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Mitigation of high voltage induction effect on ICCP system of gas pipelines: a field case study

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Abstract

An analysis of the high voltage induction effect on the impressed current cathodic protection (ICCP) system on pipelines parallel toward high voltage power lines was employed in this research. Mitigation of high voltage effect throught human and environment is necessary to implemented. Direct current induction was used to increase the electrical potential of the gas pipeline, from Klumpang to sicanang area, Indonesia. During the mitigation process, the highest induction value was obtained 0.00574 KV which is previously was 0.01732 KV, and occurred at the limit of the allowable secure touch tension value of 0.015 KV. The data that acquire from the measurement of test point of ICCP underneath the transmission line revealed a comparison data between field measurements occurred of mitigation process. The direct current induction method is found to be safe for ICCP system and environment.

Keywords*: ICCP, induction, mitigation, stransmission*

1. Introduction

The presence of an electric transmission line parallel to the gas pipelines that induces an induced voltage in the gas pipeline affects the cathodic protection system of a gas pipe using direct current to increase the potential value of the pipe to the ground [1, 2]. In addition, the induced voltage will harm the operator and the residents around the location [3, 4]. The induction electric field caused by current flow potential interruption in the pipeline cathodic protection system which controls the rate of corrosion on the pipe [5-8]. Numerous research has been conducted regarding the interference of electric induce phenomena which is affected the ICCP system that applied in protecting the pipe line [9-12]. During the functioning of transmission line in a normal condition, three overhead line phases generally balance each other and pointedly decrease the electric field which is close to the pipeline and yield the electromagnetic fields, and when pipeline is placed in a time-varying magnetic field the inductive coupling ascends [13, 14].

A potential divider that utilized both to the transmission line and to earth position is by functioning the capacitive coupling due to only affected the pipe line above ground position [15]. In addition, the pipe line installation buried under the ground is protected from capacitive coupling [16]. The resistive coupling occurred at the transmission line and a pipeline when the levels of current flow into the earth during ground faults. The lightning storm also can be a circumstantial indication interference of impressed current cathodic protection (ICCP) systems being damaged caused by lightning storms, this possibly caused the damage of the pipeline coating as depicted in Figure 1 [17]. The others objective of that become a concern regarding safety and protection under the high voltage transmission to the operator that work on the pipe line checking, is electric shock. The allowable power system frequency fault current is typically between 300 V and 1500 V [18].

In general, AC current density is the main source for AC corrosion, since even the highest quality coating has deficiencies, countenancing for an exchange of current between the metal pipeline and the adjacent soil. Currently, special research effort was prearranged to the corrosion affected by alternating currents. Formerly, AC corrosion occurrence was

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considered insignificant compared to DC interference. Conversely, numerous research works have been proved the contrary result. In this research, the interference effect and the performance of mitigation system is undergo using field data collection by measuring potential chatodic protection at six test station, the measurement result hence compare to the mitigation process to obtain comparison data of AC voltage secure touch tension on the pipeline with cathodic protection system.

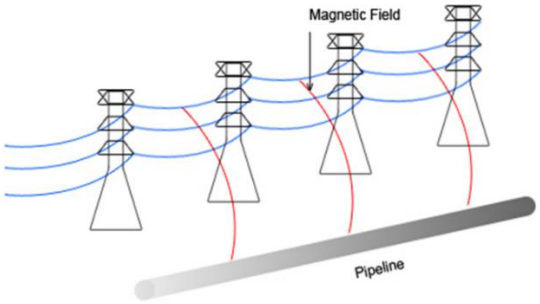

Figure 1. Interference of electric induce phenomena [17]

2. Research Method

2.1. Cathodic Protection System

The cathodic protection system was used in numerous practical of corrosion effect that occurred at the metal surface, mostly the pipeline corrosion protection application was using the installation system with sacrificial anode cathodic protection (SACP) [19, 20]. This system was installed by attaching the material with higher electrochemical series, such as Zinc, magnesium, and aluminum are applied as anode material in SACP system. The drawback of this protection model is not appropriate applied at the higher resistivity area and also for large diameter of pipeline the set up picture shown in Figure 2, the detail process on sacrificial anode method. Due to the disadvantage of SACP system in some protection system the researcher preferred to applied impressed current cathodic protection (ICCP).

