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-TITLE -

**ANALYSIS OF A CORRODED DESALTER REPAIR**

**(Case of Conocophillips CPF desalter )**

Defended on: // 2021 before the examination board

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*We first want to thank the Almighty and Merciful God, who has given us the strength and patience to do this modest work.*

*Secondly, we would like to thank our supervisor Dr. Bennouna Mohamed Salah and the members of the jurors, Please accept my thanks, sir, for the great honor you have given me in accepting the supervision of this work.*

*Mr. Chetti djamal eddine , Mr. Atlili med elhadi and Mr Sid Rohohadj Med*

*I have had the honor to be among your student and to benefit from your rich teaching. Your educational and human qualities are a model for me. Your kindness and your permanent availability have always aroused my admiration.*

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*Thank you for your welcome and your advice.*

*Please find here the expression of my gratitude and esteem*





# Dedicate

*To everyone who taught me letters in this mortal world*


*To the pure pure soul of my father*

*To the soul of my dear, dear mother, who prayed for my  
sake*

*To all members of the educational family in the free  
and proud Algeria*

*To all of these and these I dedicate this modest work*

*We ask God to make it a beacon for every student of  
knowledge*



# Abstract

The quality of the crude oil produced from the wells is considered insufficient for global marketing. Therefore, it must pass through processing facilities (CPF) to remove all useless and toxic components and make it a Valuable product.

During this stage and due to the presence of the harmful elements the processing facilities face several problems, mainly the corrosion.

In this study we presented the causes of corrosion in desalter and applied a system to curing the problem, which consist on the secondary prevention method represented by the sacrificial anode system.

The primary results were positive, as the corrosion rate decreased. However, the final results will appear in the next shut down in 03/2022.

We also provided some recommendation to avoid such a problem in the future.

**Key word:** corrosion, Anodic protection, desalter, Crude oil

# Résumé:

La qualité du pétrole brut produit à partir des puits est considérée comme insuffisante pour une commercialisation mondiale. Par conséquent, il doit passer par des installations de traitement (CPF) pour éliminer tous les composants inutiles et toxiques et en faire un produit de valeur.

Au cours de cette étape et en raison de la présence d'éléments nocifs, les installations de traitement sont confrontées à plusieurs problèmes, principalement la corrosion.

Dans cette étude, nous avons présenté les causes de la corrosion dans le desalter et appliqué un système pour résoudre le problème, qui consiste en la méthode de prévention secondaire représentée par le système d'anode sacrificielle.

Les premiers résultats ont été positifs, car le taux de corrosion a diminué. Cependant, les résultats définitifs apparaîtront lors du prochain arrêt en 03/2022.

Nous avons également fourni quelques recommandations pour éviter un tel problème à l'avenir.

**Mot clé :** corrosion, protection anodique, dessaleur, pétrole brut



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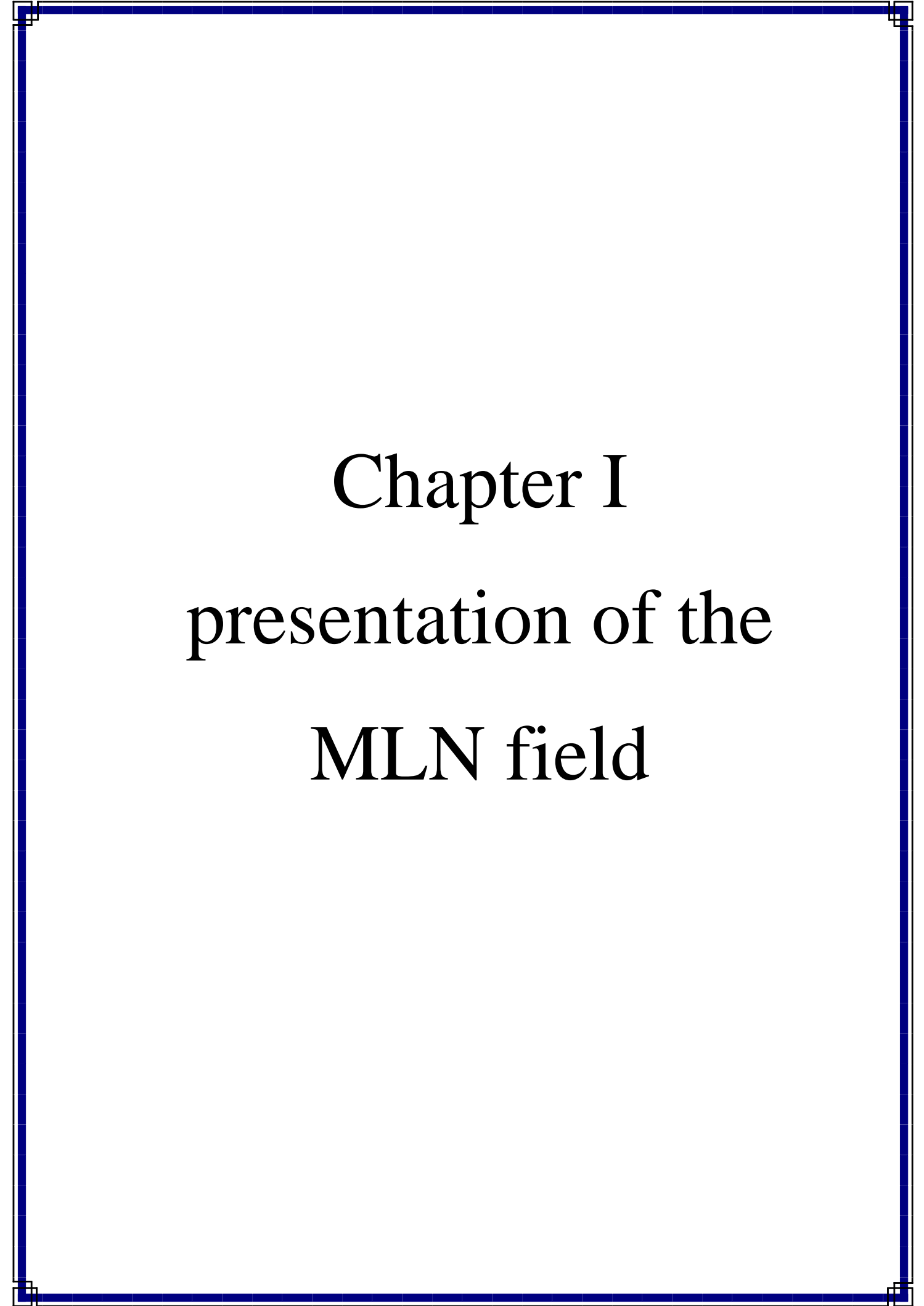
# General introduction

# *General Introduction*

Hydrocarbons have a very heavy impact on global activity in the world and help give it economic and social consistency. The second industrial revolution made oil and gas the driving energy sectors, that is, sources of energy gradually eclipsing the absolute omnipotence of coal (first industrial revolution). Oil is the world's leading source of energy (37.7%) ahead of coal (26.6%) and natural gas (23.9%). Hydrocarbons remain the most widely used source of energy for proper functioning of the world economy in this century [26]. However, the production of crude oil and natural gas does not always go smoothly even if solutions are always found, these problems remain complex and numerous. Among these, there is at least one that the producers encounter and which remains relatively unknown and more unpredictable: it is corrosion. The corrosion of metals and alloys is a universally known phenomenon, generally affecting the economic aspect, it has estimated a loss of 15% of annual steel production or even 5 tonnes / second according to global studies. [1] The objective of our work is to conduct a study on the presence of corrosion in general and corrosion particular in oil and gas processing facilities.

This study is divided into three chapters and a general conclusion:

- ✓ The first chapter is A short presentation of the MLN Conoco Philips field
- ✓ The second chapter is devoted to a bibliographical and general study on corrosion.
- ✓ The third chapter represents an experimental study on the detection of corrosion in Desalter of MLN Conocophilips CPF and how to fix it.



# Chapter I

## presentation of the MLN field

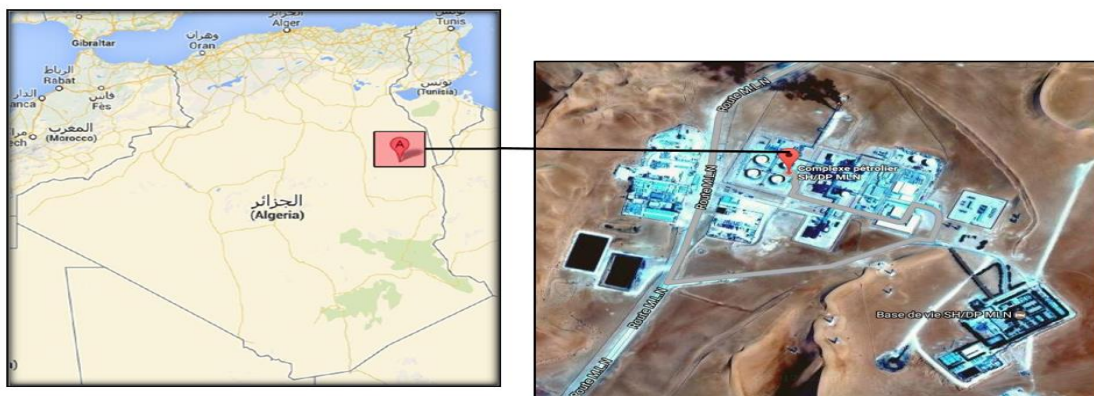
## Introduction

MenzelLejmet North field is one of a series of oil field discoveries in block 405a in the Berkine basin which is located near the town of HassiMessaoud and about 700 km southeast of Algiers. It was discovered in 1996 and started production in 2003 and during this time it has been majority owned by Burlington Resources (an American company), then by ConocoPhillips (an American company) since 2006

### I.1. Presentation of Sonatrach -ConocoPhillips / MLN

MLN (MenzelLejmat Nord) is an association between Sonatrach and ConocoPhillips MLN's oil processing center began operating in June 2003 with a capacity of approximately 30,000 barrels per day.

The MLN Field is located south of the wilaya of Ouargla, about 300 km from Hassi-Messaoud and less than 100 km from the Hassi-Berkine field. And its seat in HassiMessoud:[26]



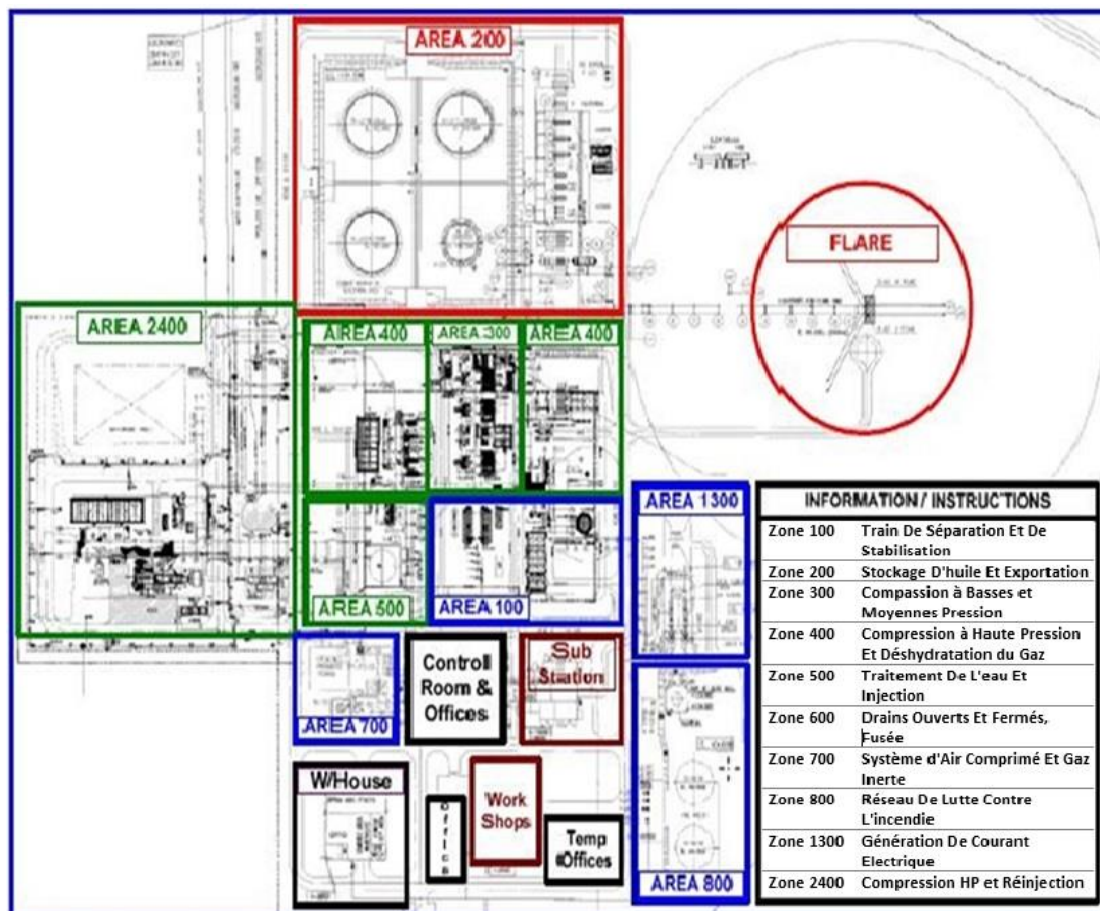
**Figure I- 1:** Geographic Location Of MLN Fields.[26]

The MLN field is designed to receive and process fluids from the MenzelLedjmat North (MLN) on the ground and its satellite fields, MLNW, KMD and the MLC block 405a of the Berkine Algeria basin region. The MLN field is in the north of building 405a about 240 km southeast of HassiMessaoud in a deserted and remote location. The development of block 405a took place in two distinct phases. MLN phase 1

development involved the installation of equipment to receive fluids from these wells in the north of Block 405a.

The MLN Phase II development phase was concerned with expanding the MLN facilities to cope with the production of additional satellite wells.

Total facilities include a central processing facility (CPF), a permanent accommodation camp and an off-site.



