

## THE CABLE SNIFFER, A NEW AND PROVEN TECHNIQUE FOR LOCATING LV CABLE FAULTS

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### INTRODUCTION

The CableSniffer is an intuitively simple device to pinpoint Low Voltage (LV) cable faults. It operates by “sniffing” the gases given off by faulting LV cables as the cable insulation burns.

The CableSniffer was developed through a collaborative research programme involving a number of parties, including all of the UK Distribution Network Operators (DNOs) through the Strategic Technology Programme (STP), local universities and the UK Department of Trade & Industry (DTI). Its development was needs driven, with very substantial cost to, and disruption of, the electricity networks being caused by lengthy fault finding techniques.

The CableSniffer has been widely adopted within the UK DNOs with very substantial cost benefit resulting. It has been trialled across Europe, the Middle East and Far East and has potential globally to reduce the impact of LV cable faults on customer minutes lost and restoration costs.

### THE OPERATIONAL NEED

LV cable faults are the single most significant cause of loss of supply incidents within the UK electricity industry, contributing to more than 10% of Customer Interruptions (SAIFI) and more than 20% of Customer Minutes Lost (SAIDI). They also attract the most significant element of operational expenditure within the DNO.

Many LV cable faults can be located quickly and easily, more often than not by identifying the location of the nearest mechanical excavator, with third party damage representing c40% of the failures. Whilst approximately 10% of failures are caused by other events such as land slippage or other disruption to the cable, it is estimated that around 50% of faults are caused by failure in the cable joints.

Locating the faults caused by cable sheath failure represents a significant technical challenge and occupies many hundreds of cable fault location teams within the UK. The objective of the CableSniffer was to benefit from the anecdotal evidence of cable fault team engineers that a fault could be “sniffed out” due to the very distinctive gases given off when a cable fails, caused by the burning of the sheath insulation.

The challenge of the research programme, therefore, was to effectively identify the characteristic gases emitted on failure of an LV cable and to determine whether detecting the gases could be used as a means of accurately locating faults.

### CURRENT PRACTICE

The traditional techniques for identifying the location of a cable fault include the most obvious of approaches, namely, identifying those customers without power. Often these customers identified themselves very quickly. Once the DNO has been alerted to the occurrence of a fault, available local circuit plans are consulted to locate broadly which circuits are potential culprits. A fault team is then sent to the area where the fault is thought to have occurred to check for third party damage or other more obvious causes of failure. This can include a multitude of events, most often associated with other excavations occurring in the highway. In the event that no obvious cause and location is available, the echo location instrument is deployed. In simple terms, this involves sending an electronic pulse from a local substation down the cable identified as having failed, and measuring the time taken for the pulse to reflect off the fault.

This approach is estimated to be accurate to within 10% of the total distance of the fault from the substation. Whilst this is of great assistance, given that the average fault is perhaps 100 metres from the nearest substation, it still leaves a 10 metre stretch of cable over which the fault may have occurred. Furthermore, branching of the cable may leave several alternative locations of the fault, and whilst this can sometimes be determined through identifying customers without power, this is not always possible.

Using the echo location approach, once an estimated location has been identified, the hole is excavated and the cable is cut and tested to identify in which direction the fault is located. Once completed further excavations and cutting tests are conducted until the fault is finally pinpointed (see Figure 1).

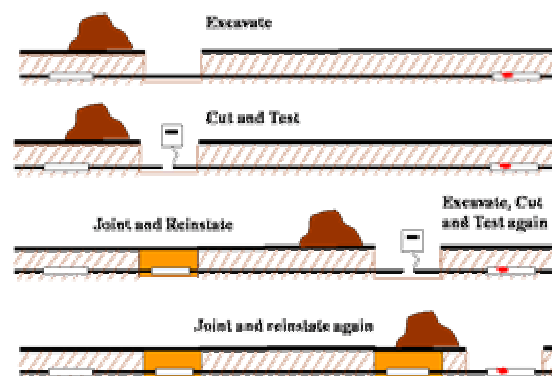


Figure 1

The above approach normally takes 2 to 3 attempts to identify the location of the fault. It requires, therefore, 2 to 3 excavations and 2 to 3 joints to be made in the cable and reinstatements of the highway.

It is estimated that each excavation, joint and reinstatement using the above technique costs the DNO a minimum of £500 and in some cases up to several thousand pounds.

### NEW APPROACH REQUIRED

Given the significant costs and lengthy restoration time involved in using the current fault location techniques, the need for an alternative which was quicker and involved much fewer excavations was clear.

