ABSTRACT:

Corrosion of aboveground storage tank bottom plates is a common damage mechanism found in several Petroleum storage tanks in the Middle East countries and in the world at large. Corrosion of the floor plates can occur either from the underside (soil side) or from the top side (product side). Both types of corrosion is common in the storage tanks and eventually lead to metal loss and ultimately perforations in the tank floor. The consequence of such failures are sometimes severe with respect to loss of containment, possibility of explosion and loss of human lives and damage to the environment. The accumulation of water at the bottom of storage tanks is a primary prerequisite for development of corrosion. On the other hand, soil side corrosion from underside the floor plate sometimes plays a predominant role in the premature loss of product and failure of the tank in service. Although the product side of the floor plates are generally protected with various types of non-corrosive paint coatings and there are several protective measures including cathodic protection and use of dry compacted sands with chemical inhibitors were existent to protect the soil side of the floor plates, several failures of bottom plates in terms of through holes and/or severe corrosion of the bottom plates almost reaching down to the minimum allowable thickness have been noticed in quite a few cases. It has been noticed that in many cases the soil side (underside) corrosion occurred mostly at or near the annular plates particularly in the critical zones inside the tank. Magnetic Flux Leakage Technique is a very useful tool to assess the corrosion of bottom plates of Storage tanks and hence is a preliminary requisite for Risk assessment of Storage tanks in service. In this present case study, an above storage tanks which was taken out of service for scheduled maintenance and inspection, has been subjected to thorough magnetic flux leakage examination of entire bottom plates. During the MFL examination, several areas of significant corrosion have been observed in the bottom plates and an assessment of fitness for service have been carried out based on Risk Based Inspection in accordance with the guide lines of API RP 580 & 581. A general recommendation have been provided based on RBI study and API 653 recommendations.

**Keywords:** Soil corrosion, paint blisters, storage tank bottom, fitness for service, risk based inspection, Magnetic Flux Leakage.
1. Introduction:

An oil storage tank has been internally and externally inspected in accordance with the guidelines of API 653: 2014 edition. The tank was built in the year of 1970 and has been in service since then with some local minor repairs. The details of the tank is given below:

1.1 Diameter: 34.14 meter
1.2 Height: 14.5 meter
1.3 Product stored: Gas Oil.
1.4 Year of construction: 1970
1.5 Product specific gravity: 0.84
1.6 Internal pressure: Atmospheric
1.7 Bottom/ annular plate thickness: 7.5mm / 10mm.
1.8 Roof plate thickness: 6mm.
1.9 Shell plate thickness: 10mm to 6mm (bottom to top shell course)
1.10 No of shell courses: 8 nos.
1.11 Material of construction: Not known (assumed to be ASTM A 36).

During internal inspection of the storage tank, several through holes were observed in the bottom plates and annular plate associated with several corroded areas of bottom plates. Roof plates were also severely corroded and through holes were observed in several areas of roof plates. In at least one area of the shell plates, a through hole was observed. A large portion of the shell in the 3rd to 4th shell portion was found deformed towards inside. Other than that, general and localized corrosion were observed in attachment welds, hand rails, staircases and nozzle welds. A report of magnetic flux leakage survey has also been shown in photo-3, which reveals several areas of bottom plate corrosion. Suitability for service assessment has been done as per API 653 and it was observed that at the present condition, the tank cannot be operated under the existing operating conditions. Repairs of the affected areas have been recommended. The owner has decided to replace the roof completely and full replacement of the affected location of the shell plate by putting one new insert plate. However the bottom plate replacement is a cumbersome task and will take huge time to replace, hence they asked us to have a general RBI study of the bottom plates whether with the existing condition and after all repairs have been carried out the tank bottom, the tank can run for another 5 years. A team comprising API RBI engineer and API 653 inspector has performed RBI study and following are the conclusion and still it was observed that the risk of operating the tank is quite high and replacement of bottom plate is necessary to run it for another 5 years. Here is a brief summary of the work that has been carried out to estimate the risk of the tank serviceability as per API 580 & 581.

2. Risk analysis procedure:

2.1 In API RBI, the risk as a function of time is calculated in accordance with the following formula. The equation combines both probability of failure and consequence of failure and is a product of both factors. Only financial risk is used for atmospheric storage tank components.

\[ R(t) = P_f(t) \times FC \]  

(1)
Probability of failure is a function of time since the most damage factors are time variant and thus the severity increases as the time increases. The thinning damage factor for storage tanks is mainly a time dependent phenomenon. On the other hand, the consequence of failure is generally considered as time invariant and hence time does not have much effect on the consequence of failure. For storage tanks the consequence is mainly financial based.

