RISK ASSESSMENT PROGRAM

of

UNDERGROUND STORAGE TANK SYSTEMS

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SYNOPSIS

This paper describes the Risk Assessment Program (RAP) developed by the South African (SA) Oil Industry Corrosion Control Group (OICCG) for the testing of Underground Storage Tank (UST) systems such as those found at retail and consumer sites.

The various studies carried out into the failure of UST systems in SA is presented.

The Environmental Protection Agency (EPA) regulations governing UST systems is summarised and serves as an introduction to the RAP methodology of "Prevention is better than Cure".

The fundamental corrosion mechanisms applicable to UST systems are described. The relationship between the corrosion rate and the penetration of a buried steel surface is discussed.

The construction standards used for UST systems in SA is presented. The need to asses the majority of non conforming UST systems is emphasised.

The development of the OICCG Risk Assessment Program is introduced. The method of data collection and analysis is described.

The limitations and economic benefits are presented. The control measure options used to reduce site risk are discussed.

INTRODUCTION

Studies carried out by the South African Oil Industry [1] estimate that approximately 53% of sites have a history of leaking UST systems.[2] From a study of withdrawn UST's it is apparent that life expectancy can range from 8 to 27 years with an average of 17 years, depending on soil conditions, proximity to DC traction systems, quality of coating, etc.[3] These trends are shown graphically on pages 9 and 10.

Whilst mechanical failure due to poor construction may be the main reason for UST system failure during initial service, thereafter corrosion becomes the principal cause of leaks. The connecting pipes in a UST system are particularly vulnerable to corrosion induced leaks.

Environmental, health and safety concerns have led to new regulations governing UST installations used for the storage and handling of hazardous substances. A Risk Assessment Program is necessary to assure the integrity of the UST system thereby limiting the exposure to unnecessary liabilities, protect capital investment, provide public safety and compliance with regulations as well as protect the surrounding environment and avoid costly remediation.

REGULATIONS

In 1991 the OICCG reviewed the Environmental Protection Agencies (EPA) regulations in the USA governing UST systems used for the storage of hazardous products. The following is a summery of the EPA requirements.[4]

No person may install an underground storage tank unless:

1. It will prevent releases resulting from corrosion or structural failure for the life of the tank.

2. It is cathodically protected (<12000 ohm-cm), constructed with non corrosive material, or its equivalent.

3. Materials of the tank or liner are compatible with the product stored.

Regulations such as EPA have forced oil companies to comply with stringent legislation with far reaching cost implications. Most of these regulations address the consequences of leaks (containment) rather than the cause (corrosion).

Corrosion is responsible for the majority of UST leaks. It stands to reason therefore that the mitigation of corrosion will substantially reduce the incidents of leaks. Furthermore, it is far more viable and economic to treat the cause rather than the consequence.

Protection against the consequences of leaks involves the installation of costly secondary containment systems. It is far more cost effective to treat the cause of leaks by installing corrosion control systems such as cathodic protection.

* Numbers in brackets refer to numbered references on page 8.

CORROSION OF UST SYSTEMS

reaction with its environment. At the surface of a corroding metal there are active electrochemical cells where electric current is discharged from the which **corrodes** **cathode** which is .[5]

backfill soil, the presence and magnitude of stray DC current and the use of dissimilar materials such as galvanised pipes. The time taken for corrosion to penetrate the tank wall depends upon the original

diameter of a tank also increases the intensity of concentration cells between the top and bottom of the UST. This is due to the fluctuations in oxygen, moisture, soil composition and temperature which exist

Also contributing to the corrosion of tanks are spillage's associated with the site operation which impinge and deteriorate the epoxy tar coating on the top of the tank. The large areas of coating **cathode** of the corrosion cell **anode**.

Whilst internal corrosion of UST's is not a common problem, some cases are documented. It has been the authors observation that internal corrosion is mostly restricted to the shell plate directly below the

which is present on the steel surface.

UST CONSTRUCTION

comprised of epoxy tar coated tanks and steel pipes. New standards were introduced in 1991 to improve the manufacture (SABS1535) and installation (SABS089) of UST systems. These standards

- Glass Reinforced Polyester (GRP) coated steel tanks (Composite tanks) as apposed to epoxy tar

- High Density Polyethylene (HDPE) pipes as an alternative to steel pipes.

  Tanks fitted with manways to facilitate inspection and repairs.

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Tests carried out on GRP and epoxy tar coated tanks in 1992 by the OICCG confirm that a correctly manufactured and installed composite UST system achieves a far greater level of external corrosion [6]

However, UST systems constructed to the old standards of epoxy tar coated tanks and steel pipe by far

of UST systems in SA are not adequately protected and hence are susceptible to corrosion induced leaks.

