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SECTOR A

Paper A06

a.c. corrosion – Some results of the activities

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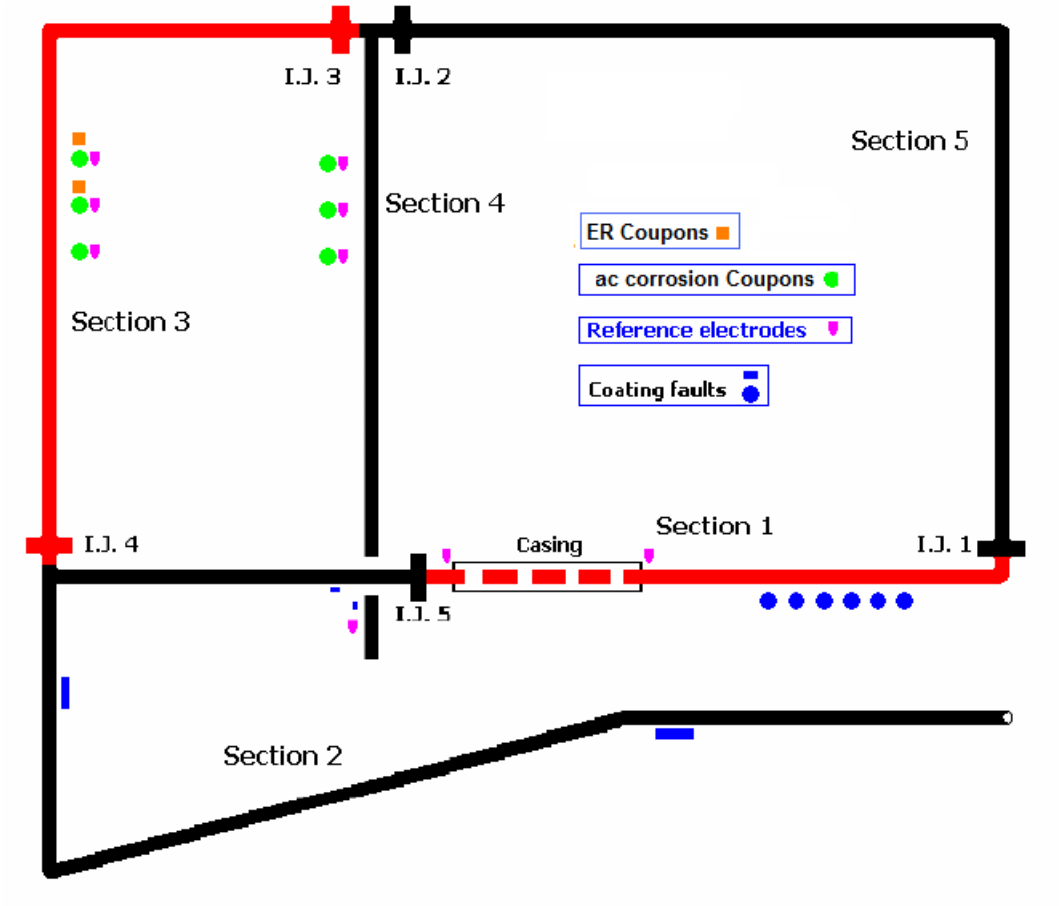
Abstract
a.c. corrosion has become a great concern in the last decades, mainly for gas operators, since the use of very high quality coatings (e.g. three-layers polyethylene) have been applied on buried pipelines.
Many studies have been performed in various laboratories in last 15 years by major Gas Operators in Europe and world-wide.
A great effort has been made in Europe by Joint Projects such as the one developed within the GERG (European Group for Gas Researches).
Since the publication of the very first CEOCOR booklet on this subject in 2001, many other experiences have been gained and reported in various studies.
During the elaboration of the European Standards on this subject, which resulted in the final document EN TS 15280, a parallel work in the Standardisation has been developed in the CENELEC, even with some heavy debates. In the framework of the ECDA (External Corrosion Direct Assessment) program, launched by US Authorities and particularly the requirements of DOT (Department of Transportation), has led NACE to elaborating a document on a.c. corrosion, starting with a State of the Art Report, now in a draft phase.

