ANALYSIS OF CATHODIC PROTECTION SYSTEM OPERATION AT THE STORAGE TANKS IN OIL&GAS INDUSTRY

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Storage tanks are exposed to external and internal corrosion. One successful tool for external corrosion protection is the cathodic protection system. This paper describes the cathodic protection system applied to the storage tank which works in the refinery. The cathodic protection system uses a sacrificial anode, and the measurements presented in this paper show that the anode wears out. This paper presents a suggestion for the next step to protect the storage tank.

Keywords: storage tank, corrosion, cathodic protection, sacrificial anode, polarity.

Introduction

Storage tanks store liquids such as crude oil, intermediates and refined products, gaseous chemicals, waste products, and water/product mixtures. The storage tank can be constructed in different types, sizes and materials depending on essential factors such as the volatility of the stored liquid and the desired storage pressure and temperature [1]. The petroleum industry's storage tanks (often called atmospheric tanks) are typically used for liquids with less vapour pressure than atmospheric pressure. Crude oil, heavy oils, gas oils, furnace oils, naphtha, gasoline and non-volatile chemicals are usually stored in atmospheric storage tanks. In general, there are many classifications of tanks according to many criteria, such as their dimensions, shapes, operating parameters, etc. One of the widespread parameters for the classification of tanks can be the type of their roof.

Corrosion is a serious problem in metal structures in oil refineries, where it attacks metal structures such as tanks, pipes, and metal components of machinery and equipment. Corrosion is an electrochemical process between a metal and its environment, which results in its progressive degradation or destruction [2]. When internal corrosion is experienced or expected in storage tanks, the tanks can be lined with various corrosion-resistant materials such as epoxy or vinyl coatings, cast or sprayed fiberglass concrete, alloy steel, aluminum, rubber, lead, synthetics such as HDPE or hypalon and glass. Cathodic protection systems are often provided to control external bottom corrosion and, combined with internal liners, can also be used for internal tank bottom protection [2]. Cathodic protection is a technique to prevent corrosion by having the entire surface of the metal being protected act as the cathode of an electrochemical cell. Cathodic protection aims to minimize the kinetics of steel oxidation through the imposition of an electronegative potential obtained through an impressed or galvanic current, which aims, in general, to convert anodic areas into cathodic ones [2]. The paper describes the analysis of the work of cathodic protection, the importance of applying cathodic protection, and suggested solutions if the sacrificial anode is worn out.

Cathodic protection system for cone roof storage tanks

The most commonly used type of atmospheric tank in oil and gas plants is the accumulation tank with a conical roof, primarily because of its simplicity of construction. Considering the fact that the problems on these tanks during their working life in the available literature sources have yet to be sufficiently investigated during their working life.

Corrosion mitigation for crude oil storage tanks are required to protect against storage tank failure. The tank would corrode inside and out. Cathodic protection is one of the effective ways to reduce the corrosion rate. Corrosion protection of bottom plates, ring plates, shell layers and roof plates is extensive but necessary for good practice and cost savings. Corrosion allowance and coating can reduce the effects of external corrosion to a great extent in above-ground tanks, including the inner tank shells exposed mainly to crude oil. But the bottom plate exposed to water retention is subject to a more corrosive environment.

Experience has shown that corrosion can occur on the inner surface of the tank bottom. The degree or nature of corrosion depends on many factors related to the composition of the fluid in contact with the steel bottom. Factors include conductivity (a function of dissolved solids), suspended solids, pH level, and dissolved gases such as CO_2, H_2S, or O_2 [3]. Cathodic protection is a system that can be applied to structures that make metals immune from corrosive attack by causing direct current to flow from its electrolyte environment to the entire metal surface. It is obvious that the cathodic polarization is continued by using an external current above the corrosion potential to the open circuit potential of the anode. There are two cathodic protection systems — galvanic and impressed current. Both electrodes reach the same potential, and no metal corrosion can occur, or the corrosion rate remains zero. To eliminate the limited driving voltage connected to the galvanic anode, a voltage from some external power source can be "squeezed" into the circuit between the protected pipeline and the ground. Rectifiers are usually equipped with means to vary the DC output voltage over a reasonably wide range. For larger structures, galvanic anodes cannot economically deliver enough current to provide complete protection. ICCP systems use anodes connected to a DC power source, often a rectifier from a local alternating current (AC) system [4]. A general schematic of an impressed current cathodic protection system is shown in Fig. 1 [5].

