

E-Log-I TEST ON OIL PRODUCTION WELLS CASE STUDY

Vincenzo Saviello
Enereco S.p.A.
Via Einaudi, n. 82
Fano 6102, Italy

ABSTRACT

The aim of the present paper is to describe the E-log-I test performed on Oil Production Wells in a brown field area in the South of Iraq. The scope was, at the time, to determine the CP current to be applied to new well casings to protect them against external surface corrosion.

Initially, CP potential measurements were performed on existing well casings equipped with oil pumps and associated VSD (Variable Speed Driver), the equipment used to manage the AC powered motor of the pump installed inside the casing.

As verified during measurements, due to the presence of pumps and VSD, the grounding network cannot be completely isolated from the casing thus invalidating test results on some structures analysed.

To this end, the final tests were performed on new well casings where pumps and associated VSD were not installed yet, obtaining the typical E-log-I curve to be used for CP system design. These tests also confirmed the hypothesis of drainage created by grounding connection due to installed pumps and associated VSD.

The paper presents potential measurements and data analysis, provides a technical explanation of the drainage caused by pumps VSD grounding connection, and includes instructions and photos showing the temporary system used to perform the tests and final E-log-I curve obtained.

Key words: well casing, E-log-I test, Tafel, grounded structures, NACE SP0186.

INTRODUCTION

The E-log(I) criterion described in NACE SP0186-2007 “Application of Cathodic Protection for External Surfaces of Steel Well Casings” states that adequate protection is achieved with “a voltage at least as negative (cathodic) as that originally established at the beginning of the Tafel segment of the E-log(I) curve. This voltage shall be measured between the structure surface and a saturated copper-copper sulphate half-cell contacting the electrolyte”.

According to the above, the purpose of the E-log(I) test is to know the current required to protect the well casing and allow calculation of the necessary current density. This is achieved by delivering direct current on the well casing external surface by means of a DC source associated to a groundbed, and then measuring the “ON” and instant “OFF” potentials of the structure itself while the applied current is increased step-wise through the DC source.

The E-log(I) test as described in NACE SP0186 is a consolidated methodology, preferably performed in the field at an early design stage, in order to define the correct current figures to be used in the subsequent sizing of the impressed current CP system.

This paper discusses a series of E-log(I) tests performed in an oil field located in Southern Iraq (Basra Region), targeting the determination of an optimal current value to be applied for the cathodic protection of fifty-six (56) new well casings clustered inside six (6) different plant areas.

All casings were distributed in 6 plant areas arranged in a number of 8 or 10 well casings (clusters) per area. The plants were located in the same area with a distance of about 2Km between them. In 4 plant areas, the production had started five (5) years prior explaining the presence of a certain number of well casings for which a cathodic protection system (designed by other engineers) was present and functioning.

Here, new well casings, which were the object of the tests, had been constructed and the production had started a few years after the existing casings and for which a new cathodic protection system had to be designed and constructed.

In the remaining 2 plant areas new well casings were constructed but the production had not yet started at the time these tests were performed, and no existing CP systems were present. Also, since the casings were not in production, no connecting pumps or piping or grounding network was in place at the time of the tests.

For design purposes, E-log(I) Tests were considered necessary due to the absence of such tests on existing well casings, for which a design current of 15 Amps had been considered and used to design the existing cathodic protection systems.

Additionally, for the new wells present in 4 plant areas a temporary production system was put in place for which a new cathodic protection system is needed.

The temporary flowlines associated to these well casings where all aboveground and insulating kits were installed to electrically isolate the casings from the associated piping.

The E-Log(I) tests for well casings CP design were performed using two different scenarios:

- Well casings in service through temporary electrically isolated aboveground piping connections and associated pumps regulated through a VSD system. The VSD system is used to set the well head performances during the production phase, avoiding possible pump cavitation and subsequent failure.
- New well casings, not in service, for which the pumps with the VSD system and their associated production piping had to be installed at the time of the tests.

20 E-Log(I) tests were performed in total. For some of these, existing cathodic protection systems were used, while a temporary system was installed where this was not possible, in order to perform the tests. The temporary system was also used in cases where the existing CP system groundbeds were not able to supply the required current for casing polarization.

