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STUDY ABOUT THE CATHODIC PROTECTION AND DIAGNOSIS OF A BURIED GAS PIPELINE IN HUNEDOARA COUNTY

SUSANA ARAD[1], LILIANA SAMOILĂ[2], ILIE UȚU[3], FLORIN GABRIEL POPESCU[4], DUMITRU SFARLOAGA[5]

Abstract: The paper deals with an important issue concerning the corrosion of gas underground metallic pipelines. Some general consideration about the corrosion phenomenon are made and the main methods of anti-corrosive galvanic protection are presented. A cathodic protection station is presented and details about its use in monitoring the pipelines network are given. A specific pipeline in Hunedoara County is diagnosed.

Key words: corrosion, cathodic protection, diagnosis, pipeline.

1. INTRODUCTION

Machinery and metal constructions are exploited in the conditions of contact with different chemical-active environments: wet atmosphere, water, solutions of chemicals, industrial gases, etc.

Corrosion is the process of degradation and destruction in time of metals under the action of chemical, electrochemical or biochemical agents in the technological environment or the environment in which they are located. The degradation process begins at the surface of the metal and propagates into the mass of the material, which can lead to complete destruction of parts or subassemblies over time [3], [4].

Excepting the so-called noble metals, all other metals are unstable in contact with atmospheric air. The way this instability manifests, as well as the extent to which it occurs, depends on the nature of the metal and the aggressiveness of the environment. The damage caused to the world economy by corrosion reaches huge proportions, as an important amount of metal production is out of use due to corrosion. Damage due to corrosion is often related not only to direct metal losses but mostly to indirect losses through plant stagnation and repair or replacement of affected parts.

[1] *PhD, Professor, Eng., University of Petrosani, susanaarad@yahoo.com*
[2] *PhD, Associate Professor, Eng., University of Petrosani, branaliliana@gmail.com*
[3] *PhD, Associate Professor, Eng., University of Petrosani, ilieutu@ yahoo.com*
[4] *PhD, Lecturer, Eng., University of Petrosani, floringabriel82@yahoo.com*
[5] *PhD, Student, University of Petrosani*

The anti-corrosive galvanic protection methods are intended to protect against electrochemical corrosion of metal installations and structures, metal tanks, buried metal pipes, metal pillars, etc. Anticorrosive galvanic protection is achieved by cathodic polarization (the potential shift to negative values in the immunity area) called cathodic protection or anodic polarization (the shift of potential to passive values) called anodic protection [3].

These methods are [1], [2], [6]:

• cathodic protection with sacrificial anodes;
• cathodic protection with external power supply;
• anodic protection with external power supply;
• anode protection with protection cathode.

Cathodic (active) protection is one of the major means of reducing corrosion speed, especially in the case of large metal structures in contact with natural environments.

2. METHODS OF ANTI-CORROSIVE PROTECTION OF UNDERGROUND METALLIC PIPELINES

The degradation of the underground metallic networks (gas, oil, water, electric cables, etc.) produced by electrochemical underground corrosion leads to significant economic damage as well as to the risk of explosions and fires, with special social, economic and ecological implications. Corrosion protection measures are imperative for the reliability and long-term exploitation of underground networks [1]. These fall into two groups:

• passive protection, i.e. anticorrosive insulation with special materials;
• cathodic protection.

The classical protection system against corrosion of underground pipelines consists in covering them with insulating materials and applying cathodic protection. Only insulation coating is not sufficient to prolong the life of the pipeline. Cathodic protection is the one that applies to all insulated pipes.

Cathodic protection is one of the most cost-effective anticorrosive protection of large, costly installations and constructions with long service life. This method can be used to protect any kind of metallic structures such as underground metallic pipes, drilling platforms, ships, storage tanks and other equipment and is effective for combating both general and localized corrosion [2].

The cathodic protection of a metallic structure in contact with an electrolyte consists in shifting its electrical potential to a value more negative than the natural metal-soil potential (its equilibrium potential or base potential) after a sufficiently long contact with soil or water so that corrosion becomes thermodynamically impossible.

The choice of a cathodic protection system is made by the following criteria:

• electrical resistance of the soil;
• the state of the pipe insulation;
• cost of protection.

