In Partial Fulfillment
of the Requirements for the Degree
Master in Mechanics and systems engineering

TOPIC

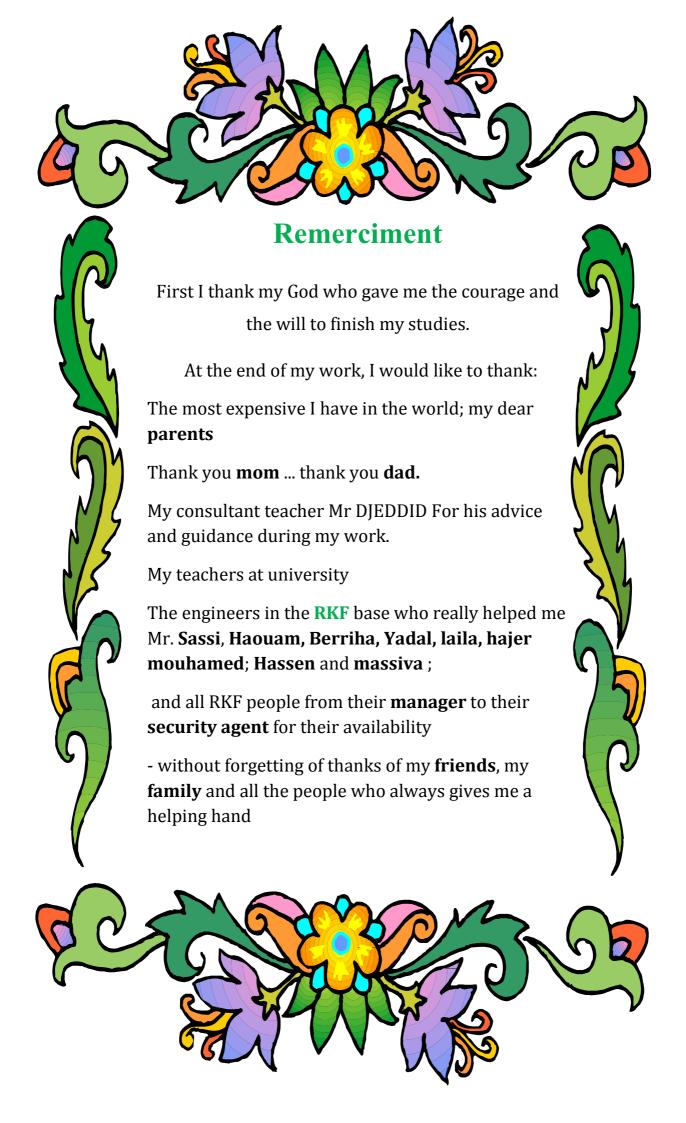## *Reliability study of the AJAX_ SUPIRIOR Compressor*

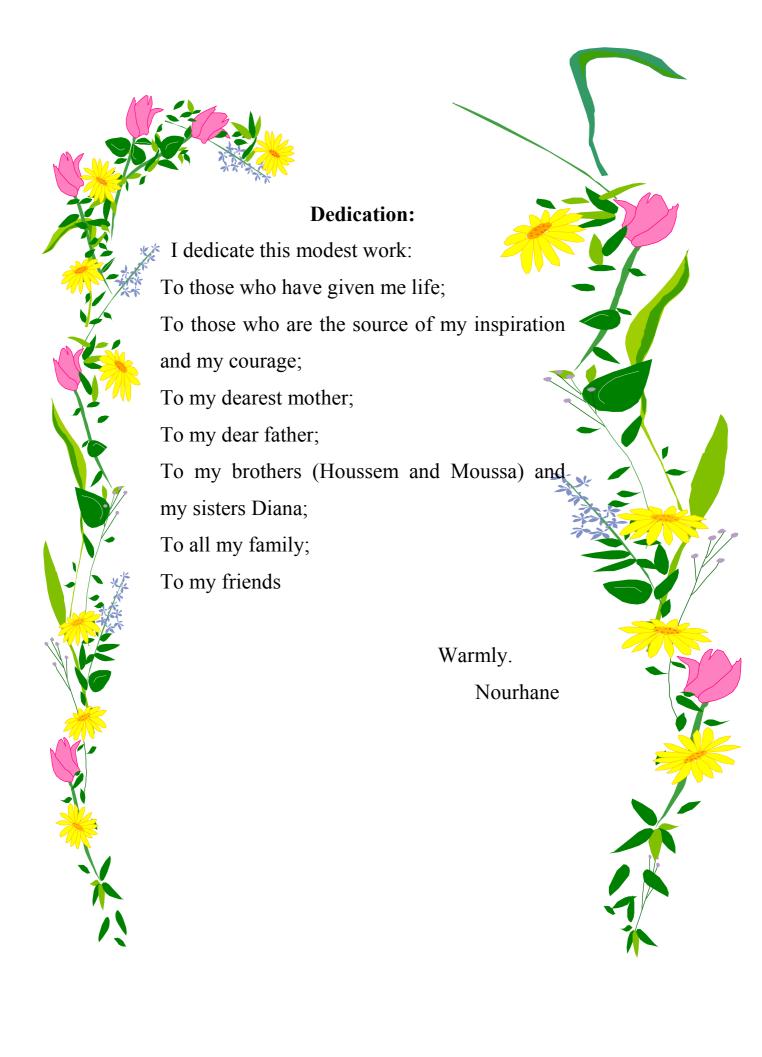**Realised by**:

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PROMOTION 2016/2017

Remerciment

First I thank my God who gave me the courage and the will to finish my studies.

At the end of my work, I would like to thank:

The most expensive I have in the world; my dear **parents**

Thank you **mom** ... thank you **dad.**

My consultant teacher Mr DJEDDID For his advice and guidance during my work.

My teachers at university

The engineers in the **RKF** base who really helped me Mr. **Sassi**, **Haouam, Berriha, Yadal, laila, hajer mouhamed**; **Hassen** and **massiva** ;

 and all RKF people from their **manager** to their **security agent** for their availability

- without forgetting of thanks of my **friends**, my **family** and all the people who always gives me a helping hand

Dedication:

I dedicate this modest work:

To those who have given me life;

To those who are the source of my inspiration and my courage;

To my dearest mother;

To my dear father;

To my brothers (Houssem and Moussa) and my sisters Diana;

To all my family;

To my friends

Warmly.

Nourhane

Abstract

The work presented in this project has an objective to analyze the reliability of a volumetric compressor using Weibull method to evaluate the actual state of the machine. To realize this work we have used the historical data of the machine evaluated by the company during the last 5 years

Résumé

Le travail présenté dans ce projet a pour objectif d'analyser la fiabilité d'un compresseur volumétrique utilisant la méthode de Weibull pour évaluer l'état actuel de la machine pour réaliser ce travail, nous avons utilisé l'historique de la machine évalués par l'entreprise au cours des dernières 05 années

ملخص

العمل المعروض في هذا المشروع له هدف لتحليل موثوقية الضاغط الحجمي باستخدام طريقة ويبول لمعرفة الحالة الفعلية للآلة. لتحقيق هذا العمل استخدمنا البيانات المسجلة للآلة من قبل الشركة خلال السنوات ال 5 الماضية

Summary

List of figures :

Liste of tables

Nowadays mechanics occupies a preponderant place in the world. Any energetic process consists in organizing transfers of work and heat.

In the field of maintenance, that has become a level of the company; the maintenance of production equipment in constant running condition is automatically required.

The proper functioning is required in particular at the factory level.

The objective of our work is to study the reliability of a volumetric compressor and in this machine there is an exchange of energy well on this exchange takes place by deformation of capacity inside which the fluid is temporarily caught.

For this we have structured our work in this way

- **Chapter I:** Is entirely devoted to the organization that welcomed us during our course and nevertheless enriching practical training course
- **Chapter II:** Presents a bibliographic synthesis on the concept of compressors
- **Chapter III:** A reliability study was carried out on the compressor
- **Chapter IV**: Is devoted to maintenance and safety of compressors
- **Chapter V:** A reliability study was carried out on the compressor
  - Description and study of reliability
  - The practice of Weibull law
  - Machine failure study
- **Conclusion:** summarizes the results of our work.

general introduction

Nowadays mechanics occupies a preponderant place in the world. Any energetic process consists in organizing transfers of work and heat.

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chapter I
presentation of RKF

I .Introduction:

Sonatrach ("National Society for Research, Production, Transport, Transformation and Marketing of Hydrocarbons s.p.a") is an Algerian public company created on December 31, 1963, a major player in the petroleum industry known as the African major. Sonatrach is ranked the first company in Africa.

II.Localization of the field rhoude el khroufe (RKF):

The rhede el khrouf (RKF) deposit is located in the intractonic basin of ghadames at 320 km of hassimessaoud, 1200 km south east of Algiers.

This field was discovered in September 1992 on the perimeter of roudeyacoub 406 A whose research surface permissible is 1640 square km

- having regard to the promising results of the drilling, the preliminary development plan for the RKF deposit has been completely revised, giving way to a new plan which has made it possible to achieve several accomplishments, among others - a total number of wells equal to 23
- an improvement in provisional facilities to ensure better technical reliability in a language period of operation
- an increase in crude processing capacity of 20,000 BOPD
- a recovery of the associated gases and their injection into the deposit
- an important regional infrastructure (road - pipeline, ect ...)

III. Association (SH / CEPSA):

III.1 Sonatrach:

A world leader in the field of energy **sonatrach** is the Algerian company of research of exploitation of pipeline transport of transformation and commercialization of thehydrocarbons and other sectors such as the electrical generation, the new and renewable energies and Desalination of seawater

It carries out its activities in Algeria and all over the world where

Is the first company in the African Container. It is ranked 12th among the world oil companies, 2nd exporter of (LNG) and LPG and 3rd exporter of natural gas. Its total production (all products combined) is 230 million toe in 2006

Its activities constitute about 30% of the GNP of Algeria

It employs 120000 people in the whole group

Today **sonatrach** conceives for economic development without sustainable development **(CEPSA)**

III.2 CEPSA:

In addition a strong petrochemical division which is closely integrated with the

Refineries, and is also involved in other energy-related businesses, such as oil and gas exploration and production, natural gas and

Operations of generations of electrical power and sales.

CEPSA has been on the market for nearly 80 years, thanks to its flexibility and ability to adapt, CEPSA has become one of the leading companies in its field

In Spain, thanks to the progressive internationalization of its activities, it has also invested in Algeria, Brazil, Canada, Colombia, Egypt, Panama, Peru, and Portugal, and sells its products all over the world

The operations implemented by CEPSA in Algeria Exploration and production of crude oil and natural gas.

At present, CEPSA operates under the Production Distribution Contract and

With the Algerian national company SONATRACH, two deposits located in the Berkine basin, in block 406 A.

The first of these, Rhoude el Krouf (RKF), entirely located in block 406 A

, Currently produces 1000 barrels / day.

The Ourhoud (ORD) deposit, the second largest in all of the country's discoveries, and extending over Blocks 404 and 405, has been in operation since December 2002.

In order to increase its presence in the natural gas business, CEPSA is part of a

A consortium led by TOTAL, which was awarded exploration and gas production permits in the Timimoun basin and in basin From Béchar respectively With SONATRACH, it also formed the company MEDGAZ. The company,

In which other energy companies participate, is to study and promote a gas pipeline that will link Algeria and Europe, passing through Spain.