**Figure I- 2:** Deferent area of CPF MLN treatment center.[26]

## I.2. Sonatrach - ConocoPhillips / MLN Fields

The MLN field contains wells ranging in depth from 2,500 m to 4,000 m.

Currently, the MLN field has 41 wells.

There are three types of wells:



**I.2.1 Crude oil well:**

The crude oil produced from wells is subject to several controls and specification in the following table .we review the most important specification

**Table I.1:** Specification of Crude oil

Specification	
Specification Gravity @ 15C°/150C°	0.7949 to 0.8086
Gravity API	43.5° to 46.5°
Sulfur Content	0.2% wt max
Crude RVP0	0.59 bar max
BS&W	, (maximum)0.5 % by vol max
Salt content	(maximum)40 mg/l max
Storage Temperature2	(maximum)55 C°

**I.2.2 Injector wells:**

It is a receiving well into which either gas or water is injected

- **The specifications of the reinjection gas:**

The produced gaz is used in three basic cases,either it is a gaz intended for marketing ,a gaz to maintain the pressure of the reservoir or a gaz lift ,and it is also subject to criteria ,the most important of which are shown in the following table

**Table I.2:** Specification of the reinjection gas

Specification	
Maximum water content	112 g/Sm3 (7 lb.MMSCF)
Injection pressure	400 barg downstream of choke valve

▪ Specification of the injection water

Table I.3: Specification of the injection water

Specification	
Solid filtration required	98% of particles greater than 10 microns
Max oil content of produced water	20 mg/l
Maximum oxygen content	10 ppb
Injection pressure Minimum	200 barg downstream of choke valve

I.2.3 Water producing wells:

It is a well that produces water for different uses such as: domestic uses, or process needs (washing crude).

I.2.4 Gas lift wells:

It is a producing well with a very low downhole pressure. The gas lift made it possible to lighten the density of the crude and help it to raise the production column in the "lift up".[02]

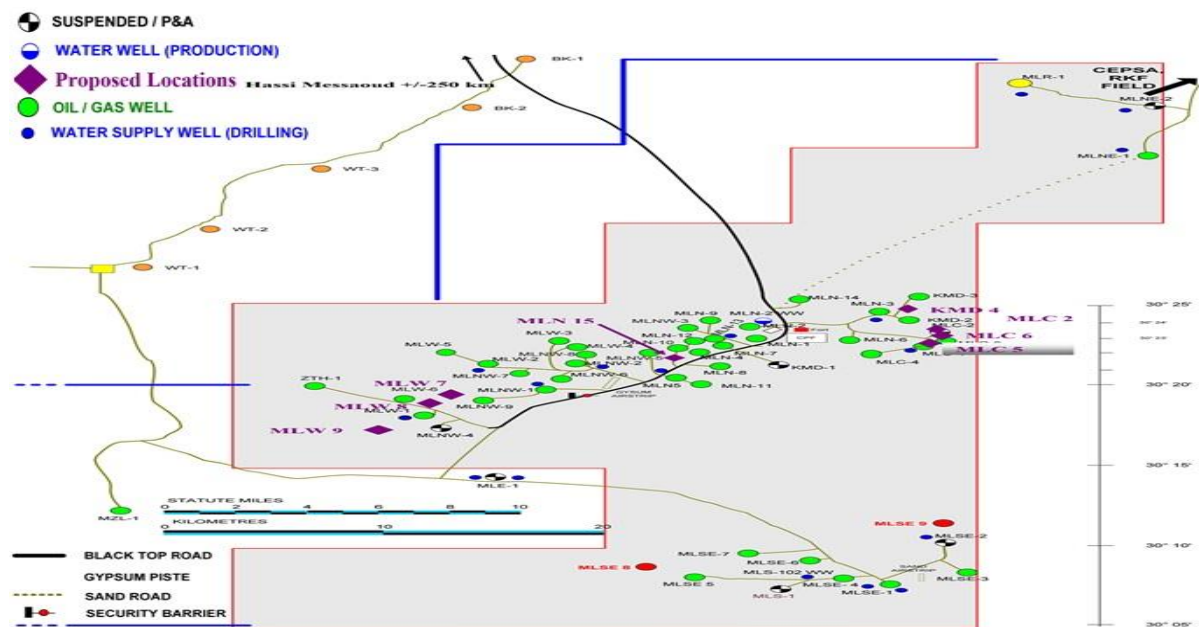
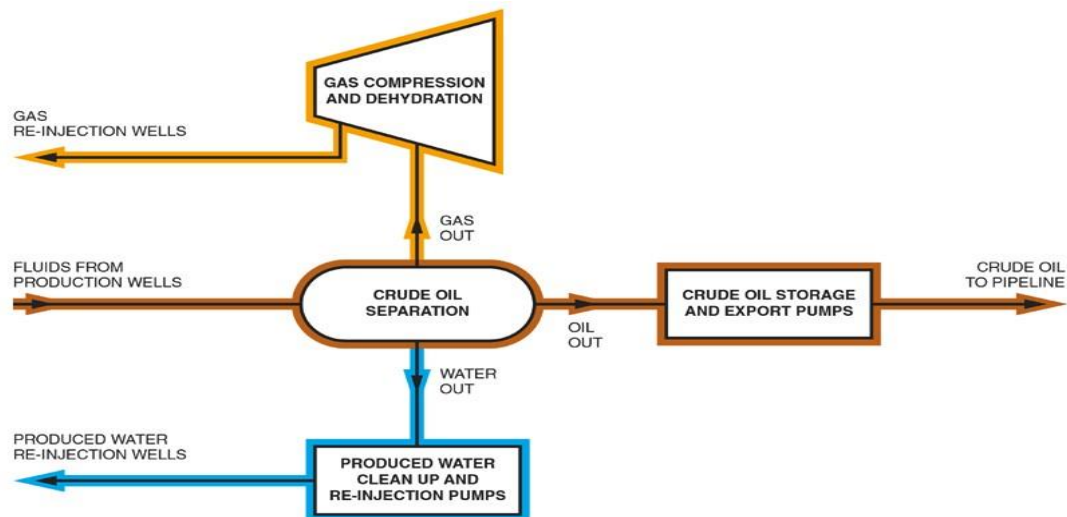


Figure I- 3: Location of MLN field wells[02]

### I.3. Description of production systems

The function of the crude oil stabilization system is to receive and process fluids from reservoirs to produce crude oil, stabilizing in accordance with the specifications required for export [2].



**Figure (I.4):**Diagram of MLN CPF Treatment Process

The system includes:

- HP V-101 separator.
- MP V-102 separator.
- Pumps of the MP P-101A / B / C separator.
- Water filter F-101A / B.
- P-104A / B washing water pump.
- Desalter V-103 / V-104.
- P-103A / B water recycling pump.
- T-101 stabilizer.
- Reboiler stabilizer pump H-101 and reboiler P-112A / B / C.
- Fuel gas filter for the F-102 A / B reboiler.
- E-101 crude oil air cooler.
- Flash balloon for crude oil out of OFF-Spec specification, V 221.
- Crude oil degassing column outside the OFF-Spec V 222 specification.
- Crude oil storage tanks out of specification, V 221.
- Crude oil recovery pump out of specification, P 221 A / B / C.

### I.3.1 System 100: separation and stabilization

#### ✓ HP V.101 separator

The HP separator receives the flow from the collection system and normally operates at 39 barg.

The separator is sized for a capacity of 65,730 SBOPD. The design parameters are (47 barg and 80C).

The residence time of the crude is more than 4 minutes and for the water more than 12 minutes for the maximum expected water recovery (13.730 BWPD).

The liquid level for normal operation is 50%, which gives a generous separation surface on the gas side.

The produced water is sent to Flash Drum V-511 under interface level control and the separated light gas is sent to the HP compression section. And the crude goes to the MP V-102 separator.



**Figure I- 5:** HP V.101 separator[02]

#### ✓ MP V.102 separator

The MP V-102 separator is also sized for the oil content of the design with an excess of 10% taking into account the crude off specification recycled.

This separator has the same dimensions as the V-101 except it works with a pressure of 13 barg.

The MP separator is equipped with a system for diverting the flow to the off-spec line via a manually operated bypass only in the event that the results of laboratory analyzes indicate that this stage of separation is operating abnormally.

The water produced in this step is also sent to the V.511 flash drum via a level control valve. The separated gas is sent to the MP compression section. And the crude is pumped through the P-101 (A.B.C.D) pumps and goes to the V-103 / V-104 desalter

### **Desalting process:**

Crude treatment consists of separating the main components of the effluent in order to allow the delivery to customers of products that comply with defined standards such as salinity



**Figure I- 6:**Desalter V-103 / V-104[02].

In this course we will discuss the desalting operation and its equipment: the desalter.

#### ➤ **What is a desalter for?**

The role of the desalting unit is to wash off mineral salts present in crude oils by washing with water. These salts are in fact liable to cause corrosion and fouling in crude processing units. This desalting operation also makes it possible to recover the sediments still present in the crude.

#### ➤ **Process description:**

The PT.101 desalination tank is a two-stage desalter (1st stage V.103 / 2nd stage V.104) electrostatic coalescing with two P.103 A / B water recycling pumps.

The crude leaving the MP separator is pumped via the P.101 A / B / C / D pumps at a pressure of around 20 bars, to allow the coalescer to operate under steam-free conditions.

Wash water from wells and crude from V-103 are mixed through a mixer valve before entering V-104,

The water from this stage is recycled and pumped by pumps P.103 A / B to mix with the crude coming from V-102 and the dehyulsifier via another mixing valve before they enter the first desalting stage V- 103.

The water from the 1st stage is drained under an interface level control to the flash drum V.511 produced water tank.

In the event of an indication that the product leaving the PT.101 is off.spec, a desalter bypass is available to divert the flow to the off.spec line

The skid is fitted with a pressure control valve (PSV) in each compartment of the desalter.[26]

➤ **Desalination objectives**

There are three reasons for the desalination:

- Under certain conditions, salts crystallize in slabs in tubings, pipes and treatment facilities. These deposits slow down production.
- The presence of salts promotes electrical and chemical corrosion.
- By contract with the refiners, the operators are required to deliver crudes with a salinity of less than  $\approx 40$  mg of chlorides per liter.

So the objective will be to:

**Eliminate:**

- "DEHYDRATION" water
- "DESALINATION" salt

**For:**

- Meet commercial specifications
- Salinity <40 mg
- Limit the transport of water in the pipes (pressure drops, corrosion).

➤ **Column T.101**

The T-101 stabilizer is required to bring the crude back to a TVR that meets specifications by optimizing oil recovery volumes.

The bottom temperature is approximately 160 ° C, at the operating pressure (top of the column) of 5 barg. The column is designed to operate with the crude oil production rate of the design with over 10% for the return flow. The design pressure and temperature are 15 barg and 200 ° C.

The tower has two entrances; a cold inlet collects oil from the Enhanced Liquid Recovery System (ELR), and a hot inlet receives dehydrated crude oil from the desalter. The cold feed is in effect reflux from the V-451 low temperature separator, which increases the recovery of light components from the steam leaving the bottom section, and so that the top section can be viewed as a rectification section.

The column can operate without the top feed and in this case it acts as a simple stripping column, the reboiler provides steam.

- The upper section of the column has 6 trays and is 1,400 mm in diameter. The lower section of the column is 3100 mm and has 14 trays and a baffle at the bottom, the latter separates the feed of the Reboiler H-101 from the liquid leaving the column to the raw storage tanks. It is perforated to equalize the liquid levels of the two compartments.



**Figure I- 7** :Column T.101[02]

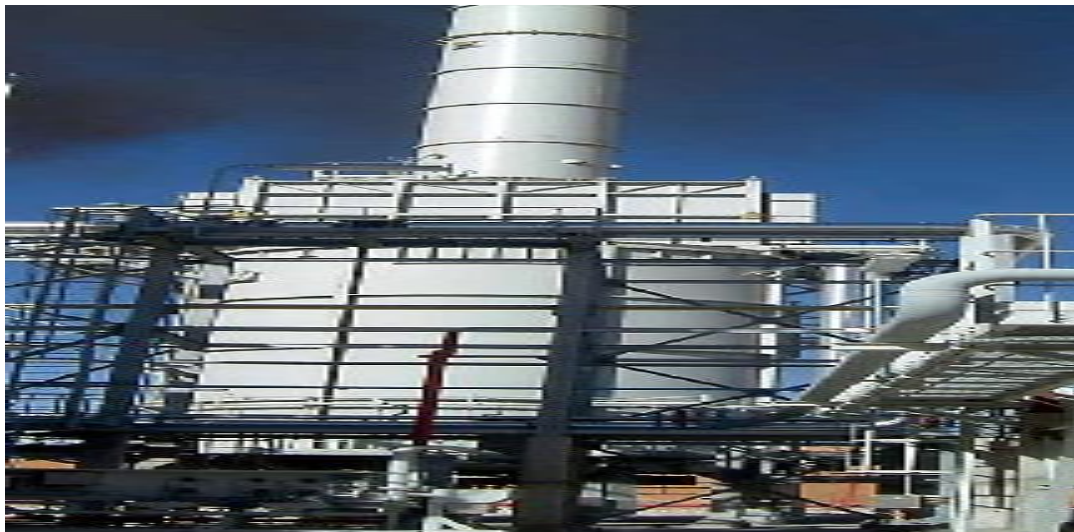
➤ **P-112 A / B / C reboiling pumps:**

The P-112 A / B / C pumps are centrifugal type pumps which transport the unstable crude from the bottom of the column at a pressure of around 17 bar to heat it in the H-101 oven and then return it to the column. .

In normal operation, two pumps will be in service and the third will be in stand-by.

➤ **The H.101 reboiler (heater)**

The H-101 reboiler includes 8 pilots and 8 gas burners (A / B / C / D / E / F / G / H), thanks to its last one varies the temperature from 20 ° C to 150 ° C approximately. At this temperature, the vaporization rate is between 20% and 40% (depending on the case). The temperature in the column at the sensitive tank is controlled by 01TC-056, which cascades over-01FC 091 to regulate the flow of fuel gas to the reboiler gas burners.



