# Influence of expansion on electric field distribution of stress cones for high voltage cable accessories

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## ABSTRACT

*Premoulded stress cones for cable accessories, made from elastomeric materials, are designed by use of computer calculation of the electrical stress in the accessory.*

*During installation the stress cones are expanded and the semi conductive deflectors get out of their original shape. Thus the electrical field calculation is no longer accurate.*

*The paper describes an approach for this problem. The outline of the surface contours are calculated by a simple method, based on the assumption that the volume as well as the length of the elastomeric part is not considerably changed by expansion.*

## KEYWORDS

Accessory field control, silicone elastomers, calculation of deformation during expansion…

## INTRODUCTION

The use of stress control systems made from premoulded elastomeric materials is widely established in modern accessories for extruded HV and EHV cables.

A stress cone is made from insulating material on the outside and embeds a semi conductive layer or part, which is formed to create a field controlling contour. Silicone elastomers have won recognition in this field due to the good manufacturing properties and the outstanding dielectric performance. It is common practice to determine the exact shape of the stress cone parts by a computer aided calculation of the electric field distribution in the accessories.

At joints and outdoor terminations the stress cones have to be installed on the cable with considerable expansion in a defined range. This expansion creates the surface pressure that is needed to withstand the electrical field stress in the gap between stress cone and cable surface.

By expanding the stress cone gets out of its original shape, the wall thickness is reduced and the deformation changes the outline of the semi conductive surface. Thus the original electrical field calculation is no longer valid. The electrical field stress may be increased and the installed accessories may perform worse than calculated.

Today cable systems tend to use higher voltages, which are often combined with comparative less insulation thickness. As a result of this some cables have a very high electrical field in the insulation that is straining the accessory field control system. At the same time the use of very large conductor cross sections is increasing, ever raising the electrical field in outdoor terminations. Consequently the stress cones have to be designed in an optimal way and it is sensible to consider the deformation effect.

In search for a simple approach for the problem how to calculate the expanded outline of the surface contours some basic considerations have been made. Silicone elastomers are nearly incompressible. Experiments have shown that the length of stress cones for high voltage cable accessory does not change very much by the expansion during installation. Based on this it can be assumed that the volume of the elastomeric part as well as the length are not changed considerably by expansion.

With this boundary condition the new form of an expanded elastomeric field control part can be calculated. The new surface contours are then used in the electrical stress calculation. Eventually the original contour of the stress cone is modified to give optimum performance after expansion.

## DEFLECTOR FUNCTION AND DESIGN

The electric field in the insulation of modern day polymeric high voltage cables can reach more than 16 kV/mm (long-term stress at $U_0$ on inner semiconductor) [1]. This is in contrast to the allowed stress on the surface of insulators in air, as used in cable terminations, which is about 0.5 kV/mm. That for cable terminations make use of stress cones as a grounded electrode to manage the transition to air and the insulation of the cable ends.

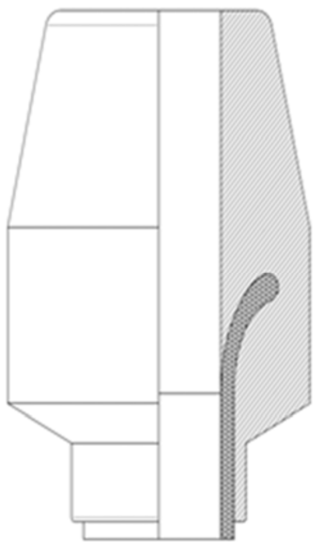

**Fig. 1: Example of stress cone for outdoor termination**

Terminations for gas insulated switchgear (GIS) or 'plug-in' type terminations work by the same principle. There is a bushing insulator added, regularly made from cast resign, that encloses the cable end with the stress cone.