

A Study Of Corrosion In Oil And Gas Tanks

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A B S T R A C T

Corrosion is the degradation of materials usually metal owing to chemical reaction with the environment which result in a functional failure of component. Corrosion is a reverse extractive metallurgy, which depends on the concentration of environment, stress, erosion and the temperature. It causes major economic losses ranges from 1% to 5% of GNP per year for any nations. In addition, corrosion not only increases the costs of component but it also responsible for life losses and safety hazard. Hence, the aim of this review paper is to provide an overview of distinct types of corrosion and their preventive method. So, that corrective action may be taken to minimize the effect of corrosion related problems..

INTRODUCTION

Corrosion of metals brings together multiple phenomena linked to the environment in which it takes place. These phenomena depend on a large number of factors that intervene not individually but in more or less complex relationships with each other (the nature and structure of the material, the environment and its chemical characteristics, the temperature, etc.). Multiple means of combating corrosion exist, and each must be appropriate for each case. Passive prevention remains the best solution to avoid corrosion of metal installations.

The most common way to prevent a metal from corroding or to delay its corrosion is to apply a waterproof coating to its surface. If the coating layer provides a perfect protective barrier to the metal in a corrosive environment, then neither oxygen nor water will be able to reach its surface and corrosion will ultimately be prevented. The role of the coating is, therefore, to limit the flow of these products (oxygen, water) by creating a physical barrier.

Unfortunately, most coatings, such as paints, are not perfect barriers against corrosion and, therefore do not protect metals from

the existence of defects or diffusion of oxygen and water through them. For all these reasons, it is necessary to resort to other methods of metal protection, such as corrosion inhibitors, anodic protection and cathodic protection. [1]

METHODS

Chapter 1: Bibliographic Study

Notions of metal corrosion:

1. Introduction:

Like all construction materials, steel tends to deteriorate superficially when subjected to corrosive environments such as soil, air, and the marine environment. Corrosion is the deterioration of materials by physicochemical interaction with their environment, leading to changes in the properties of the metal, often accompanied by functional degradation of the latter (alteration of its mechanical, electrical properties, etc.). The mechanisms involved are diverse and lead to different forms of corrosion. [1]

2. Definition of corrosion:

Corrosion is a chemical or electrochemical reaction between a material, generally a metal, and its environment which leads to degradation of the material and its properties. Corrosion refers to the physicochemical interaction between a metal and its surrounding environment, leading to modifications in the properties of the metal and often a functional degradation of the metal itself, its environment, or the technical system constituted by the two factors. Corrosion, therefore, represents any process of degradation of metallic materials or their properties following a reaction with the environment [2]

3. the different forms of corrosion:



Figure 01 Corrosion general (rust) of a piece in steel



Figure 02 Corrosion friction of a piece in steel [3]



Figure 0 Corrosion galvanic of a piece

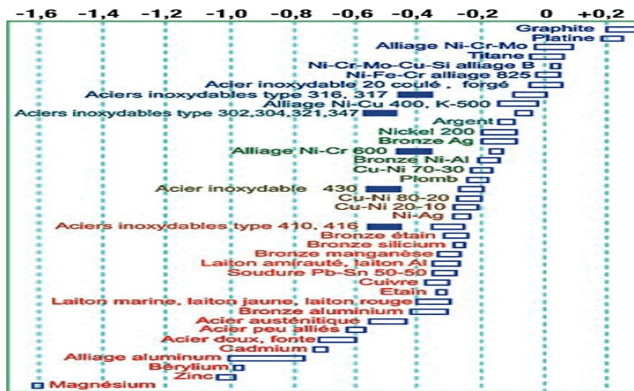
Figure 04 Series galvanic of graphite And of miscellaneous metals And alloys In the water of sea [3]

4. Corrosion-fatigue :

Corrosion-fatigue is distinguished from CSC by the fact that the stresses

applied are no longer static, but cyclical (alternating periodic forces).

the oxygen content of the environment, its temperature, its acidity, its composition have a great influence on the sensitivity of a material to this mode of corrosion.