2.2 Risk Matrix:
The results combined and summarized in a risk matrix is an effective way of showing the distribution of risks for different components in a process unit without numerical values. In the risk matrix, the consequence and probability categories are arranged such that the highest risk components are toward the upper right-hand corner. The risk matrix may be expressed in terms of consequence area or financial consequence. In the case of storage tanks, the consequence is mainly financial based.

Risk categories (i.e. High, Medium High, Medium, and Low) are assigned to the boxes on the risk matrix. In API RBI the risk categories are asymmetrical to indicate that the consequence category is given higher weighting than the probability category.

Tank components residing towards the upper right-hand corner of the risk matrix will most likely take priority for inspection planning because these items have the highest risk. Similarly, items residing toward the lower left hand corner of the risk matrix tend to take lower priority because these items have the lowest risk. Once the plots have been completed, the risk matrix can then be used as a screening tool during the prioritization process.

2.3 Probability of Failure:
The probability of failure as a function of time and inspection effectiveness is determined using a generic failure frequency and damage factors for the applicable active damage mechanisms. For the storage tank in question, we utilized the thinning damage factor which is typically used for tank components. However, damage factors for other active damage mechanisms may also be computed.

2.4 Consequence of Failure:
Consequence of failure calculation procedures to be used is provided in API RP 581 in a very detailed way. Only the Level 1 consequence analysis in financial terms is used for the analysis of tank components. In addition, only consequences from component damage, product loss, and environmental penalties are considered.

2.5 Inspection Planning Based on Risk Analysis
It is understood that at some point in time, the estimated risk will reach a specified risk target. Therefore, inspection of the equipment is recommended based on a ranking of the component damage mechanisms that have the highest calculated damage factors. Inspection provide knowledge of the damage state of the Tank and reduces uncertainty. The probability that loss of containment will occur is directly related to the amount of information that is available from inspection and the ability to quantify that damage.

Reduction in uncertainty is a function of the effectiveness of the inspection in identifying and quantifying the type and extent of the damage. Some inspection techniques are better, for example, in detecting thinning (general corrosion) damage than others. On the other hand, an inspection technique appropriate for general corrosion may not be very effective in detecting and quantifying damage due to local thinning or cracking.
3.0 Probability of Failure calculation:

API RP 581 suggests the probability of failure shall be calculated by the following formula:

\[ P_f(t) = gff \times D_f(t) \times F_{ms} \quad \ldots \ldots \quad (2) \]

In this equation, the probability of failure, \( P_f(t) \), is determined as the product of a generic failure frequency, \( gff \), a damage factor, \( D_f(t) \), and a management systems factor, \( F_{ms} \).

The adjustment factors on the generic frequency of failure reflect differences between damage mechanisms and the reliability management processes within a plant. The damage factor adjusts the generic failure frequency based on the active damage mechanisms the component is subject to and considers the susceptibility to the damage mechanism and/or the rate at which the damage accumulates. The damage factor also takes into consideration historical inspection data and the effectiveness of both past and future inspections.

3.1 Management System Factor: The management systems factor, adjusts for the influence of the facility’s management system on the mechanical integrity of the plant. The damage factor is applied on a component and damage mechanism specific basis while the management systems factor is applied equally to all components within a plant.

Adjustment factors with a value greater than 1.0 will increase the probability of failure, and those with a value less than 1.0 will decrease it. Both adjustment factors are always positive numbers.

The generic failure frequency of a component type is estimated using records from all plants within a company or from various plants within an industry, from literature sources, and commercial reliability data bases. Therefore, these generic values typically represent an industry in general and do not reflect the true failure frequencies for a specific component subject to a specific damage mechanism.

3.2 Generic Failure Frequency: The generic failure frequency is intended to be the failure frequency representative of failures due to degradation from relatively benign service prior to accounting for any specific operating environment, and are provided for several discrete hole sizes for various types of processing equipment (i.e. process vessels, drums, towers, piping systems, tankage, etc.).

The overall generic failure frequency for each component type was divided across the relevant hole sizes, i.e. the sum of the generic failure frequency for each hole size is equal to the total generic failure frequency for the component.

3.3 Damage Factors: Damage factors are intended to support the API RBI methodology by providing a screening tool to determine inspection priorities and to optimize inspection efforts. Damage factors do not provide a definitive Fitness-for-Service assessment of the component. The basic function of the damage factor is to statistically evaluate the amount of damage that may be present as a function of time in service and the effectiveness of an inspection activity.

