Permanent Reference Electrode

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Abstract:

GRTgaz decided in 2007 to install remote monitoring systems in all CP devices: impressed current stations, drainage stations and ac mitigating devices.

In 2013, GRTgaz launched its program to install remote monitoring units on test stations to follow-up continuously the general assessment of the cathodic protection system.

In parallel, from 2012, GRTgaz led a research program with ENGIE Lab CRIGEN to get feedback on some types of permanent reference electrodes chosen for test stations. This program included first, laboratory tests on different marketed reference electrodes, followed by more than 2 years of field tests of the most stable and accurate devices identified in laboratory. It helped to define the reliability and the maximum tolerable error for the permanent reference electrodes in field conditions.

It confirmed there are relevant choices to make for permanent reference electrodes installed on test stations.

Key words:

Cathodic protection – Remote monitoring – Reference electrode.

Full text:

By the beginning of 2000, GRTgaz led a program to invest in Remote Monitoring Systems (RMS) for its cathodic protection equipment installed in the field. This program was planned to have two steps:

- Step 1: remote monitoring on all CP equipment (impressed current stations, drainage stations, ac mitigation devices),
- Step 2: test stations.

The aim of remote monitoring for GRTgaz was to assess the proper function of the CP system: it shall be able to carry out the general assessment of cathodic protection (according to EN 12954). In addition any malfunction shall be detected automatically and an alarm shall be transmitted to the relevant CP department for repairing.

This program started in 2007: GRTgaz decided to install a remote monitoring system on all its impressed current stations and all drainage stations. This program was scheduled to last 5 years for the existing stations. In 2012, almost all stations were remotely monitored.

GRTgaz decided to have data thanks to a website which is daily updated by the supplier by data transmitted by Remote Monitoring Unit (RMU) installed on each CP equipment. When a defined threshold is overloaded on an equipment, an alarm is automatically transmitted by e-mail to the dedicated CP Department in charge of this equipment.

In addition, in 2010, GRTgaz decided to remote monitor ac mitigation devices. This program was scheduled to last 3 years for the existing stations. In 2013, almost all stations were remotely monitored.

Then in 2013, GRTgaz launched the last step of its program by installing RMUs on test stations. This step is scheduled to last up to 2018. CP department defined rules to help the selection of test stations where RMUs shall be installed. RMUs allow to check that CP is working properly and to evaluate that ac and/or dc influences are acceptable. RMUs are installed on:

- Test stations where ac and/or dc influences are the highest,
- Test stations where dc level is the lowest,
- Extremities of pipelines,
- Test stations next to crossing of rivers, motorways or railways where ILI is not possible,
- Test stations on metallic casing in wet areas or where water underground level may vary,
- Test stations where there is a risk of SRBs,
- Test station where there is a connexion with another pipeline (not belonging to GRTgaz).

Now, GRTgaz remote monitors:

- 1060 impressed current stations,
- 98 drainages stations,
- 350 ac mitigation systems,
- 2300 test stations (about 3000 by the end of 2018).

GRTgaz considers that a pipeline is fully under control with the remote monitoring system when:

- RMUs are installed on :
    - All its impressed current stations,
    - All its drainage stations,
    - All is ac mitigation stations,
    - All its selected test stations,
- There is a major malfunction on this pipeline.

In that conditions, detailed and comprehensive assessment of the CP (according to EN 12954) can be carried out every four years (instead of three years).

In parallel of this program, GRTgaz decided to launch a research program for reference electrodes used with RMUs installed on test station. Indeed, if feedback is under control for RMUs installed on each CP equipment or test station, an additional feedback is necessary for reference electrodes as they represent the weak point of RMS.