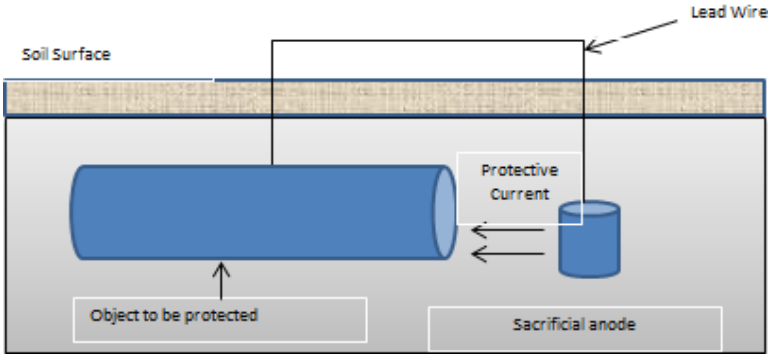

Figure 2. Sacrificial anode cathodic protection (SACP) [20]

2.2. Impressed Current Cathodic Protection

The ICCP system was conducted by several researchers in term of pipe line protection due to the voltage and current that can be varied to target the specific conditions. The European Standard EN 12954 have been specified [5, 21] the standard for buried pipe lines installation with voltage required 0.85 V copper-copper sulphate electrode. The ICCP comprises of A DC source as the input to the pipeline protection system, the auxiliary electrode act as anode and the pipeline act as cathode [22, 23]. The AC transformer use to alternate the voltage to a variable DC output. The integrated protection system was conducted to ensure the protected pipeline poses at a constant DC condition with respect to the surrounding area as shown in Figure 3.

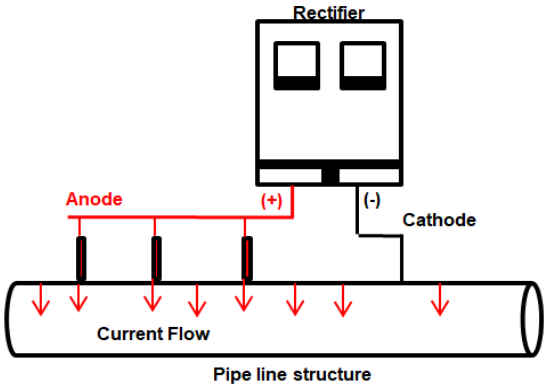

Figure 3. Impressed current cathodic protection (ICCP) [22]

3. Experimental

3.1. AC Voltage Measurement on Gas Pipeline

The pipeline was a section of a transmission of natural gas main line own by PT Perusahaan Gas Negara (Persero). The external diameter was 16 inch. The entire pipeline surface was coated with fused bonded epoxy primer and three-layer extruded polyethylene. Heat-shrinkable polyethylene-compatible sleeves covered every girth weld (applied in the field) while a coal tar polyurethane coating was used for the valves. The pipe line was employed a cathodic current protection system (ICCP), parallel to High Voltage Power Transmission from Sicanang-Belawan area with 150 KV Power Plant as depicted in Figure 4, this area is the experimental area of study. Measurements of the AC power voltage values on the pipes are carried out at the cathodic protection station test that spread across five point's pipelines, as well as the first point of measurement on the transformer rectifier that transmits the DC current to the pipeline location along 12.3 km the measurement point shown in Figure 5.

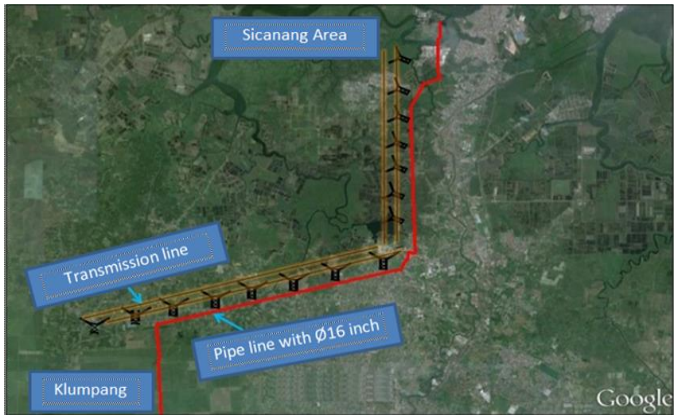

Figure 4. Measurement location of pipe line test station under transmission line

Figure 5. Measurement point of cathodic protection system

3.2. Experimetal Set Up of Pipeline Mitigation Process

In this section the mitigation step was conducted with installation depicted in Figure 6. This cathodic protection consists of transformer rectifier and two junction box with different component used and also different material anode. The first junction box equipped by variable resistor and MMO material as anode, the second junction box only utilize as grounding jumper and using Magnesium as anode which is connected directly to the pipeline.

