Nigerian Journal of Technology (NIJOTECH)
Vol. 35, No. 2, April 2016, pp. **317 – 320**

Print ISSN: 0331-8443, Electronic ISSN: 2467-8821
www.nijotech.com
http://dx.doi.org/10.4314/njt.v35i2.11

PIPELINE CORROSION CONTROL IN OIL AND GAS INDUSTRY: A CASE STUDY OF NNPC/PPMC SYSTEM 2A PIPELINE

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ABSTRACT
Corrosion in pipelines is one of the major challenges faced by oil and gas industries all over the world. This has made corrosion control or management a major factor to consider before setting up any industry that will transport products via pipelines. In this study the types of corrosion found on system 2A pipeline were; pitting, microbial, sulfide-stress cracking, hydrogen-stress cracking and hydrogen-induced cracking and these were caused by poor maintenance of the pipeline system, severe mutilation of the pipeline coatings, substrates due to vandalization and coating failures. The data from cathodic protection control method from Nigeria National Petroleum Corporation (NNPC)/ Pipeline and Product Marketing Company (PPMC) for system 2A line was analyzed and it was deduced that about 10.3km of the pipeline was well protected and possibly fit for use and about 62.7km is experiencing under protection which means corrosion is predicted to take place in that segment in a short time and finally about 16km of the pipeline is experiencing corrosion. From the results obtained, it can be deduced that the use of cathodic protection technique as a method of controlling corrosion in oil and gas pipelines is effective and efficient when compared to other methods and thus constant monitoring is needed to achieve optimum efficiency.

Keywords: *Corrosion, Cathodic Protection, System 2A Pipeline, NNPC, PPMC*

1. INTRODUCTION.

Crude oil and gas pipelines could be onshore, offshore or in swamp. The transportation operations has remained a high complex and challenging effort against forces of nature. The importance of the use of pipelines as the most efficient means of product conveyance from well head to the gathering-points, from the flow stations to the storage tanks in the terminals and to the loading or export platforms far into the Atlantic cannot be overemphasized. For every new field discovered, the pipelines are further exposed to the test in the harshest environments Irrespective of the field location with all the environment unfriendliness, the plain carbon steel pipes, remains the best means of product transfer from the holes to the well head due to its favourable thermo-mechanical properties.

The crude oil and gas pipelines in the cause of being used for the purpose of transporting products are exposed to various environments especially the offshore installations. Furthermore, the lines could be buried but eventually this exposure results in liability to various forms of external and internal corrosion problems [1, 2, 3].

In the field of crude oil production and associated engineering work, the key characteristics of choice materials normally considered are: corrosion resistance, cost, strength, toughness etc.

Due to the natural composition of crude oil with oxygen, nitrogen and sulphur compounds as its major constituents, one would say that corrosion will not be a problem in the internal off-lines. Water is essential to low temperature corrosion. Pure water containing no dissolved substances is mildly corrosive to iron, Water containing impurities or dissolved substances can be corrosive or non-corrosive, depending upon the nature of dissolved substances. For example chromate and phosphates are added to water for the purpose of inhibiting or reducing corrosion. On the other hand substances such as sodium chloride,

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hydrogen sulphide, carbon-dioxide and oxygen can increase the rate of corrosion when combined with oil field water [4, 5]. Oil field water generally contains one or more of these substances which are highly corrosive. Pipelines can also fail for reasons that do not depend on the crude composition alone, rather the operating environment do contribute.

Corrosion is undoubtedly experienced in all spheres of life. For example, the petroleum industry, which is the basis for this study, transportation viz. Land, air and sea, food processing, construction, Nuclear power generation, petrochemical and agriculture and even in our homes. This operating expense can be high or minimized, depending on how well we understand it and are able to recognize it and instigate control procedures and processes [6-10].

This study is interested in analysing the cathodic protection data of NNPC/PPMC pipeline (System 2A pipeline from Warri Pump-Station to Benin Oil Depot, 1988) and (Warri – Amukpe axis, 2004).

2. MATERIALS AND METHODS.

2.1 Research Materials.

The materials used for this study was obtained from the Pipeline & Product Marketing Company (PPMC), a subsidiary of the Nigerian National Petroleum Corporation (NNPC) Warri Area Office, Delta State. The data are presented in Tables 1 to 2, and Figures 1 to 3 respectively.

