Investigation of Metal Contact by Utilizing Combination of Current Attenuation Survey (CAS) and Ground Penetrating Radar (GPR) Methods on Congested Urban Gas Pipeline

Sufi Hamdan Mazida[1,2](✉), Ari Kurniawan[3], Fajar Rahman[4], Vinda Puspasari[5], Tedi Kurniawan[6], Isdaryanto Iskandar[1], and Seiful Huda[2]

[1] Engineering Faculty, Universitas Katolik Indonesia Atmajaya Jakarta, Jakarta, Indonesia
sufi.hamdan@capella.co.id
[2] PT Capella Global Inovasi, Jakarta, Indonesia
[3] Equipment and Material Dept, Saipem SpA - Qatar Branch, Doha, Qatar
[4] PT. Perusahaan Gas Negara (PGN) SOR II, Jakarta, Indonesia
[5] Research Centre for Metallurgy-National Research and Innovation Agency, Jakarta, Indonesia
[6] Engineering Technology Department, Community College of Qatar, Doha, Qatar

Abstract. This paper reports a field investigation of the metal contact phenomenon in gas pipelines buried underneath urban areas by utilizing the combination of current attenuation survey (CAS) and ground penetrating radar (GPR) methods. CAS examined pipeline integrity based on standard NACE SP0502 and utilized pipeline current mapping (PCM) as the tool. The method enables detecting potential metal contact in a pipeline by investigating the current drop in the measured area. GPR was then utilized by setting the frequency of 450 MHz to determine the exact location of metal contact in the pipeline buried at one to two meters below the ground surface. Utilizing these two methods enables determining the existence of metal contact and its precise location so that it helps the pipeline workers to do excavation and restoration whenever gas pipeline leakage occurs underneath the ground. The results reveal that the CAS indicates the metal contact in the pipeline by knowing more than 50% current reduction. It can be supported using GPR analysis, where anomalies in the contour line indicate the location of metal contact. Therefore, the engineer didn't have to dig along the pipeline to predict the metal contact location; hence, it saves cost and time.

Keywords: Pipeline · metal contact · current attenuation survey (CAS) · ground penetrating radar (GPR)

1 Introduction

The reliability of gas pipelines is crucial in maintaining a proper energy transmission system [1]. As we know that the urban underground pipe network system has been used recently in many fields, such as telecommunications, electric power, heat, water supply, and drainage [2]. The increasing urban population which leads to highly complex pipeline

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configuration renders interaction between gas pipelines inevitable [3]. Moreover, the problem of bad mapping and incomplete line coordination information is caused by the disordered of urban underground pipeline's management system [4]. Such interaction could potentially cause failures if not managed appropriately, for instance, metal contact happens when two or more steel pipelines are connected with each other. In this situation, the step to reposition the urban underground pipeline and redraw the map are urgent, because of that, optimizing the urban underground pipeline detection technology is the first priority [5]. The utilization of geophysical methods as the solution to overcome the prediction of metal contact location has helped a lot of engineers because of their cost and time effectiveness, in other ways they are also non-destructive methods to the ground surface. Hence, these methods becoming popular to be used in underground projects related to the various disciplines of earth science [6]. Although these methods have several drawbacks such as the specific location of deep below-ground surveying, several of them such as electromagnetic methods also can be used for shallow depths, such as in soils [7].

Based on the common geophysical methods available, ground penetrating radar (GPR) and current attenuation survey (CAS) have been the most widely applied in soil surveys. These two methods differ in the physical properties they measure, where GPR measures the soil dielectric permittivity, CAS detects changes in soil potential. Moreover, based on NACE SP0502-2010, there are some methods to detect metal contact depending on the location and condition [8]. Metal contact happened when two or more steel-pipeline connected to each other. It may generate corrosion problems since the gas pipeline will have a different protection potential compared with the others pipeline [9]. The indication of metal contact is determined by current attenuation survey (CAS) methods by analyzing current drops from field measurements [10]. CAS is a survey method to examine pipeline integrity based on standard NACE SP0502 for External Corrosion Direct Assessment (ECDA). A current Attenuation Survey (CAS) was used in this study due to the pipeline location in a paved area, in this case, a city road. CAS employs an electromagnetic field to determine current drop [11]. It can detect potential metal contact that may exist, but it cannot determine the source of the metal contact precisely. Figure 1 shows the guidelines to determine the severity of pipeline defects. The challenge is to determine the exact location of the metal contact, it is needed for pipeline excavation to repair it. The exact location of the metal contact location will lead to a lot of beneficial factors including cost, time, and safety.

