

**Progress Report
of
Study Committee No. 13
Switching Equipment**

by O. Völcker, Secretary of the Study Committee

1. General

Modern switching equipment offers many advantages over older technologies, e.g. more economical solutions such as reduction of the number of interrupting chambers in circuit-breakers or less mechanical complexity. On the other hand this results in higher electrical and mechanical stresses on single parts of the equipment. Therefore more detailed knowledge on severity and number of stresses switching equipment might be exposed to in the system is required to propose adequate test procedures with the aim to improve equipment reliability.

This will be supported more and more by the incorporation of electronics for both controlling the operation to reduce the stresses and monitoring the performance of switching equipment. Moreover improved diagnostic methods will help utilities to reduce life cycle cost and to extend the life of this equipment.

To reduce stresses in the systems also existing and future techniques for short circuit current limiting are being investigated.

Study Committee 13 considers it as an important task to contribute by relevant studies and proposals for standardization to the progress of work towards more economical and reliable switching equipment and to the understanding of its interactions with the system. On the other hand work was started to establish an "Application Guide for IEC 60056 and 60694". This will provide background information for the various requirements in the Standards IEC 60056 "High-voltage alternating-current circuit-breakers" and IEC 60694 "Common specifications for high voltage switchgear and control gear standards". It is expected that this application guide will help the engineering community to apply these Standards correctly and to avoid controversy concerning the interpretation of these Standards.

2. Activities of the Study Committee

In 1998 the Study Committee held its annual meeting in September during CIGRE Main Session in Paris.

2.1 Contributions to general CIGRE activities

The Study Committee agreed upon to co-operate with other Study Committees in the following Joint Working Groups:

"Guidelines for collecting data on reliability" (leadership by SC 23)

"Coordination Committee on Electronic Control Systems" (with SC 23 and SC 34)

The Study Committee will contribute by three papers to the CIGRE Symposium "Working plant and systems harder" to be held in June 1999 in London (United Kingdom).

2.2 Cooperation CIGRE SC 13/CIREN Session 1

There was a good and fruitful cooperation in the Joint CIGRE/CIREN Working Group CC 03 on TRV stresses in medium voltage systems. As regards an earlier request from CIREN Session 1 to deal with medium voltage multifunction switching devices it was stated that the discussion on this item under Preferential Subject 1 during Group 13 Session in Paris on August 31st, 1998 has not brought new aspects. Since rules and requirements already exist for each single function of those devices the Study Committee did not see specific actions necessary in this field.

2.3 Cooperation CIGRE SC 13/IEEE Switchgear Committee

The US-delegate, who acts also as liaison man to IEEE Switchgear Committee, draws the attention of the Study Committee to items such as the new ANSI-draft on testing switchers.

There was also a request from STLNA (Switching Test Laboratories of North America) that CIGRE SC 13 should deal with the problems of non-sustained disruptive discharges (NSDD) in detail. This was discussed by the Study Committee. It was pointed out that one has to differentiate clearly between non-sustained disruptive discharges without any power frequency fault current and dielectric breakdowns with a power frequency follow current. Requirements for testing in this respect have been already fixed by STL (European switching test laboratories).

The Study Committee stated that the existing STL-guidelines are sufficient to cover the NSDD problem. Further studies on this topic are not considered to be necessary since in practice there are no problems with real NSDD in systems.

2.4 Cooperation CIGRE SC 13/IEC TC 17 and SC 17 A

At last IEC SC 17 A-meeting in Frankfurt (Germany) there was a request that CIGRE SC 13 should deal with problems arising when maximum permitted contact temperatures in switching devices would be increased from 115 °C as fixed now, to 150 °C.

It was mentioned that contact materials might become creeping and spring drives loose their force. A Task Force in WG 26 of IEC SC 17 A has already dealt with those problems. It considered them not to be dangerous when the higher contact temperatures can be kept away from sensitive material or when other, not sensitive material is used.

The Study Committee considered this item mainly to be a problem for manufacturers. They have to choose appropriate material and to test the equipment at higher temperatures. To investigate material behaviour under long-term high temperature stresses, however, could be a task for Universities. Therefore it was envisaged to create a common CIGRE SC 13/IEC SC 17 A Task force for this topic.

