Delay for steel coupons potential measurement after OFF disconnection

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After approaching, in previous CEOCOR editions, of several techniques used in the last 20 years for "OFF potential measurements in steel coupons" in this paper we´ll present the results of the measuring methods that are been carried out actually.

These measuring methods are obtaining depolarization curves from several steel coupons showing the influence that different parameters such as the steel coupon surface area, the coating quality or the soil resistivity have on the depolarization speed rate.

The scope of this work is to know if it´s convenient or not, in function of that different parameters, to adjust by a different way the delay time for the steel coupon potential measurement after the OFF disconnection

1. Introduction

The OFF potential measurements at buried steel coupons are useful for knowing the IR free potential in those cases which OFF potentials measurements done directly to the pipeline shows important reading errors. For carrying out this type of measurement an ON-OFF interrupter it´s installed between the pipeline connection and the steel coupon.

Errors at the OFF potential measurement done directly to the pipeline, installing an ON-OFF interrupter at the CP rectifier, are related to compensation currents, galvanic currents in complex structures and off course due to stray currents.

In presence of stray currents the OFF potential measurements should be carried out using a long term potential recording, in many cases for a 24 hours period, which allows knowing the steel coupon OFF potential in periods of time with variable interferences.

During many years the characteristics and performance of the available data loggers only allowed to carry out a 24 hours recording by using measuring intervals closed to 1 second after the disconnection.

In now days the available data loggers allows to synchronize the delay time between the OFF interruption and the OFF potential measurement allowing also to carry out measures at very small intervals.

2. Delay for potential measurement

The main aim of the following presentation is the visualization and analysis of the OFF potential variation at steel coupons as time passes by since the steel coupon disconnection from the pipeline and the exact moment in which the measurement is carried out.

In the last 20 years we have performed a great amount of steel coupon OFF potential measurements at buried pipelines deciding now to carry out new ones.

For this purpose we have trace the depolarization curves of several steel coupons by performing potential measurements at each millisecond after the coupon-pipe disconnection

A second issue is an attempt to associate the different results from the depolarization data to other factors such as the steel coupon surface area, CP current density, pipeline age or soil resistivity.

Finally the interest to perform OFF potential measurements before an excessive depolarization takes place it´s also valued.

3. Carried out measurements

From the several steel coupons in which measurements has been carried out we choose 10 samples: Two (2) samples with 100 cm^2 steel surface are, one (1) with 15 cm^2, six (6) with 10 cm^2 and one (1) with 1 cm^2.

The 100 cm^2 steel surface coupons are used in pour coated pipelines, 1 cm^2 coupons are normally installed at a.c. interference risk areas and the 10 cm^2 ones, the most commons, used for good coating pipelines.

Table I shows the different OFF values obtained from the performed potential measurements records as well as other parameters such as the steel coupon surface area, coupon current and current density in A/m^2, pipe age and soil resistivity for non urban or industrial areas.
The steel coupons have been arranged from bigger to minor according to their surface area and then from bigger to minor according to their CP current density.

Table I: Steel coupons samples v/s Obtained OFF potential values

Nº Steel Coupon	Coupon Surface Area (cm^2)	Current (mA)	δ (A/m^2)	Pipe Age	ρ (Ω.cm)	OFF Potential @20 msec (V)	OFF Potential @50 msec (V)	OFF Potential @1 sec (V)
1	100	1,600	0,160	1990	5.094	-1,05	-1,04	-1,01
2	100	0,280	0,028	1980	25.000	-1,12	-1,02	-0,86
3	15	0,500	0,333	1999	2.758	-0,87	-0,86	**-0,82**
4	10	1,500	1,500	1978	21.000	-1,18	-1,16	-1,15
5	10	1,200	1,200	1997	Urban area	-0,89	-0,89	-0,86
6	10	0,900	0,900	1994	Industrial area	-1,32	-1,21	-1,06
7	10	0,100	0,100	2000	9.825	-1,10	-1,06	-0,99
8	10	0,004	0,004	2010	Urban area	-0,97	-0,96	-0,91
9	10	0,003	0,003	1995	Urban area	-0,88	**-0,84**	**-0,76**
10	1	1,030	10,300	2010	3.024	-0,89	**-0,84**	**-0,67**

