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Presented by: BENADJILA Sid Ahmed

TEDJINI Nawal Ndjla

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Thesis

Chemical risk assessment in a gas production laboratory

examination committee:

Name and last name	Grad	Quality
Bouarar Fahima	MCB	President
Zerrouki hamza	MCA	Examinator
Aouadj Sarra	MCB	Reporter, Supervisor

Promotion: June 2024

Dedications

To the man of my life, my eternal example, my moral support and source of joy and happiness, the one who always sacrificed himself to see me succeed, to you my father Djamel.

In the light of my days, the source of my efforts, the flame of my heart, my life and my happiness; my mother Zineb whom I adore.

To my brothers: Mustapha & Ben Youcef.

And to my sisters: Halima & Meriem.

To my dear partner: Nadjla .

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To all students of the 2023/2024 class.

To all those who, with a word, gave me the strength to continue...

Sid Ahmed

Dedications

I dedicate my humble effort to my loving father Ali and mother Fatima whose affection, love and pray make me able to achieve such success.

To my dear grandmothers and the souls of my grandparents who have left us.

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To all those who, with a word, gave me the strength to continue...

Nawal Nadjla

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Abbreviation table

ABBREVIATION	DEFINITION
$AGNO_3$	Silver nitrate
AM	From Latin post meridiem, translating to "after midday"
ASTM	American Society for Testing and Materials
$C_{12}H_8N_2$	Phenanthroline
$C_7H_6O_3$	Salicylic Acid
CAS	Chemical Abstracts Service
CMR	Carcinogenic, Mutagenic and Reprotoxic
CPE	Collective protective Equipment
DI	Daily Inhaled
DS	Danger Source Inventory
ED	Exposure Dose
EDTA	Ethylenediaminetetraacetic acid
EF	Exposure Frequency
EL	Exposure Level
EPH	Elimination of Precarious Housing
EVRP	Evaluation risque professional, translating to "professional risk assessment"
HCL	Hydrogen chloride
INRS	Institut national de recherche et de sécurité National Institute for Research and Security
IOSH	Institution of Occupational Safety and Health
ISO	International standardization organization
K_2CRO_4	Potassium chromate
KISS	Keep It Super Simple
LEL	Limit Explosion Lower
LUE	Limit Upper Explosion
M^2	Square meter
M^3	Cubic meter
MADS	Method of Analyzing Deficiencies in Systems
MG	Milli gram
MPP2	Module processing plant 2
NAOH	Sodium hydroxide
NH_4CL	Ammonium chloride
PH	Potential of hydrogen
PM	From Latin ante meridiem, translating to "before midday"
PPE	Personal protective equipment
RL	Risk Level
SDS	Safety data sheet
SEIRICH	System for evaluation and information on chemical risks in the workplace
SL	Severity Level
SONATRACH	Société Nationale pour la Recherche, la Production, le Transport, la Transformation, et la Commercialisation des Hydrocarbures, translating to National Society for Research, Production, Transport, Transformation, and Marketing of Hydrocarbons
TWA	Time-Weighted Average

General introduction

Industrial gas production laboratories play a crucial role in various industrial sectors by providing high-purity gases essential for a wide range of processes. These gases are used in applications such as semiconductor manufacturing, pharmaceutical production, steelmaking, and petrochemicals.

In essence, industrial gas production laboratories are the unsung heroes of modern industry. They provide the essential building blocks for countless processes, drive innovation, and ensure responsible practices. Their contributions are vital for a sustainable and efficient industrial landscape.

Industrial gases definitely come with inherent chemical risks. Here's a breakdown of some of the main concerns: **Toxic Gases, Flammable Gases, Corrosive Gases and Asphyxiation.**

It's important to remember that these are just some of the chemical risks. The specific hazards will depend on the particular gas being used. However, industrial gas facilities have strict safety protocols in place to minimize these risks. These protocols rely on laboratories to monitor gas composition, ensure proper handling procedures are followed, and develop safe storage and transportation methods.

A thorough risk assessment is essential for any industrial gas laboratory to minimize the chemical risks mentioned earlier.

By following a structured risk assessment approach, industrial gas laboratories can proactively identify and manage chemical hazards, creating a safer work environment for their personnel.

The first step on our study is about to know the routine of a laboratory agent and collect the data about the risks related to his work according to the chemical products used and the time of exposure. After that, we apply our methods to identify and evaluate the risk and define its severity. At last, we will try to find solutions and give recommendations.

We chose in our study a qualitative method EVRP and a software called: SEIRICH and applied it on a Sonatrach’s laboratory in Hassi R’mel field.

Chemical risk assessment falls within this framework and forms the theme of this dissertation.

To emphasize the importance of the subject covered, we chose to organize the manuscript as follows:

A general introduction talks about laboratory and chemical risk and its assessment

First chapiter presents the family of risk and detailed chemical risk “its consequences and how it penetrates to the human body”

The second chapiter presents the Algerian regulation concerning chemical risk and the tools we used “methods” .

The third chapiter presents the site we studied and the analyses held in the laboratory.

After that in the practical part, we applied our methods to assess the chemical risk then we gave recommendations.
The last step is a general conclusion about the results of the study.

Chapiter I: General information on chemical risk

Introduction:

Before embarking on a detailed exploration of chemical risk and its management, it is essential to establish a foundational understanding of the concepts at hand. In this introductory paragraph, we will set the stage by defining the overarching concept of risk and delineating its various manifestations. Additionally, we will provide an overview of chemical risk, outlining its distinct characteristics, potential consequences, and pathways of exposure. By laying down this groundwork, we can ensure a comprehensive understanding of the complexities surrounding chemical risk management.

I.1 Definition of risk

1.1.1 In Merriam webster dictionary risk is defined as;

the chance of loss or the perils to the subject matter of an insurance contract also: the degree of probability of such lost **[1]**.

1.1.2 In Stanford university dictionary as:

Risk: The possibility that the occurrence of an event will adversely affect the achievement of the organization's objectives **[2]**.

1.1.3 In Cambridge dictionary;

the possibility of something bad happening **[3].**

1.1.4 In ISO 31000;

Effect of uncertainty on objectives;

Note 1 to entry: An effect is a deviation from the expected — positive and/or negative.

Note 2 to entry: Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process).

Note 3 to entry: Risk is often characterized by reference to potential events and consequences, or a combination of these.

Note 4 to entry: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence.

Note 5 to entry: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood **[4]**.

1.1.5 In IOSH dictionary;

Risk is the likelihood of hazardous event occurring in combination with consequence of that event **[5].**

I.2 The family of risk

- Mechanics,
- Electricity,
- Pressure,
- Temperature,
- Chemistry,
- Biology,
- Radiations,
- Noise,
- Gravity (Weight),
- Movement (personnel / equipment).

This family of is represented in the this figure

figure I.1 the types of risks **[6]**

I.3 Risk assessment

Risk assessment is a systematic process of identifying hazards and evaluating associated risks within a specific context, such as a workplace or a project . The goal of risk assessment is to determine the measures that should be implemented to mitigate those risks and ensure the health and safety of employees and customers. Risk assessments are essential for various industries, including cybersecurity, IT, health and safety, and construction **[7]**.

Key aspects of risk assessment include:

- Identifying hazards: This involves recognizing potential sources of harm or danger in a specific context
- Evaluating risks: Assessing the likelihood and potential impact of each hazard on the organization's operations and the well-being of individuals involved
- Implementing control measures: Determining the appropriate actions to reduce or eliminate the identified risks, such as implementing safety protocols, training employees, or investing in infrastructure
- Reviewing and updating risk assessments: Regularly reviewing and updating risk assessments is crucial to ensure that they remain relevant and effective in addressing new hazards or changes in the organization's activities.

The figure in below shown the risk assessment of risk

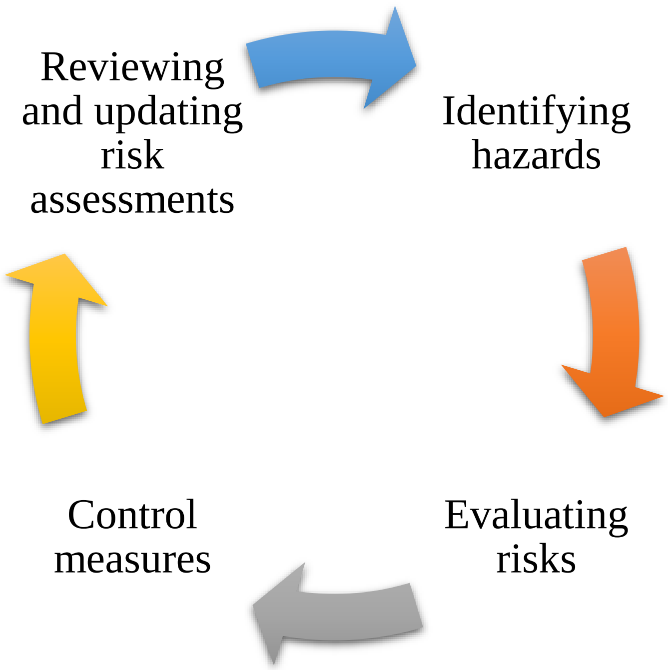

figure I.1 Risk Assement proccess diagram

1.3.1 Different types of risk assessment

There are several methods of risk assessment, including qualitative and quantitative approaches. Some common methods and tools used in risk assessment are:

a. ***Qualitative Risk Assessment:*** This approach is used to quickly identify risk areas and is more subjective. It involves methods such as Keep It Super Simple (KISS) and Probability/Impact analysis

b. ***Quantitative Risk Assessment:*** This method involves assigning numerical values to the probability and potential impact of a threat. It requires data collection and statistical analysis.

c. ***ISO 31000 Methodology***: This methodology defines risk assessment as a process comprising risk identification, risk analysis, and risk evaluation

d. ***Risk Assessment Tools:*** Common tools used in risk assessment include the risk matrix, decision tree, failure modes and effects analysis (FMEA), and the bowtie model

e. ***Other Approaches:*** Organizations can also use semi-quantitative, asset-based, and vulnerability-based risk assessment methodologies, depending on their specific needs and the nature of the risks involved. These methods and tools are used to assess and manage risks across various industries and help organizations develop a clear view of their threat landscape.

I.4 Chemical risk

1.4.1 Chemical product (CP):

Any element or chemical compound, either as it is or within a preparation, as it occurs in its natural state or as it is produced, used or released, particularly in the form of waste, due to a professional activity, whether or not it is intentionally produced and whether or not it is placed on the market

Chemical risk:

Chemical risk refers to the potential for a chemical substance to cause harm to human health or the environment. It is determined by the combination of the inherent hazard of the chemical and the level of exposure to it. The hazard of a chemical is its inherent property to cause adverse effects, while the risk is the probability of these adverse effects occurring.

Chemical risks can arise in various settings, including workplaces, consumer products, and the environment. Workers in industries such as manufacturing, agriculture, and healthcare may be exposed to chemicals during the production, use, or disposal of chemical substances. Consumers can encounter chemical risks through the use of everyday products, such as cleaning agents, personal care items, and household chemicals. Environmental chemical risks can result from the release of substances into the air, water, or soil, impacting ecosystems and human populations.

1.4.2 The ways of penetration of chemical products to the human body

1) **inhalation:** Chemicals can enter the body through the respiratory system when they are in the form of vapors, mists, fumes, or gases. This is a common route of exposure in many work environments.

The figure in below represents inhalation way of penetration

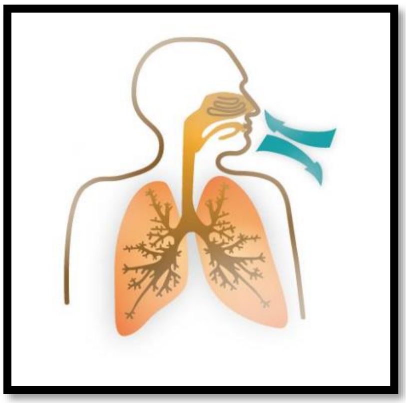

figure I.2 Inhalation way of penetration **[8]**

2) **Skin Contact:** Chemicals can be absorbed through the skin and eyes, especially if they are in direct contact with the skin for an extended period. This can occur through contact with liquids, solids, or mists.

The figure in below represents skin and eyes way of penetration

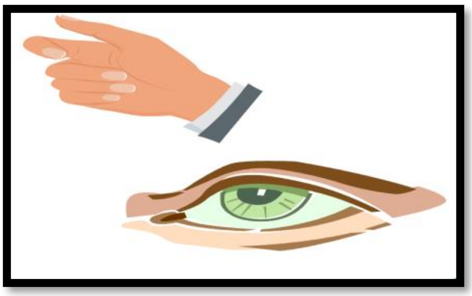

figure I.3 Skin & eyes way of penetration **[9]**

3) **Ingestion:** Ingestion occurs when chemicals are swallowed. This route of exposure can occur if food, drinks, or cigarettes are contaminated with chemicals, or if proper hand hygiene is not practiced.

