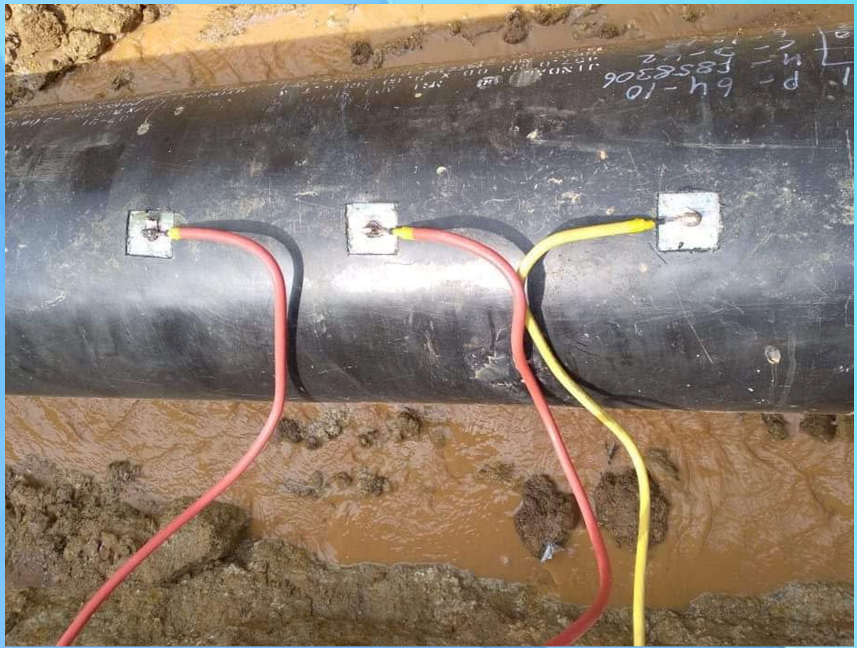
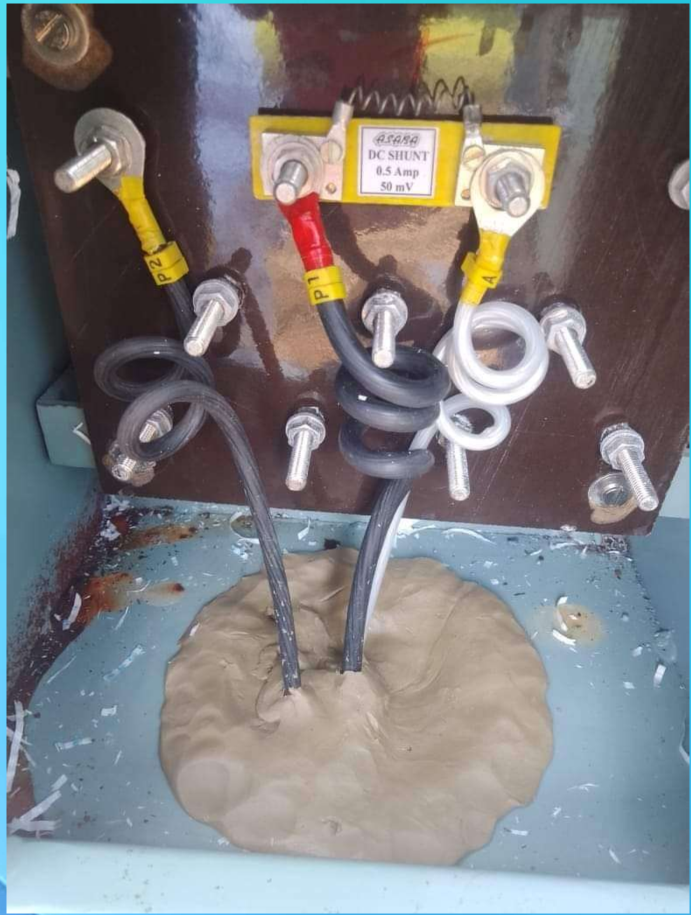
Galvanic cathodic protectio





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Cathodic Protection
Of External Tank Bottoms

General

- The corrosion process as it relates to buried, partially buried, and submerged metallic structures is a naturally occurring phenomenon. The principles of this process and the benefits of cathodic protection (CP) in controlling this type of corrosion have been demonstrated in many different situations.
- Concern has increased, at an alarming rate, over failures of ground storage tank bottoms resulting from internal and external corrosion. This paper will discuss various options for CP of the external (groundside) surfaces of tank bottoms that are in contact with corrosive environments. The advantages and disadvantages of these options will be discussed, along with limitations that exist in determining the effectiveness of CP through traditional measurement techniques. Suggestions for an alternative design approach intended to improve protective current distribution will also be discussed.