Time dependent factor	Factors define conditions	Metallurgical factors	Corrosive environment factors
Aging	Surface condition	Composition of the alloy	Concentration of the reagent
Mechanical tensions	Shape of the parts	Processes Of development	Oxygen content
Modification of protective coatings	Use of inhibitor	Impurities	Environnement PH
	Processes assembly	Thermal treatment	Temperature
			Pressure

Although there is no direct relationship between sensitivity to this type of corrosion and the mechanical characteristics of the material, alloys with high mechanical strength are often the most sensitive.

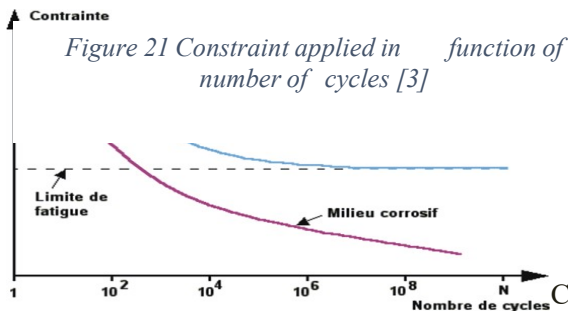


Figure 21 Constraint applied in function of number of cycles [3]



Corrosion-fatigue can be eliminated or reduced by

Figure 22 Blistering related has an overprotection cathodic of a pipeline oil. [3]

5. The different forms of corrosion:

Corrosion phenomena can develop through different processes: chemical, electrochemical, biological corrosion, and corrosion accompanied by erosion. [7]

- Chemical corrosion:
- Biochemical Corrosion:

- Companioned erosion Corrosion :
- Electrochemical Corrosion:

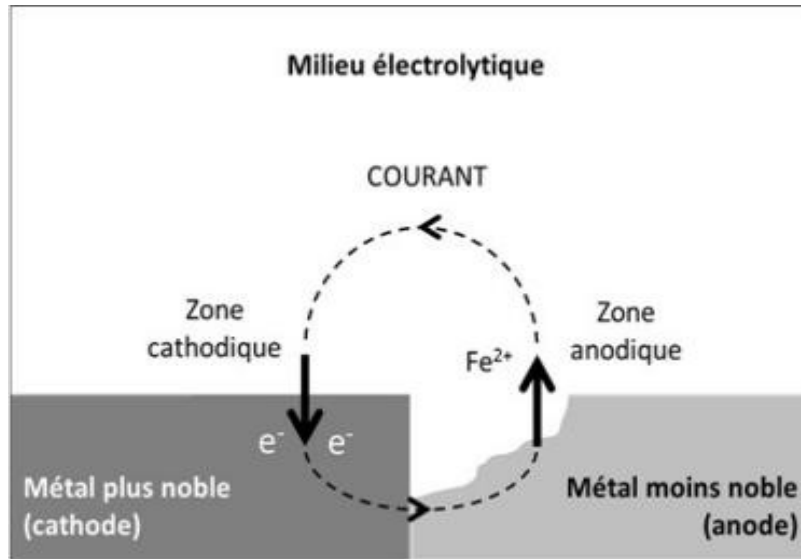


Figure 23 there corrosion of the materials metallic in water of sea galvanic corrosion

6. Factors of corrosion:

Corrosion phenomena depend on a large number of factors and they can be classified into four main groups:

The protection of the metals against corrosion:

Corrosion prevention should start already in the planning phase. In other words, corrosion must be taken into consideration from the start of a project until its completion. This is about guaranteeing a certain lifespan for an object. In addition, the solution adopted must be compatible with the requirements concerning the protection of the natural environment and must allow the recycling or elimination of the various components at the end of their use. Corrosion control includes the following methods:

- Prevention through a suitable shape of the parts,
- Prevention through a judicious choice of materials,
- Protection by coatings,
- Protection by inhibitors,
- Electrochemical protection. [5]

I. STORAGE OF PETROLEUM PRODUCTS

1. Introduction

Oil and gas storage consists of temporarily immobilizing specific volumes of oil or gas in storage capacities called pressure vessels or tanks depending on whether the stored product is or is not under pressure. The main characteristic of the oil industry is the use of very large tonnage of hydrocarbon. In liquid or gaseous form, it is obliged to provide enormous storage capacities. This trend will increase with the obligation made by the new regulations which provides for the creation of a stock equivalent to three months of consumption for each country in order to protect itself from possible shortages. [9]

2. Presentation of storage tanks: tank equipment and accessories

2.1. Definition:

A tank is a cylindrical and vertical tank intended for the storage of liquid hydrocarbons.