Dangerous

Situation

The figure in below represents ingestion way of penetration

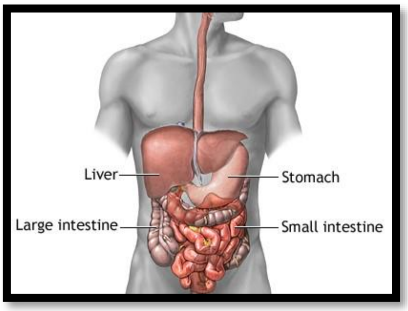

figure I.0 4 Ingestion way of penetration **[10]**

1.4.3 The effects of chemical risk

The chemical effect depends essentially on:

- ❖ the physical state of the products (vapors, dust, aerosols, fumes, mists), which partly condition their aggressiveness on the human organism,
- ❖ their physicochemical and toxicological characteristics,
- ❖ the type of contact with these products (inhalation, ingestion, / skin contact),
- ❖ their route of entry into the body (respiratory, digestive, skin).

As we know the effects could be obvious in short term causes accident or in long term causes disease, we can clarify that as follows;

1) Accidental mechanism

The figure in below represents accidental mechanism

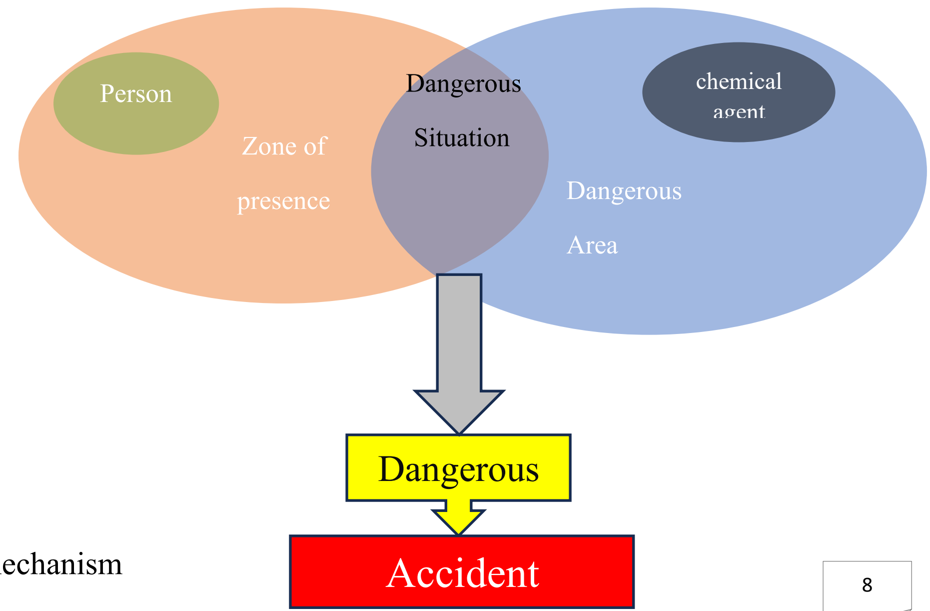

figure 0.5 Accidental mechanism

This family has a lot of effects but we can close them with those;

- Fire
- Dangerous reactions
- Explosion
- Burns
- Asphyxia
- Acute poisonings

a- Fire;

Fire is significantly present when three factors are combined: the presence of a fuel, an oxidizer and an energy supply. This is what we commonly call the fire triangle.

- **Dangerous reactions:**

Products that are incompatible with each other may react violently with projections, release of dangerous vapors and gases, inflammation and/or explosion….

- Unstable products can give rise to explosive decomposition under the effect of heat, shock, humidity, impurities, catalysts (for example: nitrocellulose, organic peroxides, oxide ethylene).
- Some can ignite spontaneously in air (pyrophoric products such as phosphorus or hydrides).

b- Explosion;

Combustible product mixtures (gases, vapors, mist or dust) and air.

- Extremely rapid violent combustion reaction
- Releases a high quantity of energy in a short time
- Explosion.
- Coexistence of an ignition source and an explosive mixture
- Explosibility <==> Determined concentration range ==> between the Lower Explosion Limit (LEL) and the Upper Explosion Limit (LUE)

c- Burns;

- *Thermal burns*: hot products, cryogenic fluids, etc.
- *Chemical burns:* severe damage to the skin, eye and respiratory mucosa (corrosive products; concentrated acids or bases, strong oxidizing products; concentrated hydrogen peroxide, phenol, chlorine, etc.)

The severity of the lesions depends on the nature of the chemical agents, their concentration, the duration of contact and the surface of the body affected.

d- Asphyxiation;

This risk could appear:

- In closed and unventilated premises (wells, tanks, silos, reactors, basements, service galleries, basins, etc.).
- When the oxygen in the air has been consumed by combustion, by respiration, by slow oxidation of a metal,
- When diluted in or replaced by an inert gas for respiration (nitrogen, carbon dioxide)

❖ The concentration of oxygen in the ambient air is about 21%. It should never be less than 19%.

e- Acute poisoning;

- Related to the toxicity of chemical
- Instant toxic effect after significant absorption resulting in death (hydrocyanic acid, ammonia, chlorine….)
- Technical failure; pipeline failure, runaway reaction, leakage or accidental opening of a container, etc.)
- Accidental or voluntary ingestion; products in food packaging

The table in below shown the pictograms of effects of the accidental mechanism

Table I.1 pictograms of accidental mechanism

Pictograms					
Fire	Dangerous reactions	Explosions	Burns	Acute poising	Asphyxiation
					

2) Chronic mechanism;

The figure in below represents chronic mechanism

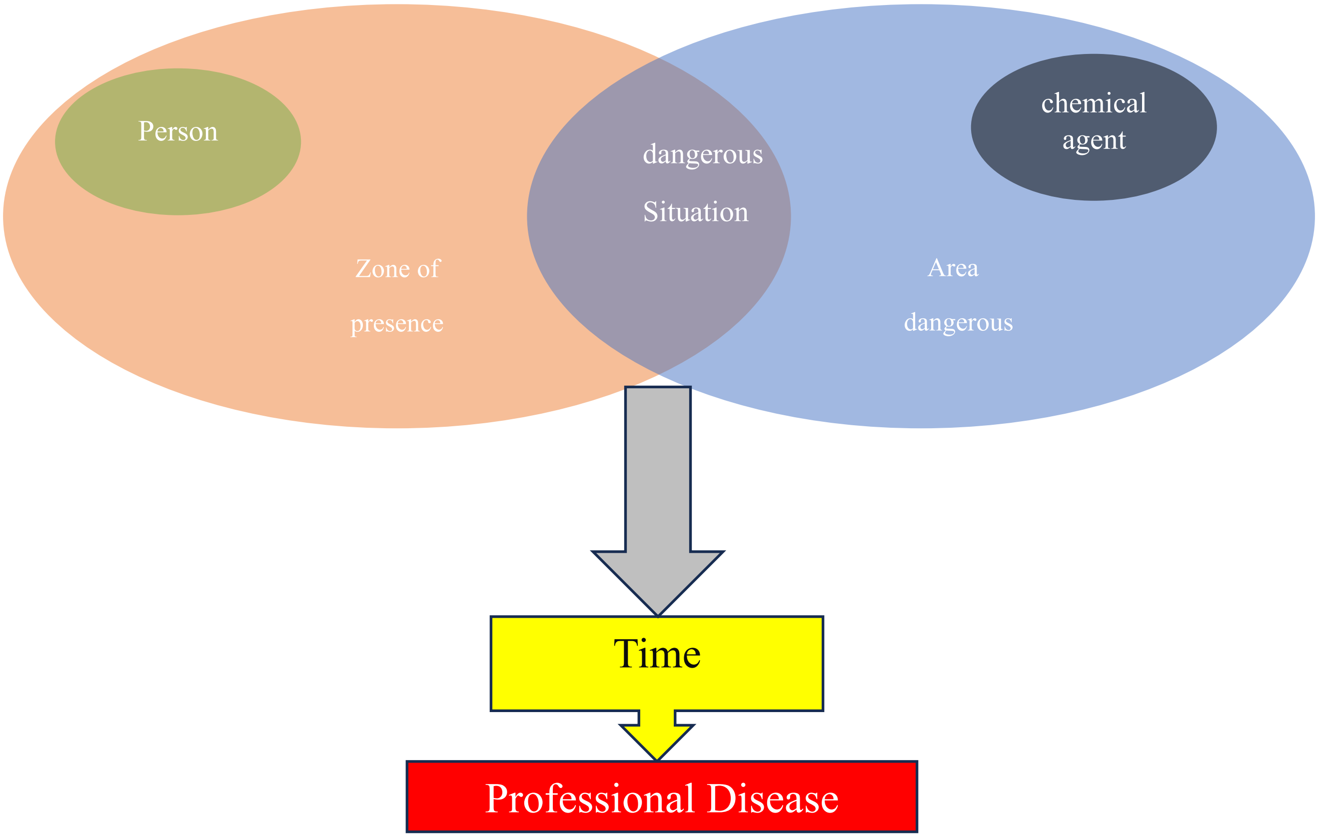

figure I.6 Chronic mechanism

a- Occupational disease;

Occupational disease occurs gradually following a more or less prolonged exposure to dangerous products, during the usual practice of the profession. Most often, these diseases appear after repeated multiple exposures to low doses of product: it is chronic poisoning.

b- CMR;

A Carcinogen (C) is: a substance or mixture of chemicals that induces or increases the incidence of cancer (disease caused by the transformation of cells that become abnormal and proliferate excessively. These abnormal cells eventually form a mass called a malignant tumor)

A mutagen (M) is: a substance or mixture of substances capable of inducing changes in an individual's genetic code and promoting the occurrence of hereditary genetic defects.

Reprotoxic (R) is: a substance or mixture of substances capable of altering reproductive functions and fertility (in men or women) and inducing adverse effects on the development of their descendants.

The figure in below pictogram of CMR

And this table in below represents the classification of CMR substances

Table I.2 Classification of CMR substances

Category 1A	Substances with proven carcinogenic potential for humans**.**
Category 1B	Substances whose carcinogenic potential for humans is assumed.
Category 2	Substances suspected of being carcinogenic to humans.

1.4.4 Examples of chemical workplace accidents.

Setting: A bustling petrochemical plant on the outskirts of Houston, Texas. The roar of machinery and hiss of steam fill the air. A team of three chemical engineers, David (senior), Jessica (experienced), and Alex (new hire), are conducting a routine pressure test on a distillation tower containing a volatile mixture of propane and butane.

The Incident :

1. **Equipment Failure:** Unknown to the team, a faulty pressure gauge malfunctions, giving an inaccurate reading. The pressure inside the tower steadily climbs beyond safe limits.
2. **Missed Warning Signs:** David, focused on his readings, misses the subtle changes in the tower's performance, such as increased vibration and a high-pitched whine. Jessica, entrusted with monitoring the pressure gauge, is preoccupied with finalizing a report. Alex, still unfamiliar with the plant's intricacies, hesitates to speak up.
3. **Catastrophic Failure:** The pressure within the tower surpasses its capacity. A deafening explosion rips through the air as the vessel ruptures, spewing a fiery inferno of hydrocarbons and debris.

Immediate Aftermath:

1. **Panic and Injuries:** The blinding blast triggers mass panic. Workers flee the immediate zone, some sustaining burns and shrapnel wounds. Thick, black smoke billows into the sky, threatening to engulf nearby storage tanks.
2. **Emergency Response:** The plant's emergency response system activates. Alarms blare, and automatic fire suppression systems attempt to contain the inferno. The on-site emergency medical team rushes to aid the injured.
3. **Evacuation:** With the potential for a larger catastrophe, plant management initiates a full-scale evacuation. Security personnel ensure a safe and orderly evacuation of non-essential personnel.

Wider Impact :

1. **Environmental Damage:** The thick smoke plume carries airborne pollutants, potentially impacting air quality in nearby communities. Firefighters work tirelessly to extinguish the blaze and prevent flames from reaching storage tanks that could trigger a city-wide disaster.
2. **Media Frenzy:** News helicopters swarm the scene, capturing the chaos and destruction. Social media erupts with concerns about public safety and the potential environmental impact.
3. **Investigation:** In the aftermath, a multi-agency investigation examines the cause of the explosion. Focus falls on potential equipment failure, human error, or a combination of both.

