

On-line cable condition monitoring

EDF Energy's 11kV and 6.6kV underground cable network is 38,000km long and worth around £4 billion (replacement value), but we know very little about its condition.

The fault rate is slowly increasing and this trend is likely to accelerate as the cable gets older. Ofgem is increasing pressure on us to improve network performance, operate the network more smartly and reduce operational cost.

As the cost of replacing all older cables is prohibitive we are seeking lower cost replacement strategies that will extend the use of the remaining cable lifetime. Partial discharges (PD) are small electrical breakdowns within an insulation system that partially bridge the space between two regions at different potentials.

PD activity can eventually degrade the insulation of a cable to such an extent that it can no longer withstand the electric stress across it. At a basic level, cables with high PD activity can be classified as having a greater risk of failure than cables in which no PD activity can be detected.

Offline testing techniques have been used for 15 years but they are comparatively expensive and require a network outage, which itself increases the overall system risk.

Five years ago, we took on the challenge of developing online techniques which could provide round-the-clock information on the status and risk of a piece of network. Very few people believed it could be achieved at the time.

The aim of the online condition monitoring project is to develop tools that provide an assessment of the condition of a section of network. Longer term objectives include:

- The reduction of the overall level of risk on the power system.
- Targeting replacement/refurbishment programmes by identifying and locating high risk sections of cables and/or reconfiguring networks.
- Developing systems and tools that can later be applied to other assets such as the low-voltage underground network, switchgear or overhead lines.
- Helping deliver the Networks Branch vision of "zero customer interruptions" and "total network knowledge".

In 2002, we agreed to cooperate with IPEC (Independent Power Engineering Consultants Ltd, a UK based technology company delivering solutions to the electricity sector). This strategic decision was taken in order to develop a robust hardware and software solution. Since then, a web based application and monitoring equipment have been developed, older equipment has been upgraded whenever possible and a database has been designed to efficiently store the data collected.

An international Online Partial Discharge



Monitoring Equipment & Sensors

consortium has also been established in order to address the industry's growing concerns over cable ageing. Consortium members include Kema (the Netherlands based R&D and consultancy group), EDF Energy, EDF R&D (France), Nuon & Eneco (power network owners in the Netherlands), University of Manchester Institute of Science and Technology (UMIST), Technical University of Eindhoven, STW (a Dutch governmental organisation which contributed €0.5 million to the consortium) and two UK based consultancy companies. Since development began, valuable technical knowledge has been gained:

- The magnitude of the partial discharge (as detected using the peak detection technology) alone does not provide sufficient information to evaluate how critical the discharges are. Two partial discharges of the same magnitude when detected at the substation could have different magnitudes at their origin.
- The number of discharges above a threshold per 50 Hz cycle (count) can provide information on the level of degradation of a cable or an accessory. The changes over time are a main indicator of the evolution of the degradation process and the failure may occur shortly

after a period of intense PD activity.

- The shape of a partial discharge provides fundamental information and can be used for calculating the amount of energy produced by the discharges as well mapping, noise reduction and rejection.

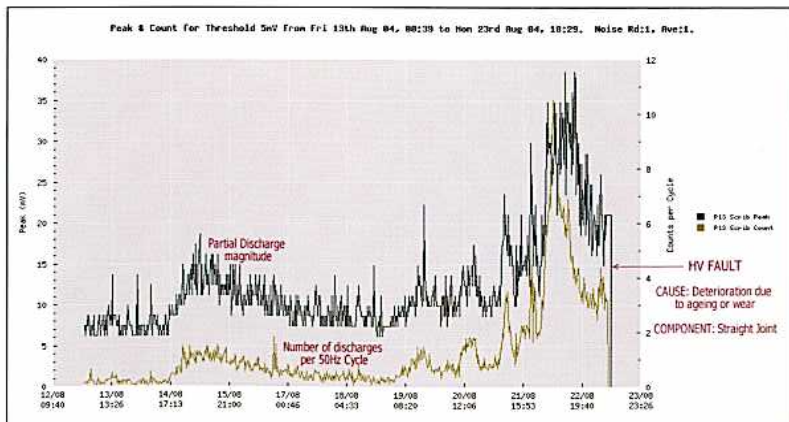
30 substations (primary and secondary) and 540 circuits are currently being monitored and the techniques are still under development. Increasing numbers of faults are being detected in advance and our knowledge of how progression to failure occurs has greatly improved.

On monitored circuits, around 30% of failures are being detected in advance. Upcoming developments in noise reduction and pattern matching are expected to significantly improve this detection rate.

A technician has recently been trained to support the condition monitoring project with installations, upgrades and online mapping trials. Current development work includes the comparison of offline and online mapping location techniques, the development of a long-term strategy for inclusion in the NAMP and the management of an ongoing programme of university research projects in Manchester and Brighton. With the introduction of Ofgem's Innovation Funding Incentive (IFI) from October 2004, we can expect the level of our research and practical trials in this area to grow significantly.

Published papers have stimulated worldwide interest and EDF Energy is increasingly recognised as a pioneer of new cable testing techniques. The regulatory regime and the ageing electricity network will make the next few years increasingly challenging and condition monitoring will help the company to efficiently manage cost and network performance.

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Web interface showing fault trend increasing before failure