4. Results

Table II is created from the values obtained in Table I in which the last 2 columns show the potential depolarization of the steel coupon at two different time intervals. The first of these columns shows the potential depolarization between the measurement recorded at 20 milliseconds after the OFF disconnection and the one carried out at 50 milliseconds in which showed values are between 10 and 110mV depending on the coupon sample. The second column shows the potential depolarization between the measurement recorded at 20 milliseconds and the one carried out at 1 second after the OFF disconnection. Here we can see bigger differences in some cases reaching up at 220 and 260mV.

Table II shows that major depolarization's carried out between the OFF potential measured at 20 milliseconds after the OFF disconnection and the one measured at 1 second after the disconnection are the ones related to steel coupons Nº2, 6 and 10.

Table II: Steel coupons samples v/s Potential depolarization differences

Nº Steel Coupon	Coupon Surface Area (cm^2)	Current (mA)	δ (A/m^2)	Pipe Age	ρ (Ω.cm)	OFF Potential Difference from 20 msec to 50 msec (mV)	OFF Potential Difference from 20 msec to 1 sec (mV)
1	100	1,600	0,160	1990	5.094	-10	-40
2	100	0,280	0,028	1980	25.000	-100	**-260**
3	15	0,500	0,333	1999	2.758	-10	-50
4	10	1,500	1,500	1978	21.000	-20	-30
5	10	1,200	1,200	1997	Urban area	0	-30
6	10	0,900	0,900	1994	Industrial area	-110	**-260**
7	10	0,100	0,100	2000	9.825	-40	-110
8	10	0,004	0,004	2010	Urban area	-10	-60
9	10	0,003	0,003	1995	Urban area	-40	-120
10	1	1,030	10,300	2010	3.024	-50	**-220**

In first place it´s not possible to see any relationship between the steel coupon surface area and the obtained depolarization due that major depolarization's takes place at 100, 10 and 1 cm^2 coupons.

Also the major depolarization can´t be associated with the CP current density due that it goes from 0,028 A/m^2 at steel coupon Nº2, to 10,3 A/m^2 at coupon Nº10.