In order to avoid any possible interference, before all tests were performed, all grounding connections (with the only exception of the VSD System direct grounding connection) and all CP systems present in the plant area were disconnected, a depolarization period of 48 hours was allowed, and free corrosion potentials were registered.

The tests considered in the present document have the most significance for its purpose and two (2) of them were selected for the well casing CP design.

PRE-TESTING CONSIDERATIONS

According to NACE SP0186, the methods of choice in order to assess the cathodic protection design current required to protect a well casing external surface are the following:

1. Use of a profile tool to measure the voltage drop (IR) across a portion of an in-service well casing;
2. Use of a mathematical model based on a modified attenuation equation;
3. E-log-I test.

The E-log(I) test method was selected for the scope, primarily due to the additional necessity to estimate an appropriate current density to be applied to the well casings within the project scope. The use of a profile tool was ruled out because considered inapplicable to most well casings under investigation, as they were already in service and the presence of a Christmas tree does not allow the use of a profile tool. Also, relying on collected field data from E-log(I) tests was preferred to relying on a theoretical, mathematical model.

It was then decided to perform several sample tests on different plants. Although it is known that a pre-requisite to perform a reliable E-log(I) test is that the well casing under investigation is electrically isolated from any foreign, metallic structure, given the site conditions, the measurements were taken considering two main different scenarios:

1. Well casings in service, already cathodically protected by an impressed current CP system. In this case, all accessible grounding network connections were opened, but AC powered pumps and associated VSD system mechanically connected to the casing were kept in service and grounded for safe operations. Unfortunately, VSD system, grounded through the direct connection of the pump motor, cannot be isolated so wasn't disconnected as the Owner did not authorize the unavoidable well casing shutdown. However, they provided the test current with a preferential path towards the bare tinned copper grounding network. For the scope additional tests were performed

on grounding network to understand the grounding potential (made with tinned copper) and if it was polarised.

2. Well casings not yet in service or not cathodically protected. In this case, the well casings were not equipped with any pump or VSD system, so they were completely electrically isolated.

The impressed current CP system equipment (rectifier, groundbed, wires, etc.) was used when testing well casings in service, at least initially, while when testing well casing not yet in service a temporary set up, including a DC source and a groundbed, was arranged.

The position of temporary groundbed was estimated to be at a sufficient distance from the well under investigation, to ensure optimal current distribution along with the casing, and far from foreign rectifiers or other DC sources that could influence the test¹. When needed, the “electrical remoteness” of the of temporary groundbed position with respect to all the metallic structures in the surroundings was evaluated using the following formula³:

$$\%V_a = \frac{E_r}{I R} * 100 = \frac{\ln\left(\frac{L + (L^2 + r^2)^{0.5}}{r}\right)}{\ln\left(\frac{8L}{d}\right) - 1} * 100\% \leq 10\%$$

where:

%V_a= Percentage voltage rise above remote earth at point “r” [V]
 E_r = Voltage rise above remote earth at point r [V]
 IR = Voltage rise of the anode to remote earth [V]
 L = Length of active zone of the anode groundbed [m]
 D = Diameter of anode groundbed [m]
 r = Radial distance from the anode [m].

Being the temporary test groundbed chosen to be 0.219 m in diameter and 30 m in length, the temporary groundbeds were always positioned at a minimum distance of 100m where the voltage rise was 5% of the total anode increase, according to the calculation graph below:

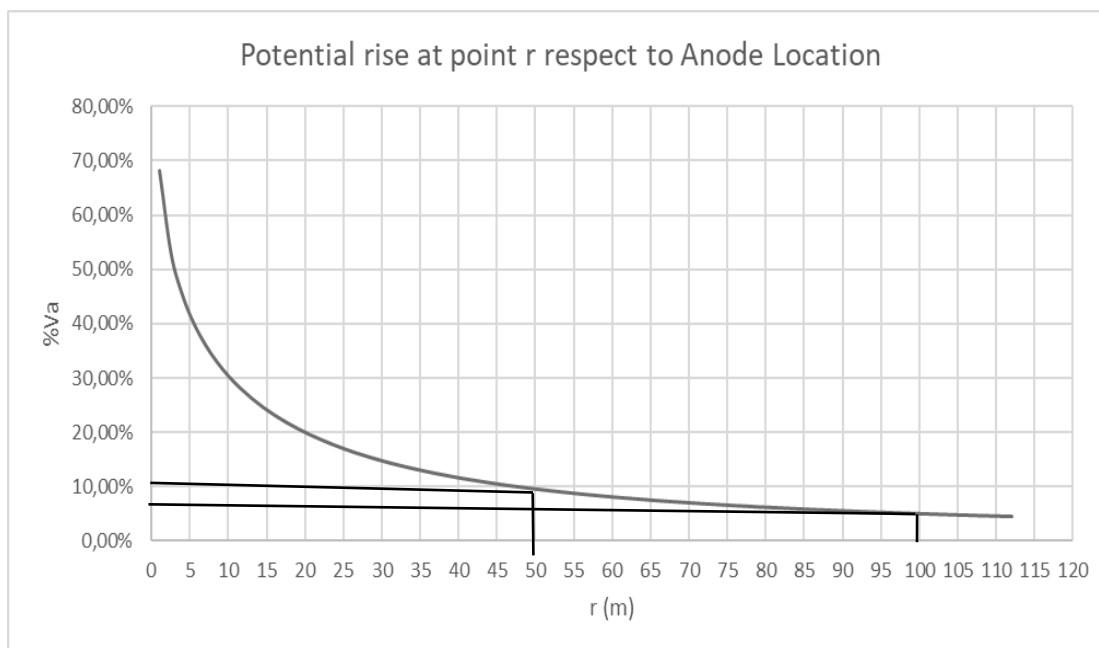


Figure 1 – Potential Rise Vs Distance from the Anode

This position was later used as the permanent anode location, in order to allow a uniform potential distribution on the well casing surface and to ensure the design to be realistically based on field collected data.

The below figure shows the typical well casing under investigation:

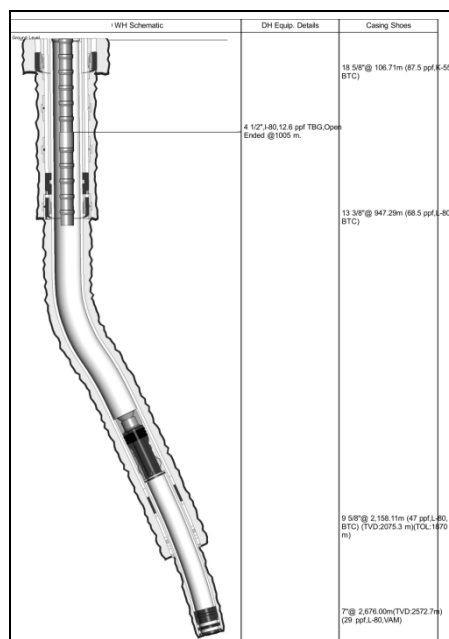


Figure 2 – Typical Well Head

FIELD TESTING PROCEDURE

For the well casings in service, the existing impressed current CP system, including its deep-well anode groundbed, was initially used to perform the E-log(I) tests by executing the following steps:

1. The electrical continuity/isolation between the well metallic parts was checked. The mechanical connections between wells and related piping were removed to ensure that only the well casing under investigation would receive the test current.
2. The well casing under investigation was disconnected from the others, in case more than one casing was protected with the same CP system.
3. Prior to start the test, the CP system active on the well casing under investigation was switched off for a period of 48 hours to depolarize the well casing external surface. For the same reason, any neighbouring operating foreign rectifiers, or DC sources, that could also influence the test were switched off 24 hours before the test.
4. The portable CSE reference electrode used for the test was positioned 20m away from the well, on the opposite side of the test groundbed, and beyond its influence (e.g. electrical field of the test groundbed).
5. Well casing free corrosion potential was measured and recorded prior to start the test.
6. The CP system was then switched back on.
7. A predefined increment of current (2 A as per NACE SP0186) was impressed for a short period of time (i.e. 3 minutes). The achieved total current was then recorded. The rectifier was operated in constant current mode.
8. The test current was interrupted and the well casing "instant OFF" potential vs. CSE was measured and recorded. The "OFF" period was set to less than 2 seconds.