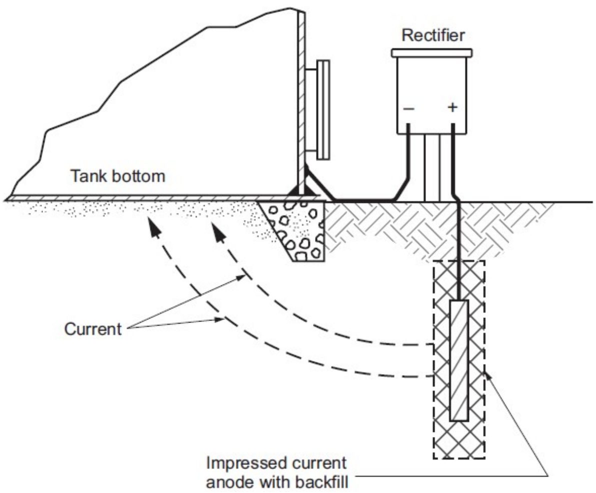

Fig. 1. Cathodic protection system with impressed current [5]

In practice, the metallic materials used as anodes are Zn, Mg or Al alloys because they are among those that have a higher potential difference in relation to the metallic materials actually used in constructions and because they present low anodic polarization characteristics. From this fact, galvanic protection is only effective in electrolytes with low electrical resistance, such as seawater and soils up to 6,000 ohm.cm, for Mg anodes. Using Zn anodes, this limit is much lower and should not exceed 1,500 ohm·cm [6]. The great advantage of the impressed current system is the fact that the generating source is AC/DC (alternating/direct current) and can have the required power, as well as the required voltage, as a function of the electrolyte resistance. The inert anodes are connected in parallel and can be buried horizontally or vertically. In some cases, conductive charging is used, in a similar way to galvanic systems, in order to reduce the resistance between the anode and the ground and improve the best current distribution [6]. It is extremely important to take into account that the negative pole is the current source that should be connected to the structure to be protected and the positive pole with the anode bed. In either hypothesis, this polarity should be reversed under the penalty of having highly accelerated corrosion of the structure. [2] Regarding the findings of the main causes of the decrease in the thickness of the tank bottom, an additional analysis of the operation of the device for cathodic protection was performed. The cabinet for the cathodic protection system (Fig. 2) was opened, and the current and voltage values in the cabinet were found to be zero. The block diagram of the cabinet is shown in Fig. 3.

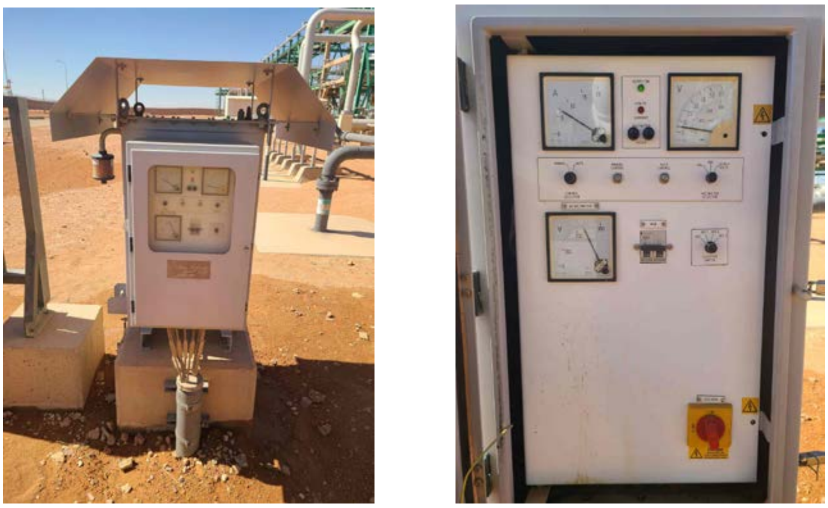

Fig. 2. Cathodic protection system cabinet after its opening and current stimulation from control room