C. P. Of Tank Bottoms

Sacrificial anode system:

For small diameter thank, effectively isolated from other underground structures.

Impressed current systems:

Where current requirement are substantial

Types of anode installations:

Horizontal or vertical, around periphery (Fig. 1).

Horizontal or vertical under tank bottom (Fig. 2).

Deep well configuration (Fig. 3)

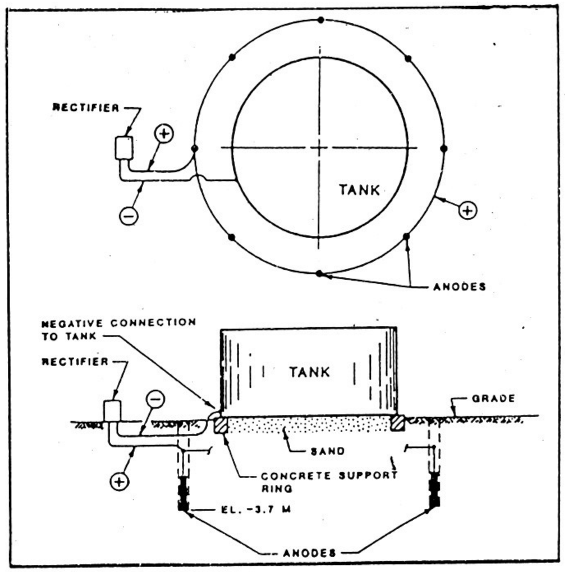

FIGURE 1 — Commonly installed vertical impressed

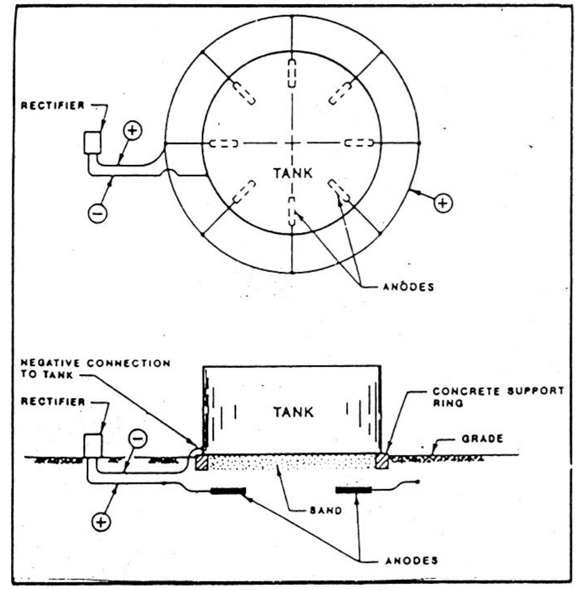

FIGURE 2 — Anodes installed under a tank bottom.

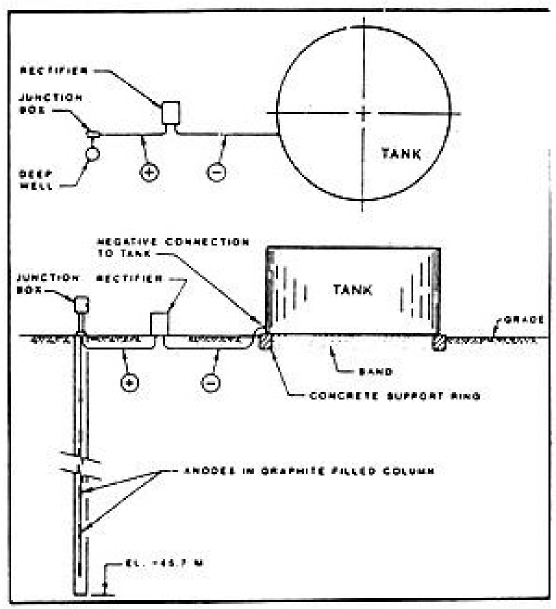

FIGURE 3 — Commonly installed deep well impressed current anodes.

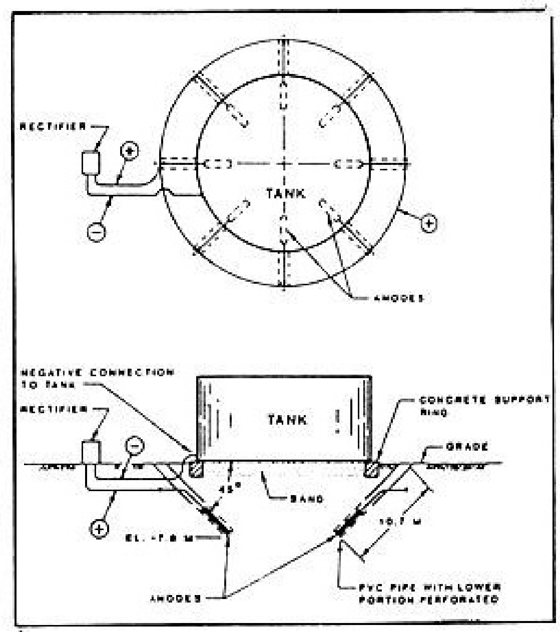

FIGURE 4 — New system approach: angled, impressed current anodes.