IV. Current Composition of the Field:

- Oil production wells: 24
- Gas injector wells: 11
- A CPF processing center: Central Processing Facilities.
- A collection network and services.
- An industrial base.
- A base camp for (SH / CEPSA) staff.
- A base camp for subcontractors.

V. Field Facilities:

V1.General installation:

The RKF field consists of two parts:

CPF (Central Process Facilities) Offices and Lifestyle
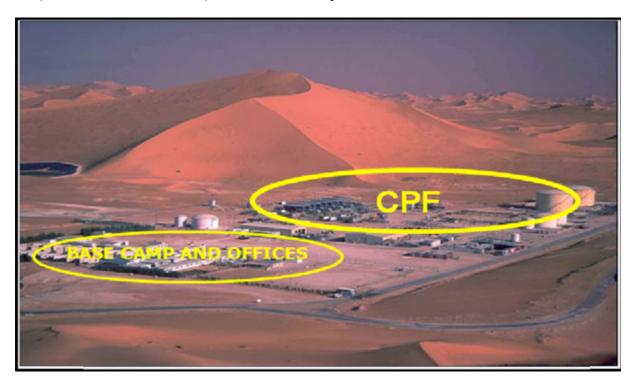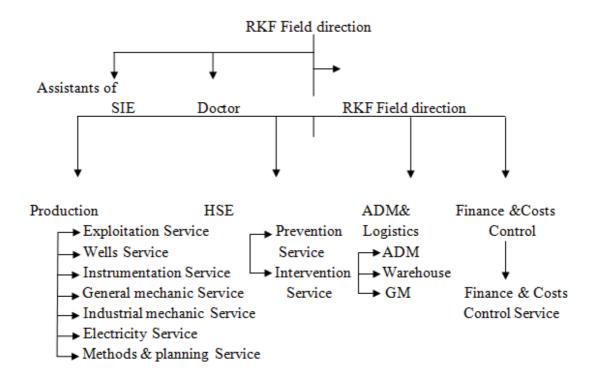
Figure01: Overview of the RKF field

Flowchart of the RKF field:

Flowchart01 :RKF field

1. The main objectives of each department:

➤ <u>Production:</u>

a. **Exploitation service:**

the analysis of the produced oil to ensure that RVP (TVR) ≤ 10, 6 and salinity ≤ 40mg/l.This service is concerned also about controlling three parameters which are level, pressure and temperature from control room, and regulating them in case of variation (increase or decrease) according to a set point. The regulation is done either automatically or manually by operators.

b. **Wells service:**

reading and checking the pressure and temperature in well and in the line as well. In addition to the injection of corrosion inhibitors from period to period depends to the need of the well. Also all operations concerned the well such as slick line (wire line), coiled tubing, work over...etc. is supervised by this service.

c. **Instrumentation service:**

maintenance and reparation of instruments, testing them to ensure that they work as it should be. In addition to that, regulating the parameters mentioned above if it is needed (operators).

d. **General mechanic service:** maintenanceand reparation of cars, vans…etc

e. **Industrial mechanic service:**maintenance and reparation of industrial equipments (compressors, separators, valves…etc).

f. **Electricity service:**the electricity in RKF comes from sonelgazOurhood station 30 kv. It is used for lightening and alimentation of electrical machines. A system of electricity back up has been installed in the CPF with two generators (gas/diesel) in case ofany interruptionin electricity in Sonelgaz network which insure continuous power infield.

g. **Methods & planning Service:** the essential roles of this service are the verification (by programming preventive and corrective inspections, periodic maintenance), and updating documents and schemas.

➢ **HSE:**
From the name of the department (H, health S, safety E, environment) it is obvious that it depends and focuses on all relevant processes to protect persons, equipment, and environment from any hazard.

a. **Prevention Service:** to prevent persons, equipment, and environment there are a lot of activities to do such as :
✓ HSE Inspections.
✓ HSE Audit
✓ The application of HSE processes (exp: work permit).
✓ Insure the regulatory compliance with HSE laws and standards.
✓ HSE training.
✓ Job safety analysis.
✓ Risk assessment.
✓ Accident investigation.

b. **Intervention Service:**
✓ Maintenance of safety equipments (extinguishers, fireboxes...etc).
✓ Testing and servicing fire systems (pumps, foam system, deluge system, CO_2 system).
✓ Intervention in case of fire, leakage, accident...etc.
✓ Fire drills (exercises of intervention).
✓ Giving assistance during high risk operations.
✓ Giving medical evacuation and first aid in case of an accident.

c. **ADM& Logistics:**

a. **ADM Department :** this service is concerned about:
✓ Casework.
✓ Payroll.
✓ Planning (training, mission order...etc).
✓ Flight schedules.
✓ Planning of medical check−ups.
✓ Social (assurance, Chifacard...etc).
✓ Control personnel leaving and entering facility.
✓ Human resources management.
    Camp Boss (Camp Administrator): Camp Boss has the added responsibility of managing the base staff and relatedissues (lodging, catering...etc).
    Warehouse Service:
✓ Material Storage management.
✓ Purchase of needed equipments.
✓ Survey of min and max stock.

d. Finance & Costs Control:

Finance & Costs Control Service:the cost of any operation, installation, services, or products are controlled by this service.Bills are sent through a network directly to Madrid to seek the approbation.

After going through a process of approval at different stages (coordinating with the office in Madrid), the payment will be either with cheque (if the cost is big) or cash (if the cost is small).Then the service should confirm with RKF Warehouse service that the products has been delivered.

Control of the department's budgets is one of their duties too.

Chapter II

Generalities on compressors

I.   Description of compressor :

1.1.1 Introduction:

Compressors are devices which convert the mechanical energy supplied by a power plant into pressurized energy; (By affecting an increase in pressure of a fluid in the gaseous state).

1.1.2 Definition of the compressor:

- A machine for compressing a compressible fluid (eg, air) at a desired pressure.
- A component of a refrigeration system that sucks the gaseous refrigerant and delivers it to a higher pressure. (Piston compressors are used in low power installations, screw compressors and centrifugal compressors in medium and high power plants.)

1.1.3 Purpose of Compression

Compression in general can be imposed by technical necessity to move a certain quantity of gas from one system to a certain pressure to another system at another higher pressure. Operation is intended to:

- Circulating a gas in a closed circuit
- Produce favorable (pressure) conditions for chemical reactions.
- Send gas into a pipeline from the production area to the user
- Obtain compressed air for combustion Recover gas (G.N.L unit or other

1.1.4 Classification of Compressors:
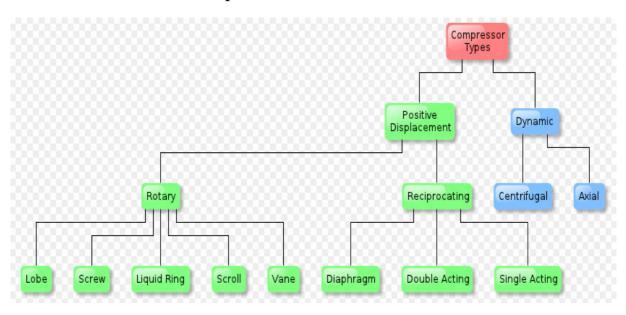
Figure 02: **classification of the different types of compressors**

1.1.4.1 Turbo-compressors:

Turbochargers are commonly used on truck, car, train, aircraft, and construction equipment engines. They are most often used with otto cycle and Diesel cycle internal combustion engines. They have also been found useful in automotive fuel cells.

There are three types:

- Centrifugal compressors
- Axial compressors
- Hélico-centrifugal compressors

1.1.4.2 Positive displacement types (volumetric):

A-Rotary Types:

1. Rotary Sliding Vane Type:

The rotary vane compressor consists of a rotor mounted eccentrically in a housing As the rotor turns, the vanes slide out by centrifugal force until they seal against a thin film of lubricant coating the stator wall. There is no metal-to-metal contact as the blade tip glides on the surface of the lubricant. Air compression occurs when the volume of the spaces between the sliding vanes is reduced as the rotor turns in the eccentric cylinder. Single-stage rotary vanes are oil injected and are most common in industrial applications ranging in pressure from 60 psi to 200 psi. Multi-stage versions range in pressure from 60 psi to 150 psi, use flow-through lubrication that "consumes" lubricant and are most typically used in moving bulk material i.e., concrete. While there are oil-free rotary vane blowers and ,vacuum pumps, rotary vane compressors are not oil free.
Some of the advantages of rotary vane compressors are smooth and pulse-free air output, low noise, high output volume, low vibrations, prolonged service intervals and long life.

Figure 03: rotary sliding vane type

2. Lobed compressors:

Two straight mating lobed impellers trap the gas and carry it from intake to discharge. There is no internalcompression.
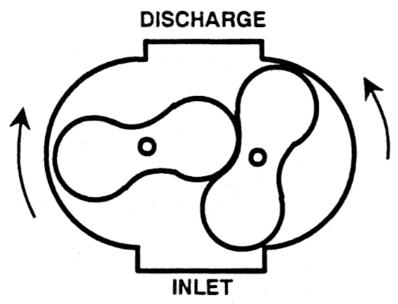
Figure 04: lobed compressor

3. Rotary Helical Screw Type:

Rotary helical screw compressors utilize two intermeshing helical rotors in a twin-bore case. In a single-stage design, the air inlet is usually located at the top of the cylinder near the drive shaft end. The discharge port is located at the opposite end of the cylinder. As the rotors unmesh at the air inlet end of the cylinder, air is drawn into the cavity between the main rotor lobes and the secondary rotor grooves. As rotation, continues, the rotor tips pass the edges of the inlet ports, trapping air in a cell formed by the rotor cavities and the cylinder wall. Compression begins as further rotation causes the main rotor lobes to roll into the secondary rotor grooves, reducing the volume and raising cell pressure.

Oil is injected after cell closing to seal clearances and remove heat of compression. Compression continues until the rotor tips pass the discharge porting and release of the compressed air and oil mixture is obtained. Single or multi-stage versions are available. This type of compressor can be oil lubricated water lubricated or oil-free. Some advantages of the rotary helical screw compressors are smooth and pulse-free air output, compact size, high output volume, low vibrations, prolonged service intervals and long life.
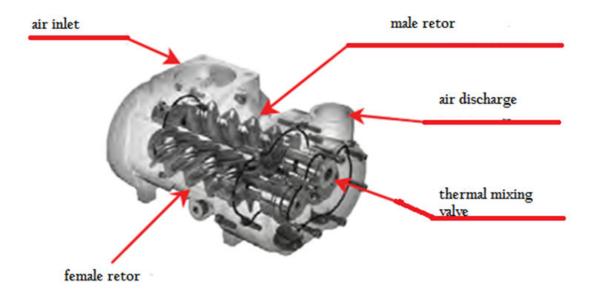
Figure 05 : rotary helical screw type

4. Rotary Scroll Type

Air compression within a scroll is accomplished by the interaction of a fixed and an orbiting helical element that progressively compresses inlet air This process is continuously repeated, resulting in the delivery of pulsation-free compressed air. With fewer moving parts, reduced maintenance becomes an operating advantage. Scroll compressors can be of lubricated or oil-free design.
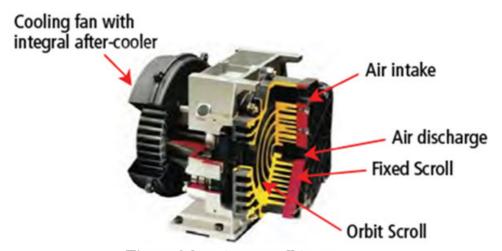
Figure 06 : rotary scroll type

