Effect of air density factors on performance of EHV cable terminations during lightning transients

Meena.K.P,Thirumurthy, R.Arunjothi;Central Power Research Institute, (India),
arunjothi@cpri.in, thiru@cpri.in, meena@cpri.in

ABSTRACT

At present, to meet the demand for high power handling capacity in transmission and distribution system, XLPE power cable system are in use up to 500 kV Voltage level with conductor cross sections up to 2500 sq.mm . As these costly cable system works under higher stress, effective verification of each components of the system including joints and terminations as per the relevant standards is mandatory to ensure the reliability. IEC 62067 enlists the list of tests to be conducted for power cable systems of voltage rating above 150 kV up to 500 kV rating. Out of the sequence tests, one of the important test is lightning impulse voltage withstand test followed by power frequency withstand test. EHV cable terminations consists of oil filled porcelain or polymeric insulators mounted over the cable ends with stress cone at the semicon terminus point. Generally, as per standard, impulse test is carried out at the defined impulse voltage levels of standard conditions. As the terminations consists of both external and inter insulation, the design of insulators for termination needs considerations of atmospheric pressure and ambient conditions. The relevant standard for cable system and impulse tests does not consider the air density factor in obtaining the withstand level tests, as the cable system includes both internal and external insulation.. Hence the design of insulator of EHV terminations shall consider an increase in creepage length and flashover distance for altitudes above 500 meters.

KEYWORDS

Air Density Factor, Power Cable System Lightning Impulse voltage withstand test

At present, XLPE insulation has replaced all other insulating materials for power cable application due to its better thermal and electrical characteristics. At present, XLPE power cables are available up to 500 kV rating. Along with power cables, Power cable accessories, the weakest link in power cable system also has gone through several advancements. Up to 66 kV system voltage, terminations are of dry type and above 66 kV oil filled termination with composite or porcelain insulators are used. The main purpose of this termination is to reduce the stress concentration at the semicon terminus of power cable. In addition to stress control, the required creepage length to avoid internal and external flashover is achieved by providing the porcelain or polymeric insulators filled with oil. Hence the Power Cable termination consists of both internal and external insulation, whereas both joint and power cable consists only of internal insulation. Both internal and external insulation needs to be considered while carrying out electrical tests on power cable system.

EVALUATION OF POWER CABLE SYSTEM

The quality evaluation of EHV Cable system comprising of cable and accessories are carried out by conducting various electrical tests as per relevant IEC specifications. IEC 60502-4 covers accessories of voltage rating up to 33kV, where all terminations are of dry type. however, for power cables of voltage rating above 33 kV up to 150 kV rating is covered by IEC 60840 and cable system of voltage rating above 150 kV up to 500 kV are covered in IEC 62067-2011. As accessories are an integral part of power cable system IEC 62067 calls for testing of cable system as a whole to ensure overall quality, integrity and compatibility.

As per IEC 62067, the cable system has to undergo electrical tests in sequence after installation of all accessories. The sequence of tests are partial discharge test, Heating cycle voltage test, Partial discharge test after heating cycle voltage test, and Impulse voltage withstand test followed by AC high Voltage Test. Out of these tests, Impulse withstand test is seemed to be a very critical test. Several failures have been reported during the impulse voltage withstand test.

LIGHTNING IMPULSE VOLTAGE WITHSTAND TEST

Studies of transient disturbances on transmission system has shown that lightning strokes &switching operations are followed by travelling waves of a steep wave front. It causes an unequal stress distribution and may lead to breakdown of the insulation system. The magnitudes of this travelling waves depends up on the system voltage.

When designing high-voltage electrical systems intended to be located at altitudes exceeding 1000 m, it is imperative to consider the effects of the atmospheric conditions on the design of specific components, otherwise it may result in reduction of operation performance or even failure. The dielectric strength and transient overvoltage withstand levels are critical factors to design external insulation of any high voltage equipment. With increase in altitude, the air density decreases, which in turn lowers the dielectric withstand voltage for a given geometry.

Unlike other parts of cable system, EHV cable termination has both internal and external insulation, like bushings. As per IEC 60060-1, the disruptive discharge of external insulation depends on the atmospheric conditions. (air density and humidity) . Disruptive discharge voltage increases with air density and humidity (up to 80% relative humidity).Standard recommends correction factor for the test voltages, for