Later on, however, IEC SC 17 A decided not to develop this subject further since from the manufacturers side there is no interest to sponsor further investigations in this field. Therefore it does not need any input from CIGRE SC 13 now.

2.5 Session 1998

The Study Committee criticized that there was an overlap of Group 13 Session and SC 23 meeting at this CIGRE Session. CIGRE Central Office was asked to take care that overlaps between Group Sessions and Study Committee meetings of SC 13 and SC 23 and as far as

possible also of SC 34 will no more occur in future. The Conveners who held meetings with their Working Groups at this CIGRE Session also criticized that the meeting rooms were too small and too noisy. Moreover, it was proposed that the Special Reports for CIGRE Group Sessions should be made available earlier, eventually also on a CIGRE Web-page.

3. Activities of Working Groups and Task Forces

3.1 WG 13.01: Practical application of arc physics in circuit-breakers Convener: K. Möller (Germany)

The last report prepared by the Working Group on “Survey on analytical and graphical tools for circuit-breaker behaviour description” has been published in CIGRE Technical Brochure No. 135 titled: “State of the art of circuit-breaker modeling” together with the two earlier reports of the Working Group:

- Practical application of arc physics in circuit breakers. Survey of calculation methods and application guide. Electra 118 (1989)
- Application of black box modeling to circuit-breakers. Electra 149 (1993)

The relevant summary was published in Electra No. 181 (December 1998). By that WG 13.01 has finished its work. Therefore the Study Committee disbanded the Working Group.

3.2 WG 13.04: Switching test methods Convener: I. Bonfanti (Italy)

The Working Group held two meetings one in February 1998 in Ludvika (Sweden), the other in September 1998 in Paris (France).

The last report on capacitive current switching titled “Shunt capacitor bank switching. Stresses and test methods” was finalized and sent to CIGRE Central Office. Because of its length the report will be splitted up into two parts and published in the February (Part 1) and the April 1999 issue (Part 2) of Electra. Lateron it is provided, to publish all reports prepared by WG 13.04 on “Capacitive current switching” in a CIGRE Technical Brochure.

As a result of the work of Task Force 13.00.2 (Revision of IEC-Standards relevant to switching devices) new tasks have been given to WG 13.04 as follows:

- Switching of asymmetrical currents
The main contents of a report on switching of asymmetrical currents have been fixed as follows:
 - Aim of the tests
 - Field needs
 - Switching device technology dependency
 - Standards criticism and harmonization
 - Testing aspects
 - RecommendationsWork on these various items was started.
- TRV requirements and test circuit topology for high voltage systems.
It is expected that this work can be based at least partly on results of the work already done by WG CC 03 for medium voltage systems. Main items will be
 - Requirements for second and third pole opening
 - Test circuit topology

3.3 WG 13.07: Controlled switching **Convener: K. Fröhlich (Switzerland)**

The Working Group held three meetings one in April 1998 in Vancouver (Canada), the second in May 1998 in Baden (Switzerland) and the last one in September 1998 in London (United Kingdom).

The report: "Controlled switching of HVAC circuit breakers – Guide for application. Lines, reactors, capacitors, transformers" has been finalized.

It gives a general overview on the possibilities and advantages of controlled switching and deals with items as follows:

- General phenomena of controlled switching
- Shunt capacitor bank switching
- Unloaded line switching
- Energizing and de-energizing of shunt reactors
- Controlled switching of transformers
- Requirements on secondary installation

The Study Committee agreed upon to ask CIGRE Central Office for its publication. Since the report is too long for publication in a single Electra issue it has been splitted up into two parts to be published in the April and in the August 1999 issue of Electra.

The next report to be prepared by the Working Group will deal with the realization of controlled switching for specific cases. For the four basic switching cases of line, reactor, transformer and capacitor bank switching basic studies will be performed to get guidelines on

- How to specify the controllers needed
- How to test controllers.

In a third report more futuristic applications not practiced today like load and short circuit current interruption or energization of power transformers (with consideration of the actual residual flux) will be dealt with if more information will be available in these directions.

Finally it is intended to deal with economical aspects of the application of controlled switching even if it is still outside of the scope of the Working Group.