B- Reciprocating Compressors:

1. Diaphragm Type

Diaphragm compressors (Figure 5) are a variation of reciprocating compressors. The diaphragm compressor develops pressure through a reciprocating or oscillating action of a flexible disc actuated by an eccentric. Since a sliding seal is not required between moving parts, this design is not lubricated. Diaphragm compressors are often selected when no contamination is allowed in the output air or atmosphere, such as hospital and laboratory applications. Diaphragm compressors are limited in output and pressure and they are used most often for light-duty applications.
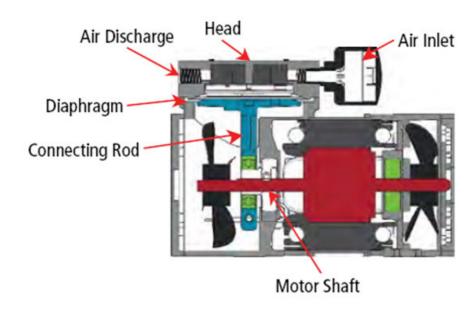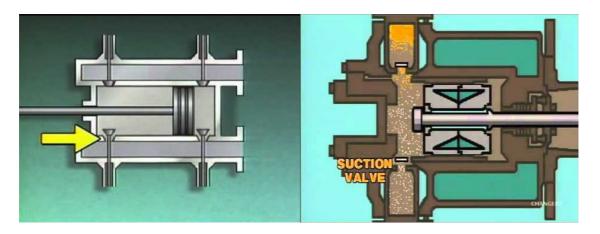
Figure 07: diaphram type

5-A piston compressor:

A piston compressor as its name indicates is equipped with a piston which slides in a cylindrical chamber equipped with intake and delivery valves of the refrigerant in the gaseous state. Its operation is the reverse of that of a conventional combustion engine since the rotary movement is created by a generally electric motor which drives the shaft and the connecting rod itself connected to the piston. Three phases of admission, compression and delivery of the refrigerant are provided by this compressor in the cylindrical chamber. The adjustment of the power depends on the size of the compressor: all or nothing generally for the small powers, shutdown of some cylinders or change of the driving speed for the medium to strong powers. Her are many types of this compressors According to the number of stages and the type of movement (single acting double acting).

Our machine is a reciprocating compressor with double acting pistons, driven by a gas engine.

Double acting pistons   **Single acting pistons**

Figure 08: **different types of pistons**

1.1.5 Compressor AJAX- SUPERIOR (X101A) :

1.1.5.1 Description of the machine:

The AJAX-SUPERIOR compressor is of compact design and has been efficiently engineered for reliable, continuous, heavy duty and long life with trouble free operation
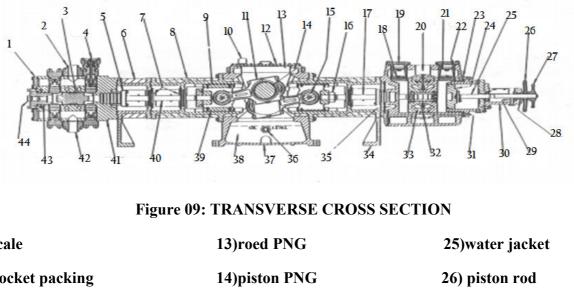
These raggedlyconstructed, balanced opposed type compressors are built to the same high precision, high quality field proven standards as the AJAX-SUPERIOR engines

Ready accessibility of all warning parts means simplified maintenance and dependable service

The balance opposed design with two crank throws separated by a crank check, has become the modern standard for reciprocating compressors.

Main and connecting rod bearing are of thin wall , steel backed , split ,precision design , the crankshaft can be removed through the top of the base without disturbing the cylinders , the lube oil pump and the force feed lubricator are gear or shaft driven and mounted on the auxiliary end cover

Either may be removed independently lube oil is drown from the sump through a screen type strainer which protects the lube oil pump.

An oversize full-flow lube oil filter protects all from running parts.

Figure 09: TRANSVERSE CROSS SECTION

1)scale

2)pocket packing

3)cylinder head

4)cylinder liner

5)rodpaking

6)crossheadgud

7)crosshead shoe

8)spacer bar

9)breather cap

10)top cover

11) valve retainer

12) piston

13)roed PNG

14)piston PNG

15)section plate

16)thru valve

17) cylinder body

18)water jacket

19) cylinder head

20)ping

21)valve cap

22)discharge nozzle

23) water jacket

24)plate valve

25)water jacket

26) piston rod

27)base

28) crankshaft

29)connecting rod

30)crosshead PN

31)crosshead support

32)packing spacer

33)piston VV packet

34) bonnet

35)voke

36)adjesting handwheel

1.1.5.2 Lubrication and cooling:

A good mineral oil which provides resistances to oxidation and corrosion is generally satisfactory for lubrication in a reciprocating compressor which has its crankcase sealed off from the cylinders. However there is no objection to the use of detergent type oil if this is more readily available. The best assurance of obtaining a suitable oil is to use only products of well know merit , produced by

responsible concerns and used in accordance to be used as an experimental unit for trying out new or questionable lubricants

1.1.5.3 Characteristics of the AJAX-SUP (X101A):

<u>Characteristics of the AJAX-SUP (X101A):</u>

The compressor is manufactured by**SUPERIOR,** which is identified by a logical nomenclature **W76**that defines:

> **W:** Model
> **7:** Stroke of compressor in inches
> **6:** Number of throws or compressor cylinders

Here are the important characteristics of the compressor:

> 4 StagesReciprocantCompressor

> **Ratedhorspower:** 4500 BHP

> **Ratedspeed:** 900 RPM

> **Ratedpistonspeed:** 1050 FPM

> **Number of cylinders:** 1st stage(1 cylinder), 2^{nd}stage(1 cylinder) 3^{rd}stage(2 cylinders) 4^{th}stage(2cylinders)

> **Gassuction/discharge pressure:**

- 1st stage: P_s= 55 psi   ,P_d=200 psi
- 2nd stage: P_s= 190 psi   ,P_d= 650 psi
- 3rd stage: P_s=   640psi   ,P_d= 1725 psi
- 4th stage: P_s=   1715 psi   ,P_d= 5525 psi

> **Gassuction/dischargetemperature:**

- 1st stage: T_s= 144°F   ,T_d=248.7 °F
- 2nd stage: T_s= 142 °F   ,T_d= 260.8 °F
- 3rd stage: T_s=   140 °F,T_d= 261.9 °F
- 4th stage: T_s=   140 °F   ,T_d= 282.1 °F
  > **Capacity:**
- 1st stage: 1.45 MMSCFD
- 2nd stage: 7.629 MMSCFD
- 3rd stage: 13.834 MMSCFD
- 4th stage:12.29 MMSCFD

Quality of performance:

Cooper energy services do not guarantee the quality or performance of lubricating oils.

Satisfactory oil quality is the responsibility of the refiner blender or rebranded only reputable companies with proper service organizations should be used as suppliers.

Coopers energy services does not endorse particular of oil

For customers conveniences a file of the preferred lubricating oil by brand name is maintained by cooper energy services

Customers are invited to advice the superior engineering department or service representatives what brands of oils are preferred. Cooper energy services can then advise which products have given satisfactory services in similar applications

Chapter III

Generalities on reliability

III.   Reliability :

***III.*1. Introduction:**

The main objective of reliability studies is to help get better designs. All the analyzes done in mechanical reliability have to be made concrete by technical decisions and not by a simple satisfaction of our scientific rigor. From this point of view we cannot overemphasize the importance of design and decision-making: "design by reliability", this must be the first motto of the truck mechanic.

Neither at least, the analysis of the operational reliability of a system, based on feedback, allows us to define certain objectives:

- Measure a guarantee over time;
- Strictly assess a degree of confidence
- Decrypt a lifetime;
- Determine an intervention program;
- Provide a reassuring stock of spare parts.

These objectives allow us to better exploit the equipment in order to optimize their operation and satisfy the production which is ultimately the essential goal of any company.

In the study that will follow applied to a gas compressor we will look at each of these objectives with more or less insistence.

III.2 . Definitions and notations:

III.2.1. Reliability:

According to standard X05-501(ASME), reliability is the ability of a device to perform required function under given conditions of use and maintenance for a given period of time.

Maintenance activities are therefore closely linked to the "reliability" characteristics of equipment / products.

A system, equipment or product is said to be reliable when the probability of performing its intended functions over a given period of time corresponds to that specified in the specification.

The reliability of a system, equipment or product characterizes its ability to function without failure. It is a component of quality that involves time. It cannot be verified with certainty upon receipt. .

Probability that an entity can perform a required function under given conditions during a given time interval [t1, t2]; that we write R (t1, t2).

- **Availability:**

Probability that an entity is capable of performing a required function under given conditions at a given time t; It is denoted D (t).

- *Maintainability:*

Probability that a given maintenance operation can be performed during a given time interval [t1, t2].

- **MTA:**

Average time during which the system is unavailable. It includes the time of detection of the breakdown, the time of displacement of the service maintenance, the time of supply of the material in breakdown, the time of repair.

- **MTBF:**

Average time between failures of a repairable system.

- *MTTF:*

Average time before the first failure.

- **MTTR:**

Average repair time.

- **Feedback:**

Operational reliability data collected during equipment failures in operation
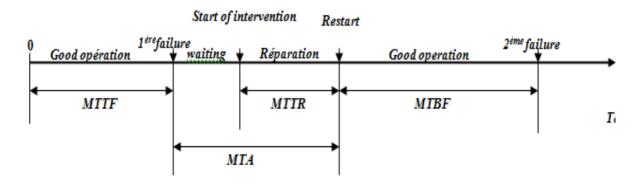
Figure10: Relation between the different quantities characterizing reliability, maintainability and availability of equipment.

III.2.2.Objectives and interests of mechanical reliability:

Reliability analysis is an essential step in any safety study.

Originally reliability related to high-tech systems (nuclear power plants, aerospace) today reliability has become a key parameter of quality and decision support in the study of most components, product and process, General public, transport, energy, buildings electronic components, mechanical components

Many industrialists are working to improve and improve the reliability of their products during their cycle of development from conception to commissioning (design, manufacturing and operation) in order to unlock their knowledge on the cost / Reliability and control the sources of failure

Reliability analysis in the field of mechanics is a very important tool to characterize the behavior of the product in the different phases of life to measure the impact of design changes on the integrity of the product, to qualify a new product and to improve its performances throughout his mission.

III.2.3.Evolution of costs according to reliability:

The unreliability increases the costs of after sale (warranties, legal costs) build more reliable, increases the design and production costs)

III.2.4. Reminders of statistics:

III.2.5. Random variable, probability laws:

III.2.6. Notion of Random Variable:

A random variable T is a variable such that at each value t of T we can associate a probability. A VA can be discrete or continuous. The correspondence between VA and the probability associated with it establishes a probability law. Consequently, we distinguish continuous and discrete laws.

III.2.7.Reliability of a system:

- The de fi nition of the reliability of an electronic system or else requires first of all to know the law of the reliability (or the failure law) of each of the components involved in the system)
- The reliability of the electronic system is calculated according to the reliability of all its components
- The calculations are carried out under the assumption that the failure rates are constant over time
- A mechanical system:
  Unlike electronics, relies on the reliability of some elementary components responsible for itsmalfunctionContrairement à l'électricité repose sur la fiabilité de quelques composants élémentaires responsables de son dysfonctionnement

III.3. Reliability:

It is the probability of good operation at time t_i

$$R(t_i) = \text{Pr}(T \succ t_i)$$

II.1.3. Distribution functions:

This is the probability that the device will fail at time t_i

$$F(t) + R(t) = 1$$

Note that these two functions are complementary:

$$F(t) + R(t) = 1$$

III.3.1. Probability Density:

The probability density of the instant of failure T is obtained by deriving the distribution function F (t):

$$f(t) = \frac{dF(t)}{dt} = -\frac{dR(t)}{dt}$$

III.3.2. Failure rate:

Probability that an entity loses its ability to perform a function during the interval [t, t + dt], knowing that it has not been failing between [0, t]; It is noted.