Ground penetrating radar (GPR) was applied to determine the location of underground utilities in the metal contact area. GPR has been claimed as the superior technique for subsurface measurement which is widely used in detecting, scanning, marking, and locating buried utilities [6]. GPR can determine subsurface structures quickly and accurately. The equipment can be maneuvered with ease on the ground surface, so it is suitable for surveys in congested areas [12]. In using GPR, the balance of frequency needs to be considered because high frequency generates high-resolution images, but lower frequency leads to deeper penetration [13]. Typically, the frequency of GPR required for the detection of buried objects such as metal pipes is around 300–700 MHz depending on the depth of the object and the resolution we would like to achieve [14]. In view of

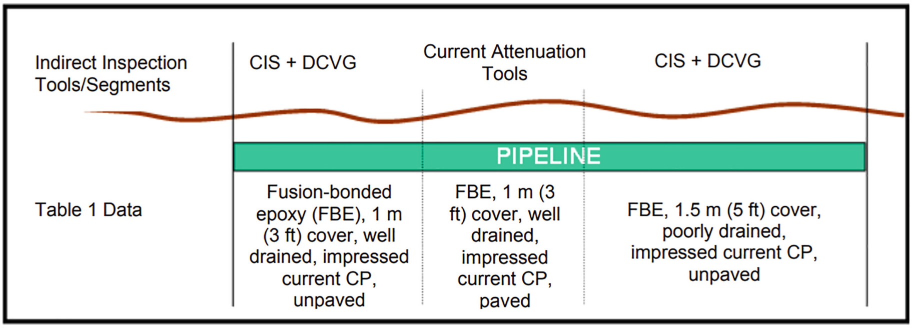

Fig. 1. Example selection of indirect assessment tools [6]

this, this experiment aims to deeply analyze urban underground pipeline detection technology based on GPR and CAS to provide strong technical support for the operation and maintenance of urban underground pipelines. The gas pipeline in this study is located in Jakarta which is a congested area since its location in the main street is very crowded. The combination of CAS and GPR was used to verify the existence and precise location of metal contact so excavation and pipeline repair can be done economically.

2 Material and Methods

2.1 Data Acquisition

The data acquisition was done according to the indication of metal contact in a buried gas pipeline. The location mentioned is at the junction of Jl. Merdeka with Jl. Moh. A. Salmun, Bogor (Coordinate: 6°35′25.33"/106°47′16.24"). The geophysical radar survey path was conducted with a grid shape of 10 × 10 m and an average pace of 1 m. In addition, the measurement is also done in several paths surrounding the target area locations. The survey was done using geophysical radar equipment called MALA Easy Locator Core with an antenna frequency of 450 MHz. The path of the georadar survey in Bogor consisted of 34 lines as can be seen in Fig. 2.

2.2 Data Processing

After the acquisition data was done, the raw data obtained will be processed using Reflexw software. The data processing consisted of frequency filtering and noise reduction to be easily interpreted. Figure 3 indicated the stage of data processing in GPR survey to produce georadar image indicating the target anomaly. The results obtained from data processing can be continued using data interpretation.

2.3 Data Interpretation

Data interpretation was functioned to comprehend the anomalies happened in radargram. In the interpretation process stage, identification is carried out by taking into account

Fig. 2. Survey location of geophysical radar and path of georadar survey located in Bogor

