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EVALUATION OF CATHODIC PROTECTION SYSTEM FOR PIPELINES AT BREGA PETROLEUM MARKETING COMPANY IN LIBYA

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Abstract:
Cathodic protection (CP) is the most effective method for protecting petroleum facilities against corrosion. As part of this protection, care should be taken to continuously evaluate the existing system in order to maintain the system in favorable conditions. The subject of the paper's research is an oil plant for the transportation of oil derivatives located at the Brega company in Tobruk, Libya. In the present work, a case study on how to evaluate the CP system for an existing company for petroleum transportation is considered. The procedure was planned in three steps. The first step is a historical survey of the CP system from when the company started. The second was a diagnostic analysis study of the problem and how to fix it along the system. The third is the conclusions and recommendations regarding the measures for evaluating the CP system without stopping production.

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1. INTRODUCTION

Cathodic protection (CP) is the technique of causing a metal that would typically behave as an anode and corrode to behave as a cathode and be shielded from corrosive attack [1,2]. In essence, CP involves fabricating a large corrosion cell to subdue the smaller ones or anticipating the anode in the corrosion cell. This is accomplished in cathodic protection in one of two main ways. First, a more active metal can be chosen and added to the electrolyte by employing the galvanic series to create a metallic pathway. The term "galvanic cathodic protection" or "sacrificial cathodic protection" refers to this technique [3,4]. Installed as a self-sacrificing metal (anode) that is more galvanically active to safeguard the structure (cathode). The potential difference between the two distinct types of metal is the single factor influencing the voltage and, consequently, the current. Using a source of DC to compel current to flow from installed anode(s) to the structure, the second fundamental approach of cathodic protection turns the entire structure into a cathode.

This CP technique is referred to as impressed current cathodic protection. The amount of current required for cathodic protection depends on the surroundings and the metal that must be shielded. Galvanic series considerations do not affect anode material selection; economical anodes or metals with a negligible weight loss per ampere year of current are selected. The circuit contains a rectifier, solar cell, battery, generator, or other DC power supply installed [5].

Pyrophore tic coatings and cathodic protection (CP) shield pipes against external corrosion [6]. Although the coating offers the initial protection barrier, CP acts as a fallback to stop corrosion attacks at coating flaws like pinholes and holidays or disbandment of the undercoating [7-11]. On the other hand, a lot of research has been done on pipeline corrosion and corrosion-induced cracking [12,13]. CP current can be fully or partially shielded to reach the disbanding fissure when coating disbands at minor imperfections such as pinholes or vacations, especially at the

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bottom of the aperture. As a result, the region was left exposed to corrosive environments without any CP protection. This is known as "CP shielding."

Disbandment of a flawless coating due to insufficient coating application technique or coating adherence to the steel substrate lost throughout service is another real-world scenario that results in CP shielding. For instance, spirally-wrapped tape coverings may be disbanded over pipeline welds. In this case, the coating property is responsible for the CP shielding [14]. Research [15] shows that up to 85% of all external pipeline corrosion has been linked to dissolved CP shielding coatings. Non-shielding coatings allow CP current to pass through the ceramic layer and onto the steel substrate [16].

Applying cathodic protection and the protective coating simultaneously preserves the pipeline's integrity [17,18]. Specifically, cathodic protection is frequently used to prevent the corrosive effects of practically all aquatic fluids acting as electrolytes and metal structures immersed in soil [19].

Altering CP systems, using materials that are more expensive than standard C-Mn steels, and applying relatively low operating temperatures and pressure levels may be essential to reducing pipeline failures [20].

Moreover, coating improvements may be necessary, particularly in bonding [21]. One important consideration may be the development of suitable corrosion inhibitors to which primers and coatings can be applied [22].

The overall lifetime of well-designed CP systems and services can be extended [23]. However, results from the field indicate that poor management of oil companies is associated with CP system maintenance practices that lead to reduced operational capacity.

2. MATERIAL AND METHODS

The subject of the paper's research is an oil plant for the transportation of oil derivatives located at the Brega company in Tobruk, Libya. This facility's cathodic protection system is damaged, causing corrosion issues. Moreover, the "Arabian Gulf Oil Company" (AGOCO) facility, a new oil corporation, was built in the same vicinity, disrupting the current CP system and spanning the pipes. The research aimed to examine and analyze the existing CP pipeline system in the Brega company, based on which an appropriate solution was proposed.

The experimental work in the research was based on evaluating the CP system by following the schematic diagrams in Figs. 1 and 2. Fig. 1 explains the CP system arrangement for pipelines. Two CP systems are used to protect all areas of pipelines, as shown in Fig. 2. The hashed area presents the double CP system from the system at the Booster station (CPS1) and the Terminal station (CPS2).

