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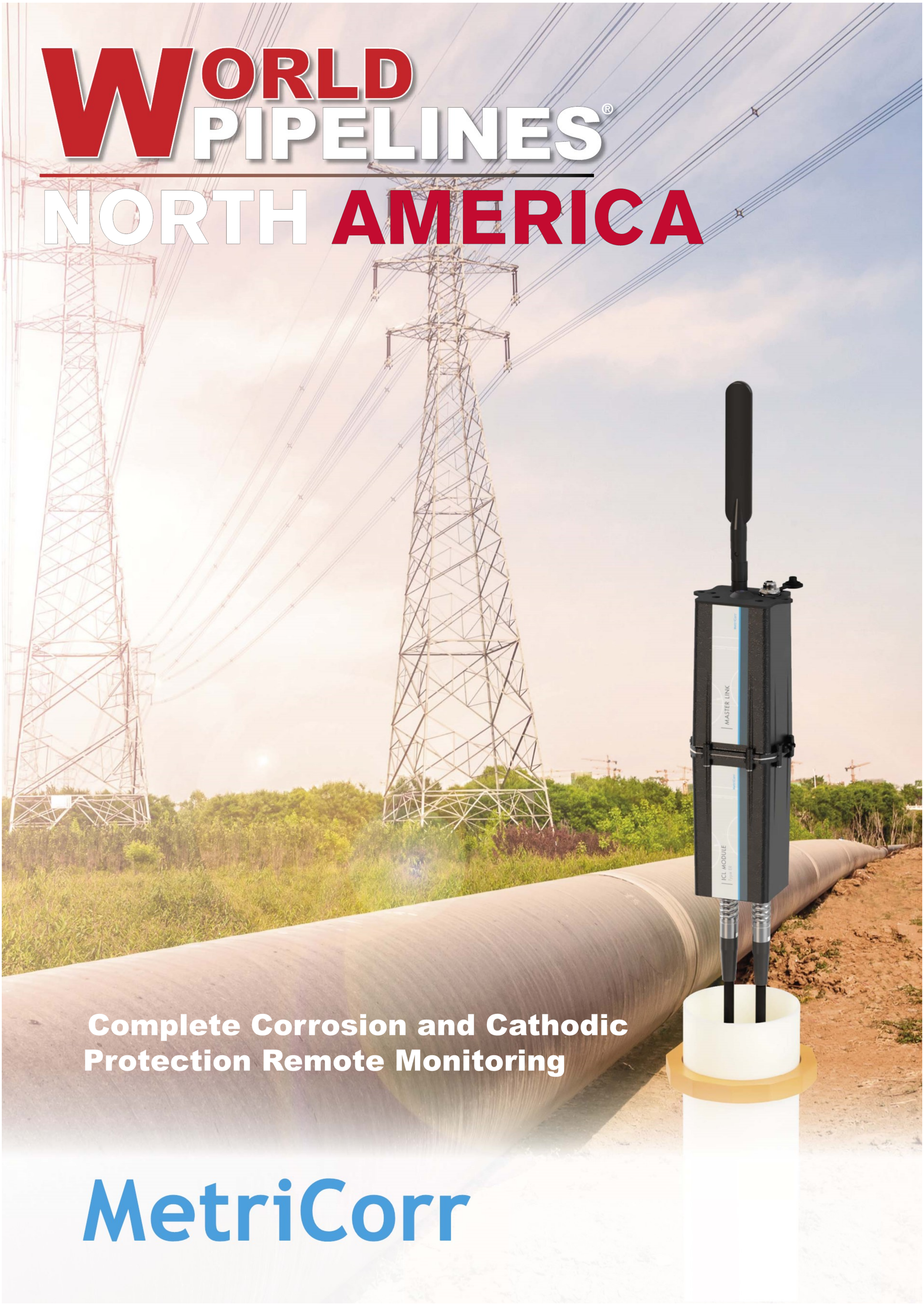
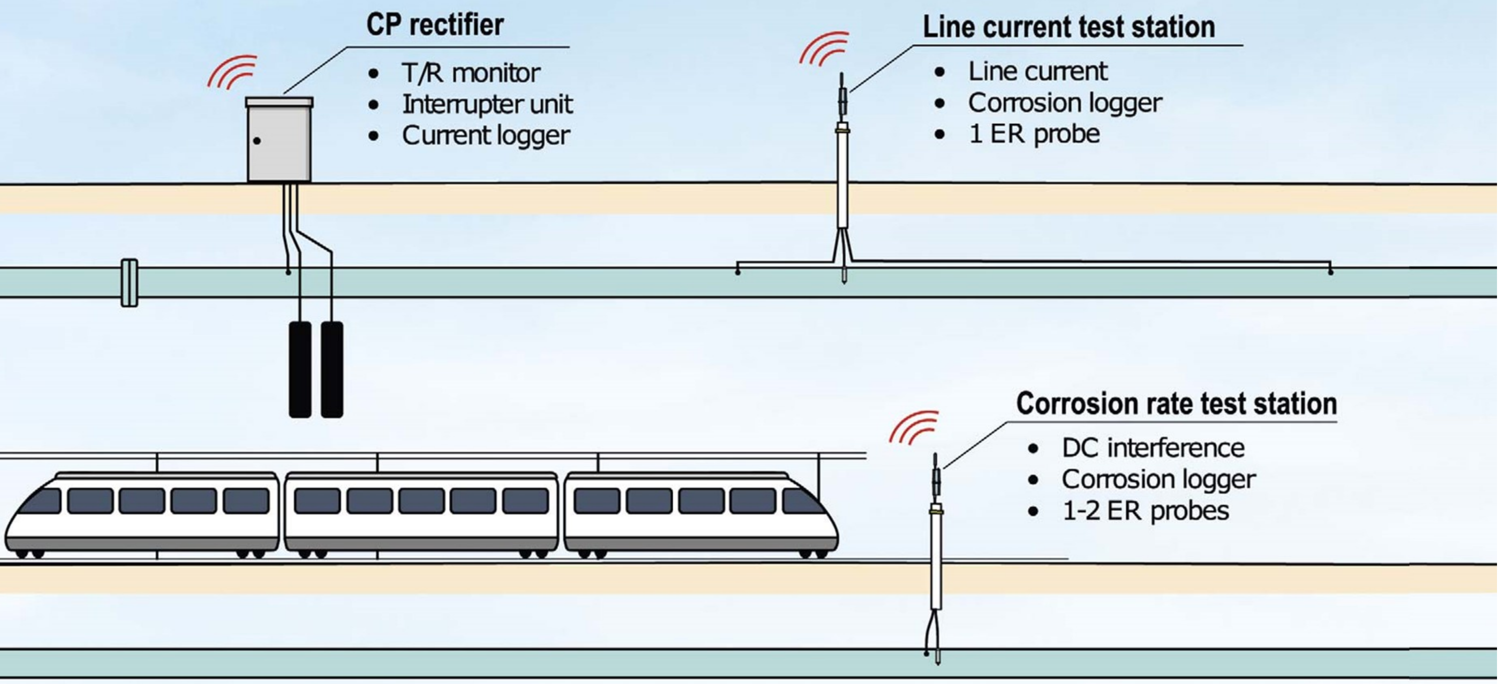