Long-Term Consequences:

1. **Casualties:** The investigation reveals the extent of the human cost. Several workers are confirmed dead, while others face life-altering injuries.
2. **Financial Repercussions:** The plant suffers significant financial losses from property damage, production delays, and potential lawsuits.
3. **Safety Regulations:** Regulatory bodies conduct a thorough review of the plant's safety protocols and may impose stricter regulations to prevent similar incidents in the future.

Key Points :

- This scenario highlights the domino effect that can occur in a chemical plant, where a single misstep can lead to catastrophic consequences.
- It emphasizes the importance of preventative maintenance, clear communication, and a culture of safety awareness within industrial facilities.
- The scenario showcases the potential environmental and social impact of a major chemical accident.

I.5 Conclusion:

This chapter has provided a comprehensive overview of risk concepts, with a specific focus on chemical risks and their potential consequences on human health. By examining the various ways in which chemical substances can penetrate the human body, we have underscored the importance of implementing effective safety measures. This foundational understanding serves as a critical basis for more detailed analyses and practical solutions in subsequent chapters, aimed at reducing risks and safeguarding the health of laboratory personnel.

I.6 References

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Chapter II: Regulations and analysis tools

Introduction

Prior diving into the intricacies of chemical risk management and the regulatory landscape in Algeria, it's essential to lay down a solid foundation of understanding. This includes familiarizing ourselves with the fundamental concepts of risk analysis and the legal framework that governs chemical risk management. In this chapter, we will explore the Algerian legislation surrounding chemical risk management. Additionally, we will introduce the selected methods for risk analysis.

II.1 Algerian legislation governing chemical risk management

The table in below shown the Algerian legislation governing about chemical risk

Table II.1 Algerian legislation about chemical risk

Type of law	The date of law	The contain of law
Executive Decree No. 02-427	3 Chaoual 1423 corresponding to 7 December 2002	The conditions of organization of training, information and training of workers in the field of the occupational risks' prevention.
Intermenstrual decree	5 Chaâbane 1424 corresponding to October 1st ,2003	The protection of workers against the risks related to the inhalation of asbestos dust.
Executive Decree No. 03-451	December 1st , 2003	Defining the safety rules applicable to activities concerning hazardous materials and chemicals as well as pressure gas receptacles.
Executive Decree No. 03-452	December 1st ,2003	Laying down special conditions for the road transport of dangerous products.
Intermenstrual order	April 10th, 2004	Laying down the composition, tasks and functioning of the Technical Committee for Hazardous Materials and Chemicals
Intermenstrual order	April 10th ,2004	Laying down the composition, tasks and functioning of the Technical Committee for Hazardous Materials and Chemicals.
Executive Decree No. 05-08	27 Dhou El Kaada 1425 corresponding to January 8th ,2005	On the specific requirements applicable to dangerous substances, products or preparations in the workplace.
Interministerial order	21 Chaâbane 1435 corresponding to June 19th ,2014	Setting the conditions and modalities of acquisition on the national market of hazardous materials and chemicals by natural or legal persons whose professional or personal activities require the use of hazardous materials and/or chemicals on an ad hoc basis, circumstantial and/or incidental.
Interministerial Order	27 Joumada El Oula 1437 corresponding to March 7th, 2016	setting the conditions and modalities of acquisition, on the national market, paramedical products and toxic or hazardous products containing hazardous materials and chemicals. **[1]**

II.2 Presentation of the analysis tools:

2.2.1 Risk analysis methods selected:

In our study, we used two Analysis tools to evaluate the chemical risk in a laboratory

2.2.2 EVRP

The assessment of occupational risks is part of the general responsibility of the employer to ensure the health and safety at work of his employees (moral & physical responsibility).

Assessing the potential occupational risks at the workplace, before the occurrence of malfunctions and the occurrence of accidents or declaration of occupational diseases is an essential prerequisite for building a relevant prevention action plan **[2]**.

This is the initial stage of an occupational health and safety policy.

2.2.2.1 Methodology

The **MADS** (Method of Analyzing Deficiencies in Systems) approach aims to apprehend unwanted events, these events are defined as failures that may cause unintended effects on the individual, the population, the environment and the facility.

This approach is based on the hazard process model, which aims to describe the sequence of events leading to a dangerous situation.

The process links processes that are sources of danger to processes that may be affected at the target level.

2.2.2.2 Geographic Segmentation:

The approach adopted according to the EvRP repository is a segmentation by geographical area, namely:

- Define observation spaces called ↔ fields of application
- Divide them for convenience into smaller perimeters or sub-assemblies ↔ work unit.
- Conduct a Danger Source Inventory (DS) for all identified areas.

2.2.2.3 Identification of sources & hazard scenarios:

Using hazard typologies as a list of questions to ask when seeking to identify scenarios for DS.

- First, take only the sources of danger that carry major risks.
- Limit the number of main scenarios to 02 or 03 for each DS.

2.2.2.4 How to write a danger scenario?

Hazard typologies are a list of questions to ask when trying to identify hazard scenarios for a source of danger:

- Do the physical or chemical characteristics of the source of the hazard naturally make it dangerous for the health of workers? (Weight, Chemical characteristics, Sharp edges, Sensitivity to static electricity, etc.),
- How can the source of danger affect the health of workers when it is in operation or when it is used? (Fumes, Noise, Vibrations, etc.)

➢ **The source of danger:**

Are there any possible faults, which could be harmful for workers' health?

➢ **A worker:**

Can he commit an awkwardness or an involuntary gesture, which would make him victim of the source of danger?

- **The health status of an operator:**

Could his health status make him a victim of the source of danger? (Allergies, Pregnant woman, Vertigo, Physical or psychological disability, etc.)

- **Non-compliance with an operating procedure:**

Can it generate a Work Accident and/or Occupational Disease, with this source of danger?

2.2.2.5 Magnitudes of Quantifications.

The Company has taken into consideration 03 quantities:

1. The Exposure Frequency (**EF**)
2. The Exposure Dose (**ED**)
3. The severity Level. (**SL**)
   - Assess Exposure Level (**EL**):

combination of EF and ED,

   - Assess Risk Level (**RL**):

combination of EL and SL.

a. **EL: Exposure Level**

Combination of hazardous occurrence and exposure dose (Low, Medium, Important)

EF: Exposure Frequency (Occurrence of Hazardous Phenomenon):

EF 1: Rare (once a year);

EF 2: Frequent (once a month);

EF 3: Permanent (once a week).

This table in below shows the combination between Exposure Frequency and Exposure Dose

Table II.2 Exposure Level

EL	EF1	EF2	EF3
ED1	Low	Medium	Medium
ED2	Low	Medium	Important

b. **ED: Exposure Dose**

ED1: Low to Medium

ED2: Medium to High

The criteria to find which is Exposure Dose chosen is by this table in below

Table II.3 The criteria to define ED

N°	Criteria	ED1	ED2
01	Exposure duration	Weak	Important
02	The number of workers exposed	<=2	>2
03	Training and empowerment of workers	+	-
04	Personal protective equipment	+	-
05	Aggravating factors "work in night, climatic condition, lighting…"	-	+
06	Detection or not of risks	+	-
		>=4	>=3

c- **SL: Severity Level**

SL1: Little damage to health,

SL 2: Serious reversible impairment,

SL3: Irreversible damage without aggravation,

SL4: Irreversible damage with deterioration,

SL5: Death instantly.

d- **RL: Risks Level**

The table shown the results of combination of Risk level and Exposure Level
Table **Erreur ! Utilisez l'onglet Accueil pour appliquer 0 au texte que vous souhaitez faire apparaître ici.**.4 The Risk Levels

RL	SL 1	SL 2	SL 3	SL 4	SL 5
EL=L	P5	P4	P4	P2	P1
EL=M	P5	P4	P3	P2	P1
EL=I	P4	P3	P3	P1	P1

Green	Area of palliative actions and PEI
Orange	Area of PEI et PEC
Red	Danger Removal Zone

Legend:

- **RL** = Risk Level
- **EL** = Exposure Level
- **SL** = Severity Level
- **P** = Order of Priority

Formula:

- **Risk Level =** Exposure Level x severity level

RL = EL x SL

2.2.3 Seirich software:

Seirich (Occupational Chemical Risk Assessment and Information System), developed by INRS serves as a comprehensive platform enabling companies to acquire information and conduct assessments of their chemical risks. This modular tool is meticulously crafted to accommodate users of all backgrounds, irrespective of their proficiency in chemical risk management or the scale of their enterprise **[3]**.

It is a software dedicated to the assessment of chemical risks in the professional environment. It facilitates the identification of hazardous substances, evaluates associated risks, and implements appropriate preventive measures to ensure the safety of workers.

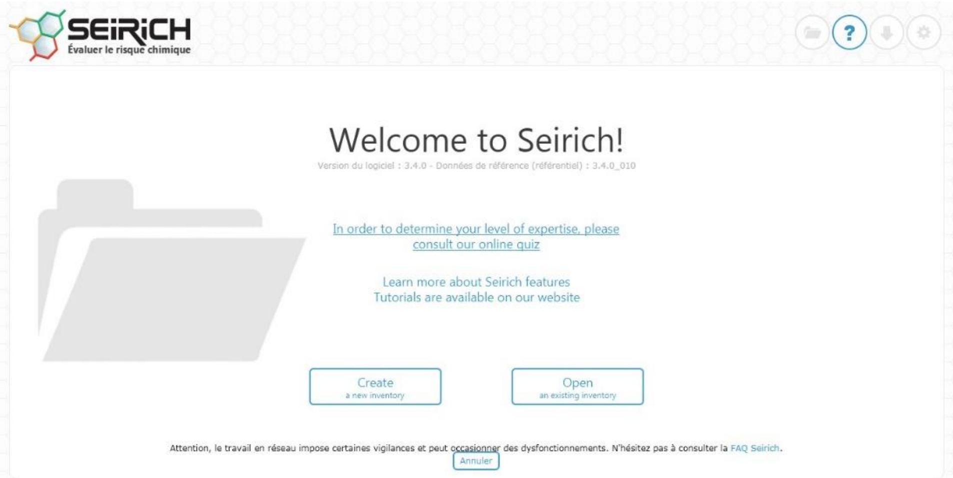

figure 3.1 Main screen of SEIRICH

2.2.3.1 How does the Seirich software operate?

The Seirich software operates through a meticulous chemical risk assessment procedure. Key phases encompass:

- ***Chemical Identification:*** Users input data concerning chemicals utilized within the workplace.
- ***Hazard Assessment:*** Seirich scrutinizes the attributes and associated hazards of each chemical, drawing from extensive databases and regulatory standards.
- ***Exposure Assessment:*** The software meticulously considers usage conditions, exposure frequency, and implemented protective measures to gauge workers' exposure levels accurately.
- ***Risk Assessment:*** By amalgamating hazard and exposure data, Seirich meticulously computes the risk level attributed to each chemical substance.
- ***Proposed Preventive Measures:*** The software offers recommendations for preventive and control measures, aimed at mitigating risks to an acceptable threshold.
- ***Documentation:*** Seirich systematically generates exhaustive reports to meticulously document the chemical risk assessment, thereby facilitating adherence to regulatory standards.

2.2.3.2 The Nature of Input Information

The input data required for the utilization of Seirich in chemical risk assessment typically encompasses:

- ***Identification of Chemical Substances:*** This entails comprehensive details such as nomenclature, chemical formulae, Chemical Abstracts Service (CAS) numbers, and other pertinent identifiers.
- ***Quantities Used:*** This pertains to the precise quantities of chemicals manipulated within the workplace environment.
- ***Conditions of Utilization:*** This delineates the specific methodologies by which chemicals are employed, including nuanced details such as production processes or specialized applications.
- ***Pre-existing Protective Measures:*** This references the extant inventory of personal protective equipment (PPE) and technical safeguards already enacted to ameliorate potential risks.
- ***Frequency and Duration of Exposure:*** This encompasses an exhaustive examination of the frequency and temporal span of workers' direct exposure to chemical agents.

This corpus of data furnishes Seirich with the requisite foundation to execute a meticulously detailed chemical risk assessment, integrating nuanced substance characteristics, operational contexts, and prevailing safety protocols.

