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Analysis of the Implementation of Sacrificial Anode Type Cathodic Protection on Trunk Lines in Oil and Gas

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***Abstract* - The oil and gas industry is one of the important industries in Indonesia. Indonesia has abundant oil and natural gas resources and is one of the largest oil producers in Southeast Asia. The Indonesian government has an important role in the oil and gas industry, by regulating production activities through regulatory bodies such as the Upstream Oil and Gas Business Activities Implementation Agency (BPMIGAS). Trunklines in the oil and gas sector are likened to heart arteries by carrying important life supplies such as water, natural gas, and petroleum products through underground distribution networks. One of the problems that occurs with trunklines is corrosion. This research aims to analyze the implementation of the cathodic protection method on the SPU Nglobo-MGS (Main Gathering Station) Menggungtrunkline, Pertamina Exploration (EP) Cepu, by placing a sacrificial anode to prevent corrosion on the Trunkline. This protection method is one of the most widely used methods because it has been proven to be effective in inhibiting corrosion. Based on the analysis carried out on the SPU Nglobo-MGS Menggungtrunkline using a magnesium alloy, it was obtained that the weight required for the sacrificial anode was 20946 kg and the number of anodes was 863 pcs.**

Keywords: cathodic protection, corrosion, sacrificial anode, trunkline, oil and gas.

I. INTRODUCTION

PT Pertamina Exploration (EP) Cepu is a company engaged in oil and gas exploration and production operating in the Cepu Block area, Central Java, Indonesia. The Cepu Block is an oil and natural gas mining area with the largest reserves in Indonesia. Exploration in the Cepu Block has been going on since 1870.

In 2022, the average price of Indonesian crude oil will increase by 66.75% compared to 2021. In the first semester of 2022, crude oil production will be 616.82 MBOPD and natural gas will be 1,141.65 MBOPD [1].

An export pipeline is a tool that distributes processed oil or gas from one platform to another or between platforms and facilities on land [2]. Trunk lines have the potential for damage due to corrosion. Trunk lines used at PT Pertamina Ep Cepu are on the ground surface and on the ground, controlling corrosion on trunklines can be done in various ways, including coating and installing cathodic protection [3].

Corrosion is one of the main problems in the oil and gas supply chain transportation system, which can occur in both the upstream, midstream and downstream sectors. In the upstream sector, corrosion that usually occurs is corrosion of subsurface components such as casing, tubing, cement, valves, and seal assemblies. The harsh humid environment stimulates corrosion, in addition, the high and high temperatures present in production wells accelerate the chemical reaction of corrosion [4].

Cathodic protection is one of the most commonly used methods for controlling corrosion and preventing corrosion with the working principle of minimising the potential difference between the cathode and anode [5-8].

Cathodic protection works by changing the metal which acts like an anode and is corrosive to the cathode which is not exposed to the corrosive effect. Cathodic protection has two mechanisms to prevent and control corrosion. The first mechanism is to use a sacrificial anode, where a galvanically active metal (anode) is installed to be sacrificed to protect the structure (cathode). The voltage and current used in cathodic protection systems originate from the potential difference between two different types of metal.

The second cathodic protection mechanism is called "impressed current". In this method, a direct current or voltage source is used to provide a compulsive current from the attached anode to the structure, thus turning the entire structure into a cathode. The amount of current required for protection depends on the metal being protected and the environment [9-11].

The use of Cathodic Protection with the sacrificial anode method as an implementation of corrosion control will be tried to be applied to the SPUNglobo-MGSMenggung trunk line of PT Pertamina EP Cepu, Central Java, Indonesia. The purpose of this paper is to analyze the need for sacrificial anodes if

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implementing cathodic protection using the sacrificial anode method on the SPU Nglobo-MGSMenggung trunk line of PT Pertamina EP Cepu (Figure 1).

