Corrosion studies and remedy options for low-voltage cable

James **STEELE,** Nathan **LAURIE;** Novinium, (USA), James.Steele@Southwire.com, Nathan.Laurie@Southwire.com,
Wayne **CHATTERTON**, Southwire, (USA), Wayne.Chatterton@Southwire.com

ABSTRACT

Low-voltage cables form the last link in the power grid by delivering service to homes and businesses. Relative to the total amount of installed undergound cable, low-voltage cables are responsible for a disproportionately large number of service interruptions throughout the world. Failures on low-voltage cables are often attributed to a loss of ampacity due to corrosion and evidence suggests a particular failure mechanism related to the density of the alternating current. Silicone-gel injection of these cables prior to exposure to a highly corrosive environment will be presented as a remedy with data showing injected cables significantly outperform non-injected cables by preventing conductor loss as measured by conductor resistance and operating temperature.

KEYWORDS

Cable rejuvenation, corrosion, low-voltage power cables, power demand, power grid, power system faults, power system restoration, power distribution reliability, robustness, Silicone-gel injection, stray voltage, underground power cables.

INTRODUCTION

As the transition of the modern home to full electrification occurs over the coming decades, dependence on the low-voltage cables, rated under 600 V_{ac} and forming the last link in the distribution grid, is set to increase. While these cables represent only a small portion of the underground electrical cable installed around the world, they account for a disproportionally large percentage of annual service interruptions [1], [2], [3]. Insulation breaks occur through a variety of means in low-voltage power cables and allow electrolyte, in the form of groundwater, to contact the aluminum conductor causing significant ampacity loss and eventual failure due to corrosion. In this paper, a study into the corrosion of low-voltage cables will be presented. In particular, a remedy in the form of silicone-gel injection of low-voltage cable will be described with data showing a resistance to corrosion despite exposure to highly corrosive environments. The relative difference in conductor loss caused by the corrosion of injected and non-injected cables will be measured through changes in conductor resistance and operating temperature.

WATER INGRESS AND CORROSION

The underground low-voltage power cables that service homes and businesses typically fail in service due to either the full or partial loss of ampacity of the conductor due to corrosion. Corrosion commonly occurs when electrolyte comes into contact with the aluminum conductor strands for an extended period of time. Flaws in the aluminum oxide layer become initiation sites for the corrosion process and the rate of corrosion is determined by the rate at which more flaws are produced. The mechanisms have been well documented in literature [4], [5], [6]. Due to the higher specific volume of the corrosion product when compared to conductor aluminum, swelling and deformation of the cable is common with breaks in the insulation revealing white aluminum hydroxide powder (Figure 1).

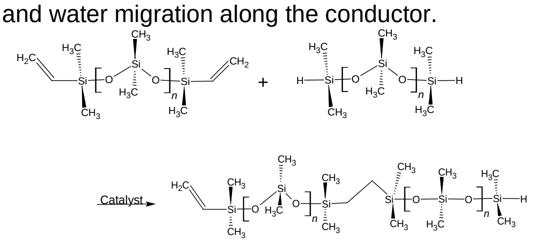
Ingress of water into the conductor of low-voltage cables can be due to many factors including; craftwork practices for installation of accessories, external damage such as dig-ins and chemical or thermal degradation. Any of these factors can introduce groundwater into the cable [7]. Consequently, blocking of the water entry pathway into the cable and limiting water migration along the conductor can be extremely effective at preventing corrosion.

Since the proliferation of low-voltage cable beginning in the 1960's, many advancements have taken place to improve performance such as the introduction of ruggedized insulation [2], [8]. Nevertheless, there exists a need to protect cables already installed.

Fig. 1: Typical low-voltage cable that has failed in service due to a loss of ampacity caused by corrosion.

Silicone Gel

The silicone gel used to protect low-voltage cable from corrosion is a two-part formula that is field-mixed prior to injection [7]. The two components undergo a hydrosilation reaction that transitions the mixture from a fast-flowing fluid with a viscosity of 5 cSt into a non-flowable gel in approximately 48 hours [Eq.1]. The injection of silicone gel purges standing water from the conductor, fills cracks in the cable insulation and once cured, prevents water ingress and water migration along the conductor.



[1]

Injection Process

Similar to the process used to rejuvenate medium and high voltage power cables described in [9], low-voltage cable systems are typically injected by taking a transformer