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Cathodic Protection Maintenance and Repair Concept for Storage Tank Bottoms.

Eman Saad El Deen Noamy[1]*, Ali Gomaa Abdel Aziz[1], Mahmoud Ibrahim Abdou[1], and Hussein Abu El- Leil[2].

[1]Production Department, Egyptian Petroleum Research Institute (EPRI), Cairo, Egypt
[2]Integrity Department, Qarun Petroleum Company, Cairo, Egypt

ABSTRACT

Above ground, tanks are frequently used for the storage of Oil & Gas products and they can present a challenge to design an optimum corrosion control system. The bottom of the tank usually lies on or near the surface of the ground and in contact with materials used to support the tank and therefore presents a corrosion challenge. One method of protecting the bottom of a tank is the impressed current cathodic protection (ICCP) system. Monitoring the CP system is critical to maintain and extend the service life of the exterior bottom of the storage tank. The risk of rectifier failure, aging of ground beds, and cables disconnection are increasing. Repair procedure that allows corrective actions for the system was then developed. This paper presents EPRI successful monitor and repair procedure of ICCP external system for above ground storage tanks 5,000 BBLs at QARUN Petroleum Company (QPC) with significant cost reduction and time saving over conventional methods.
Keywords: EPRI, Cathodic Protection, Storage Tanks, Impressed Current, maintenance, Repair.

Corresponding author

INTRODUCTION

Cathodic protection is an electrochemical technique of corrosion control in which the oxidation reaction in a galvanic cell is concentrated at the anode and suppresses corrosion of the cathode in the same cell. This method is used to control corrosion for steel structures such as underground pipelines, tanks, platforms, pile sheets, etc. A proper designed, installed, operated, and maintained CP systems shall mitigate corrosion by passing direct electric current (DC) to the metal surface. DC is discharged from the anodes installed in the electrolyte near the structure to be protected. By this way, corrosion is arrested when the DC is of sufficient magnitude and is evenly distributed over the surface of the structure to be protected[1].

There are two types of Cathodic Protection: sacrificial anode, or passive, systems and impressed-current, or active, systems. Both types are widely used.

CP maintenance is one of the most important activities necessary to ensure the long-term integrity of the bottom of above ground storage tanks. CP maintenance mainly consists of two activities; namely CP potential monitoring and CP system inspection. CP potential monitoring is conducted to evaluate the adequacy of CP level of above ground tanks bottom. Conducting a periodic tank-to-soil potential survey is one representative method of CP potential monitoring, and the results are evaluated with respect to the CP criteria based on tank-to-soil potential, such as (-0.850)V_{CSE} polarized potential [2]. CP system inspection is conducted to determine the operating conditions of the CP equipment regarding rectifiers, periodic checks of output voltage and current. In case of protection failure, CP system repair is money saving compared with replacing the entire system.

It is worth mentioning here that, Cathodic Protection division for corrosion control of underground structures is part of a technology transfer program between EPRI researchers and Petroleum Companies.

EPRI developed a well established procedure to provide complete maintenance and repair services to above ground storage tanks Cathodic Protection systems (CPs). This paper is introducing the methodology carried out for many years, with excellent results at QARUN petroleum company (QPC), under the supervision of the operation department and the responsibility of EPRI.

A case study is presented to illustrate the developed CP procedure performed on the CPF firefighting tanks of 5,000 BBLs capacity at KARAMA field, which is currently repaired and maintained by EPRI.

CASE STUDY:

Figure 1: CPF Firefighting tanks at Karama Field (QPC)

The study illustates the maintenance procedure on two identical storage tanks of 12.8 m diameter and 7.2 m height. Each tank has three peripheral pipe connections, three manholes and three anode nozles (for internal CP system). All flanges are equiped with insulation kit. Both tanks are cathodically protected by a single ICCP system with one rectifier rated 40 A/ 60 V DC; each tank has two test posts and four distributed horizontal ground beds each have one 2"×60" Si-Fe-Cr anode. The designed criteria of adequate protection is a minimum Tank/ Soil (T/S) potential of (-0.850) volts and a maximum of (-1.20) volts reference to a copper- copper sulfate reference electrode [3]. The two protected tanks are shown in Photo:1, while the CP protection system for the tanks bottom is illustrated as shown in the schematic drawing Figure:1.