3. MONITORING THE WORKING CONDITIONS OF THE PIPELINES CATHODIC PROTECTION SYSTEMS

The monitoring of the operating conditions of the cathodic protection systems (Fig. 1) of the natural gas transport pipelines consists in the follow up, the surveillance and the systematic gathering of information on the state of the protection against corrosion.

The monitoring of cathodic protection status is an integral part of the Pipeline Network Security Management System [5] and has the main objectives:

• Preventing and avoiding damage to the components of the pipelines Cathodic Protection System (CPS) that would affect the safe operation of the pipeline;

• promptly detecting the damages in order to make decisions for their operative solving.

• pipeline-soil potential on the pipeline which is protected by an injection station or galvanic anode;

• the technical state of the outer insulation on the pipe line by performing intensive potential measurements using one or more specific methods, as well as by direct measurements (thickness, adhesion, specific strength, continuity);

• the technical condition of the outer insulation in the area of the air crossings and valves, traps, the underground separators along the pipeline;

• the technical state of the electrical separations to the aerial crossing support elements, obstacles under passages provided with protective tubes, insulating joints;

• resistivity of the soil along the pipeline.

Monitoring includes activities that capture signals from the cathodic protection system related to functional parameters. These signals are not only those indicated by the equipment mounted on the cathodic protection stations, but also those resulting from the planned measurements taken along the pipeline.

It is necessary to monitor the parameters and conditions that may lead to the materialization of time-dependent hazards (corrosion processes, damage to the electrical and electronic components of the CPS, etc.), but also the parameters and conditions that can create time-independent hazards (unauthorized third-party interventions, landslides, floods, earthquakes) that cause CPS components to fail or rapid and significant damage to their normal and safe operation [6].

Verification of the technical state of the CPS and the assessment of its integrity must be carried out periodically throughout its lifetime [7].

Defects detected on CPS components are subject to evaluations using appropriate methods and equipment. Based on these evaluations it is determined whether defects do not intolerably affect the functionality of the component and therefore do not require the follow up and / or subsequent application of corrective maintenance. If the defects have significant negative influences on the functional capacity of the components, appropriate surveillance and corrective maintenance measures be taken.

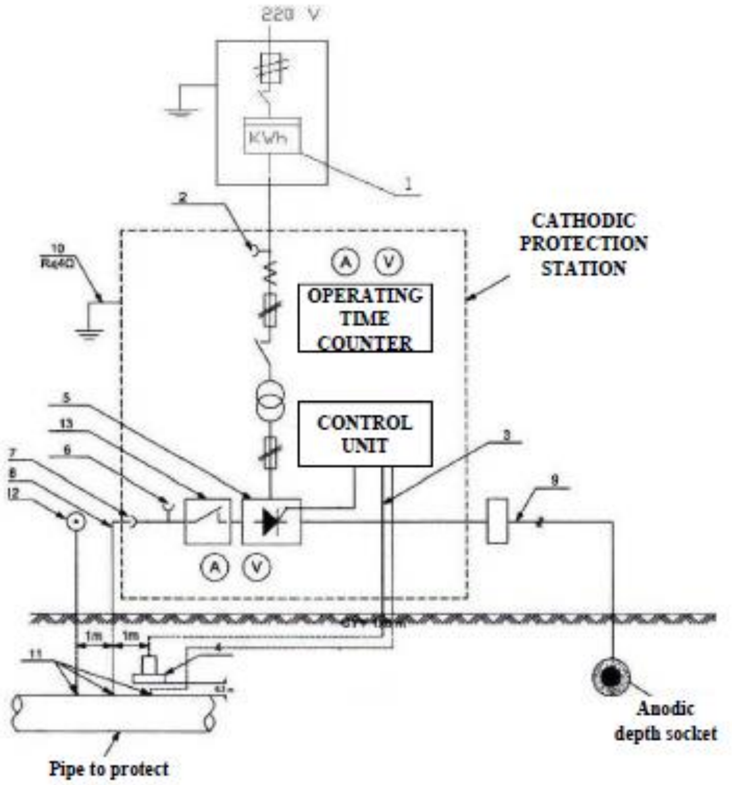

Fig. 1 Schematic of a cathodic protection station
1 - Single-phase electric counter. 2 - Socket for measuring the supply voltage. 3 - Copper conductor, 4 - Cu / CuSO4 permanent reference electrode. 5 - Transformer-rectifier set. 6 - Socket for measuring the rectified voltage. 7 - Socket for measuring the protection current intensity. 8 - Grounding conductor. 9 - Cyclic circuit breaker. 10 - Electrical cable for connection to the buried metal pipe, 11 - Anodic connection cable, 12 - Potential outlet

4. DIAGNOSIS OF THE PIPELINE SECTION BETWEEN ORASTIE AND BACIA

The general pipework data are:
- Diameter: Ø 20"
- Year of commissioning: 1962
- Operating pressure: 40 bar
- Length: 19.5 km

The general working data of the cathodic protection stations in the inspected area during the measurements are presented in Table 1.

