The Cathodic Protection of 34" BMK Gas Pipeline

Maftah H. Alkathafi

Abstract— This study is concerned with the potential survey along the 34" Brega-Misurata-Khoms (B M K) gas pipeline to verify a function of the cathodic protection system. The most widely used method of providing cathodic protection to pipelines has been with the use of impressed current anode system. The potential survey was done using copper-copper sulfate reference electrode, the protection range can be achieved when the potential is not less than -850mV when measured with respect to Cu/CuSO4 reference electrode. The potential survey readings have been demonstrated that 34" gas pipeline from Brega to Khoms was protected using the impressed current technique with the coating. Similarly, the potential readings of test posts on cathodic protection station number 26 and 27 appeared a better result. From the results obtained, it can be deduced that the use of cathodic protection technique as a method of controlling corrosion in gas pipelines is effective and efficient when compared to other methods and thus constant monitoring is needed to achieve optimum efficiency.

keywords— Cathodic protection, impressed current, gas pipeline, potential survey.

1 Introduction

THE Cathodic Protection (CP) is usually described as an electrochemical method for prevention or reduction of corrosion on a metal surface by making the protected metal the cathode of an electrochemical cell[1,2], using either galvanic or impressed current. It has widespread application on underground pipelines, and ever increasing use as most effective corrosion control method for numerous other underground and underwater structures.[3] The cathodic protection of metals can be classified into sacrificial (galvanic) anode cathodic protection (SACP) and impressed current cathodic protection (ICCP).The main difference between the two is that ICCP uses an external power source with inert anodes and SACP uses the naturally occurring electrochemical potential difference between different metallic elements to provide protection. The most common type of cathodic protection systems used for protecting buried pipelines are impressed current cathodic protection systems where a direct current power supply is used to polarize the pipe cathodically and protect it. The capacity of ICCP to supply high current densities makes these systems preferable for most underground pipeline applications.[4] The objective of this work is to understand and explain the main role of the cathodic protection in protective of the underground steel pipelines, in addition to determine the pipe-to-soil potential. The potential measurements can be done using portable copper-copper sulphate half-cell reference electrode to measure the pipe to soil potential of the underground metallic gas pipeline.

2 FIELD WORK

2.1 Materials

Table 2.1 shows a pipeline, ground bed and coating type.

Table 2.1 Materials

Pipeline	API 5L Grade X52 line pipe
Ground bed (anodes)	Shallow Anode Ground bed (SAGB), High Silicon Chromium Cast Iron (Si Cr Fe) anodes.
Coating Type	Polyethylene (PE) tape wrap coating

2.2 The Components of Impressed Current System

2.2.1 Transformer Rectifier

The most common type of power supply used for impressed current CP is a transformer/rectifier, commonly referred to simply as a rectifier. The transformer unit reduces the high voltage from distribution network to the required voltage for cathodic protection . A rectifier converts the AC power supply voltage to the required output voltage and then converts it to DC.

Figure 2.1- Rectifier at cathodic protection station no. 26.

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ISSN 2229-5518

Figure 2.2- Step-down transformer at cathodic protection station 26.

2.2.2 Ground Bed

Anodes of high silicon cast iron are the most widely used for ground beds of cathodic protection system (impressed current anode). The anode can operate at current densities up to two amperes per anode, with an expected life of ten years. These anodes can be supplied either as standard or with chromium additions. The standard anodes are somewhat less expensive, however, the chromic anodes have lower consumption rates. Typical vertical anode shows in Figure 2.3. Backfill is extend at least one foot above and below vertical anodes. Gases are generated at the anode by electrolysis of the electrolyte. The gases act as an insulator decreasing the current output of the anode. They can be vented to atmosphere by extending the backfill above the anode to the surface, by placing gravel above the backfill, or by installing plastic pipe vents.[5]