2.2.3.3 The output Information

The output furnished by the Seirich software typically encompasses:

- ***Risk Assessment Report:*** An exhaustive dossier summarizing details concerning the evaluated chemicals, discerned risks, estimated exposure levels, and endorsed preventive measures.
- ***Risk Matrices:*** Visual representations in tabular format delineating the correlated risk levels for each scrutinized chemical. These matrices expedite the identification of prioritized areas in risk management.
- ***Prevention Recommendations:*** Tailored directives for the execution of preventive measures aimed at attenuating risks to acceptable thresholds. This may encompass recommendations regarding the utilization of personal protective equipment (PPE), technical controls, and analogous strategies.
- ***Regulatory Documentation:*** Essential components requisite for adherence to pertinent regulations, facilitating communication with regulatory entities.

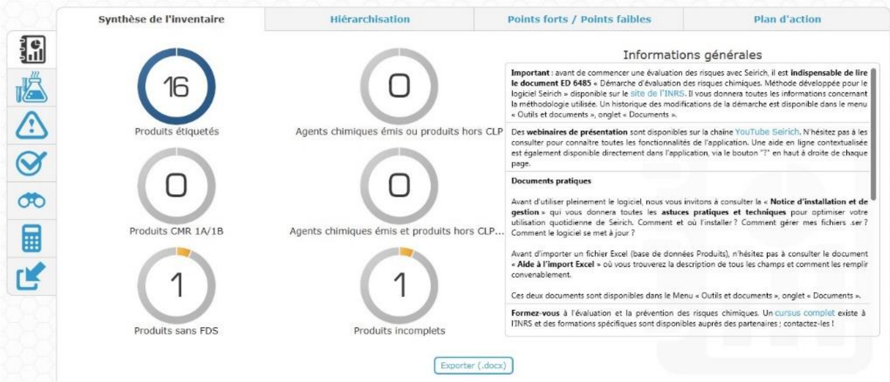

figure II.332 screen including windows displaying the outputs.

These outputs afford safety officials and managerial personnel heightened comprehension of the inherent chemical risks within the workplace, thereby facilitating the identification of requisite mitigation measures and the documentation of the assessment process in alignment with prevailing standards.

II.3 Conclusion:

This Chapter provided an in-depth exploration of the Algerian legislation surrounding chemical risks. Through our analysis, we have gained a comprehensive understanding of the legal framework, including laws, regulations, and standards that govern the handling, storage, and use of hazardous substances in Algeria. Additionally, we have introduced two selected methods of risk analysis, namely EVRP and SEIRICH, which are crucial tools for assessing and managing chemical risks effectively.

II.4 References

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[2] Power point : Mr.FILALI, power point Formation EvRP IAP Skikda ,2023, page59

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Chapiter III: Presentation of the industrial site studied and application of the analysis tools.

Introduction

In this chapter, we will present a detailed overview of the industrial site that serves as the focal point of our study. This includes a description of the gas treatment process at the laboratory MPP2 and the equipment of gas analysis. Additionally, we will discuss the analyses performed by the laboratory to assess the potential risks associated with the site's operations. Furthermore, we will explore the routine tasks and responsibilities of laboratory personnel tasked with monitoring and managing chemical hazards within the site. By laying down this groundwork, we aim to provide a comprehensive understanding of the context in which our study is situated, facilitating deeper insights into the challenges and opportunities related to chemical risk management in industrial settings.

III.1 Presentation of Sonatrach :

Sonatrach (French : *Société Nationale pour la Recherche, la Production, le Transport, la Transformation, et la Commercialisation des Hydrocarbures*) is the national state-owned oil company of Algeria. Founded in 1963, it is known today to be the largest company in Africa with 154 subsidiaries, and often referred as the first African oil "major". In 2021, Sonatrach was the seventh largest gas company in the world **[1].**

Established on December 31, 1963, just after Algeria's independence, SONATRACH is the Algerian national company for the exploration, production, pipeline transportation, transformation, and marketing of hydrocarbons and their derivatives **[2]**.

As the jewel of independent Algeria, SONATRACH, due to its size and scope of activity, has been intimately linked to the destiny of Algeria throughout its history.

Established as a national company by excellence following the nationalization of hydrocarbons on February 24, 1971, it has always been in a fruitful dialectic with the different phases of economic, political and socio-cultural development of a young Algeria that is being built and seeking itself **[3]**.

The idea of SONATRACH is inseparable from a deep awareness of the responsibility that rests on it as the custodian of the national hydrocarbon heritage and the locomotive of the national economy.

Always at the forefront in terms of modernization of both managerial and technological processes of development and strategy, SONATRACH has taken an evolutionary and ascending tangent, each time opening up new avenues of expansion and initiating major projects whose positive impacts on the optimal valorization of national hydrocarbon resources and wealth creation are most significant.

With over 50,000 permanent employees and over 200,000 across the Group, SONATRACH is today an integrated oil company and a major player in the oil and gas sector.

It is the first hydrocarbon company in Africa and the Mediterranean. It is present in several projects with different partners in Africa, Latin America and Europe.

In this capacity, it ensures that Algeria has financial resources in foreign currency, promotes national integration and supports any initiative that adds value.

SONATRACH's deployment is structured around central and corporate directorates and operational structures.

The operational structures consist of five Activities: Exploration-Production (EP), Pipeline Transportation (TRC), Liquefaction-Separation (LQS), Refining & Petrochemicals (RPC) and Marketing (COM).

These Activities are relayed by 154 subsidiaries and holdings, of which about fifteen are 100% owned.

III.2.1 SONATRACH's Activities, from Upstream to Downstream

a- Upstream Activities:

- Exploration for new oil and gas fields within Algerian territory
- Management of partnership activities
- Development of new projects in Algeria and internationally

b- Midstream Activities:

- Expansion of the pipeline transportation network
- Storage, loading, and unloading facilities at onshore and offshore port facilities

c- Downstream Activities:

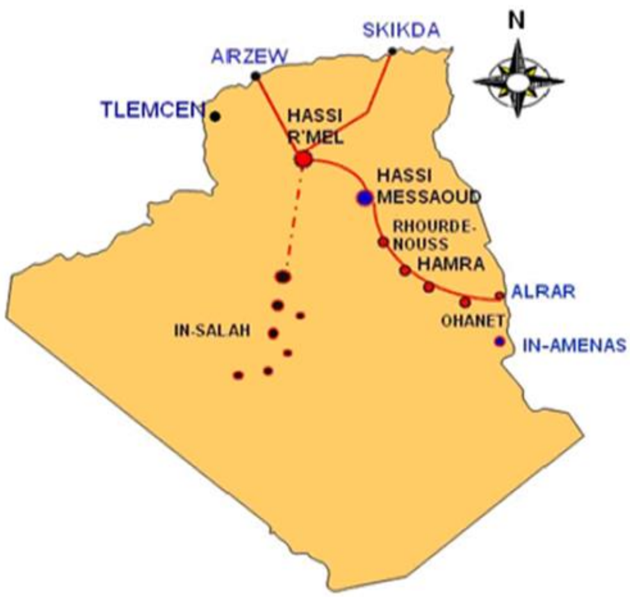
- Transformation of hydrocarbons through natural gas liquefaction and LPG separation
- Increase in LNG production capacity
- International trading activities

III.2 General description of SONATRACH industry in Hassi R'mel

3.2.1 Location

Hassi R'mel, renowned as the gateway to the desert, is situated within the district of Laghouat province, positioned 120 km distant from it and 550 km from Algiers, at an approximate altitude of 750 m. The topography comprises vast rocky plateaus, characterized by a climate featuring minimal annual precipitation of 140 mm and an average humidity of 19% in summer and 34% in winter. Temperature fluctuations range between -10 and +50°C. The region is distinguished for its prevalent strong winds, frequently accompanied by sandstorms.

The next figure represents the location of the region of Hassi R'Mel



[4]

figure 0.1 Geographical location of the region of Hassi R'Mel.

At a distance of 35 km to the north, created ex-nihilo... This phenomenon can also be attributed to Algeria's imperative, starting from the year 2000, to bolster its legal infrastructure, particularly concerning urbanization control and risk management, in alignment with international agreements and conventions ratified in the environmental domain.

Housing constitutes a focal point of concern for local authorities regarding urbanization control within this zone designated as high-risk.

3.2.2 History of Hassi R'Mel

The two products, gas and oil, initially found in their crude state, require the presence of significant processing complexes, which have undergone continuous development over the last decade. The first well, H-R1, was drilled in 1956 beneath the summit of the anticline constituting the Hassi R'mel field. This well revealed the presence of gas rich in condensate at a temperature of 90°C and a pressure of 310 kef/cm².

The development of the Hassi R'mel deposit was carried out in several stages:

- 1961-1969: commissioning of six (06) gas processing units with a capacity of four billion cubic meters per year.
- 1972-1974: operation of six (06) additional units to reach a capacity of fourteen billion cubic meters per year.
- 1975-1980: implementation and implementation of the development master plan with the following objectives:
- Increased processing capacity from 14 to 94 billion m3/year.
- Maximizing the recovery of liquid, condensate and LPG hydrocarbons through partial gas recycling.

- 1985: construction and commissioning of a unit for the recovery of flared gases and the production of LPG from modules 0 and 1.
- 1987-2000: construction and commissioning of gas treatment centers in Djebel Bissa and Hassi R'mel Sud.
- 1981-1993: commissioning of five (05) oil processing centres.
- 1995-1999: commissioning of gas hydration units in Sbaa (Adrar) near In Salah.
- 1999: construction and commissioning of the associated gas recovery plant from oil treatment centres.
- 2001: implementation of BOOSTING II project.
- 2020: implementation of BOOSTING III project.

III.3 Description of the gas treatment process at the MPP2

The biphasic raw gas extracted from 39 production wells is aggregated into nine collectors, which subsequently converge into a manifold leading to the boosting station. The primary objective of the boosting station is to elevate the pressure of the raw gas from 93 kg/cm² to 120 kg/cm², thereby optimizing the recovery of liquid hydrocarbons. It is then distributed among three identical trains (A, B, C), each boosting a capacity of 20 million m³/day, to diffuser D001 at a pressure of 120 kg/cm² and a temperature of 58°C.

Following dispersal from the diffuser, the raw gas undergoes cooling to 40°C within air cooler E101. The chilled gas then undergoes separation within inlet separator D101, effectively segregating gas from water and liquid hydrocarbons. The separated water is directed towards the evaporation basin. Gas emanating from D101, maintained at a pressure of 118 kg/cm², traverses through gas/gas heat exchangers E102 and E103, where it is further cooled to -9°C. Subsequently, it progresses through the Joule Thomson valve (PRCV108), experiencing an initial isenthalpic expansion to 100 kg/cm² and -13°C, before entering the high-pressure separator D102.

To prevent the formation of hydrates, which could potentially obstruct the heat exchangers, an 80% mass solution of glycol is injected at the E102 and E103 exchangers. Within the D102 separator, the gas, MEG solution (monoethylene glycol), and liquid condensate are once again separated. Following water absorption, the MEG solution undergoes pressurization and is conveyed to the glycol regeneration section.

The gas from D102 undergoes an isentropic expansion within the turbine of the "Turbo-Expander K101." This turbine serves to recuperate energy produced as high-pressure gas traverses through it, thereby reducing pressure to 67 kg/cm2 and achieving a temperature of -35°C before passing through the cold separator D103. Subsequently, the cooled gas from D103 passes through the gas/gas heat exchanger E102 A/F, facilitating the cooling of raw gas while simultaneously heating itself to a temperature of 43°C. Following this, it undergoes compression to 74 kg/cm2 at the K101 compressor and is directed toward the gas sales pipeline.

The liquid hydrocarbons from the inlet separator D101 are expanded at the rich condensate separator D105 to 33 kg/cm2 and 42°C. The hydrocarbons recovered from D102 and D103 proceed to the low-pressure separator vessel D104 at a temperature of -40°C and a pressure of 34 kg/cm2.

The liquid entering D104 contains dissolved gas. This gas, along with that from the cold reflux drum of the de-ethanizer D107, passes through the shell side of heat exchanger E103 A/B to cool the raw gas. Following heat exchange, the gas from D104 and D107 heats up and combines with the gas exiting D105 at a temperature of 21°C and a pressure of 32 kg/cm2. The mixture then proceeds to the recompression section and subsequently to the gas sales pipeline.

The liquid hydrocarbons from the low-pressure vessel at a temperature of -40°C and a pressure of 34 kg/cm2 pass through the E106 exchanger (shell side) and are heated to -23°C. They then feed the fifth tray of the de-ethanizer C101 (cold feed), where heat exchange occurs with the overhead vapors of the de-ethanizer C101 at a temperature of -16.5°C. These vapors partially condense in the E106 exchanger tube side to separate from the liquid in reflux drum D107. Injection of MEG is planned at the inlet of the E106 exchanger tubes to prevent hydrate formation.

