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CP System for aged Upstream & Downstream Oil & Gas Field Facility

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ABSTRACT

Challenges for cathodic protection engineers especially for aged upstream and downstream oil and gas field facility, where accident, oil leak, production losses are common and routine. Cathodic protection is widely acceptable corrosion prevention technology in oil and gas industry. Every cathodic protection system design start with the first question whether to go with Galvanic/Sacrificial anode cathodic protection system or impressed current cathodic protection system. Effective designing of a CP system is a challenging task especially when the field is dying and production is reducing day by day; results have obtained for optimized design and life by cost effective cathodic protection system by experimental method with the compliance industry standard. In this paper 3 case studies will be discussed with the methods used, in accordance with NACE standard and industry norms. (1) Complex pipeline in oil field without an existing cathodic protection system (2) Onshore Gas Well Casing in a gas filed (3) Floating storage offloading facility (FSO).

The various methods adopted during pre-design survey, design engineering and in installation are discussed in this paper.

INTRODUCTION

API divides the petroleum industry into three categories - Upstream, Downstream & Pipelines. Other organizations use terms like Production, Piping, Transportation, and Refining.

SAFER Exploration and Production Operation Company's (SEPOC) upstream operation, with an emphasis on production, and pipelines, which are closely tied to upstream operations. In SEPOC production facility piping means mainly production flow lines (production manifold, injection manifold etc.), transfer line and export pipeline.

Technologies involved in materials selection and corrosion control are similar for all three categories of equipment. Metals used in upstream production operations were primarily carbon steels. Developments of deep, hot gas wells in the 1980s led to the use of Corrosion Resistant Alloys (CRAs), and this trend continues as the industry becomes involved in deeper and more aggressive environments. 1 Nonetheless, the most used metal in oil and gas production is carbon steel or low - alloy steel, nonmetallic materials are used much less than metals.

Increased emphasis on reliability also contributes to the use of newer or more corrosion - resistant materials. SEPOC oil and gas fields that were designed with anticipated operating lives of 20 years by its previous operator are still economically viable after more than 30 years. This life extension of oil fields is the result of increases in the market value of petroleum products and the development of enhanced recovery techniques that make possible the recovery of larger fractions of the hydrocarbons in downhole formations.

Unfortunately, this tendency to prolong the life of oil fields creates corrosion and reliability problems in older oil fields when reductions in production and return on investment cause management to become reluctant to spend additional resources on maintenance and inspection. For the SEPOC's oilfield, this as well as the earlier operator's operation methodology contribute a major factor of sever corrosion failure in many structures.

With the largest expenses associated with pipelines followed by downhole tubing and increased capital expenditures (CRAs, etc .), the most important opportunity for savings is the prevention of failures that lead to lost production. It is estimated that corrosion costs are approximately equal to mechanical breakdowns in maintenance costs.

The facility management of SEPOC oilfield decided to implement anti-corrosion system installation by cathodic protection techniques. The facility is more than 20 years old when the decision of CP system installation taken in to consideration, soon after the earlier operator leased period over. Frequent buried pipeline leaks are almost every week, maintenance team engage in excavation and replacement, Oil and Gas Wells are plugged and abandoned due to corrosion failure and other production issues. Export terminal FSO facility was unprotected by the existing cathodic protection system for long time, costly rehabilitation do not allow including it in to the yearly budget.

CASE STUDY 1

Facility Piping and Flow Lines

A detail study of layout drawings for flow-lines gathering at manifold is very important to have a proper input at the pre-design level. The main challenges were to stop frequent corrosion leak on flow line inside the facility and in the field on URGENT basis.

At Central Processing Facility, there are more than 200 pipelines of flowlines, transfer line, injection lines are buried in congestion.

Pipeline Dia: Flowlines are 6 Inches dia, transfer line and others are 8, 10, 12 Inches.

