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Activities in the field of coating fault surveys of buried pipelines

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Travaux relatifs aux études des défauts de revêtement de canalisations enterrées

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Aktivitäten auf dem Gebiet der Umhüllungsfehler von erdverlegten Rohrleitungen

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Abstract
Several methods and techniques for detecting coating faults in cathodically protected buried pipelines are available today. Since the old Pearson method was adopted, many other techniques have been developed and are today available. The choice of the appropriate methods in terms of cost/benefits and their application in the real field are essential and as important as the interpretation of the results. The experience of our Companies, gained on thousands of km of surveys along concerning oil, gas and water pipelines, in different conditions and type of soils and the relevant excavations made by the clients allowed us to gather quite a good experience on the correctness and validity of the results.
The paper is aimed at a wide discussion on the choice of the techniques, working conditions, appropriate presentation of the results and their usefulness.
The correct use of these results for understanding the adequacy of the cathodic protection conditions of buried pipelines as well as a broader evaluation of their integrity will be envisaged in the paper.

Résumé
Plusieurs méthodes et techniques de détection des défauts de revêtement sur des canalisations enterrées et protégées cathodiquement sont disponibles aujourd'hui. Depuis l'adoption de l'ancienne méthode Pearson, de nombreuses autres techniques ont été mises au point et sont à présent disponibles. Le choix des méthodes appropriées en termes de coût/bénéfice et leur application pratique sont essentiels et aussi importants que l'interprétation des résultats. Notre expérience, acquise à la suite d'études de milliers de kilomètres de canalisations d'eau, de gaz et de pétrole dans des types de sol et des conditions différents d'une part, et les excavations ciblées réalisées par les clients d'autre part, nous ont permis d'acquérir une bonne expérience quant à l'exactitude et la validité des résultats.
L'article porte sur une discussion d'envergure concernant le choix des techniques, des conditions de travail, de la présentation appropriée des résultats et de leur utilité.
L'article envisagera l'utilisation correcte de ces résultats pour comprendre l'adéquation des conditions de protection cathodique des canalisations enterrées ainsi qu'une évaluation plus large de leur intégrité.

Introduction

The integrity of a buried pipeline strongly depends on the various phases of its service life:

- selection of the type of coating
- application of the coating
- re-coating of the bare parts in correspondence of the welded joints
- laying in the trench
- backfilling
- design and installation of the cathodic protection system
- third party interventions

In almost any step of the service life coating faults may be formed, either incidentally, or due to human errors and/or to environmental predictable or not predictable events.

Coating faults do not cause immediate sudden failures, since the cathodic protection, if well designed and realized, easily provides a supplementary measure to hinder dangerous corrosion phenomena.

Nevertheless, whenever a holiday of non-negligible dimension is present in the coating, a concentration of any type of currents (macro-cells, stray currents, cathodic protection current) occurs at the bare metal.

In particular, the cathodic protection current may lead to an excessive hydrogen evolution, which could cause coating disbonding, and other phenomena such as microbiologically induced corrosion, crevice corrosion, etc.

For the above said reasons it is very important to verify, at first during commissioning and then during the service life, rather frequently which is the safety state of the pipeline by means of indirect specialised electrical surveys.

Starting from the traditional old Pearson method many improvements have led to sophisticated techniques that allow carrying out surveys at the same time reliable and not too expensive.

A careful combination of Electromagnetic Current Attenuation and Transverse Voltage Gradients may be considered the right solution for the individuation of the anomalies in the pipeline coatings.

The Electromagnetic Current Attenuation allows knowing the general conditions of the coating, at the same time evidencing the areas where a concentration of faults is present.

The Transverse Voltage Gradients technique usually gives a very precise frame of the faults location; in the case of large diameter pipelines the position of the fault around the circumference may be localised (hour-position).

Moreover, the Extrapolation Method, which includes the measurements of the V_{on} and V_{off} potentials of the pipe in some defined locations (potential measuring stations) and the extrapolation of the same parameters along the line by means of the transverse gradients, may help in individuating where insufficient cathodic protection is present.

However, situations may exist where the use of the results of these techniques can be interpreted with a certain difficulty.

The present paper, after a short description of some "regular" surveys, deals with peculiar cases in which modifications should be made to the conduction of the measurements.