Liquid hydrocarbons from D105 at 21°C pass through the grille of the E104 feed exchanger to be heated to 115°C and feed the deithanizer at the 21st tray (hot feed).

Column C101 consists of 28 valve trays:

• 12 top trays.

• 16 lower.

These two parts are separated by an accumulator tray

The liquid exiting D107 is reinjected as cold reflux at a temperature of -29°C and a pressure of 27.5 kg/cm2. The reflux pressure is increased by pump P103, which directs the reflux to the first tray. A solution of MEG is injected into the reflux pipeline. The liquids descending from the upper trays of C101 accumulate in the fixed tray, then flow by gravity at a temperature of 40°C towards the hydrocarbon/glycol separator D106. The recovered hydrocarbons are then returned via pump P102 to C101 at the 13th tray, while the hydrated MEG solution is fully recovered and sent to the regeneration section.

From the bottom of column C101, a liquid exit, part of which passes through pump P101 into reboiler H101 to be heated from 146.8°C to 173.3°C before returning to the column as hot reflux. The other part, at a temperature of 146.8°C, feeds de-ethanizer C102 at the 21st tray.

The de-ethanizer comprises 32 valve trays with a pressure of 14 kg/cm2. The overhead vapors from C102 are cooled and condensed in air cooler E108 from 68°C to 48°C, then directed to reflux drum D108. Part of the exiting liquid passes through pump P105 and enters the first tray of C102 as cold reflux, while the other part, as produced LPG, is sent to the storage and transfer section.

A portion of the residue passes through pump P104, enters reboiler H102, is heated from 185°C to 204°C, and returns to the column as reboil. The remaining portion of the residue passes through the tubes of E104 to heat the feed to C101. This residue cools from 185°C to 84°C, then undergoes further cooling in air cooler E107 from 84°C to 35°C before flowing to the condensate storage and transfer section.

III.4 **Laboratory**

The laboratory works closely with the operations department and is responsible for:

- Conducting analyses of finished products and other products involved in natural gas processing.
- These analyses are carried out to verify the conformity of the products to the required specifications.
- Contribute to the optimization of process parameters.
- Collaborate with the operations department to find solutions to corrosion and salinity problems during industrial tests on corrosion inhibitors and emulsifiers.

The laboratory staff consists of both technicians and engineers.

- Technicians work in rotating shifts to provide continuous operation.
- A laboratory manager oversees the overall functioning of the laboratory and equipment.

3.4.1 The types of analyses held in the laboratory

The analyses did by laboratory are related to ASTM norms and we can classify each analyse and norm used and without forgetting the equipment in this table below

Table III.1 The types of analysis by the norm of ASTM

Product	Analysis	Physico-chemical Characteristics	Norm ASTM	Equipment	Specifications
GAS	Composition molar	PCS, density PM, c^{5+}	D1945	Chromatographer in gas phase	PCS :9350-9450 KCal/sm^3 C^{5+} :≤0 ,5%
	Humidity		D1744	Karl Fischer	≤50ppm
	PRH	PRH EN C° à la pression de service	D1142	Dew point tester	≤-6C° à 80 bar
LPG	Composition molar	Density, C^{2-} ,C^{5+}	D2163 D2598	Chromatographer in gas phase	C^{2-}<3% C^{5+}<5%
CONDENSAT	Density	D15/4	D1298	Hydrometer	
	TVR	TVR à37.8C°	D323	Bombe normalize	≤10 PSI
GLYCOL	Concentration		D1218	Refractometer	REG 77-79% Hyd 68-70%
	PH		E70	PH meter	
Water of Separators	PH		D1293	PH meter	Monitoring of corrosion inhibitor injection
	Salinity		D512	Dosage volumetry	
	Fer		D1068		

3.4.2 Analyses Schedule

In this table below shows the schedule of analyses for each product by their type

Table **Erreur ! Utilisez l'onglet Accueil pour appliquer 0 au texte que vous souhaitez faire apparaître ici.**2 Schedule Analyses

Product	Analysis	Characteristics physicochemical	Norm ASTM	Frequencies	Equipment	Specifications
Water of collectors	PH		D1293	Hebdomadary	PH mere	Monitoring of corrosion inhibitor injection
	Salinity		D512		Dosage volumetry	
	Iron		D1068			
Cooling water	PH		D1293		PH meter	
	Water hardness		D1126		Dosage volumetry	
	Fer		D1068		Spectrophotometer	
Air instrument	Humidity	Water dew point at operating pressure	D1744	Mensal	Karl Fischer	≤10C°
Oil of lubrification	Viscosity cinematic	Viscosity cinematic à 40 C°	D445		Viscosimeter ubblhoud	As the type of oil

3.4.3 Routine of a Laboratory Technician

The laboratory technician at Sonatrach works 12 hours, and these 12 hours are divided as follows:

TIME	TASK
7:00 AM	Laboratory technician arrives at the lab.
8:00 AM	Sample collection begins. Technicians collect samples from various points in the natural gas processing facility for analysis

- **Day Shift (7:00 AM - 4:00 PM)**

Table III.3 the tasks of laboratory technician from 07:00 AM to 04:00 PM

9:00 AM	Analysis of samples commences. Technicians perform various tests on the collected samples using specialized laboratory equipment to determine their composition and properties.
10:00 AM	Morning break. Technicians take a short break to rest and recharge.
10:30 AM	Completion of sample analysis. Technician's finish analyzing the samples and record the results.
12:00 PM	Lunch break. Technicians take a lunch break to eat and socialize.
1:00 PM	Return to the lab. Technicians return to the lab after lunch to continue their work.
3:00 PM	Preparation of daily report. Technicians compile the results of the day's analyses into a comprehensive report for management review.
4:00 PM	Cleaning and equipment maintenance. Technicians clean and maintain laboratory equipment to ensure it is ready for the next shift.

- **Night Shift (7:00 PM - 7:00 AM)**

Table III.4 the tasks of laboratory technician from 07:00 PM to 07:00 AM

TIME	TASK
7:00 PM	Shift change. The day shift technicians' hand over their responsibilities to the night shift technicians.
8:00 PM	Night shift sample collection begins. Night shift technicians collect samples from various points in the natural gas processing facility for analysis.
9:00 PM	Analysis of night shift samples commences. Night shift technicians perform various tests on the collected samples using specialized laboratory equipment to determine their composition and properties.
10:00 PM	Dinner break. Night shift technicians take a dinner break to eat and socialize.
10:30 PM	Completion of night shift sample analysis. Night shift technicians finish analyzing the samples and record the results.
12:00 AM	Midnight break. Night shift technicians take a short break to rest and recharge.
1:00 AM	Return to the lab. Night shift technicians return to the lab after their break to continue their work.
3:00 AM	Preparation of daily report. Night shift technicians compile the results of the day's analyses into a comprehensive report for management review.

4:00 AM	Cleaning and equipment maintenance. Night shift technicians clean and maintain laboratory equipment to ensure it is ready for the day shift.
7:00 AM	Shift change. The night shift technicians' hand over their responsibilities to the day shift technicians.

3.4.4 Product Storage

a- Categorization of Products

Products are classified into two main groups based on their frequency of use:

1. Daily-Use Products:

Dedicated Storage Container: These frequently used products are stored in a special container that does not employ a storage matrix system. This specialized container likely provides easy access, organization, and protection for these essential items.

2. General Storage:

Warehouse Storage: Products that are not used frequently are stored in a warehouse. This centralized storage area likely utilizes a storage matrix system to efficiently organize and manage the inventory.

3.4.5 Main Equipment and Tools for Natural Gas Analysis

The analysis of natural gas involves a range of specialized equipment and tools to effectively assess its composition, properties, and quality. These instruments play a crucial role in ensuring the safe and efficient operation of natural gas processing facilities and pipelines. Let's delve into the key equipment and tools commonly employed in natural gas analysis:

1**. *Magnetic Stirrer:***

A magnetic stirrer is a laboratory tool used to mix solutions without direct contact between the stirrer and the liquid. It employs a rotating magnetic field to induce a spinning motion in a small stir bar placed within the liquid. Magnetic stirrers are particularly useful for mixing viscous or hazardous liquids.

2. 10ml Pipette:

A 10ml pipette is a laboratory instrument used to accurately measure and transfer small volumes of liquids. It consists of a graduated glass tube and a rubber bulb or plunger mechanism to control the flow of liquid. Pipettes are essential for precise measurements in various analytical procedures.

3. Beakers:

Beakers are versatile laboratory glassware used for a wide range of purposes, including mixing, heating, and storing solutions. They are typically made of borosilicate glass, which is resistant to heat, chemicals, and scratches. Beakers come in various sizes to accommodate different volumes of liquids.

4. Burette:

A burette is a graduated glass tube with a stopcock at the bottom, used to dispense precise volumes of liquids during titrations. Titrations are analytical techniques that involve adding a known concentration of a reagent to a solution until a specific reaction endpoint is reached. Burettes ensure accurate delivery of the titrant solution.

5. Vials:

Vials are small glass or plastic containers used to store, transport, and sample liquids or solids. They come in various sizes and shapes, depending on the specific application. Vials are often used in conjunction with laboratory closures, such as caps or septa, to prevent contamination and leakage.

6. Refractometer:

A refractometer is an optical instrument used to measure the refractive index of a substance, which is a property related to how light bends as it passes through the material. In natural gas analysis, refractometers are employed to determine the composition and purity of gas samples.

7***. PH Meter:***

A pH meter is an electronic device used to measure the pH of a solution, which indicates its acidity or alkalinity. In natural gas analysis, pH meters are used to assess the presence of acidic or alkaline components that could affect the corrosion of pipelines or equipment.

8. Water Bath:

A water bath is a temperature-controlled container filled with water, used to maintain a constant temperature for samples or experiments. In natural gas analysis, water baths are employed to control the temperature during specific analytical procedures.

9. Viscometer:

A viscometer is a laboratory instrument used to measure the viscosity of a fluid, which is its resistance to flow. In natural gas analysis, viscometers are employed to assess the flow properties of natural gas, which is crucial for pipeline transportation and gas turbine operation.

10. Stopwatch:

A stopwatch is a timekeeping device used to measure elapsed time with high precision. In natural gas analysis, stopwatches are used to accurately time experimental procedures or record reaction rates.

11. Thermometer:

A thermometer is an instrument used to measure temperature. In natural gas analysis, thermometers are employed to monitor the temperature of samples, reagents, and equipment during various analytical procedures.

12. Standardized Bomb:

A standardized bomb is a specialized calorimeter used to determine the calorific value of a fuel, such as natural gas. It involves combusting a precisely measured sample of the fuel in a confined oxygen-filled chamber and measuring the heat released during the combustion process.

13. Karl Fischer Titration:

Karl Fischer titration is a chemical analysis technique used to determine the moisture content in a substance, including natural gas. It involves reacting the sample with a Karl Fischer reagent, which generates an electrical current in proportion to the water content.

14. Chromatograph:

A chromatograph is an analytical instrument used to separate and identify components in a mixture, such as natural gas. It works by passing the gas sample through a stationary phase, while different components travel at different speeds based on their interactions with the stationary phase. The separated components are then detected and quantified.

These main equipment and tools, along with specialized techniques and expertise, form the foundation for comprehensive natural gas analysis. The accurate and reliable assessment of natural gas properties is essential for ensuring its safe and efficient utilization in various industrial and domestic applications. (The important pictures of the tools in annexes)

III.5 Conclusion

From this chapter, we can infer the significance of Sonatrach as a national oil and gas company in Algeria, being one of the largest companies in Africa and playing a vital role in the national economic development. Additionally, the chapter highlights the importance of the Hassi R'mel region as the gateway to the desert and its significant contribution to the Algerian hydrocarbon sector. Moreover, the chapter reveals complex operations involving natural gas processing at the MPP2 station and the role of the laboratory in ensuring the quality and safety

III.6 Refences

[1] website: Gemini, 2024, general description about sonatrrach, https://gemini.google.com/app/422f051d429b492f

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Practical part

Application of the analysis tools selected on the industrial site

In this part we start our evaluation and the assessment of chemical risk using two different tools:

1- First, we will apply the EVRP qualitative method to identify and evaluate all the risks related to work in the laboratory
2- Secondly, we will use SEIRICH software
3- Finally, we will make interpretations of the results obtained and give recommendations..

IV.1 EvRP method:

In this qualitative method applied for chemical risk during the technician of laboratory doing his work, the tables below shows the results.