Coating System: Coal tar epoxy,

CP System: No CP System installed

Pipeline Installation: 22 years old

Corrosion Leaks: every alternate week

During the initial survey following information gathered and use for further detail design for a cost effective CP system. A total of 3 CP System was in operation for export pipeline, Gas Injection manifold and plant buried piping. None of them were in delivered enough CP polarization to the existing structures. Manifolds and structures, including tanks are without any CP system.

Buried pipelines and flowline of manifold are not electrically continuous and more over copper grounding system are in use, which contribute significant interferences on the buried piping and flowlines causes frequent corrosion leak. Figure 1, shows that the complex pipeline within 1 square kilometer of central processing facility.

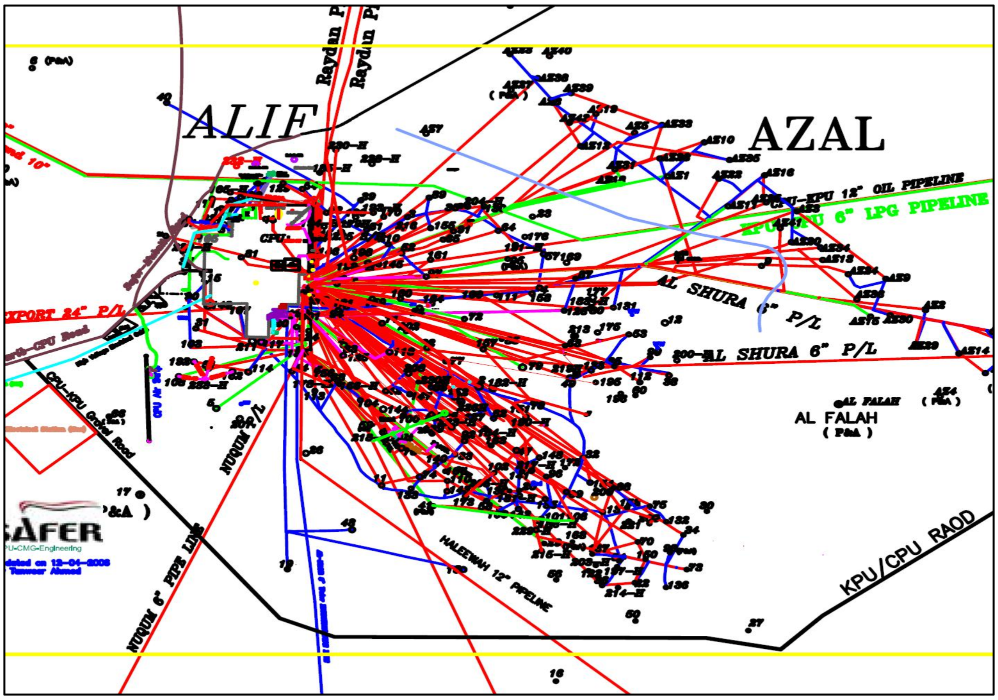


Figure 1: Buried piping at Central Processing Field.

Dry and desert sand have high resistivity and many locations have oil spill. Soil Resistivity measurement taken at propose anode bed locations as well as along the pipeline in the field and it is over 100,000 Ohm-cm at pipe depth. The result shows non-corrosive soil strata where the pipelines are placed.