Experimental

Figure 1 shows an example (taken from Ref. N. 4), concerning the very good correspondence between the preliminary current attenuation measurements and the subsequent transverse gradient measurements relevant to a gas pipeline situated in the Northern part of Italy.

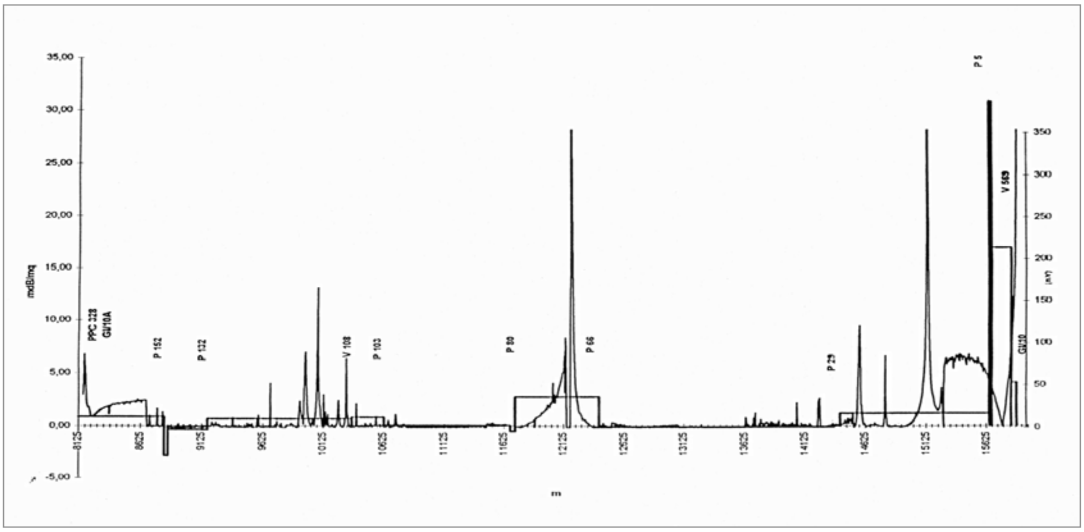

Figure 1 – Overlapping of Electromagnetic Current Attenuation and Transverse Gradient Surveys performed on the same section of pipeline

Unfortunately, in many cases it may happen that the transverse gradients and the relevant extrapolated V_{on} and V_{off} values, calculated through the formula

$$V_i = V_1 + (L_i - L_1)\left(\frac{V_2 - V_1}{L_2 - L_1}\right) + \Delta V_i$$

are affected by significant errors deriving from local situations such as those described in the following examples.