The main needs from a Standardisation point of view, according to the Authors, are the following:
A – which data should be measured
B – where these measurements should be performed
C – how these data should be measured (time duration, frequency etc.)
D – which are the parameters and which are their limits for avoiding a.c. corrosion

Some special Sections of pipelines have been installed by ISPROMA in the training Centre of Riyadh (Saudi Arabia) and elsewhere with the specific scope to answering to some of these questions. Preliminary results have already been achieved and further tests are going on in a reproduced real field conditions.
This paper aims to show some of these results in view of a discussion on this quite tricky subject.

1. – Characteristics of the training field

The Training Field is composed of a 6" pipe network having a total length of about 364 m.



The physical characteristics of the pipeline network have already been described in a previous paper (Ceocor Mondorf les Bains – Luxembourg 30th May – 2nd June 2006).

1.1. – Equipment and accessories simulating a.c. corrosion

Section 3 is coated with polyethylene, has been provided with 3 simulated coating faults having a 1 cm2 bare surface with their permanent reference electrodes (Cu/CuSO4), an a.c. feeder, and an a.c. discharge device with their relevant groundbed and earthings.
In July, 2005 three a.c. corrosion coupons had been installed in the Training Field in Riyadh.

The three a.c. Corrosion Coupons have been in conditions of a.c. corrosion for about 19 months, being the a.c. currents for the majority of time respectively of :

a.c. currents measured on the three Corrosion Coupons					
AC feeder	Total AC current	Coupon n. 1	Coupon n. 2	Coupon n. 3	Discharge Device
V (Volt)	Iac (A)	Iac (mA)	Iac (mA)	Iac (mA)	Iac (A)
0	0	0.012	0.013	0.012	
5	1.0	**5.4**	**8.8**	**4.5**	
5**	1.0	2.8	4.6	2.4	0.45
10	1.9	10.5	16.8	8.7	
15	2.7	15.8	25.4	13.2	
15**	2.7	7.6	12.5	6.5	1.23
20	3.7	21.4	34.6	18.2	
25	4.6	26.5	43.0	22.7	
25**	4.6	13.1	21.5	11.3	2.14

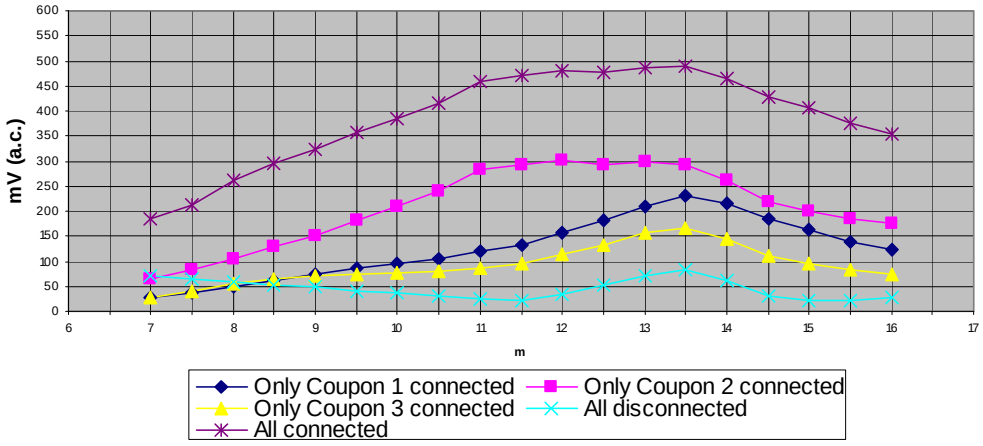
** AC Discharge Device connected

Even considering that the a.c. current has not been applied continuously, we expected that the three a.c. Corrosion Coupons would have been corroding.

