ABSTRACT

The evolution in the needs for electrical energy together with the concentration of generating units, demand a continual increase of transmitted power. Despite the progress made in other forms of transmission, use of overhead lines remains the best solution for the next few decades, owing to the fact that the rated system voltages have already been raised to the levels of Ultra High Voltages.

Air is the cheapest and major outdoor insulation, its importance increases as the rated system voltage goes upwards. Hence, the insulation in air becomes one of the most important parameters for the design of overhead lines and the various equipments required for a substation like circuit breakers and disconnectors etc. The open gap insulation of circuit breakers and disconnectors is known as longitudinal insulation. These two are vital equipments required for the operation of power system. The longitudinal insulation of these equipments is subjected tp the combined stress, due to the operating voltage at one terminal and on overvoltage or an out of phase operating voltage at the other terminal. International Electrotechnical Commission (IEC) Publications 56 for circuit breakers and 129 for disconnectors specifies to conduct either the one terminal test or bias voltage test (two terminal test) on the longitudinal insulation. The bias voltage test proposed by IEC as method of testing of the

longitudinal insulation demands an expensive test circuit. It however permits to test the insulation as per conditions that actually occur in the power system. Equivalent one terminal test procedure necessitates to increase the ground insulation inorder to prevent flashovers to ground. For switchgears of Extra High Voltages it is an important consideration that the test objects phase-to-ground insulation need not be increased for testing of the longitudinal insulation.

Chapter 1 presents the brief account of the phenomena of overvoltages in EHV systems. The general characteristics of overvoltages and causes of occurrence have been discussed. The various test procedures followed for evaluating withstand capability of longitudinal insulation and influence of atmospheric parameters is also discussed.

A brief review of the literature on relevant subject is presented in chapter 2. The requirements of the longitudinal insulation of circuit breakers and disconnectors and the philosophy of co-ordination of phase-to-ground and longitudinal insulation is discussed.

The development of bias test facility is presented in chapter 3. For conducting bias voltage test, many additional equipments are required to meet the requirements of the standards and for the protection of the testing transformer in case flashover occurs across the test object open gap. The use of additional equipments and their location in the bias test circuit for the effective protection of the testing transformer against chopped waves is discussed at depth. Preliminary test procedure has been suggested to check the proper functioning of the various equipments and the bias test circuit.

Chapter 4 gives the effect of high voltage damping resistor on the voltage distribution across the test object and supporting capacitance. IEC publications 56 and 129 have specified the conditions to be satisfied while conducting bias test. The interpretation of the bias test requirements specified by these standards is discussed based on legal aspects and from the systems requirement point of view. The location of damping resistor in the bias test circuit plays a vital role in evaluating the performance of the longitudinal insulation. Results of transferred impulse voltage measured on the AC terminal of the test object indicates that if the damping resistor is connected between the test object terminal and the supporting capacitance, the longitudinal insulation does not get stressed to the required test voltages.

Chapter 5 gives the effect of high voltage damping resistor on critical flashover voltage U_{50} and voltage distortion on AC wave. The error introduced in applying desired voltage stresses across the longitudinal insulation when damping resistor is connected between the terminals of the test object and supporting capacitance is discussed at depth for both lightning and switching impulse voltages.

The various test results indicate that it is a must to connect damping resistor between the terminals of the test transformer and supporting capacitance. Location of damping resistor can not be changed to protect the transformer insulation by sacrificing the performance evaluation of the longitudinal insulation. Hence some other method for the protection of testing transformer has been discussed and evaluated.

Chapter 6 gives the humidity correction factor developed for positive switching impulse bias voltages. The influence of AC corona, time shift between two peaks, time-to-crest of the impulse wave, ratio α and influence of rain under bias voltages is also discussed in this chapter. It has been observed that the AC corona produced at the power frequency terminal enhance the voltage withstand capability of the open gap insulation. The present correction approach specified by standards is not sufficient. A new correction approach is recommended for humidity correction, the value of exponent "w" for an open gap clearance of 1500mm is found to be 1.2 for both rod-rod and sphere-rod gap.

Finally, chapter 7 gives the important conclusions drawn from the whole investigations and suggestions for further scope of work, in particular with reference to breakdown phenomena under bias voltages.

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