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A different approach for a DC polarization coupon
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Abstract

The standard EN-12954 prescribes in general off potential measurements for the assessment of the effectiveness of cathodic protection. The standard EN-13509 prescribes seven different CP situations. In one of this seven on and off potential measurements of the pipe line are allowed. In six of these seven situations an external potential test probe is a practical solution.

The proposed robust DC polarization coupon meets the requirements for this application.

Besides showing the effectiveness of the CP system additional results from advanced measurements in the future can give a better view on the behavior of cathodic protected local coating defects.

Zusammenfassung

Der Standard EN 12954 schreibt die Messung des Ausschaltpotenzials für den Nachweis der Wirksamkeit des kathodischen Korrosionsschutzes vor. Der Standard EN 13509 beschreibt sieben verschiedene KKS Situationen. In einem von diesen ist die Messung des Ausschaltpotenzials direkt an der Leitung erlaubt. In den sechs übrigen Fällen wird eine Messprobe erforderlich.

Die vorgeschlagene robuste Gleichstrom Polarisationsmessprobe erfüllt die Anforderungen für diese Anwendung gemäss EN 13509.

Nebst dem Nachweis der Wirksamkeit des KKS können mit Hilfe des Probeblechs in Zukunft weitere Informationen gewonnen werden, welche ein verbessertes Verständnis der Schutzwirkung von Umhüllungsfehlstellen ermöglichen können.

Résumé

La norme EN-12954 prescrit généralement des mesures de potentiels Off pour l'évaluation de l'efficacité de la protection cathodique. La norme EN-13509 prescrit sept situations PC différentes. Dans l'une d'elles, des mesures de potentiel de la canalisation sont permises. Dans six de ces sept situations, une sonde externe d'essai de potentiel constitue une solution pratique.

Le coupon de polarisation CC robuste proposé satisfait aux exigences de cette application.

Outre la mise en évidence de l'efficacité du système PC, des résultats supplémentaires fournis par des mesures sophistiquées pourront conduire dans le futur à une meilleure compréhension du comportement des défauts locaux du revêtement faisant l'objet d'une protection cathodique.

1. Introduction

To control CP EN-12954 prescribes three steps, in essence:

-for general assessment of CP on potential measurements

-for the effectiveness of CP off potential measurements

-for unchanged situations current measurements

The fulfilling of this second step will be described. Gasunie owns a high pressure gas transportation grid (with compressor stations) and a medium pressure grid. These both transportation systems are electrical separated by measurement and pressure reduction stations. The high pressure grid in the Netherlands was originally one complete electrical coupled transportation grid with the compressor station isolated from the grid in bypasses. Still today it is hard to arrange separate CP systems in this high pressure grid. The medium pressure grid contains enough isolating joints to created small separated and well controllable CP systems.

To monitor the effectiveness of CP periodic off potential measurements shall be made in accordance with table 1 in EN-13509. Only in one of the seven mentioned different situation off potential measurements by simple switching the impressed current is possible. In the other six of the seven mentioned different situations no simple measured off potential of the pipeline are allowed, but for these six situations external potential test probes are part of the solution. In order to demonstrate the effectiveness of CP for a small part of the separated medium pressure grid CP systems, impressed current switching in absence of stray currents and galvanic anodes is possible. For all other situations for practical reasons potential test probes at selected test stations is an answer.

The size of the potential test probes (coupons) shall be in accordance with the size of the expected coating defects. For small size defects a coupon of 1 cm^2, medium size defects a coupon of 10 cm^2 and for large size defects a coupon of 100 cm^2. Normally, the shape of the coupon is a circle of bare steel. So for medium shape defects a circle coupon with diameter 3,6 cm (surface area 10 cm^2) should be chosen. However this is not the shape of a scratch, disbonded coating, or any other imaginable coating defect.