Experience has shown

- Structure to earth potential at perimeter of tank does not indicate actual C.P. levels at center, particularly for large diameter tanks.
- Pot. Measurements at center & other parts are necessary.
- Liquid level in the tank as a significant factor.
- Certain C.P. designs may not be effective in providing adequate C.P. to tank bottom in certain areas.
- Using slant or angle drilling can improve current distribution (Fig. 4).
- Standard method to verify effectiveness of C.P.: Structure to soil potential. (High impedance voltmeter & reproducible ref. electrode).
- Natural potential of C-steel $\simeq$ 0.600 mV Vs Cu/$CuSO_4$. More positive values: means corrosion of structure, while more negative values: indicate protection (or well-coated).
- Effective protection at -0.85 V Vs Cu/$SuSO_4$ (One of the accepted criteria)

Problem of monitoring:

Inability to place portable reference electrode in close proximity to the underside.

Placement of ref. electrodes at the perimeter: may yield erroneous results, especially when using distributed anodes installed along the periphery.

Table (1): Actual measurements showing a potential difference of $\simeq$ 300 mV between perimeters a center of tank.

So, recommended: At least one measurement taken at tank center.

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For new tank construction: permanent reference electrode and a lead wire underneath tank pad (Fig. 5) or a perforated PVC or FRP pipe (Fig. 6) for potential profiling.

For existing tanks: A hole can be bored (water jetting) in a configuration shown in Fig. 6.

Table (1): Potential Measurements Obtained Under a 36.6m Diameter Tank Bottom

Reference Electrode Location (m)	Tank-to-Cu/$CuSO_4$ (V)
Perimeter	-1.492
1.5	-1.379
3.0	-1.291
4.5	-1.242
6.0	-1.183
7.5	-1.151
9.0	-1.127
10.5	-1.109
12.0	-1.097
13.5	-1.109
15.0	1.109
16.5	-1.101
18.0 (center)	-1.112

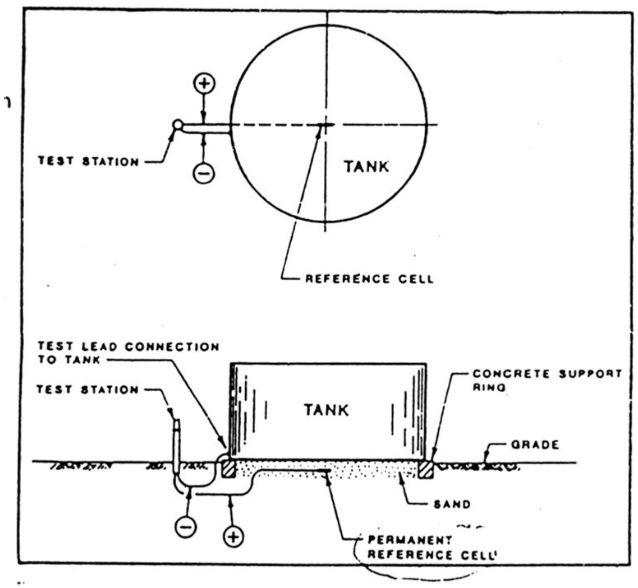


FIGURE 5 — Permanently installed reference cell and test station.

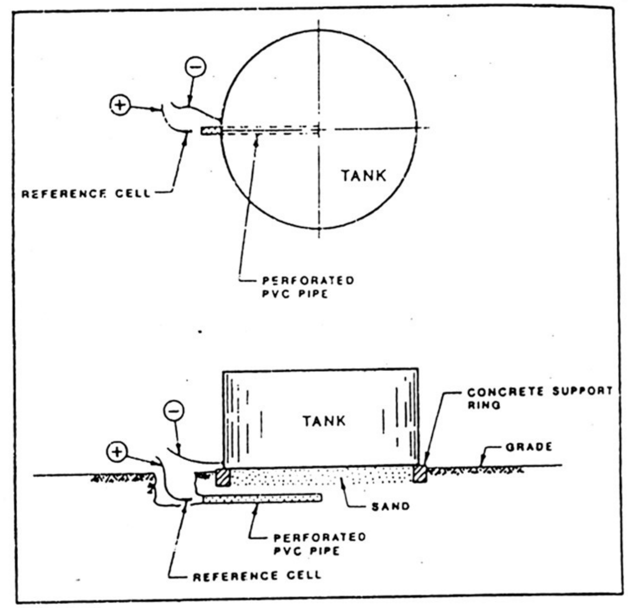
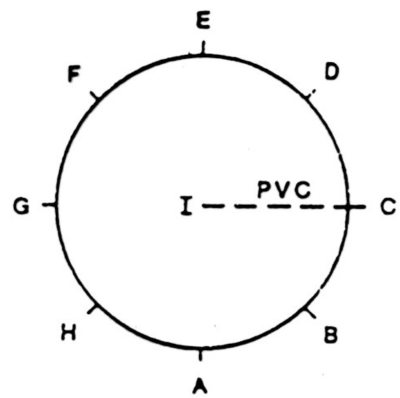