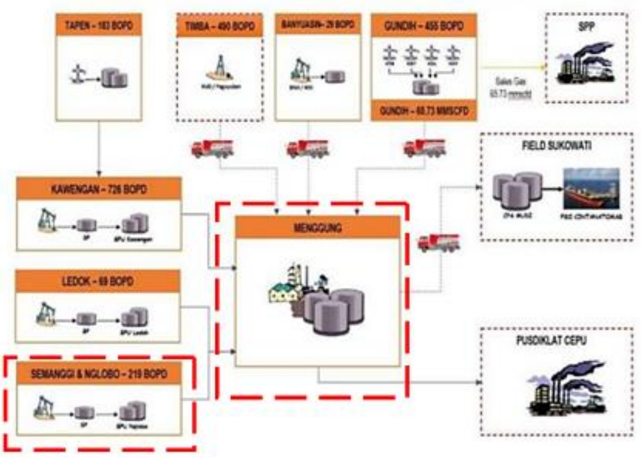

Figure 1: PFD Pertaminafield Cepu

II. METHODOLOGY

In this research, analytical calculation methods are used to process existing data to determine the need for sacrificial anodes in the cathodic protection system on the SPU Nglobo-MGSMenggung trunk line of PT Pertamina EP Cepu. The data used for the calculation process is the SPU Nglobo-MGSMenggung trunk line report data where the report contains trunk line specification data, and reports on inspection results on trunk lines as well as several findings of damaged trunk lines.

2.1 Trunkline Specifications SPU Nglobo - MGS Menggung

The following are the specifications of the SPU Nglobo - MGS Menggungtrunkline.

Table 1: Technical Data of SPU Nglobo–MGS Menggung Trunk line

1	Content		Crude Oil
2	Trunk line Data Specification		
	a	Material Specifications	Variable API 5L Gr.B
	b	Length	16.200 meter
	c	Nominal Diametre	4 inch/101.6
	d	Thickness	Min 4.54 mm.
3	Parameter		
	a	Design Pressure	430 psi
	b	Design Temperature	122 F
	c	Operating Pressure	145 psi
	d	Operating Temperature	98.6 F
3	Additional Information		
	a	Construction Type	Underground and Aboveground
	b	Location Class	1
	c	Corrosion Protection	PolykenWrapping Tape
	d	ROW	1-8 meter
	e	Built-in	1940
	f	Remaining Life	< 1 year
	g	Safety Equipment	9 Unit Block Valve

2.2 Trunkline and anode property specifications

Cathodic protection with sacrificial anode is designed for pipes buried underground at a depth of 1.5 metres soil resistivity in the Cepu region, Blora, Central Java is 0.79-4 Ωm and at a depth of 0.84 m amounts to 2.16 Ωm. The length of the pipeline is limited to a section of 4000 meters. The pipeline specifications and anode specifications can be seen in Table 2 and Table 3 [12].The type of anode type used is magnesium alloy.

Table 2: Pipeline Specifications

Pipe Diameter	0.11m
Pipeline Length	4000m
Pipelined Design Life	100year

Table 3: Anode Specifications

Anode Material	Magnesium Alloy
Dimension	0,1 x 0,1 x 0,34 m
Potential with ref to CuS04	-1.55 volts
Weight Of Anode	4 kg
Electrochemical Capacity Of anode	1230 Amp-hour/kg
Current Density	25mA/m^2
Utilization	0.85

2.3 Design Method of Sacrificial Anode

In an effort to design a sacrificial anode to be applied to the pipeline at Pertamina EP Cepu, several calculation steps and technical condition analysis are required. In this research, there are at least twelve steps and stages that must be carried out to produce the best sacrificial anode design to be installed in the desired location. The steps taken are as follows:

a) Determine soil resistivity

Soil resistivity can determine the location of the anode. In addition, the soil resistivity value can be different at several points so it is necessary to find an average.

b) Determining pipe properties

Pipe properties include the length of the pipe to be protected, the diameter, and the design life.