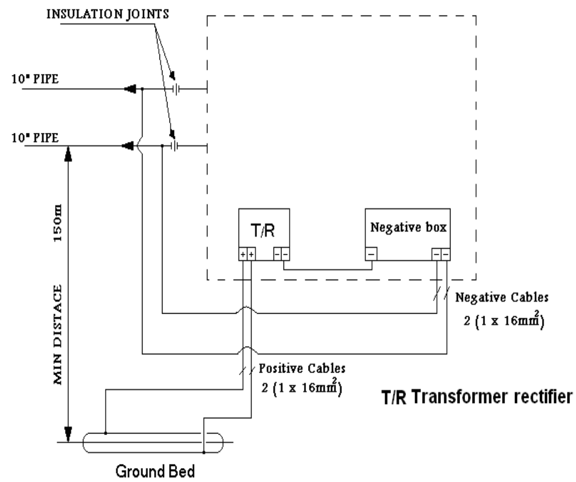

Fig. 1. CP system arrangement

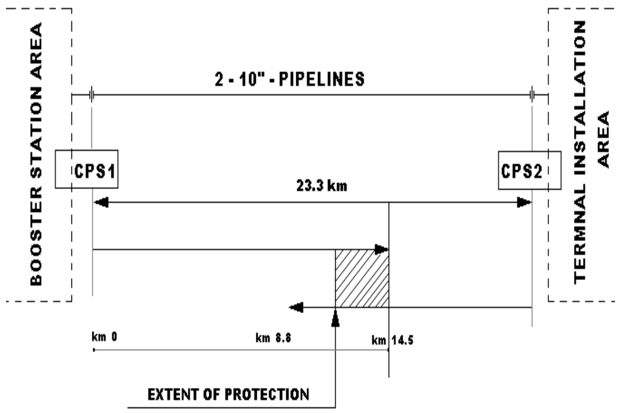

Fig. 2. Maximum current spread from each station

The Cathodic protection system in this study was applied to Brega Company's pipelines in the city of Tobruk. These pipelines extend along a path of 23.3 km, starting from the Brega Company's jetty in the Bay of Tobruk and ending in the company's storage tanks west of Tobruk. The experiment includes the visual investigation of all cathodic protection systems, photography, and case analysis.

On the other hand, new materials (to replace worn-out parts) should be selected and examined, and corrective measures should be taken to replace worn parts.

3. RESULTS AND DISCUSSION

Fig. 3 shows the position of the AGOCO company as well as the pipelines that connect the (Booster station) to the (Terminal station) and the Brega company.

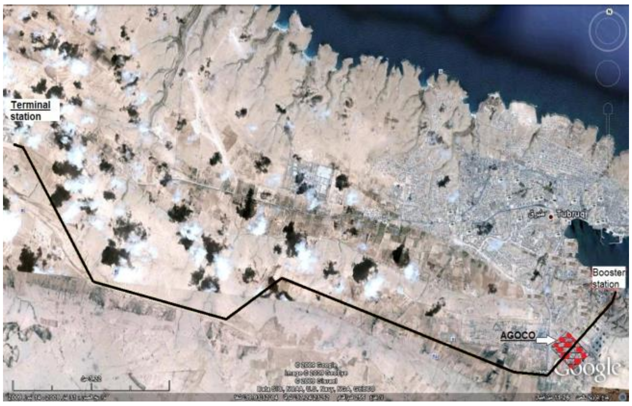

Fig. 3. Plane of Brega pipelines route from booster station to terminal station and AGOCO facilities

An old pipeline route via AGOCO company is indicated by the red arrow in Fig. 4, which depicts the intersection of the pipeline with AGOCO (Arabian Golf Oil Company) facilities.

Fig. 4. More details on the Plane of intersection location between Brega pipelines and AGOCO facilities

Due to the cross-linking of the AGOCO, as illustrated in Fig. 5, this circumstance damaged the CP system in the Brega company. Table 1 shows the output of transformer rectifiers in the cathodic protection systems. The extent to which the interference with the AGOCO CP system impacted the Brega CP system was elucidated, and the potential was decreased by several points (Fig. 5), below the suggested potential difference (-850 mV). Point 4 (the intersection location) saw a severe drop in potential, and the pipelines there served as the AGOCO CP system's anode.

Table 1. Transformer rectifier reading of Brega CP systems

Location	Booster station (CPS1)	Terminal station (CPS2)
T/R Outputs	45V; 0A	36V; 3A

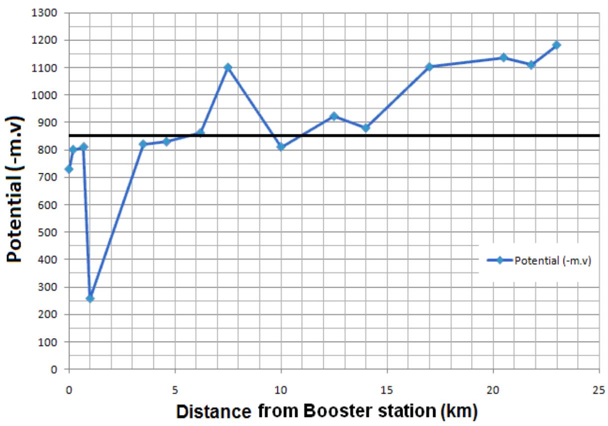

Fig. 5. The potential survey before linked with the AGOCO CP system

One solution to this problem was connecting the two CP systems in this area at a suitable underground point to overcome this interference and keep the two systems running correctly. The potential survey after the connection is shown in Fig. 6, and the output of transformer rectifiers of cathodic protection systems used is obtained in Table 2. The potential value of all tested points is higher than that recommended by the manufacturer company. However, that solution cannot be maintained due to technical problems at AGOCO company.