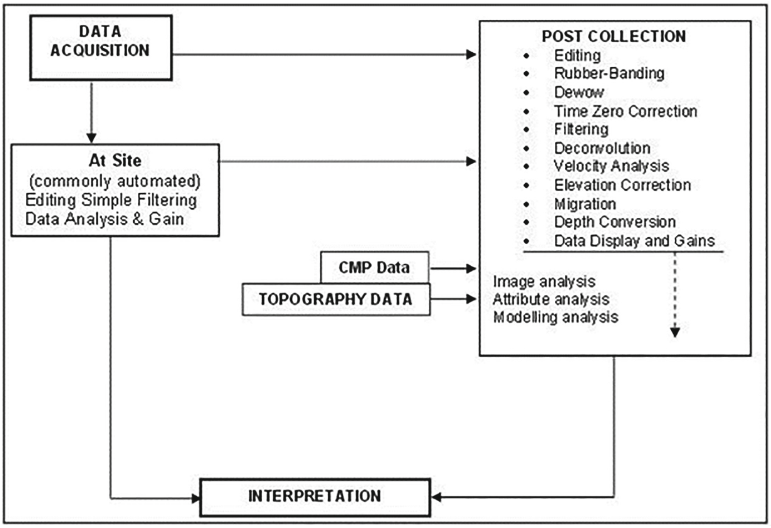

Fig. 3. Flow diagram of Ground Penetrating Radar (GPR) survey

the following: amplitude uniformity, wave continuity, wave phase shape and colour on the radargram. The anomaly then interpreted as the utilities lied underground depend on the continuity and its characteristic respond.

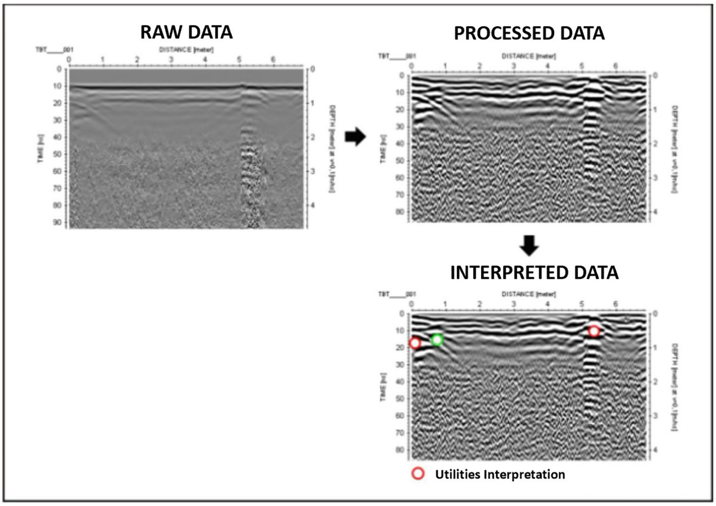

Fig. 4. Data interpretation stage

3 Result and Discussion

Data gained from Current Attenuation Survey (CAS) using PCM tool field acquisition was processed and interpreted to understand the current attenuation along the pipeline. The result of data processing is shown below:

Based on the figure above, it can be interpreted that there was metal contact indication in the pipeline, shown by the current reduction more than 50% between 150–200 m from cumulative distance Fig. 4 and Fig. 5. The slope could happen if there was other structure connected to the pipeline. The challenge was to determine exactly where the metal contact was located since it was buried underground [15]. Ground Penetrating Radar (GPR) was used to solve the limitation that Current Attenuation Survey (CAS) posed using PCM tool. GPR produces subsurface imaging so we can have better understanding of the

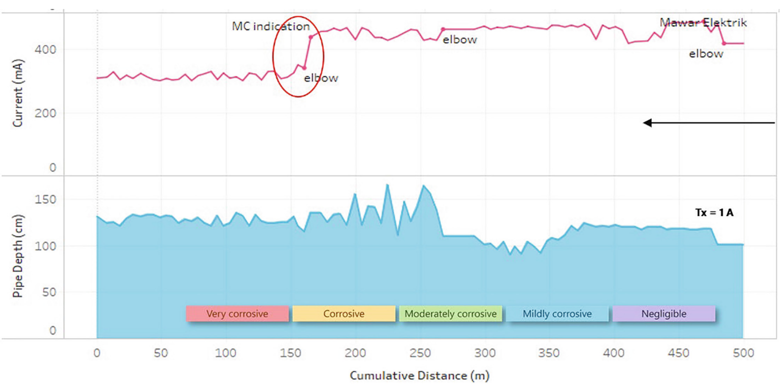

Fig. 5. Current attenuation survey data

utilities beneath subsurface. It can map not only the gas pipelines but also other utilities that may be connected to the targeted pipeline [16].