4.0 Calculation of Probability of failure:

As described in the previous paragraph, the probability of failure is a product of generic failure frequency (\( gff \)), the damage factor (\( D_f(t) \)) and the management system factor (\( F_{ms} \)).

For the purpose of the probability calculation of tank bottom plates, the thinning has been considered in this study.

\[ \text{Thinning damage factor} = D_f^{\text{thin}} \]

4.1 Calculations:

Since the tank has no release prevention barrier, the minimum required thickness as per API 653 is 2.54mm for bottom plates.
The $A_{rt}$ parameter (Damage factor parameter):

$A_{rt}$ can be calculated as below:

$$A_{rt} = \text{Maximum of } \left[ \frac{1 - (t_{rd} - C_{r,bm} \times \text{age})}{(t_{min} + CA)}; 0.0 \right]$$

For the present tank:

- $T_{rd}$ = Thickness of the bottom plates at the time last inspection. Since the tank was running for quite a long time without any effective inspection and no data is available, the thickness was taken as the measured thickness during installation, which is 7.5mm.
- $C_{r,bm}$ = Corrosion rate (long term) is calculated based on the simple principle described in API 653, which is calculated as maximum 0.089mm/year.
- Age = the age of the tank is 46 years since its installation.
- $T_{min}$ = The minimum allowable thickness as per API 653 = 2.54mm for bottom plates.
- $CA$ = corrosion allowance = 0.00mm.

Based on the above information, the $A_{rt}$ parameter can be calculated as:

$$A_{rt} = \text{Maximum of } \left[ \frac{1 - (7.5 - 0.0891 \times 46)/2.54}{2.54 + 0.00}; 0.0 \right]$$

= 0.34

API 581 provides a table for the calculation of thinning damage factor to be used for probability of failure calculations (Table 5.12) specifically for storage tank bottoms.

From the table 5.12, the thinning damage factor for tank bottom with no effective inspection & $A_{rt}$ value of 0.34;

The thinning damage factor can be taken as: $D_{IB}^{\text{thin}} = 170$

So the composite damage factor for thinning damage mechanism taking into account all the adjustment parameters will be:

The damage factor for thinning:

$$D_{f}^{\text{thin}} = \left( D_{IB}^{\text{thin}} x F_{IP} x F_{DL} x F_{WD} x F_{AM} x F_{SM} \right) / F_{OM} \ldots \ldots (4)$$

Where:

$F_{OM}$ = Adjustment factor for online monitoring = 1 for tank bottom corrosion.

$F_{IP}$ = Adjustment factor for injection point = 1 (not applicable for tank bottom)

$F_{DL}$ = Adjustment factor for dead legs = 1 (not applicable for tank bottom)

$F_{WD}$ = Adjustment factor for welded construction = 1 (for welded tank)

$F_{AM}$ = Adjustment factor for maintenance = 5 (since the tank is not maintained as per API 653)

$F_{SM}$ = Adjustment factor for tank settlement = 1.5 (since settlement values are not known)

(NOTE: all the above values are taken as per the recommendations from API 581 Part 2: Para 5.5.3 (h))

So,

$$D_{f}^{\text{thin}} = \left( 170 x 1 x 1 x 1 x 5 x 1.5 \right) / 1$$

= 1275

= Probability of failure Category 5

Hence we come to a conclusion that the probability of failure category of the subject tank is highest.

So, quantitatively, the probability of failure is calculated as almost 92%,

$$P_f(t) = gff x D_f(t) x F_{ms}$$

= $7.2 \times 10^{-4} \times 1275 \times 1$

= 0.918
*: Management system factor:
In the above formula, a management system factor has been included, which is based on the fact how effectively the management program of the equipment (Storage tank) implement the inspection of the tank to provide routine inspections and thus prevention from failure. The scale recommended for converting a management systems evaluation score to a management systems factor is based on the assumption that the “average” plant would score 50% (500 out of a possible score of 1000) on the management systems evaluation, and that a 100% score would equate to a one order-of magnitude reduction in total unit risk. Based on this ranking, the following may be used to compute a management systems factor $F_{MS}$ any management systems evaluation score (%):