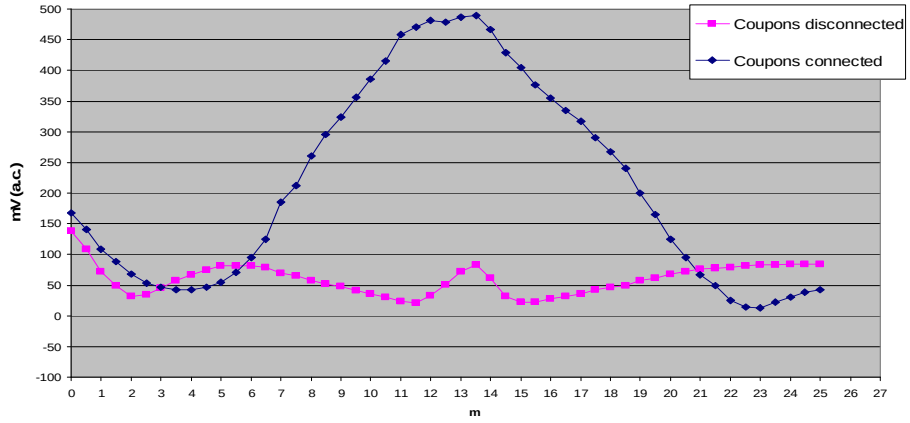
In March, 2007, the three a.c. Corrosion Coupons existing in the Section 3 have been excavated:

All three coupons have been found with a slight a.c. corrosion, as expected. Further, detailed examination are in course in our laboratories.

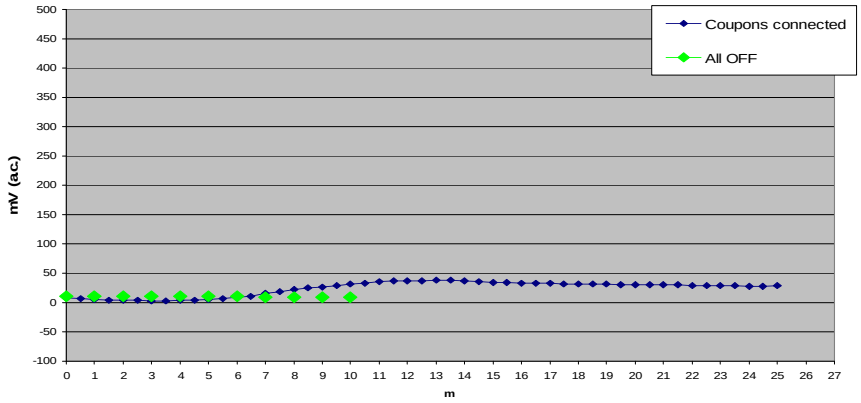
Some a.c. and d.c. Gradient Measurements had been performed over these coupons :



a.c. gradients measured over the Corrosion Coupons



a.c. Transverse Gradients – 1 A a.c. (C.P. Station OFF)



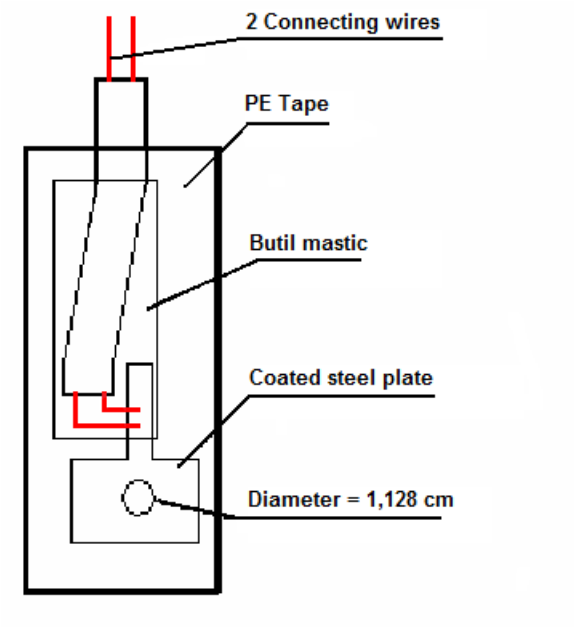
a.c. gradients measured over the Corrosion Coupons
(a.c. Discharge Device connected)