This research program has been carried out with ENGIE Lab CRIGEN. In 2012, this program selected seven Reference Electrodes (RE) to be tested and defined tests to carry out in laboratories. It was agreed to base tests on NACE Test Method TM 0211 « Durability Test for Copper/Copper Sulfate – Permanent Reference Electrodes for Direct Burial Applications ». The most relevant parameters that can have an effect on the RE were identified:

1. Temperature : not tested because it can be calculated thanks to Nernst law,
2. Light : not tested as RE should be used in conditions where light is not present,
3. Copper ions diffusion from RE to soil : tests in non-ionised water,
4. Pollution from soil: test in salty water with chloride ions,

5. Seasonal variations (wet and dry successive periods): test with cycles of 8 wet days and 50 days of dry conditions.

Tests 3 and 4 were carried out in a first step. Results were not as relevant as expected. They did not allow to rise the best RE. All RE had a higher drift than expected, in a positive or negative way (it was not possible to define any rule). But we observed the drift was usually lower than ±100 mV.

These results allowed to select three RE to test the seasonal effect (test 5). We observed that no RE drifted with the wet conditions. But they all drifted during the dry period, from 200 mV for the best one up to 300 mV for the two others. In fact, with the dry conditions, the RE is not correctly in contact with soil.

As a general conclusion of this first part of the research program, it was not possible to define "THE BEST RE" to use with RMS. In fact, conditions to test RE were too severe and far away from real conditions they can have in real use with RMUs.

As a consequence, GRTgaz decided to lead an additional research program where RE were test in the field and connected to a RMU. This program started in 2015.

Two RE were selected for these tests:

- The one (Model A) which gave the best results for the previous step. GRTgaz decided to carry out tests with and without its bag containing a specific medium, in order to analyse the impact of this medium (4 RE with bag / 2 RE without bag),
- The one (Model B) used with RMUs installed since one year (4 RE).

For each test station, it was installed in an underground box:

- The RE to be assessed,
- A coupon connected to the cathodically protected pipeline,
- A calibrated RE. This RE is periodically changed and is used as the reference for the tests. A comparison between the calibrated RE and the RE to be tested is periodically made.

Both RE are installed as close as possible from each other to limit the RI drop. Measurements are carried out with the coupon connected / disconnected from the pipeline. Both diagrams are recorded: coupon connected / coupon disconnected. Temperature was also recorded.

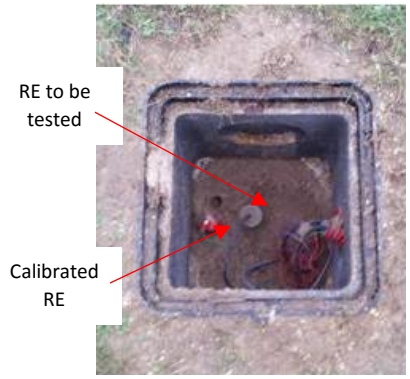

Figure 1 : RE model A installation

Figure 2 : RE model B (with bag) installation (just before backfilling)

The bedding conditions for all the selected test points resulted in a soil resistivity between 14 and 500 Ω.m.