5.1.1 Chemical risk during water analysis

Fields of application	Perimeter or subsets	workplace	Temporary number	Permanent number	Source of danger	Hazard scenarios	Existing barriers	Impact	ED	EF	EL	SL	P	Victim
Lab MPP2	Water analysis	Lab agent	04	15	The composition of water	Agitation with a magnetic stirrer splash drops of an acidic base onto the worker	EPI, FDS, shower	Irritation	ED 1	EF 1	L	SL 1	P5	Worker
					$AgNO_3$	Handling in volumetric titration	EPI, FDS	chronic illness	ED 2	EF 3	I	SL 4	P1	Worker
					K_2CrO_4	Exposure to vapors during handling	PPE, SDS, Shower	Carcinogenic, Irritation of the three pathways	ED 2	EF 3	I	SL 4	P1	Worker
					NaoH	Direct handling of the product in volumetric titration	PPE, SDS, Shower	Eye and skin irritation	ED 2	EF 3	I	SL 4	P1	Worker
					EDTA	Direct handling of the product in volumetric titration	PPE, SDS, Shower	Poisoning eye and skin damage	ED 1	EF 3	M	SL 3	P3	Worker
					$C_7H_6O_3$	The agitation with a magnetic stirrer project drops of an acidic base touching the worker either by aspiration.	PPE, SDS, Shower	Poisoning eye and skin damage	ED 2	EF 3	I	SL 4	P1	Worker
					HCl	Direct contact during the analysis	PPE, SDS, Shower	Carcinogenic, Irritation of the three pathways	ED 2	EF 3	I	SL 4	P1	Worker
					$C_{12}H_8N_2$	The vapors emitted during handling	PPE, SDS	Poisoning	ED 2	EF 3	I	SL 4	P1	Worker
					NH_4Cl	The projection of drops, penetration towards the digestive tract	PPE, SDS, Shower	Poisoning	ED 2	EF 3	I	SL 4	P1	Worker

5.1.2 Chemical risk during condensate analysis

Fields of application	Perimeter or subsets	workplace	Temporary Number (stuff)	Permanent number	Source of danger	Hazard scenarios	Existing barriers	Impact	ED	EF	EL	SL	P	victim
Lab MPP2	Condensate analysis	Lab agent	04	15	Temperature	The change in temperature from 0°C to 37.8°C between the bomb and the barometer leads to a change in pressure that can cause burrs to burst.	PPE	Wounds	ED 2	EF1	L	SL 4	P2	Worker
					Electrostatic charge of clothing	The quantity of 500 mL of condensate with a temperature of 45°C leads to evaporation of dissolved gases, which creates an ATEX, and by electrostatic charge of the worker's clothing causes a fire.	PPE, auto Extinguishing system	fire, burns	ED 2	EF 2	M	SL 3	P2	Worker
					Dissolved gases	With handling, the dissolved gases in the condensate can be inhaled by the worker and may cause bodily harm.	PPE	chronic illness	ED 2	EF 1	L	SL 4	P2	Worker
					Discarded sample	After analysis, the discarded sample has direct contact with the worker and can be transported through the skin to the digestive tract, resulting in adverse outcomes.	SDS, PPE	Intoxication	ED 1	EF 3	M	SL 3	P3	Worker
					Manual mixing preparation	The preparation of the "Methanol & Butanol" mixture with the presence of electrostatic charge can lead to the ignition of the mixture.	SDS, PPE, auto Extinguishing system	fire	ED 2	EF 3	I	SL 4	P1	Worker
					Xylene	Contact with this product is direct, which causes health problems.	SDS, PPE	Intoxication	ED 2	EF 3	I	SL 5	P1	Worker

5.1.3 Chemical risk during Glycol analysis

Fields of application	Perimeter or subsets	workplace	Temporary number	Permanent number	Source of danger	Hazard scenarios	Existing barriers	Impact	DE	EF	NE	SL	P	Victim
Lab MPP2	Glycol analysis	Lab agent	04	15	Thermocouple failure	This breakdown causes an increase in temperature on the sample and reacts with chemical reactions, which can lead to emissions of gases that are dangerous to the body.	PPE, extractor	suffocation	ED 1	EF 1	L	SL 4	P2	Worker
						The temperature increase leads to a point of self-ignition.	PPE, auto extinguishing system	fire, burns	ED 1	EF 1	**L**	SL 4	P2	worker
					Acidity de glycol	As the glycol is stirred, drops of glycol come into contact with the worker's body	PPE, SDS, shower	Burns in skin	ED 2	EF 2	**M**	SL 3	P3	Worker
					Electrode of PH metre	The electrochemical reaction leads to the emission of unwanted gases	PPE	chronic illness	ED 1	EF 2	M	SL 3	P3	Worker

5.1.4 Chemical risk while using equipment for analysis

Fields of application	Perimeter or subsets	workplace	Temporary number	Permanent number	Source of danger	Hazard scenarios	Existing barriers	Impact	ED	FE	NE	SL	P	Victim
Lab MPP2	The devices	Lab agent	04	15	CPG	Thermocouple failure causes an increase in sample temperature and reacts with chemical reactions that may result in the emission of unwanted gases harmful to the body	PPE, Hood	Asphyxiation	ED 1	EF 3	M	SL 4	P2	Worker
						Increasing temperature leads to a point of auto-ignition	PPE, auto Extingui -shing System	Fire, Burns	ED 1	EF 3	M	SL 3	P3	Worker
						Inert gas leak: H2 or N2	PPE, Air extractor	Asphyxiation	ED 1	EF 3	M	SL 4	P2	Worker
					Karl Fischer	The electrodes and the sample may react to a reaction emitted from the vapors.	PPE, Hood	Chronic illness	ED 1	EF 3	M	SL 4	P2	Worker
					Flash point tester	Thermocouple failure increases the temperature, leading to auto-ignition of the liquid	PPE, auto Extingui -shing System	Fire	ED 1	EF 3	M	SL 3	P3	Worker
					PH meter	Chemical reactions occur when the analysis emits gas vapors	PPE	Asphyxions	ED 1	EF 2	M	SL 4	P2	Worker
					Extraction hood	Malfunction of suction leads to the accumulation of gases	PPE	Chronic illness	ED 1	EF 3	M	SL 4	P2	Worker
					Storage chest	Poor storage of products leads to problems	Air extractor	Chronic illness	ED 1	EF 2	M	SL 4	P2	Worker
						The leakage of one product degrades the other bottles storing the products and causes reactions	PPE, auto Extingui -shing System	Explosion	ED 1	EF 2	M	SL 5	P1	Worker

5.1.5 Chemical risk during Oil, Gas and LPG analysis

Fields of application	Perimeter or subsets	workplace	Temporary number	Permanent number	Source of danger	Hazard scenarios	Existing barriers	Impact	ED	EF	NE	SL	P	Victim
Lab MPP2	Oil analysis	Lab agent	04	15	Thermocouple failure	This failure causes an increase in temperature in the sample and reacts with chemical reactions that may cause emissions of gases dangerous to the body.	PPE, Hood	Asphyxiation	ED 1	EF 3	M	SL 3	P3	Worker
						The temperature increase leads to a point of auto-ignition.	PPE, SDS, shower	Fire, Burns	ED 2	EF 3	I	SL 3	P1	Worker
	Gas and LPG analysis	Lab agent	04	15	Leak	The leak caused by poor contact between the sampling bottle and the device	PPE	ATEX	ED 1	EF 2	M	SL 2	P4	Worker
					Overpressure	The bottle can burst due to overpressure.	PPE	Injuries	ED 2	EF 3	I	SL 3	P3	Worker
					Gas mixture	Chemical reactions occur when the analysis emits gas vapors	PPE, Hood	Asphyxiation	ED 2	EF 3	I	SL 3	P3	Worker
					GAZ	It creates an ATEX zone.	PPE, auto Extinguis-hing system	fire	ED 2	EF 3	I	SL 3	P3	Worker
					LPG	A leak of LPG causes expansion. The expansion temperature is -160°C.	PPE, auto Extingui-shing system	Frostbite	ED 2	EF 3	I	SL 3	P3	Worker

5.1.6 Estimation of exposure concentration:

- **Inhalation method:**

Time-Weighted Average (TWA) Concentration:

$$C\ TWA = (C1 * t1 + C2 * t2 + ... + Cn * tn) / (t1 + t2 + ... + tn)$$

Where:

- C1, C2, ..., CN : Dust Concentrations of K2CrO4 Measured at Different Times
- T1, t2, ..., Tn : Corresponding Exposure Durations

And the

- Concentration taken from the inventory of laboratory
- the time during analysis

C1= 0.1 $Mol.L^{-1}$

T= 20 minutes

So

$$C\ TWA= (0.1*20) /20=\mathbf{0.1}\ mg/\ m^3$$

- **Calculation of the worker's daily exposure:**
- **Inhalation exposure:**

Daily Inhaled Dose (DI): DI = C TWA * V * t

Where:

- V: Volume of air breathed per minute (approximately1.2 m^3/h for a resting adult)
- T: Duration of daily exposure

$$DI= 0.1 * 1.2 * 20 = \mathbf{2.4}\ mg/\ m^3$$

- **Dermal exposure:**

Daily Dose Absorbed by the Skin (DA): DA = Kp * A * C * t

Where:

- Kp: Coefficient of skin permeability (variable value depending on the substance and body area)
- A: Exposed skin surface (cm^2), average is 20 cm^2
- C: Concentration of K2CrO4 on the skin (mg/cm^2)
- t: Duration of dermal exposure

$$DA = 0,\ 0001 * 20 * 0.1 * 20 = \mathbf{0.004}\ mg/\ cm^2$$

Interpretation of EVRP

During the risk assessment at the MPP 2 laboratory, we observed that the sources of danger are extensive. For this reason, we have chosen hazard scenarios related to the chemicals handled by the worker and their consequences on his health. It is noted that the majority of the analyses require chemicals with no possibility of substitution by less hazardous products, meaning that the chemical risk is always present and the exposure to risk is high. These analyses require highly hazardous products such as xylene, potassium chromate, silver nitrate, sodium hydroxide, hydrogen chloride, etc.

Our remarks on prevention and protection measures within the laboratory are as follows:

- The PPE does not conform to the area of use.
- The air extractors are not sufficient considering the nature and quantities of the products used.
- The laboratory procedure and routine do not include break periods (workers are always in the laboratory), which increases the risk of exposure to chemicals.
- The floor becomes slippery in case of liquid spills.
- The laboratory space is small and crowded.
- The equipment is in a degraded state.
- The storage matrix is not respected.

As for PPE, they include:

- Simple gloves
- Degraded eye protection
- Lab coat
- Safety shoes
- Pipette

And for EPC (Collective Protective Equipment):

- Labeling of bottles
- Shower
- Safety data sheets
- Smoke detector
- Automatic extinguishing system
- CO2 extinguisher
- Warning signs
- Air extractors

The exposure modes of these products can be generated by:

- Manual handling of products putting the worker in direct contact with chemicals.
- Secondary reactions emitting gases.

- Irregularities in workers' clothing creating sparks.
- Failure in working tools causing reactions that emit gases.
- Reagents and products added during the analysis.
- The physical parameters of the products (temperature, pressure, volume, etc.) play a role in the consequences.
- Human error in the analysis.

As for the consequences of this risk affecting the worker's health, they include:

- Chronic diseases
- Burns
- Skin, digestive, and respiratory tract irritation
- CMR
- Disorders affecting the nervous system
- Fatality

IV.2 SEIRICH

In the second stage of our survey, we use SEIRICH software to assess the risks within the laboratory. This analysis is organized into six steps, as shown in the following diagram:

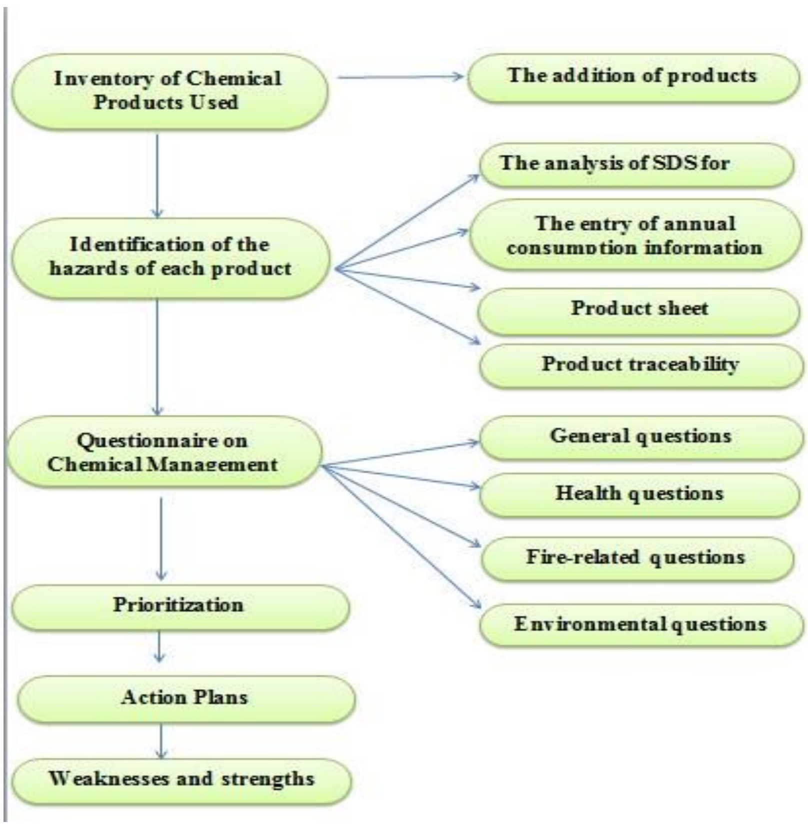

figure 0.1 SEIRICH Analysis Steps.