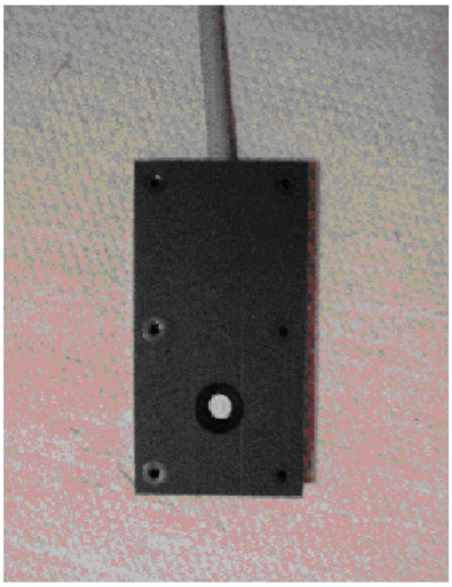
These graphs demonstrate that the Discharge Device can decrease the a.c. current on the pipe down to NON CORROSION conditions.

Also in March, 2007 some new arrangements have been realised in the Training Field.

The old a.c. Corrosion Coupons have been replaced with new ones.

a.c. Corrosion Coupon

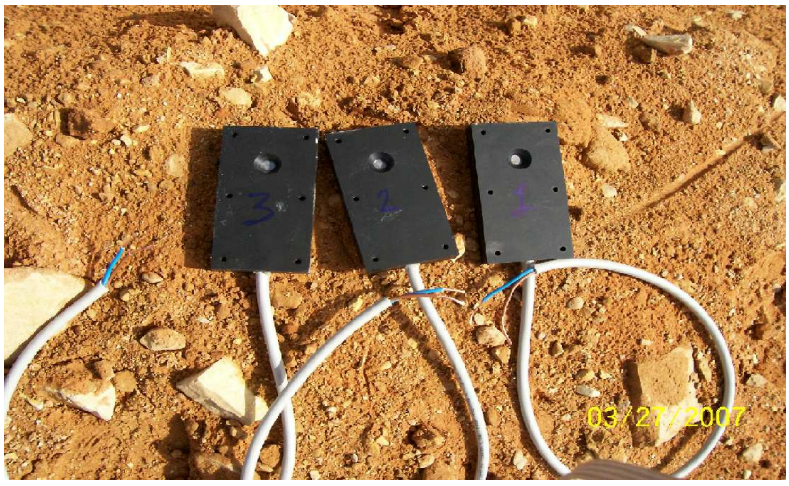




Besides the a.c. Corrosion Coupons n. 1 and 2 placed in the Section 3, n. 2 ER Coupons have been installed very near to these.

ER Coupon

In the Section 4, coated with bitumen, which includes two sacrificial magnesium anodes, and 1 coating fault (n.11) to simulate d.c. interferences, a new set of three a.c. Corrosion Coupons has also been installed. These three new a.c. Corrosion Coupons are within a certain number of existing "natural" coating faults which have already been detected and localised during the Commissioning phases.



Three new a.c. Corrosion Coupons

1.2. – a.c. Transformer Feeder

An a.c. feeder is connected to the Section 3 and 4, and simulates an a.c. resistive coupling. When a.c. voltage measurements are performed, the influence of the residual ripple a.c. 50 and 100 Hz generated by the CP Transformer Rectifier has been noticed; this can be sometimes misleading in the measurements of the a.c. voltage on the pipeline.

In the real field, many types of TR/RD may exist. The majority of them, especially the older ones, show a great voltage residual ripple which can also reach the half or the a.c.

voltage measured. This can be very deleterious when a.c. voltage measurements are made in the field as the residual ripples are superposed to induced voltage due to a.c. interference. According to the phase angle of these the effect on the measurements can be such as to get quite erroneous and misleading results.
When field measurements are performed, specific attention should be devoted to this point either by switching OFF these CP Stations (but CP will no more be efficient) or using filtered Transformer Rectifiers at least temporarily during these measurement surveys.