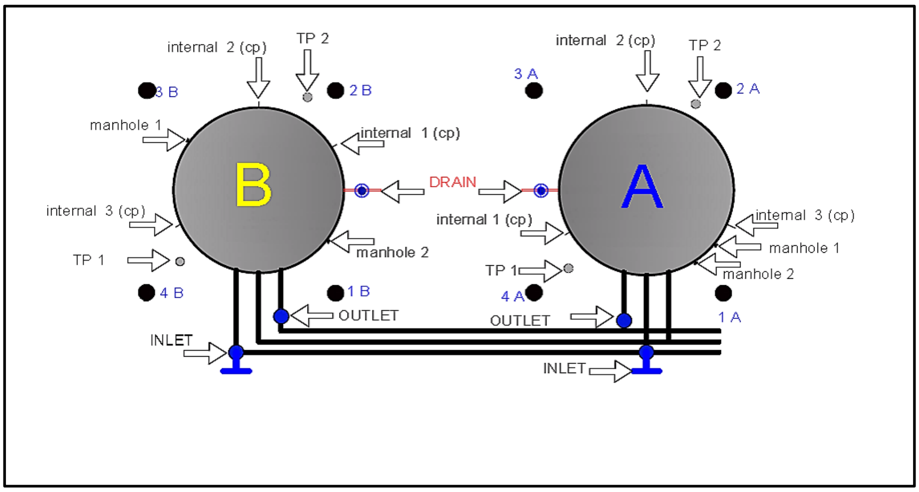

Figure 2: Schematic drawing for tank botom & anodes locations

Analysis of obtained values for potential survey reveals the following:

i. All surveyed points are considered unprotected, except for few points around anode (1B), **Figure 2& 3**.
ii. Potential readings did not respond to current disconnection which means that groundbed anodes were not functioning.
iii. Structure potential was the same at both sides for all flanges, which is firm indication of insulation failure of mounted insulation kits.

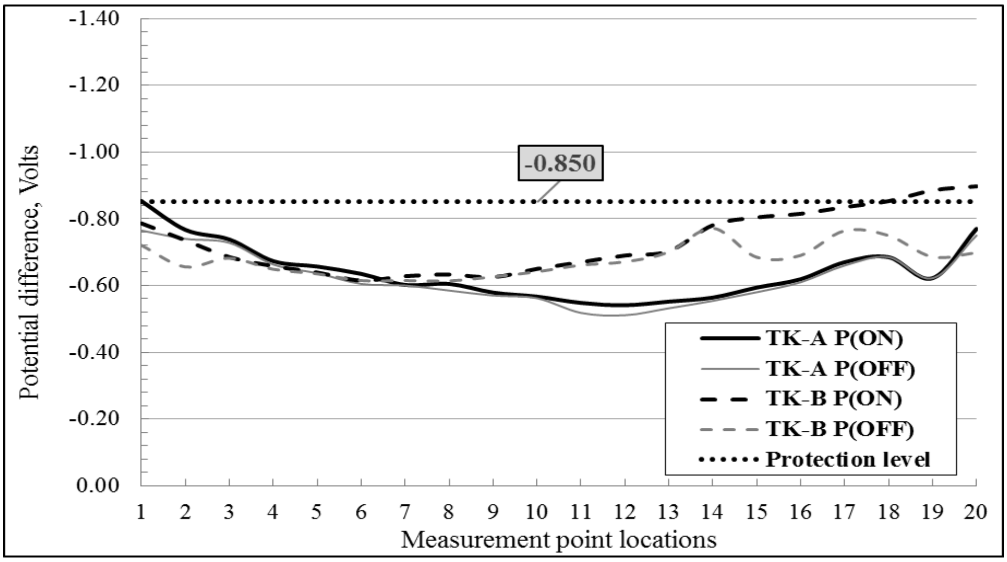

Figure 3: Polarization Curve for C PF TK A & B as Found.