Fonction	$F(t)$	$R(t)$	$f(t)$	$\lambda(t)$
$F(t)$		$1 - R(t)$	$\int_0^t f(u)\,du$	$1 - \exp-\int_0^t \lambda(u)\,du$
$R(t)$	$1 - F(t)$		$\int_t^\infty f(u)\,du$	$\exp-\int_0^t \lambda(u)\,du$
$f(t)$	$\frac{dF(t)}{dt}$	$-\frac{dR(t)}{dt}$		$\lambda(t)\exp\int_0^t \lambda(u)\,du$
$\lambda(t)$	$\frac{\frac{dF(t)}{dt}}{1-F(t)}$	$-\frac{R'(t)}{R(t)}$	$\frac{f(t)}{\int_t^{+\infty} f(u)\,du}$	

III.3.3. Main laws used:

In the reliability studies of the various equipments, a continuous or discrete random variable can be distributed according to various laws which are mainly:

III.3.4.The exponential law:

It is most commonly used in electronic reliability to describe the period during which the failure rate of equipment is considered constant. It describes the elapsed time to failure, or the time interval between successive failures..

III.3.5.The normal law:

It is a continuous law with two parameters; The mean value and the standard deviation characterize the dispersion around the mean value. It is the oldest, used to describe the phenomena of uncertainties on measurements, and those of fatigue of mechanical parts.

III.3.6.The log-normal law (or GALTON's law):

Let A be a positive continuous VA; If the variable is distributed according to a normal distribution, the variable x follows a log-normal distribution. Numerous phenomena of mortality or duration of distribution are distributed according to log-normal laws.

The table below represents the representative functions of these four laws
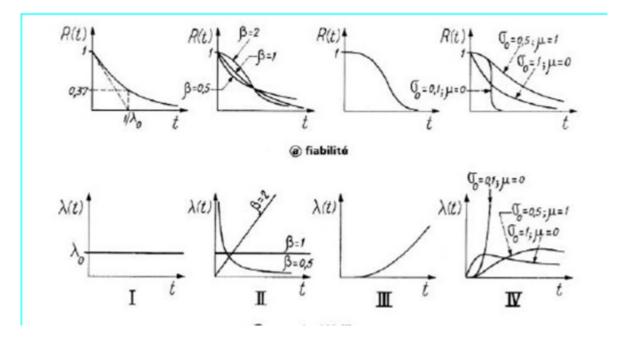
Figure 11: Main features of the weibull distribution

III.3.7. Binomial law:

The binomial law is a discrete law. It is applied to describe a phenomenon having two mutually exclusive occurrences (success or failure, failing state or in operation for example).

In reliability this law represents the probability of seeing k hardware failures during the execution of n tests, knowing that the elementary failure probability of a material is P.

- Its variance:

$$V = nP(1 - P)$$

- Its standard deviation:

$$\sigma = \sqrt{nP(1-P)}$$

III.3.8. Law of Poisson or law of weak probabilities:

The realization of random events over time is called "FISH process" and characterizes a series of independent and time-independent failures.

The law of FISH is a discrete law, it expresses the probability of appearance of an event when it can manifest itself in many ways but with a low probability

Its parameters are, by setting Its variance:
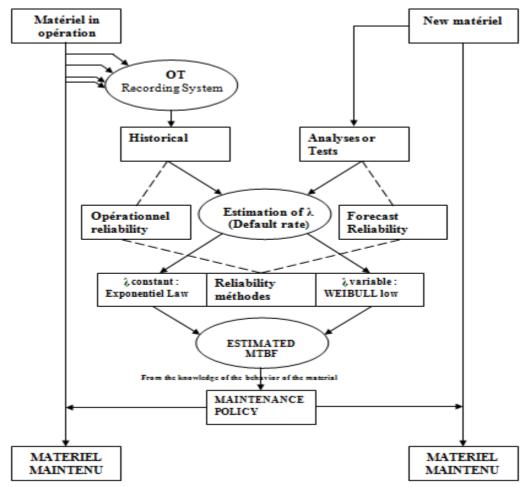
- Its frequency
$$\Pr[x = k] = \frac{m^k}{k!}e^{-m}$$

- Its distribution function:
$$F(x) = \sum_{k=0}^{x} \frac{m^k}{k!}e^{-m}$$

III.3.9 Study of the reliability of gas compressor:

III.3.9.1. Situation of the problem and objective of the study:

Normal operation of a gas compressor in a rough environment such as the Sahara requires rigorous study and diagnosis in order to ensure proper operation of the unit. In this study, we looked at technical field data collected from the history of a gas compressor installation (passive experiment) in order to evaluate its reliability and its reliability as well as to propose A.
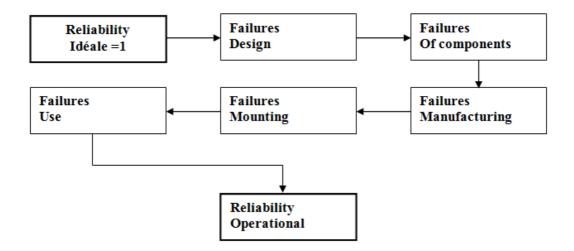
Flowchart: scientific planning of preventive maintenance actions

Reliability Research Methodology

III.3.9.2. Operational reliability and forecast reliability:

The predictive (or technical) reliability characterizes only the technical possibilities of the equipment in dependence on its construction and quality of production, provided that the regulations regarding operating and maintenance technology are respected. It characterizes the design level of the machine.

Operational reliability (or operating reliability) is determined by the actual operating conditions of the equipment taking into account all factors. It is obtained after a series of potential failures:

III.4.Medialization; Choice of the law of probability:

III.4.1. Description of the sample:

Evaluating the reliability of equipment requires obtaining information about its components. They relate to events (failures) which occurred during operation or testing of this equipment.

Very schematically, the procedure consists in observing for a certain period of operation, under actual conditions of use, a gas turbine of interest and to list all the faults that arise and the information relating thereto (TBF, TTR). In this way, the basic data are obtained which make it possible to quantify the reliability of the compressor in question

III.4.2. The Law of WEIBULL:

It is a continuous law with three parameters, therefore of a very flexible use. Depending on the value of its parameters, it can be adjusted to all kinds of experimental results. This law has been chosen to represent the lifetime of mechanical parts

- The general form of reliability is denoted by R (t) representing the probability of good operation at time t

$$R(t) = e^{\left(\frac{t-\gamma}{\eta}\right)^{\beta}}$$

Its distribution function f (t) is the probability that the device has failed at time t , It is expressed by:

$$F(t) = 1 - R(t) = 1 - e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}}$$

Its instantaneous failure rate $\lambda(t)$ is an estimator of reliability. It is expressed by:

$$\lambda(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1}$$

With the parameters and meaning: Γ, β, η define the Weibull distribution.

Three parameters are used:

- β: shape parameter (β> 0)
- η: scaleparameter (η> 0)
- γ: position parameter (-∞> γ> + ∞)

III.4.3.The density of the probability is calculated by the following expression:

$$f(t) = \lambda(t) \times R(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-\gamma} . e^{-\left(\frac{t-\gamma}{\eta}\right)}$$
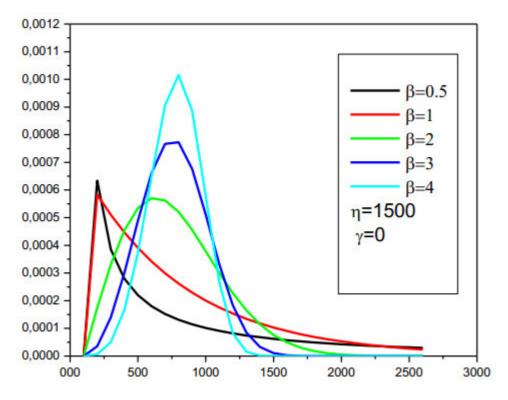
Figure 12: the theoretical curve of Weibull

If we denote by t the random variable which has any random material chosen, associates its time of good functioning before failure when b is constant We show that t follows an exponential law to cover all cases **We**ibull has chosen for Y a function dependent on three parameters ($^{\gamma}$.ß. and η) With t $\geq$ $^{\gamma}$ ß≥0; η ≥0

The important parameter being ß parameter the others ending the adjustment so when the random variable t

Corresponding to the time of good operation follows the law of Weibull parameters (ᵞ.ß.η)

III.4.2.Application domain:

The distribution of Weibull is often used in the field of lifetime analysis, thanks to its flexibility because it makes it possible to represent at least approximately infinity of laws of probability

An increasing failure rate suggests a "wear or a problem of reliability"

The elements out more and more likely to break down when time passes

III.4.3.Weibull paper:

This paper of Weibull serves to graphically read the parameters of a **W**eibull law in the case where the parameters y is zero

In effect the distribution function associated with a Weibull law of parameters b

ᵞ = 0; η is defined by

$$F(t) = 1 - e^{-\left(\frac{t}{\eta}\right)^{\beta}}$$
$$\Rightarrow \ln\left(1 - F(t)\right) = -\left(\frac{t}{\eta}\right)^{\beta}$$
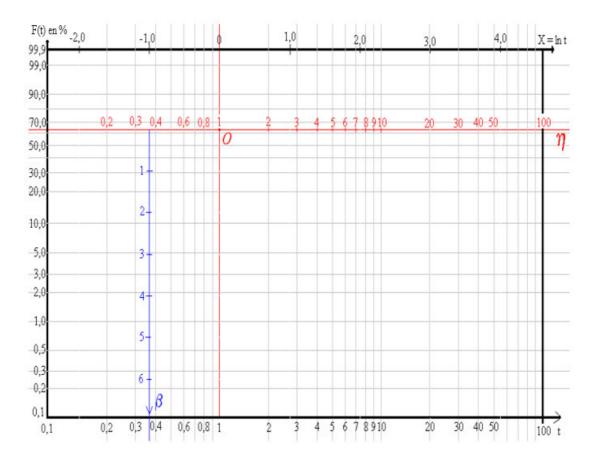
Figure 13: paper of Weibull

III.4.4.Scales used on Weibull paper:

- high abscissa: logarithmic scale (parameter reader t)

- low abscissa: logarithmic scale (we correspond to each value of t its natural logarithmln(t)

The left-handed order:we set the values of F (t) as a percentage, in scalingln (-ln (1-F (t)))

- ordered on the axis : X = -1 (parameter readout): these are the values ln (-ln (1-F (t)))

Conclusion :

By allowing periods of systematic interventions optimization of the management of the replacement part and the evaluation of MTTR and MTBF for a better management of the industrial equipments

Reliability is the masterpiece for any mastery and planning of maintenance

Chapter IV

Maintenance and security

MAINTENANCE AND SECURITY

I. Maintenance :

Introduction:

After a certain time of operation all equipment tends to deteriorate under the action of several internal and external phenomena such as:

- Corrosive and erosive wear.

- Deformation and degradation due to excessive temperature and pressure.