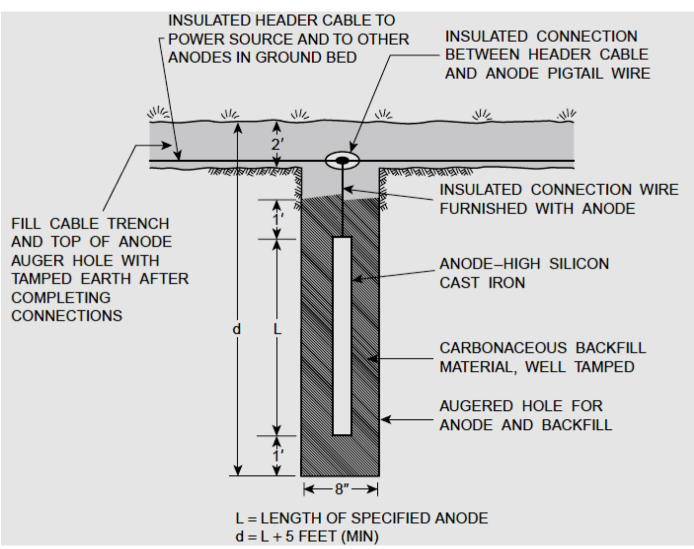

Figure 2.3-Typical vertical anode.[6]

2.2.3 Reference Electrode

The copper-copper sulfate reference electrode is the most common use in the field to measure the potential of buried gas pipelines. Figure 2.4 demonstrates Cu-CuSO4 half-cell electrode. Reference electrode consists of a plastic tube holding the copper rod and saturated solution of copper sulfate. A porous plug on one end allows contact with the copper sulfate electrolyte. The copper rod protrudes out of the tube. A voltmeter negative lead is connected to the copper rod.

Figure 2.4- Reference Electrode with digital device voltmeter

2.3 Measurement Procedure and Survey Method

The most widely accepted method of measuring cathodic protection levels on pipelines has been the structure-to-electrolyte potential measurement usinga portable cupper-cupper sulfate electrode. Conventional procedures are flexible and do not cause high investment costs because the reference electrode can be positioned at different points on the ground surface.

Pipe-to-earth potential measurements are performed by placing the electrode over the pipeline for readings. The porous plug, with cap removed, should be in firm contact with moist earth. This may require digging in at places where the earth's surface is dry. In extremely dry areas, it may be necessary to moisten the earth around the electrode with fresh water to obtain good contact. Do not permit grass or weeds (particularly when wet) to contact exposed electrode terminals because that may affect the observed potential. The reference electrode will be connected to the negative terminal of a high impedance voltmeter and the positive terminal to the pipeline (via test point terminal, probe rod, or direct contact with pipeline), as shown in Figure 2.5 and 2.6. The half cell electrode is placed on the ground surface directly over or closely adjacent to the pipe, a change in potential will be noted when the electrode is moved along the line. On along the pipelines with installed cathodic protection a potential survey done in the similar way as described above may pinpoint the hot spots along the pipeline which are over protected or whether the protective potential is not satisfactory and not secure the immunity from corrosion.[6]

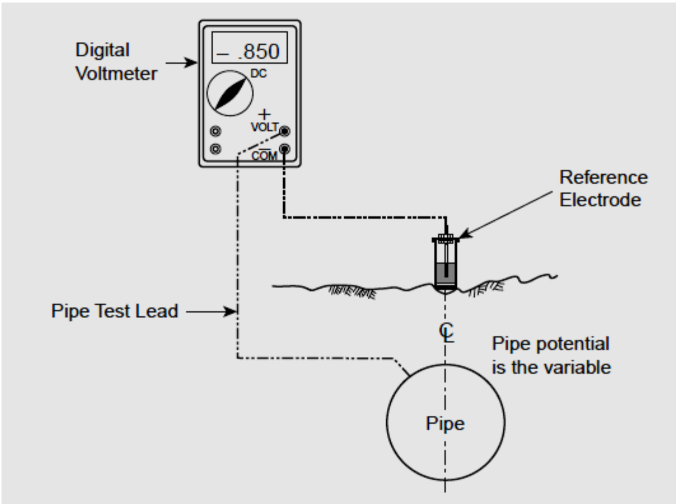

Figure 2.5- Pipe to soil potential measurement.[6]

Figure 2.6- Pipe to soil potential actual measurement

2.4 Cathodic Protection Stations

A cathodic protection station number 26 and 27 has been visited in the area close to Sirte city to check the existing equipments inside the stations. In addition, take the potential measurements at the test posts that in the surrounding area of these stations. Some of test posts are illustrated in Figure 2.8 to 2.10. The protection current has to be adjusted so that the proper protection potential is achieved and maintained on the protected pipeline, these can be done by fine, medium, and coarse switches unit, as shown in Figure 2.11.

Figure 2.7- Station number 27 at 332.64 km from Brega city.

