

## Cathodic Protection

### Remote Monitoring of Cathodic Protection on a Gas Distribution Network

Author: Martin Alderson Northern Gas Networks  
Issued for UKOPA members

*CP measurements are very labour intensive and costly to take manually - and only indicate problems after they have occurred. Northern Gas Networks, is installing a remote CP monitoring system that will deliver a quick financial payback and is already making operational improvements to the management of the gas pipeline asset.*

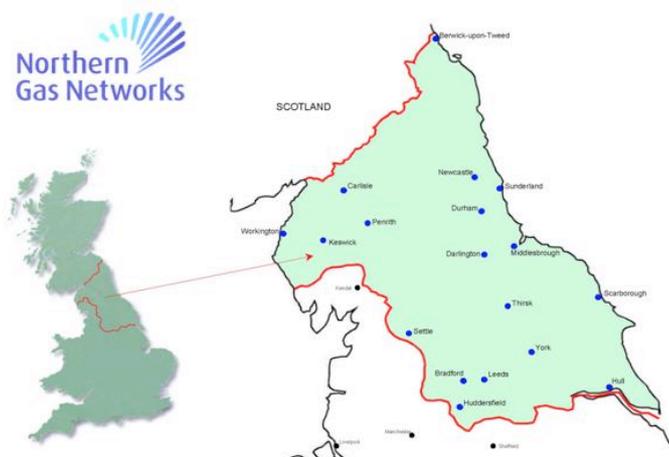
In late 2005 Chris Gorman and Martin Alderson from Northern Gas Networks met with Neil Summers and Jason Hanlon from Abriox to consider the development of a new system for automated remote monitoring of cathodic protection equipment. Abriox had come armed with a well thought out proposal which had progressed to a desk top concept; NGN had the ideal high pressure steel pipework system to undertake field trials. Following detailed discussions a joint approach was agreed to run a research and development project.

#### Northern Gas Networks

Northern Gas Networks is one of the eight regional gas distribution networks in Britain, formed following the restructuring of National Grid in June 2005. Its geographic area extends south from the Scottish border to the boundary between West and South Yorkshire and has coastlines on both the east and west sides of the region (figure 1). It contains a mixture of large cities such as Newcastle, Sunderland, Leeds, York, Hull and Bradford and a significant rural area including North Yorkshire, Northumberland and northern Cumbria. The high pressure steel pipeline system is a critical part of the gas transportation infrastructure and approximately 15% of the network (5,250km) comprises high, intermediate and medium pressure pipelines which cover an area of 27,000 square miles with a population of 6.7 million.

Northern Gas Networks has separated its asset management and ownership responsibilities from the delivery of operational activity under a model referred to as strategic asset management. Northern Gas Networks retains all the obligations and responsibilities required by its Licence to Operate – it is responsible and accountable for the continued safe and efficient running of the gas distribution network, ensuring the highest possible performance standards from planning through to asset maintenance and replacement.

United Utilities have been contracted to manage and deliver all Northern Gas Networks operations including asset maintenance, repair and renewal.



*Figure 1: NGN network boundary*

### **Cathodic Protection**

Corrosion is the action of a metal that has been extracted from ore reverting to its primary state when exposed to oxygen and water. The most common example is the rusting of steel. Corrosion of a pipeline (figures 2a and 2b) is very expensive to correct and, at worst, can lead to a pipe failure with unpredictable consequences. Northern Gas Networks' philosophy for the corrosion control of buried steel plant is the integration of high quality factory-applied coatings with the application of cathodic protection (CP).



*Figure 2: Corrosion effects at (a) pipeline coating; (b) weld*

With a proven track record over many decades, CP is now well established as an effective method of protecting metal pipelines at areas of coating damage or imperfection. The preferred technique for high-pressure transmission pipeline networks is impressed current cathodic protection, in which transformer rectifiers (T/Rs) provide the direct current power used to energise the CP system. The high current output from a T/R is capable of protecting long lengths of pipeline.

