

A remote monitoring system featuring GPS synchronized instant-off potential and line-current measurements

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ABSTRACT

The traditional instant-off survey is time-consuming and will not provide information on the continuous evolution of the pipeline instant-off potential. This paper presents results from a small- and large-scale test of a remote-controlled GPS time-synchronized remote monitoring system, that is capable of capturing the instant-off potential at every logger position, when synchronized with a rectifier interrupter unit. Additionally, the loggers have a built-in line-current measurement module, that allows for detection of changes in the CP consumption in between logger positions, allowing for detection of 3rd party coating damage incidents. Finally, the loggers are capable of full AC/DC interference analysis with associated ER probe corrosion rate measurements.

Key words: Cathodic Protection, Remote Monitoring, Electrical Resistance Probes, Polarized Potential, Instant-Off, GPS, Line Current, Coating Defect.

INTRODUCTION

There are several ways to validate the performance of a cathodic protection (CP) system for buried pipelines.¹ Over the years, pipeline networks and their corrosion challenges have become increasingly complicated, not least due to the many sources of both AC and DC interference that affects CP operation.² Also, the various measurement techniques that can be applied to test CP effectiveness has increased over the years. Finally, the sheer number of buried pipeline miles has been constantly increasing. Some of the challenges of modern pipeline CP operation are:

- Increasing complexity of pipeline networks
- Increasing number of corrosion challenges
- Increasing number of measurement techniques to perform (and interpret!)
- Increasing number of buried pipeline miles to cover for technicians
- Requirements for measurement/test frequency

It is only logical that operators are turning towards remote monitoring. Especially where AC and DC interference is present, since the corrosion conditions can change on hourly, daily, weekly or yearly

basis. Such changing conditions would be almost impossible to investigate in detail with manual measurements, especially when considering the number of measurement positions that needs to be covered on hundreds of miles of pipeline. Figure 1 illustrates the infrastructure of a remote monitoring system for cathodic protection.

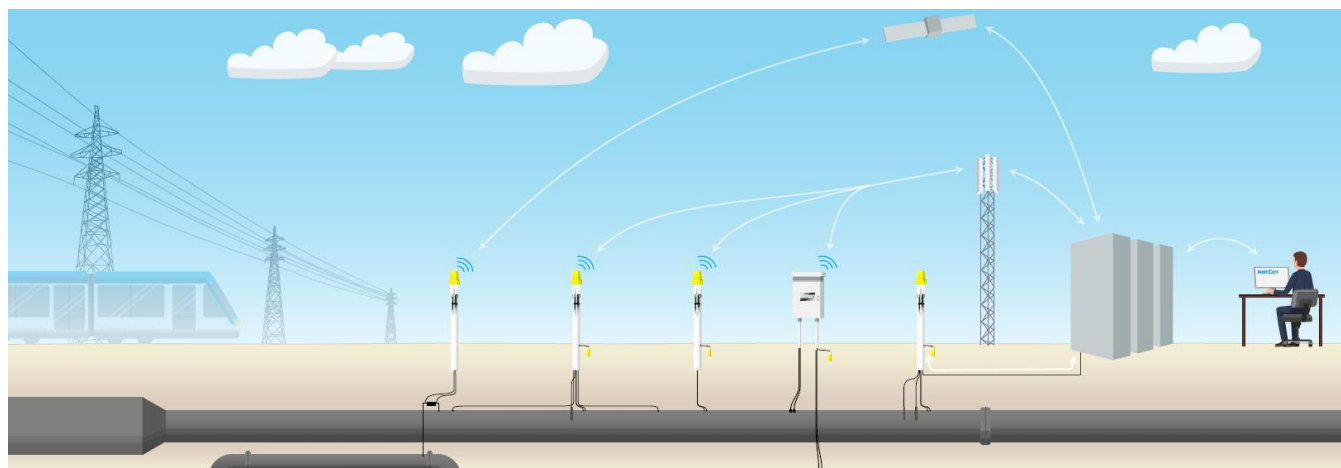


Figure 1: Infrastructure of a remote monitoring system for cathodic protection on a buried pipeline with the various challenges (AC and DC interference, casings, foreign structures, bonds, rectifiers, etc.). Data communication via cellular, satellite or wired.