Table 1 ***General data for the operation of the cathodic protection stations***

CPS Name	Injection voltage [V]	Injection current [A]	Potential ON [mV]	Potential OFF [mV]
CPS Orăştie	46	4	1100	900
CPS Spini 2	11,2	17,4	2250	1200

Intensive potentiometric measurements were performed using the Quantum CIPS instrument and CPS temporarily installed in the measuring area on the Vest 2 pipeline, on the synchronization sequence 4 sec ON / 1 sec OFF under temperature conditions of 30-35 °C, dry soil and grown vegetation.

Intensive potential measurements were made on the above-mentioned section on a length of 19,500 m, according to the data provided by the Quantum GPS equipment.

Following the intensive field measurements, it resulted the potential diagram ON / OFF (fig. 2).

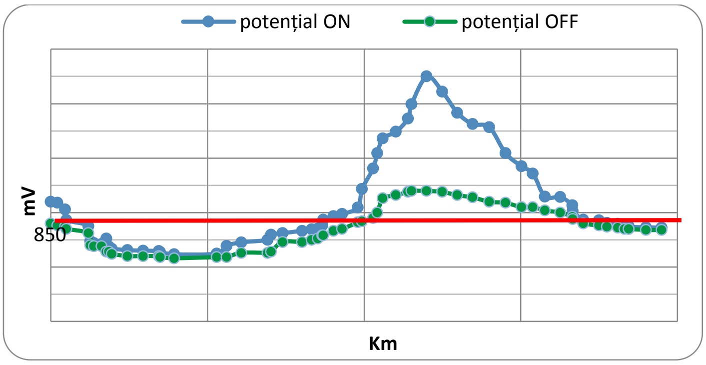

Fig. 2 Potential diagram along the main pipeline

Throughout the pipeline, soil resistivity measurements were made, whose results are presented in fig. 3.

To measure the soil resistivity, a Megger Det 5/4 R appliance was used, with the measuring range of 0.02 - 20 kΩ (measurement uncertainty 0.3 Ω) [8]. The next formula was used to determine the soil resistivity:

$\rho = 2\,\pi\, a\, r\, k$ [Ωm];

where: a - distance between the electrodes; r - the indication of the appliance; k - coefficient which varies with the degree of freezing of the soil (k = 0.9 for thawed soil and k = 0.65 for frozen soil).

For the interpretation of soil aggressiveness following soil resistivity measurements we used Table 2.

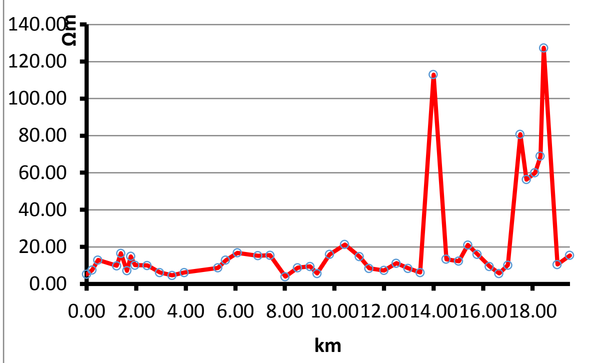

Fig. 3 Soil resistivity diagram

Table 2 ***Soil aggressiveness interpretation***

Indication	**Soil aggressiveness**
0 – 5	Very high aggressiveness
5 – 20	High aggressiveness
20 – 100	Medium aggressiveness
> 100	Low aggressiveness

5. CONCLUSIONS

The measurements along the pipeline gave that it mostly passes through a soil with high aggressiveness, according to the norm in force.

Interpreting the potential measurements, one can see some insulation defects, which are located in an area where the soil has high and very high aggression. Pipeline potential along the insulation faults has values below the corrosion protection limit (-850mV).

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