Figure 2.8 -Test post number 370 at 323.14 km from Brega city

Figure 2.9 -Test post number 376 at 329.17 km from Brega city

ISSN 2229-5518

Figure 2.10 -Test post number 377 at 329.58 km from Brega city

Figure 2.11-Control switches

3.0 Results and Discussion

3.1 Pipe-to-Soil Potential Measurements

The cathodic protection survey consists of pipe-to-soil potential measurements that have been taken at each test point along the pipeline. The survey data was measured using a high impedance voltmeter (Miller LC-4) coupled with Cu/CuSO4 half cell electrode. The criteria for protection adapted by Sirte Oil Company specifies a minimum pipe-soil potential of – 850 mV with respect to cupper-cupper sulfate half-cell electrode, along 34" gas pipeline facilities that runs from Brega to Khoms through Misurata. The potential readings have been taken at each test post along the main line are plotted in Figures(3.1-3.14) to provide a visual representation of the line protection status. The potential measurements that were conducted around station number 26 and 27 are given in Table 3.1, these readings compared with potential measurements that were taken on 2010 by working team from corrosion protection division follows technical department in Sirte Oil Company (SOC). As can be seen from Figure 3.1, there was a decrease in the potential of cathodic protection to the value of -500 mV at test post number 380, 332.15 Km from Brega City, the decrease in the potential value due to exist a crossing road in that area. In addition, the potential readings in 2010 are higher than the potential readings that were taken on 2016, as a result of the poor security situation in the country (Libya), which did not enable the technical staff to perform the maintenance task successfully. Figure 3.2 indicates that the potential measurements are in the desired range in 2010 and 2016 as well, but at station number 32, 33 and 34 there are slight drop in the potential values (in 2016) up to -720, -700 and -740 mV, respectively, for the same reason mentioned above.

Table 3.1 Potential Readings around Station No. 26&27

Test Post No.	Type	Distance Km	Potential 2016	Potential 2010
369	A	323.14	1070	1106
370	A	324.24	1080	1143
374	A	327.18	947	1145
375	A	328.24	910	1135
376	A	329.17	872	1115
377	A	329.58	892	1046
378	A	330.18	1000	1060
379	A	331.17	975	1154
380	C	332.15	500	955
381	A	332.6	915	1065

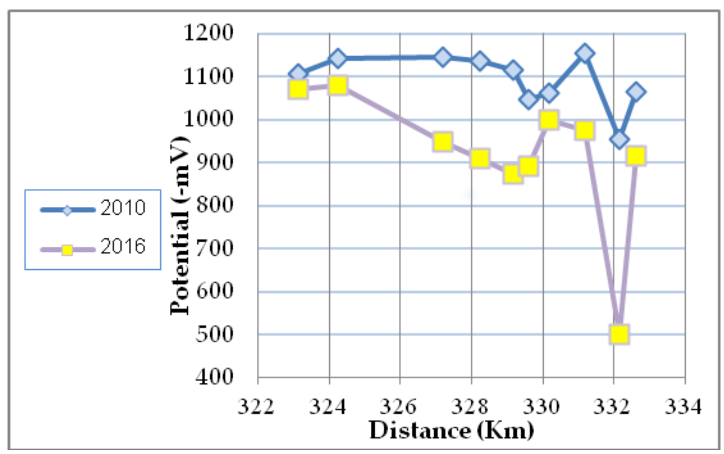

Figure 3.1- Variation of potential with distance

3.1.1 34" Brega-Misurata Gas Pipeline

Compared to the survey of the potential in 1997 and 2010. The potential readings in Figure 3.3 shows that the cathodic protection become more negative at some test posts compared with the potential readings in Figure 3.4, the potential reaches to the value of -1245 mV at the test post number 30. As is apparent from Figure 3.5, the potential measurements along the test posts increased up to -1270 mV at the test post number 45. On the other hand, it is evident from Figure 3.6 that the maximum value of potential reaches to -1141mV at the test post number 71.Figure 3.7 and 3.8 indicate that the cathodic protection system is in the protected range. There was a significantly rise in the potential measurement up to -1383 mV at the test post number 105.