Below is a brief description of the various loggers and the different measurement capabilities that are part of the remote monitoring system described in this paper.

Voltage Logger

A simple single channel voltage logger (VL100) for monitoring of potentials (Figure 2a).

- Pipeline potential (AC/DC)

The logger is equally useful for monitoring of other potentials or currents in a pipeline network

- Casing (AC/DC)
- Foreign structure (AC/DC)
- Shunts (AC/DC) for current measurements

Interference Corrosion Logger

The Interference corrosion logger (ICL) has two ER probe channels and offers the possibility of monitoring the corrosion rate of two adjacent probes in different environments or alternatively having one of the probe channels configured as native for a direct comparison between the corrosion conditions with and without CP (Figure 2b).

- ER probe measurements:
 - Corrosion rate
 - Coupon instant-off
 - IR compensated potential
 - Native potential
 - Current densities (AC/DC)
 - Spread resistance
- Pipeline potential (AC/DC)

The combined simultaneous measurements of corrosion and electrical fingerprints performed on the ER probes offers a way for operators to quantify, analyse and understand the corrosion threat under complex AC and DC interference and make the necessary decisions on mitigative measures easier, and to verify the effectiveness after changes.

Interference Corrosion and Line Current Logger

The interference and line-current logger (ICL-C) is a combined logger for ER probe measurements, pipeline potentials and line-current measurements (Figure 2c).

- ER probe measurements:
 - Corrosion rate
 - Coupon instant-off
 - IR compensated potential
 - Current densities (AC/DC)
 - Spread resistance
- Pipeline potentials (AC/DC)
- Line-current (AC*/DC)

The line current is measured as a voltage drop across a pipeline section with a known DC resistance.

*) The AC voltage drop across the pipeline section is also measured, but since the pipeline is not a pure ohmic resistor, this requires knowledge about the pipeline impedance to calculate the actual AC current.

Transformer Rectifier Monitor

A transformer rectifier (T/R) monitor (TRM) continuously logs important CP parameters (Figure 2d).:

- Pipeline potential (AC/DC)
- T/R current (AC/DC)
- T/R voltage (AC/DC)

It also monitors below logical inputs and has built in alerting if any of them are triggered.

- Rectifier power supply (and thus CP operation)
- TRM battery condition (necessary for communication if T/R power is down)
- “Tamper”. This can be linked to a door switch to detect unauthorized access to the T/R installation for example.

Finally, and perhaps most importantly, it enables GPS time-synchronized remote control of relay switching for instant-off potential surveys which is described in the following section.