RAP DEVELOPMENT

The revised SABS standards were introduced in 1991 to address the manufacture and installation of new UST systems. The SA oil industry also embarked upon a Vacusonic tank leak testing program to assess the extent of leaking UST's. This assessment involved the testing of tanks which exceeded 25 years of age using the acoustic emission technique. The results released by the SA Oil Industry Environmental Committee in 1992 revealed that of some 979 tanks tested, 94 were leaking.

Whilst the 25 year program revealed some interesting statistics, the cost and difficulty of performing the test as well as the fact that age does not necessarily predict tank failure reduced the effectiveness of Vacusonics as a long term risk assessment technique. In 1993 the OICCG reviewed the problems associated with UST's and solicited support from the oil companies to develop a pro-active corrosion control program.[7]

In 1994 a working group was established to devise a protocol on underground tank testing. A number of workshops followed to assess the feasibility and method of risk ranking. These workshops provided some useful ideas and highlighted the need to reach consensus on a common Industry approach.

As a Joint Industry Facility with some 35 years of corrosion experience, the OICCG started work on a conceptual design for a risk ranking system culminating in the Risk Assessment Program (RAP) described in this paper. The basic concept of RAP involves three aspects, namely:

1. RAP data collection - collection of data pertaining to five elements.

2. RAP data analysis - a computer based Risk Assessment Program.

3. RAP control measures - risk reducing site remediation options.

RAP DATA COLLECTION

RAP includes a **desk top exercise** to record *site details*, *construction details* and *site history* as well as a **site survey** to determine the *site characteristic* and *environmental sensitivity*.

The **desk top exercise** involves the input of the following data:

- *Site Details* - Owner, description, site code, operator, address details, etc.

- *Construction Details* - Building details, UST capacity, UST material, pipe material, overfill protection, etc.

- *Site History* - Leak history, leak detection, land usage, public image, product throughput, site inspection and maintenance details, etc.

The **site survey** is conducted to determine the following information:

- *Environmental details* - Population density, soil type/permeability, depth to ground water, proximity of boreholes, distance from surface water, water use, etc.

- *Site Characteristics* - Soil resistivities, structure to soil potentials, stray current influence, soil pH, CP current drain details, etc.

The above details are entered into RAP, a computer based risk assessment program.

RAP DATA ANALYSIS

The RAP computer data base combines the **desk top** and **site survey** information to derive a ***Risk Grade*** and ***Failure Prediction Index*** (FPI) for each site. The ***Risk Grade*** determines the control measures required to reduce the risk of UST leaks and the consequential contamination, cost, safety hazard, adverse publicity, etc. The ***FPI*** indicates the length of exposure and assists in determining and prioritising the Control measures.

The ***Risk Grade*** is attained by equating risk values and weighting factors derived from *Site Measurements, Construction Details, Site History* and *Environmental Details*. The ***FPI*** is calculated by equating the age of the site with a corrosivity factor derived by the RAP data base. Once RAP has assigned a ***Risk Grade*** and ***FPI*** to a site, where necessary, recommendations for control measures to reduce the site risk are established in consultation with the site owners

RAP has been developed to provide a user friendly Windows operating environment. The **Data Maintenance menu** of RAP allows the initial set up of owner details and facilitates the desk top and site survey exercises. The **Query** and **Report menu** of RAP provides comprehensive processing of information such as risk grade, leak history, environmental sensitivity versus town, region, age with immediate reporting functionality. The **Utility menu** of RAP allows for the update of data from different assessors, security of confidential information and the remote monitoring of control systems.

It is important to note the limitations of RAP. Firstly, corrosion is a complex phenomena and whilst RAP conceptualises the risk grading procedure, it does not entirely remove the level of expertise required for accurate site assessment. Secondly, whilst it is possible to assess the corrosion rate of a site, penetration of the tank or pipe wall and hence leak prediction is more difficult. Penetration of the steel depends on the nature of the corrosion occurring which is virtually impossible to determine on a complex UST system with non destructive tests. For example, two tanks under similar site conditions would have vastly different life expectancies should one be subject to general corrosion (extensive coating failure) and the other localised pitting corrosion (good coating with small defects).

RAP CONTROL MEASURES

Whilst RAP provides an informed risk analysis for each site, the site will remain a problem until such time as the appropriate action is taken to reduce that risk.

Where applicable, RAP includes a number of recommended control measures to reduce risk. These may include, but are not limited to inventory analysis, tank testing, repairs, replacement or abandonment, cathodic protection and leak detection systems. The decision as to which control measures to apply is taken in consultation with the site owner after due consideration for safety, economics and regulations. As it is not practical or economically viable to replace all the non standard UST systems built prior to 1991, other means of ensuring system integrity has to be considered.