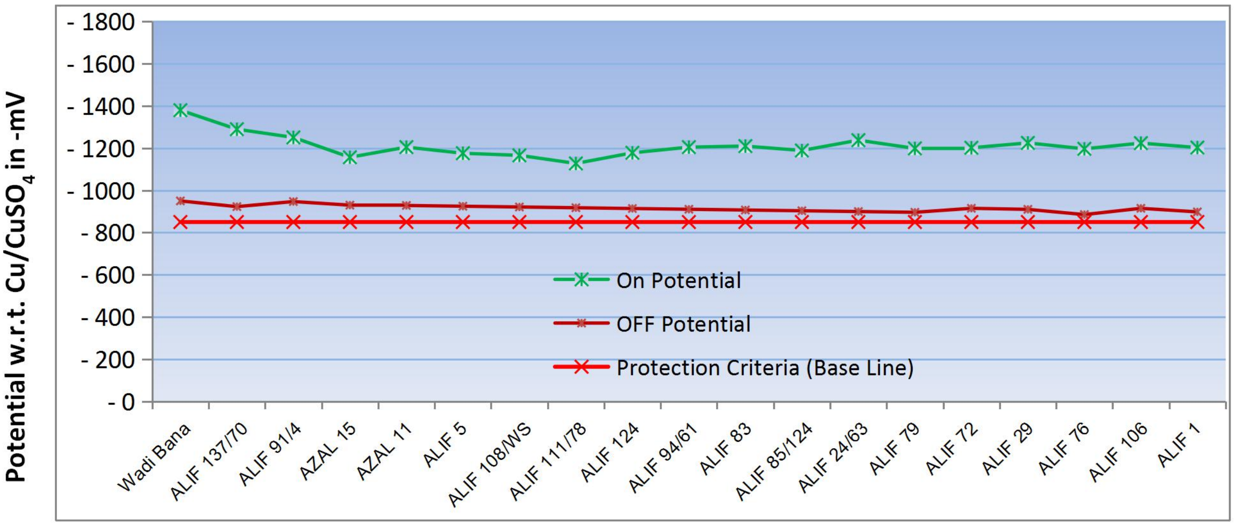
Figure 2: Flow line gathering station

Existing CP system for export line ground bed resistance is too high. Potential measurement at each flow lines, manifold and transfer line shows dc stray current interferences in the flowline and other buried piping. There are 5 manifolds where 100s of flow line gather in central processing field. Figure 2 shows one of the manifolds (production manifold) where the new CP system installed.

Current Requirement: The 1983 edition of the NACE Reference Book specified current requirement between 10 to 30 mA/m^2 for bare steel in soil but the table was removed in the later editions. Similar values are mention in other standards without specifying the type of soil and relevant protection criteria. A study was conducted by PRCI (Pipeline Research Council International) in 2001 indicates that the current required to polarize the carbon steel to -850mV CSE in aerated soil is around 2.0 micro-amp/cm^2 (200 mA/m^2) about two (2) orders of magnitude higher than the current density in clay (non-aerated soil). We recommend using a current density of 2.0 mA/m^2 of coal tar coated pipe system in aerated sand where coating deterioration not exceed 1% of bare steel area (1% of 200 mA/m^2 = 2.0 mA/m^2). In reality as per ISO coating breakdown is over 1% and as per DNV for factory coated pipe is less than 1% (See section 7). A current density of 2.0 mA/m^2 considered for impressed current cathodic protection of the buried piping during commissioning (initial polarization), a current density of 1.0 mA/m^2 during the normal operation of the CP system.

Each pipe and underground installation brings in to a single negative grid by electrical bonding via cable with pin brazing in order to facilitate easy dismantling of mechanical maintenance if required. This step immediately removed all the existing interference issues in facility buried piping and as result leak frequency reduced. Anode bed installed beyond the plant battery limit as well as inside the facility to flood the CP current in facility piping as well as flow lines. Existing anode bed resistance is very high due to dry desert sand and old anodes are consumed over the period of 20 years. 6 new CP systems installed with 60 meter deep anode bed. After 6 to 9 months of operation anode bed resistance become 3 times higher than the commissioning time. As an alternate anode bed, old and abandoned water well use for the CP system. This helps the cost reduction and smooth polarization of piping system (See Graph 1).

Corrosion can be minimize by keeping all individual buried structures connected as one single negative grid and use of galvanized grounding rod instead of copper grounding system. But a cathodic protection system is absolute necessary for longer life of the facility. It is not always true that you have to invest heavily for CP system, rather you can have a detail study of available resources then you can reduce the cost significantly.