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c) Selecting the type of sacrificed anode

The anodes usually used are magnesium or zinc. Anode specifications will include anode weight, anode size, utilization factor, electrochemical capacity, and anode potential.

d) Calculation of the net driving potential

Calculating the net driving potential for the anode is done with Equation 1:

$$E=E_a - E_c \qquad (1)$$

E_a is the driving potential at the anode and E_c is the driving potential at the pipe. The potential at the standard magnesium alloy anode is -1.55 volts with reference to $Cu/CuSO_4$. $Cu/CuSO_4$ is usually used for potential measurements of systems buried in the ground. According to Ezekiel (2015), a practical approach is to assume that the pipe iron is polarized to -0.85 volts [12]. For cathodic protection design with magnesium anodes, this potential can be selected to be.

e) Calculation of the surface area

This surface area is the external part of the pipe to be protected. For this reason, the surface area is calculated by Equation 2.

$$S_a = \pi DL \qquad (2)$$

f) Calculation of the Current requirement

The current requirement is the electric current required. It is affected by the surface area and current density at the anode. To find this, you can use the following Equation 3.

$$I_r = S_a L_C \qquad (3)$$

L_C is the current density at the anode.

g) Calculation of the resistance to earth

Resistance to earth is one of the parameters that need to be calculated because it affects the anode current output. This can be found in Equation 4.

$$R_V = 0.00512\rho\frac{[\ln\left(\frac{8A_L}{A_d}\right)-1}{A_L} \qquad (4)$$

A_l is the anode length, A_d is the anode diameter, and ρ is the soil resistivity value.

h) Calculation of the current output per anode

This current output affects the design life of the anodes used. This can be found with the following Equation 5.

$$I_r = \frac{I}{R_V} \qquad (5)$$

i) The total mass of the anode

The total mass of sacrificed anodes is needed to determine the design life. The total mass is obtained from the following Equation 6.

$$M=\frac{I_{CD_l}8760}{u\varepsilon} \qquad (6)$$

u is the utilization factor of the anode, ε is the electrochemical capacity of the anode and D_l is the design life of the pipe.

j) Calculation of life design per anode

Life design is obtained from Equation 7 as follows.

$$d_a = \frac{Mu\varepsilon}{I_a.8760} \qquad (7)$$

k) The number of anodes required

The number of anodes required is influenced by the desired design life and current requirement of the anodes. This can be found with the following Equation 8.

$$N_a=\frac{I_r.d_l}{1000.W} \qquad (8)$$

W is the mass of the anode.

l) The distance between anodes

The last calculation is to find the distance between the installed anodes and is obtained with the following Equation 9.

$$A_s=\frac{\text{pipeline length}}{\text{Na}} \qquad (9)$$

III. RESULTS AND DISCUSSION

The results of analytical calculations using Equations 1 to Equation 9 are displayed in Table 4.

Table 4: The Results of Analytical Calculations

No	Step	Result
1	Net driving potential	$-0{,}7volt$
2	Surface area	$1381.6m^2$
3	Current requirement	34500mA
4	Resistance to earth	0.555Ω
5	Current output per anode	15.45 A

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6	The total mass of the anode	20946 kg
7	Design life per anode	161 hrs
8	Number of anodes required	863anoda
9	Distance between anodes	4.63 m

From the calculation data shown in Table 4, first, a net driving potential value of -0.7 Volts is obtained. The results of surface area calculations using a practical approach assume that the steel pipe is polarized to -0.85 volts due to the cathodic protection design with a magnesium anode-protected section of 4000 m. The surface area is found to be 1,381.6 m^2, where this surface area is the external surface area of the trunk line section that will be protected.

The current requirement is the electric current needed for the protection process, where the value is influenced by the surface area and current density of the anode. The results of calculating the current requirement value show a value of 34,500mA.