Initial research was carried out within the Post Graduate Training Partnership between EA Technology and UMIST, funded by the DTI and the STP, a collaborative research and development programme run by EA Technology involving all of the UK DNOs<sup>[3]</sup>. A project was conducted to identify the gases that were given off as a result of burning insulation in the sheath of the cable as it failed. The concept in mind was that if an identifiable class of gasses could be determined, and their relative concentrations shown to indicate the proximity of a fault then, inserting a probe into the ground along the route of the cable at a number of points could potentially pinpoint the point of failure. This would involve piercing a small hole through the ground surface above the cable, perhaps 15mm in diameter and 20cm deep into which a probe could be inserted and gas samples analysed. See Figure 2.

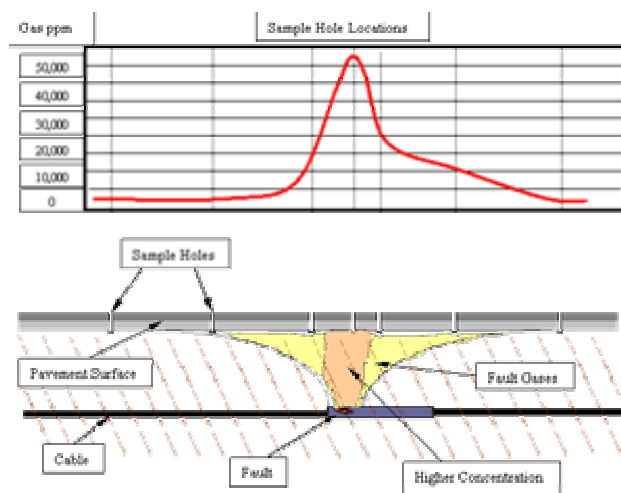


Figure 2

### DEVELOPMENT METHODOLOGY

The research methodology involved the following stages:

- (1) Burning a series of insulation materials in laboratory environments to determine the gases given off. The insulation materials that were tested in this way included XLPE, PILC, PV, Polyurethane resin and Butyl rubber.
- (2) All of the gases emitted were assessed using gas chromatography to determine their composition. 96 discrete gas components were identified in total. 12 of these gases were found to be common into all of the cable insulation types. 6 of these gases were found to be produced in sufficient quantities to be detected in a field environment.
- (3) This stage involved identifying the appropriate gas sensor technology which would allow identification of the target gases.
- (4) A prototype unit was produced which comprised a laptop contained within a small suitcase, a battery pack, a gas pumping mechanism and a sensor array. A trough containing cables in close to field conditions was produced and failures were induced on these cables. It was found that the relevant gases could be identified and used to pinpoint fault location in this controlled environment.



Figure 3

- (5) The prototype was deployed in the field and a series of tests conducted to identify faults in several DNO areas. This was found to be successful, although the operation of the prototype was impractical for normal operation as the gas sensors required significant power and time to warm up.

- (6) A production unit was developed, in conjunction with a gas detection equipment manufacturer, which could be operated effectively and in the field.



Figure 4



Figure 5



Figure 6

## INDUSTRY BENEFITS

All of the UK DNOs conducted extensive trials with the production unit CableSniffer over a period of 12 months and found the unit to be highly effective. As a result, many of the UK DNOs are in the process of equipping all of their cable fault teams with a CableSniffer.

In a typical DNO licence area there are approximately 5,000 LV cable faults per year, approximately 2,500 of these are caused by cable or cable joint failures (rather than third party damage or land slippage) and can be located using the CableSniffer. The extensive prototyping and trialing, has illustrated that the CableSniffer saves on average one

excavation per fault. Given an average cost per excavation of £750 we estimate for one licence region the annual saving for full deployment of the CableSniffer is in the region of £1.8M. To fully equip the relevant number of cable fault location teams to identify this number of faults using the CableSniffer would cost in the region of £200,000. The payback on the investment is therefore in the region of 6 to 8 weeks from purchase. There are clearly also substantial benefits in terms of improved restoration times and companies who are fully deploying CableSniffers are also seeing marked improvements in their quality of supply performance indicators.

## SUMMARY

The CableSniffer is a superb example of a research idea being converted into a successfully deployed instrument for improving quality of supply and reducing operational expenditure. It has been achieved through collaborative work and the effective involvement of universities and other agencies. It is increasingly becoming an icon in the UK, demonstrating the benefits of need-driven research and development. It has been useful in highlighting some of the commercial challenges in exploiting research outputs and has motivated a number of parties to investigate and invest further in well considered research opportunities.

## REFERENCES

- [1] D E Miller, 1999, "Underground Cable Fault Location using Multi-element Gas Sensing", PhD Thesis, EA Technology Ltd
- [2] B Clegg, 1993, "Underground Cable Fault Location", McGraw-Hill Book Company
- [3] M I Lees, 2001, "The Strategic Technology Programme – a model for high value and focused collaborative technology development", CIRED 2001