In view of above findings, EPRI recommended full maintenance& repair actions as follow:

1. Investigation of the rectifier performance, **Photo 2.**
2. Installation of new insulation kits at all tanks nozzles.
3. Investigation of Ground Beds Performance.

A full maintenance and repair actions were conducted on the rectifier, replacing contactor, fuses, traps and reostate. The rectifier was adjusted twice within one week to maintain the protection potential (-0.850→ -1.2 V) according to Cu/Cu SO_4 reference electrode by trial method[4].

I. The rectifier after repair was performing with high effeciency.
II. Most of surveyed points were considered protected.
III. After few days the system tends to return back to the unprotected mode which indicates a state of current dissipation through the system, **Figure 4.**
IV. Structure potential was the same at both sides for all flanges, which is firm indication of insulation failure of mounted insulation kits.

Photo2: Rectifier Investigation

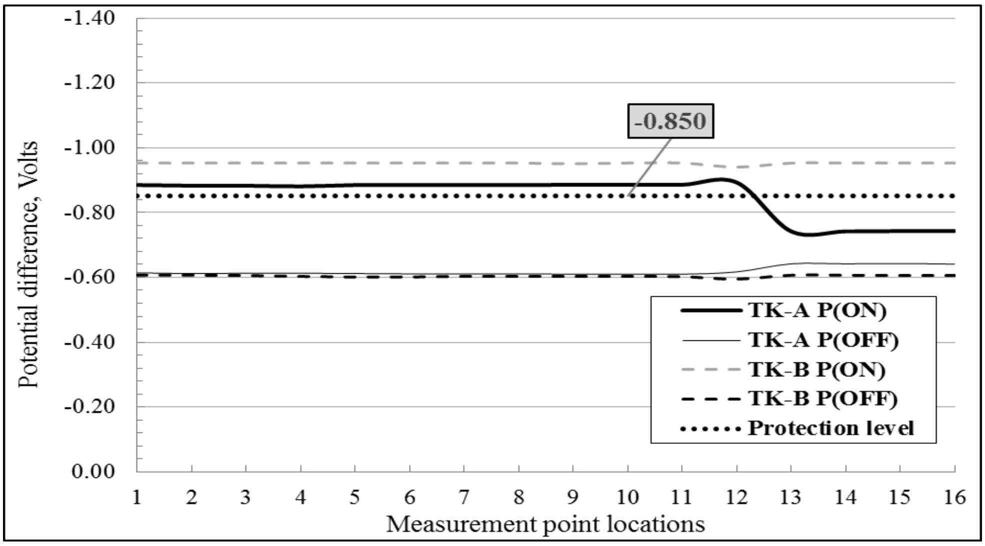

Figure 4: Polarization Curve for C PF TK A & B after readjusting the rectifier

After installing the insulation kits at tanks nozzels to insure complete isolation of designed CP current within the system, few points remained below protection limits for both tanks, **Figure 5.**