3.4 WG 13.08: Life management of circuit breakers **Convener: A.L.J. Janssen (Netherlands)**

The Working Group held two meetings one in April 1998 in Paris (France), the other in September 1998 in Brussels (Belgium).

Based on the results of an international enquiry the Working Group prepared the report "An international survey on electrical stresses on high voltage circuit breakers in service". This report was requested by IEC SC 17 A and has been sent to its Task Force "Electrical endurance tests". It shows that more than 90 % of all short circuits in HV transmission networks occur on overhead lines. The average number of short circuits per overhead line is 1.7 per year. Since most short-circuits are single or two-phase faults only about 60 % of all faults have to be interrupted by the same breaker pole. Most of the overhead line short circuits interrupted have relatively low amplitudes: Even the 90 % percentile is only about 35 % of the rated short-circuit current of the circuit-breakers involved. For short-circuits in substations, however, the 90 % percentile is about 75 % and the average about 50 % of the rated short-circuit current of the circuit-breakers. These results should be taken into account when defining procedures for electrical endurance testing.

Another report on "Studies on life management of circuit-breakers" was presented to CIGRE Group 13 Session 1998 (report 13-204). In addition to the results of the international enquiry on electrical stresses on high voltage circuit breakers shown in the report mentioned above it also deals with systems now being applied by some utilities to support their maintenance management.

The main task of the Working Group now is to deal with non-electrical stresses on circuit-breakers in service. A questionnaire for an international enquiry has been elaborated and distributed. The answers sent back will be evaluated and the results compiled in a final report of the Working Group. It will also include a survey on utility experience with life management and life extension. This report is not expected until mid of the year 2000.

A report titled "Advanced maintenance technologies for high-voltage circuit-breakers" is envisaged for the CIGRE Symposium 1999 on "Working plant and systems harder". It will give an overview on risk management and maintenance tools.

3.5 WG 13.09: Monitoring and diagnostic techniques for switching equipment **Convener: C.J. Jones (United Kingdom)**

The Working Group held two meetings, one in March 1998 in Vancouver (Canada) and a short one during CIGRE Session in September 1998 in Paris.

The Working Group is preparing the report "Monitoring and diagnostic techniques for switching equipment". It will consist of 8 chapters that are under preparation each by a small Task Force:

1. Definitions
2. Need for monitoring
3. Justification of monitoring
4. Sensors and diagnostic techniques
5. Design and test requirements
6. Dependability
7. Management of information
8. Future applications

A first Study Committee draft is envisaged for spring 1999. The final report to be published in a CIGRE Technical Brochure is expected for spring 2000. A summary paper will be presented to CIGRE Session 2000.

3.6 WG 13.10: Specifications for short circuit current limiters **Convener: A. Greenwood (USA)**

The Working Group held two meetings, one in April 1998 in Edinburgh (United Kingdom), the other one during CIGRE Session in September 1998 in Paris.

The report "Specifications for fault current limiters" is in an advanced stage of preparation. It will be submitted to the Study Committee mid of 1999. Important parameters have been agreed upon.

The report will contain the following chapters:

- What is a fault current limiter
- Description of fault current limiter techniques
- Results of the enquiry among potential users of fault current limiters distinguishing industry and utilities

- Specifications for fault current limiters
- Testing of fault current limiters

As future task for the Working Group it was proposed to prepare a review on “State of the art of fault current limitation”. This should include also the interaction of fault limiters with the system. On the other hand also “Requirements for testing current limiters” were asked for since there are no relevant IEC Standards. Particularly in North America there is an increased need for such devices since system power will be increased there without improving the existing networks. Also in Europe the requirements on systems might become similar in the future. A final decision will be taken later on.

3.7 WG 13.11: Application guide for IEC 60056 and 60694 **Convener: H.H. Schramm (Germany)**

The first meeting of this new Working Group was held in November 1998 in Berlin (Germany).

The scope and a preliminary list of tasks are as follows:

Scope: Application guide to provide background information for the requirements of Publications IEC 60056 “High-voltage alternating-current circuit-breakers” and IEC 60694 “Common specifications for high-voltage switchgear and control gear standards” and to give guidance to users of these publications.