Impressed current systems rely on the continuity of the AC supply to the T/R; moreover the level of CP current that they apply is very important. With too little

current the corrosion rate would be unacceptably high; excessive current can lead to disbonding of the pipe coating and hydrogen embrittlement. For these reasons impressed current systems require regular monitoring of their voltage and the current. Northern Gas Networks' policy stipulates a monthly check at T/Rs where a single T/R is the only source of CP on a pipeline. Additional measurements (pipe-to-soil potential, instant "off" potential and current density) are taken less frequently at CP test posts.

The majority of Northern Gas Networks HP and IP pipelines are protected against corrosion using impressed current CP systems energised by 208 T/Rs, located at an average spacing of 20km along the pipeline route, and also at above-ground installations.

### System Development

Abriox is a high technology company based in Newport, UK, and with its US office in El Paso, Texas. The company's expertise is in the development of robust field instrumentation for utilities, especially the combination of measurement electronics and telecommunications.

With the active encouragement of Northern Gas Networks meetings were held with United Utilities pipeline maintenance team and in particular Network Officer Kevin Young a recognized CP professional to gather input to the specification of the system and thus ensure that it met the requirements of the CP community. With support from the Welsh Assembly's SMART innovation scheme, the system (now called MERLIN) was developed throughout 2006.

It now consists of the following.



*Figure 3: Transformer Rectifier Monitor*

- A monitor which measures the output of the T/R (voltage and current) and also checks the AC supply to the T/R (figure 3). Optionally, this monitor can also measure the pipe-to-soil potential at the drain point where the T/R is attached to the pipeline.
- A monitor which takes CP measurements at test posts (figure 4): including pipe-to-soil potential, instant "off" potential and coupon current values. An important feature is AC (as well as DC) measurement on all channels.

- Communication of data from field to HQ using GSM/SMS, selected because of its reliability, good coverage and economic cost.
- Software for displaying and archiving/exporting the data – and for controlling the configuration of the monitoring units (eg setting alarm thresholds).



*Figure 4: CP Test Post Monitor*

### **The Case for Remote Monitoring**

United Utilities carried out a careful financial evaluation of the case for remote CP monitoring. This was primarily based on the cost of monthly “functional” checks of the T/Rs (figure 5). However, since one annual inspection is required to comply with electrical safety procedures, only 11 visits per annum were actually considered for the evaluation. Using an average of 1.5 hours of technician time (including travel between T/Rs) for each set of measurements, plus 0.25 hours for uploading/downloading information from the CP database, the annual saving per T/R was calculated to be 19.25 hours. At £35 per hour (including vehicle depreciation, fuel, equipment, etc.) the annual cost per T/R was £674. The average cost of installing a remote monitoring unit, including reference electrodes, where required, was £1,000. A simple payback could therefore be achieved within 18 months.



*Figure 5: Manual TR checks are labour-intensive*

However, the case for remote monitoring was not purely economic. In the event of an AC supply or T/R failure, the CP system can remain inoperative, and the pipeline unprotected, for up to a month until the fault is detected manually. It is universally accepted that effective CP extends the operating life of a pipeline - while ineffective CP can shorten it. So there is a clear rationale for ensuring that the CP system is maintained in a fully functioning and effective state. Remote monitoring was seen as a way of Northern Gas Networks taking a more proactive operational approach to corrosion prevention.

Safety was another important factor – many T/Rs are located on busy roadsides or at relatively inaccessible locations, posing additional risks to lone-working technicians. Working on a T/R exposes staff to 2 separate earthing systems, so it is necessary for technicians to be trained in electrical isolation and to maintain such qualifications.

Northern Gas Networks sees the development and implementation of this project as visible proof of its commitment to best practice engineering techniques and supports its commitment to the asset management methodologies as defined in PAS 55 specification for asset management.

Furthermore Northern Gas Networks recognised the importance of achieving the international environmental standard ISO14001 and each business area had assessed the environmental impact of its activities. High mileages are soon clocked up visiting the same T/Rs on a monthly basis – this was seen as an area where the company could deploy new technology to assist in meeting performance indicators to reduce carbon emissions.