Graph 1: On-Off Potential Survey Graph

CASE STUDY 2

Gas Field Well Casing

A thorough study of layout drawings is a key factor for to reach a cost effective system design specially in a gas field where no other electrical power source other than CAMP DG set, that also for the camp operation only, whereas the field is about 16Km radius of the Camp center.

The site survey results are necessary to have a proper input for the pre-design level. The main challenges were the distance of well casing is far from CAMP AC supply and installing 220/440V transmission line was not a viable solutions. Alternatively Solar Power with Battery operated CP system attracts theft problem.

Figure 3: Al-Raja Gas Field Well Casing CP System by Camp AC Supply.

CP System: No existing cathodic protection system for plant facility buried piping and Well Casing.

Gas Pressure: 3000 psi to 5000 psi.

Average Well to Well Distance: 500 meter & 1 to 2 Km.

No Isolation of flow lines and well casing. Current requirement for the bare well casing in the region is about 18 Amps to 22 Amps. One CP system installed for nearby high pressure gas well through camp electric supply (see Figure 3). TR Unit operating circuit (load) resistance is about 0.97 Ohms during commissioning, with time its increases to 1.17 Ohms.

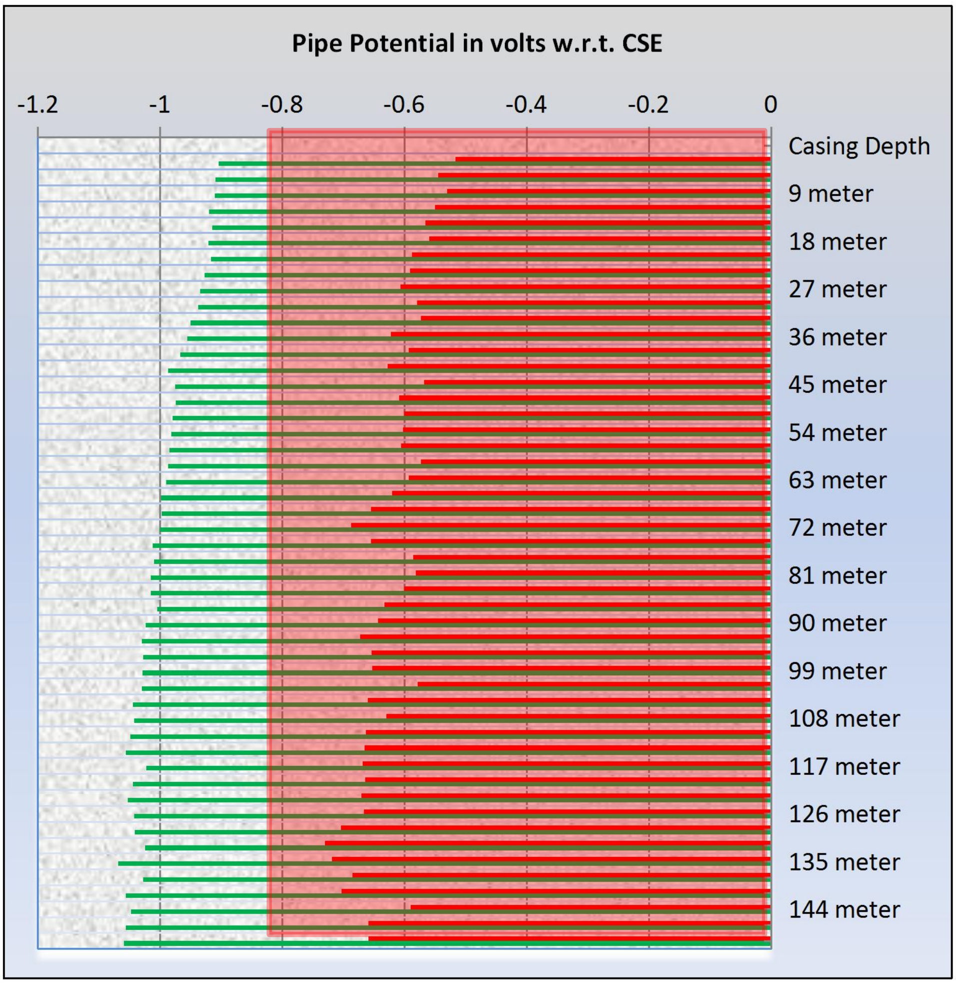
Beyond camp no other options available for a viable CP system other than choosing of Thermo-Electric Generator operated by natural gas. Keeping the overall circuit resistance of 1 Ohm a 500 Watt TEG selected as trial, but due to their higher cost an alternative option becomes an eminent necessity for cost effective solution.