- Deterioration or failure due to the negligence of the technical operating instructions.

All these phenomena can damage the equipment and even cause of the dangers for the personnel as well as losses of material which will lead to considerable losses of production.

To ensure the maintenance of industrial equipment and to reduce their failure rate, an adequate maintenance system must be implemented and rapid action must be taken to increase the possibility of equipment (continuous production).

1. General maintenance concepts

Maintenance is defined as the set of actions to maintain or restore a device, equipment or system in specified states or capable of performing a well-determined service.

It is therefore performing operations (troubleshooting, lubrication, visit, repair, etc.)

This means that the potential of the equipment can be retained to ensure the continuity and quality of the production and guarantees the finality of the equipment at lower cost.

2. Purpose of maintenance

The maintenance function played an increasingly central role in the company, it contributes to increases productivity and reduces the costs generated by production stoppages caused by breakdowns, ensure a good state of equipment and facilities they tend to occupied A prominent place in the company thanks to its objectives which are:

• Ensure planned production;

• Respect the deadlines;

• Maintain the quality of the product manufactured;

• Look for optimal cost;

• Improve safety at work

3. Maintenance policy :

In order to achieve these objectives, it is necessary to define the various aspects, depending on the nature of the equipment and the means available. For this purpose, the following must be taken into account:

- Long-term forecast: related to the company's policy and allow the scheduling of investment stocks.
- Medium-term forecast: the desire to maintain the potential for activity, leads to a decrease in the frequencies of mobilization of equipment and a shutdown that disrupts production. Therefore, it is necessary to provide early the schedule of the maintenance interventions, this one having an influence on the ordering of production.
- Short-term forecast: in this case, the maintenance department will endeavor to reduce equipment capital costs and the cost of these interventions.

4. Types of maintenance :

The different types of maintenance are summarized in the diagram on the previous page, the choice and adoption of the type of maintenance depends on:

- The objective of the company;
- Behavior and operation of equipment;
- The cost of maintenance;
- The operation of the equipment;
- The cost of production losses.

4-1 Corrective Maintenance :

This is maintenance after failure. The latter is defined as the alteration or cessation of an equipment which gives the required function. It may, in fact, be accidental, scheduled or inspection.

a.Maintenance of accidental maintenance: repairs, after the breakdown, restoring the initial good functioning.

B. Maintenance of programmed maintenance:

is subdivided in turn in three parts:

- Cyclic: This is a maintenance cycle with time fixed in advance according to the time of failure.
- Off: This is a concentration of cyclical maintenance, inspection and accidental over a fixed period of time.
- Opportunity: this is a maintenance to be performed at the first occasional outage caused by a breakdown, or at the first stop caused by an economic evaluation of the reduction in efficiency due to an accumulation of breakdowns which, in itself, does not Cause no stopping.

C. Maintenance inspection:

can be carried out under two conditions:

1- With the machine or apparatus stopped: the inspection can be programmed or carried out in this case following a breakdown either by the visual inspection or the non-destructive method.

2- With machine or machine running: It is defined as maintenance on condition or productive. It can supplement or replace cyclical maintenance and, at the same time, facilitate the limitation of accidental maintenance when costs warrant.

Inspection staff use visual inspection and non-destructive testing.

4-2 Improvement maintenance:

This is a simple improvement which makes it possible to obtain a better efficiency (the cost of modification and / or replacement is compared with the difference in the cost of maintenance).

By leaving the cost of maintenance "improvement", less interesting, the maintenance can be subdivided into scheduled or preventive maintenance, and in accident or emergency maintenance.

4-3 Preventive maintenance:

Maintenance is the way to prevent equipment failure during its use, cost analysis should highlight a grain in relation to the failure it avoids. Preventive maintenance for:

- Increased life of equipment;
- Reduced probability of service failures;
- Prevention and prediction of costly corrective maintenance interventions;
- Permission of good conditions for corrective maintenance;
- Avoid abnormal consumption of energy;
- Improvement of working conditions for production staff;
- Reducing the causes of serious accidents.

However, we can distinguish two kinds of preventive maintenance, one systematic and one conditional.

a. **Systematic preventive maintenance**:

it is carried out according to a schedule established according to the time or the number of usage units. It applies in the following cases: pressure vessels, equipment whose accident is likely to cause serious consequences (aircraft, trains, etc.), and equipment with a high cost of failure

B. Conditional preventive maintenance:

this is preventive maintenance subordinate to a type of predetermined events (auto, diagnostics, sensor information, measurement of wear and tear, etc.). It therefore depends on and involves information gathered in real time. It is characterized by highlighting weaknesses and putting

them under surveillance in order to make an intervention decision when the threshold is reached, but the control remains there systematically.

All materials are affected by this type of preventive maintenance.

5. Maintenance operations

5-1. Troubleshooting

It is the action of an equipment in order to restore it in working order. Troubleshooting is a corrective maintenance operation and has no special application requirements. Knowledge of the behavior of the material and the mode of degradation is compensable.

Troubleshooting generally applies to equipment that works continuously.

5-2. Repair

This is a limited intervention for corrective maintenance after failure and failure.

Application of the representation can be decided immediately following an incident or failure either after a corrective maintenance troubleshooting or after a preventive maintenance visit.

5-3. Inspection

These are constant monitoring activities periodically reveals simple anomalies of execution and do not require specific tools or equipment shutdown

5-4. Visit

These are systematic preventive maintenance monitoring operations.

5-5. Control

They correspond to verifications of conformity with closely established data followed by a judgment the control little includes an information activity, including a decision acceptance, rejection.

5-6. Revision

It is the set of control action actions and interventions carried out to ensure the equipment checks for any major failure, for a time or for a member of a given use unit. It distinguishes partial revisions and revisions The general principles.

It is necessary, however, to carry out a series of cyclical inspection and inspection in order to guarantee the continuity of operation of the machines for its own machines

5.7. Maintenance of the compressor AJAX-superior :

Before start working in the machine:

Shut down the compressor first;then prevent it from being started before the work is done.

If electric motor driven the electric power supply must be disconnected and locked out. This is very important if the unit has remote start capability

a- Remote operations center may try to start a unit without knowing that work is being performed on it .suction and discharge block valves ,must be closed to prevent gas from flowing into the compressor during maintenance(gas pressure could rotate the compressor section of manual)

b- Before attempting any maintenance or repair on the compressor , vent all gas pressure from the cylinders ,piping and ather pressurized components or chambers know the piping system associated with this compressor .open discharge blow-down and or bypass valves to vent system to atmosphere.allow compressor to cool for at least 15 minutes before opening suction or inter-stage vents

Atmospheric air can be drawn in if a vacuum exists and can create an explosive mixture .check local or panel pressure gauges for zero reading before removing any gas passage components such as valves ;valve caps or cylinder heads

c- Regularly check around compressor and piping gaskets and joints for leaks wich could result in a fire or an explosion

d- Before replacing any studs , measure stud height from machined surface and position replacement stud to the same height

e- Check all safety shutdown devices (low oil pressure , high and low gas pressure , vibration….etc) per the schedule in the maintenance section of this manual

6-1 Start up:

The instructions form a guide to assist the operator at start-up and then during operation of the volumetric compressor.

It is obvious that the compressor must never run without pressure or lubricating oil flow. To prevent damage to the bearings. It is also essential to have a sealing oil flow, because it is this oil which ensures the only lubrication of the sealing rings. The rings would be seriously damaged if they were turned dry. Under no circumstances should the compressor be run as long as the lubricating oil and seal circuits are not in operation.

Similarly, the compressor will never be fed with gas without there being a flow of oil in the seals preventing any leakage and passage of gas in the bearing compartment.

If the process gas piping is to be purged prior to start-up and the entire purge gas flow through the compressor, the lubricating oil circuit must be in operation. This is necessary to avoid damage to the bearings as the purge gas flow could move the compressor rotor.

1. Follow the manufacturer's instructions for main drive and auxiliary equipment.

2. Check that the drainage of the compressor bodies is completely closed after evacuation of any condensate and before putting the unit under pressure.

3. Check that the lubricating oil system is in operation and that the oil supply to the compressor is at pressure and temperature.

4. Check that the seal oil system is in operation and that the oil reaches the compressor at the correct pressure.

5. The process control equipment for this compressor is supplied by other manufacturers. The following instructions are a general procedure to follow in addition to the instructions found in the operating instructions.

6. If the main suction valve is to be closed on the compressor's technological gas piping either to facilitate start-up or for technological reasons related to the unit, it must be reopened as soon as possible To prevent overheating of the compressor bodies and the rotor.

7. If there is a flush valve on the discharge piping, it must be fully opened before starting and then gradually close when the compressor is mounted at a high speed.

8. Do not operate a compressor when pumping. High pumping is easily detected by an audible "beat" of the compressor, vibrations and large fluctuations in pressure and discharge flow. Partial pumping is still audible but can be detected in the event of unstable pressure and discharge conditions

6-2. Stop

1. Whenever possible, reduce the load, or both the load and the speed of the main drive, ensuring cooling, if this is provided in the manufacturer's instructions, avoid pumping the compressor.

2. Stop the main drive in accordance with the manufacturer's instructions. The sealing and lubricating oil pumps must be left in operation until the group rotation is stopped by inertia. Avoid pumping the compressor.

3. If specified in the operating instructions, close the suction and discharge valves of the compressor. If they are left open and the system is under pressure, the sealing circuit must remain in operation.

4. The compressor is subjected to the maximum pressure.

A) Leave the sealing system in operation.

B) Do not allow the pressure to exceed the value specified in the specification section.

C) Continue "service" monitoring of the oil console and compressor (pressure oil seal tank and oil traps).

6.3.Insolation:

COMPRESSOR ISOLATIONS

1. **Normal compressor isolation.**

    1.1 Depressurize all stages of the compressor (automatically done).

    1.2 Close manual isolation valves upstream on first, second and third stage suction scrubbers on inlet gas lines, which are located near the piperack.

    1.3 Close the manual isolation valves on Level Control Valves (LCVs) on first, second, third and fourth stage suction scrubbers

    1.4 Close isolation valve on fuel gas supply line off fourth stage suction scrubber.

    1.5 Before stopping the compressor, ensure fuel gas supply is lined up from another compressor.

2. **Total isolation for compressor maintenance.**

    In addition to the procedure described in the former point, follow the next steps :

    2.1 Close individual isolation valve fuel gas to compressor, NOT outlet of fuel gas scrubber.

    2.2 Close isolation valve starting gas to compressor.

    2.3 Close both isolation valves from R.V. headers to flare.

    2.4 Close 2" isolation valve downstream of BDV 2806.

    2.5 If chain and padlock fitted, these valves should be locked in closed position (see TP-11).

    2.6 Close instrument air isolation valve.

    2.7 Close common isolation valve on 2" collective line suction scrubbers liquid to flare.

6.4. Routine maintenance

Routine maintenance, including the periodicity of partial and general revisions, depends to a large extent on the type of the compressed gas and on the operating mode of the group, whether continuous or not. The degree of internal fouling, erosion or corrosion of the compressor can not be estimated accurately. Controls will be considered to assess the degree of fouling, etc. Especially if there is a gradual decline in compressor performance.

Instructions may help to develop maintenance modalities that are appropriate for the particular use of the group.

a. Once a day :

1. Record and record all pressures and temperatures that are not automatically recorded by measuring instruments. The list below the main surveys to be made. However, all the installations are different and it is good knowledge of the installation that the operator will deduce which vital readings are required for the good operation of the equipment.