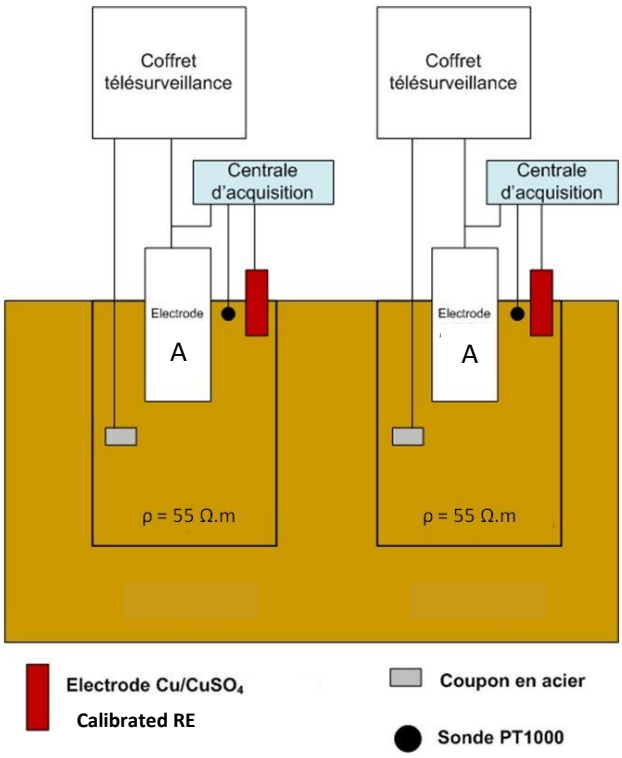

Figure 3: schematic installation of RE model A

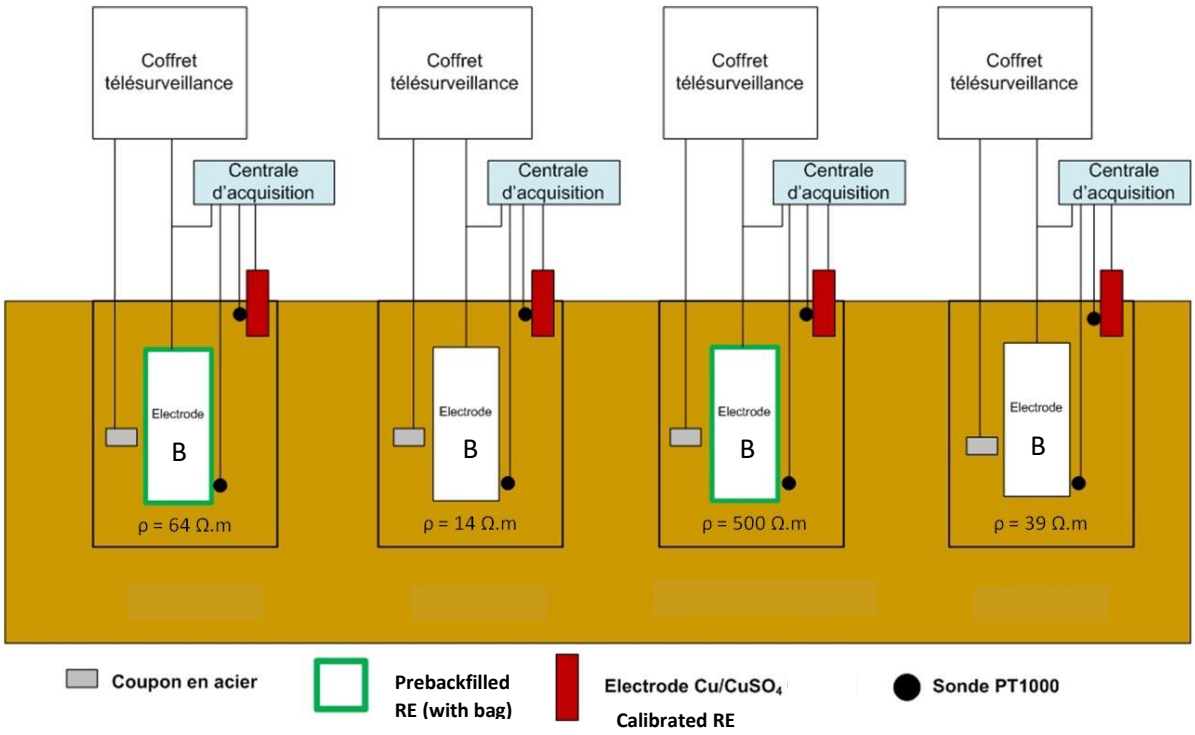

Figure 4: schematic installation of RE model B

The series of records obtained showed very good results. Whatever the coupon is connected or disconnected from the pipeline, the difference of voltage between calibrated RE and RE to be evaluated is always lower than ±100 mV. It was consistent with the results obtained with the previous research program.

As a consequence, as RMS installed on GRTgaz network is to carry out the general assessment of the CP (according to EN 12954), it has been decided that **±100 mV is the Maximum Acceptable Error for the Reference Electrode used with a Remote Monitoring System**. This value of accuracy is satisfying for the general assessment carried out with On-potentials. It shall be noticed that detailed and comprehensive assessment of the CP is always carried out by certified CP operator (EN 15257) with calibrated CP devices (EN ISO 10012).