Step 1: Inventory of Chemical Products Used

The first step involves gathering information about the chemicals used, including their quantities and any available safety records. the following table presents a list of chemicals consumed by the laboratory.

products	*Quantity*
AQUAMICRON-A	/
SILVER NITRATE	5.1g
AQUA MICRON C	/
NITRIC ACID	170 ml
HYDROCHLORIDE ACID	20ml
SULFURIC ACID	/
XYLENE	240ml
BUTANOL-1	300ml
AMMONIUM CHLORIDE	/
Ammonia	/
ACETO-ACETIC BUFFER	/
AMMONIA BUFFER	10ml
O, phenantroline, HCL	/
HYDROXYLAMINE, HCL	/
POTASSIUM CHROMATE	/
E, D, T, A, 2NA	/
ERICHROME BLACK T	5ml
SODIUM HYDROXIDE	/
SULFOSALYCILIC ACID	130sachets
METHANOL	185ml
STANDARD SOLUTION PH=4	/
STANDARD SOLUTION PH=7	/
IRON CITRATE BUFFER	130sachets
SODIUM PERIODATE	134sachets
Man Ver HARDNESS Indicator	8sachets
TITRAVER STANDARD	6nozzles (52ml)
Tampon Hardness 1	16ml
SODIUM EDTA 0.0800 M	0.5nozzles (6.5ml)
TITRAVER STANDARD	0.25 nozzles (3.25ml)

The chemicals are added regardless of their type: emitted chemicals agents or CLP labeled products, as shown below:

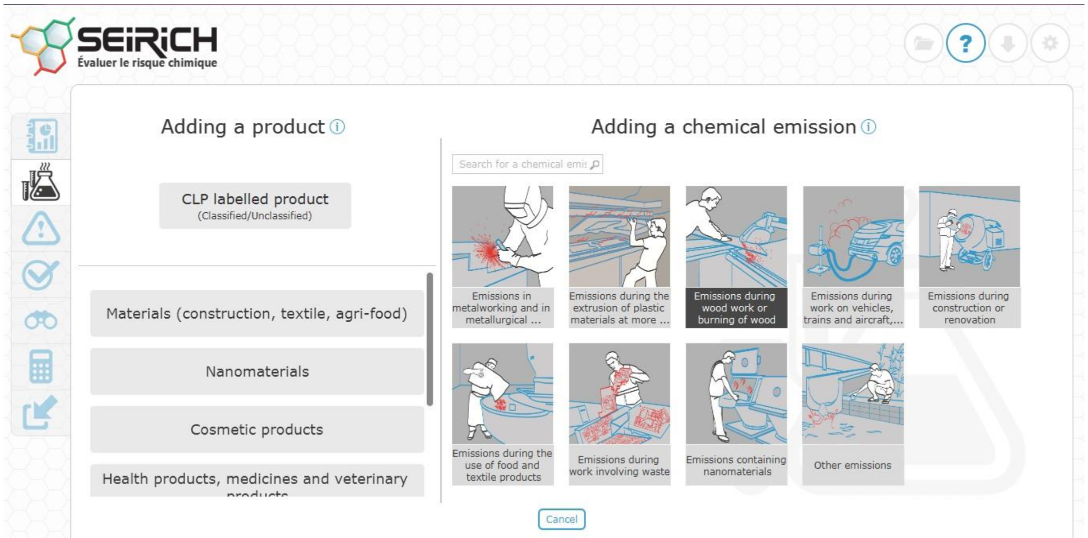

figure 0.2 Screen for adding products and emissions.

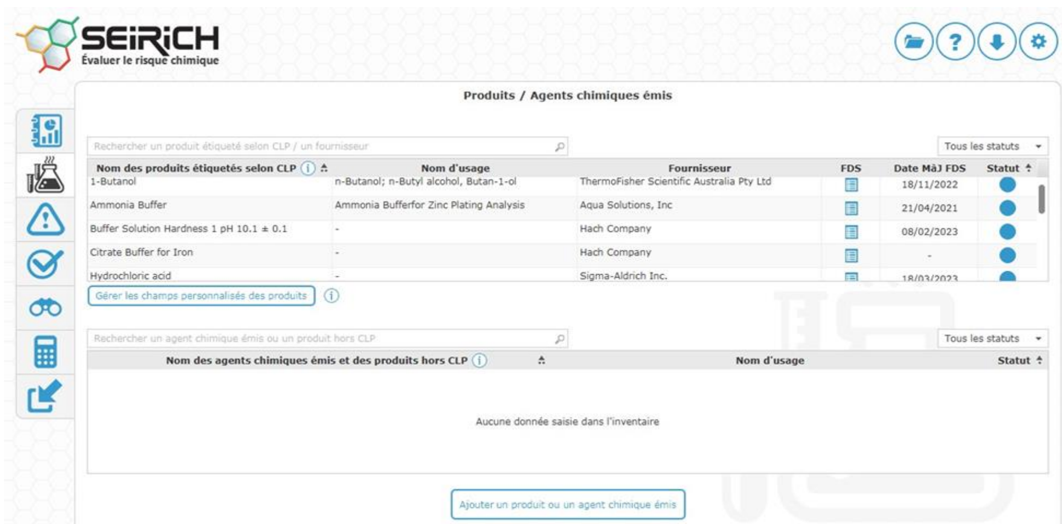

figure IV.3 Screen displaying the list of added products.

The identification of the labeled product is done by entering its identification information such as:

• Name.

• Common name.

• UFI (Unique Formula Identifier code of the product which is the unique identifier of the product's formulation).

• Supplier's name.

• Supplier's contact information.

• Usage class.

• Availability of an SDS and its update date.

• Photo.

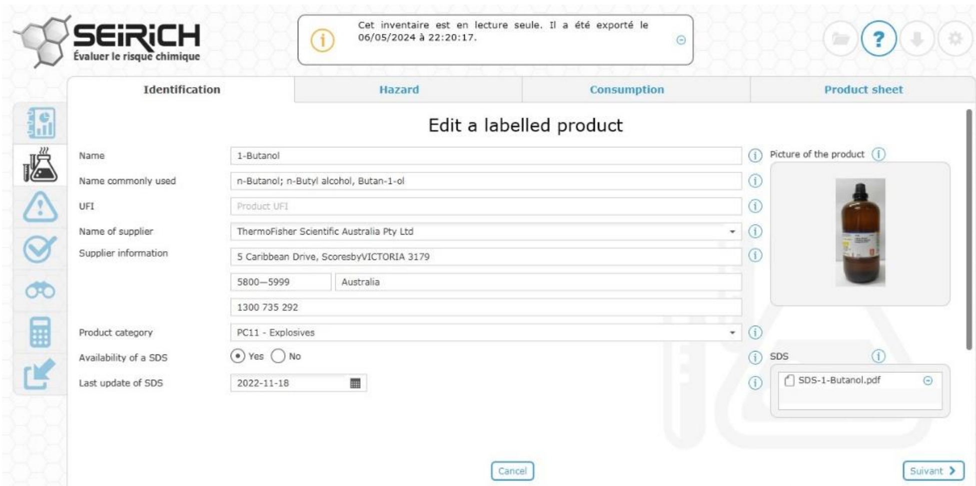

figure 0.4 Labeled product identification information entry screen.

Step 2: Identification of the hazards of each product

At this stage, we assess the risks of each chemical substance, taking into account their annual consumption quantities. We also analyse their safety data sheets (SDS) to a better understanding of potential hazards.

Here is an example of the quantity and SDS analysis of butanol.

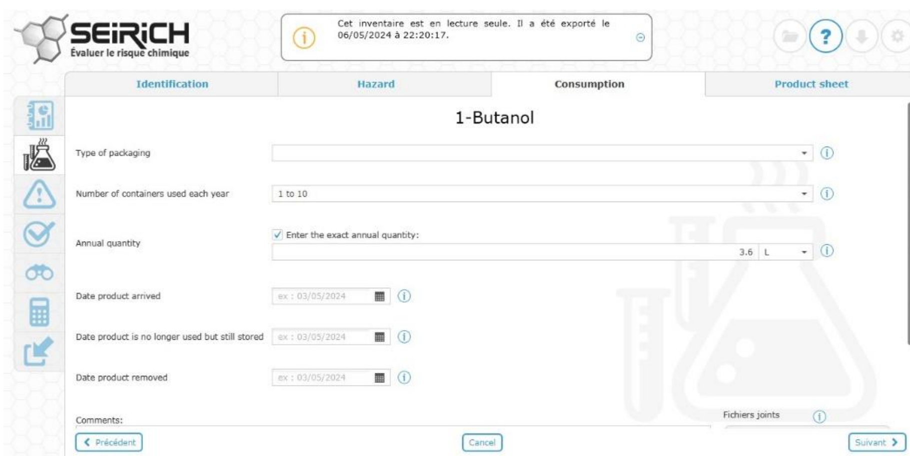

figure IV.5 Annual consumption information entry screen.

Pratical part

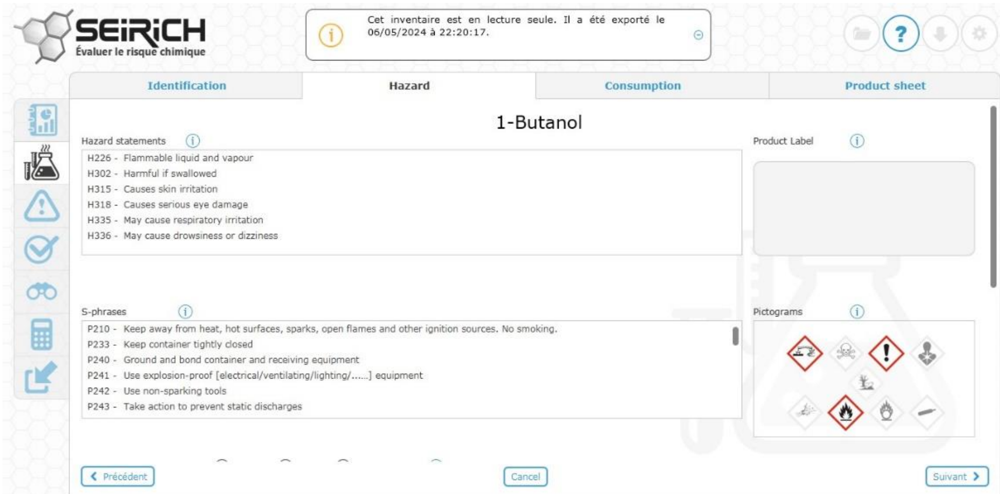

figure IV.6 Butanol SDS Analysis.

The potential risks are presented in the form of a product sheet summarizing the previous information, where the potential risks are presented with:

• Logos for Health, Fire, and Environment risks

figure IV.7 logos

• And colors as follows:

Table IV.3 shows the results of potential risks related to the use of Butanol.

Color	Priority
Green	Moderate
Yellow	High
Red	Very high

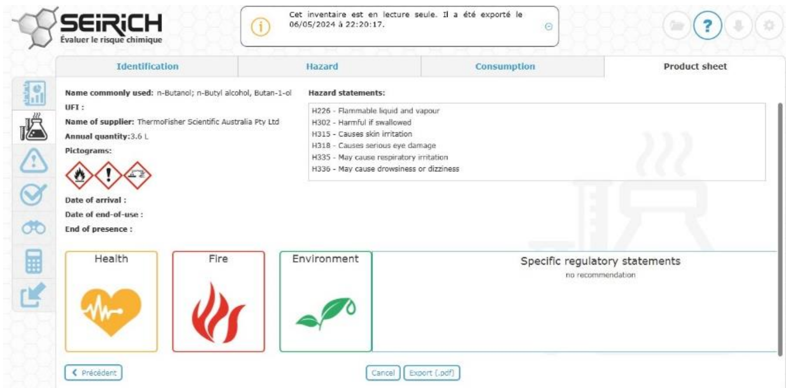

figure IV.8 Butanol Product Sheet.

