LPR : The Linear Polarisation Resistance Technique and Pipeline Corrosion in Soils

Estimates of pipeline corrosion rates are an essential element for any adequate risk analysis of major sub-surface utilities. Apart from direct detection of pitting, faults and fractures, observations relating to wall condition are required to confirm indirect estimates of longevity based on soil properties and burial history.

Pipeline segments have been previously exhumed to provide physical samples for inspection and more general statistical analysis of the asset condition. However there is a significant cost as well as some physical damage associated with cutting coupons for laboratory analysis. In contrast, cost-effective geophysical methods can now be mobilised to provide an almost continuous profile of corrosion levels along the pipeline with minimal physical impact.

Kear et al (2006) have considered a range of factors influencing the corrosion rate of metals in soil. Water content, temperature, pH and microbial activity are all fundamental accelerants of the corrosion process. Chemical species influencing corrosion rate include chlorides, sulphates and carbonates. These can arise from both natural and artificial sources. Moreover, non-uniform corrosion processes in soil, such as pitting and crevice corrosion, can rapidly reduce the effectiveness of metallic coatings and ultimately, the service life of buried assets.

LPR is considered the best technique for the direct measurement of local corrosion rates of buried structures (although polarisation resistance soil probes and electrochemical impedance spectroscopy or EIS are also considered by Kear et al, 2006). Data can be readily obtained using small samples of soil taken from the field for laboratory analysis. Usually data are derived from the Tafel constants using variations of a potentiostat or galvanostat commonly associated with investigations of aqueous electrochemistry. However considerable care is required in sample preparation, equilibration, and ohmic compensation. Futher details are provided by NACE (2011) and others.

N.B. : EGV have now developed quality control standards providing synthetic soil / electrolyte mixtures to ensure system stability and precision are maintained in any project. Comparable standards have been available for aqueous conditions but no prior soil standards have been available (please contact EGV for further details : info@elorane.com.au).

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Appropriate use of electrochemical measurements such as polarization resistance, electrochemical impedance spectroscopy, Tafel extrapolation, and galvanic cell testing ultimately results in the estimation of a corrosion current density. This current is a measure of the corrosion rate. In many practical situations, this number needs to be transformed into a penetration rate to make a practical prediction in industry, to enable comparison with other mass loss derived coupon immersion results, or just be presentable to individuals not familiar with corrosion terminology.

The corrosion rate as a penetration rate is calculated from the corrosion current by the following equation (NACE, 2011) :

$$\mathbf{CR = K * (I_{cor} / \rho * W_E}$$

where:
CR = corrosion rate (mm per year depending on units of K)
K = constant for converting units
Icor = corrosion current density (microamp/cm2 or amp/cm2)
ρ = alloy density (gram/cm3)
W_E = alloy equivalent weight (gram/equivalent)

References

Kear, G., Flatley, I., and Jones, S. (2006).
Application of polarisation resistance measurements for the estimation of corrosion rates of galvanised steel structures in soils. Presented at *Corrosion and Protection 06 Conference*, Grand Chancellor Hotel, Hobart Australia, 19–22 November 2006

NACE (2011)
General Principles of LPR; www.NACE.org

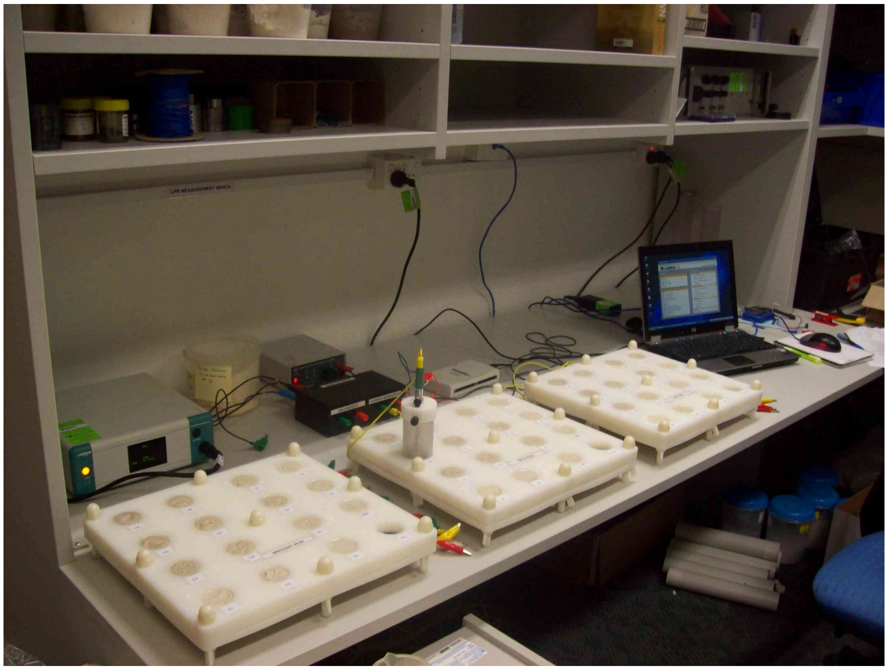

Fig 1. Sample grids containing soils ready for measurements of LPR for corrosion analysis at EGV.