The equivalent variation in the DC potential of the pipe was observed and measured by using a multi-meter at the test station. Earlier study on steady state analysis of the induced voltage commonly occurred at voltage range between 0 and 50 V [24]. The rectifier transformer in this experimental setup employed as a cathodic protection system. However, the AC source acts as the inductive coupling of transmission line along the pipeline area. This study compares the revealed data which is measure in two different states to observe the gap data that obtain during the measurement before and after mitigation work.

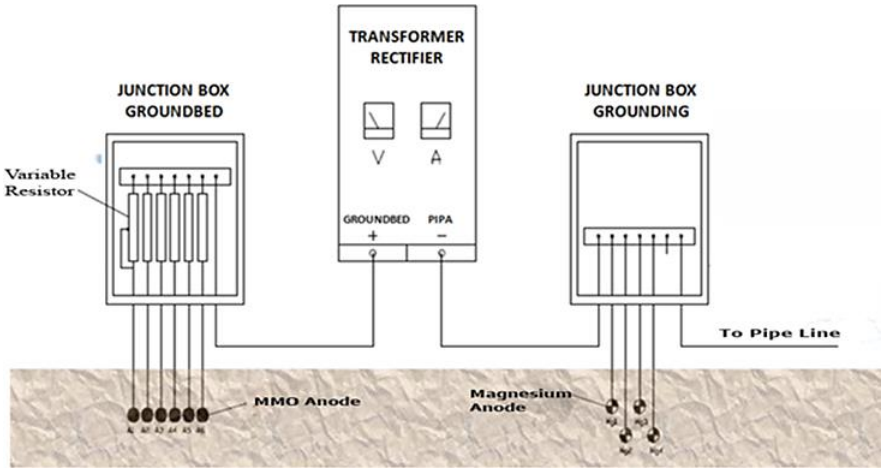

Figure 6. Experimental setup of mitigation process

4. Results and Analysis

4.1. AC Voltage Measurement Results on Gas Pipeline Before Mitigation

The voltage measurement results of 5 test point station are shown in Figure 7. It shows the various level of AC voltage which is measured at different test point before the mitigation step, at the TP 15A the voltage was 0.00648KV, TP 16 A 0.0138 KV, TP 17 A 0.01732 KV, TP 18 A 0.01177 KV, and TP 19 A 0.0042 KV. Based on the measurement result revealed the pipeline protection system was indicated the critical condtion might be caused danger circumstances under the transmission line dueto AC voltage induce. The most highest point was measured at TP 17A this test point revealed 0.01732 KV, which is beyond the secure touch tension on the pipeline which is the minimum level was 15 V (0.015 KV) according to Standard Practice Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems [25].

4.2. AC Voltage Measurement Results on Gas Pipeline after Mitigation

The measurement result depicted in Figure 8 was conducted at the same test station, the measurement applied after the mitigation process, at the TP 15A the voltage was 0.00229 KV, TP 16 A 0.00574 KV, TP 17 A 0.00561 KV, TP 18 A 0.00201 KV, and TP 19 A 0.00359 KV. The mitigation process that was conducted on pipeline installation shown the decrement value of AC measurement after the mitigation process, as shown in the graph in Figure 8. Most of test point result measurement that was employed at the same point revelaed significant value of measurement under the permissible voltage namely 15 V, that was standardize by NACE as International professional organization for the corrosion control industry [26].