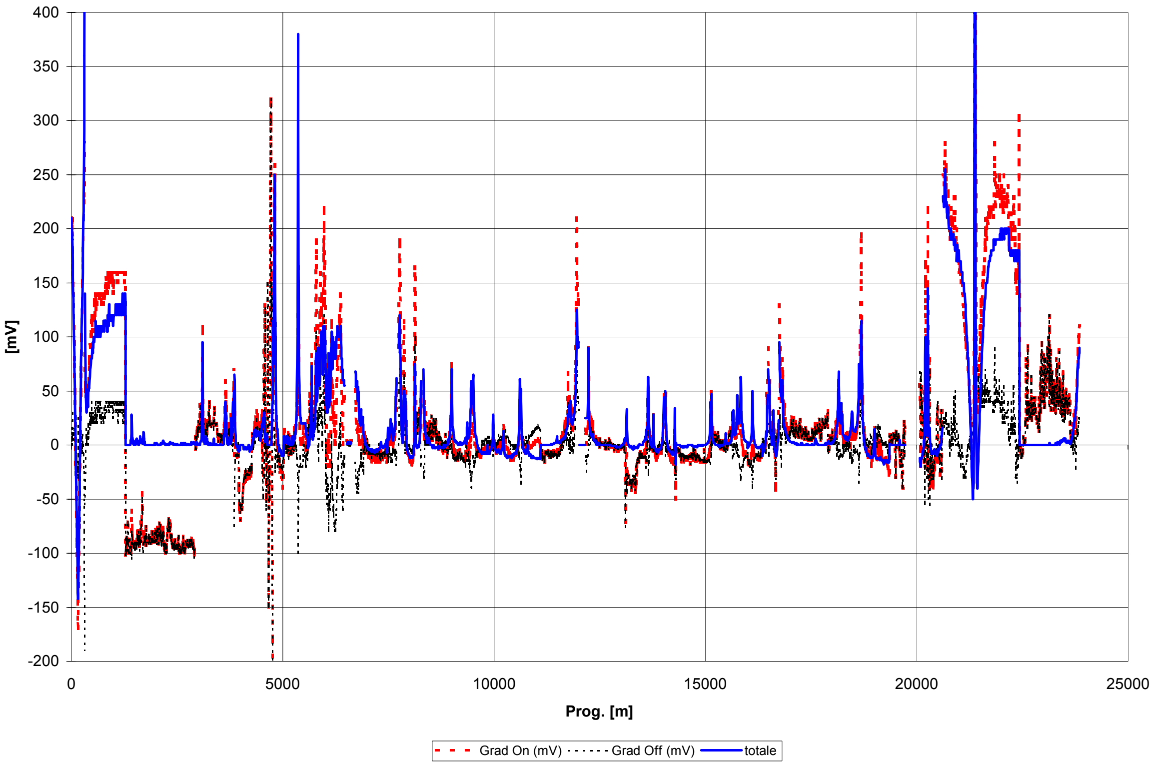

Figure 2 – Transverse gradients

Example n. 1

Oil pipeline in Northern Italy, 25 Km long

Figures 2 and 3 show the overall values of the transverse gradients and the extrapolated V_{on} and V_{off} values. It can immediately be observed that there are some locations where anomalies are present.

- around 1550 m
- between 4000 and 5500 m
- between 20000 and 23000 m

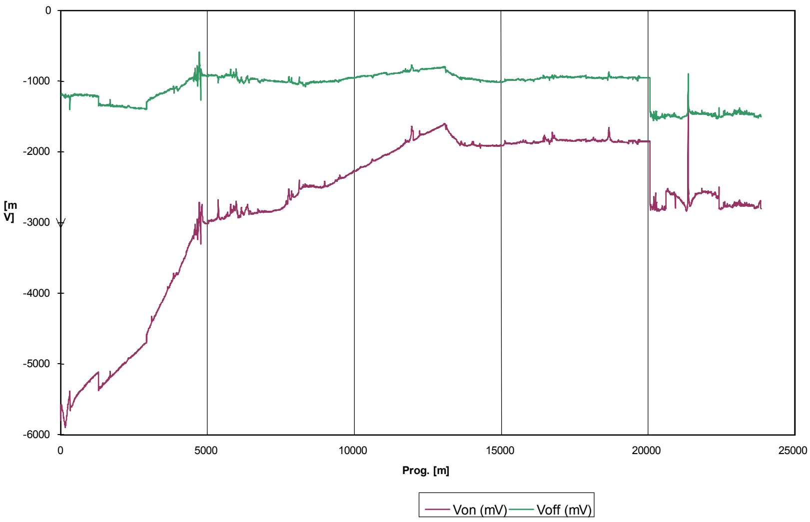

Figure 3 – Extrapolated V_{on} and V_{off} values

The detailed results obtained in these locations are shown in the Figures 4-7, being this last figure a magnification of a part of Figure 6.