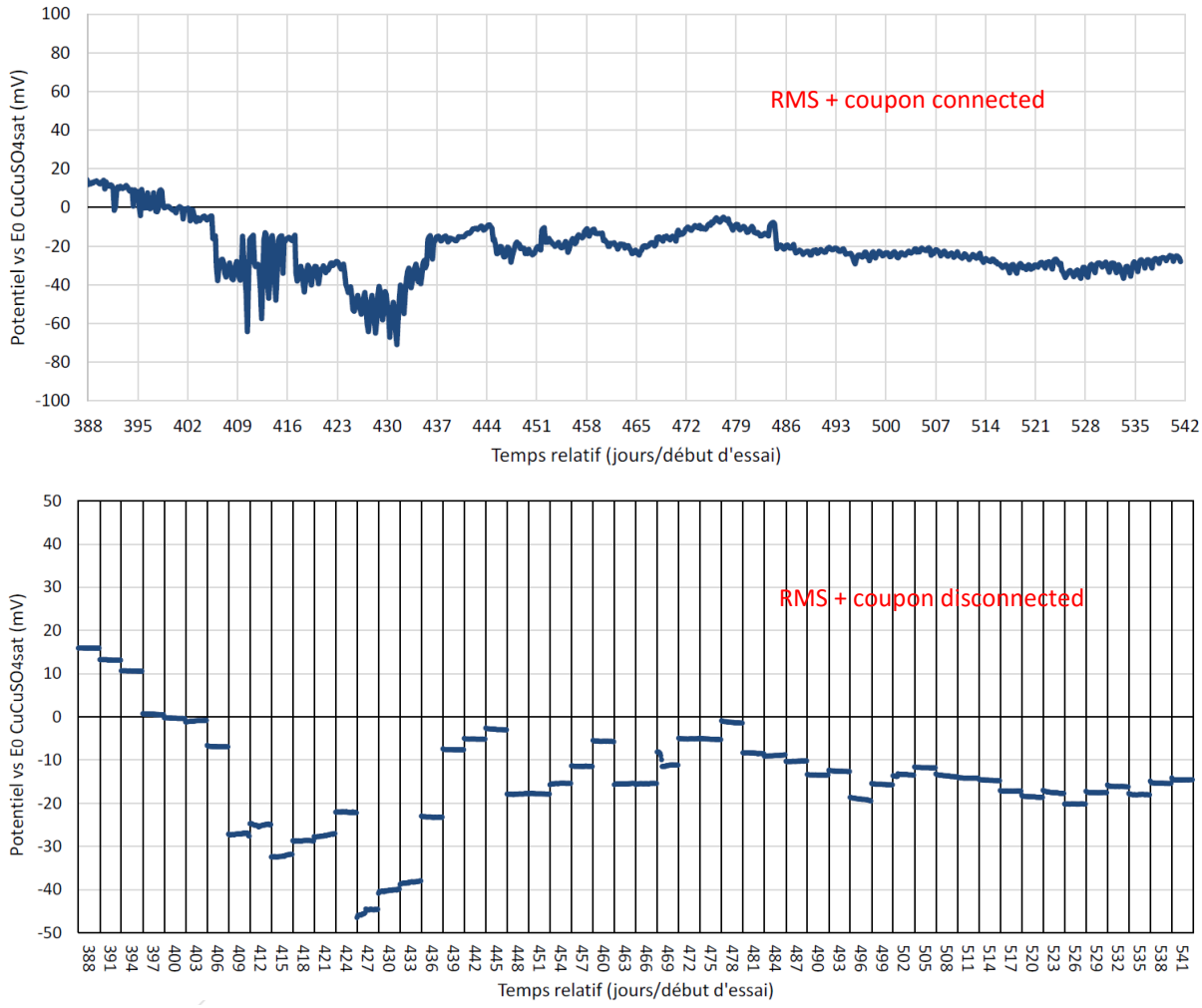

Figure 5: Example of results obtained on Model A – Worst results obtained