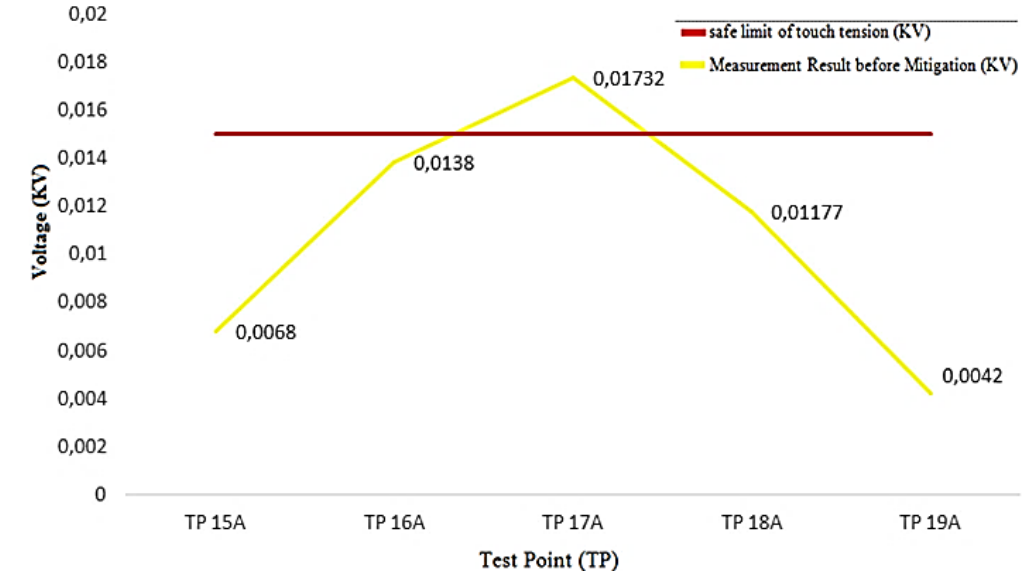

Figure 7. AC voltage measurement results on pipe

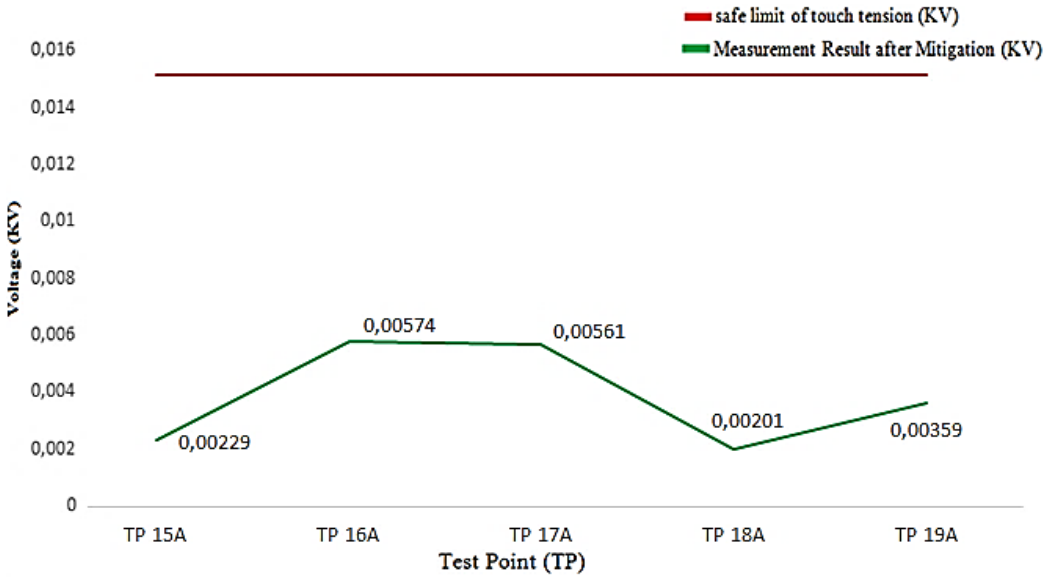

Figure 8. AC voltage measurement results on gas pipeline after mitigation

5. Conclusion

The existence of a power transmission line parallel to the gas pipeline that causes induced voltage in the gas pipeline will interrupt the cathodic protection system on the gas pipeline which uses a AC source in increasing the potential value of the pipe to the soil. In addition, the induction voltage will endanger the worker and residents around the pipeline location. The mitigation process was done to maintain the reliability of the cathodic protection system in gas pipelines, so that the system can still function properly in an electric field under induction environment.

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