(A) Temperature of the compressor bearings;

(B) Temperature and pressure at the discharge and suction of the process gas from the compressor;

C) Temperature and pressure of the lubricating and sealing oil upstream and downstream of the cooler and the filter.

D) Pressure of the lubricating oil at the compressor bearings.

E) Differential pressure of the sealing oil at the compressor seals.

2. It is recommended that the operator list the normal operating values of the pressure, temperature, differential pressure, etc. specified in this manual and the other manufacturer's manuals for the associated equipment. In addition, it is recommended to also list the maximum permissible deviations from normal conditions.

Note:

Continuous recording of these values, visually or by automatic means, is of no use if these records are not checked and prophylactic measures taken if necessary. Under normal operating conditions, the service life of all mechanical parts depends on common sense and the care taken by the operator.

3. In addition to the main equipment, all lubricating oil pumps, etc., shall be checked for performance against the manufacturer's instructions.

4. If the instrument air lines are equipped with hand-operated drain valves for draining condensate, open the drain valve and close it after purging.

B. Once a week

1. The installation includes duplex type oil filters. Check the differential pressure (which indicates the degree of soiling) and start the filter that is not in operation. Do not switch from one set to another if the differential pressure is not excessive. Before proceeding to the reserve assembly, make sure that it is filled with oil and that it has been vented from any air. The duplex units can be switched to a single transfer valve without the need to stop the entire group. Ensure that the unit that is in service is cleaned and ready for reuse.

2. Check the control of the auxiliary oil pump, if possible during the maintenance procedure.

C. Every three months :

1. If operation of the system permits, check all emergency stop devices.

2. Recalibrate all measuring devices that are accurate and subject to caution.

3. Check the lubricating oil for acidity, sedimentation, viscosity and moisture content. If necessary, change the oil and the filter cartridge. The pressure drop at the filter must not be greater than 1.05 Kg / Cm2 of differential pressure.

D. Once a year or at intervals corresponding to a complete cycle of the "general overhaul"
1. Beforehand, prepare all necessary equipment to check the alignment of the couplings immediately after the compressor / clamping unit is switched off. Record the measurements taken and reset the alignment during revision, if necessary. At each end of the compressor there are provided on both sides visual alignment rods for monitoring the "hot" alignment.

2. Open and inspect the oil coolers. Clean them if necessary.

3. If possible, clean the oil tank completely.

4. Dismantle the compressor and check the condition of bearings, seals, wheels, membranes, etc. Check all the clearances between the ends of the fins and the walls of the body. Clean all internal components and replace all rings and seals, etc., which would have been damaged during disassembly.

5. Reassemble the compressor and adjust the alignment if necessary.

6. Check the wear and shrinkage of the couplings and replace if necessary.

7. Tighten all anchor bolts, flange bolts, instrument air line connections, and so on.

Before restarting the compressor after a normal shutdown, ensure that all body purges are open to drain all condensate.

Before starting or pressurizing the body, close all bleed valves.

If the shutdown of the unit has been caused by the triggering of an automatic alarm, ensure that the cause of the shutdown has been detected and remedied. Beforerestarting.

II.   Security :

Introduction

Since the emergence of industry in the world, the safety of operating personnel as well as production equipment has been one of the major concerns of industrial managers.

The application of safety measures, especially in the petroleum field, requires that the operating personnel be very conscious of the good resulting from compliance with the safety instructions.

To raise staff awareness of the safety rules of posters and signs must be worn in all corners on the setting of the production unit.

1.1. Definition of security :

It is the set of measures and technical and hygienic means whose reliability is to create good working conditions, limiting the influence of hazardous industrial factors causing damage.

It studies industrial hazards, accidents and occupational diseases and highlights methods of reducing accidents, thus increasing production or output

1.2. Place of safety in the company

Security is a general function in the company, it is one of many concerns, the direction for it is directly attached to the management and has no responsibility that vises it is one of the state services Of the company.

1.3 .Security Mission

It performs two main functions:

1. Prevention: This is the set of measures that aim to reduce the incidence of a dangerous behavior or event.

We distinguish :

- Passive prevention.

- Active prevention.

2. Intervention: Once the accident or fire occurs, safety must have all the material and human means to face this danger, fire-fighting effectiveness depends on:

- The speed of the intervention.

- The attack technique

6.4. Fires

Fires may be due to carelessness, negligence on the part of the workers to safety instructions or other causes. Products and materials presenting dangers of ignition must be kept in places specially designed for this purpose.

6.5 .Different lights

The fires are obviously diverse, the many combustible bodies capable of fueling a fire, but experience has shown that they can be hunted in a few categories.

All fires of the same category being subject to the same extinguishing agent.

a. Class "A", dry lights: Wood, textile, papers, etc. Apparently simple.

Dry fires may be difficult to fight, since slow burning occurs with embers.

B. Class "B", called "grease" :means fat, hydrocarbons, oil, grease, paint, gasoline, etc. Generally speaking, these lamps do not exhibit slow combustion, the disappearance of the flame corresponds to the end of the fire.

C. Class "C", electric lights: Very dangerous, it may have electrical origins either occur near electrical appliances, without any electrical origin.

D. Class "D", special lights: Cinematographic films, magnesium, etc.

Fortunately these fires are very uncommon, as they require for their extinction a particular material and techniques.

6.6. Safety at the compressor station

The compressor station comprises several machines such as the gas turbine, the compressor used to compress the gas during its operation, for the sake of these equipment several fire protection systems are arranged.

Among these systems, the fire-fighting system is applied to water and other systems, the carbon fire extinguishing system (CO_2) is applied

(B) Carbon dioxide extinguishing systems:

This CO_2 extinguishing system extinguishes the fire by reducing the oxygen content in the compartment from the normal proportion of 21% to less than 15% insufficient concentration to allow combustion.

The CO_2 gas is supplied by a high pressure cylinder group or by a low pressure cardox group to a distribution system feeding the CO_2 gas to discharge nozzles located at the various compartments of the group.

The discharge mechanism opens the bottles of CO_2 gas is powered automatically by an electrical signal from heat-sensitive fire detectors, installed at judicious locations in the various compartments of the group.

The system can also be operated manually in the event of power outages.

The activation of these two systems triggers the turbine.

In order for the carbon dioxide system to be effective, the compartment panels must be in place and the doors must be closed. There is sufficient CO2 gas in the system to compensate for leaks from the inevitable ventilation openings in the group heat insulation, but there is not enough to be able to tolerate the uncontrolled loss of the panels

Warning :

CO2 gas at a concentration sufficient to produce the extinction of a fire and establishes an atmosphere. It is extremely dangerous to enter a compartment as a result of a carbon dioxide discharge

Any person who has lost consciousness as a result of exposure to CO2 gas must be rescued as quickly as possible and resuscitated by artificial respiration.

The nature and type of precautions, as well as possible and be resuscitated by artificial respiration.

The nature and type of precautions, aswell as the warning to personnel that will be peculiar to each installation.

It is recommended that staff receive appropriate training on how to deal with such emergencies.

6.7 Safety rules within facilities:

A . In general, it is forbidden to:

- Smoking inside the facilities.

- To carry out work without authorization.

- To introduce unauthorized materials or products.

- To carry out repairs or intervention during the operation of the equipment.

- Disassemble any appliance before making sure it is insulated and maintained at atmospheric pressure.

- To abandon tools or objects whose fall can cause accidents

B. It is mandatory to:

O To use special safety equipment, personnel required to operate service devices must be equipped with helmets, safety shoes and gloves.

O Provide personnel with waterproof tracksuits and eyeglasses in all cases where projections are likely to occur;

Wearing protective glasses is mandatory when handling hot or corrosive liquids. If the presence of polluted atmosphere is possible the properly detected gas detectors and respiratory equipment are made available to the personnel.

- Keep personal passages, ladders and stairs clean and free of obstructions.
- Provide effective lighting for locations or workers are required to work at night

Wearing protective glasses is mandatory when handling hot or corrosive liquids. If the presence of polluted atmosphere is possible the properly detected gas detectors and respiratory equipment are made available to the personnel.

- Keep personal passages, ladders and stairs clean and free of obstructions.
- Provide efficient lighting to locations or workers are required to work at night.

6.8. Safety of the compressor:

The instrumentation installed on the compressor keeps the machines in good working order and this by having them monitored continuously

6.9. Monitoring and safety apparatus:

1. All controllers, regulators and control valves must be set exactly. All hand valves shall be in their normally open NO position, normally closed NC unless otherwise specified in section 3 of this manual. We recommend attaching to each valve an NO or NC tag in accordance with its function.

2. All safety switches must be set and controlled precisely to ensure safe operation.

When lubricating and sealing oil systems are pressurized, oil coolers, filters, manotec ... must be emptied from the air coming from the systems.

a. Axial displacement sensors :

A certain axial thrust will be achieved in the body stop, which will result in a bearing insulation resulting in axial displacement.

The sensors are placed on the body of the compressor and are responsible for detecting a maximum displacement of the compressor so as to avoid friction between the contact parts.

B. Vibration sensors :

For the vibrations of the probes are placed in the vicinity of the bearing, their role is to detect the additional unbalance on the rotor.

C. The temperature sensors

These sensors are positioned at the bearing and thrust bearings in order to avoid overheating of the parts and triggering of the unit (alarm and safety).

The temperature of the oil at the outlet of the sealing device is measured by means of the thermometers placed on the drain pipe of the sealing device