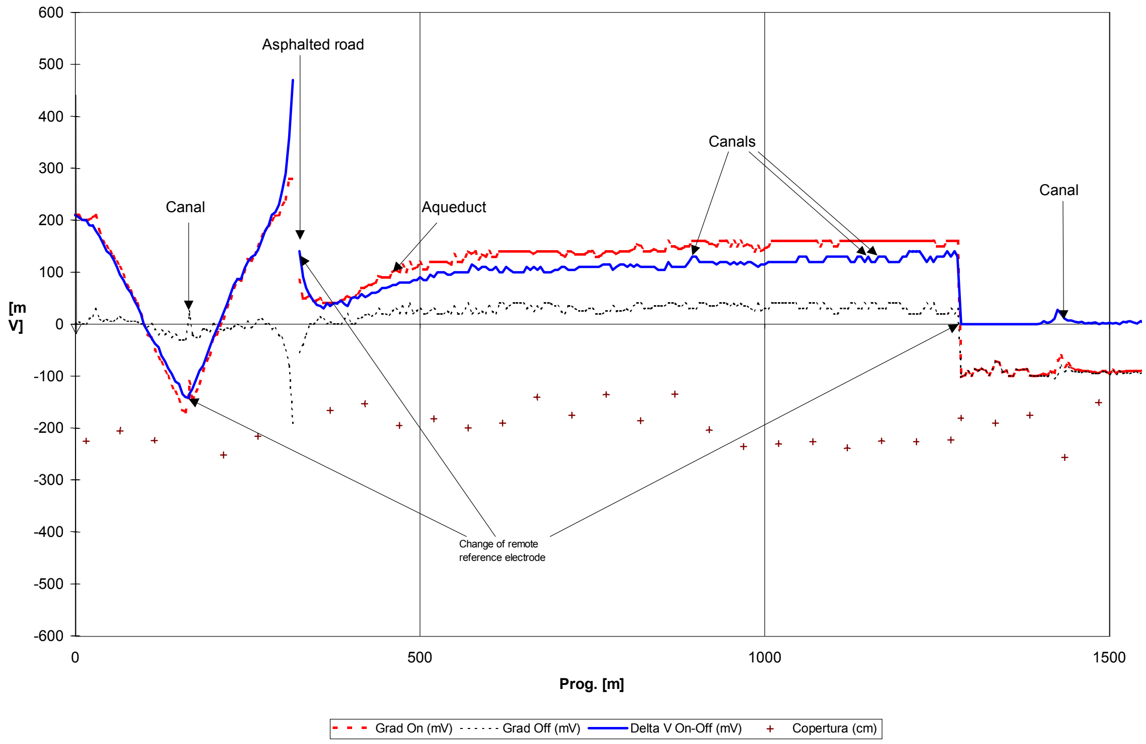

Figure 4 – Section 0-1500 m

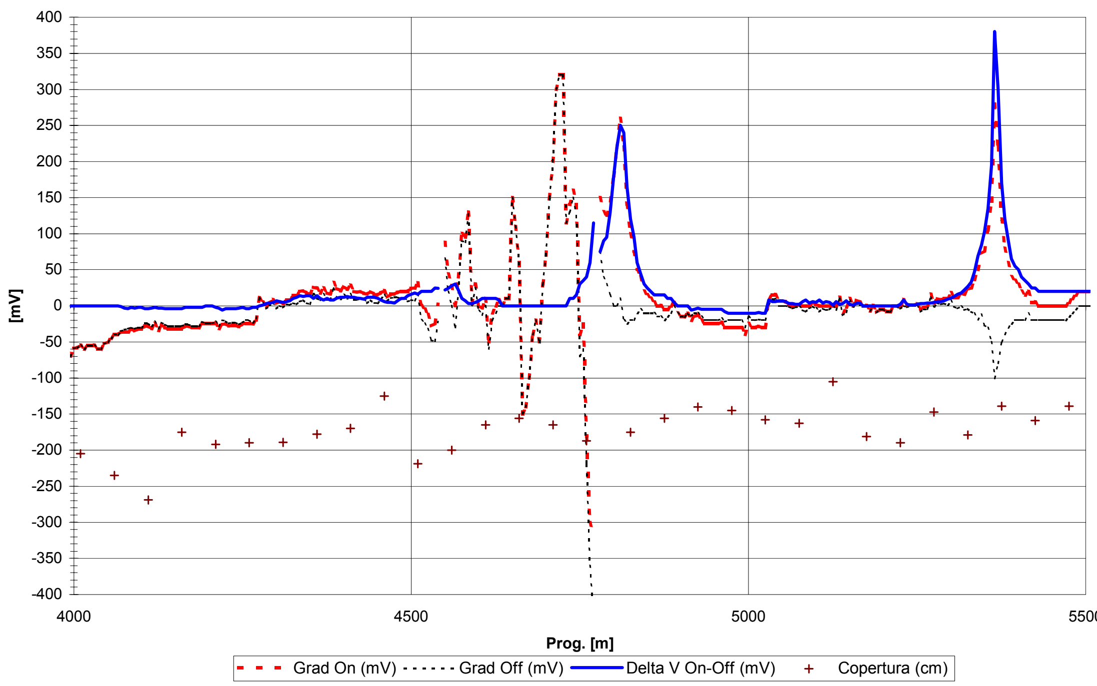

Figure 5 – Section 4000-5500 m

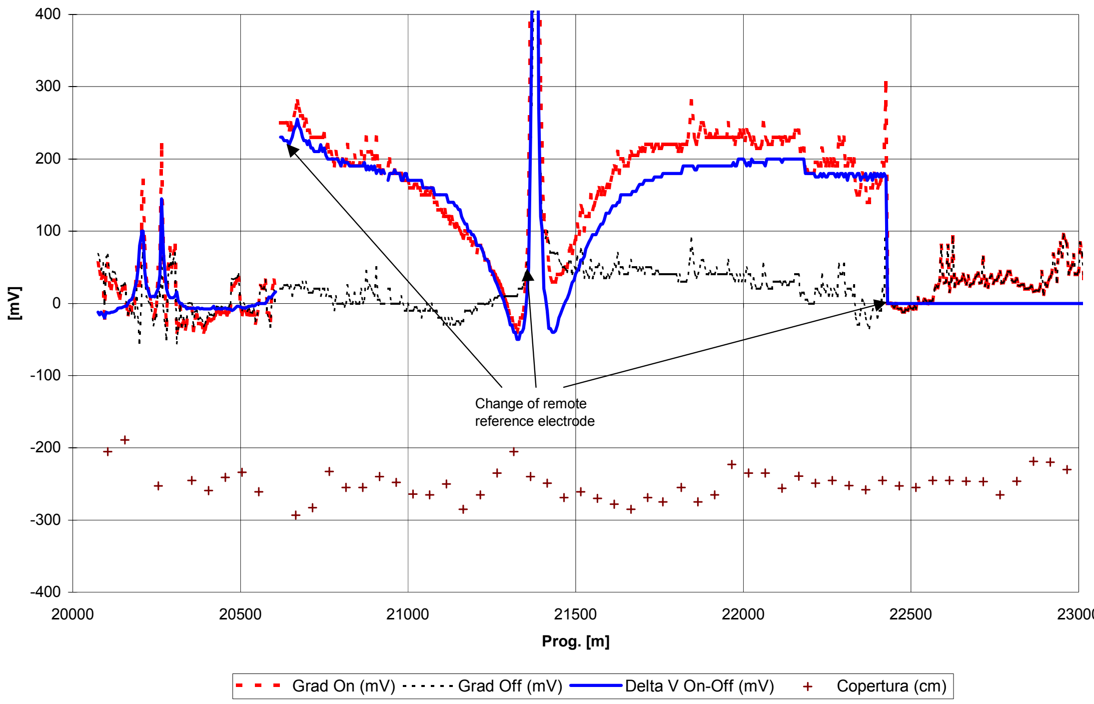

Figure 6 – Section 20000-23000 m

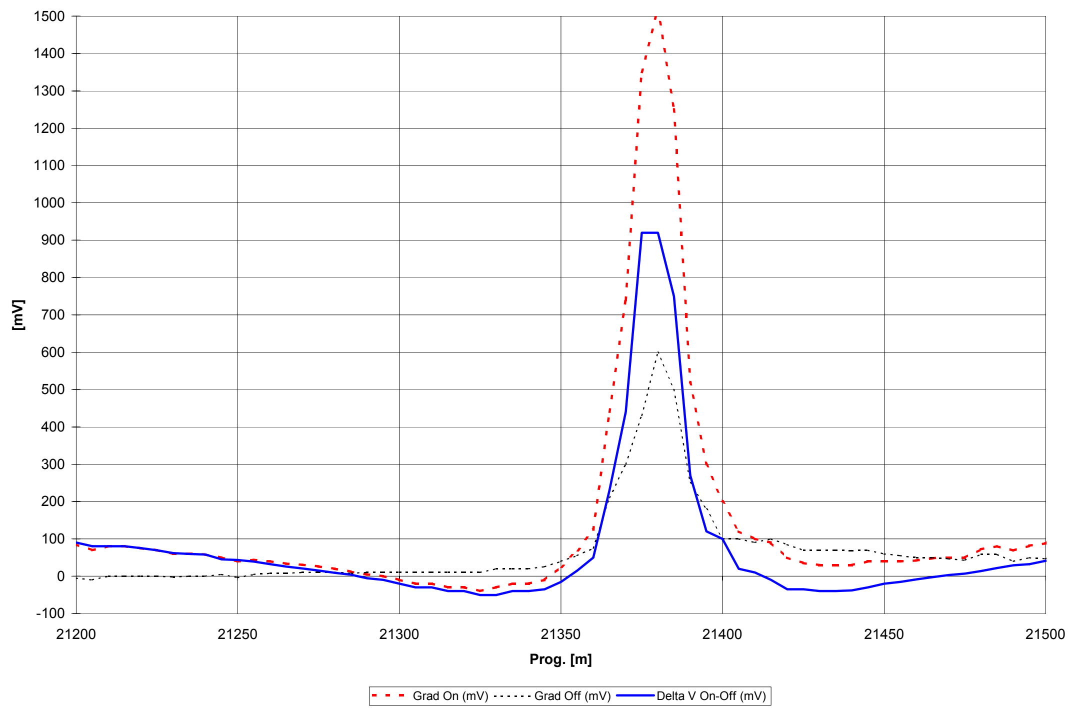

Figure 7 – Section 21200-21500 m

Example n. 2

Oil pipeline in Northern Italy, 23 Km long

Figure 8 shows the only anomalous situation observed along this line, in correspondence of both a Cathodic Protection Station (PPC) and an asphalted road.

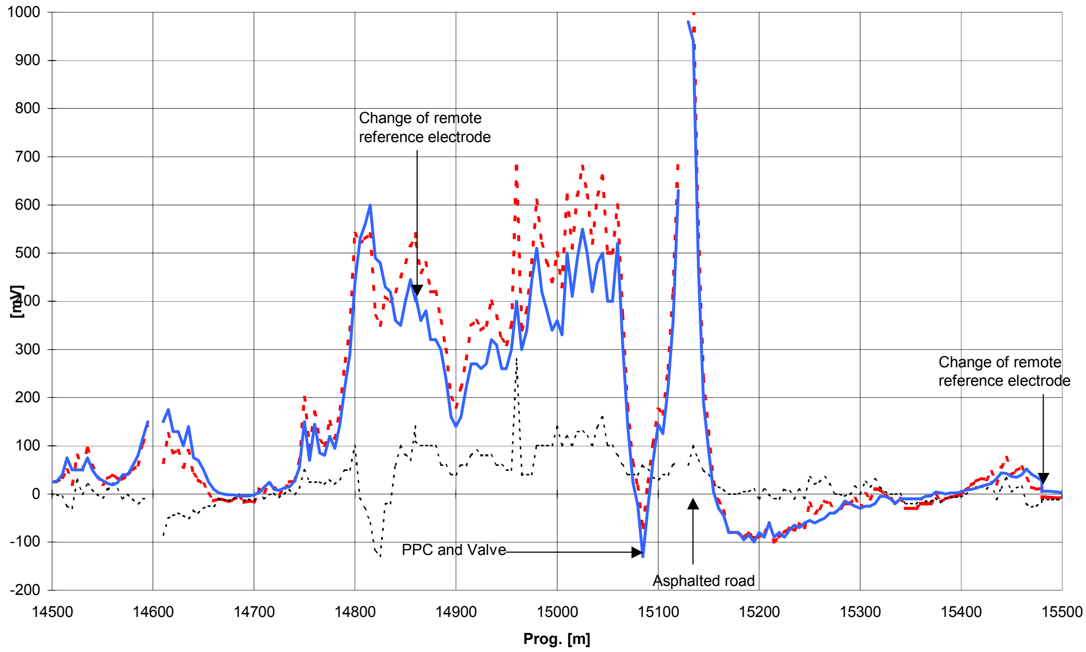

Figure 8 – Section 14500-15500 m

Discussion and conclusions

Great attention must be paid whenever along the pipeline route power suppliers, roads, canals, etc. are present.

In correspondence of power suppliers the value of the "remote" potential may be influenced very much and therefore only the trend of both the extrapolated potential values and the gradients should be considered, since the absolute values may lead to very erroneous interpretations.

The same happens, but not always, in correspondence of road and canal crossings; in these cases the measured values are influenced by the presence of either reinforced concrete slabs or casings in which occasional short-circuits may have been happened.

Another important aspect is the position of the remote reference electrode. Although the distance of 50 m from the pipeline is generally considered sufficient for the scope, in many cases it has been observed that a change in the position makes the measurement results very different.

This fact is certainly due to unexpected, but sometimes predictable, anomalous flowing of current in the soil (e.g. nearby the groundbeds), and sometimes to local soil characteristics.

Therefore, the interpretation of the results of specialized electrical surveys may be critical and must be very carefully carried out by experienced personnel.

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