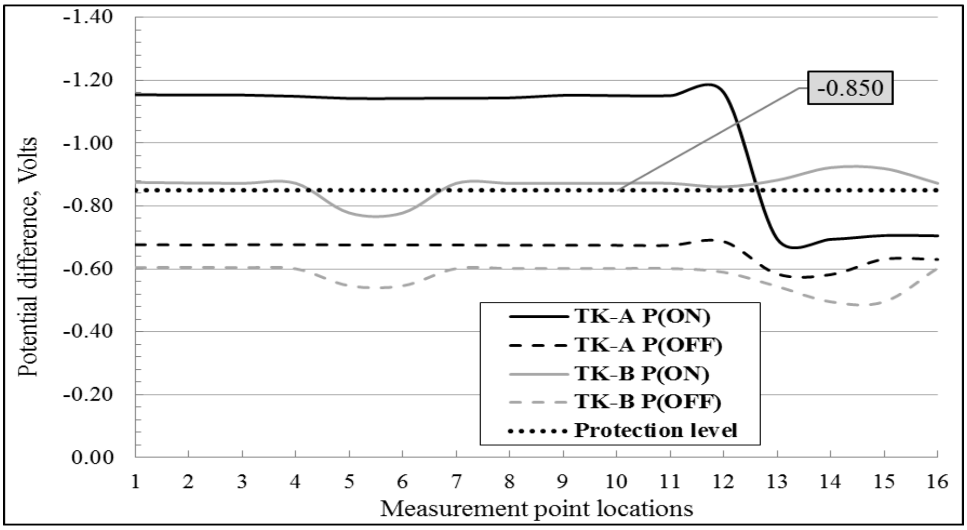

Figure 5: Polarization Curve for CPF TK A & B after installing the insulation kits

Groundbed excavation procedure were carried out and the followings were discovered:

a. Cable for anode No 1 of tank A was disconnected, **Figure 5.**
b. Anodes No 2& 3 for tank A and No 2, 3&4 for tank B were not functioning, **Figure 6.**
c. High soil resistivity according to soil survey[5], **Figure 7.**
d. A layer of residue material covering the anodes surface acting as shielding preventing the current from passing by[6], **Photo 3.**
e. Gas blockage[7], vents were blocked with sand and some of them were broken

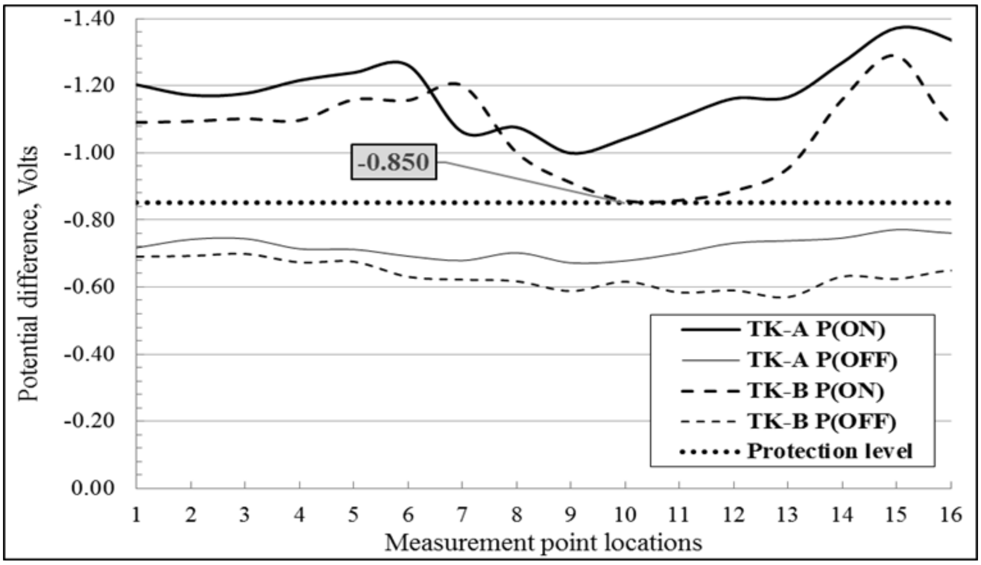

Figure 6: Polarization Curve for CPF TK A & B after excavation and Groundbed maintenance