For the present case, it is assumed as 50%, please see below for the calculation of management system factor based on $p_{score}$, which is a management system evaluation score expressed as a percentage. Based on the below calculations, the management system factor was found as having a value of 1 (refer below):

$$P_{score} = \frac{score \times 100}{1000} \text{ (unit is in %)} = 50\%$$

$$F_{MS} = 10^{-0.02 \times p_{score} + 1} = 10^{-0.02 \times 50 + 1} = 10^0 = 1$$

4.0 Consequence of Failure calculation for Tank bottom plates:
Consequence analysis of storage tank has been calculated based on Part 3 section 7 of API 581. The calculation procedure is as per the following:

Parameters:
Liquid stored: Gas Oil.
Representative fluid (Table 7.1 of API 581):
Heavy fuel oil: Density: 900 kg/m$^3$; Dynamic viscosity: 4.6 x $10^{-2}$ N-s/m$^2$
Soil type underneath the tank floor plate: fine sand;
Soil porosity ($p_s$): 0.33 (as per table 7.2M of API 581)
Water hydraulic conductivity ($K_{h, \text{water}}$): lower bound: $10^{-2}$ cm/s; upper bound: $10^{-3}$ cm/s; (as per table 7.2M of API 581)
Conversion factor: $C_{31} = 864$ (as per table 3.B.2.1 of API 581)

So, average hydraulic conductivity of water can be calculated by taking average of the upper and lower bound values:

$$K_{h, \text{water}} = C_{31} \frac{K_{h, \text{water-lb}} + K_{h, \text{water-ub}}}{2} = 864 \left(10^{-2} + 10^{-3}\right)/2 = 4.752 \text{ cm/s.}$$

Hydraulic conductivity of product stored in the tank (Gas oil) can be calculated by the following formula using density and dynamic viscosity of water and the liquid:

$$K_{h, \text{prod}} = K_{h, \text{water}} \left(\frac{\rho_{l}}{\rho_{w}}\right) \times \left(\frac{\mu_{w}}{\mu_{l}}\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots$$

$$= 4.752 \times \left(\frac{900}{1000}\right) \times \left(\frac{1.002 \times 10^{-3}}{4.6 \times 10^{-2}}\right)$$

$$= 0.09316$$

Where:

$\rho_l$ = Density of the liquid = 900 kg/m$^3$
$\rho_w$ = Density of water = 1000 kg/m$^3$
$\mu_w$ = Dynamic viscosity of water = 1.002 x $10^{-3}$ N-s/m$^2$
$\mu_w$ = Dynamic viscosity of product = 4.6 x $10^{-2}$ N-s/m$^2$ (Table 7.1M of API 581)
The product seepage velocity is a function of Hydraulic conductivity of the product and soil porosity underneath the tank:

Product seepage velocity = \( V_{s,\text{prod}} = \frac{K_{h,\text{prod}}}{p_s} = 0.09316/0.33 = 0.282 \)

Release hole size selection:
Here, we have considered the tank bottom plates only for the RBI study since the shell course leakage have been repaired by inserting a new shell course of same thickness and material as per API 653 requirements. All the leakage holes found in the bottom plates are within 0 – 3mm diameter, hence the assumptions have been made:
Release hole diameter within the range of 0-12.7mm as per table 7.4M (API 581) from small size holes without release prevention barrier. \( D_1 = 12.7 \text{mm} \). (The tank has no release prevention barrier).

From table 4.1 of Part 2 of API 581, Failure frequency as a function of hole size; small hole = \( 7.2 \times 10^{-4} \) failures per year.
Failure frequency as a function of hole size; rupture = \( 2.0 \times 10^{-6} \) failures per year.
Total generic failure frequency = \( \text{gff}_{\text{total}} = 7.2 \times 10^{-4} \) failures per year.