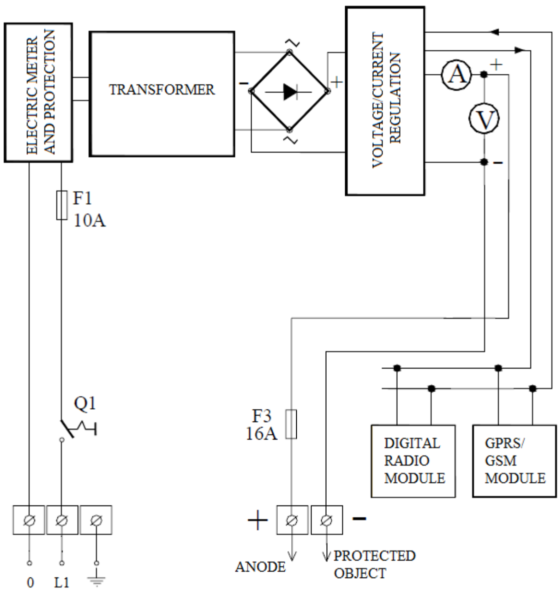

Fig. 3. Block diagram of the cabinet

The main switch was placed in the appropriate positions and additional current stimulations were performed from the control room of the plant for the purpose of determining the impressed current in sacrificial anodes. The Table gives the values of current parameters after introducing impressed current in the corrosion protection system, while Fig. 4 presents dependency of OFF-Potential and native potential (in mV) during normal system operation. It should be mentioned here that, due to disruption in normal system operation, needles in the measuring instruments will start to oscillate or to go in zero position. The oscillation of the needles shows that there are some problems in impressed current sent from the control room with appropriate parameters or in junction box (Rectifier) connected directly to the tank. When needles start to get closer to zero position, it is one of the first signals that sacrificial anodes are nearing the end of their service life. At the end of the lifespan of the sacrificial anodes, potential dependency cannot be established anymore, and impressed current supply should be immediately stopped in the control room, while the junction box and rectifier should be dismantled from the storage tank. At this point, it is necessary to determine in detail the way to restore the cathodic protection system.

Cathodic protection in a sacrificial anode system is essentially a controlled electrochemical cell. Corrosion on the protected structure moves to the anode. The anode is consumed in the process but is designed and installed so that it is easily replaced when consumed. A common lifespan of an anode is 10 to 15 years and depends on the amount of current emitted by the anodes and their size [3].

According to the current/voltage values on the control room displays and according to the Table and Fig. 4, it was established that the sacrificial anodes were completely consumed. Taking into account these facts, the root cause of the accelerated corrosion of the tank bottom was determined. During the analysis of the cathodic protection system, the functionality of the overflow protection system was examined. According to the values of the instrumentation in the control room, it was found that the mentioned system was working properly.

Values of current parameters in the cathodic protection system after applying impressed current

Native (–mV)	OFF (–mV)	Shift (–mV)
129	941	812
210	956	746
207	1039	832

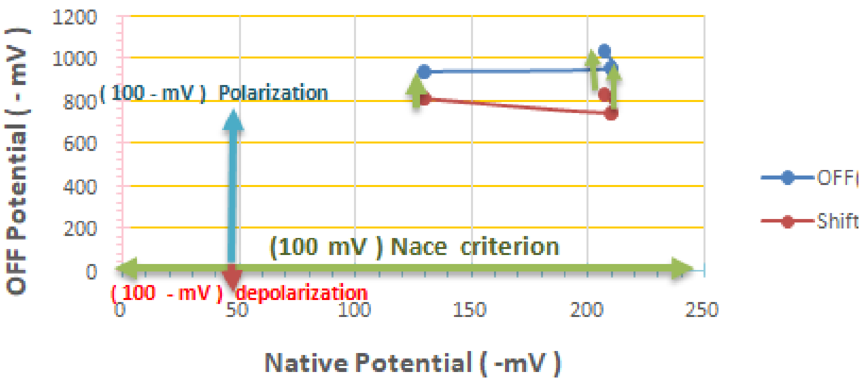

Fig. 4. Dependency of half-cell potential of electorde and native potential (in mV) according to NACE requirements

Conclusion

Taking into consideration the necessary facts for the complete tank bottom remediation, techno-economic analysis was prepared. In the mention document, all elements related to the new tank bottom system were detail analysed (cathodic protection system and positions of the new anodes, leak detection system, release prevention barrier, junction box and its elements, possible filling below the tank bottom). Final decision has been made according to the previously mentioned facts, and new bottom was fabricated in the position above to the existing tank bottom and below to the existing manhole while new sacrificial anodes were installed in the space between these tank bottoms also in the new filling. New sacrificial anodes were connected to the existing junction box and commissioning of the remediated tank was successfully conducted.

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Аналіз роботи системи катодного захисту в резервуарах нафто- та газопромисловості

Резервуари піддаються зовнішній і внутрішній корозії. Одним з успішних засобів зовнішнього захисту від корозії є система катодного захисту. У цій роботі описано систему катодного захисту, застосовану до резервуара для зберігання, який працює на нафтопереробному заводі. У системі використовується тимчасовий анод, і наведені результати вимірювання вказують на те, що анод зношений. Пропонований катодний захист по суті є контрольованою електрохімічною коміркою. Корозія на захищеній конструкції переходить на анод, який є витратним елементом, але він сконструйований та встановлений таким чином, що його можна легко замінити.

Ключові слова: накопичувальна ємність, корозія, катодний захист, тимчасовий анод, полярність.