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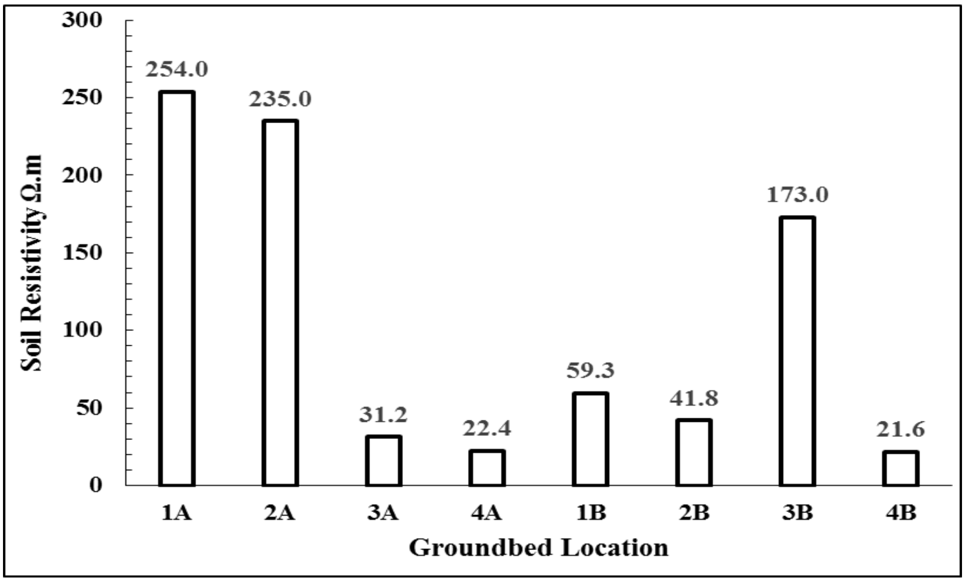

Figure 7: Soil Resistivity survey at Groundbed Locations

Photo 3: Anodes Residual Material

The following repair actions were carried out:

1. Anode No 1 cable was connected using Splice Kit and resin.
2. Ruptured PVC Vents were replaced, and new elbows were fitted on top to prevent sand blocking and to allow regular irrigation (salt water) of the ground bed to overcome the high soil resistance.
3. Cook Breeze was replaced (data sheet analysis according to standard)
4. Salt (Na CL) was mixed with the cook breeze
5. Anodes were Polished, cleaned and re-installed, **Photo 4**
6. Rectifier, Junction boxes and test post were cleaned and the bars were polished to maintain accurate readings.
7. Rheostats were adjusted and permanent resistances were installed to maintain protection levels all around tanks bottom.
8. Potential measurement were surveyed according to standard (ON& OFF) [8] **Figure 8.**

Both tanks are within protection criteria and perform with high efficiency for the last two years. **Figures 9&10**