Corrosion control systems which inhibit metal loss are an effective means of reducing leaks and providing protection to Environmental Health and Safety. Cathodic protection is gaining support as a viable cost effective means of reducing the risks associated with UST system failure. The OICCG are installing CP systems which not only provide the UST system with protection but also allows remote access to information critical to the integrity of the site. Remote monitoring is achieved from an office computer which has access to the CP unit via a built in modem card.

The RAP procedure is shown on the schematic chart on page 10.

RAP ECONOMICS

Pending legislation in SA will have far reaching economic consequences for UST system owners. For this reason the SA Oil Industry have taken the initiative to invest in a means of risk assessment which can identify acceptable alternatives to costly tank replacement, secondary containment, corrosion protection and leak detection systems.

The average cost of conducting a RAP survey on the entire UST system amounts to approximately R950. In comparison, the cost to conduct a Vacusonic leak test on a single UST amounts to approximately R1700.

The cost to retrofit CP to a typical UST system amounts to approximately R15000 which includes the protection of all the buried tanks and pipelines. The estimated cost to replace a single $23m^3$ tank amounts to R35000 which does not include the possible costs associated with the loss of business, environmental cleanup or litigation.

It can be seen that a comprehensive approach to the problem of corrosion control costs less than 45% of the cost of replacing a single tank. Should other costs such as cleanup be incurred during tank replacement then the advantage of corrosion control increases substantially. Prevention is better than cure and corrosion prevention makes both economic and environmental sense.

CONCLUSION

There are large liabilities associated with the operation of UST systems. RAP provides a viable, economic means of collecting and analysing data with a view to controlling corrosion and minimising liability. The main conclusions are:

- Regulations can have far reaching consequences for UST system operators without the correct attention to risk management.

- UST systems fabricated from steel **are** exposed to aggressive electrolytes and **will** corrode if not protected.

- Corrosion is largely an electrical process which can be measured and controlled.

- RAP provides a viable economic method of evaluating risk and determining control measures.

- Cathodic protection is an effective and economic means of providing corrosion and hence environmental protection.

UNDERGROUND STORAGE TANK STATISTICS

A national study carried out by the OICCG in 1977 on withdrawn UST's as a result of corrosion revealed the following information: [1]

- The life of 476 UST's studied was as little as 8 years, as much as 27 years and an average of 17 years. (see chart 1)
- Some 10% of UST's had a life of less than 15 years.
- Inspection of withdrawn UST's revealed that invariably tanks leaked due to external pitting corrosion.

The 1992 results of the Vacusonic Testing Program carried out by various participating Oil Companies revealed the following: [2]

- Of 979 UST's tested, 94 (9,6%) were found to be leaking.
- It was speculated that failures could be influenced by age, non standard modifications, soil conditions and proximity to DC traction systems.

A Service Station assessment carried out by the OICCG in 1995 involving the risk grading of three sites prior to closure and the comparison of these results with the subsequent inspection of the removed tanks revealed the following:

- The RAP values obtained corresponded with the inspection results.
- Localised paint failure resulted in deep pitting corrosion whereas extensive paint failure resulted in less severe general corrosion.
- Low soil resistivity is more conducive to corrosion activity and soils consisting of heavy clay often supports Microbiologically Induced Corrosion (MIC).

The 1996 results of the RAP surveys carried out by the OICCG at 206 service station sites in South Africa revealed the following: [3]

- Of some 109 (53%) confirmed leak histories, 8 (7%) was due to mechanical failure and 101 (93%) were corrosion induced. At least 68 (62%) of the total number of leaks were due to pipe failures.
- 155 (75%) sites exceeded 15 years of age.
- 96 (47%) the sites are installed in aggressive soils with resistivies less than 6000 ohm-cm.
- 35 (17%) the sites were influenced by stray current potential fluctuations in excess of 76 millivolt.
- 117 (57%) sites had RAP ratings exceeding 60 with 107 (52%) of sites exceeding an FPI of 60.

REFERENCES

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7. OICCG “Corrosion Protection of UST’s and Pipelines”, CC1681 technical report, July 22, 1993.