Release rate calculation:
Maximum fill height (as per operation information) = 13 meters
Height of liquid for each release hole size = \( h_{\text{liq}} = 13 \) meters
Conversion factor: \( C_{36} = 30.5 \) (as per table 3.B.2.1 of API 581);
Tank diameter = 34.14 meters; \( n_{\text{rh,}1} = 1.25 = 1 \) (nearest integer)
\( C_{34} = 86.4 \) (as per table 3.B.2.1 of API 581)
The discharge rate through a hole as per hole size (\( d_n \)) specified (\( W_n \)):
\[
W_n = C_{35} \times C_{qo} \times d_n^{0.2} \times h_{\text{liq}}^{0.9} \times k_h^{0.74} \times n_{\text{rh,n}}
\]
\[
= 2.382 \times 0.21 \times 12.7^{0.2} \times 13^{0.9} \times 0.09316^{0.74} \times 1
\]
\[
= 1.444 \text{ bbl/day}.
\]
Where:
\( C_{qo} \) is the adjustment factor for degree of contact with soil = 0.21 for consequence analysis.
Amount of liquid available =
Total liquid in the tank: \( L_{\text{vol, total}} = \pi \times D^2/4 \times h_{\text{liq}} = 3.14 \times 34.14^2/4 \times 13 = 11894.33 \text{ m}^3 \)
Total volume in barrels:
\( \text{Bbl}_{\text{total}} = L_{\text{vol, total}}/ C_{13} = 1890.99 = 1891 \text{ barrels} \)
Where conversion factor \( C_{13} = 6.29 \) (as per table 3.B.2.1 of API 581)
Release rate as determined in the previous equation \( W_n = 1.444 \text{ bbl/day} \).
The leak detection estimated as per API 581 Para 7.7.3 for tank without a release prevention barrier: \( T_{\text{ld}} = 360 \text{ days} \)
Therefore the leak duration \( L_{\text{d,n}} \) for the release as stated above can be calculated as:
Ld_n = min of \[
\frac{Bbl_{\text{total}}}{W_n}; 360 \] = [1309; 360] = 360 days

Now, the release volume from the above leakage can be estimated as:

\[
Bbl_n^{\text{leak}} = \min \{W_n \times Ld_n; Bbl_{\text{avail},n}\}
\]

Release volume from leakage = \min \{(W_n \times Ld_n); Bbl_{\text{total}}\} = 520 barrels.

\[
Bbl_n^{\text{rupture}} = 1891 \text{ barrels}
\]

**Determination of financial consequences:**

- \(P_{\text{lvdike}}\) = percentage fluid leaving the dike.
- \(P_{\text{lvdike-onsite}}\) = percentage fluid leaving the dike but remains onsite.
- \(P_{\text{lvdike-offsite}}\) = percentage fluid that leaves the site.

- \(S_{gw}\) = total distance to ground water underneath the tank = 5 meters (from local information)
- \(T_{gl}\) = time to initiate leakage to ground water.

\[
T_{gl} = \frac{S_{gw}}{Vel_{s,prod}} = \frac{5}{0.282} = 17.7 \quad \text{so } t_{gl} < t_{ld}\ (t_{ld} = \text{leak detection time for a tank without release prevention barrier = 360 days})
\]

Since \(t_{gl} < t_{ld}\), so \(Bbl_{\text{leak,groundwater},n} = 0\) (Para 7.12.3e of API 581)

- \(Bbl_{\text{leak,subsoil},n} = Bbl_n^{\text{rupture}} - Bbl_{\text{leak,groundwater}} = 520 - 0 = 520 \text{ barrels.}\)

**Environmental financial consequence of a leak:**

\[
FC_{\text{environ,leak}} = (Bbl_{\text{leak,groundwater},n} \times C_{\text{groundwater}} + Bbl_{\text{leak,subsoil},n} \times C_{\text{subsoil}}) \times gff_n / gff_{\text{total}} \quad \text{............(7)}
\]

\[
= (0 \times 5000 + 520 \times 1500) = 520000
\]

\[
Bbl_{\text{rupture,release}} = bbl_{\text{total}} \times gff_4 / gff_{\text{total}} = 1891 \times 2 \times 10^{-6} / 7.2 \times 10^{-4} = 5.2527
\]

**Cost parameters based on environmental sensitivity (medium):**

- \(C_{\text{indike}} = 10\) (USD/barrel)
- \(C_{\text{ss-onsite}} = 50\)
- \(C_{\text{ss-offsite}} = 250\)
- \(C_{\text{subsoil}} = 1500\)
- \(C_{\text{groundwater}} = 5000\)
- \(C_{\text{water}} = 1500\)

\[
Bbl_{\text{rupture,indike}} = Bbl_{\text{rupture,release}} \cdot (1 - P_{\text{indike}}/100) = 5.2527 \times (1 - 30/100) = 3.67
\]

\[
Bbl_{\text{rupture,ss-onsite}} = (Bbl_{\text{rupture,release}} - Bbl_{\text{rupture,indike}}) \times (P_{\text{onsite}}/100) = (5.2527 - 3.67) \times 0.5 = 0.8
\]

\[
Bbl_{\text{rupture,ss-offsite}} = (Bbl_{\text{rupture,release}} - Bbl_{\text{rupture,indike}} - Bbl_{\text{rupture,ss-onsite}}) \times (P_{\text{offsite}}/100) \quad \text{............(8)}
\]

\[
= (5.2527 - 3.67 - 0.8) \times 0.2 = 0.15
\]

\[
Bbl_{\text{rupture,water}} = Bbl_{\text{rupture,release}} - (Bbl_{\text{rupture,indike}} + Bbl_{\text{rupture,ss-onsite}} + Bbl_{\text{rupture,ss-offsite}}) \quad \text{............(9)}
\]

\[
= 5.2527 - (3.67 + 0.8 + 0.15) = 0.6327
\]