Figure 05 Crude storage bin

3. Tray equipment:

- The dress: It is a vertical wall made of sheets curved to the diameter of the tank.
- The ferrule: It is a ring made of sheets whose succession gives the dress.
- The bowl: It is a compartment built around a tray or a set of trays intended to receive the contents of the tray or set of trays in the event of an accidental leak. The bottom: This is the base of the tank; it is also made of a set of sheets.
- The base: This is the foundation on which the tank rests. The roof: This is the upper part of the tank, which is made of sheets assembled. It can be fixed or floating.

4. Tanks and components:

Vertical metal tanks are classified into three types:

- Fixed roof tanks,
- Floating roof tanks,
- Fixed roof and floating screen tanks,

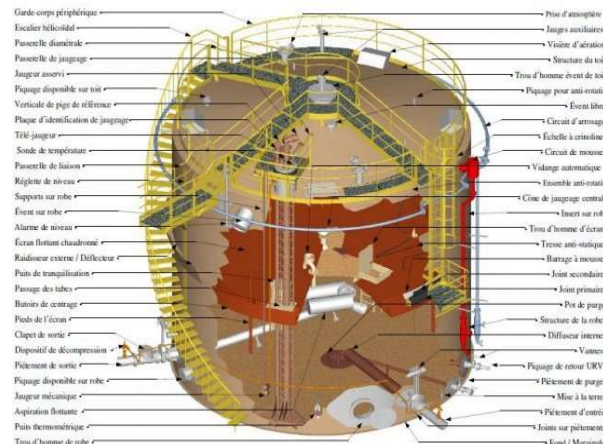


Figure 06 Plan of a reservoir with a fixed roof

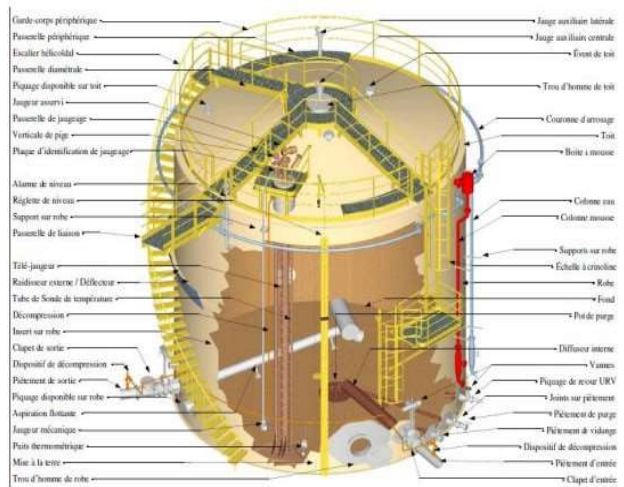


Figure 07 Plan of a reservoir with a floating roof

Chapter 02: The Experimental Part

II. Corrosion of R8 storage bin:

1.1. Introduction:

In this chapter, we presented, Following a request made by the Production division (DP) in the TFT industrial region, and after the sanding of the bottom sheets and the first shell of the tank following the recommendations mentioned in the report previous expertise, we carried out second technical expertise on the bottom sheets and the sheets of the 1st shell of the R8 storage tank located at the CPC storage center, this operation carried out by a specific organization of expertise and control quality.

1.2. Technical characteristics of the equipment:

Vertical cylindrical tank with a fixed roof made up of 05 shells in the form of a vertical cylindrical envelope with a welded conical roof.