Table 2. The transformer rectifiers are reading after being linked with the AGOCO CP system

Location	Booster station (CPS1)	Terminal station (CPS2)
T/R Outputs	20V, 6A	36V, 3A

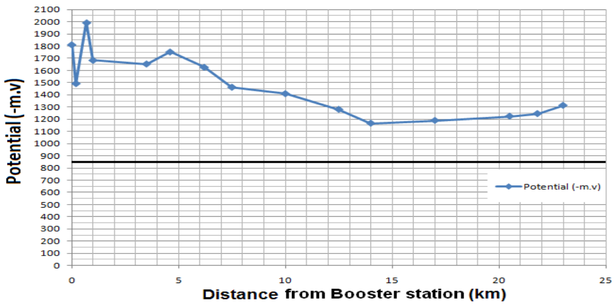

Fig. 6. Potential survey after linked with AGOCO CP system

Another solution to overcome this problem was bypassing the route around the AGOCO in order to avoid cross-linking between the two systems. Practically, this is done on upper ground, not underground.

The yellow arrow in Fig. 4 indicates the new path; the route of the pipes was modified so that the part of the path that passes under the AGOCO company was canceled, and the path in this part became above ground and revolved around the AGOCO's facilities.

Fig. 7 explains the soil resistivity measured along the pipeline's placement. The soil resistivity drops in the booster station's direction, reaching its lowest value near the junction of AGOCO and Brega pipelines. This is a result of the damp ground close to the ocean.

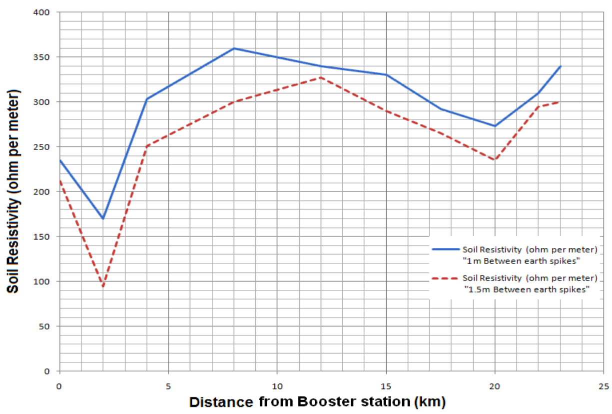

Fig. 7. Soil resistivity along the route of pipelines

The potential survey along the pipelines measured is shown in Fig. 8, and the output of transformer rectifiers of cathodic protection systems used is obtained in Table 3. Almost there is no change in the potential difference between the application of cathodic protection systems (turn on) and without application of it (turn off).

Table 3. Transformer rectifiers reading on position ON and OFF

Location		Booster station (CPS1)	Terminal station (CPS2)
T/R Outputs	ON	V 35, A 0	V 12, A 0
	OFF	V 0, A 0	V 0, A 0

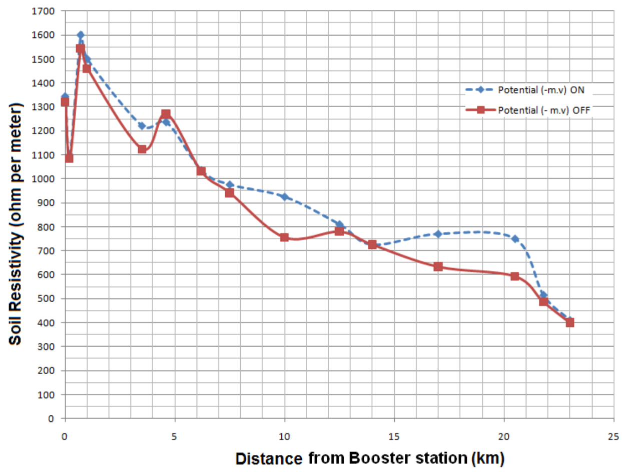

Fig. 8. Change in the potential difference between turn on and turn off of the CP system

This is attributed to anode decay in different locations because of the ending of its time life of 5 years, as shown in Fig. 9. So, the AGOCO CP system is still affected by Brega pipelines; this is quite clear from the potential value near the Booster station.

Fig. 9. Consumed anode ground bed in Brega CP system

4. CONCLUSION

It is recommended that the cathodic protection system be analyzed in detail for a successful evaluation of the CP system for oil transportation. To ensure further reliable operation, the blocked anodes must be replaced, and the rectifier must be maintained comprehensively. To ensure the sustainability of cleaner generation systems, a careful monitoring system must be implemented that considers both excess and decreased potential.

A general survey of the area must be conducted to address any changes in the areas surrounding the pipelines. The technical service also needs to maintain these installations to keep production running smoothly.

Conflicts of Interest

The authors declare no conflict of interest.

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