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Photo 4: Polished Anodes

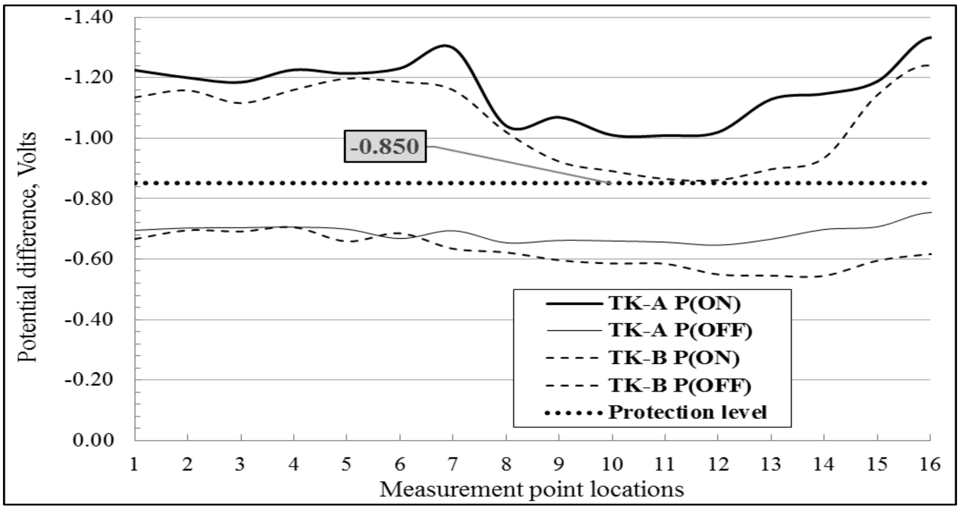

Figure 8: Polarization Curve for CPF TK A & B after Reostate Adjustment

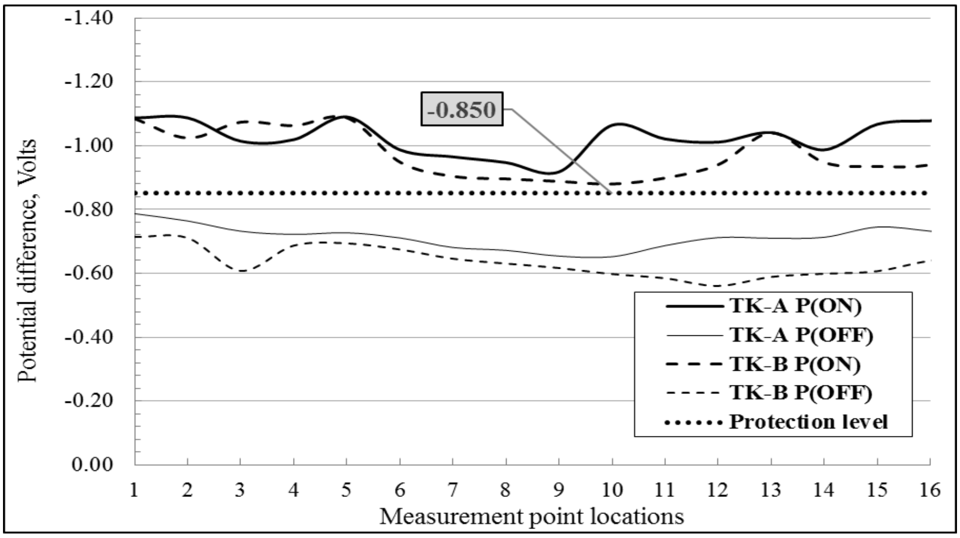

Figure 9: Average Polarization Curve for CPF TK A & B after Repair (year 2015)

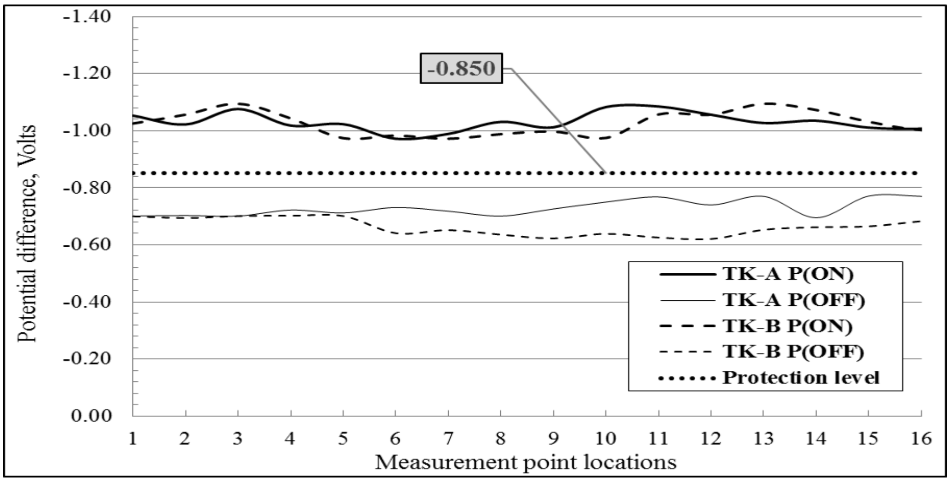

Figure 10: Average Polarization Curve for CPF TK A & B after Repair (year 2016)

RESULT AND DISCUSSION

Maintenance procedure is conducted to enable operating staff in charge of cathodic protection systems to carry out routine surveys and to interpret results for identifying type of faults, its location to perform repair actions.

