

# DISCUSSION MEETING



## GROUP A3 HIGH VOLTAGE EQUIPMENT

*Friday 29 August 2008*

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*Andre GIBOULET (FR) meeting secretary*

The discussion meeting was chaired by M. WALDRON (UK), chairman of the Study Committee. A. JANSSEN (NL) as special reporters. The secretary of the Study Committee E. KYNAST (DE) and the meeting secretary A. GIBOULET (FR)

The chairman opened the meeting with a presentation of the present state of the Study Committee, addressing the field of activities and the technical strategies.

Based on **31** papers which have been selected the special reporters prepared the questions. The questions were divided into **8** sub-groups. We received **69** prepared contributions and **10** spontaneous contributions during the session.

Many thanks to the authors, the contributions were of good quality and a great effort of synthesis has been done, in order to allow exchanges during the session.

Origin of the prepared contributions:

Manufacturers	<b>42 %</b>
Consultants / testing organisation	<b>11 %</b>
Utilities	<b>32 %</b>
CIGRE / IEC WG	<b>5 %</b>
Universities	<b>10 %</b>

### **Preferential Subject 1: Managing an ageing high voltage asset population.**

- End of life assessment (age, capability, reliability, technical risks, expertise)
- Refurbishment and replacement strategies
- Application of monitoring and condition assessment techniques
- Operation of equipment beyond design life

9 Reports for this Preferential Subject 1 and 22 prepared contributions were presented to answer the questions of the special report.

## Q1-1

In addition to the CIGRE definition of Major Failure (**MF**) and minor failure (**mf**), some utilities have developed some improvements; one of them has showed its method of classification of failure to equivalent MF respectively mf had been determined by analysis of failure mode effects and weighting of each failure mode.

The importance of the three main steps of the analysis procedure which are, collection of data, statistical treatment and analysis and finally prediction were stressed.

The CIGRE WG A3 06 "Maintenance and Reliability" has presented its approach, to support the user in statistical analysis, to determine influence of population size on failure rate, to introduce failure rate interval instead of number of failures/population. This will help the utilities to compare its own failure rate intervals to the CIGRE results. It has been proposed to utilise the outcomes from this WG, to get application by more utilities so that the database can be expanded by more participation next time.

## Q1-2

A statistical analysis for lifetime estimation of SF6 gas sealing, based on a combination of acceleration ageing tests and practical data of O-rings gathered from aged switchgears in service was presented.

An experimental solution of early detection of small SF6 gas leakage < 0.5% was shown. Some additional tests seem necessary to validate the technical and economical approach of this solution.

Wear of silver plated contacts, due to the grease deterioration mainly due to loss of oil in the grease and by solid by-products contaminants has been shown.

A proposal to review the technical brochure 165 "Life management of Circuit-Breaker" has been done, in particular:

- Study the impact of technical improvement on maintenance strategy.
- Improve the models of end of life issue.
- Study methods to assess performance of older switchgear with regards to the evolution of the grid stresses.

An interesting approach done by one utility was presented, mainly to show how to prioritise asset replacement or refurbishment and to define maintenance policy.

## Q1-3

The challenge of network renewal was presented by a utility mainly based on:

Review of technical asset lives as continuous process.

Replacement/refurbishment modelling is essential.

One utility presented the factors which have been taken into consideration to define the end of life of one typical group of Circuit-Breakers 420kv 63kA:

- High and increasing failure with age.
- High repair costs.
- Poor reliability of the repaired equipment.
- High risk of critical failure on one specific component

A utility presented its policy to replace its old air blast circuit-breakers even having a very low failure rate. The economical considerations were predominating to take the decision.

In addition to its criteria of end of life for circuit-breakers, a utility showed interesting bath curves of failure rate comparing the results of a complete overhaul to a partial overhaul.

It was pointed out that CIGRE A3 could assist in standardising important criteria used of end of life decisions and guide on how measures could be implemented.

#### **Q1-4**

One experience, on a switch with an overload current for a short period of time 30mn was reported, this test confirmed that older switch could perform this overload in a consistent manner. But the contact resistance measurements do not guarantee that the equipment can fully perform within its ratings.

A contribution mentioned in a very particular case of three phase line fault, if the fault duty at supply bus is >80% of CB rating, TRV peak will exceed the tested TRV required by IEC standard.

The Brazilian regulator presented some figures showing the predictable overstress of substation equipments (i.e., CB, DISCONNECTOR, CT, line trap) at horizon 2011 like symmetrical short-circuit current, load current, time constant (X/R), TRV.

A comparison of the electrical endurance test-programs, between MV CB and HV CB has been presented, as conclusion, questions were put forward about the relevance of the requests of IEC standard for MV CB.

A study of nozzle wear due to ablation was presented by a power tests laboratory in most case this lab follows the wear-curve provided by the manufacturer. It seems that this method for power tests CB is rather conservative, in spite of that, this conclusion can not be used for a line circuit-breaker for example.

Based on its experience on 800kV network a utility addressed several basic questions to the relevant CIGRE and IEC committee, concerning UHV CBs on the two following aspects:

- No-load energization of UHV power transformer and how to deal with the corresponding transient over voltages and inrush currents.
- Application of MOSA to the CB.

A utility presented its method to define the life duration of their CB; the following criteria have to be considered: Field experience, performance in tests, real needs, cost of maintenance, availability of spare parts, skills of maintenance teams.

A long term tests on real size of solid insulating material for support insulators and operating rods was presented by a manufacturer, showing a good correlation between the test results and the return of experience in service for GIS and AIS equipments.