**Figure I- 8 :**The H.101 reboiler[02]

**Stabilized crude cooler (Air coolers) E.101**

The stabilized crude is sent to the storage tanks via the E-101 air cooler, at a TVR of 0.59 bar (8.5 psi) and must be cooled to prevent vaporization in the storage tanks, which are floating roof type.



The air cooler is sized to cool the stabilized oil at the temperature of 55 ° C with a maximum ambient temperature of 45 ° C. Two new air coolers (G and H) have been added to the air cooler E-101 to process the new debit.



**Figure I-9** :crude cooler (Air coolers) E.101[02]

### **I.3.2 System 200: crude storage and shipping:**

➤ **TK.211 A / B / C storage bins:**

The stabilized crude cooled in the E.101 air cooler flows to the TK.211 A / B / C storage tanks. Three floating roof bins are installed and calculated for a storage capacity of 24 hours of nominal production.

The system allows from the control room to switch between the following modes:

- Fill a tank: then fill the stabilization column;
- Changeover: fill a bin from another bin;
- Emptying a bin.



**Figure I- 10** :storage tank TK 211 [02]

➤ **Filling operation**

During the filling operation, the quality of the crude stored is checked by sampling means taken at the entrance to each tank. Usually two bins will be used for production (filling), where the third will be shipped (emptying



**Figure I- 11** :Export pumps

**➤ Shipping operation**

The tanks are emptied by the Booster pumps P.211 A / B / C and the main pumps P.212 A / B / C.

The pumps are designed to pump the entire production in 18 hours with a discharge pressure of 73 barg.

The P.211 A / B / C booster pumps are fitted with 02.PSV.036 safety valves which are fitted with rupture discs placed on the discharge line for protection against backflow from the main pumps.

**➤ Permutation operation**

It is possible to transfer the contents of one tank to another on / off spec tank using booster pumps.

**✓ Storage bin outside TK.221 specifications:**

The objective of the off-spec system is to receive the product out of specification (while respecting the TVR and salinity), store it and re-inject it into the process once in normal operation.

The off spec system contains:

- Off spec flash drum V.222 for gas flash to the HP torch.
- P-221 A / B / C pumps.
- The V-221 degassing cigar which receives the liquid from the V.222, it is placed just in front of the off spec TK.221 tank
- TK.221 designed to accommodate 10 hours of off spec production, with a fixed conical roof.
- The degassed gases will be routed to the LP troche and the pressure is maintained at 0.01 barg.

The main power for the off-spec system can come from 4 sources:

- Slugs coming from the HP separator
- The total flow of the MP separator
- The total flow of the desalter when the column cannot receive it
- The total flow of the stabilization column when the product is off spec

# Chapter II corrosion phenomen review



## II.1. Introduction

Many studies carried out in different chemical industries in order to better understand the corrosion mechanisms to better protect them. Along with corrosion studies, several protection methods are applicable depending on the aggressive environment, all of which have the objective of slowing the rate of corrosion.

Decreasing the aggressiveness of the medium by adding inhibitors has wide industrial application, especially in the pickling and descaling industry .

This chapter is devoted to a bibliographical summary on the phenomenon of corrosion and the applied protection methods.

## II.2. the Corrosion

### II.2.1. Definition

Corrosion is defined in different ways, but the usual interpretation of the term is an irreversible interfacial reaction of a material, with a corrosive agent in its environment which involves consumption of the metal and production of a reduced form of the corrosive agent ,corrosion is a degradation of the material or its properties, rendering it unusable for an intended application by chemical reaction with the environment, this definition admits that corrosion is a harmful phenomenon Corrosion is the phenomenon whereby metals tend, under the action of atmospheric agents or chemical reagents, to return to their original oxy state. [ 14].

### II.2.2. Corrosion factors

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

The rate of corrosion of a metal in a corrosive environment depends both on the characteristics of the two parameters, temperature and pH. They have a direct influence on the corrosion rate, and an indirect influence through the aqueous phase (condensation water, production water). The flow conditions, the film formed on the metal surface and the pressure have a direct influence through the partial pressure of CO<sub>2</sub> [18]

*Table II.1: The main corrosion factors*

<b>Environmental factors</b>	<b>Factors</b>	<b>Defining factors</b>	<b>Dependent factors</b>
<b>Corrosive</b>	<b>metallurgical</b>	<b>employment conditions</b>	<b>of time</b>
Concentration	Composition Of the alloy	Surface condition	Aging
Durable	Processes of development	Shape of parts	Mechanical tension
Oxygen content	Impurities	Inhibitor use	Changing coatings Protectors
medium pH	Heat treatment	Assembly processes	
Temperature	Mechanical processing		
Pressure			

➤ **Effect of temperature**

Generally, the increase in temperature accelerates the corrosion phenomena, because it decreases the domains of stability of metals and accelerates the kinetics of reactions and transport. The extent of its influence, however, differs depending on the corrosive environment in which the material is found [17]

➤ **Effect of acidity**

The susceptibility of the material to corrosion is a function of the pH of the electrolyte. A high concentration of protons in the solution increases the aggressiveness of the medium, which changes the equilibrium of chemical and electrochemical reactions. Corrosion increases with the decrease in the pH of the medium, [18]

➤ **Hydrodynamic regime**

The transport of reagents to the interface and of the electrolyte reaction products is likely to modify the kinetics of electrochemical reactions by changing the concentration of species and therefore the equilibrium potential. The hydrodynamic conditions fixed the reaction rates by controlling the transport of matter by establishing a boundary layer of diffusion of the species, called the Nernst layer, which explains the importance of the agitation of the electrolyte during corrosion tests. in the laboratory,[19]

**Salinity**

Chlorides are aggressive ions, often at the origin of localized corrosion, their presence in solution is accompanied by complementary effects, on the one hand, their local concentration induces an acidification of the environment and on the other hand, the salinity has an influence on the conductivity of the medium

**II.2.3. The forms of corrosion**

The process of corrosion of metals takes a few many forms, which are classified mainly according to the form that manifests itself on the corroded surface.

**II .2.3.1 uniform Corrosion (generalized)**

We speak of uniform corrosion when the entire surface of the metal in contact with the solution is attacked in the same way. It results in a uniform dissolution of the metal surface in contact with the aggressive agent. This form of corrosion of the material develops in acidic or alkaline media.



**Figure II.1:** General corrosion (rust) of a steel part [22].

### II.2.3.2. Localized corrosion

This phenomenon occurs on the contrary when the material is placed in the presence of an environment exhibiting a selective behavior towards it. This selectivity can have multiple origins both at the level of the material (hetero phase alloy, presence of inclusions, locally defective surface protection, bimetallic material, etc.) and at the level of the environment (local variation in composition, pH or temperature [22])

This form of corrosion occurs at a few points on the surface of a material.

### II.2.3.3. Galvanic corrosion (bimetallic corrosion)

It is one of the most common forms of corrosion in aqueous media. It is due to the formation of an electrochemical cell between two materials in which one of the electrodes (the anode) is consumed for the benefit of the other (the cathode) which remains intact (figure II.2). This selectivity of the reactions is due to a heterogeneity originating either from the material or from the medium or from the Physicochemical and thermodynamic conditions at the interface

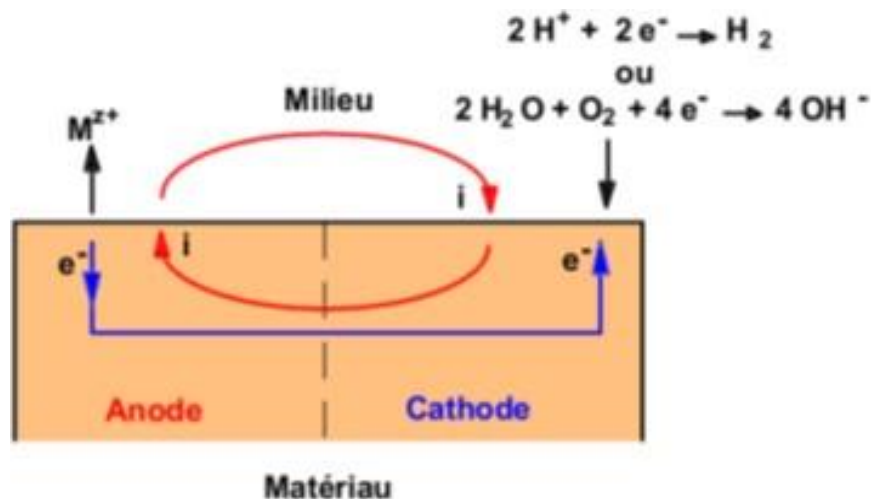


Figure II.2: Schematic representation of a corrosion pile [22].

### II.2.3.4. Pitting corrosion

It occurs when metals protected by a thin oxide film such as aluminum and its alloys and stainless steels are brought into contact with an aqueous medium (for a pH close to neutrality) containing halides, in particular chloride  $Cl^-$ . The amount of corroded



metal is very small, it introduces cavities a few tens of micrometers in diameter inside the material from a small area opening

There are two stages in the pitting corrosion process (figure II.3), the initiation which occurs during the local breakdown of the passivity and the growth or propagation [12]

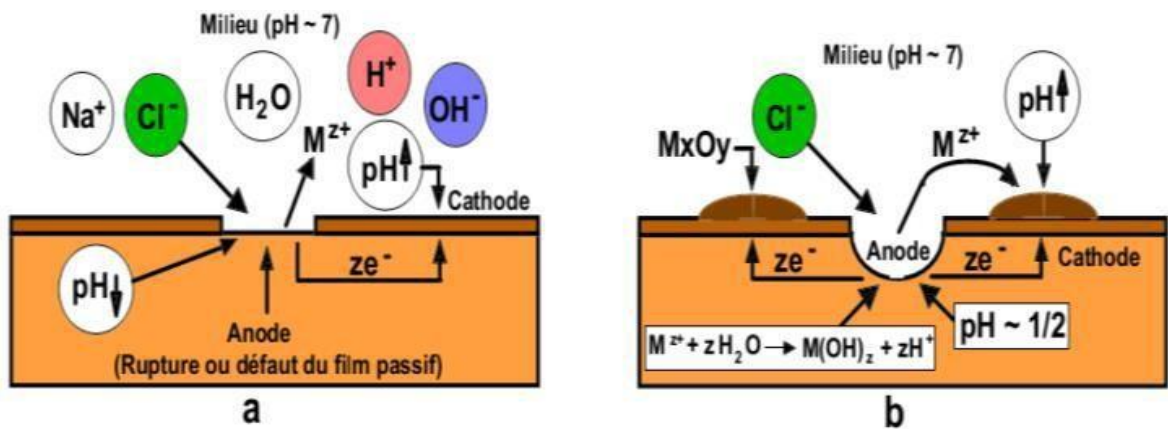


Figure II.3. Initiation (a) and propagation (b) of a bite

#### II.2.3.5. Intergranular corrosion

This type of corrosion manifests itself at grain boundaries. This phenomenon can cause cracks which weaken the mechanical characteristics of the metal (figure II.4). Certain stainless steels and alloys (iron, chromium, nickel) are very affected by this mode of corrosion which catastrophically reduces their mechanical resistance. This type of corrosion is a microscopic phenomenon (invisible in the initial stages) [21]



Figure II.4: Intergranular corrosion of stainless steel by HCl [21]

**II.2.3.6. Selective corrosion**

This is a very dangerous type of corrosion because it is unsuspected, the corroded part hardly seems to be affected, while its resistance decreases considerably. It consists of the selective dissolution of an element of an alloy, the other elements remain unattacked. The metal becomes porous and loses its resistance ..

**II.2.3.7. Cavernous corrosion**

Cavernous corrosion is caused by a difference in the accessibility of oxygen between two parts of a structure, thus creating an electrochemical cell. This selective attack on the metal is seen in cracks and other places that are not easily accessible to oxygen. Often, crevice corrosion is associated with the presence of small volumes of stagnant corrosive solution, due to the presence of cavities, contiguous surfaces or discontinuous deposits [21]

**II.2.3.8. Filiform corrosion**

This type of corrosion is often associated with the presence of a protective coating (paint, varnish, etc.) which is semi-permeable to oxygen and water. The attack is manifested by filaments emitted in all directions, from coating defects, which can affect various materials such as iron and aluminum when subjected to humid atmospheres between 20 and 30°C.

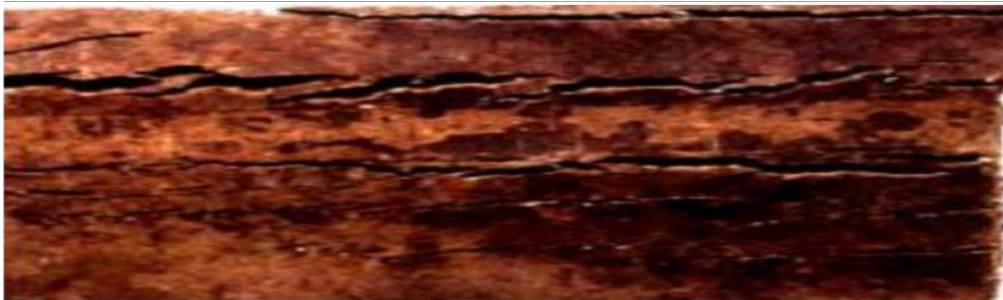
Oxygen and water are the reactants necessary for the development of thread-like corrosion. The presence of aggressive ions such as Cl, SO<sub>4</sub>, CO<sub>3</sub> promotes the initiation of this corrosion by developing local acidification. Based on potential and pH measurements, the threadlike corrosion wire consists of a head containing an acidic aqueous solution and an alkaline tail containing corrosion products. The alkaline conditions favor the detachment of the coating.

**II.2.3.9. Stress corrosion**

Stress corrosion is the cracking of metal that results from the joint action of mechanical stress and an electrochemical reaction.

The process takes place in two successive phases, namely an initiation and a propagation.