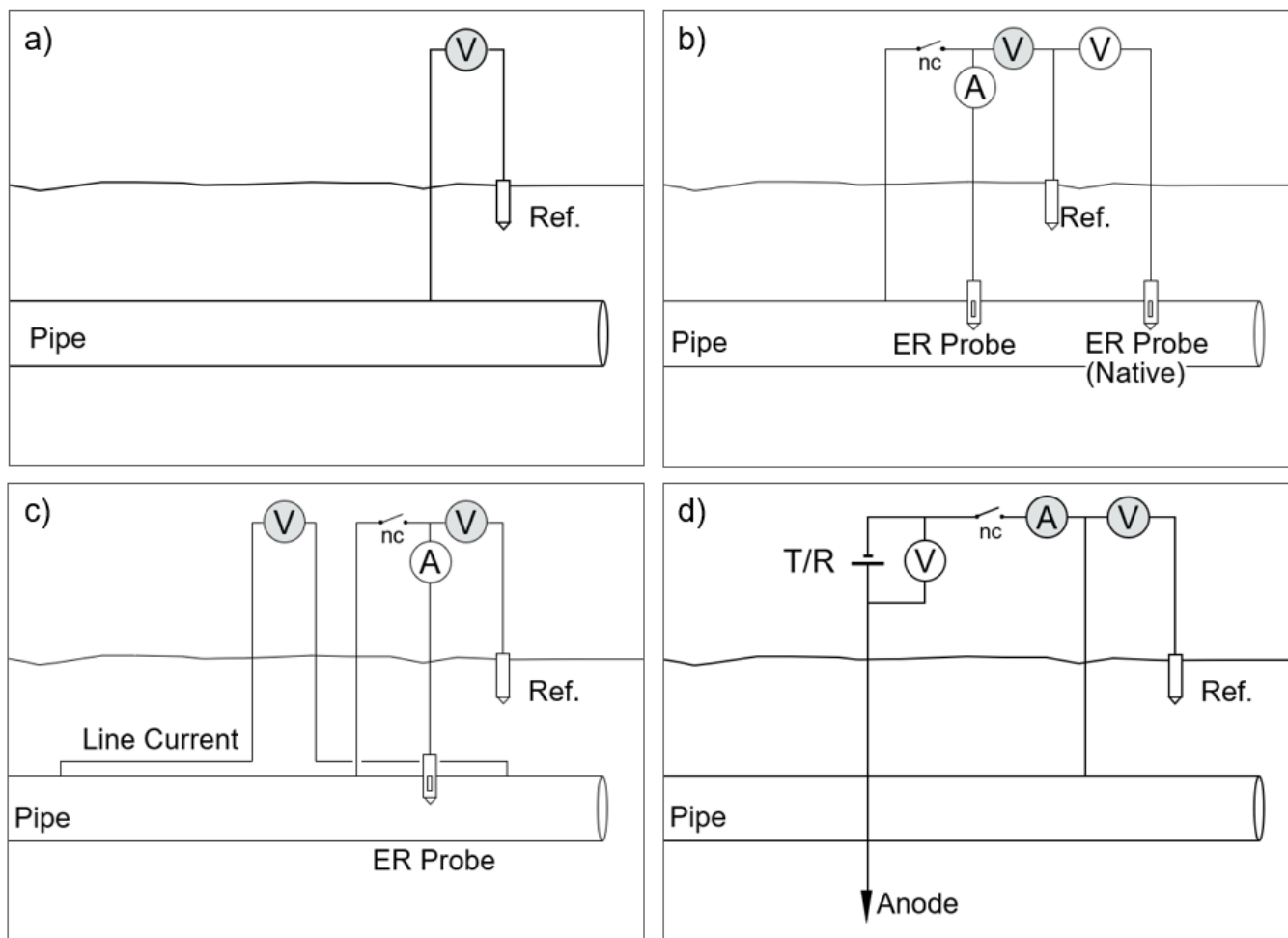


Figure 2: Various logger configuration examples indicating current or voltage measurements. Measurement channels in grey are measured during an instant-off campaign. The shown switches are normally closed (nc). a) VL100 as a pipeline potential logger. b) ICL with one connected and one native ER probe. c) ICL-C with ER probe and line current measurement. d) TRM logging the output of a transformer rectifier and controlling CP current interruption.

Remote controlled pipeline instant-off campaign

A novel feature of this system is the GPS time-synchronization between all loggers. This enables for programming a number of TRM's on a pipeline to interrupt the cathodic protection current at a very specific time, and subsequently perform a simultaneous potential (AC/DC) and current (AC/DC) measurement at a pre-defined time after the interruption, e.g. 200ms. In Figure 2, the measurements that are performed during an instant-off campaign are marked as grey. ER probe measurements are not performed during the instant-off campaign. Figure 3 illustrates the sequence of the instant-off campaign. The blue line represents the potential that shifts positively at each interruption.