Reference Parameters for Routine Operation

Reference Parameters is to be prepared for extreme operation conditions, i.e. at maximum and minimum temperatures and dryness. In case of QPC fields, these conditions are within December- January, and July- August.

Setting out of reference parameters is carried out in the following sequence:

a. Exclude any shortage in the system by:
   - Check all cable connections
   - Clean the interior of T/R by compressed air.
   - Repair any damaged or shorted cables at test points.
b. Record I, V, AC values and ΔEo
c. Start recording T/S around the tank perimeter. Data is to be plotted.
d. Interrupted potential shift ΔEo is measured by switching off the rectifier T/R and reading the corresponding value of T/S instantaneously after that. ΔEo shall be the difference between $\left(\frac{T}{S}\right)_o$ and the measured value.
e. Calculate Re, ΔEo and η_{TR}. and keep the obtained values as reference parameters for the system in this time of the year.

Routine Surveys

These surveys are intended to check the performance of the system in comparison with the available reference values. Any deviation out of limits set by reference parameters shall mean a shortage in the system to be repaired relevantly.

There are two main routine surveys, one to be done daily at the T/R site and the other is periodic around the tank perimeter:

Daily Survey

This survey is to be carried out at a fixed time every day:

- Measure at T/R site the following parameters: I, V, Ia, Va, $(T/S)_0$ and ΔEo
- Then calculate: R, Re, and T/R efficiency as indicated above. Keep the obtained values in a special book.
- If a difference within =5% from the previous day readings is found, no special action is required unless such difference is occurring systematically in one direction. If such thing happens, therefore the item with deficiency should be investigated.

Periodic Survey

This survey is to be carried out every two month in which the T/S value at all test point and around tank perimeter are measured and plotted on a graph together with the results of the previous survey.

During this survey if a drop in protection level at certain T.P. is found it has to be investigated locally as long as there are no shortage at the T/R site.

Figures 11& 12 illustrates EPRI procedures for System Leakage Investigation, Maintenance Procedure and Repair Procedure.