2. A different approach

To show the effectiveness of CP for instance in case of medium size coating defects one should measure enough polarisation on a medium size circular coupon. The measured off potential directly after disconnecting the coupon can be used to demonstrate the effectivness of CP by meeting the criteria in EN-12954. This measured off potential value is a mean value of an unknown off potential distribution on the circular coupon. Polarisation at the edge of the coupon is larger than in the centre of the coupon due to a higher current density at the edge of the coupon than in the centre of the coupon. Besides the judgement on the effectiveness of CP (which could be expected with a reasonable negative on potential) it can’t bring additional information/understanding on the local CP situation due to the unknown distribution on the coupon surface.

If we can produce better off potential values and in addition in the future probably a better understanding of the local CP situation this would be desirable.

For understanding and modelling a coupon in the shape of a ball is logic, due to the simple and well defined current distribution. The ball coupon is practical and not expensive. In case of a complete ball with an insulated wire or a thin insulated rod, one can expect a homogeneous current density on the bare metal and symmetrical spherical changes of the surrounding soil due to the CP process. An example of a ball shaped coupon together with the installation drawing are shown in Fig. 1 and 2.

What should be the size of this ball compared to a flat circular coupon? The (mean) polarisation corresponds to the (mean) current density. A flat circular coupon (one side bare steel) in a (theoretical) homogeneous surrounding has according to W. v. Baeckmann [1] the following characteristics:

$R_c = \rho/2d_c$ $\quad S_c = \pi/4 \times d_c^{\,2}$ $\quad i_{cm} = \Delta U/(R_c \times S_c) = \Delta U/\rho \text{ X } 8/\pi d_c$

- d_c diameter of a circular coupon
- R_c spread resistance for circular coupon
- ρ soil resistance
- S_c surface area circular coupon
- i_{cm} mean current density circular coupon
- ΔU potential shift

A ball coupon (completely bare steel) in a (theoretical) homogeneous surrounding has according to Beckmann the following characteristics:

$R_b = \rho/2d_b$ $\quad S_b = \pi/4 \times d_b^{\,2}$ $\quad i_b = \Delta U/(R_b \times S_b) = \Delta U/\rho \text{ X } 2/d_b$

- d_b diameter ball coupon
- R_b spread resistance for ball coupon
- ρ soil resistance
- S_b surface area ball coupon
- I_b current density ball coupon
- ΔU potential shift

To get the same (mean) current density for the circular and the ball coupon:

$8/\pi d_c = 2/d_b$ >> $d_b = \pi/4 \times d_c$

For example:

$S_c = 10 \text{ cm}^2$ >> $d_c = 3{,}6$ cm >> $d_b = 2{,}8$ cm >> $S_b = 24{,}7 \text{ cm}^2$

The ball coupon consumes two and a half times larger current compared to the circular coupon.

Fig. 1: Example of a ball shaped coupon with a surface of 24,7 cm^2.