THE KEY TO CORROSION CONTROL

Andreas Junker Olesen, PhD, Engineer, MetriCorr, Denmark, details the remote monitoring of corrosion and cathodic protection.



Cathodic protection (CP) of pipelines or other buried assets is a complex business. It is the operator's interest and responsibility to maintain a high level of system integrity and comply with regulatory requirements, while at the same time paying close attention to operating costs.

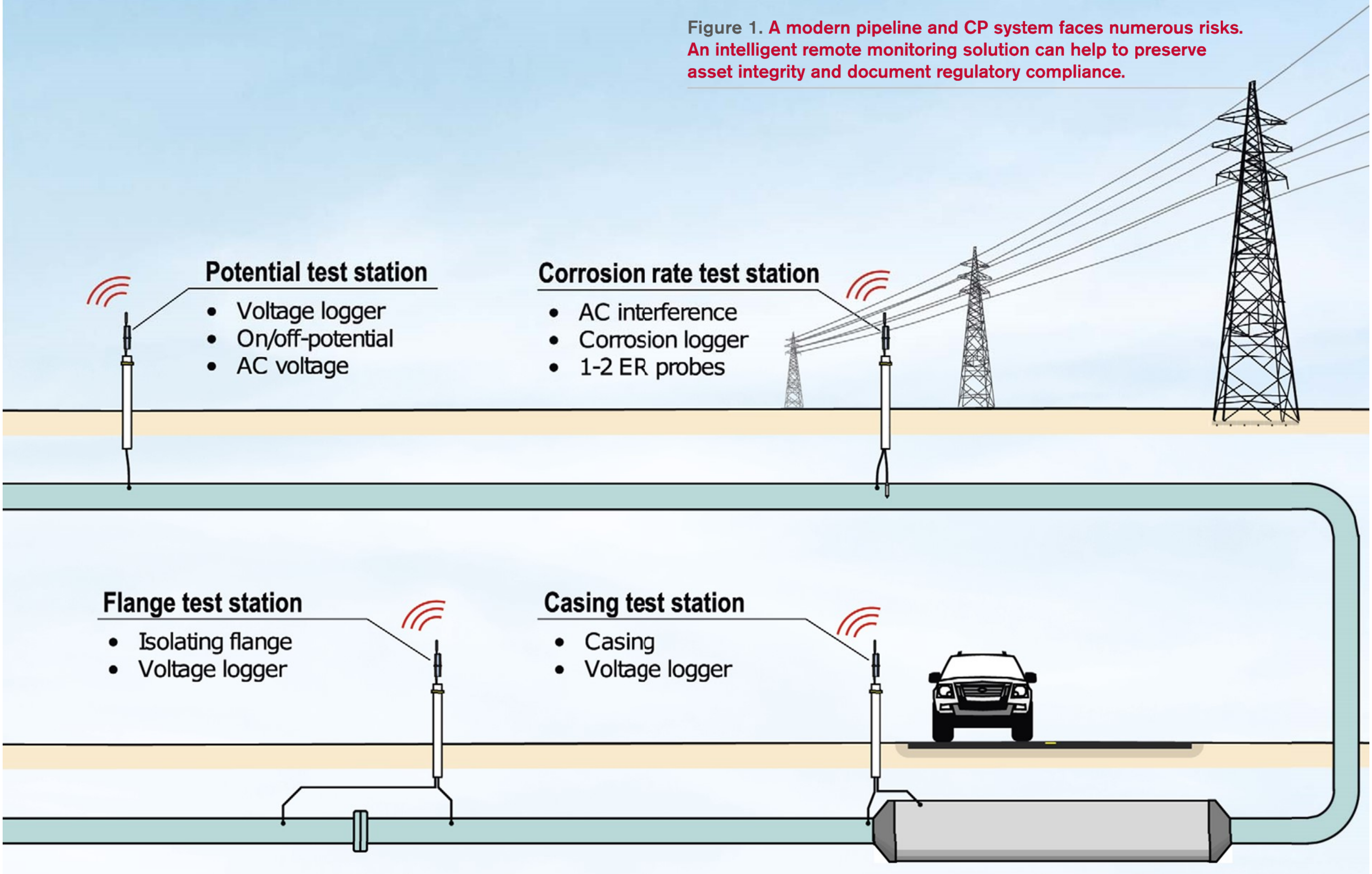
Compliance requires data – often the more the better. But acquiring large amounts of data has traditionally been associated with high expenditures. To overcome this, remote monitoring units have become a key component in modern cathodic protection systems, and in combination with an intelligent webservice and reporting tool, the task of documenting compliance is one step closer for the pipeline operator.

Remote monitoring of corrosion and CP

In this article we will discuss some of the critical components in (and threats to) a modern CP system and highlight some of the available solutions. Below are some of the typical reasons to choose CP remote monitoring and CP control.

- Accessibility of data from remote areas.
- Non-stationary corrosion conditions.
- AC interference that varies daily and seasonally.
- DC interference with high temporary levels (e.g. electrified railways).

Figure 1. A modern pipeline and CP system faces numerous risks. An intelligent remote monitoring solution can help to preserve asset integrity and document regulatory compliance.



- Seasonal temperature variations.
- Seasonal humidity variations.
- In-situ and real-time corrosion rate measurements.
- Traceability of foreign excavation damage.
- Automated alerts for key monitored parameters.

Figure 1 illustrates the complexity of a modern pipeline and CP system, even though this overview is largely simplified. On the other hand, it shows how remote monitoring can be used in several aspects of CP operations from rectifier control and monitoring, to interference analysis and critical bonds and isolations.