This process depends mainly on the intensity of the imposed stresses, the nature of the material (chemical composition and structure), the surface condition and the corrosive environment and the temperature[21]



**Figure II.5:** Stress corrosion cracks (CSC) [24]

### II.3. Corrosion modes

The phenomenon of corrosion can develop according to different processes:

#### II.3.1. Chemical corrosion

It corresponds to the reaction of the metallic material with a gaseous phase or a liquid phase in the first case we speak of dry corrosion and a more or less protective solid deposit is formed. Cases of chemical corrosion by a liquid phase that do not fall under electrochemical corrosion are extremely rare. However, we can cite the example of the reaction of a metal with another liquid metal such as during the formation of an amalgam between liquid mercury and metals such as copper, cadmium, etc. [09]

#### II.3.2. Electrochemical corrosion

This is the most common mode. It results in electronic transfers between a metal and an electrolytic solution in contact with it.

##### ➤ Mechanism of electrochemical corrosion

From a practical point of view, the coupling of one or more reactions of oxidation of the metal at the anode, with one or more reactions of reduction of species in solution at the cathode, leads to obtaining a “mixed” corrosion potential, also called free potential or abandonment potential, located in a domain of the potential-pH diagram (Pourbaix diagram) where the metal is active. The entire surface of the metal takes on this potential value and is the site of corrosion described by the reaction:



Where *Red* denotes the reduced species and  $\text{OXn}^+$  the associated oxidant.

Corrosion can only take place if the electrons given up by the oxidation of the metal

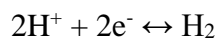
are captured by another redox couple corresponding to the reduction reaction of the corrosion engine.

In wet corrosion, the main drivers are water,  $H^+$  protons (deaerated medium, the dissolved  $O_2$  concentration being considered negligible compared to that of  $H^+$  ions) and dissolved oxygen (aerated medium, the dissolved  $O_2$  reduction current greater than that of  $H^+$  ions). Thus, in these different environments, the reactions taking place:

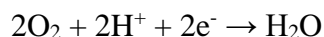
- Oxidation reaction of a metal M to its  $Mn^+$  ions



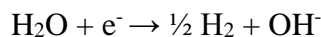
- Reduction reaction of the oxidizing agent, corrosion driver: In an acidic and deaerated environment:



In an acidic and ventilated environment:



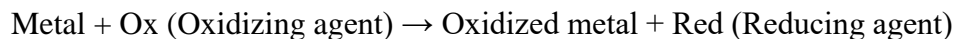
In a neutral or basic and deaerated environment:



In a neutral or basic and ventilated environment:



The overall corrosion reaction can be schematized as follows:



### II.3.3. Biological corrosion

It results from the action of bacteria or products of bacterial activity such as organic acids or gases such as  $CO_2$  and  $SO_2$ , on the metallic material. Buried pipes are subject to this type of corrosion [20]

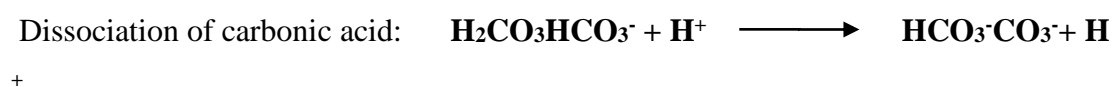
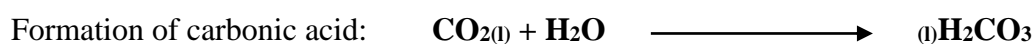
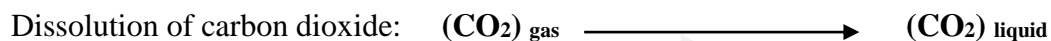
## II.4 common Corrosion in oil and gas facilities

### II.4.1 $CO_2$ corrosion "Sweet corrosion"

As  $CO_2$  is an acid gas present in oil sites in varying amounts, this corrosion concerns all oil production equipment for which there may be contact of free water containing carbonic acid with carbon steels. and weakly alloyed: we can cite well tubing, separator, pipeline.... etc

**II.4.1.1. Mechanisms and parameters influencing CO<sub>2</sub> corrosion**

Carbon dioxide dissolved in water leads to several forms of corrosion of carbon and low alloy steels: widespread corrosion as well as three variants of localized corrosion which are pitting corrosion and localized corrosion caused by hydrodynamic turbulence. Dissolution of carbon dioxide in water leads to the formation of carbonic acid which reacts with carbon and low alloy steels to form iron carbonates and hydrogen carbonates:



Corrosion reaction of iron:

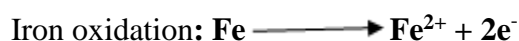
**II.4.2. CORROSION BY H<sub>2</sub>S "Sour corrosion"**

Like CO<sub>2</sub>, hydrogen sulfide is an acid gas that is readily soluble in water. In aqueous solution, the corrosivity of H<sub>2</sub>S towards carbon steels and low alloy steels is very close to that of CO<sub>2</sub>. But, the H<sub>2</sub>S has an additional characteristic: it friction promotes hydrogen uptake in steels and can lead to hydrogen embrittlement cracking problems. As H<sub>2</sub>S is an acid gas present in many oil fields, these forms of corrosion concern all oil production equipment for which there may be contact of free water containing hydrogen sulphide with carbon steels and weakly alloys: we can cite well tubings, wellheads, pipes, pressure devices (separators), pipelines, pumps.[16]

**II.4.2.1. Mechanisms and parameters influencing corrosion by H<sub>2</sub>S .**

The main corrosive agent in the petroleum industry is hydrogen sulfide, which comes both from crude and mainly from the thermal decomposition of sulfur compounds. This corrosion is essentially a function of the H<sub>2</sub>S concentration and the temperature, but it is independent of the pressure [14].

Water corrosion by H<sub>2</sub>S is caused by the following mechanism: Dissolution of hydrogen sulfide: (H<sub>2</sub>S) gas (H<sub>2</sub>S) liquid Acid dissociation: (H<sub>2</sub>S) liquid HS<sup>-</sup> + H<sup>+</sup>



Proton reduction:  $2\text{H}^+ + 2\text{e}^- \longrightarrow \text{H}_2$

Formation of iron sulphide:  $\text{Fe}^{2+} + \text{H}_2\text{S} \longrightarrow \text{FeS} + 2\text{H}^+$

However, the major risk in the presence of  $\text{H}_2\text{S}$  is not uniform corrosion, but the various forms of hydrogen embrittlement cracking. As a result of the proton reduction reaction, atomic hydrogen can follow two distinct paths:

- Either react with another hydrogen atom to form a molecule of dihydrogen ( $\text{H}_2$ ) in solution,
- Either penetrate into the metal in the form of absorbed hydrogen.

These two reactions take place on the metal surface and involve adsorbed intermediates. In the presence of  $\text{H}_2\text{S}$ , the balance between two reactions (recombination and absorption) is greatly shifted in favor of absorption. The precise mechanism is not clearly established: some authors consider that the  $\text{H}_2\text{S}$  adsorbed on the surface of the steel acts as a poison for the recombination of hydrogen, promoting the loading reaction; other authors suggest a mechanism of direct charging of hydrogen from solution to metal, via adsorbed  $\text{H}_2\text{S}$ . Whatever the exact mechanism, it should be remembered that the presence of  $\text{H}_2\text{S}$  promotes the loading of atomic hydrogen into the metal, causing very specific problems of embrittlement which can lead to cracking. These failure modes constitute the principle of risk in an  $\text{H}_2\text{S}$  environment [15]

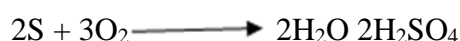
### II.4.3. BACTERIAL CORROSION

This process mainly concerns the bacterial attack of underground pipes or reservoirs: these bacteria use some chemical elements found in the material to transform it into a metal ion or secrete chemicals that are aggressive towards the metal

The mechanism of this corrosion mode can be of several types:

a. Chemical by the production of corrosive substances such as  $\text{CO}_2$ ,  $\text{H}_2\text{S}$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{NH}_3$  or an organic acid, the most frequently answered case is that encountered in buried pipes and which results in the formation of sulfuric acid which attacks the metal.

Aerobic bacteria capable of oxidizing sulfur according to the following reaction:



b. Some bacteria can reduce sulfates through hydrogen.



The hydrogen comes for example from the cathode regions, there is therefore a

depolarization of the cathodes and accelerated formation of  $\text{Fe}^{2+}$  at the anodes.



vs. In certain cases, adherent deposits can be observed on the pipes resulting from the attack, not of the metal itself, but that of certain components of the ambient environment by bacteria. As a result it forms pits on the metal, where the deposit occurred, following a corrosion process due to the difference in oxygen concentration

## II.5. Methods and means of corrosion control

Corrosion prevention must be considered from the design phase of an installation. Indeed, preventive measures taken at the right time make it possible to avoid many problems when it comes to guaranteeing a certain lifespan to an object, in particular for industries such as nuclear, chemical industry or aeronautics, where the risk of accident can have particularly serious consequences for people and the environment. In terms of protection against corrosion, it is possible to act on the material itself (judicious choice, suitable shape, stress depending on the applications, etc.), on the material surface (coating, painting, any type of treatment of surface...) or on the environment with which the material is in contact (corrosion inhibition)

### II.5.1. Prevention through a judicious choice of materials

It will be possible to control the risks of corrosion by acting on the judicious choice of material.

The choice of materials takes into account the following factors:

- Field of use,
- Nature and level of mechanical and thermal stresses,
- Selected treatments,
- Price and availability of materials.

#### *a. Protection by the geometry of the parts*

It is possible to reduce the risks of corrosion by giving the objects a shape adapted to the conditions of use, and thus significantly influence their lifespan. We will discuss here some standard solutions commonly used to limit the risks according to the type of corrosion to be feared

#### *b. Removal of wetlands*

Generally, atmospheric corrosion only occurs in the presence of moisture. By providing a more or less perfect drainage, one avoids an accumulation of humidity,

hence the risk of corrosion[13]

### II.5.2. Cathodic protection

It consists of placing the metal in its area of immunity. It can be carried out either by sacrificial (reactive) anode or by imposed current. Sacrificial anode protection consists of coupling to the metal to be protected a less noble metal which acts as the anode.

In impressed current protection, a current passes between a cathode made up of the metal to be protected and an inert anode (graphite, lead, precious metal, etc.).

The intensity of the current must be sufficient to bring the metal to a potential at which the anodic reaction cannot take place.

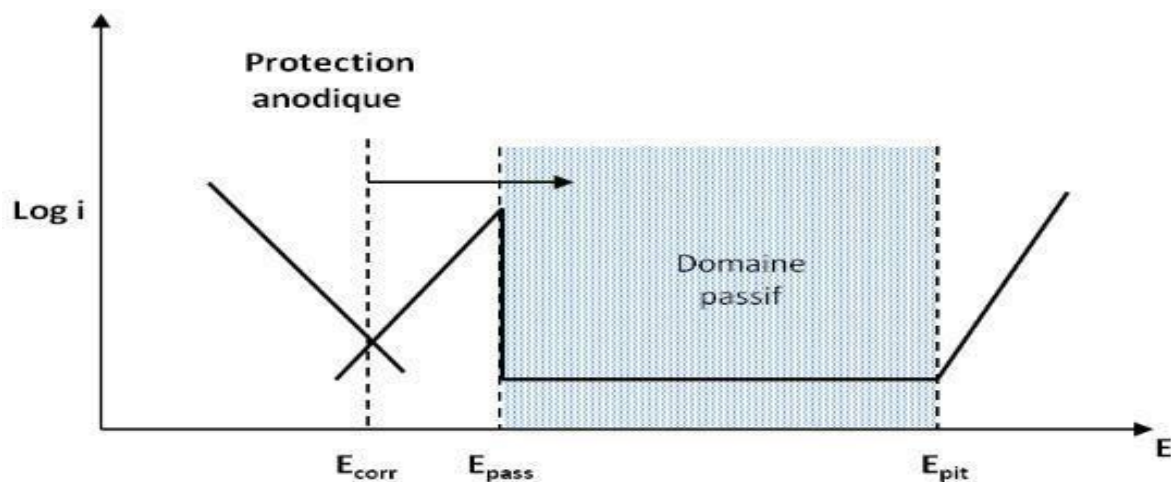


Figure II.6: Principle of cathodic protection [15]

### II.5.3. Anodic protection

It is reserved for passivable metals whose corrosion potential is in the active range ( $E_{\text{corr}} < E_p$ ). An anodic polarization makes it possible to shift the potential in the passive domain. The current density required to keep the metal in a passive state is very low (equivalent to  $i_{\text{passive}}$ ). Maintaining anodic protection requires little current. On the other hand, the applied current density is markedly higher because it must be greater than the passivation current density





$E_{pass}$ : passivation potential;  $E_{pit}$ : potential for depassivation or skinning

**Figure II.7:**Principle of the anodic protection of a passivable metal:

Displacement of the potential in the passive domain corresponding to:  $E_{pass} < E < E_{pit}$ .

#### II.5.4. Protection by coatings:

##### II.5.4.1. Metallic coating:

They are commonly used to protect steel, especially against atmospheric corrosion. They can also be applied to other substrates such as copper or brass, as is the case eg for chrome coatings on taps. In general, we will distinguish two types of metallic coatings:

##### II.5.4.2. Non-metallic inorganic coatings:

These are layers obtained by chemical surface conversion and layers foreign to the substrate.

The conversion layers are obtained by a reaction of the metal with a chosen medium (phosphating, anodizing and chromating), while the layers foreign to the substrate are manufactured by deposition processes which do not involve a reaction of the substrate (enameling, etc.), the chemical composition in this case is independent of that of the substrate[14]

##### II.5.4.3 Organic coatings:

Organic coatings form a more or less impermeable barrier between the metal and the electrolytic medium. They are classified into three families:

-Bitumen coatings (protection of buried structures),

- Polymeric coatings,
- Paints and varnishes

Polymeric coatings are applied by different processes: by powder, by gun, by rolling, by immersion... etc. Their effectiveness depends on their chemical resistance

intrinsic to the environment and the absence of flaws.

Paints are opaque two-phase liquids. Some paints contain pigments which act as a corrosion inhibitor. They protect the substrate by different Mechanisms: barrier effect, suppression of electrochemical cells, inhibition of reactions

Electrochemical..Etc.