Builder/Country	ENCC HASSI LOVE / Algeria
Year of manufacturing	1991
Landmark	R8
Stored fluid	Hydrocarbons
The pressure of service (bar)	Atmospheric
Coded of construction	API 650 STD
Kind	Air
Extra thickness of corrosion (mm)	03
Ability (m3)	1000
Height (mm)	10950
Diameter interior (mm)	34137

1.3. OBJECTIVE:

The assessment aims to determine the various anomalies and defects encountered in the bottom plates, and the 1st shell to inspect the tank breaks down as follows:

- Visual inspection of all sheets, welds, and their general condition.
- Control of the average residual thickness by sampling.
- Approximate assessment and recommendations of the general condition of the bottom plates and the 1st shell.

1.4. VISUAL STATES AND OBSERVATIONS:

Our findings and observations will be carried out on all of the bottom sheets as well as on the sheets of the first shell; the visual surface condition is as follows:

1.4.1. Fund sheets:

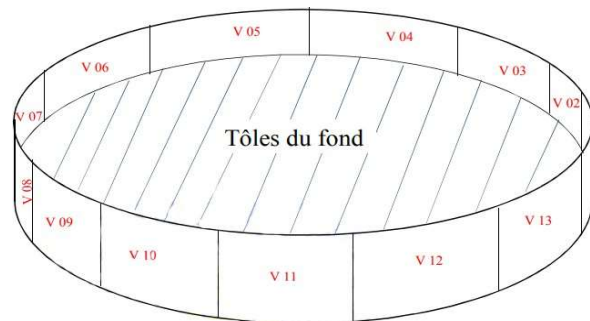


Figure 39: Representation schematic approximate of the distribution of the sheet metal of their 01^{era} ferrule of bac R8

a.General condition:

The general appearance of the base, which has already undergone repairs by reloading points Fig39 and by welding of patches only at the junction between the sheets of the 01st shell and those of the base, Fig40 reveals an irregular relief on specific sheets due to their warping Fig41.

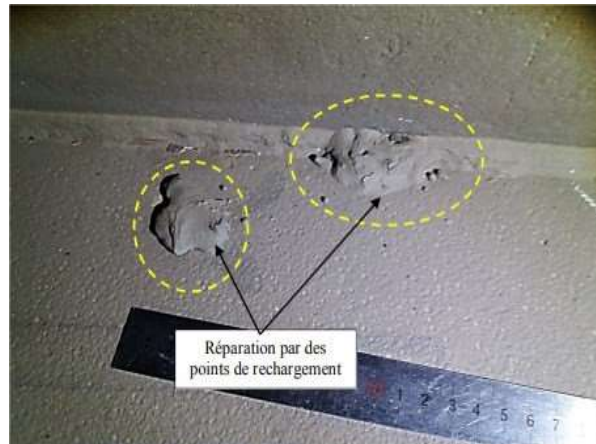


Figure 08 Repair by of the points of reloading

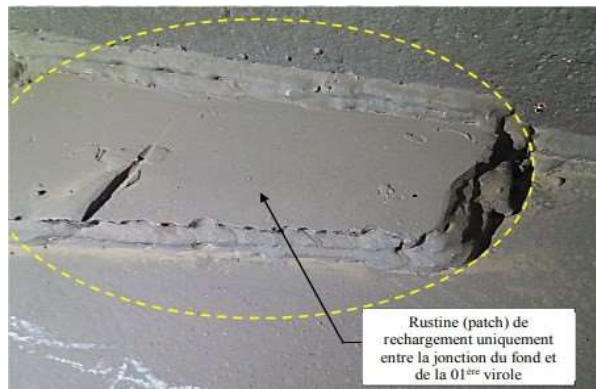


Figure 09 : Repair by patch (patch) uniquely between the junction of the bottom And of the 01^{era} ferrule

For deformation defects:

Most of the bottom sheets have suffered deformation, some of which presented in severe condition.

1.4.2. Sheets of the first shell:

All the sheets on the 01st quarter of the first shell represent an erosive aspect by the presence of craters and corrosion pits ranging from light to severe, while in the remaining $\frac{3}{4}$, the corrosion is only partial with the same form and type only in $\frac{1}{4}$ of the sheets.

