# Fault mechanisms of incorrectly installed force springs for ground screen connections in medium voltage cable systems

Hans Lavoll **HALVORSON**, Sverre **HVIDSTEN**; SINTEF Energy Research, (Norway), hanslavoll.halvorson@sintef.no, sverre.hvidsten@sintef.no

Robin **BAKKEN**, Frank **MAUSETH;** NTNU, (Norway), robinlb@stud.ntnu.no, frank.mauseth@ntnu.no

## ABSTRACT

*Laboratory tests have been performed to reproduce local overheating which occurred in a 24kV cable system in service. The overheating was due to incorrectly installed force springs at cable joints. The same installation was done in the laboratory and the test loops were subjected to moderate ground screen currents. The results show that all test objects experienced local high temperatures and the dissection indicated excessive overheating. The results are in agreement with what was detected during forensic analysis of the joints suffered from service breakdowns. The results can be used to improve technical specifications, testing and installation of such connections.*

## KEYWORDS

Cable screen connections. Force springs. Incorrect installation. Fault mechanism. Standardization.

## INTRODUCTION

Several cable failures have been reported in the Norwegian power grid the last 25 years due to local hotspots in cable ground screen connections or close to accessories such as joints and terminations [1,2,3]. The failures are often costly due to the interruption of delivered power and the time required for repairs. Possible reasons for failures can be limited ampacity, bad design, unclear or misleading installation procedure, lack of information from both supplier of cable and accessories, unskilled engineering/installers and relatively large currents in cable ground screens [4]. As of today, no qualification tests or standards exist for determining the ampacity of the metallic ground screen connection systems of different cable designs. An international CIRED working group has been established to propose a test procedure and verification of ground screen connections [5]. The test procedure could lead to less failures providing a more reliable distribution grid in the future.

A specific failure type which occurred in the Norwegian power grid has been studied and reproduced in the laboratory to better understand the failure mechanism. A test setup was made to investigate the performance of the ground screen connections of the "force spring" method, including an incorrect installation experienced causing a service failure. A DC current was applied to 12 screen connections with 2 different types of force springs. The springs were subjected to different heat cycles where the temperatures and the contact resistances were measured simultaneously.

### Screen currents

For most cable systems, the normal practise is to connect the cable screens to earth at both ends of the cable. During normal operation (symmetrical current load at power frequency), currents are induced in the cable screens due the magnetic field resulting from the conductor currents, in addition to the capacitive charging currents. The magnitude of the induced currents depends on the installation geometry (flat or trefoil), magnitude of the conductor currents, and the metallic screen design (i.e. geometry and electrical conductance of the screen elements). The induced currents can be in the order of 5-35 % of the conductor current. In addition to normal operation, the cable ground screens must be able to carry transient currents originating from induced voltages during short circuit and ground fault conditions [4].

### Screen connections

Screen connections are used to galvanically connect the cable and joint screen, or to connect the cable screen to ground. They are of nature complicated contact system and can consist of several different materials and components with individual material characteristics. Typical designs can involve contact-plates or metallic meshes pressed onto the cable screen with the help of constant force springs, collar ties, other clamping devices or by soldering [6,7].

Manufacturers utilize the force springs in different ways in their screen connection design. Some designs have two force springs per screen connection (four per joint), where one of the force springs is mounted directly on the outer sheath. Cu-wires from the cable and the joint screen (Cu-mesh) are then placed together over the first force spring and a second, larger force spring is applied directly over the screens. Another type of screen connection design use only one force spring per screen connection (two per joint). One round of the force spring is laid directly on the outer sheath of the cable. The Cu-wires and the joint screen (Cu-mesh) are then placed together on the force spring such that the rest of the spring can be rolled over to apply force on both of the screens. Both methods use the same principle and a sketch of installation is shown in Figure 1.

### Design issues

A ground screen connection design should through its service lifetime maintain a stable and sufficiently low contact resistance, thus preventing any local temperature increase exceeding the allowed temperature of the cable and accessories. The screen connections should not introduce any reduction of the ampacity of the ground screen system.

Wrongly installed electrical connections can cause local heating due to high contact resistance. On a microscale, the contact surfaces are rough, and the resistance is due to the constriction resistance in contact area between the interfaces. In addition, thin oxide layers (aluminum) might also be present at the interface causing an additional resistance by introducing a series resistance or by reducing the area of metallic contact. Degradation mechanisms of screen connections can for example be chemical (corrosion) or mechanical (wear or loss of contact force).