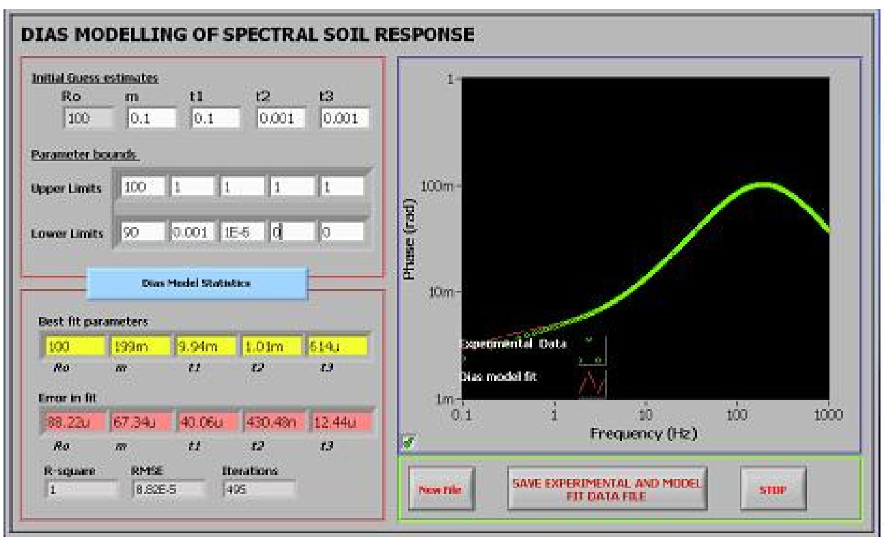

Fig 2. Control panel for entry of LPR parameters and curve-fitting interpolation process.

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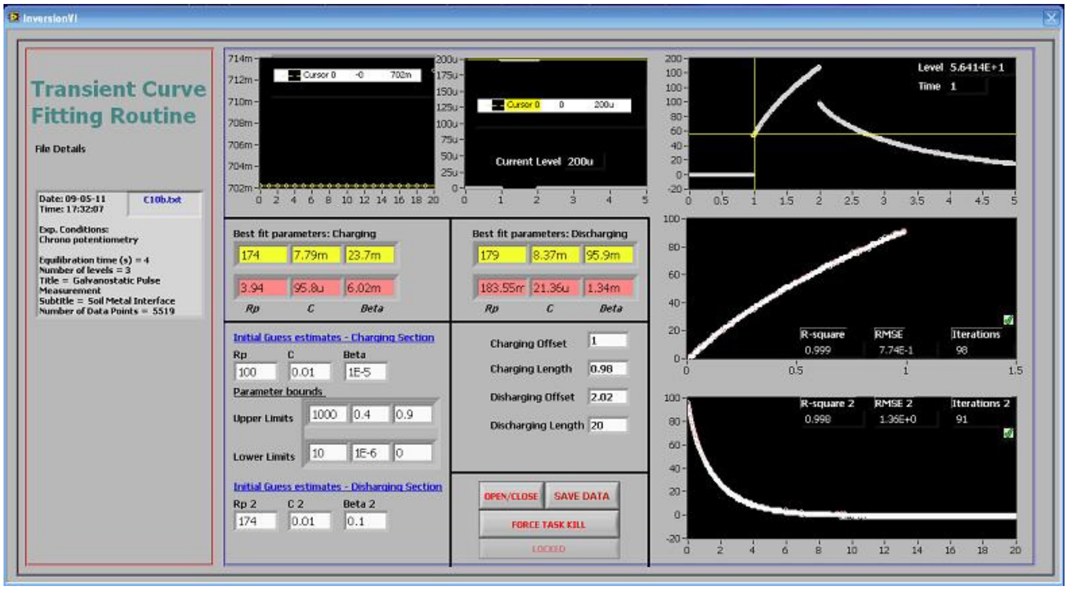

Fig 3. Curve fitting for Tafel constants and LPR response for corrosion analysis.

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