Table 1. The various functionalities of different remote monitoring units from MetriCorr

Parameter	T/R monitor	Voltage logger	Corrosion logger	Line current logger
Rectifier output current, i_{rect} (A/mA)	x			
Rectifier output voltage, E_{rect} (V)	x			
Rectifier interruption	x			
Pipeline on-potential, E_{on} (V)	x	x	x	x
Pipeline AC voltage, U_{AC} (V)	x	x	x	x
Pipeline off-potential*, E_{off} (V)	x	x	x	x
Galvanic anode output, i_{ano} (A/mA)		x		
Line current, i_{line} (A/mA)				x
Corrosion rate (ER), v_{corr} (µm/y)			x	x
IR-free potential*, $E_{IR\text{-}free}$ (V)			x	x
Coupon off-potential*, E_{off} (V)			x	x
Coupon DC current density, J_{DC} (A/m²)			x	x
Coupon AC current density, J_{AC} (A/m²)			x	x
Spread resistance, R_S (Ωm²)			x	x
Native and polarised potential, E (V)			x	
Casing – isolation		x		
Isolating flange – isolation		x		
Bond current, i_{bond} (A/mA)		x		

* These are theoretically similar, but different from a measurement perspective.

Figure 2. The logger modules are designed to fit into a Fat Fink test station.

A diverse challenge requires diverse solutions

Staying in control of cathodic protection on an entire pipeline often requires more than a single set of data. Several different parameters need to be monitored, in order to show regulatory compliance. Therefore, a range of monitoring units are required. An important feature of a remote monitoring system is GPS time synchronisation of all units, which allows for simultaneous current interruption and instant-off potential measurements along the pipeline. Table 1 outlines a long range of parameters that are valuable to the CP operator, and a list of remote monitoring units that are capable of measuring these. The units are specified as:

- Transformer rectifier (T/R) control and monitoring unit capable of current interruption, for pipeline instant off potential measurements and output current monitoring.
- Voltage logger unit that can be used for a pipe-ref or potential difference measurement or a current measurement by installation of a shunt.
- Corrosion logger unit capable of measuring corrosion rate on up to two high sensitivity electrical resistance (ER) probes, that can be set to native or connected. Several other electrical fingerprints are logged, making this unit ideal for interference corrosion analysis or simply CP effectiveness verification.

- Line current logger. Like the corrosion logger, but where one of the ER ports are replaced by the capability of measuring line currents on a pipeline.

When it comes to installation of remote monitoring units, the requirements tend to be equally diverse. Some operators value convenience above all, while others are more concerned about the visibility, durability and risk of vandalism to the installations that of course needs to be left unattended and subject to wear and tear. Therefore, the above units can be installed in anything from a standard Big Fink test station with concealed battery or solar panel (Figure 2), to larger junction boxes with multiple units.

Figure 3. Data can be analysed directly from the office. From here, measurement and upload frequency can also be changed.

Corrosion rate test station

A test station that features a corrosion logger and ER probes for in-situ real-time measurement of the corrosion rate, as well as a range of electrical fingerprints, is an extremely valuable tool for AC or DC interference risk evaluation. Take AC interference as an example: the alternating voltage on a cathodically protected pipeline may lead to very high corrosion rates, and it is key to be able to monitor the interference levels. In many cases with AC interference, AC corrosion can be avoided by proper control of the CP system and close monitoring of the AC and DC parameters and corrosion rate. From an integrity point of view, a measurement of zero corrosion is more powerful than all the potential and current measurements in the world, and according to the NACE standard on AC corrosion (SP21424-2018) this is enough to document compliance. In Figure 4, ER probe data from a corrosion rate test station in a power corridor is shown. Both the AC and DC current densities are periodically above critical levels but the corrosion rate is zero. The ability to monitor and document the wellbeing of an interfered pipeline can potentially save millions of dollars in AC grounding installations for AC mitigation.

Line current test station

The ability to measure line currents on a pipeline enables an operator to assess the current distribution of a CP system. Continuous logging and remote monitoring of this parameter, using a line current logger unit, allows for detection of sudden or gradual changes to current consumption caused by, for example, foreign excavation damage. Having more line current test stations on a pipeline section may help to pin down the location of such new coating damages. At the same time, a line current