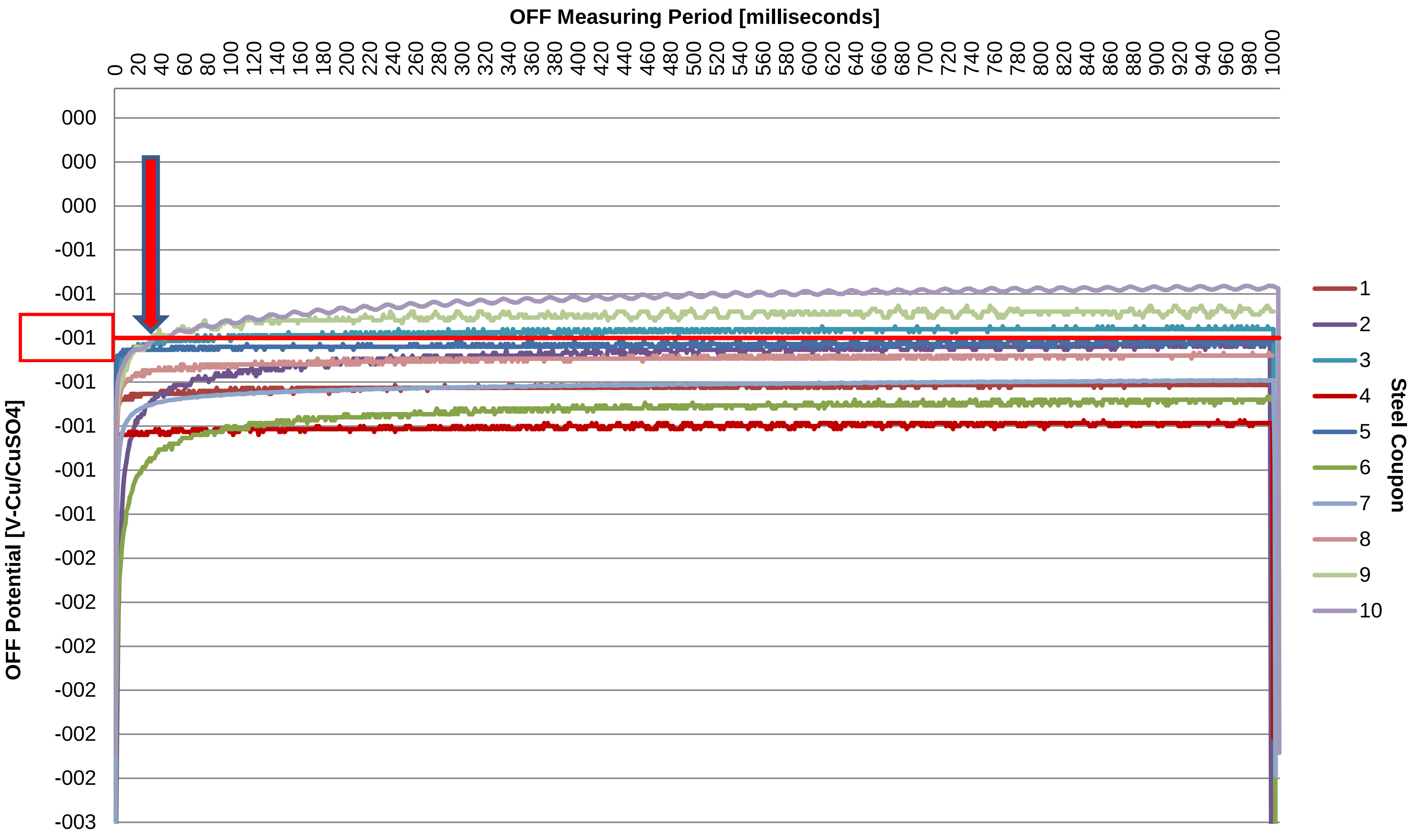
The attempt to relate the steel coupons depolarization with the pipeline coating quality, which is more or less possible to associate to the pipeline age, also is not possible due that from the steel coupons with the major depolarization, the coupon Nº2 has 33 years old while coupon Nº10 has only 3 years old.