Resistance to earth is a parameter that needs to be calculated because it affects the anode current output. The Cepu area, Blora, Central Java has a resistance to earth value of 0.79-4Ωm and at a depth of 0.84 m, it has a value of 2.16 Ωm [13] so the result is 0.555Ω.

The current output per anode is found to be 15.4A. The total mass of the anodes was found to be 20,946 kg, the number of anodes required was 863 anodes to meet the desired design life of 100 years and each anode could last for 161 hours and the distance between anodes was 4.63 m.

IV. CONCLUSION

Based on the analysis and calculation on the SPU Nglobo-MGSMenggung trunkline, it is found that 863 magnesium anodes are needed to fulfil the desired design life of 100 years and per anode can last for 161 hours and the distance between anodes is 4.63 m.

REFERENCES

[1] Statistik Minyak dan Gas Bumi Semester I (2022).Diakses darihttps://migas.esdm.go.id/uploads/uploads/FA--Statistik-Semester-I-2022-LOW.pdf.

[2] Ismoyo,A.(2016),(PT. Job Pertamina-Talisman Jambi Merang New Gas Pipeline Realibility Analysis)Undergraduate Thesis,Institut Teknologi Sepuluh November Surabaya).

[3] Wahyuningsih, U., Rusjdi, H., dan Sulistiyo, E., 2017, Penanggulangan Korosi pada Pipa Gas dengan Metode Cathodic Protection (Anoda Korban) PT PGN Solution Area Tangerang, Jurnal Power Plant, STT-PLN.

[4] Ahmed, S., Vince Orth, V., Foley, M., Kottas, K., Catalin Teodoriu, C., 2021.Designing in-house cathodic protection system to assess the long-termintegrity of natural gas pipelines. Journal of Natural Gas Science and Engineering 94,104116.

[5] Seok-Ki, J., Min-Su, H., Seong-Jong, K., 2009. Electrochemical characteristics of stainlesssteel using impressed current cathodic protection in seawater. Trans. Nonferrous Metals Soc. China 19, 930–934.

[6] Bertolini, L., Redaelli, E., 2009. Throwing power of cathodic prevention applied by means of sacrificial anodes to partially submerged marine reinforced concrete piles: results of numerical simulations. Corrosion Sci. 51, 2218–2230.

[7] Aijun, Y., Lajun, F., Zipeng, W., 2010. Influence of yttrium addition on properties of Mg-basedsacrificial anode. J. Rare Earths 28, 393–395.

[8] Oghli, H.M, Akhbari, M., Kalaki, A., Eskandarzad, M., 2020. Design and analysis of the cathodic protection system of oil and gaspipelines, using distributed equivalent circuit model.Journal of Natural Gas Science and Engineering 84, 103701

[9] Popov, B.N., Lee, J.-W., 2018. Cathodic protection of pipelines. In: Handbook of Environmental Degradation of Materials. Elsevier, pp. 509–532.

[10] Parker, M., Peattie, E.G., 1984. Pipeline Corrosion and Cathodic Protection: A Practical Manual for Corrosion Engineers, Technicians, and Field Personnel. Gulf Professional Publishing.

[11] Von Baeckmann, W., Schwenk, W., Prinz, W., 1997. Handbook of Cathodic Corrosion Protection. Elsevier.

[12] Ezekiel, E. (2015). Introduction to Electrical Design for Cathodic Protection System. Ezekiel Enterprises, LLC. https://d6s74no67skb0.cloudfront.net/course-material/EE410- Introduction-to-Electrical-Design-for-Cathodic-Protection-Systems.pdf

[13] Febriana, R. K., Minarto, E., &Tryono, F. Y. (2017). Identifikasi Sebaranaliran air bawah Tanah (groundwater) denganmetode vertical electrical sounding (VES) konfigurasischlumberger di wilayah CEPU, Blora Jawa Tengah. Jurnal Sains Dan Seni ITS, 6(2). https://doi.org/10.12962/j23373520.v6i2.25280.

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