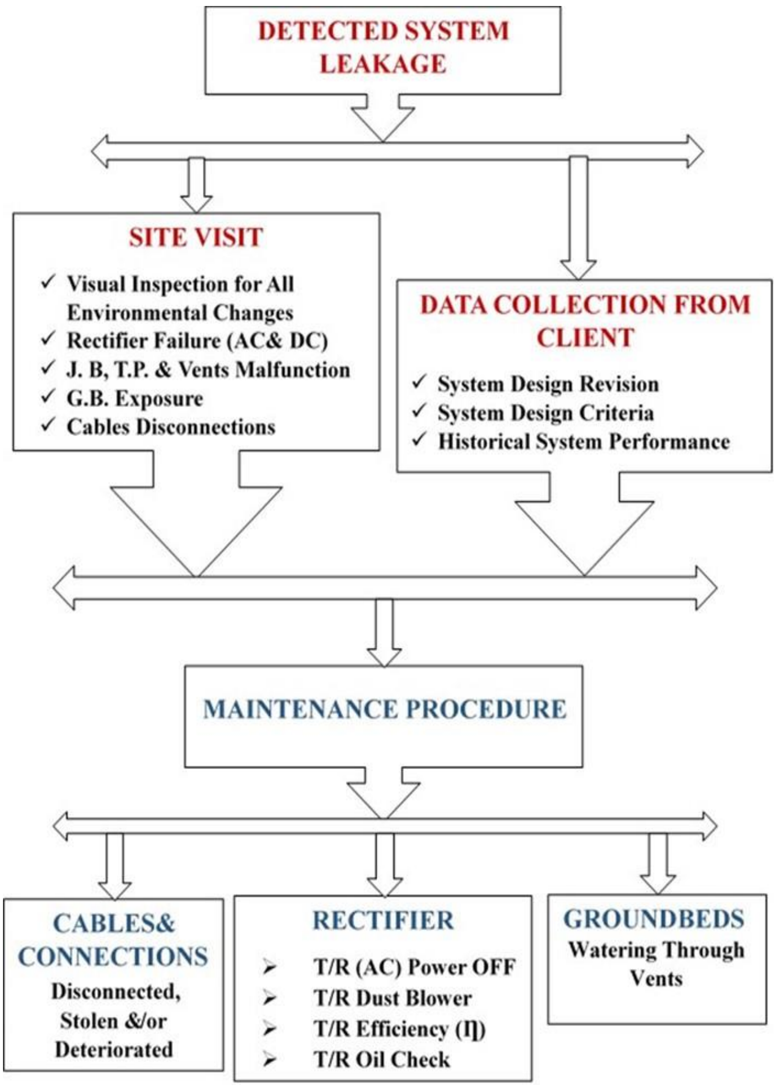

Figure 11: System Leakage Investigation& Maintenance Procedure Flow Chart

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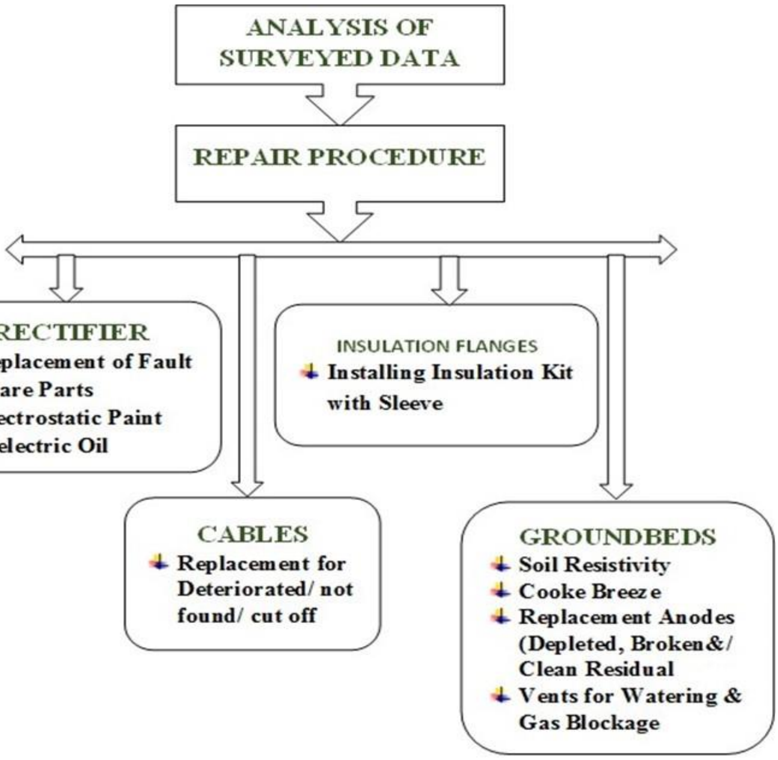

Figure 12: Repair Procedure Flow Chart

CONCLUSIONS

- To identify abnormalities in cathodic protection system of tanks botom EPRI carried out a well proved depend-on procedure for inspection, monitor, maintenance and repair.
- By following EPRI maintenance and repair procedure, the company assets can be preserved at significant cost and time saving.

ABBREVIATIONS

ICCP	Impressed current cathodic protection
CP	Cathodic protection
EPRI	Egyptian petroleum research institute
QPC	Qarun petroleum company
DC	Direct current
Si-Fe-Cr	Silicon- Iron- Chromium (anode material)
CPs	Cathodic protection system
CSE	Copper sulphates electrode
I	Current Consumption
V	Driving DC Voltage
R	Circuit Resistance
T/S	Tank- to- Soil Potential measurement
ΔEo	Interrupted Tank- to- Soil potential shift
η_{TR}	T/R efficiency
Re	Tank effective resistance
AC	Alternative Current
J.B	Junction Box
T.P	Test post
G.B	Ground Bed

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