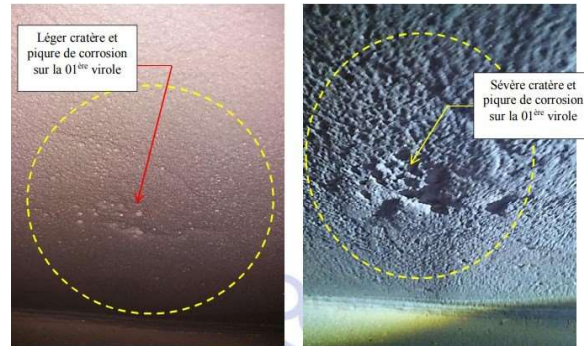


Figure 12 Light And severe craters and bites And bites of corrosion on there 01^{era} ferrule

✓ Beginning of degradation of the bridle of line shipping At the level of their V10 .



Figure 13 Degradation by corrosion of the flange of their line shipping side back

✓ Degradation of the brackets of a tube of gauging and the stems of the touch plate



Figure 14 Degradation by corrosion of the brackets of tubes of gauging

III. MEASURE BY ULTRASOUND:

the Ultrasonic testing is a method of non-destructive testing allowing the detection of defects inside a material. Ultrasonic testing is based on transmission And there reflection wave of ultrasonic type the interior of a material. the waves used can be free (of compression Or of shear) Or guided (surface or plate).

1. Used Equipment :

the 27MG from Olympus is an inexpensive ultrasonic thickness gauge designed to take precise single-sided measurements of internally corroded or eroded metal tubes, tanks and other equipment. Its lightweight design (only 340 g) And ergonomic allow of the manipulate has a hand. Despite his little one size, This meter thick East endowed of a big number of innovative features leveraging the same technologies as our more advanced thickness gauges. Powered by batteries, this device sustainable And robust East team of a big screen LCD has backlight facilitating there reading of the numbers. He offer Also A keyboard Intuitive color coded giving direct access to many essential functions. [12]



Figure 18 the meter thick portable 27MG

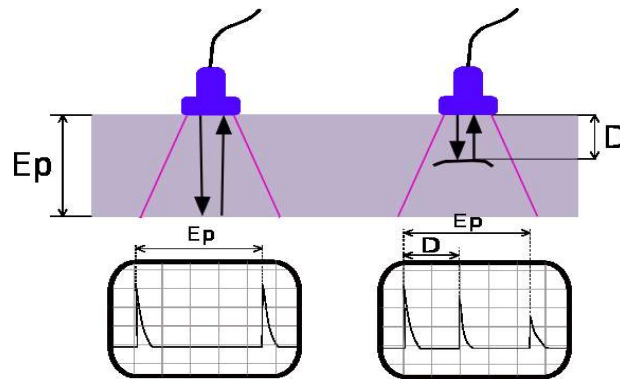
The standard functions are: automatic recognition of probes for to optimise performance, compensation automatic zero For improve the accuracy of measurements made on high temperature surfaces, gain adjustment For improve the measures on the materials has strong mitigation (as the cast metal), fashion differential, alarms high And bass And fashion minimum And maximum which keep the minimum or maximum measurement at 20 measurements per second. [12]

2. Principles:

An ultrasonic wave is emitted by a transducer placed on the surface of the material to be tested and propagates in the material. there are methods by contact (the probe is in contact with the part) or by immersion (the part and the probe are immersed in water). In the case of the contact method, it is necessary to add a couplant (water or gel) between the probe and the part to ensure the transmission of the waves. When these ultrasounds encounter an interface delimiting two environments having different acoustic impedances, there is reflection. Ultrasound think are captured by A feeler (Who can be the even that the transmitter). An “echo” is created.

In the case of a part comprising two surfaces, defect detection is done by comparing the time taken to make a round trip through the part's thickness and the time taken to reflect on a defect.