Table 3.2 Compared between potential measurements

Distance Km	Station No.	Potential (-mV) 2016	Potential (-mV) 2010
323.14	26	1350	1106
332.64	27	1330	1065
345.37	28	1140	1053
360.6	29	1025	1017
373.6	30	1074	1177
384.04	31	1000	1181
396.52	32	720	1189
407.62	33	700	1131
417.3	34	740	1157
427.2	35	1000	1089
439.9	36	1040	1080
448.7	37	1015	1042
458.27	38	1170	1183
472.5	39	1060	1045
487.3	40	1070	970
498.7	41	990	998
510.27	42	920	1065
520.04	43	930	1033
528.42	44	940	1039
541.01	45	980	1016

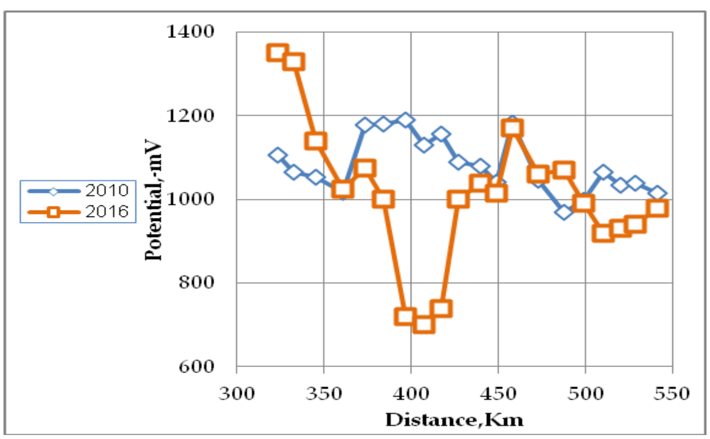

Figure 3.2- Variation of potential with distance

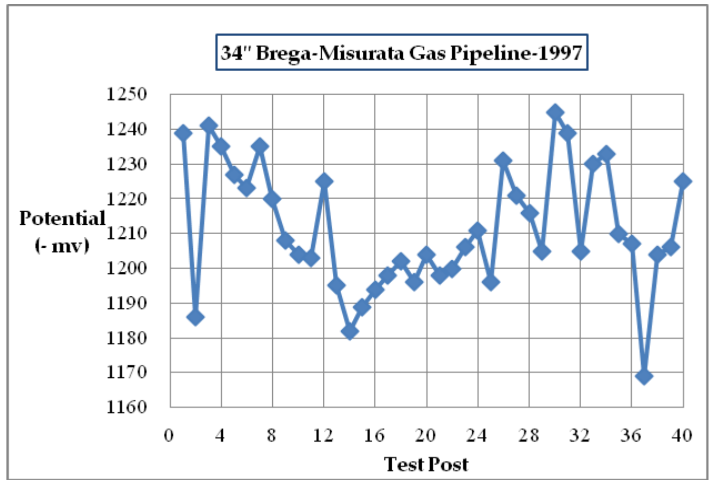

Figure 3.3- Variation of potential with test post