*Figure 6: Remote monitoring at a Transformer Rectifier*

## **Implementation**

In early 2007 prototype T/R and test post monitors were trialed by United Utilities on Northern Gas Networks' pipelines in Yorkshire and Durham over a 3-month period

(figure 6). The MERLIN system worked exactly to specification. Data was checked against measurements taken manually and showed excellent consistency; DC values were found to be accurate even in the presence of induced AC; communications were very reliable. During the trial period two interruptions of the power supply to a T/R were identified: one was a test carried out by United Utilities to check the system response to a supply failure, the other a genuine power cut. On both occasions the monitoring system immediately generated a user alert (figure 7).

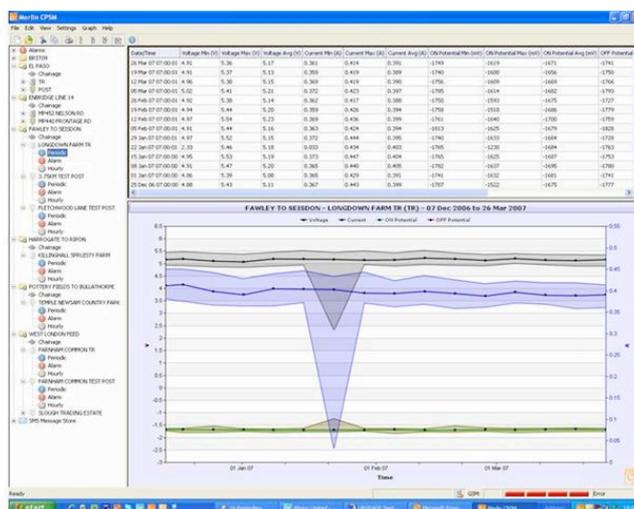


Figure 7: A power failure is immediately identified

Resulting from the successful trials, Northern Gas Networks has developed an implementation programme to roll-out remote CP monitoring across its network. Work will commence in earnest in spring 2008 initially monitors are being installed at all 208 T/Rs (or their drain points). This removes the need for monthly functional checks and provides timely information on T/R performance and CP effectiveness. Faults are identified immediately rather than going undetected for up to a month, thereby reducing the likelihood of corrosion occurring. This will improve pipeline integrity and ultimately reduce the probability of pipeline failure or the need for pipeline repair.

## Monitoring AC Interference



*Figure 8: Monitoring induced AC from overhead power lines*

Pipelines running in joint utility corridors are now recognised to be vulnerable to AC interference and the increased risk of AC-induced corrosion. This is of particular concern in the case of new pipelines with high quality (eg fusion-bonded epoxy) coatings which run parallel to high-voltage overhead transmission lines. Using the MERLIN system, Northern Gas Networks is now able to remotely monitor AC voltages and current densities at areas of suspected interference (figure 8). The adaptability of the test post monitor means that it can easily be re-sited at areas of concern, giving vital information on the state of AC and the pipeline's CP system at any moment. The setting of warning parameters will allow United Utilities, on behalf of Northern Gas Networks, to instantly monitor the effects of AC interference rather than collecting this information manually and retrospectively.

The MERLIN unit can also be used to monitor Sacrificial Anode CP systems, as it can measure the "off" potential at a coupon as well as current density. It can be installed within an existing M28 test post in urban areas and at areas of low potential within galvanic CP systems. It can also be installed easily in remote locations (figure 9), reducing the frequency of site visits, which allows United Utilities to focus its resources in a more efficient manner.



*Figure 9: Many TRs are in very remote locations*

## **Conclusion**

Northern Gas Networks, through United Utilities, is deploying remote CP monitoring across its entire network, the first UK gas distribution company to do so on such a large scale. This strategic move has been made possible by new technology which will deliver an attractive return on investment as well as improving asset management, safety and environmental performance. The MERLIN system is an example of what can be achieved by end users working closely with a technology-based company to ensure that the product development meets market requirements.