Drilling of well up to 80 meters does not bring the result needed for to have a lower wattage TEG unit in order to have enough CP current for well casing as well as flowlines. Also higher rating TEG unit needs an open space for heat dissipation, which again raises the theft problem.

Finally the use of old and abandoned water well give a total circuit resistance less than 0.3 Ohm with a higher size anode and cathode cable. This allows the use of lower wattage TEG unit of 120 watt inside a ventilated RCC room (See Figure 4).

The results of the proposed CP system are satisfactory (See Graph 2). The experimental procedure followed above save the initial CP system cost and reduces the operating cost significantly.

Figure 4: Al-Raja Gas Field Well Casing CP System by TEG.



Graph 2: Downhole Casing Off Potential

Proposal for Solar CP System Cost = US$ 260,000.00

TEG of 500 Watt CP System Cost = US$ 95,000.00 (Operating Cost 3 times higher than TEG of 120 watt, as the gas consumption is over 3 times more)

TEG of 120 Watt CP System Cost = US$ 49,000.00

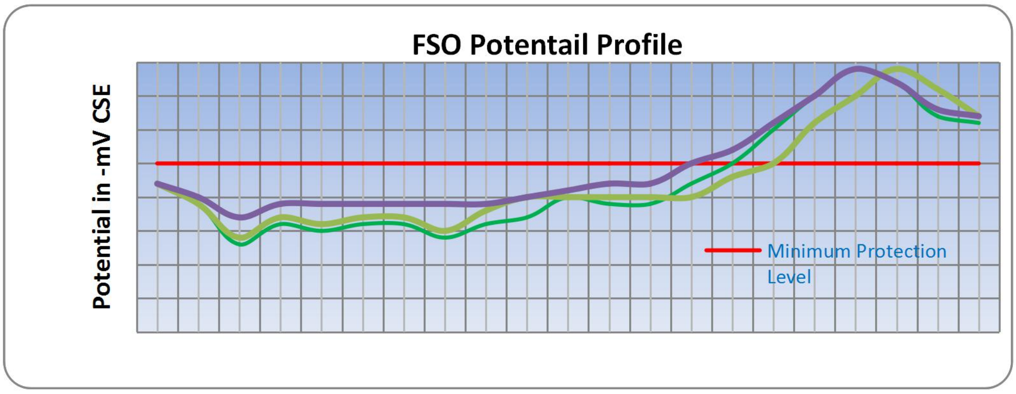
CASE STUDY 3

Floating Storage Offloading (FSO) Facility at Red-Sea

The SEPOC Floating Storage & Offloading (FSO) facility stationed at Red Sea (see Figure 5), about 5 nautical miles from the Ras Al-Isa shoreline with a sub-sea pipeline of length about 10 Km. Scope of work including the upgrading of the existing system by installing two new CP system using suspended anode as well as enhancing the existing AFT CP system of FSO. The main challenges were sea-bed survey, alternate CP system design, procuring CP specialty materials and design sled anode, installing of sled anode in to the sea bed, and execution of engineering work at onsite in accordance with established codes and specification of certification agency ABS as well as international standards of NACE, DNV etc.