- \(P_{\text{indike}} = 30\%\)
- \(P_{\text{onsite}} = 50\%\)
- \(P_{\text{offsite}} = 20\%\)
Financial cost for a bottom rupture:

\[ FC_{\text{rupture\ environment}} = Bbl_{\text{rupture\ indike}} \times C_{\text{indike}} + Bbl_{\text{rupture\ ss-onsite}} \times C_{\text{ss-onsite}} + Bbl_{\text{rupture\ ss-offsite}} \times C_{\text{ss-offsite}} + bbl_{\text{rupture\ water}} \times C_{\text{water}} \]

\[ = 3.67 \times 10^5 + 0.8 \times 50 + 0.15 \times 250 + 0.6327 \times 1500 = 1063.25 \]

\[ FC_{\text{environ}} = FC_{\text{leak\ environ}} + FC_{\text{rupture\ environ}} = 520000 + 1063.25 = 521063.25 \]

\[ FC_{\text{cmd}} = \frac{[\text{ghf}_n \times \text{holecost}_n + \text{holecost}_4 (D_{\text{tank}}/C_{36})^2]}{\text{gff}_{\text{total}} \times \text{matcost}} \]  
\[ = 208871929.6 \]

\[ = \text{Financial consequence category} = E \]

So the financial consequence category is also stand at the highest.

5.0 Financial Risk analysis:
The risk analysis can be performed by the Risk matrix or by the formula:

\[ R(t) = P_f(t) \times C(t) \]  

So total financial risk at the time RBI analysis:

\[ R(t) = P_f(t) \times C(t) = 0.918 \times \text{USD} \ 208871929.6 = \text{USD} \ 191744431 \text{ per year approximately.} \]

In accordance with the above calculations, the probability of failure and the consequence of failure have been categorized as:

Probability of failure = Category-5
Consequence of failure = category-E

If we look into the risk matrix below, the Risk factor is the highest. Accordingly the tank needs immediate repair or retire from service.

6.0 Role of Magnetic Flux leakage scanner for tank bottom plate corrosion evaluation:
Evaluation of tank bottom plate corrosion is a difficult and huge task and Magnetic Flux leakage technique is one of the techniques for fast and reliable results for evaluation tank bottom plate underside corrosion. Earlier tank floor scanner have the ability to detect underside and top side corrosion but unfortunately could not differentiate between top side and bottom side corrosion. Latest SilverwingFloormap 3Di can also detect and differentiate top side and bottom side corrosion and thus helped a lot to evaluate the risk and analysis of the tank bottom plates. Figure-3 represents a typical floormap scan results of the storage tank bottom plate discussed in this study.

7.0 Conclusion:
The calculation of risk in the Risk-Based Inspection methodology involves the determination of a probability of failure combined with the consequence of failure. Failure is defined as a loss of
containment from the pressure boundary resulting in leakage to the atmosphere from a storage tank. The amount of leakage rapidly increases depending on number and sizes of holes and the condition of the soil underside the tank bottom plates. At some point, a risk tolerance or risk target is exceeded and an inspection is recommended of sufficient effectiveness to better quantify the damage state of the component. The inspection action itself does not reduce the risk; however, it does reduce uncertainty thereby allowing better quantification of the damage present in the component. From the study of the present tank and analysis based on available data and inspection results, it is very clear that Magnetic flux leakage technique pays a major role in calculating the risk assessment study. Present MFL study can also differentiate the corrosion from topside or bottom side. This is a very important information to understand the source of corrosion and the types and rate of corrosion. All the above information are essential in the risk assessment study. The present study also corroborates this fact that MFL is an essential part of Risk Based Inspection of Tank bottom plates.

Figure – 1 (Risk Matrix)
Photo – 1: Topside corrosion at the bottom plates

Photo – 2: Topside corrosion at the bottom plates
Photo – 3: MFL imaging of the bottom plates showing severity and distribution of corrosion areas on the top and bottom sides of the floor plates.

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