Effect of Soil on Refinery Buried Cooling Water Pipe

Kareem B. Afan* - Riyadh M. Noaman* – Kareem T. Shnaihj**
Hussam A. Asli* - Aqbal A. majeed** – Najwa S. Ali**

* Chemical & petrochemical research center
**Petroleum research & development center

Abstract: This work is focused to investigate soil parameters (resistivity, PH, sulfate, moisture) that affect the corrosive nature of soil toward the buried cooling water pipe carbon steel used to supply the water to refinery units and the work include on line survey of this unprotected pipe to measuring the potential at each unit of refinery to evaluate the pipe coating.

The soil resistivity measuring at two depth (2&4) meter at many sites, it is found that the soil resistivity at the depth (2) meter (pipe depth) either slightly corrosive or moderately corrosive and other soil parameters were measured at summer and winter seasons, found they change seasonally.

The average pipe potential at each unit of refinery is around (-410mV) and that is mean the carbon steel pipe coating is poor.

Keywords: Soil Parameters, , Soil Corrosive, Cathodic Protection, Potential Survey.

1. Introduction

Corrosion is an electrochemical process that takes place when a metal pipe is exposed to its environment, it causes gradual wearing away and eventual destruction of a metal then the pipe metal must be protecting against it.

Soil parameters such as resistivity, moisture content, pH, and sulfate ions can give an indication of the soil corrosivity towards the buried-carbon steel pipe used in refinery cooling water system

An understanding of the corrosive of a particular soil can minimize such soil corrosion of the buried-pipe material, and intensive study of the soil resistivity of buried-structural materials is very importance for its operating life.

2. Soil resistivity surrounding pipe:

Soil resistivity is the fundamental factor in determining the corrosion potential, table (2-1) shows the relationship between soil resistivity and the potential of corrosion.

Table (2-1) soil resistivity versus corrosion potential

Corrosion Potential	Soil Resistivity
Slightly Corrosive	$\rho E > 100\ \Omega.m$
Moderately Corrosive	$50\ \Omega.m < \rho E < 100\ \Omega.m$
Corrosive	$10\ \Omega.m < \rho E < 50\ \Omega.m$
Severe	$\rho E < 10\ \Omega.m$

2.1 Protecting pipe against corrosion ways:

2.1.1 By applying:

- High quality coatings to minimize the interaction between the pipe and the surrounding soil, but defects will occur in the coating during pipe transporting and construction.
- Cathodic protection system.

3. Resistivity measurement: the soil resistivity measuring in three sites at two depth (2&4) meter according to standard ASTM-G57 is shown in tables (3-1) and (3-2) where T_1, T_2, T_3 are:

1. T_1: inlet cooling tower.
2. T_2: outlet cooling tower.
3. T_3: midpoint along the piping length.

Table (3-1) soil resistivity at depth (2) meter

Soil Resistivity (Ω .cm) at depth (2) meter		
T_1	T_2	T_3
24504	15079	6408

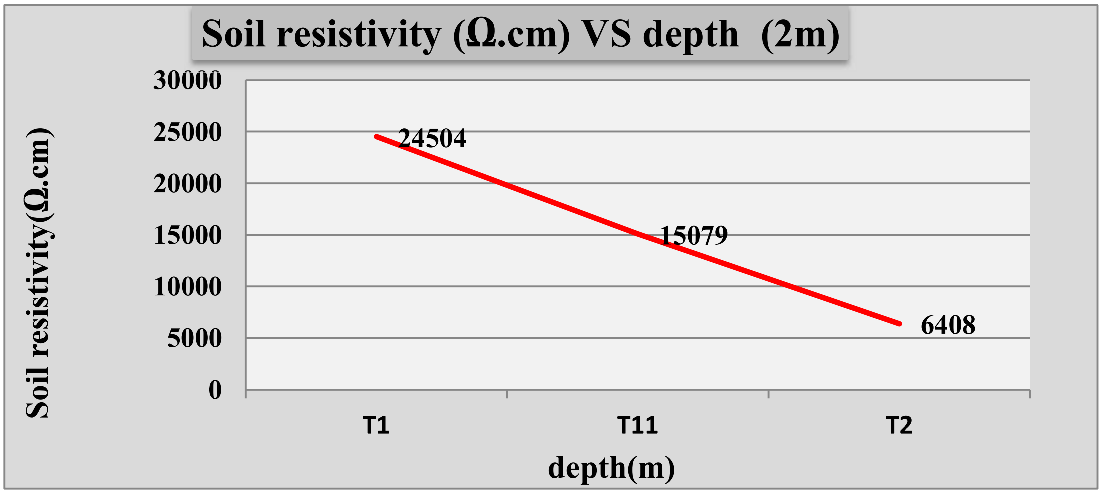

Fig. (3-1) soil resistivity at depth (2) meter

Table (3-2) soil resistivity at depth (4) meter

Soil Resistivity (Ω .cm) at depth (4) meter		
T_1	T_2	T_3
7037	2513	2450

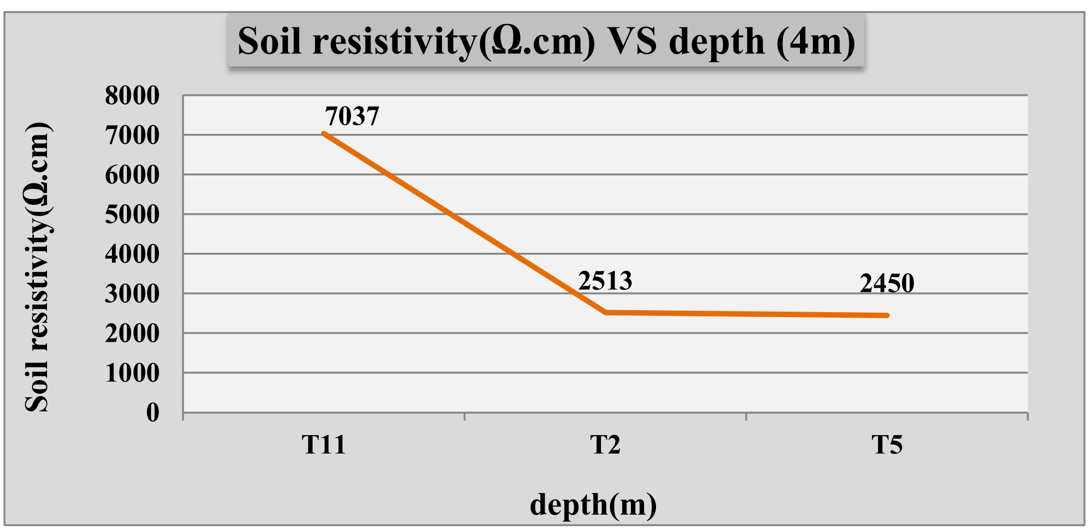

Fig. (3-2) soil resistivity at depth (4) meter

4. On line survey of pipe potential (at soil surface):

4.1 The potential of unprotected pipe measuring at (10) sites, starting from inlet and outlet of cooling tower and at each of eight refinery units as shown in table (4-1).

Table (4-1) pipe potential inside of refinery units

Location	Potential (mV)	Reference Electrode Type
T_1 Inlet Cooling Tower	-391	$Cu/CuSO_4$Electrode
T_2Outlet Cooling Tower	-382	
T_3	-426	
T_4	-423	
T_5	-410	
T_6	-410	
T_7	-423	
T_8	-421	
T_9	-420	
T_{10}	-420	