Figure 5: Floating Storage Offloading (FSO)

The existing Hull CP anode system fail frequently as result more than 70% hull don't meet protection criteria. Graph 3 shows the polarization level, which are below the protection criteria.



Graph 3: Ship Hull Potential

A thorough study of layout drawings of existing hull CP system, a key factor for to reach a cost effective system design for rehabilitation project.

Find out new location for reactor type Transfer Rectifier.

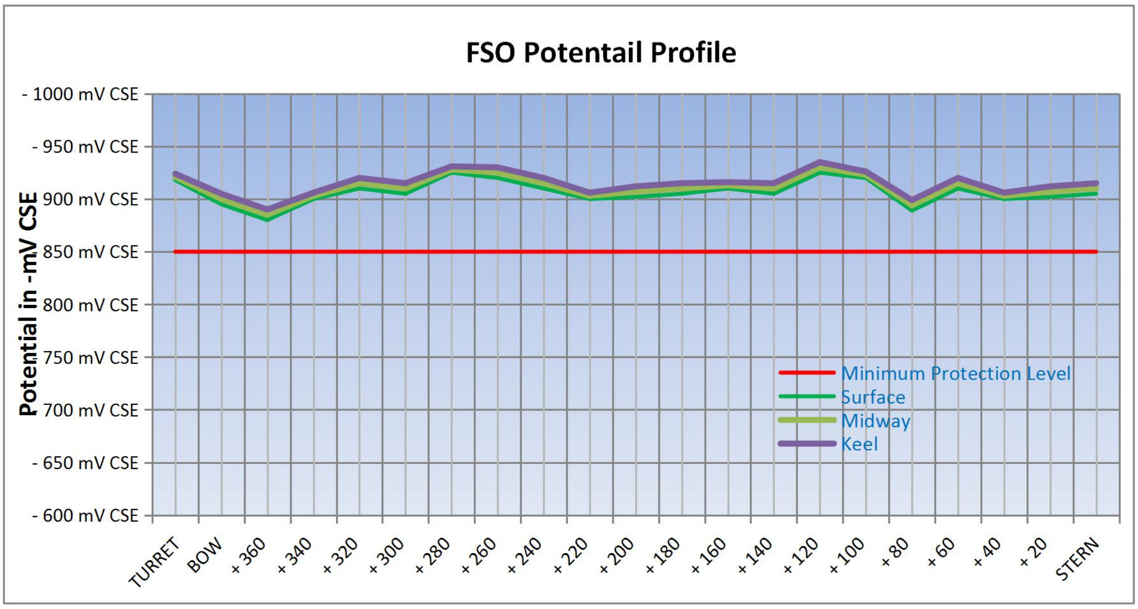
Decide cable route from TR unit to the suspended anode location.

Conduit layout and their fixing arrangement in classified area of deck and along the walkway.

First option of changing all existing platinum anodes, unfortunately each time after changing the anodes, its fail within 1-2 years and it's become in operative. Then second option by a renewed vendor for re-design the entire hull CP system, keeping in mind as FSO, not as ocean going ship (as it was at the beginning). This costing a lot and approval from the certification authority was in question due to couple of modification request in the deck. Finally sled systems on the sea-bed propose for both sub-sea line and ship hull as it is mooring in a fixed location. This option is costly as the previous one.

Finally a factory assembled tensioned string system design with much lower cost to protect the entire hull from corrosion with the same existing CP system.

Results are extremely satisfactory and uniform CP potential achieves throughout the ship hull (See Graph 4). A Cost effective solution can be possible within the agency guideline and established engineering standard practices, if it studied well.



Graph 4: Protection level after the modification

Rehabilitation of entire Ship Hull CP system Cost = US$ 780,000.00

Changing of all anodes and new TR unit proposal cost = US$ 280,000.00

Simple modification without changing all anodes and sled anode proposal, in house cost = Less than US$ 20,000.00

Protection level at ship hull area before modification

ACKNOWLEDGMENTS

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