Chapter V

Cas study
Application of the weibull law

I = N	TBF	F(t)	F(t) %
01	117	0.02093	20.93 %
02	160	0.0508	05.08 %
03	178	0.0807	08.07 %
04	211	0.1106	11.06 %
05	296	0.14055	14.05 %
06	435	0.17045	17.05 %
07	444	0.2003	20.03 %
08	465	0.23026	23.03 %
09	476	0.26016	26.02 %
10	504	0.4694	46.94 %
11	510	0.3199	31.99 %
12	518	0.3498	34.98 %
13	529	0.3798	37.98 %
14	535	0.4096	40.96 %
15	547	0.4395	43.95 %
16	549	0.4694	46.94 %
17	552	0.4994	49.94 %
18	553	0.5293	52.93 %
19	565	0.5592	55.92 %
20	597	0.5891	58.91 %
21	604	0.6190	61.90 %
22	618	0.6489	64.98 %
23	621	0.6788	67.88 %
24	622	0.7087	70.87 %
25	630	0.7386	73.86 %
26	634	0.7685	76.85 %
27	652	0.7984	79.84 %
28	654	0.8283	82.83 %
29	669	0.8582	85.82 %
30	719	0.8882	88.82 %
31	720	0.9181	91.81 %
32	722	0.9479	94.79 %
33	744	0.9778	97.78 %
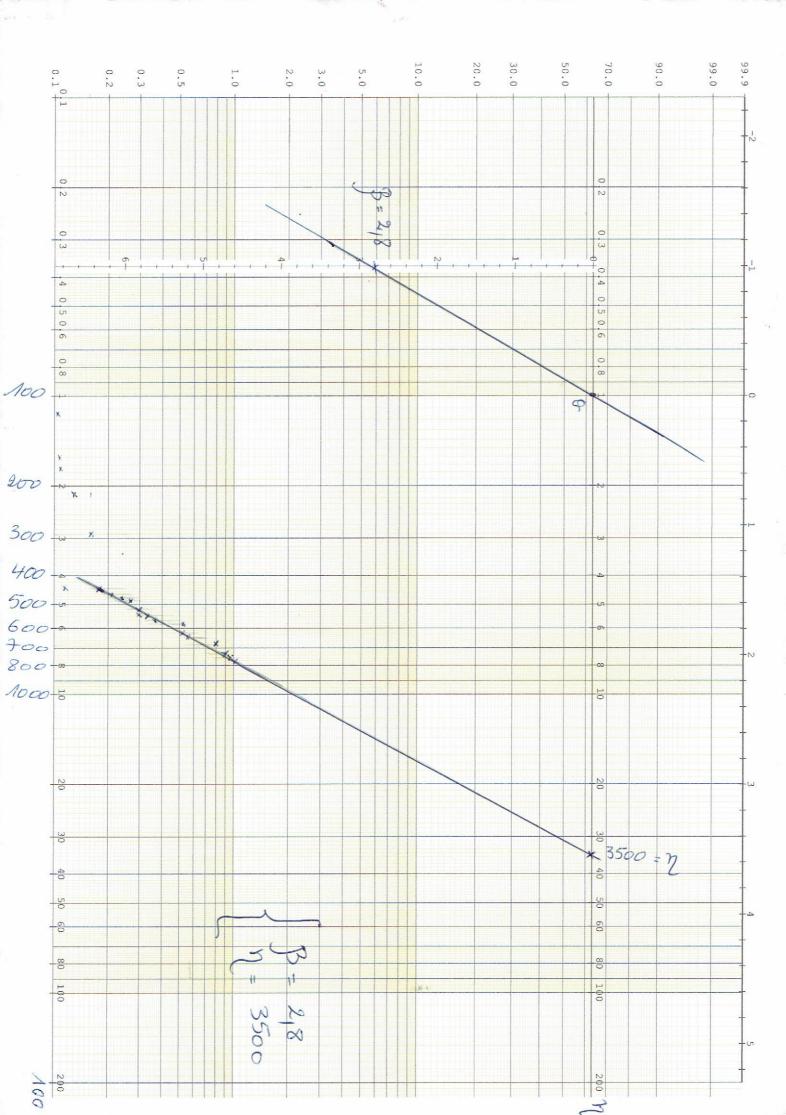
TEBLE1 : TBF of the compressor in 05 years

In this case we have **20<N<50 :**

So : $\mathbf{F(i)} = \frac{i}{N+1} = \mathbf{F(t)}$

- The graph of F(i) in function of TBF is drawn using Weibull's paper
- According to the graph , the values are almost linear,it can be concluded that the first parameters is **ZERO:** $\gamma = 0$
- To determine the other parameters,Weibull's paper is used
  - $\gamma = 0$

β = 2,8

3500 = η

β = 2,8
η = 3500

- β = **2.6**
- η = **3800**
-
- According Weibull's table, we have the coefficients A and B :
- β = **2.6** $\Rightarrow \begin{cases} A = 0.88 \\ B = 0.36 \end{cases}$

➢ **Calculate the MTBF :**

$MTBF = A\eta + \gamma$ = (0.88)*(3800)+(0) = **3344** hours

➢ **Calculate the disparity type :**

$\sigma = B\eta$ = (0.36)*(3800) = **1368**hours

➢ **Calculate the probability of opération :**

$$R(t) = e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} = e^{-(3344/3800)^{2.6}} = \mathbf{0.4214}$$

$$R(t) = 0.4214 = 42.14\%$$

$$F(t) = 1 - e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} = 1 - e^{-(3344/3800)^{2.6}} = 1\text{-}(0.4214) = \mathbf{0.5786}$$

$$F(t) = 0.5786 = 57.86\%$$

➢ **Calculate the failure rate :**

$$\lambda(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} = \lambda(t) = \frac{2.6}{3800}(3344/3800)^{1.6}$$

$$\lambda(t) = 0.0005609 = 5.6*10^{-4}\text{failure /h}$$

Comments :

❖ We can see from these results : β = **2.6,** we can easily deduce that the machine is in a periode of old age or fatigue.

❖ R(t) is **42.14 %** wich means that the machine has **42**chances of survival beyond **3800** hours

❖ A probability of breakdown of **57.86 %** ie : the machine has **57** chances in **100** and breaks down during the same periode

❖ A rate of domage **56.09**probability of breakdown every **10000** hours

In this table the summary of the results determined by calculation using the law of Weibull:

TBF	R(t)	$\lambda(t) * 10^{-4}$	F(t)	$f(t) * 10^{-4}$
117	0.92307	2.6	0.07693	2.4
160	0.98631	4.3	0.10369	3.9
178	0.88533	5.1	0.11467	4.5
211	0.86557	6.7	0.13443	5.8
296	0.81666	1.2	0.18334	9.4
435	0.74257	2.1	0.25743	1.6
444	0.73802	2.2	0.26198	1.6
465	0.72749	2.4	0.27251	1.7
476	0.72203	2.5	0.27797	1.8
504	0.70833	2.7	0.29167	1.9
510	0.70543	2.8	0.29842	2.01
518	0.70158	2.8	0.29842	2.01
529	0.69632	2.9	0.30368	2.02
535	0.69347	3	0.30653	2.03
547	0.6878	3.1	0.3122	2.1
549	0.68686	3.1	0.31314	2.12
552	0.68686	3.1	0.31455	2.2
553	0.68545	3.1	0.31502	2.4
565	.0.68498	3.2	0.32062	2.41
597	0.67938	3.2	0.33534	2.5
604	0.66466	3.5	0.33851	2.51
618	0.66149	3.6	0.34482	2.51
621	0.65518	3.7	0.34616	2.52
622	0.65384	3.8	0.34661	2.53
630	0.65339	3.8	0.35018	2.6
634	0.64982	3.9	0.35195	2.7
652	0.64805	3.9	0.35988	2.9
654	0.64012	4.1	0.36076	2.9
669	0.63924	4.1	0.36729	2.91
719	0.63271	4.2	0.38857	2.93
720	0.61143	4.8	0.38898	2.97
722	0.61102	4.8	0.38982	2.98
744	0.60106	5	0.39894	3

Table 02 : table of results
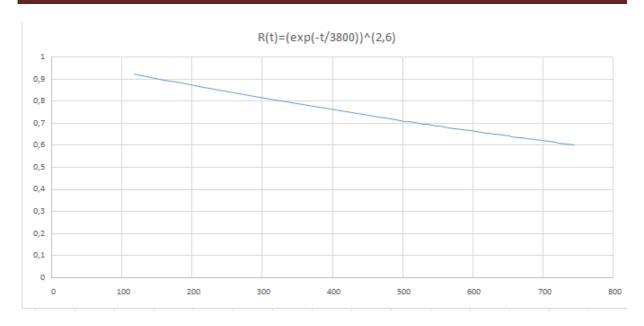
Figure01 :Plot of the reliability function
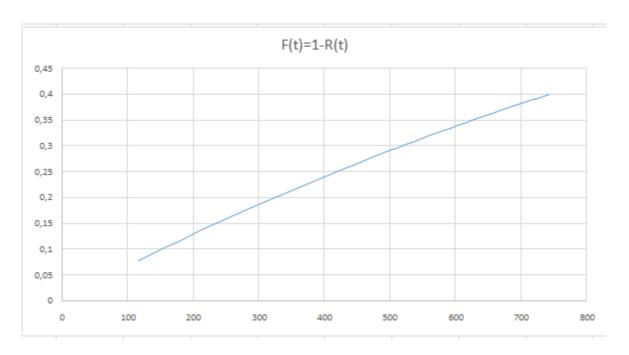
Figure 02 : Plot of the distribution function
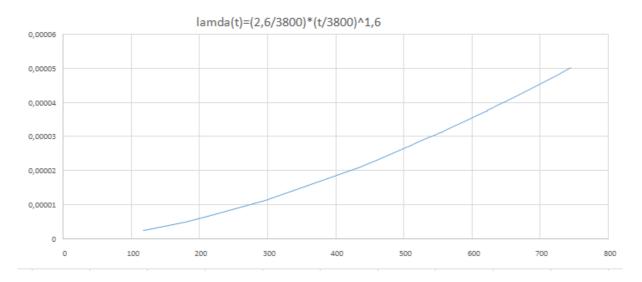
Figure 03 : Plot of the failure rate function
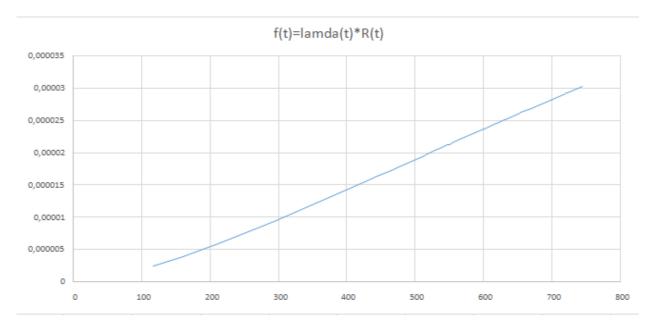
Figure04 : Plot of the probability density function

Interpretation:

➢ The curve of the reliability R(t) illustrated on figure V.1 and the plot of the distribution function F(t), figure V.2show, that the machine is continuously degraded (old age)

➢ The failure rates, figure V.3, increases with nonlinear tendency as a function of time which suggests the increase of breakdowns and their high frequencies.

➢ The curve of the probability density function is quasi-linearly proportional according to time.

N	Body failure	Number of failure	%	Duration of intervention	%	Life insurance	%
01	Hydraulic accessories	02	1.03	02	0.8	02	0.64
02	coupling	06	3.11	11.97	4.77	11.97	3.85
03	Motor shaft	02	1.03	13.83	5.51	13.83	4.45
04	Power cable	02	1.03	1.8	0.71	1.8	0.58
05	Vacuum cleaner	01	0.52	0.9	0.36	0.9	0.29
06	sensor	01	0.52	2	0.8	2	0.64
07	wedge	03	1.55	3.5	1.39	3.5	1.12
08	belts	01	0.52	0.25	0.1	0.25	0.08
09	Blade cover	01	0.52	1	0.4	1	0.32
10	studs	02	1.03	1.5	0.6	1.5	0.48
11	pebble	18	9.32	17.83	7.1	17.83	5.73
12	Wheel trim	07	3.62	13.11	5.22	13.11	4.21
13	generator	04	2.07	3	1.19	3	0.96
14	blade	19	9.84	11.16	4.45	11.16	3.59
15	Oil development	04	2.07	8.33	3.32	8.33	2.68
16	Electric motor	01	0.52	10	3.98	46	14.7
17	Wheel hub	03	1.55	2.5	0.99	2.5	0.85
18	bearing	45	23.33	38.4	15.3	38.4	12.3
19	skates	03	1.55	3.4	1.35	3.4	1.09
20	pinions	02	1.03	21	8.37	21	6.75
21	Plate roller	01	0.52	1	0.41	25	8.04
22	desk	01	0.52	0.33	0.13	0.33	0.11
23	Electrical connections	07	3.63	21.67	8.64	21.67	6.97
24	Speed reducer	02	1.03	3.37	1.34	3.37	1.08
25	Coating crampons	03	1.55	1.67	0.66	1.67	0.58
26	Drive wheel	08	4.14	4.9	1.95	4.9	1.57
28	Measuring wheel	02	6.73	9.1	3.62	0.67	2.92
29	ball bearing	15	1.03	0.67	0.26	8.09	0.21

30	Roller bearing	02	7.78	8.09	3.21	1.91	2.6
31	Roll support	01	1.03	1.91	0.76	2	0.61
32	Speed variator	05	2.59	2	0.8	20.60	0.64
33	pebble	06	3.01	28.67	11.4	08.07	9.22

Table 03 : Compressor failure synthesis

Total:

- Number of failure :**193**
- Pourcentage :**100%**
- Duration of intervention :**250.86**
- Pourcentage :**100%**
- Life insurance : **310.86**
- Pourcentages : **100%**

Analysis of compressor failure:

➢ The analysis of the reliability underlying the Weibull model shows the current state of the machine namely the degradation and the decline of the latter

➢ A fault analysis is needed to determine the critical components that cause the compressor decline.