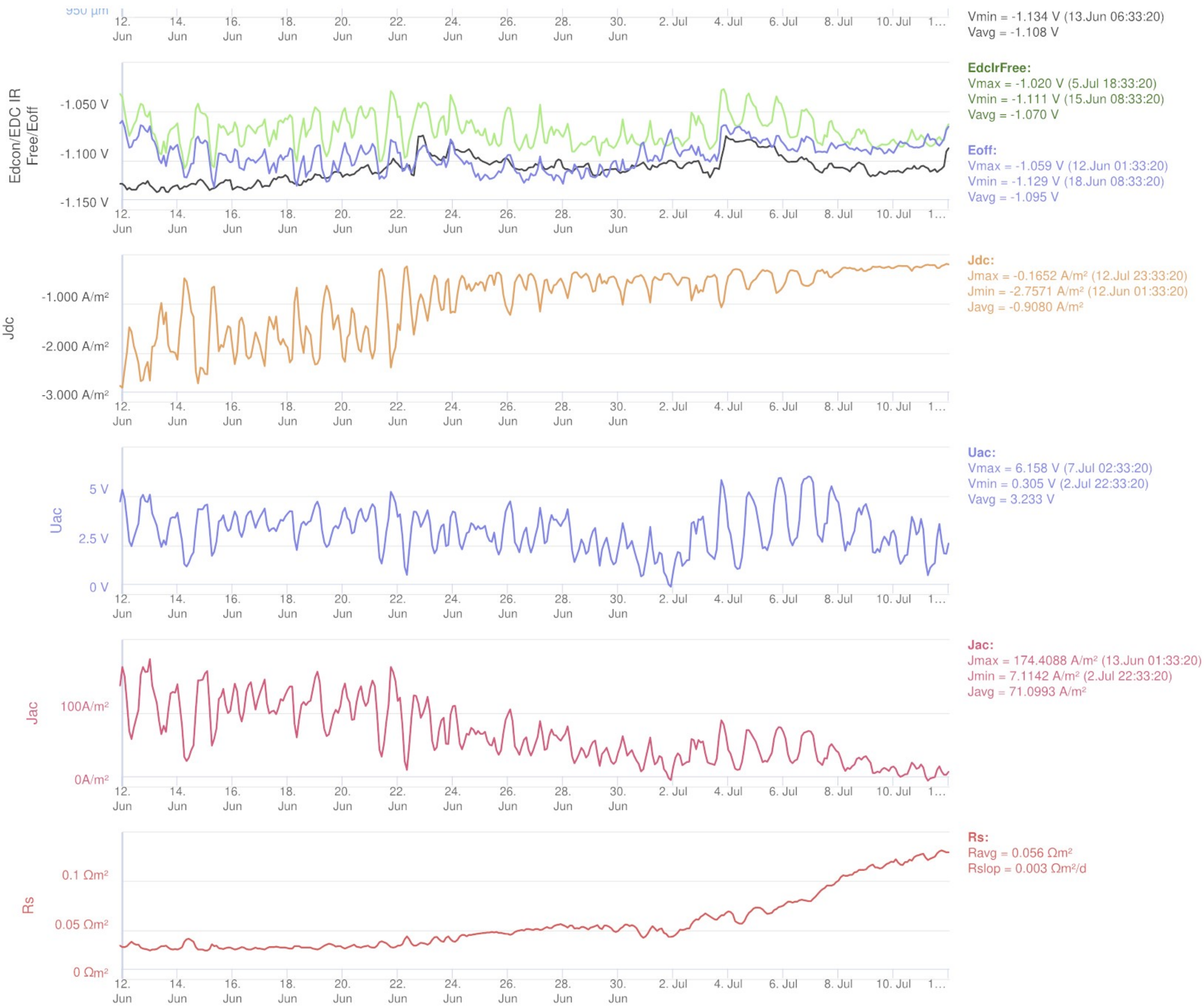


Figure 4. **Data example from an ER probe in a power corridor gives valuable insight into interference levels and corrosion risk on a buried pipeline. Corrosion is evidently not an issue despite high AC levels.**

logger unit with an ER probe will also be a corrosion rate test station for CP effectiveness verification.

Potential/flange/casing/etc – test station

Potential or current measurements are fundamental building blocks in cathodic protection monitoring. A voltage logger is a nifty tool in many CP applications and by implementation of a suitable shunt it becomes a high sensitivity ammeter. The applications are endless and the added value of having a variety of measurements readily at hand through remote monitoring is significant to any pipeline operator.

- Pipeline potential, AC voltage and instant-off.
- Isolating flange (potential difference).
- Casing isolation (potential difference).
- Critical bonds (current).

Data evaluation

Data from remote monitoring units is uploaded to secure servers via cellular, satellite or cabled connections and is made accessible via an online web service or a data acquisition system. This allows the pipeline operator to monitor the health of a pipeline directly from a PC, anywhere in the world, while at the same time being able to change measurement intervals and upload frequency remotely (Figure 3).

Customisable alerts are built into the webservice to let the operator know if, for example, a potential is no longer within a desired range, an AC current density exceeds a threshold value, or an ER probe is experiencing corrosion.

Finally: reporting and documentation has never been easier, with data already in a presentable and interpretable format directly from the web page. New export formats are continuously being developed to meet the demands and desires of dedicated users of the system.