FIRST RESULTS FROM ON-GOING CIGRÉ ENQUIRY ON RELIABILITY OF HIGH VOLTAGE EQUIPMENT

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SUMMARY
CIGRÉ WG A3.06 in cooperation with WG B3.02 is presently carrying out a worldwide survey of failures in service on high voltage equipment rated for voltages greater than or equal to 60 kV. The survey covers circuit breakers (only SF_6 technology), disconnectors, earthing switches, instrument transformers and GIS. The collection of information from utilities about their equipment populations, and about failures that occur in these populations, started in January 2004, and will go on until December 2007. At present (April 2005) 36 utilities from 18 countries have submitted information about their apparatus populations, together with a total of 1446 failure cards, each describing one failure. Many more utilities are currently collecting information for the survey, and a large number of extra cards will be submitted. The information will, when the data acquisition has been completed, be subjected to extensive statistical analyses with the purpose of obtaining trustworthy information on reliability and failures for the considered component types.

Keywords: *High voltage apparatus - Failure statistics - Reliability survey - Service experience*

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1. INTRODUCTION

Accurate information about service experience of high voltage equipment is of significant value for both electric utilities and for manufacturers of such equipment. It helps the manufacturers improve their products, and provides important inputs for the utilities when buying equipment and when organizing maintenance. Equipment reliability data are also required when assessing of the overall reliability of an electric power system, including studies of the electric energy supply security. Furthermore, international standards applicable to high voltage equipment are being improved on the basis of service experience and reliability data.

Hence, CIGRÉ has considered collecting, analyzing and publishing reliability data important tasks. A number of years have now passed since the previous surveys on high voltage equipment. For example, in the previous study on circuit breaker service experience, the data collection ended in 1991. Deregulation and new technologies, among other things, have caused the service and maintenance practises to change significantly, and it is thus time for renewed studies.

Against this background, CIGRÉ decided to launch a new worldwide enquiry on service experience on high voltage equipment. The survey is fairly comprehensive in that it includes several types of high voltage components: circuit breakers, disconnectors and earthing switches, instrument transformers and gas insulated substations (GIS). Information is collected by asking utilities to complete and return equipment population and equipment failure forms to a CIGRÉ working group, which in turn analyses the data and reports the findings.

This paper starts by briefly reviewing the previous CIGRÉ enquiries on high voltage equipment. Then some essential features of the new survey are summarised, including a brief description of the applied data collection forms and procedures. Some data showing the initial participation complete the paper.

2. PREVIOUS SERVICE EXPERIENCE ENQUIRIES

The first circuit breaker survey was carried out in 1974 - 77 and concerned nearly 79,000 circuit breaker years of service. The results were published in 1981 [1] and had a significant impact on IEC standardization work, including mechanical and environmental test procedures.

The second circuit breaker survey covered almost the same number of circuit breaker years, but was limited to single pressure SF_6 technology. Service data were collected in the period 1988 – 91. The very comprehensive and detailed 180-page report [2] remains a very valuable source of information for the circuit breaker community, and a CIGRÉ bestseller.

A first failure survey of conventional instrument transformers was published in 1990 [3]. It covers failures from the time interval 1970 - 86. Both manufacturers and users contributed. There was no age limitation to the overall population.

A second failure survey has also been performed, covering the years 1985 - 95. This survey only made use of contributions from users. These results are unpublished. As for the first survey, there was no age limitation to the overall population.

Two enquiries on GIS reliability have been conducted. The first enquiry covers service experience up to 1990, and the second up to 1996 [4]. Both surveys address not only the GIS as a whole, but also the apparatus inside. Failures were collected without age limitation and users and manufacturers (only in first survey) contributed.

No previous service experience enquiries have been performed for disconnectors and earthing switches.

3. THE PRESENT ENQUIRY

The present study is a cooperation between CIGRÉ Study Committees A3 and B3. A working group, "A3.06: Reliability of high voltage equipment", was established to organize the work and analyze the results.

The enquiry comprises equipment rated for voltages greater than or equal to 60 kV. For circuit breakers only single pressure SF_6 technology is included, thus in practice excluding equipment installed before around 1970. For disconnectors, earthing switches and instrument transformers there is no such limitation in age or technology.

Only failures occurring in a four-year period starting January 2004 are collected. To be able to determine failure rates, the numbers and details of the equipment populations that are covered by the survey also have to be recorded for the same time interval. Thus for each of the four equipment types included, the enquiry employs two types of forms or cards or questionnaires: one for equipment populations and one for failures. Population cards are to be completed annually (i.e., one for each year 2004 - 07), whereas a failure card should be filled in each time a failure occurs.

The population cards ask for the age and number of components being covered, grouped by voltage level, application, technology, design and maintenance strategy. The failure cards request the same type of information about the failed component, together with information describing the failure itself, such as its origin and cause, what sub-assembly failed, whether this is a minor or major failure, if environmental stress contributed, etc. Furthermore, a few questions addressing the service history of the failed component as well as repair and consequential measures, are included.

