Controlling fluid leaks in damaged fluid filled cables

Susmit **BASU**, Ian **GERMAN**; Dr., Research Chemist, Gnosys Global Limited, Guildford, United Kingdom, s.basu@gnosysgroup.com, i.german@gnosysgroup.com

Rhys **RHODES,** Janet **THOMAS**; Dr., Research Scientist, Gnosys Global Limited, Guildford, United Kingdom, r.rhys@gnosysgroup.com, j.l.thomas@gnosysgroup.com

Gary **STEVENS**; Professor, Managing Director, Gnosys Global Limited, Guildford, United Kingdom, g.stevens@gnosysgroup.com

Delphine **LAURICHESSE**, Yves **BERTRAND**; Dr., EDF – R&D, Laboratorie des Matériels Électriques, Avenue des Renardières – D14 Ecuelles 77818, Moret sur Loing, France, delphine.laurichesse@edf.fr, yves.bertrand@edf.fr

ABSTRACT

Fluid filled cables are widely used among the electricity distribution networks. The problem arises with ageing and failure of the cable sheath followed by major or minor oil leaks into the environment. Detection of the leak and onsite reparation are both costly and time consuming. In this paper we describe an effective solution to these problem by formulating self-healable oil blends, where the healing takes place via contact with atmospheric oxygen. An effective oil blend has been developed which can be used with the existing cable oil to carry out the self-repair process without disrupting the operation of the cable.

KEYWORDS

Fluid Filled Cables (FFC), Self-healing, Alternative cable fluids, Insulation oils, Drying oils, T3788 oil.

INTRODUCTION

Fluid filled cables (FFCs) have been used in electricity distribution networks for over 100 years [1]. Compared to early polymer-insulated cables, FFCs were capable of operating at substantially higher voltage ratings (see Fig. 1) until the 1980s, at which point the majority of FFCs were replaced by cables insulated with a solid core of cross linked polyethylene (XPLE). At present, there are approximately 8,500 km of FFCs remaining in the UK, typically in situations where replacement is either highly complex or prohibitively expensive. Many of these cables have now exceeded their operational lifetime by 30 or 40 years, and so cable failure through sheath aging and corrosion is becoming a significant concern [2].

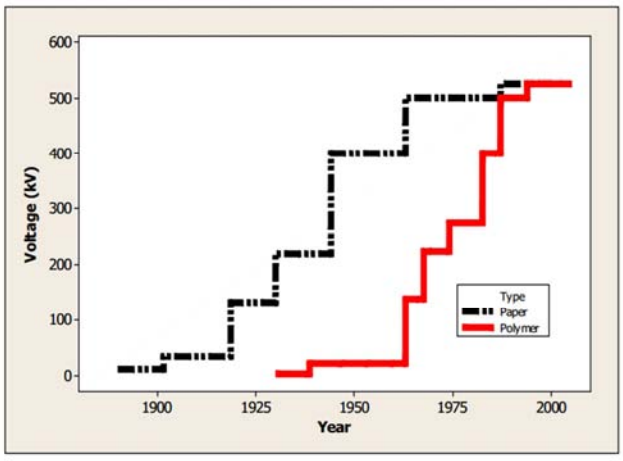

Fig. 1: Improvements in cable ratings for fluid filled (paper) and polymer cables over the 20th century [1]

Fluid filled cables possess an insulation layer consisting of overlapped insulation paper (often cellulose or polypropylene-laminated paper) that is impregnated with an insulating, low viscosity mineral oil. This oil provides a number of secondary functions, including heat transport and the prevention of void formation within the insulation layer. Both aspects improve insulation lifetimes; the heat generated by cable operation can accelerate the aging of the paper insulation if it is not transported away. The presence of voids within the insulation layer can lead to partial discharges, which can erode the insulation and lead to cable failure [2].

In order to ensure that the paper insulation is fully impregnated, the oil is kept under a positive pressure of between 3 and 4 bar [3]. Although this effectively suppresses voids, it also means that the insulation oil will rapidly leak through holes in the cable sheath, which may be caused by damage to the cable or through aging and corrosion, as outlined above. This issue is compounded by the low surface energies of the oils which allow leaks to occur through pinholes microns across.

The loss of oil raises a number of concerns. With regards to the cable, an oil leak will lower the total volume of oil in the circuit. If unchecked, this can result in the loss of pressure in the cable circuit and the formation of voids, which will eventually lead to cable failure. Although the lost oil can be replaced, contamination of the environment remains an issue; cable operators in the UK are legally obliged to report leaks above a certain volume (40 litres a month in sensitive areas [4], or 100 litres a month elsewhere) and must take immediate action to resolve the problem. As with other underground circuits, this requires that the leak be located, diagnosed, and the area excavated so that repairs can take place. This is an expensive and time-consuming undertaking [5], and so in cables with multiple severe leaks, the operators may opt instead for permanent decommissioning.

An indication of the scale of this problem is illustrated below in Fig. 2, which shows information collected by Ofgem [6] regarding the size of the FFC network and the volume of oil lost each year. It can be seen that since 2009, the volume of oil lost has remained steady at approximately 400,000 litres per year. Despite the fact that new FFCs are no longer being deployed, in 2010 there was an increase in the FFC network of approximately 1,500 km. This is attributed to ‘a more thorough audit of the DNO FFC population last year’. Based on this, it can be assumed that these cables were not leaking or developing other faults that may have drawn attention to their existence; this is borne out by the