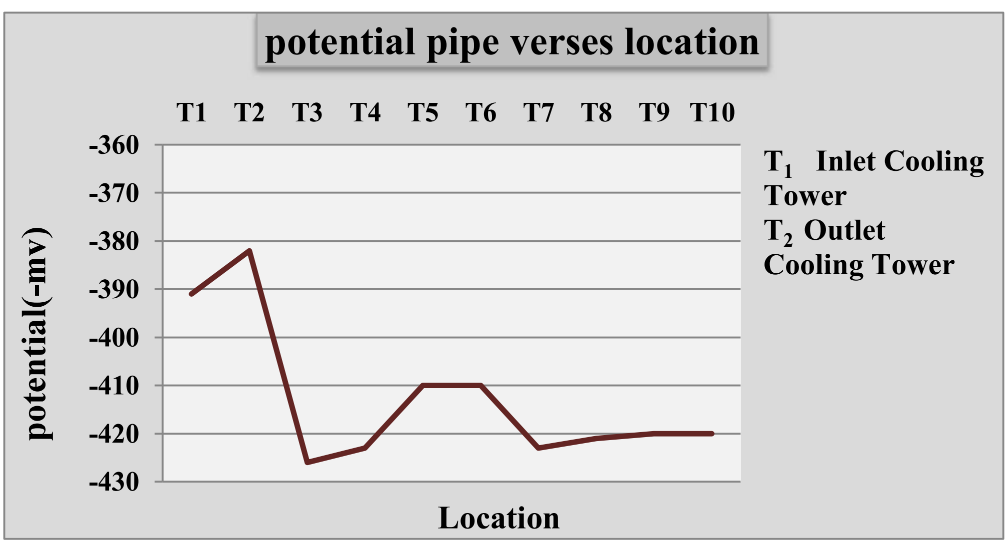

Fig. (4-1) pipe potential verses location

4.2 Pipe potential measurement inside the vacuum distillation unit:

In this unit there is problem of quantity of water that is flow in cooling pipe, length (60) meter and diameter (24) inch. After conducted the survey of this pipe and measuring the pipe potential at many points (along the pipe from surface soil) as shown in table (4-2), there is no failure at external pipe wall.

Table (4-2) potential along pipe

Test Point	Location	Length (m)	Electrode Location	Potential (mV)	Diameter (inch)
Bed Number(1)	Feeder Pipe	12	L_1	-419	24
	Bed Number(1)	Zero	L_2	-420	
	Middle Point Between Bed(1)&Bed(2)	6	L_3	-419	
Bed Number(2)	Bed Number(2)	12	L_4	-420	
	Away From Bed Number(1)	24	L_5	-419	
	Away From Bed Number(1)	35	L_6	-419	
	Away From Bed Number(1)	45	L_7	-419	
	Away From Bed Number(1)	55	L_8	419	
	Outlet the Pipe From Soil	60	L_9	420	

Table (4-3) reference electrode locations along pipe inside vacuum distillation unit