1.3. – Use of a.c. Corrosion Coupons

The use of Coupons has always deserved a great deal of discussions among Cathodic Protection Engineers and Laboratory researchers. As a matter of fact, pipeline operators know quite well that a Coupon may show a different "Spread Resistance" according to local conditions, exactly as the real coating faults. This becomes even more complicated from the fact that especially when a.c. interference is involved, this "Spread Resistance" can vary noticeably during time.
When a.c. Corrosion Coupons are used (these typically have a very small size - from a few mm^2 up to 1 or two cm^2), the "representativity" of these Coupons becomes of utmost importance. The installation and backfilling phases of these Coupons require very special attention.

1.4. – Use of ER Coupons

The initial calibrated characteristics of the ER Coupons installed in the Training Centre are the following:

ER Coupon n. 1 PA0608226 – PA-1.0-10-0.5-6
Carbon Steel - Coating defect Area = $1cm^2$
Thickness = 500 µm
Dimensions = 3.3 x 30 mm
Temperature : 21°C ± 3 °C
R_r = 3.34 mΩ
R_c = 3.37 mΩ
Reference index = 1.00859
Data Logger
MetriCorr AC Corrosion Detector ACD-03
S/N AC04410030 - Channel n. 1

ER Coupon n. 2 PA0608238 – PA-1.0-10-0.1-6
Carbon Steel - Coating defect Area = $1cm^2$
Thickness = 100 µm
Dimensions = 3.3 x 30 mm
Temperature : 22°C ± 3 °C
R_r = 16.55 mΩ
R_c = 16.09 mΩ
Reference index = 0.97202
Data Logger
MetriCorr AC Corrosion Detector ACD-03
S/N AC04410030 - Channel n. 2

The Data Logger equipment will allow to monitor over time the following parameters:

- a.c. current
- d.c. current
- ER coupon
- Rp coupon

Installation of Coupon n. 1

4 – Discussion of previous results

From the excavation of the first series of three coupons, a certain initial corrosion can be observed, as expected.

The presence of an unexpected big fault was visible during the measurements, the relevant signal was quite low compared to the one given by the 1 cm^2 coupons evidence.

Even when the soil is quite sandy and with high resistivity (over 300 Ohm.m), a.c. corrosion can occur, provided that the current exchanged between pipeline and soil is sufficiently high.

The presence of coating faults absorbing high current densities (either a.c. or d.c.) can easily be localised on a real pipeline. By a careful examination of the ratio between a.c. and d.c. gradients, some hint on the risk of a.c. corrosion seems possible.

Further tests are going on with specific devices to properly measure a.c. gradients.

5 - Conclusion

Three new Corrosion Coupons have been installed. In correspondence of two of these, in the same position, another two ER Coupons have been also installed.

One couple of these two double Coupons will be set with an a.c. current density over 30 A/m2, while the other two will be set to a reduced current which, in principle, should not give rise to a.c. corrosion.

The parallel measurements should allow to verify the efficacy of controlling the parameters for the occurrence of a.c. corrosion and its verification by electrical survey measurements.

References

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2 - **CEN/TS 15280 -** Evaluation of a.c. corrosion likelihood of buried pipelines - Application to cathodically protected pipelines - March, 2006

3 - M. Büchler, F. Stalder, H.G. Schoeneich, SGK, Swiss Society for corrosion protection technoparkstr. 1, CH-8005, ZÜrich, Switzerland; Ruhrgas AG, Essen, Germany "A new electrochemical method for the detection of AC corrosion" CEOCOR DRESDEN-Sector A, Paper N.07 2004.

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5 - L.V. Nielsen, B. Baumgarten, P. Cohen, „On-site measurements of AC induced corrosion: effect of AC and DC parameters" – a report from the Danish Activities