Long power cables: exposing incipient faults and optimizing performance using extra-long fibre optic distributed temperature monitoring.

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ABSTRACT

Distributed Temperature Sensing offers cable operators an insight into cable condition and, when combined with Dynamic Cable Rating, can be used to optimize performance. The two broad types of DTS available, Raman and Brillouin based sensing, enable all but the longest cables to be monitored.

KEYWORDS

DTS, DTSS, temperature monitoring, transmission cable, subsea cables, export cables, inter-array cables, Brillouin, Raman, strain, fibre optic.

INTRODUCTION

Monitoring the temperature of buried transmission power cables using optical fibre started in the mid-1990s. Using Raman based Distributed Temperature Sensing (DTS) utilities could at last see the temperature of their asset and ensure that it was operating at below 90^0C. In fact, early adopters of the technique in Northern Europe found that in many cases their cables were operating at little above the ambient ground temperature. DTS was 'nice to have'. In 1998 the lights went out in Auckland's Central Business District (New Zealand), due to cables overheating and failing. The benefits of Distributed Temperature Monitoring became immediately apparent and DTS became a 'must-have' on new buried cables.

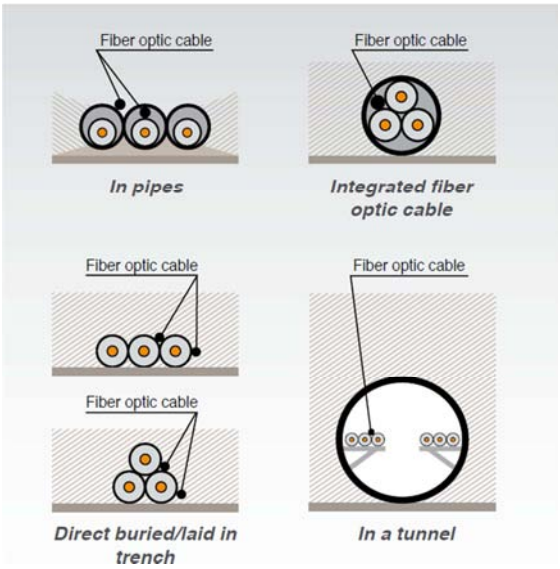

Fig. 1: Typical locations of optical fibre in power cables

Knowing the cable's temperature and relating it to load provided utilities with the means to predict for how long the load could be safely increased and how much more load a cable could transmit before overheating. Known as Dynamic Cable Rating systems (also RTTR and DRS) these help optimize and manage the cable's performance and are usually included in the purchase of the monitoring system.

With the advent of 'renewable' electricity generation, deregulation, smart grids, the desire for undergrounding, the development of cable manufacturing and installation techniques transmission cables are getting longer. As was highlighted in a recent DNV report [1], system operators demand reliability. To help provide that reliability in transmission cables, Distributed Sensing provides early detection of faults enabling these to be investigated before the cable fails. But as cables become longer and grids become smarter, how are the distance capabilities of DTS systems developing to match these trends?

To simplify this paper the terms Raman DTS is used for DTS based on Raman, and likewise for Brillouin DTS, where DTS is used on its own it refers to generic Distributed Temperature Sensing. For clarification, reference to Brillouin DTS in this paper refers to Stimulated Brillouin.

DISTRIBUTED TEMPERATURE SENSING

Raman based DTS

The first commercial Distributed Temperature Sensing Systems were based on Raman scattering techniques. Using multimode optical fibre placed beside or integrated into the power cable.

Fig. 2: fibre optic cable integrated into a power cable. Primarily used for communications, but strands are usually available for sensing.