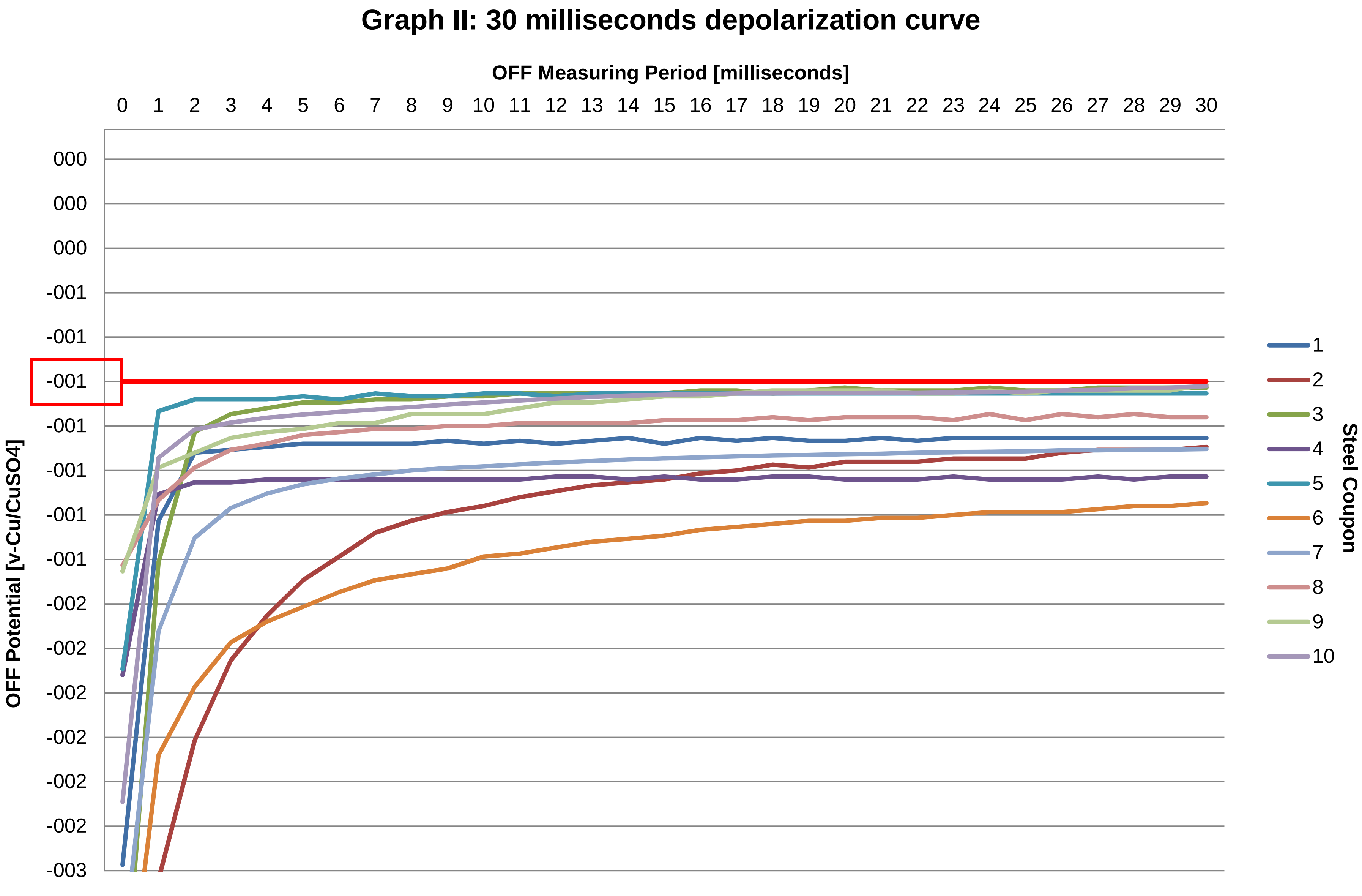
Finally steel coupon Nº2 it´s installed in a soil with a 25.000 Ωxcm resistivity while coupon Nº10 it´s in a 3.000 Ωxcm one.

What it seems to be clear is that measuring the OFF potential after leaving an important time after the disconnection (1 second or superior) it´s possible that the cathodic protection criteria can't be achieved but instead this could be reached measuring the potential more nearby the OFF disconnection.

Both Table I and following graphs shows that steel coupons Nº3, 9 and 10 doesn´t achieved the cathodic protection criteria according to the OFF potentials measured at 1 second after the OFF disconnection while all steel coupons are properly protected measuring the OFF potential before 30 milliseconds after the disconnection.

Graph I: 1 second depolarization curve





Graph II: 30 milliseconds depolarization curve
OFF Measuring Period [milliseconds]
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
000
000
000
-001
-001
-001
-001
-001
-001
-001
-002
-002
-002
-002
-002
-002
-003
OFF Potential [v-Cu/CuSO4]
Steel Coupon
1
2
3
4
5
6
7
8
9
10

5. Conclusions

No relationship has been found between the steel coupons depolarization and the available parameters data: coupon steel surface area, d.c. current density, pipeline age and soil resistivity.

Due that an important depolarization can take place when measuring OFF potentials leaving a long period of time from the disconnection, it´s interesting to evaluate performing measurements more nearby the instant OFF disconnection.

This could be specifically important in two scenarios:

- If the OFF potential obtained at 1 or more seconds after the OFF disconnection doesn´t achieve the protection criteria: Measuring before maybe could confirm that the steel coupon is already well protected.

- If a.c interferences reaches 30A/m2 of current density at the steel coupon: The apparently correct CP OFF potentials measured after an important depolarization time can mask a real risk of excessive cathodic protection for this a.c. interference level.

The carried out measurements have shown that all OFF potentials measured before 30 milliseconds after the OFF disconnection achieves the cathodic protection criteria of the steel coupons

In our opinion a good recommendation could be to measure the OFF potential of the coupons after a depolarization time of 20 milliseconds.