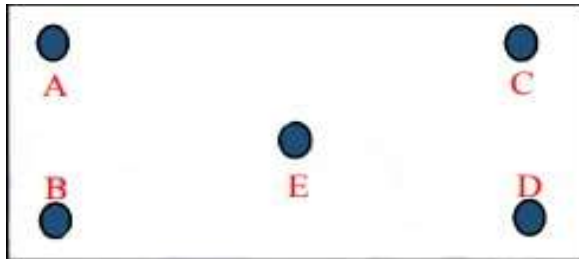
From a practical point of view, we use an oscilloscope screen. Peaks on the screen represent echoes. [13]



3. Thicknesses of funds And their 01st ferrule :

the 115 sheet metal of the bottom have summer controlled by ultrasound 27MG Since the interior has reason of 05 points by sheet metal according to the following plan:

IV. Protection cathodic of the funds of the bins of storage



1. Calculation of there pc internal of the bins

a) Protecled Surface t :

For the bins :

$$Her = \Pi \times D \times (D / 4 + Hw)$$

Or :

$$Her = \text{Surface total (m}^2\text{)}$$

p = postman Who defines there surface wet some water

D = Diameter internal (m)

L = length of boat (m)

Hw = height of reservoir in contact with the water (m)

For the tanks buried (separator , dryer, column, ships...etc.)

$$Her = \Pi \times D \times p \times (L + D)$$

b) Fluor total required For the protection :

$$I_t = i \times S_a \times x$$

Or :

I_t = fluor total required (HAS)

i_0 = density current of protection has a temperature going until 30 ° VS (HAS / m²)

i = density of fluor of protection to there temperature of functioning (HAS / m²) = $i_0 + 0.25 i_0 [(T-30) / 10]$

T = temperature of functioning (° VS)

f = postman of geometric compensation

c) Mass total anode required For the protection :

$$W_t = (VS \times I_t \times Y) / U$$

Or :

W_t = Mass total of the anode required (kg)

VS = rate of consumption anode (kg / HAS / year)

Y = duration of life theoretical (year)

U = postman of use of the anode

d) Quantity anode required by weight :

$$N / A = W_t / W_a$$

Or :

W_a = Weight of the anode unique (kg)

N / A = Quantity anodes in reason of required weight of the anode

e) RESISTANCE of the ANODE :

$$R_a = [r / (2 \times L)] \times [\ln (8 L / d) - 1]$$

Or :

R_a = resistance anodic (ohm)

d = diameter equivalent of the anode (m)

L = length of the anode (m)

r = resistivity of the water (ohm m)

Exit fluor by anode :

$$I_a = (E_a - E_p) / R_a$$

Or :

I_a = Exit fluor anodic (HAS)

E_a = potential of circuit anodic close (V)

E_p = Potential of protection in steel (V)

R_a = resistance has the anode (Ohm)

Quantity anode required For satisfy the fluent total required :

$$N / A = \text{That} / I_a$$

Or :

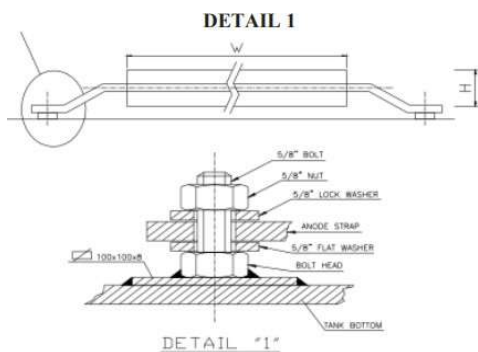
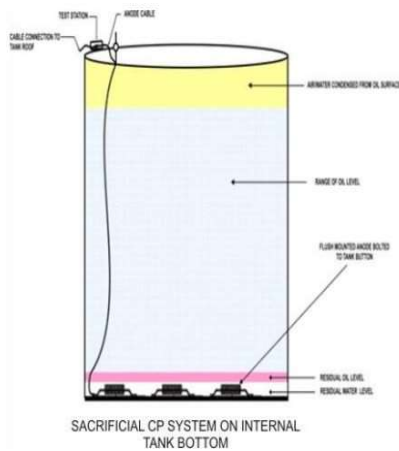
N / A = quantity anodes in reason of fluent required

Quantity final anode :

the more big number anodes between N / A And N / A defines there quantity final anodes .

