DEVELOPMENT OF COLD-SHRINK HVCA IN REGARD TO THE CRITICAL SET OF PHYSICAL PROPERTIES

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ABSTRACT

This paper presents one methodology used in the development of HV premolded mechanical-shrink (cold-shrink) cable accessories in regard to the set of physical properties of the elastomers and how these properties are affected by thermal and mechanical stresses and by exposure to different insulating liquids. It also describes type and prequalification tests on joints and terminations as final validation steps. Most notably, this paper presents methods and some results from several development tests on physical properties of elastomers.

KEYWORDS

HV extruded cable accessories, mechanical-shrink, stress cones, joints, terminations, physical properties, tension set, interface pressure, insulating liquids, type test, prequalification test.

INTRODUCTION

The elastomeric component of cable accessories for extruded cables, i.e. joint or stress cone may be designed and manufactured for slip-on installation or it may be pre-expanded at the factory and collapsed on the cable in the field. In the second case premolded part is expanded onto the tube with outer diameter larger than the diameter of the cable insulation, and consequently, for certain period of time it will be stressed more than the one in slip-on design. Some physical properties of the material might change due to this prolonged and larger expansion of the premolded part.

Certain outdoor and equipment-type terminations are filled with insulating liquid. When submerged in liquid, the elastomer may swell, changing its physical properties.

This article will describe some physical and electrical tests performed in selecting appropriate material for pre-expanded (mechanical-shrink) joints and stress cones. The set of critical physical properties that were evaluated include modulus of elasticity at different elongations, hardness, tear and tensile strength, ultimate elongation and tension set.

Both Room Temperature Vulcanized (RTV) and Liquid Silicone Rubber (LSR) materials were considered for the stress cones and joints. In addition several grades of silicone and polybutene insulating liquids were analyzed for compatibility with the stress cones and cable insulation.

The tests consisted of physical tests on material samples, scale-down components and real size joints and stress cones. They also included electrical tests on actual terminations and joints. In particular, this paper will present the methodology and some details of three sets of different development tests with the results and conclusions.

In the first group of tests we have explored the dependence of interface pressure between premolded part and cable on temperature, time and exposure to insulating liquids. The interface pressure was measured at different locations along the interface.

In the second group of tests the tension set of different silicone rubber materials was evaluated. The results of these tests were used to evaluate suitability of tested materials for mechanical-shrink applications and to determine the shelf life of expanded elastomers until its installation on the cable.

The third set of tests was designed to evaluate influence of different types of insulating liquids on physical properties of different elastomers. The hardness, tear, tensile strength, ultimate elongation and tension set of the elastomers were measured before and after submersion in insulating liquids.

Finally, the paper will describe type tests and long term tests on accessories rated 69 kV to 230 kV. It will also describe prequalification (PQ) test loop for 230 kV accessories per IEC 62067.

INTERFACE PRESSURE TESTS

Interface pressure between molded part and HV extruded cable is a critical parameter for successful operation of the device. Along with the quality of finish of the mating surfaces, the interface pressure directly affects dielectric breakdown strength along the interface [1].

The interface pressure has to be kept within certain boundaries throughout the life of the accessory. The attempt of design tests was to assess if this requirement is met when interface pressure changes with time, temperature, exposure to insulating liquids and location along the interface between premolded joint and the cable.

For the purpose of measuring interface pressure, aluminium cylindrical fixture (mandrel) was designed with an opening for a load cell cap. The load cell was connected to a data recorder for continuous data collection. The pressure was calculated by dividing the force with known area of the load cell cap. Mandrels with different diameters were used to simulate cable sizes that stress cones or joints would be installed on.

Cycling tests on rubber rings

Tests were designed to evaluate the change of interface pressure with geometry (wall thickness and bore diameter), temperature and exposure to insulating liquid. Different grades of silicone rubber material with hardness of 30 and 50 Shore A were tested. Various sizes of thick rubber rings were molded to simulate stress cone and joint sizes. Processing parameters, including curing and post-curing schedules of each ring were measured.

After the rubber ring was installed on the mandrel, initial interface pressure measurements were taken at ambient temperature with ring in air. When the pressure readings