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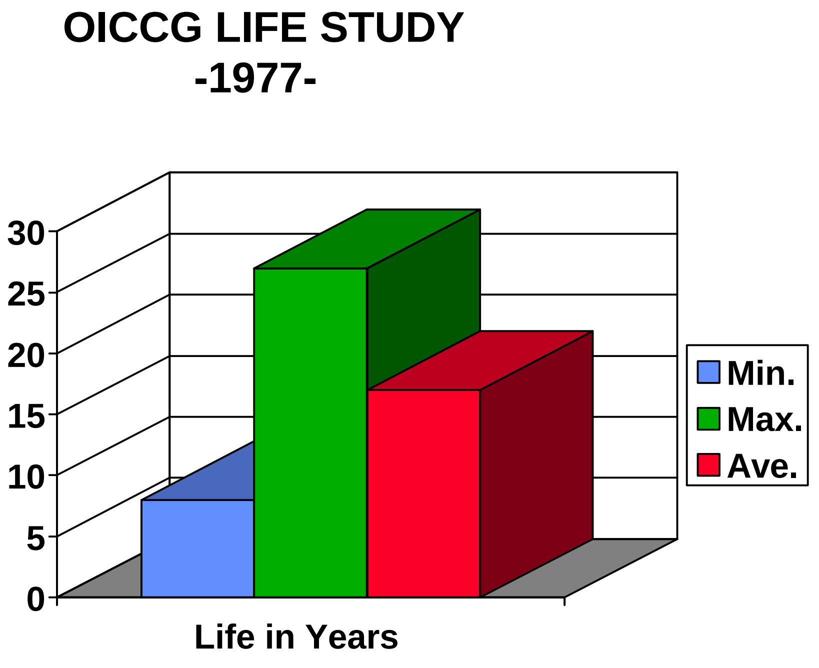
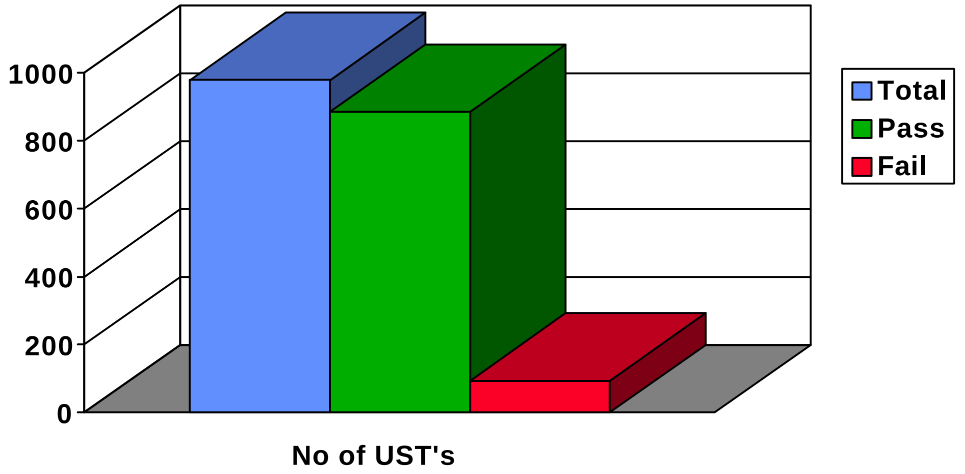
1977 STUDY OF UST's WITHDRAWN

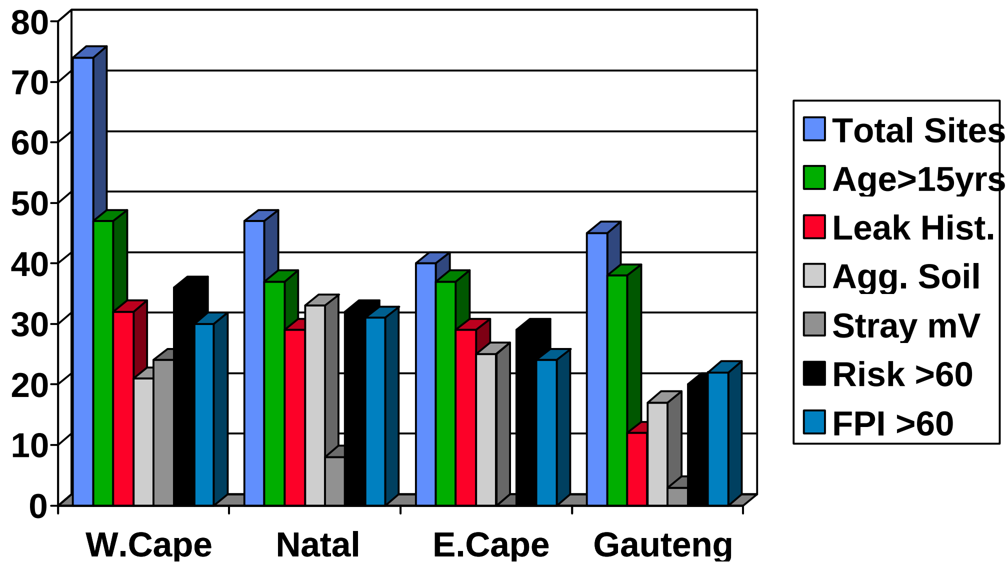


1992 VACUSONIC TEST RESULTS



CHARTS cont.

RAP Test Results



SCHEMATIC OF RAP PROCEDURE