As seen on Fig. 6 and Fig. 7, the blurred lines marked with number 1 and 2 could be interpreted as targeted pipeline anomaly. The pipeline data is determined prior to Current Attenuation Survey (CAS), other anomaly found in the GPR data result then interpreted as other utilities if there is a continuity in every line survey surveyed. The data was

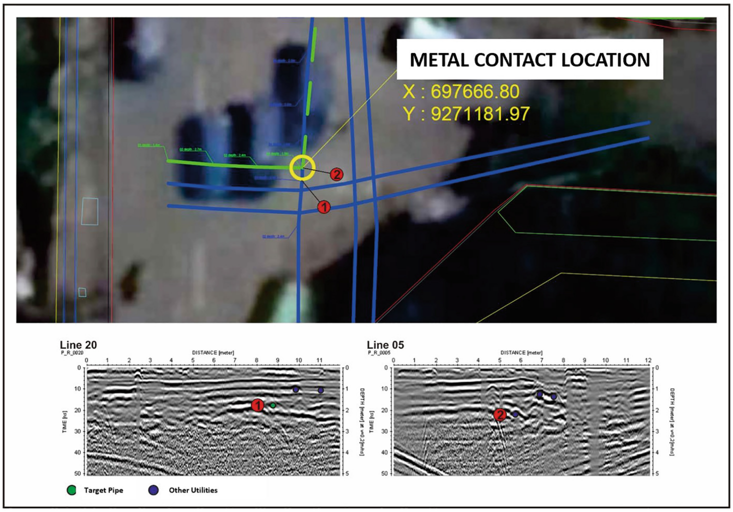

Fig. 6. Metal contact location based on GPR data interpretation

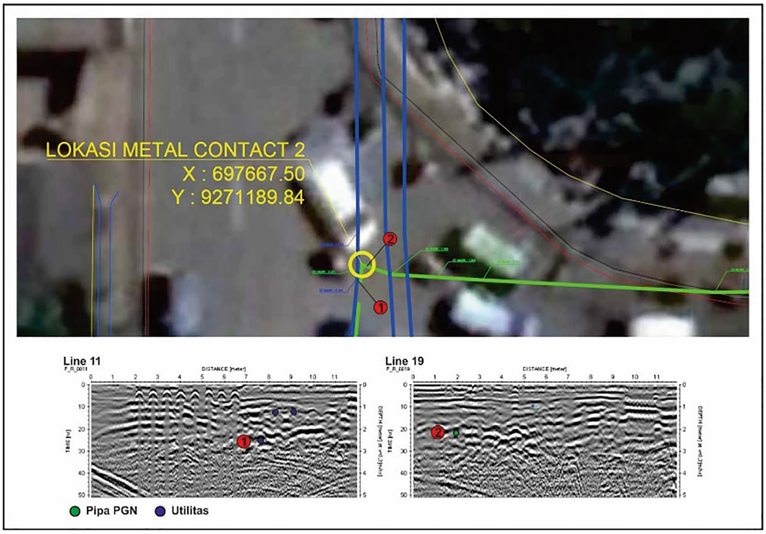

Fig. 7. Metal contact location 2 based on GPR data interpretation

Table 1. Coordinate of position and depth of metal contact pipelines

Number	Location	Coordinate UTM Zone 485		
		X	Y	Depth
1	Bogor 1	697666.80	9271181.97	2.00
2	Bogor 2	697667.5	9271189.84	2.30

analysed to obtain the full picture. The cross-section between targeted pipeline and other utilities anomaly indicated the location of metal contact [17]. Table 1 shows the location, coordinate, and depth of metal contact location based on GPR data interpretation. It can be seen that the existence of two points coordinate is caused by the movement of pipeline path in the direction of West to East which intersect with the other utilities in two points.

After the existence and location of metal contact were determined by the combination of these two methods, pipeline excavation and repairment were carried out. Without knowing the exact location, further work would be costly and time consuming because workers need to dig along the pipeline to find the metal contact location. The techniques used in this paper prevented unnecessary digging work, saving cost and time.

4 Conclusion

In this paper, metal contact was a problem that happened when two or more steel pipelines were connected to each other. It could cause corrosion problem to the pipeline if not repaired and would lead to pipeline failure. In order to detect the existence of metal contact in a paved and congested urban road, we used Current Attenuation Survey (CAS) based on NACE SP0502-201. Another challenge to detect the exact location of the metal contact was solved using Ground Penetrating Radar (GPR). Combining these two methods could save cost and time during pipeline excavation and repair. It can be concluded that there were two points of metal contact located at 2 and 2.3 m depth in Bogor.

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