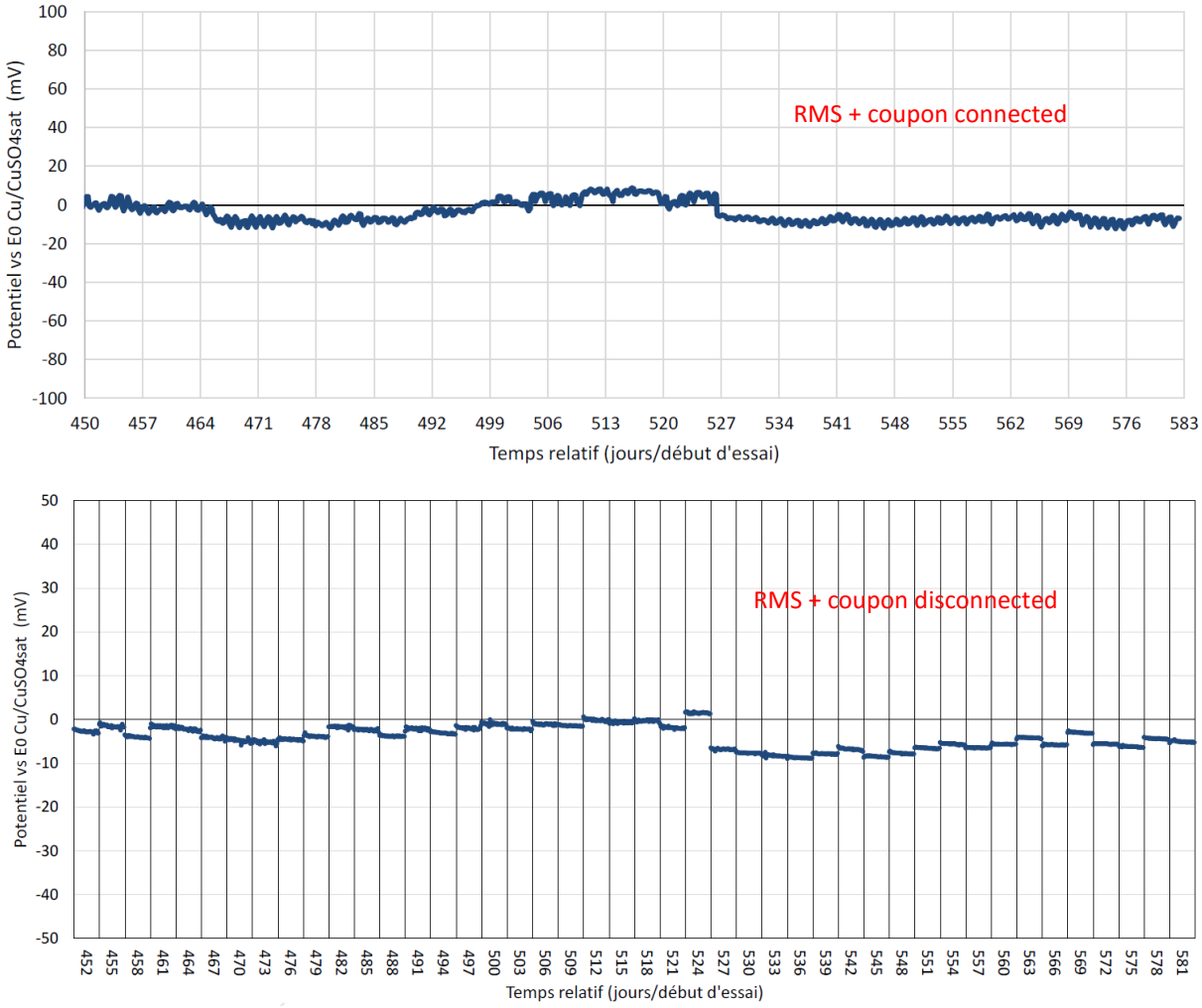

Figure 6: Example of results obtained on Model B – Prebackfilled (with bag)