3. RESULTS

The upper line shows pipe/soil potential characteristics of pipeline segment under applied C-P (impress current).The lower line shows pipe/soil potential characteristics under natural condition i.e. no impress current. This shows the difference between the pipe/soil potential and the natural potential.

Table 1: Material/Specification for system 2A pipeline

Specifications	Designation
Pipeline	Carbon steel pipeline
Length of pipeline	89.9KM
Diameter of pipeline	16" Diameter
Pipe Grade	Shedule 60 (X60)
Coating Type	Coal-Tar
Weight (W.T)/Size	0.281/0.312 inches
Periodicity of potential measurement	3 months
Periodicity of measurement staff	6 months
Distribution of test points	2km Average
Protection limit (criteria)	-ve Voltage 1- 2.5V
Time for one measurement	10 minutes excluding (travelling time)
Periodicity of thickness measurement	6 months
Preventive Maintenance on T/Rs and all pump stations	Bi-monthly
Soil resistivity survey G/B and pipeline	Quarterly
ROW surveillance on washouts, pipe exposures and encroachments	Quarterly
Test Instruments	Voltmeter 100.000 Ohms/Volt
Half cell	$Cu/CuSo_4$
Soil condition	Wet

Table 2: Corrosion Maintenance Program for System 2A Pipeline

Activities	Period
Ground bed maintenance	Half yearly
Line potential monitoring	Quarterly
Line potential fault investigation and remedial action	Quarterly
Monitoring of pipeline internal corrosion status	Quarterly
Inspection of ORMAT/TEG for energizing	Bi-monthly
Monitoring of road crossing C-P facilities	Quarterly

Table 3: Cathodic Protection Data of System 2A Pipeline From Warri Pump-Station Km 0.00 To Benin Depot Km 89.90 (1988 Survey)

S/N	Location/Power Source	CP Station Output voltage	Max. Voltage	Drain point station potential (V)
1	KM 000 T/R WARRI STATION	23 DCV (6.1A)	62-65 DCV	2.23
2	KM 57.210 (OEC) OGHAREFE	50 DCV (3.5A)	53-55 DCV	1.98
3	KM 90.00 T/R BENIN DEPOT	54 DCV (5.5A)	60-68 DCV	2.2

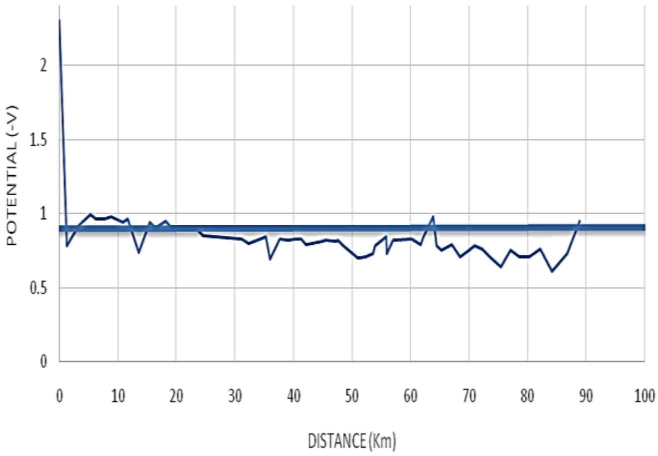

Figure 1: Cathodic Protection Survey on Pipe/Soil Potential test on system 2A pipeline (Warri Pump Station, Benin depot) showing the deviation of the pipe/soil potential values from the standard value,-0.85V.

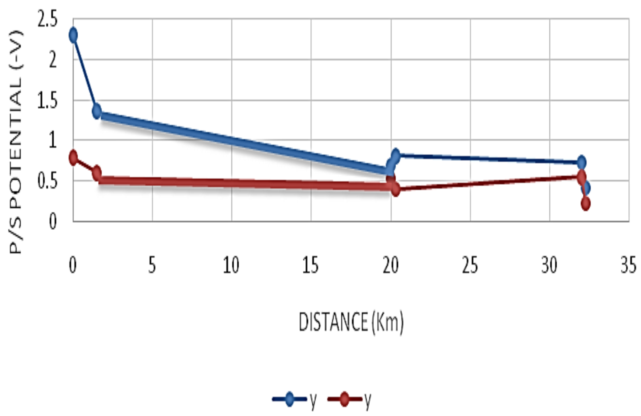

Figure 2: Pipe/Soil potential values of natural and impress current applied status of system 2A pipeline (Warri-Amukpe Axis)