The importance of paints far exceeds that of other methods of protection against Corrosion. Most by steel objects and many objects made of other materials are Protected by paints [14]

## II.6. Corrosion inhibition

### II.6.1. Definition

An inhibitor is "a chemical compound which, added at low levels to the corrosive medium, slows down or even stops the corrosion process of a metal in contact with this medium".

### II.6.2. Properties

Based on this definition, a corrosion inhibitor must therefore verify a certain number of fundamental properties:

- Lower the rate of corrosion of the metal while maintaining the physicochemical characteristics of the latter
- Be stable in the presence of other constituents;
- Be stable in the temperature range used;
- Be effective at low concentration;
- Be effective under the conditions of use;
- Inexpensive compared to the savings it provides;

Be compatible with current standards for non-toxicity and environmental protection

### II.6.3. Terms of use

Corrosion inhibitors can be used as the sole means of protection:

- Either as permanent protection; the inhibitor then allows the use of metallic materials under satisfactory conditions of corrosion resistance such as:
- Water treatment (sanitary water, industrial process water, boiler water, etc.);
- The petroleum industry: drilling, extraction, refining, storage and transport; at all stages of this industry, the use of corrosion inhibitors is essential to safeguard installations;
- Either as temporary protection during a period when the part or installation is particularly sensitive to corrosion, whether during acid pickling, cleaning of installations or storage in the atmosphere (volatile inhibitors, incorporation into oils and greases temporary protection).

An inhibitor (or a mixture of inhibitors) can be combined with another means of protection such as: additional protection of an alloy with high corrosion resistance, or in the paint industry added to a surface coating (paint, grease, oil, etc.) on metals providing their corrosion protection ;[18]

## II.7. Classes of inhibitors

Several possibilities for classifying inhibitors are available. They are distinguished from each other in different ways

### II.7.1. Classification according to the nature of the inhibitor

#### a. Organic inhibitors

Organic molecules have a very good future in terms of corrosion inhibitors: their use is currently preferred, over inorganic inhibitors for obvious Eco toxicity reasons.

The mechanism of inhibition of these organic compounds is linked to the formation of a more or less continuous barrier, but of finite thickness, which prevents the solution from reaching the metal.

There are a significant number of organic compounds capable of being used as inhibitors. From a starting molecule with a certain efficiency, it is always possible to synthesize more and more complex compounds in order to improve the inhibitory efficiency. However, since the sale of a product depends to a large extent on its cost price, we often turn to the by-products of the oil industry

Organic inhibitors have at least one heteroatom serving as an active center for their attachment to metals such as nitrogen, oxygen, sulfur or phosphorus. Increasing the temperature can severely limit the use of organic molecules as inhibitors due to their instability at high temperatures.

### **b. Mineral inhibitors**

Mineral compounds are most often used in a quasi-neutral medium, in an alkaline medium and very rarely in an acid medium. These products dissociate in solution and they are rather their dissociation products i.e. the anions and the cations which ensure the phenomena of inhibition. The main inhibitory cations are  $\text{Ca}^{2+}$  and  $\text{Zn}^{2+}$ . The main inhibitory anions are oxo<sup>-</sup>anions of the  $\text{XO}_4\text{n}^-$  type such as chromates, molybdates,....

### **II.7.2. Classification according to the mechanism of action**

Corrosion inhibitors do not work the same way. The same compound will often have a mechanism of action which will depend on the corrosion system (metal / solution).

The mechanism of action of an inhibitor is most often to be found in the vicinity close to the metal surface. However, in a closed circuit, one can get rid of the oxygen, and the corrosion is then controlled by a simple adjustment of the pH to a fairly large value. Chromates, amines and nitrites are effective in this case.

#### ***a. Electrochemical mechanism of action***

This classification of inhibitors takes into account the electrochemical nature of corrosion in the liquid phase, which involves at least two reactions:

- An anodic metal dissolution reaction (oxidation reaction):



- A cathodic reaction of reduction of an oxidant in the solution:

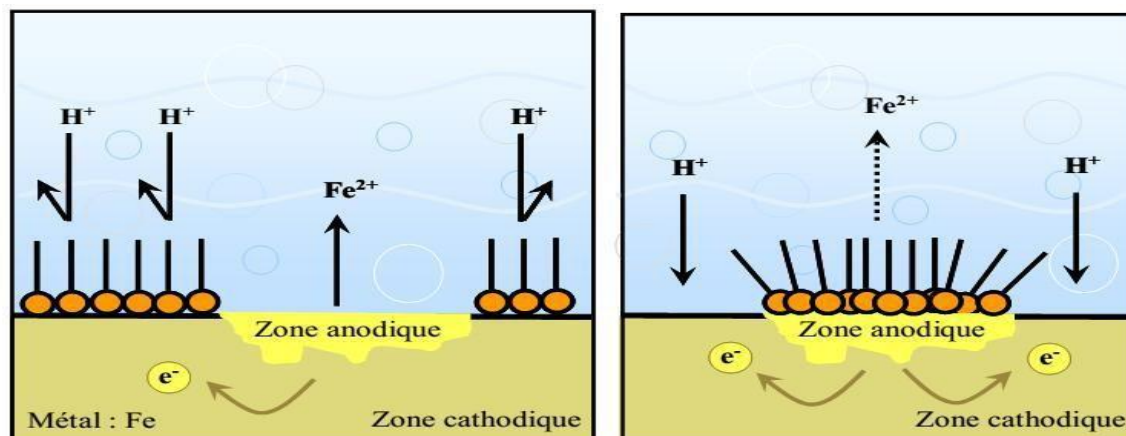


If the inhibitor decreases the rate of the oxidation reaction by blocking the anodic sites (site of metal oxidation), it is called an anodic inhibitor.

If, on the other hand, it slows down the reduction reaction by blocking the cathodic sites (site of the reduction of dissolved oxygen in a ventilated environment or site of the reduction of the proton

$\text{H}^+$  in an acidic medium), it is called a cathode inhibitor (figure II.8).

Mixed inhibitors work to both decrease the rate of the anodic reaction and that of the cathodic reaction.

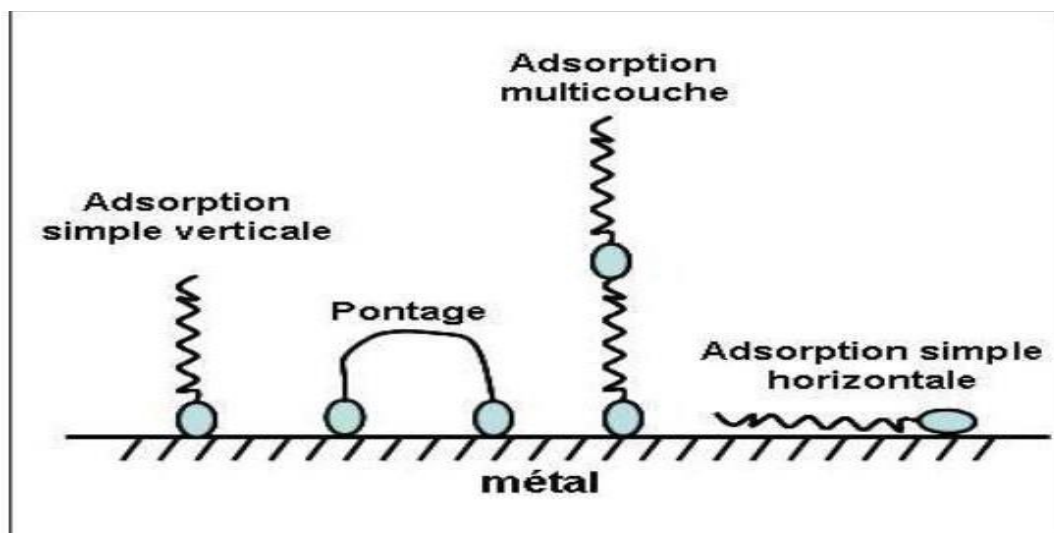


**Figure II.8:** Formation of cathodic (A) and anodic (B) barrier layers, in an acidic medium.

### *b. Interfacial mechanisms of action*

This other method of classifying inhibitors classifies them by taking into account their mode of attachment to the metal substrate. Thus we distinguish:

- Adsorption or "interface" inhibitors which appear in an acidic environment (mono or two-dimensional film).
- So-called "interphase" inhibitors which appear in an alkaline medium (three-dimensional films).



**Figure II.9:** Schematic representation of the modes of adsorption of inhibitory organic molecules on a metal surface.

### II.7.3. Classification according to the field of application

We distinguish:

- Inhibitors in an acidic environment. They are used to prevent electrochemical attack on steel during pickling.
- Inhibitors in neutral environments, which are mainly used to protect cooling circuits.
- Inhibitors in organic media (in engine lubricants and in gasoline).
- Gas phase inhibitors which are generally used for temporary protection of various packaged objects during transport (example: amines).

## II.8. Conventional corrosion protection

### II.8.1. Introduction

Anticorrosion protection consists of the creation of a coating on the metal to be protected, the role of which is to create an electrochemical barrier effect between the metal and the surrounding environment. This coating must have the following characteristics:

- High electrical insulation.
- Water and vapor tightness.
- Good impact resistance.
- Good adhesion.
- Hardness comparable to the substrate to be coated.

### II.8.2. Chemical conversion treatments

A conversion treatment is an operation which consists in forming a very thin compound, by chemical reaction between the base metal and a so-called conversion treatment bath. The compound thus formed exhibits very good cohesion with the substrate. Its role is to increase the corrosion resistance of the treated substrate, but also in most cases to prepare the surface for subsequent painting.

#### II.8.2.1. Amorphous or "iron" phosphating

This treatment, which is applied to steel, is used less and less. The bath consists of phosphoric acid, alkaline phosphates, and an oxidizer or accelerator which can be, for example, a chlorate, a molybdate, a bromate, a meta-nitrobenzene sulfates.

This treatment exhibits relatively poor corrosion behavior, on the other hand, the

adhesion and flexibility properties of these layers are excellent and delay adhesion breaks due to the cathodic reduction of oxygen

### **II.8.3. Electrolyte deposits**

Electrolytic deposits are based on the principle of electrolysis used to apply by means of an electric current a metallic deposit to the surface of a metallic object; the metal deposit being initially in the form of cations in solution in a solvent which is generally aqueous. Two principles exist:

- Cathodic barrier protection
- Sacrificial protection

#### **II.8.3.1. Chrome plating**

This technique offers barrier protection for industrial uses where one or more of the following properties is taken advantage of:

- Low coefficient of friction
- Non-stick properties
- Wear resistance and high hardness
- Corrosion resistance
- Quality of load resistances

This process involves electrolytically depositing a layer of chromium on the surface of the previously cleaned steel. The chromium plating bath consists of chromic [20]

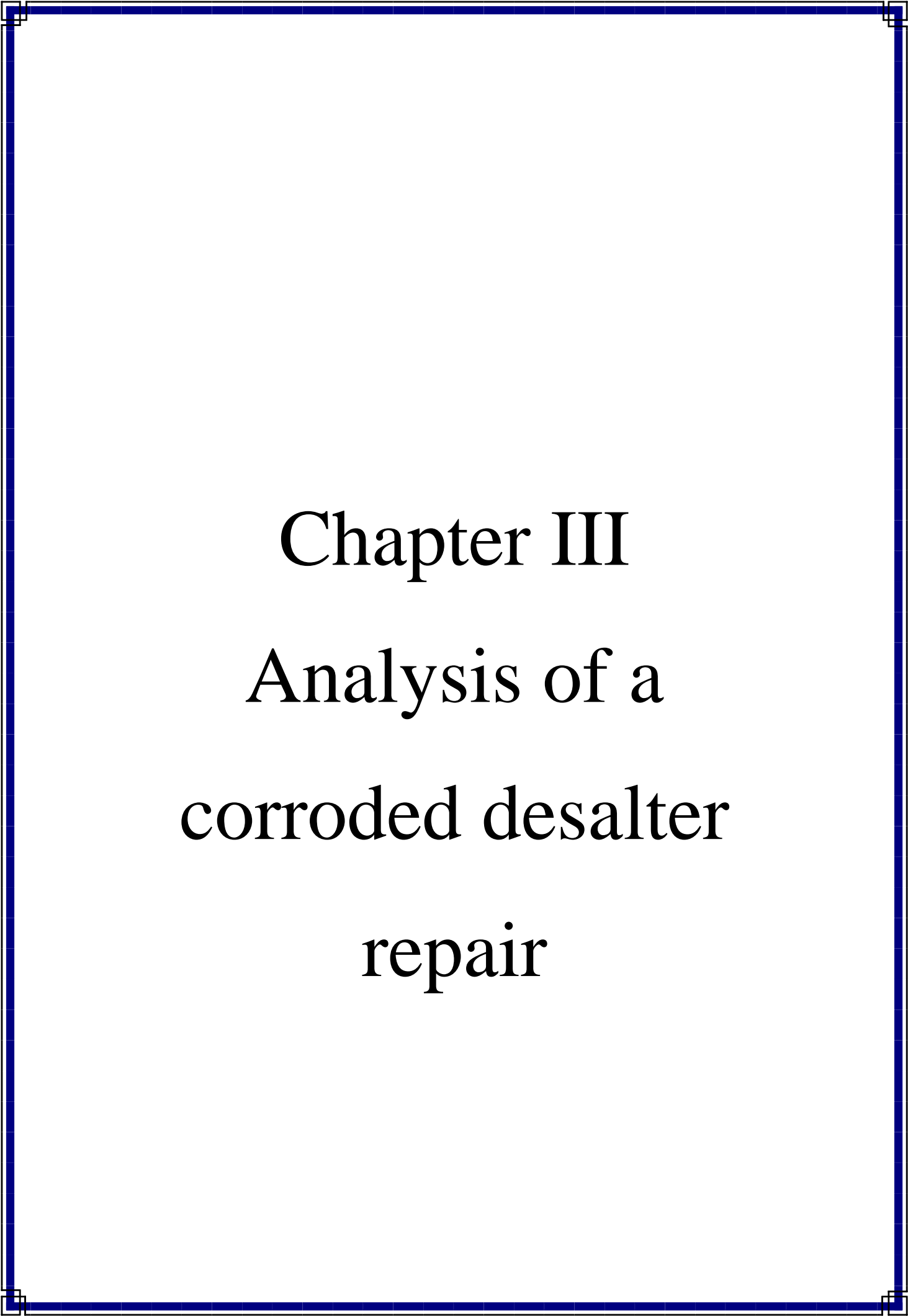
#### **II.8.3.2. Electrolytic zinc plating**

Electrolytic zinc plating is a simple to use and economically competitive process, it offers sacrificial type protection to the metal substrate. It is carried out by electrolysis of a generally acidified aqueous solution containing metallic ( $Zn^{2+}$ ,  $Na + \dots$ ) and non-metallic salts with current densities generally between 10 and 200 A.dm<sup>2</sup>[16]

## **II.9. Conclusion**

Given the importance of the corrosion problem, several studies have been devoted to this phenomenon. In this chapter we are interested in a bibliographical study on this phenomenon, on the methods of conventional protection and applied topicality.