Fashion installation of the anodes In the bins :

there shape anode next (climb on foot) must be installed on the walls from the tank to the bottom as follows:



2. CHEMICAL COMPOSITION OF ALUMINUM ANODES

The aluminum must be an Al-Zn-In alloy, the composition of which is indicated in the following table:

3. Protection cathodic of the funds of the bins external (in contact with the ground)

Impurities material	Composition (%)	Alloy of material	Composition (%)
Fe	0.01 max	Zn	2.5 – 5.50
Cu	0.006 max	In	0.015 — 0.040
If	0.150 max	Al	Stay
CD	0.002 max		
Others (total)	0.15 max		

3.1. Terms of design :

The CP system must be based on the use of the ICCP system to protect the bottom of the tanks in contact with the ground has ugly of a entrance of fluent continuous (transformer / rectifier) And anodes.

3.2. Features of the anodes in silicon

Designation	Value	Comments
Kind anode	Anodes in Ferrosilicon - chrome	/
Anodic weight	23 kg	/
Density current	10 my /m2	Calculating current density must be increased by 25% for every 10°C increase in temperature (above 30°C).
Postman damage to the coating	100%	the lower surfaces of the tank are considered as naked because he is of existing reservoirs and lining conditions are not known.
Duration of life	20 Y ears	/
Oversizing direct current	30 %	/

Painting of the features of the anodes in ferro-silicon-chromium :

Characteristic	Value
Weight (For an anode)	23 kg
Ability of fluent For a anode	0.5 kg/A.year
Efficiency of fluent	90%
Postman of use	85%
Anode length	1500mm
Diameter anode	50 mm

3.3. Criteria protection

the system must be designed For reach A potential electrolyte structure of (-) 750 mV and the potential maximum must be limit has (-) 1 500 mV in order to to avoid a protection excessive structure.

Potentials should be recorded against a saturated copper-copper sulfate (Cu/CuSO₄) reference electrode.

3.3.1. Calculation Notes

This section details design calculations for storage tanks. the following formulas will be used for the design of a cathodic protection system:

3.3.2. Surface of bottom of ST tank :

$$S_T = \pi \times (D/2)^2$$

D : Diameter of reservoir in meter

3.3.3. Fluent total required :

$$I_T = S_T \times i \times x$$

i : Density of fluent in mA/m²

ST : Surface total has protect in square meter

S : margin of security

He must be the minimum current required For the system of PC propose.

NOTE: An effective cathodic protection system must have good current distribution. This requires placing a maximum quantity of anodes around of bottom of reservoir. there quantity And the location of the anodes are governed by the size of the tank (bottom of the tank), the nominal current of the system and the resistivity of the ground

3.3.4. Weight total anode requireW :

$$W = \frac{\text{temps de design} \times \text{courant totale requis} \times \text{capacité de courant}}{\text{courant effiscience} \times \text{facteur d'utilisation}}$$

With :

Duration of life = 20 years

Anode in melting of silicon Ability current = 0.5 kg / HAS. year Cast silicon anode current efficiency = 90%
Utilization factor = 85%

3.3.5. Quantity anode required NOT :

$$N = \frac{\text{poids anodique requis}}{\text{poids d'anode unitaire}}$$

Weight of a anode : 23 kg

He must act of there quantity minimum anodes required

For the reservoir.

3.3.6. Resistance of the anode has there earth Ra :

$$Ra = \frac{0,159\rho}{N \times L} \left[\ln\left(\frac{8L}{d}\right) - 1 + \frac{2L}{s} \times \ln(0,656 \times N) \right]$$

Ra = resistance of the anode in ohms

L = length of the anode (length of package) equal has 2 m

d = diameter of the anode (diameter of housing) equal has 0.15m

ρ = resistivity in ohm-cm (the embankment surrounding the anodes has a resistivity of 0.5 Ohms.m)

S : spacing between the anodes equal has 3 m

NOT : quantity of anodes

there length of the anode has cartridge East of 2 m And the diameter of 0.15 mr. the Anodes to be installed must have an approximate spacing of 4 m.