L2	L1	L3	L4	L5	L6	L7	L8	L9
Bed Number (1)	12m	6m	12m	24m	35m	45m	55m	60m

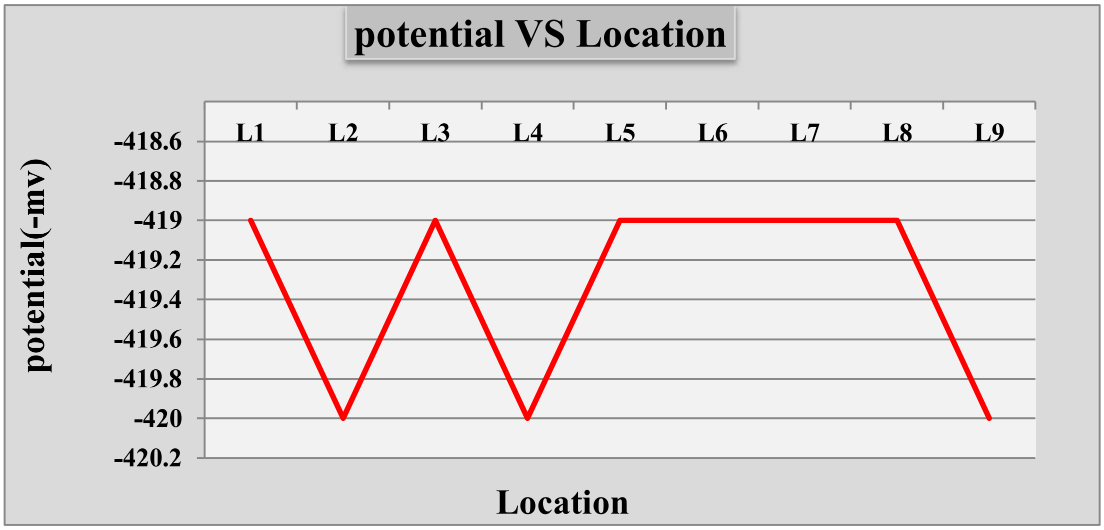

Fig. (4-2) potential pipe at many locations inside vacuum distillation unit

5. Seasonal Chemical Soil Parameters :

The chemical soil parameters like sulfate, calcium carbonate, moisture, change seasonally as shown in table (5-1).

Table (5-1) seasonal chemical soil parameters

Summer Season		Winter Season		
Sulfate	Calcium Carbonate	Sulfate	Calcium Carbonate	Moisture
8%	3%	3%	0.3%	30%

6. Soil PH: soil PH measured at three locations as shown in table (6-1) .

Table (6-1) soil PH at various locations

Location	pH
1	7
2	6.4
3	7

7. Apparatus and tools used in the measurement and evaluation:

1. Digital Fluke Multimeters, high input resistance (10MΩ).
2. Half Cell- Cu/CuSO4(CSE).
3. Digital Soil Resistance Meter.
4. Soil PH Meter.
5. Tool Box.
6. DC Clamp Meter.

Apparatus used in measurement and evaluation

8. Conclusion:

1. The Evaluation and measuring of pipe potential is according to standard:-
   - NACE RP 502-2002
   - NACE TM 0497-2012.
2. Cooling pipe is unprotected.
3. We have no permission to connected temporary cathodic protection equipments because of the pipe in service.
4. The location of reference electrode at soil surface far (2) m from buried pipe.
5. Pipe is located in a congested area and its potential measuring requires high operator quality.
6. The high soil resistivity surrounding the pipe prevents it from corrosion.
7. The average values of pipe potential around (-410mV) at all sites shows that the coating degree of pipe (carbon steel) is poor coating.
8. To prolong the piping age must, immediately, use cathodic protection system.
9. The cathodic protection system type must be impressed current because of high soil resistivity of buried pipe and large surface area of pipe (10 km pipe length and various diameters).
10. The flow of water in the cooling water pipe at vacuum distillation unit is low. After Evaluation of the soil resistivity surrounded the pipe and its potential we found there is no leak in pipe.
11. Chemical soil parameters changes seasonally.
12. The soil is neutral because of the PH around (7).

Reference:

1. NACE RP 502-2002 External Corrosion Direct Assessment.
2. NACE TM 0497-2012- Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems.
3. Yub Raj Dhakal-Kumar -P. Dahal -Jagadeesh Bhattarai -2013- Investigation on the soil corrosivity towards the buried water supply pipelines in Kamerotar town planning area of Bhaktapur, Nepal - BIBECHANA- Journal
4. West Virginia University -2011-Appalachian Underground Corrosion Short Course Advanced Course.
5. Corrosion Probe, Inc. Dr. Zuhair M. Gasem- Cathodic Protection.
6. Professor Roy Johnsen-2004-Cathodic Protection
7. International Journal of Science and Research-2012-Remote Monitoring of Oil Pipelines Cathodic Protection System via GSM and Its Application to SCADA System.
8. Marshall E. Parker & Edward G. Peattie- Pipe Line Corrosion and Cathodic Protection-Third Edition.