We will also have more depth to study this problem and methods of processing it and give an example in petroleum facilities (Analysis of a corroded Desalter repair) In the next chapter.

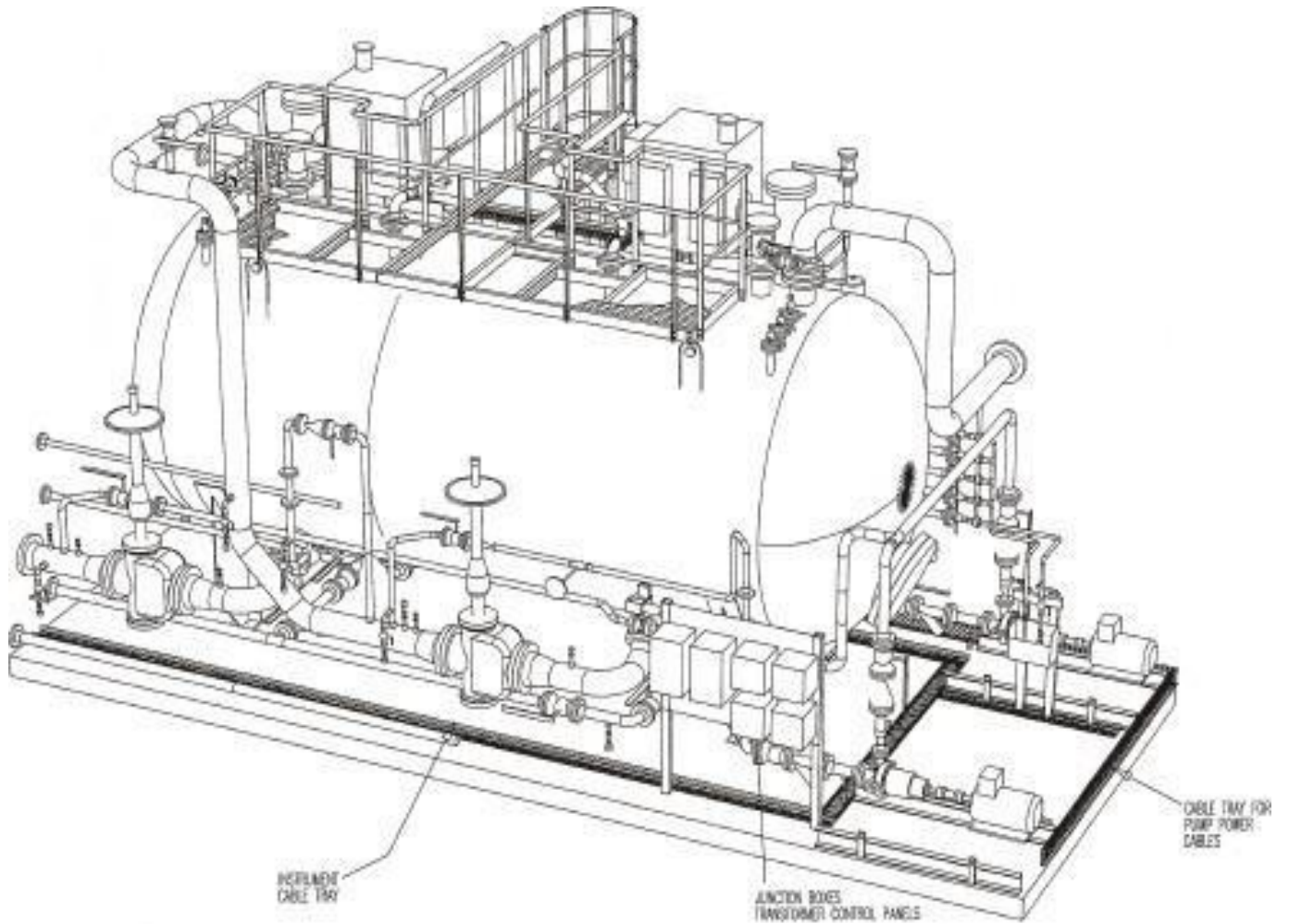


Chapter III

Analysis of a  
corroded desalter  
repair



Analysis of a corroded desalter repair(Case of ConocoPhillips-CPF desalter)



### III .1.Introduction

Desalting is a water-washing operation performed initially at the production field and thereafter at the refinery site for additional crude oil cleanup. Salt and water content, and this is the function of desalter.

The Desalter Package is a two stage electrostatic coalesce comprised of a combined Desalter Vessel First Stage, and Desalter Vessel Second Stage.

Each stage is a two-phase separator, designed to wash the oil with produced water from other resource in order to catch maximum salt solved in the oil to met the Required oil export specifications ( $\text{NaCl} \leq 40 \text{ mg/l}$ ), to reduce their negative effect in downstream processes (corrosion effect).

Based on above, and because of desalter role in the process, we notice that the milieu inside the desalter is very corrosive because is contain two corrosive agents: water and salt, which keep in gusal ways facing internal corrosion phenomena.

Generally, in the oil field of Sonatrach, to protect this kind of equipment and eliminate corrosion phenomena inside, they follow two steps:

- Coating of internal surface.
- Opening the equipment every 03 years in order to perform internal inspection.

This protection philosophy safe ctiveso far, but not definitely! Due to:

- What if the internal coating damaged after starting operation directly!
- Is there any solution make our equipment internal surface bear for 03 years in case of coating can 'than dle this period!!

In this study, we will try to figure out the problem of internal surface corrosion in Vessels such as desalter and how to treat them.

To study this problem and find out solution; we will take a real example, which face this problem and try to find and apply our suggested solution based on our investigation and calculation

### III.1.Methodandmaterial

#### III .1.1.Method:

- Historical investigation of the desalter.
- Visual inspection.
- Anode sacrificial calculation.

#### III .1.2.Material:

- MLN Desalter.
- Internal coating.
- Anode sacrificial.

#### III.1.3.MLN Desalter Materiel Specification

- Vessel is a horizontal cylindrical, semi-ellipsoidal ended steel vessel with, a partition to separate the two stages, measuring 3m in diameter and 7.4m overall length.
- The vessel is made of carbon steel SA-516 Gr 70.
- The vessel internally coated by glass flake lining to prevent corrosion.
- Nominal thickness is 40mm.
- Corrosion allowances 3mm

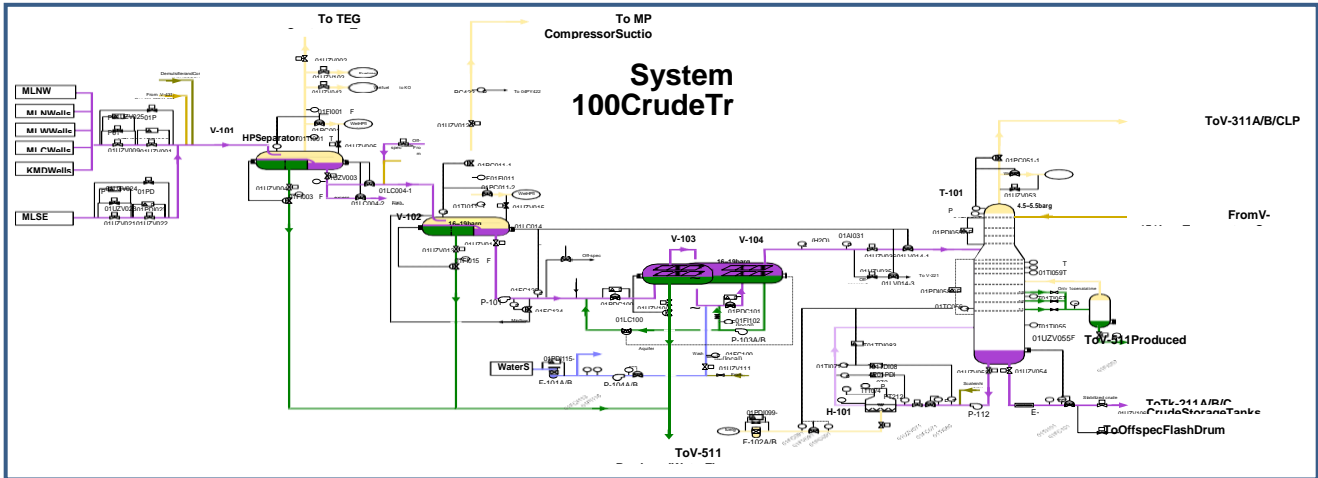


Fig.III..1: System 100, Crude Treating of ConocoPhillips Field [02]

III.1.3.1.ExternalSide:

The vessel is on good shape from external side as shown in Fig.III..2.



Fig.III..2.:Desalter from external side [02]

III.1.3.2. Internal Side:

III .1.3.2.1. Horizontal Grids Conditions

The horizontal lector degrades inside the vessel are on good shape as shown in .fig III.3



Fig.III..3:The horizontal grids in side Desalted (V-103 left,V-104 right)

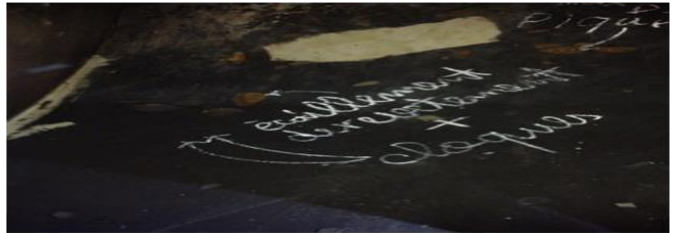
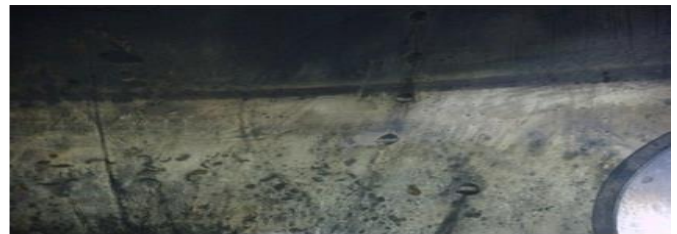


Fig .III..4.The bottom surface inside Desalter(V-103left,V-104right), [26]

---

### III.1.3.2.2 Internal Surface Conditions

### III.2.Sequence of Event

- The 1<sup>st</sup> Internal Inspection (TSD Aug 2007), mentioned peeling of the internal coating of the bottom side of V-103/V-104.
- The last Internal Inspection (TSD Dec 2018), shows that majority of coating is badly damaged and cracked specially at the bottom of the vessel, due to always contact with salty water NOL(normal operating level) of water level close to30%).
- The coating ,was damaged in the both bottom sides of the vessel (many points of flaking ,peeling, cracking),as shown in Fig .III.4.
- There is potential of corrosion under insolution, due to coating surface crack.

### III.3.Findings (Observation)

After trucking and investigating for the problem of coating which we found:

#### III.3.1.The internal coating:

- The internal coating is based on two ‘Sigma’ layers:
- The internal coating (glass flake lining) , never changed since 1<sup>st</sup> startup on 2003.
- The1<sup>st</sup>layeris Premier epoxy zinc polyamide (Sigma cover ZincPrimer).
- The 2<sup>nd</sup> layer is Polyamine epoxy coating, reinforced by glass ales(Sigmacover TCP Glass flake).
- The manual of coating‘ Sigmacover’ says that:  
\*The1<sup>st</sup>layerof coating‘ Sigma cover ZincPrimer’ must be recoverable by:

-Centre epoxy

-Freitapox

-Sigma ariteTCN300

-Sigma titesealer

-VigorEP201C

\*The “ Sigmacover TCP Glass flake ”must be recoverable by:-itself

- But we found that he applicat or didn't respect the manual, andtheyapply“SigmacoverTCPGlassflake”as recoverable (secondlayercoating) of “Sigma cover Zinc Primer”, and the same with 2nd layer, which mean the both of coating are not compatible to apply on eache here.