FIGURE 6 — Perforated pipe installed for reference cell access to tank bottom.

Typical Case Studies
Case No 1 (Fig. 7):
36.5m dia., 14.6m high C-steel ground storage tank.
Deep anode ground-bed installed in close proximity to tank (2.1 A).
Measurements at periphery & center of tank.

36.5 M DIA. x 14.6 M HIGH

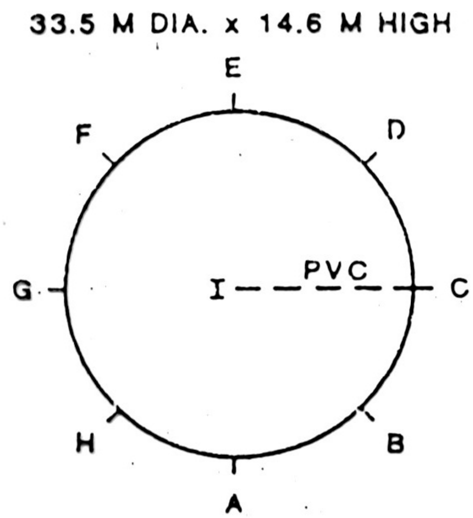


TEST DATA	
LOCATION	T/$CuSO_4$ (volts)
A	-0.775
B	-0.700
C	-0.715
D	-0.835
E	-0.885
F	-0.885
G	-0.850
H	-0.815
I	-0.380

FIGURE 7 — Typical Case Study No. 1: deep anode groundbed installed in close proximity to the tank (current = 2.10 A).

Case No 2 (Fig. 8):

- 33.5m dia., 14.6m high C-steel ground storage tank.
- Deep anode ground bed (2 A)
- Potential at center (0.640 V) does not satisfy the minimum accepted criterion.
- These examples indicate the critical nature of reference electrode replacement to assess degree of protection.
- Also: leakage current at lank perimeter (tank bottom at perimeter has the lowest resistance to earth).
- Under conditions of max product level, good contact at center, hence greater expected area & lowest resistance to earth, hence a higher required current.
- Testing on an empty tank may indicate adequate C.P. at center (limited amount of surface area being protected). Once the tank is filled, surface area in contact with earth increases & current density decrease.
- The success of the deep anode ground-bed system is usually predicted on relatively low, uniform soil sensitivities from the ground surface to the total depth of the ground-bed.
- Difficult to direct the ground-bed current to the tank bottom in areas of non-uniform soil resistively, particularly where high receptivity strata may lie between the tank bottom and the active anode area.
- Distributed anode ground-beds installed around the periphery of the tank, are intended to provide uniform distribution of the anode current to the tank.



TEST DATA	
LOCATION	T/$CuSO_4$ (volts)
A	-1.040
B	-1.150
C	-1.190
D	-1.110
E	-1.090
F	-1.070
G	-0.930
H	-0.950
I	-0.640

FIGURE 8 — Typical Case Study No. 2: deep anode groundbed installed in close proximity to the tank (current = 2.00 A).

New System Approach (Angle – Drilled Anodes)

Using distributed anodes at a 35 to 45 degree angle to the perimeter of the tank to a depth of 7.6 to 10.7m (Fig. 4): More uniform current distribution & higher protection levels at center.

In new installations of this type, potentials of – 1.00V at perimeter& -0.86V at center.

Easy to conduct these types of installations: by the use of pre-packaged or canistered anodes.

Summary

- The application of CP is an effective means of controlling corrosion on a tank bottom groundside. The success of the CP system is dependent on proper design and selection of the type of installation and effective monitoring of the level of protection being afforded the entire tank bottom (groundside). The use of angle-drilled anodes around the periphery of the storage tank should provide a better distribution of current to the center of the tank. Monitoring through the use of permanent reference cells installed under the base of the tank or reference cells passed through a slotted pipe installed under the center of the tank will provide an accurate indication of the true potential level. True potentials might not otherwise be realized by placing a reference cell around the perimeter of the tank.