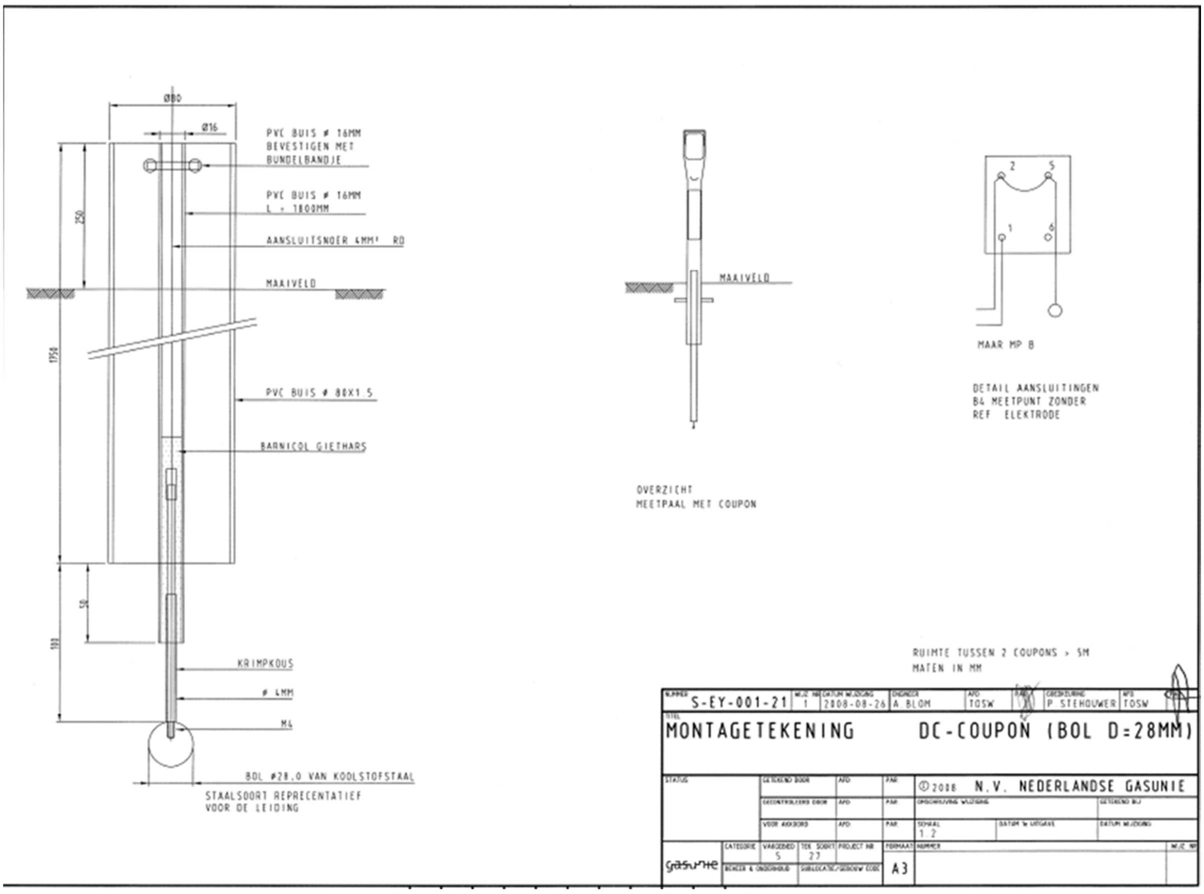

Fig. 2: Installation instruction for a ball shaped coupon.

3. Additional information using a ball coupon

After installing a ball coupon (not connected) we wait 3 to 6 months. Then the first measurement of the free corrosion potential of the coupon is taken. The free corrosion potential provides information regarding the corrosivity of the soil. (We have measured free corrosion potentials down to -780 mV (Cu/CuSO4).)

At second we measure the current caused by a known small negative potential shift of the ball coupon. With these to parameters we calculate the spread resistance of the coupon in the local soil. The spread resistance is a function of the soil resistance and should be comparable to the soil resistance measurement taken with a different method such as the Werner four pin method. The soil resistances obtained with the ball coupons were always in line with the soil resistaance values obtainedwith Werner method.

In a third step the ball coupon is connected to the cathodically protected pipe line and is used for the ir-free/off potential measurements. If on potentials are reasonable negative the coupon of potentials will always satisfy the criteria in EN-12954. So far we know the free corrosion potential, spread resistance at the start, current density related to on potential and off potential depending on the on potential (with or without AC potentials and currents). By measuring current density and off potential every three years the trends will be obtained.

4. Additional information in the future using a ball coupon

If above mentioned trends occurs and are analysed in the future, these data can be used for better understanding of CP due to a well defined and plausible coupon shape . New spread resistance measurements can bring lower or higher values than the start spread resistance and can be interpreted for example by means of a pH increase or the formation of calcareous deposits.

5. Conclusion

If coupon measurements are required by the authorities to demonstrate efficiency of the cathodic protection, they should be performed in a way to gain additional information. This will lead to an improved understanding of the cathodic protection and the related processes.

6. Literature

[1] W. v. Baeckmann, W. Schwenk, W. Prinz, "Handbuch des kathodischen Korrosionsschutzes Theorie und Praxis der elektrochemischen Schutzverfahren". (VCH, 1988)