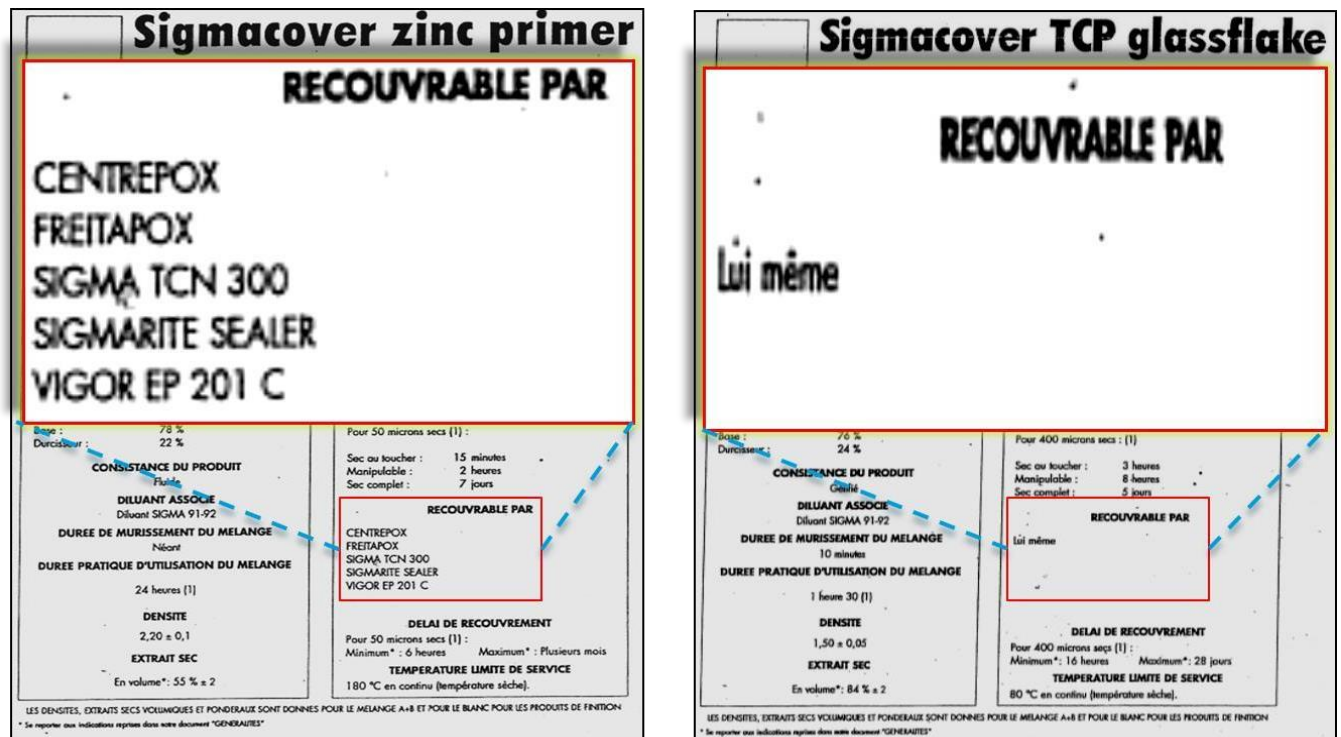


Fig .III..5: manual of sigma cover suitable recoverable coating [25]

- The manual of coating “Sigma cover ”says also:
  - \* The application of “Sigmacover Zinc Primer’ ’must be with thickness of 50 µm
  - \* The application of “Sigmacover TCP Glass flake” must be with thickness of 400µm

Based on construction coating inspection report on Jul2002,the application of both coating didn't meet thickness require The manual of coating“Sigmacover”saysalso:

\*The curing time required for ‘SigmacoverZincPrimer ’is7days.

- Based on construction coating inspection report on Jul 2002, the application of1<sup>st</sup> “Sigmacover Zinc Primer” didn't respect curing time required (07 days),which should be more than 07 days, d (exceed by 56% in 1<sup>st</sup> layer, and16.25%in2<sup>nd</sup>layer).

RAPPORT DE CONTRÔLE PEINTURE PAINTING CONTROL REPORT		Doc. n° 5758-PEINT-100A																		
<b>Client / Customer</b> : ENTREPOSE / PARAGON LITWIN <b>Ref. client / customer</b> : 5037-0100-03/007-00 <b>Affaire / Job</b> : MLN block dev. ALGERIA <b>Cde CMie / CMie order</b> : 02CD5758 <b>N° fab / Serial number</b> : 02-5758-100 <b>Désignation / Description</b> : 1 DESALTER V-103																				
<b>Document de référence / Reference document</b> : <b>Spécification applicabe / Applicable specification</b> :																				
<b>Référence peinture / Painting reference</b> : 1ère couche 2ème couche 3ème couche 4ème couche																				
<b>Résultats / Results</b> <table border="1"> <thead> <tr> <th>N° de Couche / Coat n°</th> <th>1</th> <th>2</th> </tr> </thead> <tbody> <tr> <td>ép. Requis / Thk required</td> <td>50 µm</td> <td>400 µm</td> </tr> <tr> <td>ép. Moyenne / Thk Average</td> <td>78 µm</td> <td>465 µm</td> </tr> <tr> <td>Date</td> <td>11/07/02</td> <td>12/07/02</td> </tr> <tr> <td>Hygrométrie (g/l) / Humidity (%)</td> <td>65</td> <td></td> </tr> <tr> <td>Température (°C) / Temperature (°C)</td> <td>23</td> <td></td> </tr> </tbody> </table>			N° de Couche / Coat n°	1	2	ép. Requis / Thk required	50 µm	400 µm	ép. Moyenne / Thk Average	78 µm	465 µm	Date	11/07/02	12/07/02	Hygrométrie (g/l) / Humidity (%)	65		Température (°C) / Temperature (°C)	23	
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Hygrométrie (g/l) / Humidity (%)	65																			
Température (°C) / Temperature (°C)	23																			
<b>Observation / Remark</b> Sablage [2.5] / Blasting [2.5]																				
<b>Conclusion / conclusion</b> L'appareil est conforme aux épaisseurs requises de la spécification. The vessel is conform with the thickness required by the applicable specification.																				
15/07/02	D. ROYANT																			
Date / Date	Pour / For CMie	Pour / For Inspection																		

Fig .III..6:manual of sigmacover ,thickness required for application of the coating[25]

The manual of coating ‘Sigma cover’ says also:

\*The curing time required for ‘Sigma cover Zinc Primer ‘is 7days.

- Based on construction coating inspection report on Jul 2002, the application of 1<sup>st</sup> ‘Sigma cover Zinc Primer’ didn’t respect curing time required (07 days), which should be more than 07 days,
- due to exceed thickness required from 50µm to 78µm (exceed by 56%).

SECHAGE		RECOUVREMENT	
<b>Pour 50 microns secs (1) :</b> Sec au toucher : 15 minutes Manipulable : 2 heures Sec complet : 7 jours		<b>RECOUVREMENT</b> Recouvrement : 6 H	
<b>PROPORTION DU MELANGE</b> En volume : 78 % Densité : 22 % <b>CONSISTANCE DU PRODUIT</b> Fluide <b>DILUANT ASSOCIE</b> Diluant SIGMA 91-92 <b>DUREE DE MURISSEMENT DU MELANGE</b> Filé 24 heures (1) <b>DENSITE</b> 2,20 ± 0,1 <b>EXTRAIT SEC</b> En volume : 55 % ± 2		<b>DELAI DE RECOUVREMENT</b> Pour 50 microns secs (1) : Minimum : 6 heures Maximum : 12 heures <b>TEMPERATURE LIMITE DE SERV</b> 180 °C en continu (température sèche)	
<b>RECOUVRABLE PAR</b> CENTREPOX FREDAPOX SIGMA TCN 300 SIGMARTITE SEALER VIGOR EP 201 C		<b>DELAI DE RECOUVREMENT</b> Pour 50 microns secs (1) : Minimum : 6 heures Maximum : 12 heures <b>TEMPERATURE LIMITE DE SERV</b> 180 °C en continu (température sèche)	

Fig .III..7: required curing time [25]



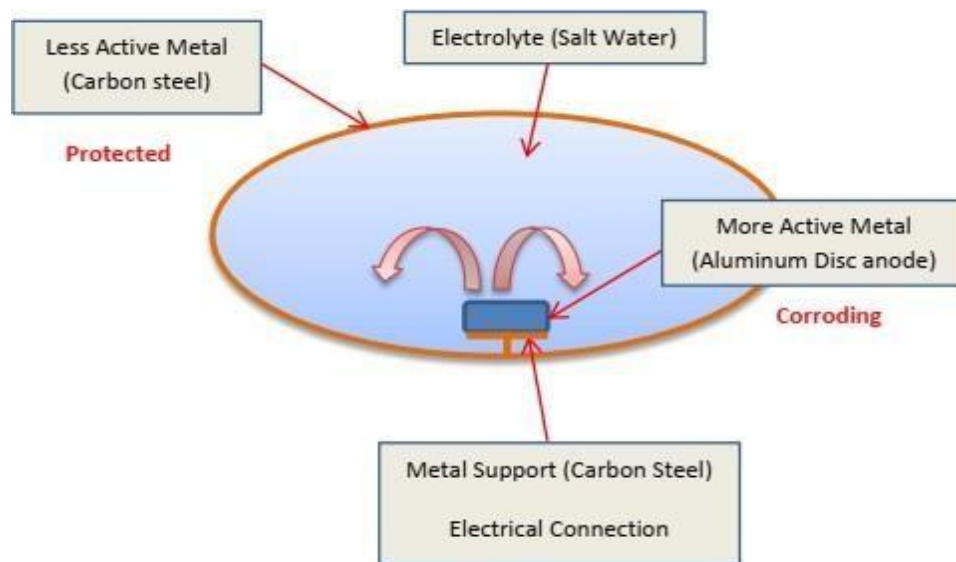
### III .4.The2<sup>nd</sup>preventionfromcorrosion

There is a back up method, in case of the internal coating has been failed, we call it 2<sup>nd</sup> prevention from corrosion.

The philosophy of this method, is installing sacrificial anodes inside the vessel in case of coating damaged, so we protect the internal surface until the next planned inspection.

#### III .4.1 Sacrificial Anode System

Sacrificial Anode (metals and alloys) system is one galvanic cathodic protection systems, depends on that anode corrodes sacrificially to protect the structure, as shown in fig.2 Sacrificial Anodes are typically alloys based on Aluminum, Zinc or Magnesium



**Fig .III.8.:**Sacrificial Anodesystem

#### III .4.2.Sacrificial Anode Type

- 1- Mg anodes cost is the most expensive ,and it used only on fresh water due not toxic.
- 2- Zinc anodes have been less expensive than aluminum, but since 2005 that's no longer the case.

The more active, longer lasting Aluminum anodes are less expensive, making the macular favorite for most commercial application

**Table.III.1;** Anodes should be selected upon location Based on ABYCR recommendations

Anode	Saltwater	Brackishwater	Freshwater
Mg(generates-1.6Volts)			√
Zn(generates-1.05Volts)	√		
Al(generates-1.1Volts)	√	√	√

**III .4.2.1 Calculation Notes**

This calculation Nistoaimed to define the number of Al SacrificialAnode to be applied in Desalter.

✓ *Vessel Ova larea S1:*

$S1 = 8.6m^2$

Rl: long

radiusRs:shortr

adius

✓ *Vessel Shell Area S2:*

$S2 = D \times L \times \pi = 5900 \times 3000 \times 3.14 = 55.6m^2 \dots\dots\dots (V.3)$

L:vessel length

✓ **Total area to be protected**

$ST:ST = S2 + (S1 \times 4) = 55.6 + (8.6 \times 4) = 90m^2$

S1: vessel Oval area

S2: vesselShell area

We know that NOL (NormalOperationlimit) of water in desalter is 30%,

so:  $ST = 90 \times 0.3 = 27m^2$

✓ **Total current required IT:**

$IT = ST \times i = 27 \times 20 = 540mA$

i: Currant density in mA/m<sup>2</sup> (Design currant density = 20

mA/m<sup>2</sup>)ST: Total surface are a to be protected in squar emete

✓ **Required anode weight W:**

*Disignlifex Total current require Current capacity*

$$W = \frac{\text{Disignlifex Total current require Current capacity}}{\text{Current efficiency x utilization factor}}$$

$$W = 10 \times 0.54 \times 3.5 / 0.9 \times 0.65 = 32.3 \text{ Kg}$$

Design life: 10 years

Al Anode Current capacity = 3.5 Kg/A.

year Al Anode Current efficiency = 90%

Utilization factor = 65%

✓ **Required anode quantity N:**

$$N = \text{required anode weight} / \text{weight of one anode} = 32.3 / 4.5 = 7.18 \approx$$

08 anodes Weight of one anode: 4.5 Kg

✓ **Protective area per one anode  $S_{\text{anode}}$ :**

$$S_{\text{anode}} = ST / N = 27 / 8 = 3.37 \text{ m}^2$$

$S_{\text{anode}}$ : protect area for one anode in square meter

ST: Total area to be protected in square meter

N: Required anode quantity

✓ **Protected diameter for one anode  $D_{\text{anode}}$**

$$D_{\text{anode}} = \sqrt{\frac{S_{\text{anode}}}{\pi}} = \sqrt{\frac{3.63}{\pi}} = 1.03$$

$D_{\text{anode}}$ : Protective diameter for one anode in meter

$S_{\text{anode}}$ : Protective area for one anode in square meter

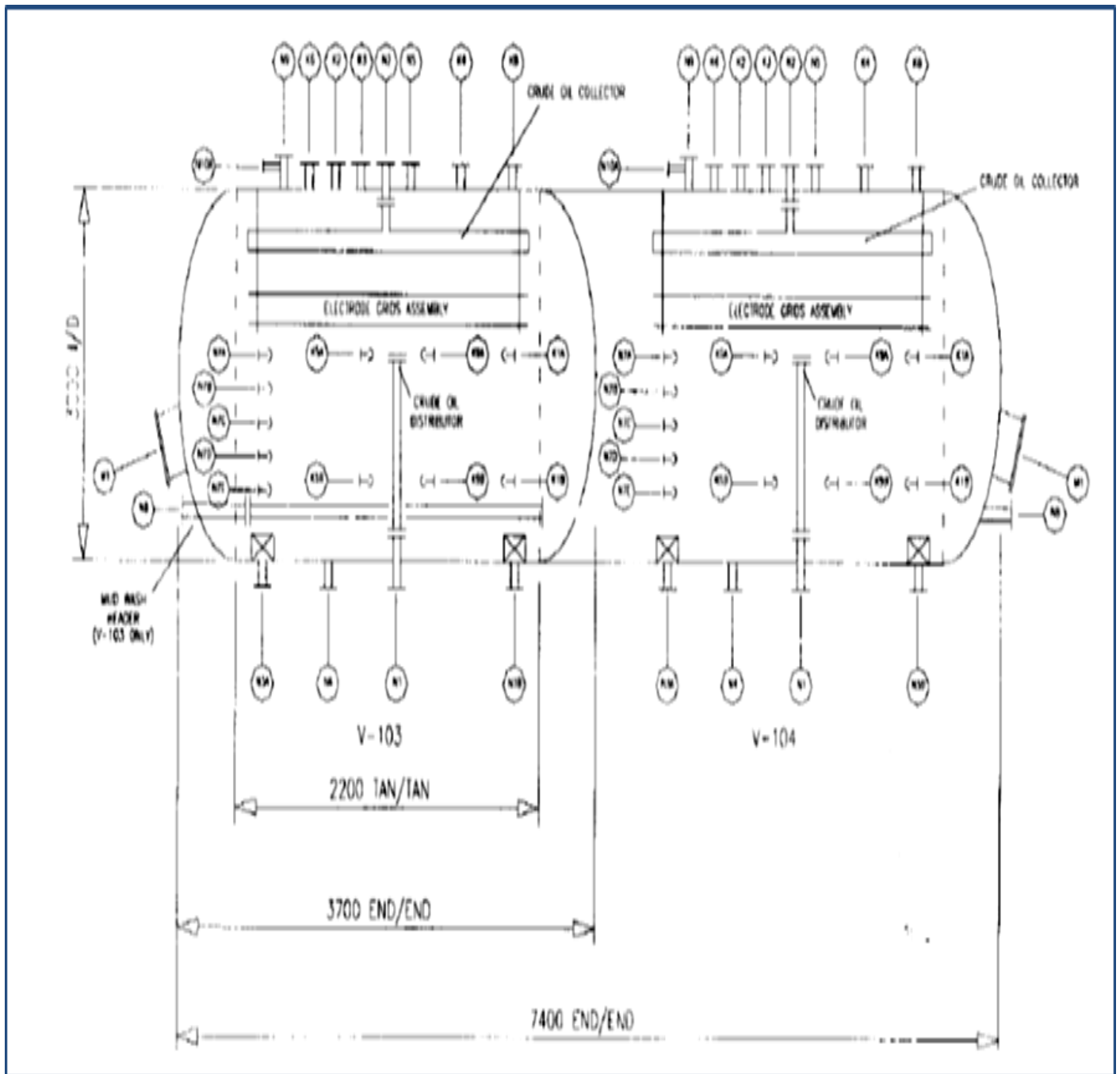


Fig .III.9:Desalter(V-103/V-104)dimension [01]

