allows already to perform **common tests for capacitive current switching**.

- Harmonization of TRVs for short-circuit breaking tests is in progress, IEC has already adopted the harmonized values in amendment 1 to IEC 62271-100, the work is well advanced in IEEE and should be completed shortly.

- When completed, harmonization of TRVs will allow to have **common making and breaking tests** according to IEC and ANSI/IEEE.
IEC & IEEE Switchgear Standards

Conclusion

- IEC is actively revising its standards and creating new standards for high-voltage switchgear and controlgear,
- Experts from India, and 25 other national committees, are encouraged to join us in our continuous effort to improve our standards.
Thanks for your attention

Good success to SWICON 2008

Questions?