Tasks:

- TRV for terminal faults
- DC components
- Short-line fault
- Test Duty No. 1
- Rated insulation level
- High voltage tests

Based on these main tasks, as a first step, the Working Group has established and weighted a much longer list of more detailed tasks in this field.

It is envisaged to submit a first draft of the application guide to the Study Committee in 1999 and the final paper in the year 2000.

3.8 WG CC03: TRV stresses in MV systems. Test circuit topology **Convener: L. van der Sluis (Netherlands)**

The report “Transient Recovery Voltages in Medium Voltage Networks” was finalized and published as CIGRE Technical Brochure No. 134. It covers the whole broad scope given to the Working Group. The general task was to study transient recovery voltages occurring on various kinds of interrupting devices in medium voltage systems. The summary was published in December 1998 issue of Electra.

There were left still 2 tasks to the Working Group

- Test circuit topology
- TRV-requirements for the second and third pole to clear

A small Task Force will prepare a report dealing with these items until next Study Committee meeting in September 1999.

3.9 TF 13.00.2: Revision of IEC Standards relevant to switching devices
Convener: J.F. Reid (United Kingdom)

Two items to be dealt with have been left to this Task Force at the Brisbane meeting last year. They have been commented now as follows:

- **New switching devices:**
This item is related to specific switching devices with switching capabilities higher than disconnectors but lower than switches. A questionnaire was sent out to get an overview on the demand for those switching devices which are not covered by the IEC standards for circuit-breakers, switches, disconnectors and earthing switches nor by the additional ANSI standards being prepared for generator circuit-breakers, autoreclosers and circuit-switchers. There was a relatively poor response on the questionnaire but the following additional switching duties were requested for a disconnector with a switching ability well below that of a switch:
 - opening unloaded transformers
 - opening very short lengths of unloaded overhead lines and cables
 - quenching primary circuit ferro-resonanceThe market for those special purpose devices, however, is small. Therefore no clear need for their standardization is seen as long as no significant market is identified by a higher number of users.
- **System quality**
The task covered by this item is seen to develop a compilation of existing material on the behaviour of switching devices that could degrade system quality. The aim will be to identify whether or not standards are adequate for the level of system quality required by users and where the standards are likely to need strengthening. The Task Force Convener will complete a literature survey in 1999.

3.10 TF 13.00.3: Influence of harmonics on switching capacity of load break devices
Convener: N.P. Cuk (Canada)

No further interest exists on the very specific topic of this Task Force since it was found that possible problems are dependent on the specific internal design of load break switches and that they could be overcome by applying circuit-breakers instead of them. Therefore the Task Force has been disbanded.

4. Activity of the Current Zero Club
Chairman: K. Möller (Germany)

The Current Zero Club is a Club of experts specialized on the field of current interruption. Its next meeting is scheduled for September 1999 in Arnhem (Netherlands).

Three so-called Inner Circles have been established dealing with

SF₆-circuit breakers
Current interruption in vacuum
Measurement, monitoring, diagnosis

Within these Inner Circles there is an internal exchange of experience with Club Members and guests interested in these fields.

- **SF₆-circuit breakers:**
Different groups are dealing now with gas flow studies on SF₆-circuit-breakers applying computational fluid dynamic codes (CFD). At present work is concentrated on distinct problems more or less separated from each other. A combined view of the dominant

aspects of CFD studies on SF₆ switching arcs requires still an appreciable amount of work to be done. At present therefore it seems not to be possible to deal with those methods within a CIGRE Working Group.

An Inner Circle meeting was held in September 1998 in Brno (Czech Republic).

- Current interruption in vacuum

At an Inner Circle meeting in April 1998 in Rugby (United Kingdom) reports on the following items related to vacuum circuit breakers have been discussed:

- Current zero phenomena
- High frequency transients
- Axial magnetic fields
- Measuring techniques
- Circuit breaker duties

Another short informal meeting took place at Eindhoven (Netherlands) in August 1998.

- Measurement, monitoring, diagnosis

A meeting of this Inner Circle took place July 1998 in Newcastle (United Kingdom).

Information on the activities of the Current Zero Club is available also via Internet:
<http://www.hast.rwth-aachen.de/czc/index.htm>.