III 4.2.2. Calculation Results:

Tabel.III.2.Calcuation Results

Vessel	Total Area to be protected (m <sup>2</sup> )	Current requirement (mA)	Number of anodes N	Protective area per one anode (m <sup>2</sup> )	Protective diameter per one anode (m)
V-103	11.38	227.6	04(4.5kg)	2.845	0.95
V-104	15.62	312.4	04(4.5Kg)	3.905	1.11
<b>Total</b>	27	540	08(4.5kg)	6.75	2.06



Fig .III.10.:Sacrificial Aluminum Disc anode which should be installed in Desalter [08]

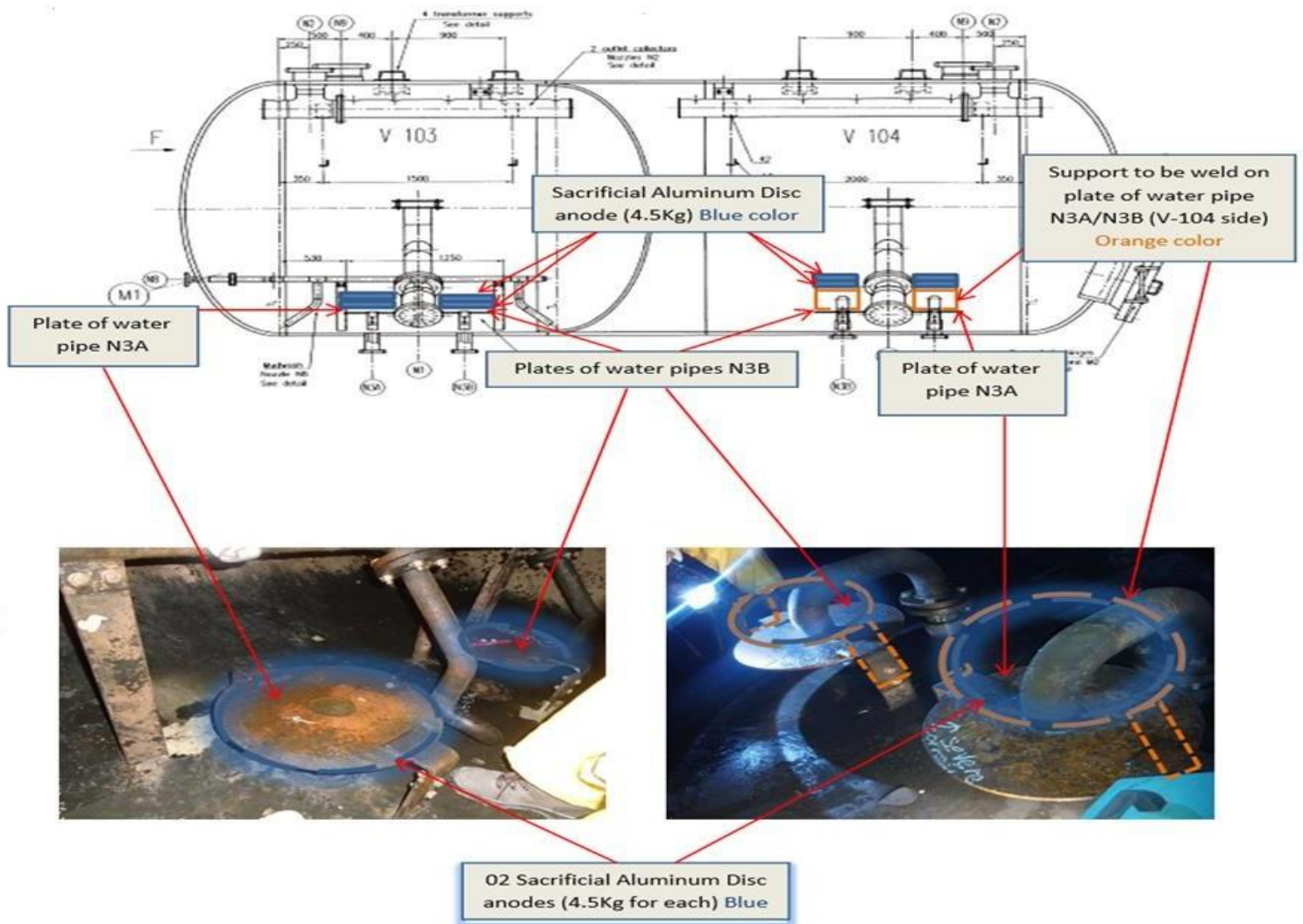
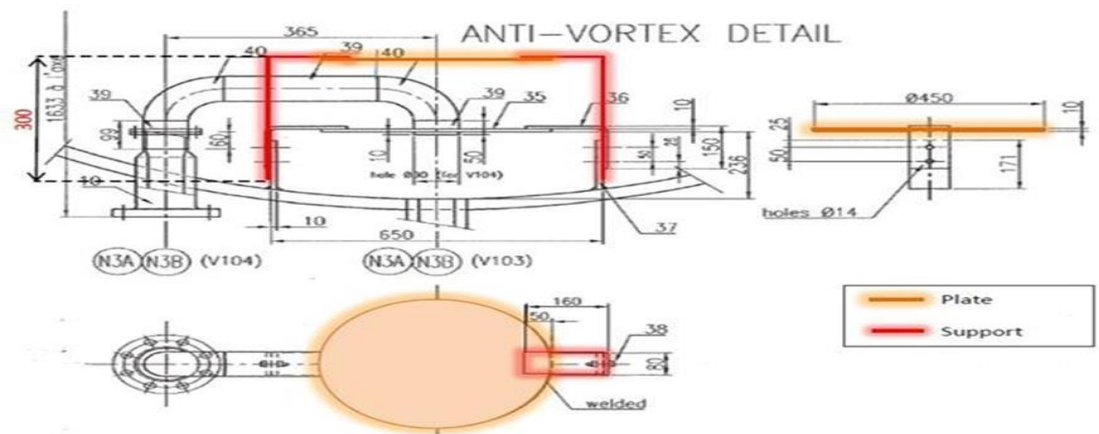


Fig .III.11 :Sacrificial Aluminum Disc Anodes Proposal Installation



**Fig .III.12:**the dimensions of plat and proposal support[01]

### III.5 Conclusion and Recommendations:

- There is a big potential to lose the internal coating of vessels directly after start the operation, so because of that: Installing sacrificial anode is mandatory in order to get 2<sup>nd</sup> prevention against corrosion
- During the coating of internal surface of any equipment, Respecting the vendor instruction manual such as: Suitability of coating layers, thickness of coating, curing time of coating, is highly recommended.
- Patch repair needs and blasting to damaged points, which are many and not localized. So, the patch repair isn't practical to repair the coating.
- The bottom part (3 to 9 O'clock (50% of desalter internal area  $\approx 45\text{m}^2$ )), must be replaced by new one.
- Plates of water pipes (N3A/N3B) of the vessel (both sides), should be replaced, due to sever corrosion.
- For double protection, in case of coating damaged. 04 Sacrificial Aluminum Disc Anodes (Fig .III.10), should be installed in the bottom of each vessel of desalter (bolting above the plates of water pipes (N3A/N3B) to avoid weld supports at the bottom of desalter), as Fig.4 shown.
- The next step is to confirm that those reparation successes to prevent the internal surface of the desalted, even we are believed that it works properly but we need to wait to the next in section to confirm.
-



**Fig .III.13:** the internal surface of desalter after applied the recommendation above [26]



Genral conclusion

## Général Conclusion

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### *General conclusion:*

Our work consisted in the study the corrosion of petroleum installations (vessels such as disaster) in MLN conocophilips field

Corrosion caused by harmful elements in petroleum facilities such as H<sub>2</sub>S,CO<sub>2</sub>,SRB..ect ,generates global economic losses in billions of Euros per year.

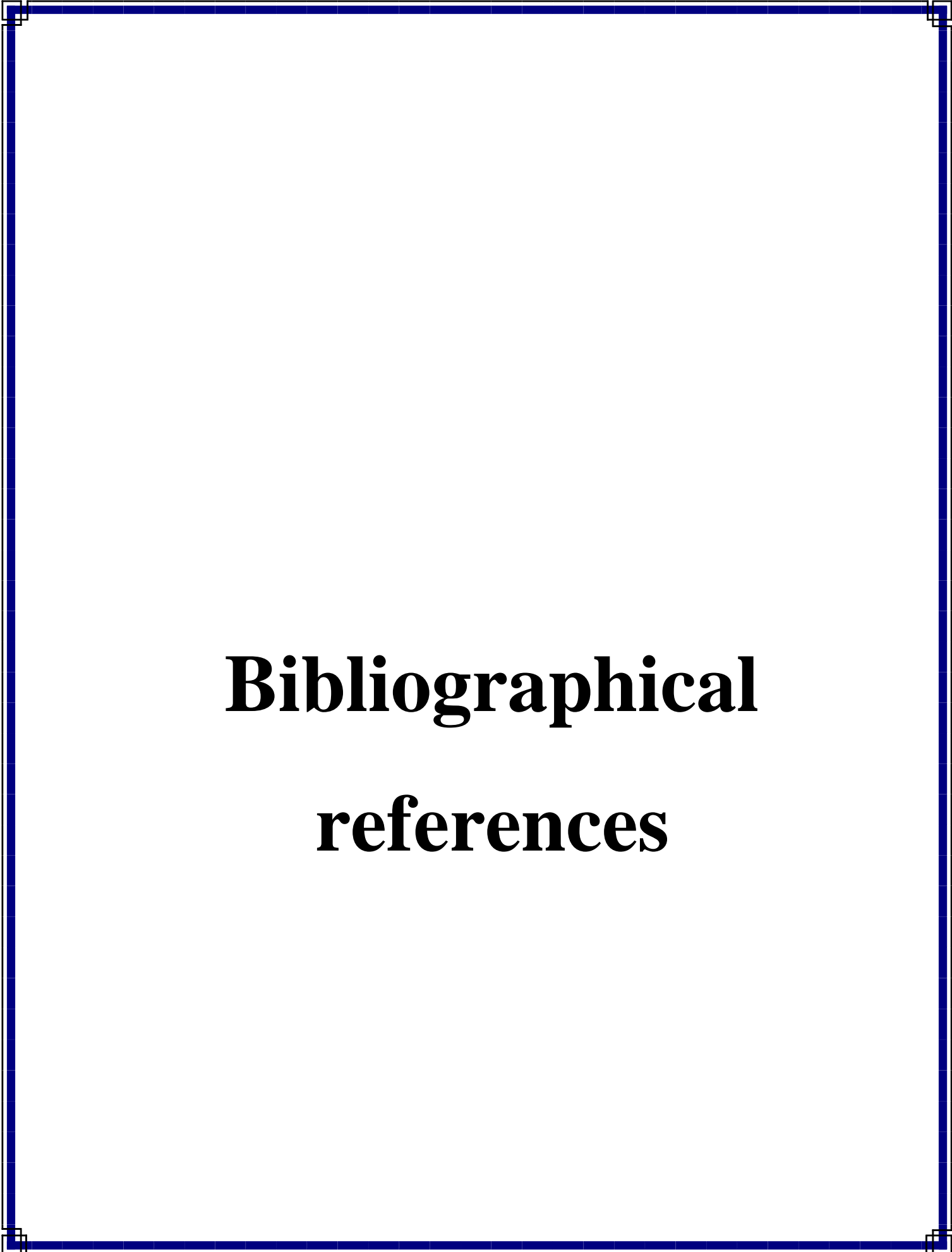
The techniques and methods of control and monitoring of corrosion have evolved a lot over time, including the technique of monitoring corrosion by coupons and probes which has proved its worth in the oil and gas industry.

To assess the degree of danger in petroleum installations, we have followed the internal corrosion in closed vessels such as disalter during shut down Which allows us to strip up inside the disalter and detect the problem of corrosion more accurately and give us a true picture of what is happening inside it.

We concluded that the primary protection against corrosion by means of the internal coating must comply with the instructions and standards given by the manufacturer.

Often the primary protection is not sufficient because we enumerate the sources and the types of corrosion, so we resort to secondary protection, in this case we used sacrificial anode method Which has proven to be effective in such cases.

The Confirmation of these works and results in the next shut downon 03/2022.



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