A main objective of the present survey is to identify trends by comparing the findings from the present survey with those from the previous ones. Consequently, the majority of the definitions and questions are completely or nearly identical to those applied earlier. For example, the division into minor and major failures follows the procedures used in the previous circuit breaker surveys. A few new topics that have attained a substantial attention in recent years, like asset management and diagnostics issues, have been addressed in the questionnaires. A specific new item for circuit breakers is that information regarding type of service is to be included, e.g. line breaker, transformer breaker, etc. All questions in population and failure cards are of the check box types, or they require numbers or dates as input.
The data collection is carried out by means of a specially developed Excel spreadsheet tool, containing the four population and the four failure cards. In addition, a separate questionnaire related to maintenance and operation issues of GIS is included in the tool. The tool is multi-

lingual; at present it is possible to choose among, and even switch between, 11 different languages. Moreover, a comprehensive "help function", including all relevant definitions is included in the tool and is easily accessed by "push buttons" next to the relevant questions.

The Excel tool is distributed by e-mail to utilities worldwide interesting in participating in the survey. They fill in the forms, and return a file with the answers to the working group member responsible for the country. After a quality check, the responses are forwarded and compiled in a database for subsequent statistical analysis. The information is collected directly and solely from the utility sector, not from manufacturers or others as in some of the previous surveys. All incoming information is treated as confidential.

Some utilities are, on a permanent basis, collecting information about the service experience of their high voltage equipment by using forms and procedures similar to those adopted by CIGRÉ. Hence, in a few cases population and failure data can be more or less directly loaded into the database.

4. PARTICIPATION

The questionnaire was distributed to utilities worldwide by mid 2004, with the objective to receive the first data at beginning of 2005. By the time of writing (April 2005) 36 utilities from 18 countries have submitted one or more completed cards. Tables I and II show the received cards sorted by component for population cards and failure cards, respectively. It has to be emphasized that these numbers are far from the final ones. The number of submitted cards is steadily growing.

It may be noted from the work with the survey, that many contacts and discussions between participating utilities and the members of the CIGRÉ WG are necessary. Such contacts help to clarify some of the questions asked and to avoid misunderstandings.

Table I. Population cards received by April 2005.

	Number of utilities	Number of countries
Circuit breakers	36	17
Disconnectors and earthing switches	35	15
Instrument transformers	26	12
GIS	23	12

Table II. Failure cards received by April 2005.

	Number of cards	Number of utilities	Number of countries
Circuit breakers	412	29	14
Disconnectors and earthing switches	764	32	12
Instrument transformers	200	33	11
GIS	70	8	4

Thus, so far the WG has received 1446 failure cards.

More interesting than the number of population cards is the number of apparatus included in these populations. Table III shows these numbers, again as by April 2005. The number of GIS circuit breaker bays included in the total population is 10470. This means that 38% of the reported number of circuit breakers is of GIS-type.

Table III. Number of apparatus included in the population cards of Table I.

	Number of apparatus
Circuit breakers	27,845
Disconnectors and earthing switches	112,909
Instrument transformers	103,797

5. DEFINITION OF FAILURES

Failures of high voltage equipment may be considered either from a system, or from an equipment point of view. With a system approach, the important issue is whether a fault caused a system outage or not, and related consequences such as transfer of power to other paths, or even loss of supplied power. With an equipment approach, the focus is on failure mechanisms, properties of the equipment, etc. In the present survey, as in the previous ones, the equipment approach is applied. The definitions of “Major failure” and “Minor failure” relate to the performance of the equipment.

Individual utilities and organizations sometimes use the system approach. Their internal failure statistics will be different from what a CIGRÉ approach would give. For example, an unplanned system outage, caused by failure of a high voltage apparatus, per definition means that the apparatus suffered a major failure. There are, however, several types of major failures that do not automatically lead to system outages (example: “Does not close on command”, for a circuit breaker). This means that a utility, which only records system outages due to faults, will not necessarily “detect” all major failures that occur. Minor failures may not be registered at all.

This discrepancy between different ways to define failures is a factor that will be kept in mind in the future analysis of failure data within the survey.

6. FUTURE ANALYSIS OF DATA

Incoming data will be analyzed and presented as far as possible in the same manner as in the previous surveys. This will make it possible to compare the outcome and to identify any trends or similarities. It is still too early to present any conclusions since there is at this point not a complete consistency between the population and failure cards. That is, failures may have been reported for equipment that has not yet been included in the population cards, and vice versa.

7. CONCLUSION

A new CIGRÉ survey on reliability of high voltage equipment was launched in 2004. It covers circuit breakers, disconnectors and earthing switches, instrument transformers and GIS. Data from participating utilities, on equipment populations and failures, is being collected by the responsible WG A3.06.

At present (April 2005) 36 utilities from 18 countries have submitted information about their apparatus populations, together with a total of 1446 failure cards, each describing one failure. Many more utilities are currently collecting information for the survey, and a large number of extra cards will be submitted.

It is still too early to present any trends or results. The compiled information will, when the data acquisition has been completed, be subjected to extensive statistical analyses with the purpose of obtaining trustworthy information on reliability and failures for the considered component types.

8. REFERENCES

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