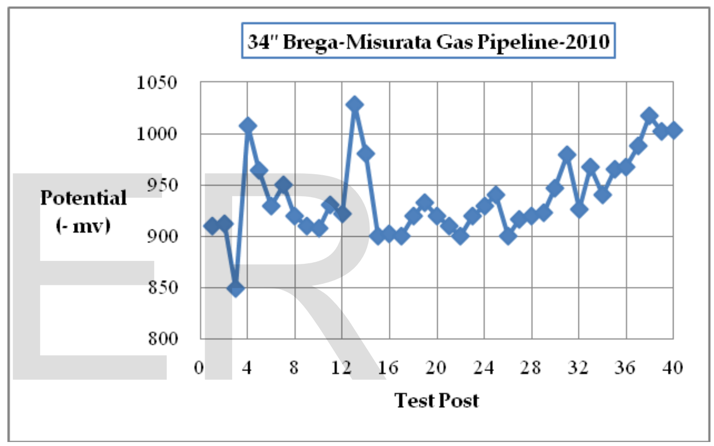

Figure 3.4- Variation of potential with test post

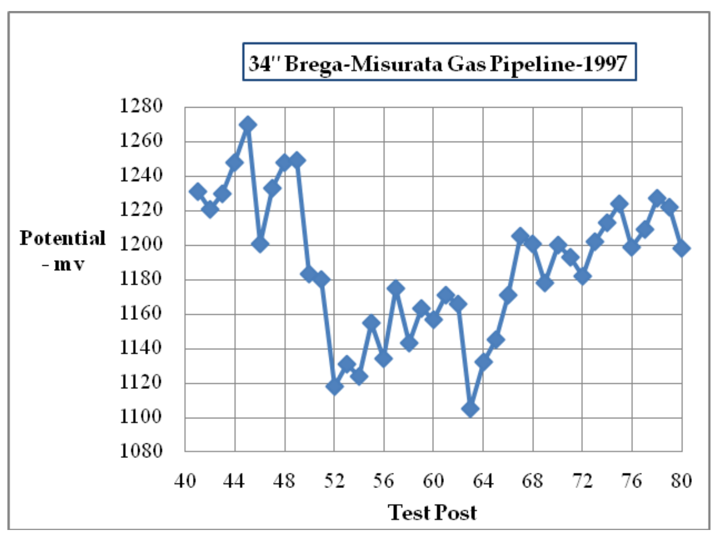

Figure 3.5- Variation of potential with test post

ISSN 2229-5518

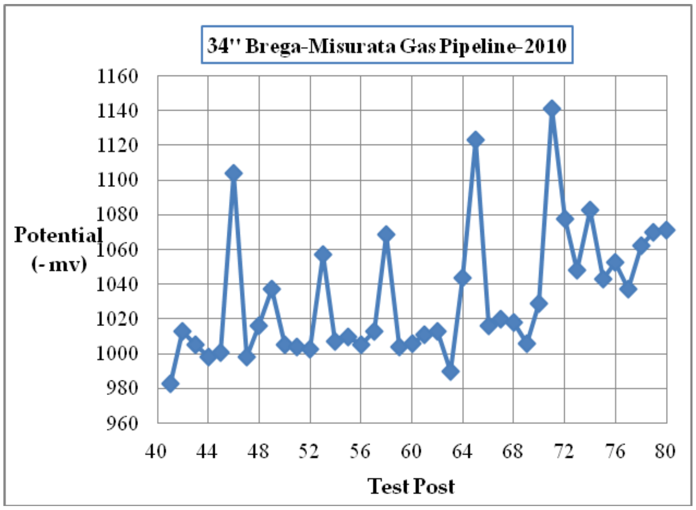

Figure 3.6- Variation of potential with test post

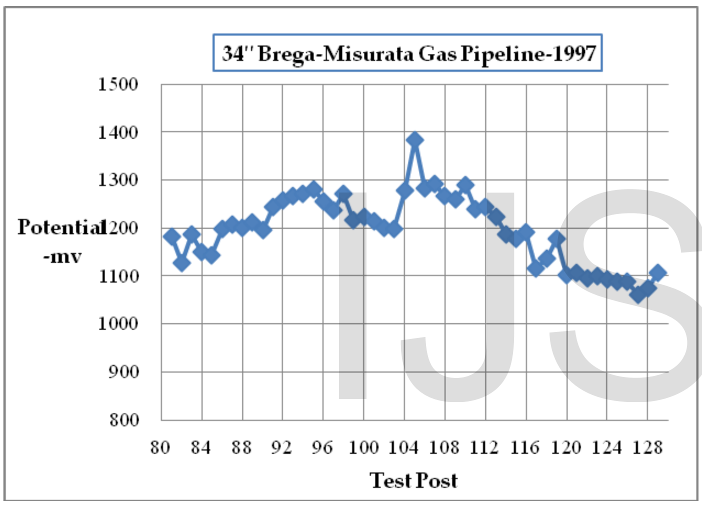

Figure 3.7- Variation of potential with test post

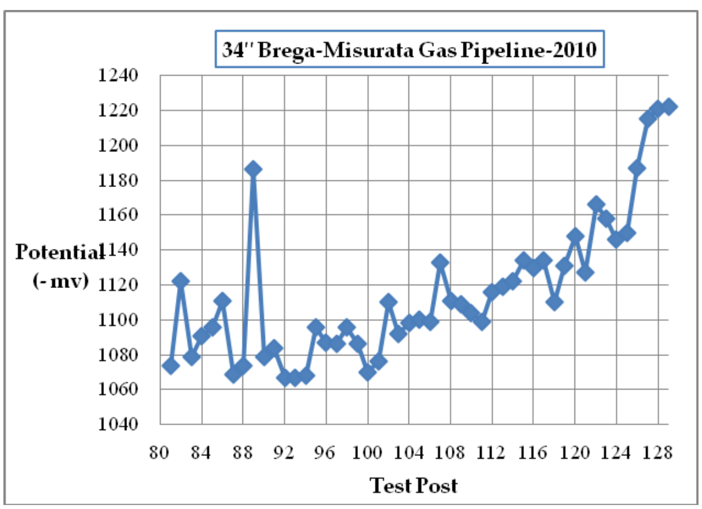

Figure 3.8- Variation of potential with test post

3.1.2 34" Misurata-Khoms Gas pipeline

It can be observed from Figure 3.9 to 3.14 that the potential survey of the gas pipeline in 1997 and 2010 are in required range of protection.