Two negative drain fittings are provided per tank for better power distribution and safety reasons.

there length of the cables of head negative East of 115 And 138m .

the cable collector positive has a length of approximately 80 mr.

the lengths of cable of tail anode are of 20 m And 25m .

the cable anode East of 1x16mm² .

3.3.7. Resistance total of circuit :

$$R_T = R_c + R_a$$

there resistance total of circuit understand there resistance anodic And there resistance of the cable. Hence total resistance R T

Rc: cable resistance in ohms Ra : resistance of the anodes in ohms

3.3.8. Assessment of transformer-rectifier :

the transformer-rectifier must to have a ability sufficient For answer has the resistance of the circuit.

there tension of the unit T / R can be calculated in using there formula :

Voltage = Fluent x Resistance

RESULTS

V. The interpretations

The condition of the bottom is often the most important factor in determining the real remaining life of the

tank, which is why we have taken particular interest in studying it visually; We count on the bottom around 840 faults of which around 213 are through. However, human error always remains probable and the possibility of the presence of other defects under deposits cannot be excluded.

4.1. Deformation:

Deformations and subsidences in the bottom can give rise to all kinds of problems:

The presence of water in stored substances can eventually accumulate in these areas so that this cannot be prevented via drainage. The presence of water can cause corrosion in these lower areas.

Another possible consequence of deformations is the creation of excessive tensions in the bottom or side walls of the tank, which can lead to cracks or the existence of areas sensitive to corrosion.

When a tank is empty, deflections may not be directly noticed. Since the bottom is not loaded with product, it may indeed happen that the bottom plate at this location no longer touches the subsoil. Appendix B of API 653 describes a methodology to determine settlements bottom of the tank.

After walking on the bottom sheets we detected by overload (with the weight of the body) critical areas where the sheets do not touch the ground such as sheet E10, E17, B9 and B10, it is therefore desired to cut the sheets on these areas to see the condition of the foundation



Figure 19 the sheet metal of bottom R8 Before there repair

4.2. Corrosion

Corrosion pitting may occur inside the bottom as well as outside:

Corrosion on the external surface of the bottom can be initiated by an electrochemical process where the soil on which the bottom is placed plays the role of electrolyte. Many factors can affect the corrosivity of the soil: pH, resistivity, moisture content, chloride ion content, sulfide ion content, sulfate ion content, oxygen content, bacteria, stray current, etc.

While internal corrosion of the tank generally comes from settling water which can contain agents that promote corrosion such as: bacteria, CO₂, salinity, pH, Cl ions, O₂...etc. especially in the absence or degradation of the coating or even the incorrect application of the coating layers can accelerate the process of degradation by

corrosion.

DISCUSSION

VI. Recommendations and conclusions

□ It is strongly recommended to carry out advanced examinations on the bottom sheets by M.F.L (Magnetic Flow Leakage), to have a detailed evaluation under the bottom sheets by consulting organizations having the necessary tools for carrying out the test; as it is desirable to consult the manufacturer's opinion for even more in-depth examinations and suggestions and to provide the technical file of the equipment.

□ Proceed to measure the roundness and verticality of the tank from the outside and also take readings from the inside of the bottom to check the criticality of settlements and deformations, according to API code 653.

It is strongly recommended to analyze the chemical composition on a sample of a cut sheet in order to obtain its nuance.

Change the corroded supports of the gauging tube.

Change the corroded flange of the shipping line and insulate the flange nuts to avoid galvanic coupling.

□ The craters on the 01st shell as well as the nests of pitting and scratches and also the corrosion craters must be sealed to avoid any propagation in depth.

□ Grind the welding grains and reload the solder joints of supports and patches.

□ Cut suspicious sheets that do not touch the ground such as E10, E17, B9 and B10 to see the condition of the foundation and carry out analyzes by taking samples from the ground to study its aggressiveness.

□ It is desirable to carry out analyzes on the aggressiveness of the substances stored in the tank.

□ Once the work is carried out, repair the bottom using an appropriate method to ensure the general integrity of the equipment.

□ Apply a cathodic protection system to the equipment to protect the sheets from the outside and to the internal coating of the bottom and the first shell.

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