## **Preferential Subject 2: Developments in testing and verification of HV substation equipment.**

- Increasing test requirements (1000 kV transmission, large out-of-phase angles, changing network topologies) and decreasing margins between operation and design/test conditions
- Use of simulations for verification
- Interpolation and extrapolation of type tests for special system conditions
- Testing of hybrid switchgear assemblies

12 Reports for this Preferential Subject 2 and 29 prepared contributions were presented to answer the questions of the special report.

### **Q 2-1**

A utility presented the particular safety measures which have been implemented to overcome problems on 420kV AIS VT having a high risk of insulation failure. PD diagnostic has been implemented and safety measures defined in case of voltage variation on the secondary side.

Return of experience of a large size population of Mixed Technologies Switchgear (MTS) was presented by a utility. Based on the failure rate found in service, the decision was taken to regularly check these equipments with a portable UHF PD diagnostic tool.

A manufacturer mentioned that, according to their own return of experience the insulation failure rates for MTS are similar to GIS. Their position on periodic checks by UHF PD detection is a questionable benefit. In particular due to a significant background noise level.

### **Q 2-2**

The chairman of IEC TC 17A presented the needs of standardization for Ultra High Voltage equipments application (UHV), for voltage above 800kV

Several manufacturers have presented their recommendations how to reduce the basic insulation level of the complete substation, by using Metal Oxide Surge Arresters (MOSA). They showed that modern MOSA are very reliable to protect equipments against fast front lightning and slow front switching over voltages including reducing TRV in some cases. The use of MOSA lead to smaller dimensions, space saving and finally by cost saving due to a lower BIL for the entire UHV substation.

A manufacturer presented a method to test the power frequency voltage across the open terminals for UHV CB by using an AC-AC combined voltage test set. The phase difference between AC voltages applied across terminals was about  $176^\circ$

UHV test methods have been addressed. Several manufacturers and test laboratory presented their solutions to cover exactly the requirements of the standard. These aspects are still under investigation, what are the exact ratings and test requirements for UHV should be. Both IEC and CIGRE are working hardly to answer these questions as soon as possible.

A test laboratory showed the comparison of full-pole test versus half-pole test particularly for UHV GIS CB. A full-pole test of 1100Kv CB has been tested successfully, including the T100 make test.

A manufacturer presented the results of type tests and field tests of 1100kV for High Speed Grounding Switch (HSGS).

### **Q 2-3**

The advantages of NCIT's by comparison to conventional It's for UHV application were presented by a manufacturer showing the great interest to use NCIT's for UHV network.

A return of experience of more than 25 years regarding GIS's MOSA has been presented by a manufacturer. The results are, accumulated service years: of more than 14000 MOSA\*years and a MTTF: of more than 4800 years.

A utility reported a very good result of GIS's MOSA since 1996 on an 1100kV network.

### **Q 2-4**

Several papers concerning simulation techniques were presented by manufacturer, utilities and research laboratories. All presentations conclude that simulation techniques are a must in the development process of HV equipments, however apart from some special cases, they are not able to replace type tests.

Such special cases are or should be described in the standards, for instance short circuit current withstand tests on transformers.

Simulation techniques become more and more important for users, many applications deviate from the conditions of type tests. The interpolation and extrapolation possibilities are a must in some cases, for example the internal arc tests, and simulations will be more and more relevant.

Simulations on AIS MOSA was showed regarding field distribution, stray capacitances to ground and temperature distribution, conclusion it is today possible to calculate the MOSA thermal stability by simulation techniques.

The thermal characteristics of different arrangements of MOSA were presented by a manufacturer, showing the thermal behaviour comparison between multi-columns in porcelain housing and a single-column, direct moulded polymer. This last solution shows a superior thermal performance.

### **Q 2-6**

A test laboratory presented internal arc tests comparison between air and SF6; the results show clearly a lot of differences between the two insulating media. Temperature and pressure are quite different. The SC A3 has decided to launch a new WG to this subject, to define the right parameters to be able to use the simulation techniques in such case, to avoid internal arc tests with SF6.

### **Preferential Subject 3: Acceptance and experience of new substation equipments and techniques.**

- Stress alleviation techniques including controlled switching and novel applications of surge arresters (mid-line, non-line to ground)
- Non-conventional instrument transformers, IEC 61850 and monitoring and intelligence within equipment
- Mixed technology and composite insulated switchgear
- capacitors

10 Reports for this Preferential Subject 3 and 18 prepared contributions were presented to answer the questions of the special report.

#### **Q 3-1**

The numerous benefits of the application of NCIT have been addressed by several experts. It appears that, standardisation and acceptance issues form the main hurdles to be taken yet. To allow a large acceptance by the market CIGRE and IEC and manufacturers can play major role, this require in particular new trained people on this new technological field.

#### **Q 3-2**

Cases of ferro-resonances in voltage transformer was presented by a utility, the conditions of ferro-resonances were addressed and also the preferred damping solutions to avoid such phenomena. Iron core with gap seems the best solution.

#### **Q 3.3**

The interoperability and calibration were addressed by one utility in Netherlands and one manufacturer in Korea both presented their experiences on this topic

#### **Q 3-4**

Several contributions by utilities and manufacturers addressed the return of experience with composite insulators. Apart from some very special phenomena like bird "picking" and biological growth where counter measures still exist and have further improvement. Composite insulators in general and more specifically for bushings and housings have excellent results in service. In addition, no severe trend of deterioration has been discovered, including bird picking.

#### **Q 3-5**

MOSA the CIGRE WG A3-17 presented its first results first in a report A3-309 and in a short tutorial. Promising results on ZNO blocks

#### **Q 3-6**

Fault Current Limiter FCL, a utility has presented its solution, based on air-core current limiting reactor and the good results gained in service on 145, 362, 550kV network.

FCL, the CIGRE WG A3-16 has presented its results into the paper A3-310, "Impact of Fault Current Limiting Devices on System Protection". An answer to the question 3.6 was given during the session by a working group member.