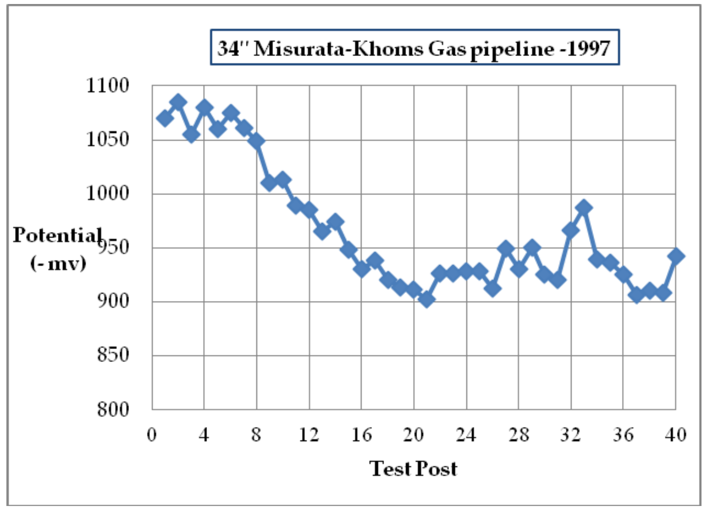

Figure 3.9- Variation of potential with test post

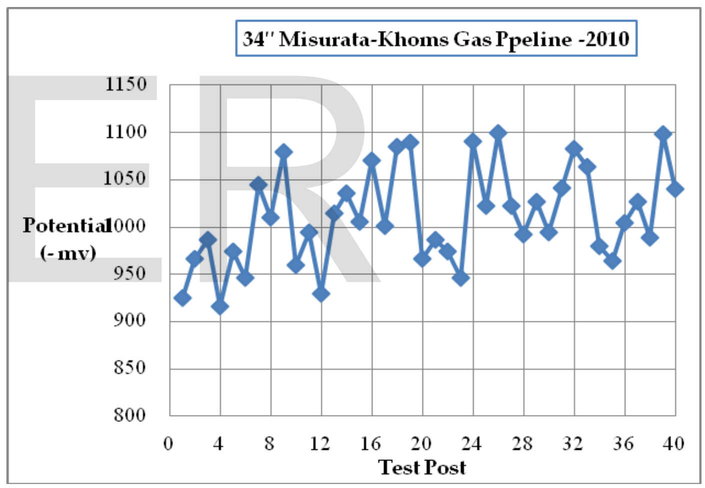

Figure 3.10- Variation of potential with test post

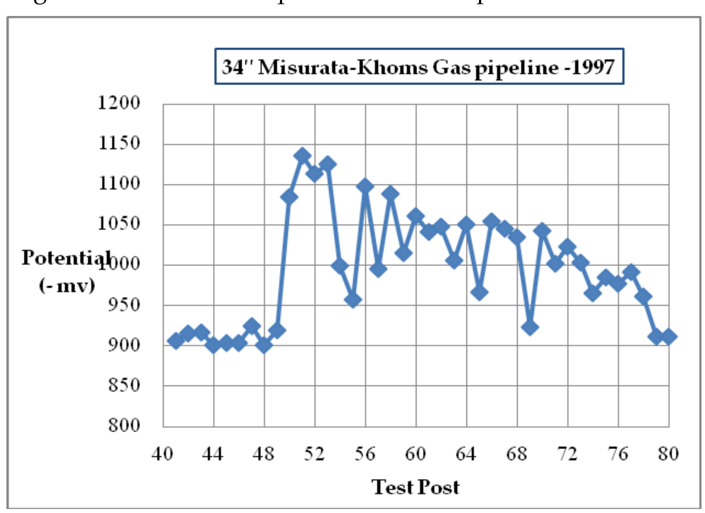

Figure 3.11- Variation of potential with test post

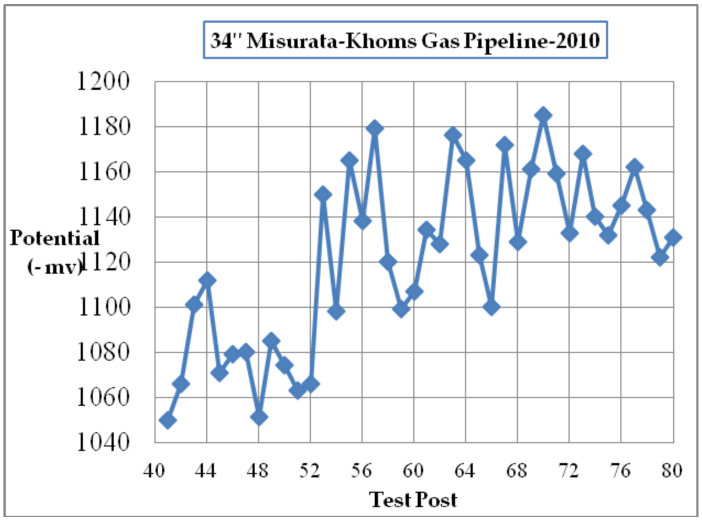

Figure 3.12- Variation of potential with test post

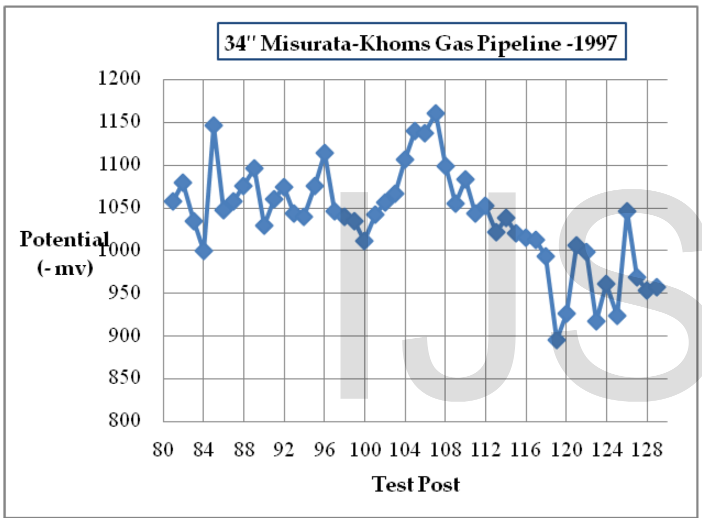

Figure 3.13- Variation of potential with test post

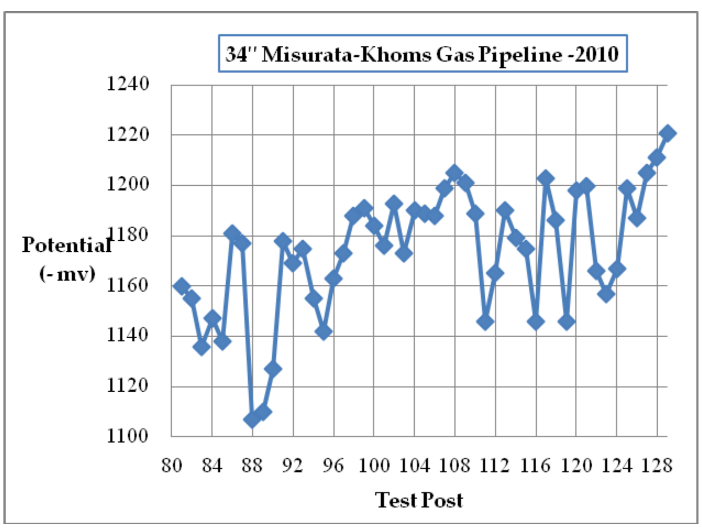

Figure 3.14- Variation of potential with test post

From the results of potential survey over the entire gas pipeline, it is noticed that the pipeline is completely protected, generally. This is attributed to the first defence line, insulating coating to the pipeline which greatly reduce the current demand for cathodic protection of the pipeline surface. Therefore, when coating and cathodic protection are employed together , the cost of each is less than it would be if each were used alone.

4 CONCLUSIONS

The main conclusions of this work are as follows:

- Cathodic protection system is a highly adaptable and effective means of preventing corrosion of underground structures.
- The results of potential readings according to field work reveal a better corrosion protection performance in 2010 as compared to 2016.
- A drop in some potential readings can be observed in the area of the crossing road at casing.
- There is no sharp decline in the pipe-to-soil potential readings through the survey due to application of cathodic protection with coating.

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