Number analysis :

Nature of failure	Number of failure	%
Mechanic	171	88.60 %
Electric	16	8.29 %
Hydraulic	6	3.11 %
total	193	100

Table 04 : Analysis of failure by nature in number of breakdowns
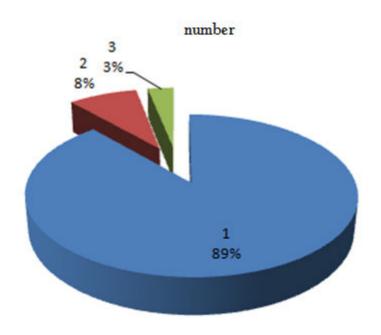
Figure 05 : Breakdown distribution graph by nature

Interpretation :

- ✓ The graph in the figure shows that the majority of breakdowns are of mechanical origin (89%), which can be explained by the fact that the machine is based on gears and belts for transmission of movements.
- ✓ The lowest rate of failure is of hydraulic origin, this is due to the fact that the machine has very few hydraulic elements.

Duration analysis and immobilization :

Natural failure	Duration of intervention	%	Duration of immobilization	%
Mechanic	201.73	80.43	225.73	72.63
Electric	38.8	15.45	74.8	24.05
Hydraulic	10.33	4.12	10.33	3.32
Total	250.86	100	310.86	100

Table 05 : duration analysis and immobilization
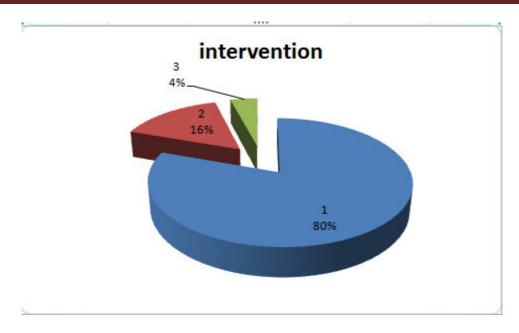
Figure 06 : Distribution of intervention durations
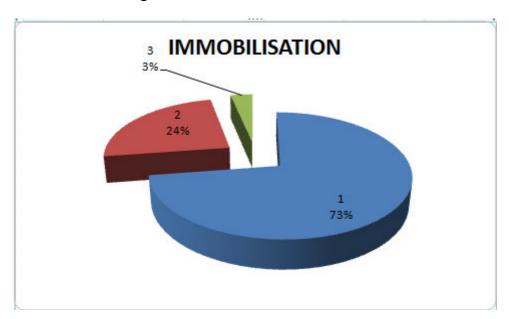
Figure 07 : Breakdown of capital period

Interpretation and conclusion :

The same observation of the graph of the preceding figure is noted on the graph of these figures. The rate of immobilization and the longest periods of intervention are of mechanical origin because of the frequent readings of the mechanical parts, with an increase in the rate of immobilization of an electrical nature due to the fact that the distribution of this type of Breakdown is long and difficult.

Conclusion:

This project of end of study is carried out within the company (sonatrach / cepsa).

During this course we were able to practice our theoretical knowledge acquired

Throughout our university training more it offered us to deepen our knowledge about the compressor.

The work presented in this project has as objective (study of reliability of the compressor) by application of the method of Weibull.

The accomplishment of this work had to go through the technological study of the equipment and its related elements in order to understand its operation, which was not easy because of the cruel lack of documentation.

Once the machine's repetitive breakdowns have been cleared up; we were able to carry out a reliability analysis based on the Weibull model in order to inform us about the current state of the machine.
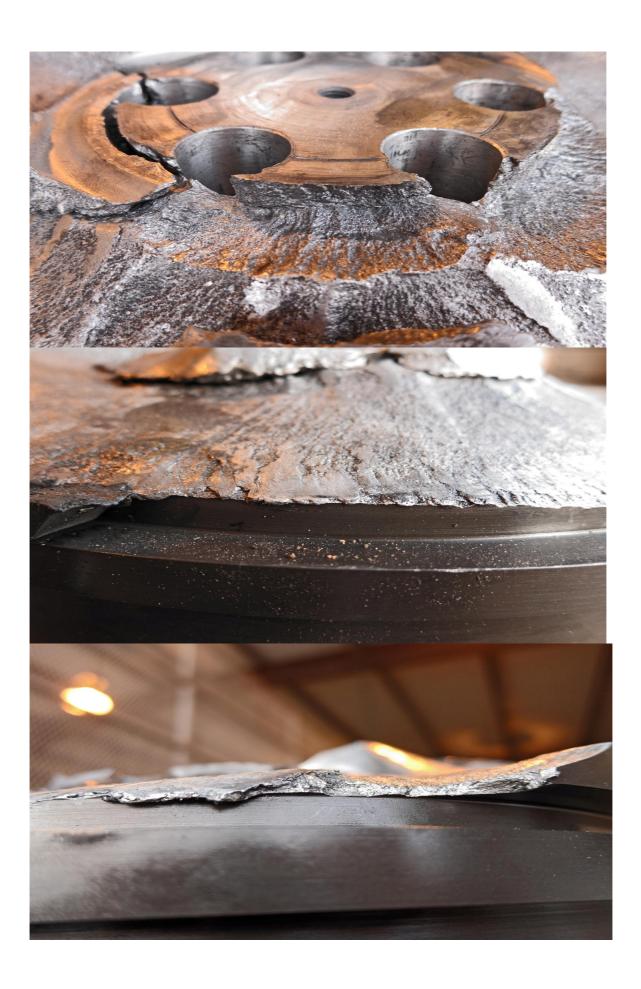
Subsequently an analysis of the failures was carried out thus supplementing the first one by highlighting the sensitive points which must be the target of concentrated efforts.

At the end of this study and in the light of the results obtained by the previous analyzes, it has been observed that the maintenance plan adopted up to now is no longer appropriate, which has led us to the development based more on the Corrective maintenance aspect and strongly insisted on its application in the shortest detail.

It is necessary to point out that reliability studies alone are not sufficient to judge the removal of a machine or its renovation.

appendix

β	A	B	β	A	B	β	A	B	β	A	B
0,05	2,43290E+18	9,03280E+23	1,75	0,89062	0,52523	3,45	0,89907	0,28822	5,15	0,91974	0,20505
0,1	3,62880E+06	1,55977E+09	1,8	0,88929	0,51123	3,5	0,89975	0,28473	5,2	0,92025	0,20336
0,15	2,59357E+03	1,21993E+05	1,85	0,88821	0,49811	3,55	0,90043	0,28133	5,25	0,92075	0,20170
0,2	1,20000E+02	1,90116E+03	1,9	0,88736	0,48579	3,6	0,90111	0,27802	5,3	0,92125	0,20006
0,25	2,40000E+01	1,99359E+02	1,95	0,88671	0,47419	3,65	0,90178	0,27479	5,35	0,92175	0,19846
0,3	9,26053E+00	5,00780E+01	2	0,88623	0,46325	3,7	0,90245	0,27164	5,4	0,92224	0,19688
0,35	5,02914E+00	1,99761E+01	2,05	0,88589	0,45291	3,75	0,90312	0,26857	5,45	0,92272	0,19532
0,4	3,32335E+00	1,04382E+01	2,1	0,88569	0,44310	3,8	0,90379	0,26558	5,5	0,92320	0,19379
0,45	2,47859E+00	6,46009E+00	2,15	0,88561	0,43380	3,85	0,90445	0,26266	5,55	0,92368	0,19229
0,5	2,00000E+00	4,47214E+00	2,2	0,88562	0,42495	3,9	0,90510	0,25980	5,6	0,92414	0,19081
0,55	1,70243E+00	3,34530E+00	2,25	0,88573	0,41652	3,95	0,90576	0,25701	5,65	0,92461	0,18935
0,6	1,50458E+00	2,64514E+00	2,3	0,88591	0,40848	4	0,90640	0,25429	5,7	0,92507	0,18792
0,65	1,36627E+00	2,17887E+00	2,35	0,88617	0,40080	4,05	0,90704	0,25162	5,75	0,92552	0,18651
0,7	1,26582E+00	1,85117E+00	2,4	0,88648	0,39345	4,1	0,90768	0,24902	5,8	0,92597	0,18512
0,75	1,19064	1,61077	2,45	0,88685	0,38642	4,15	0,90831	0,24647	5,85	0,92641	0,18375
0,8	1,13300	1,42816	2,5	0,88726	0,37967	4,2	0,90894	0,24398	5,9	0,92685	0,18240
0,85	1,08796	1,28542	2,55	0,88772	0,37319	4,25	0,90956	0,24154	5,95	0,92729	0,18107
0,9	1,05218	1,17111	2,6	0,88821	0,36696	4,3	0,91017	0,23915	6	0,92772	0,17977
0,95	1,02341	1,07769	2,65	0,88873	0,36097	4,35	0,91078	0,23682	6,05	0,92815	0,17848
1	1,00000	1,00000	2,7	0,88928	0,35520	4,4	0,91138	0,23453	6,1	0,92857	0,17721
1,05	0,98079	0,93440	2,75	0,88986	0,34963	4,45	0,91198	0,23229	6,15	0,92898	0,17596
1,1	0,96491	0,87828	2,8	0,89045	0,34427	4,5	0,91257	0,23009	6,2	0,92940	0,17473
1,15	0,95170	0,82971	2,85	0,89106	0,33909	4,55	0,91316	0,22793	6,25	0,92980	0,17351
1,2	0,94066	0,78724	2,9	0,89169	0,33408	4,6	0,91374	0,22582	6,3	0,93021	0,17232
1,25	0,93138	0,74977	2,95	0,89233	0,32924	4,65	0,91431	0,22375	6,35	0,93061	0,17113
1,3	0,92358	0,71644	3	0,89298	0,32455	4,7	0,91488	0,22172	6,4	0,93100	0,16997
1,35	0,91699	0,68657	3,05	0,89364	0,32001	4,75	0,91544	0,21973	6,45	0,93139	0,16882
1,4	0,91142	0,65964	3,1	0,89431	0,31561	4,8	0,91600	0,21778	6,5	0,93178	0,16769
1,45	0,90672	0,63522	3,15	0,89498	0,31135	4,85	0,91655	0,21586	6,55	0,93216	0,16657
1,5	0,90275	0,61294	3,2	0,89565	0,30721	4,9	0,91710	0,21397	6,6	0,93254	0,16547
1,55	0,89939	0,59252	3,25	0,89633	0,30319	4,95	0,91764	0,21212	6,65	0,93292	0,16439
1,6	0,89657	0,57372	3,3	0,89702	0,29929	5	0,91817	0,21031	6,7	0,93329	0,16332
1,65	0,89421	0,55635	3,35	0,89770	0,29550	5,05	0,91870	0,20853	6,75	0,93366	0,16226
1,7	0,89224	0,54024	3,4	0,89838	0,29181	5,1	0,91922	0,20677	6,8	0,93402	0,16121

Distribution de Weibull : valeurs