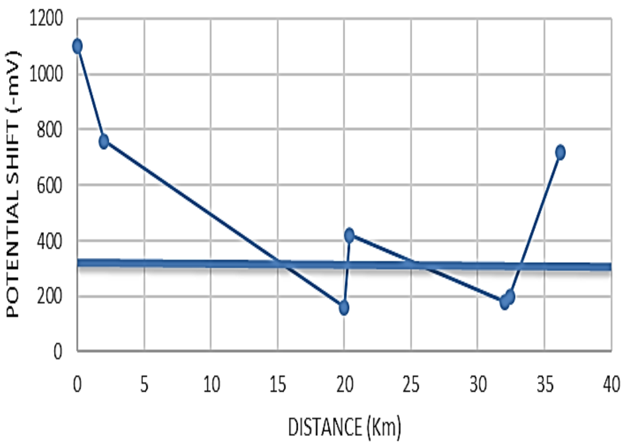

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Figure 3: Potential shift on system 2A pipeline (Warr-Amukpe Segment)

4. DISCUSSIONS

4.1 Pipe/Soil Potential Value Deviation from the Standard Value (-0.85V) was studied.

The data collected from NNPC/PPMC were analyzed using tables and graphs to show the level of cathodic protection, level of corrosion and probable hotspot. Figure 3 with T/R power output of 23DCV/6A and drain point potential of 2.23v, shows the deviation of the pipe/soil potential values from the standard value, -0.85V. The calculated mean deviation from this standard value is 0.103V, with a variance of 0.045. From KM0.00-1.3, the pipeline is protected and possibly fit for use, KM1.3 –about KM2.0 is under protected and corrosion is likely to take place in that segment in a short time. From about KM2.0 – about 11.0 KM the line is experiencing some slight corrosion, KM11.0 – 14 the line is largely under protected and thus more subject to corrosion attack From about KM14.0 – about KM17.0 the line is experiencing a slight corrosion. From about KM17.0 – about KM24.0 the line is well protected and possibly fit for use. From about KM24.0 – about KM62.0 the pipeline is slightly under protected and corrosion could possibly take place. However, KM34-37 in that same segment is highly under protected and has higher chances of experiencing corrosion sooner than other region. The crest (KM61-65) is the probable hotspot and corrosion is already taking place in that region. From about KM65.0 – about KM87.0 the pipeline is highly under protected and corrosion is likely to take place in that region in a short time. From about KM87.0 – about KM89 the protection is good and the line is possibly fit for use.

4.2 Cathodic Protection Data of System 2A Pipeline (Warri-Amukpe Axis)

The survey data from Figures 2 and 3, with T/R power output of 27.5V/18A, drain point potential value of 2.30V reveals that KM00- more than KM15 is well protected. The trough (about KM16 –more than KM20) the pipeline is under protected, that is to say corrosion is likely to take place in that region in a short time. The crest (about KM21- about 25) the localized area which is technically called the hot spot in the pipeline has a failed protection, hence, corrosion is taking place in that region. The trough (about KM25 –more than KM32) the pipeline is under protected, that is to say corrosion is likely to take place in that region in a short time. From (about KM33- 36) the line is protected and possibly fit for use. The results obtained at the end of this study are in line with previous studies [5, 6] and which correlate with NACE international standard.

5. CONCLUSION

After extensive examination and re-examination of the data presented in this study, it was concluded that the inconsistent nature of the graph or a deviation from the Sandelin curve is considerable larger than it could be and this will always limit the ability to predict the pipeline failures. The data from cathodic protection control method from Nigeria National Petroleum Corporation/ Pipelines and Products Marketing Company for system 2A line was analyzed and it was deduced that about 10.3km of the pipeline was well protected and possibly fit for use and about 62.7km is experiencing under protection which means corrosion is predicted to take place in that segment in a short time and finally about 16km of the pipeline is experiencing corrosion. There is a need to constantly monitor and maintain these pipelines to achieve optimum efficiency.

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