The previous steps enable the emergence of traceability and documentation of information on each chemical product, thus ensuring the tracking of its management and use.

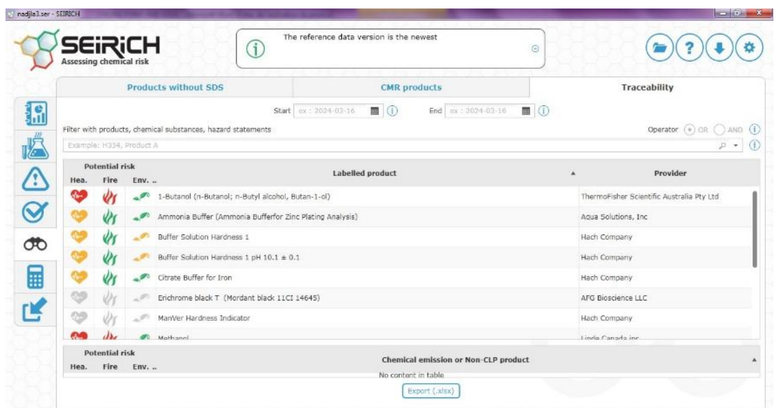

figure IV.09 Traceability of labeled products

Step 3: Questionnaire on Chemical Management

The questionnaire was presented to the stuff of the laboratory to have reliable assessment results.

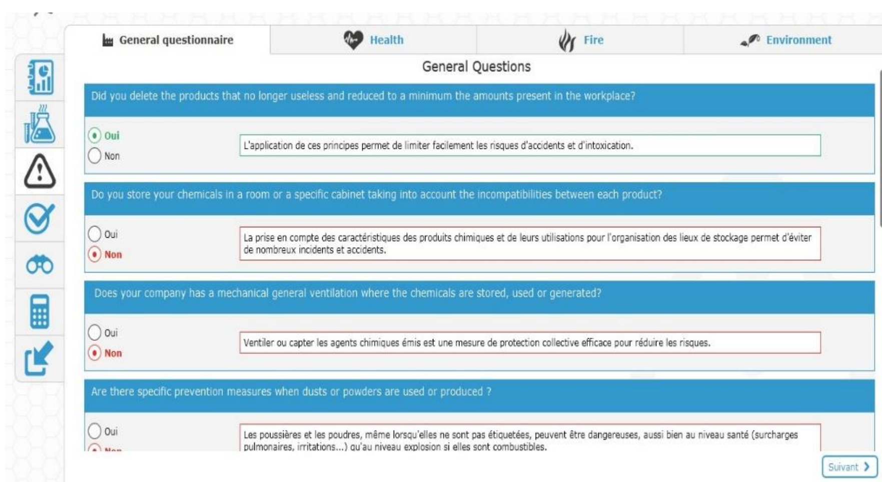

figure IV. 10 General questions.

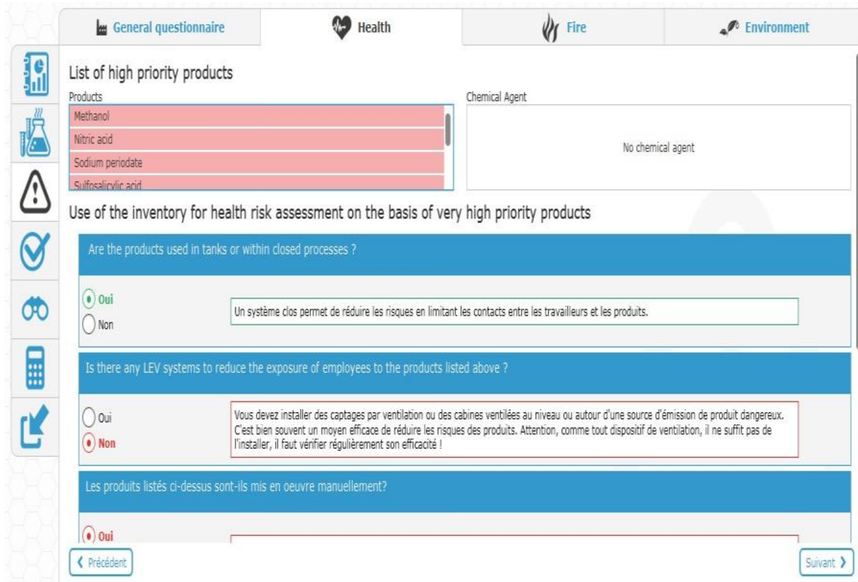

figure 0.11 Health-related questions.

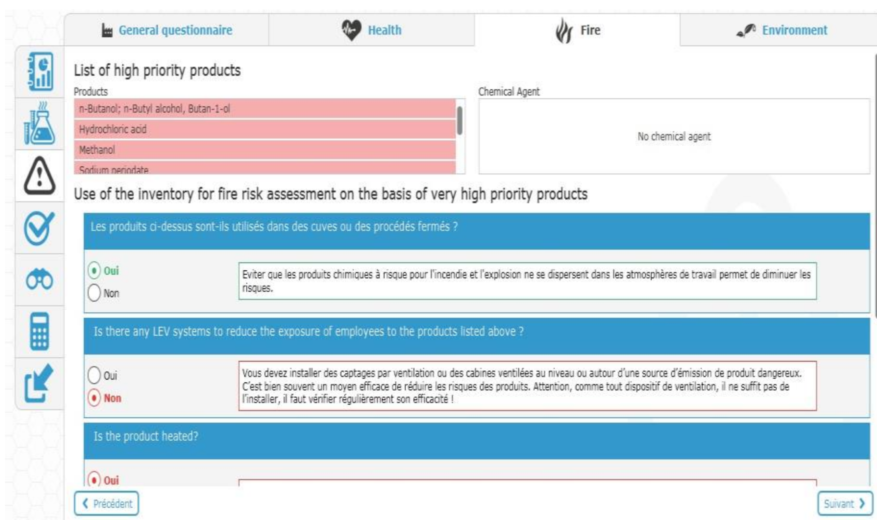

figure IV. 12 Fire-related questions.

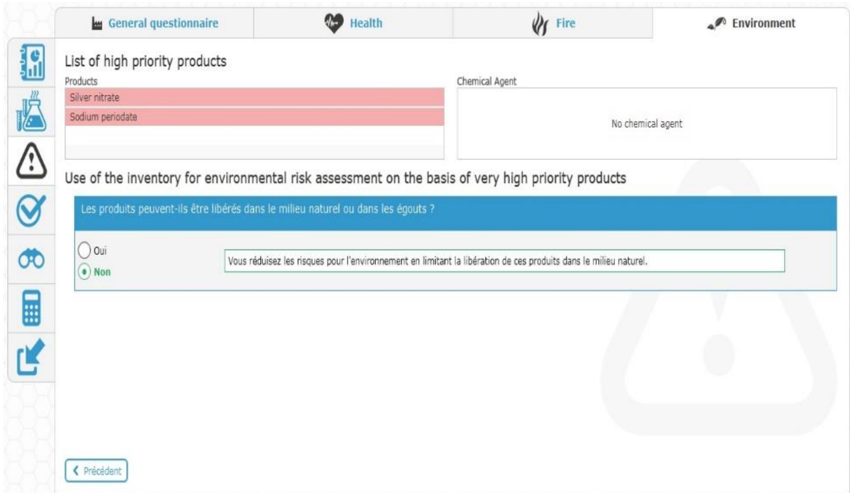

figure 0.13 Environmental-related questions.

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Step 4: Prioritization

At this stage, products are classified according to their potential risk by type of risk (health, fire/explosion, and environment).

The determination of potential risk involves considering both the degree of hazard of the product (in accordance with the hazard statements) and its annual quantity.

Various products and agents can be coded with different colors:

• Red: indicates very high priority in dealing with the product or agent.

• Yellow: signals high priority in dealing with the product or agent.

• Green: indicates moderate priority in dealing with the product or agent.

• Gray: means that the product or agent could not be classified due to missing data (hazard statements or annual quantity).

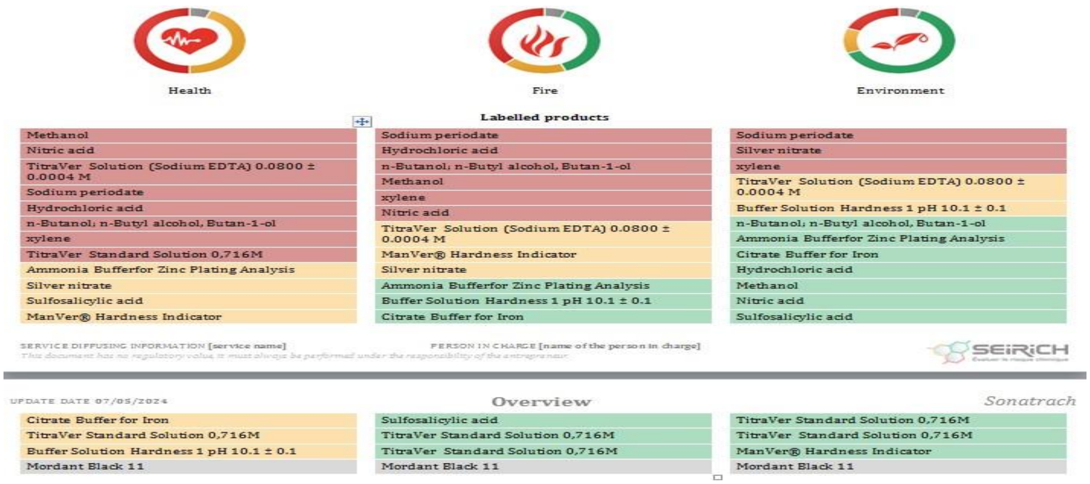

figure 0.14 Prioritization of labeled products.

Based on prioritizing, we noticed that most substances pose a high to moderate health risk, necessitating immediate and effective measures. In contrast, regarding the environment, the majority of substances pose a low risk, requiring risk control measures and monitoring. However, substances such as (sodium periodate, Silver nitrate and xylene) require emergency procedures. As for fire and explosion hazards, substances vary from high to moderate to low risk.

SEIRICH helps clarify the differences in the impact of each substance, where a substance may be hazardous to health but less hazardous to the environment (as methanol, nitric acid), and vice versa. This assists in identifying risks more accurately and taking necessary measures based on the effects of each substance in different areas.

Step 5: Definition of Action Plans

The action plan lists all ongoing and completed actions related to the inventory. For each category of chemical products or identified risks, we develop a detailed action plan describing the measures to be taken to mitigate risks and improve management.

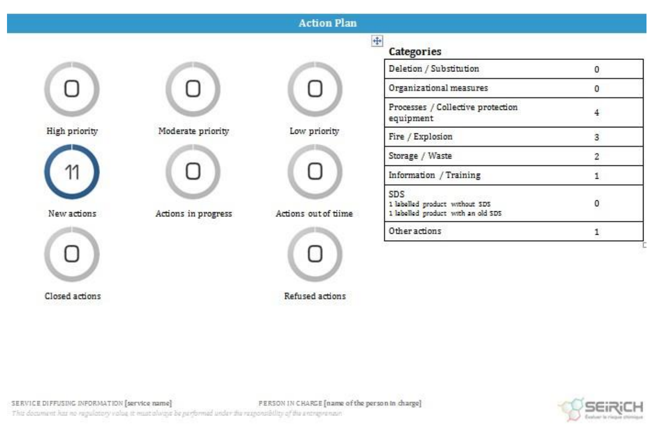

figure 0.15 The Action Plan

Step 6: Interpretation of Results - Strengths and Weaknesses

Strengths and weaknesses arise from the prioritization of inventory products and responses to the questionnaires in the "Simplified Residual Risk Assessment Questionnaires" menu. This contributes to chemical management as well as areas requiring improvements.

figure 0.16 Strengths and Weaknesses of Products.

The "export" option in SEIRICH allows us to download the risk assessment results in electronic format. This feature is highly valuable for archiving data, sharing it with stakeholders, or integrating it into other occupational safety and health management systems.

Interpretation of the results obtained from SEIRICH:

Based on prioritization, we notice that the majority of substances pose a high (50%) to moderate (50%) health risk, necessitating immediate and effective measures. However, concerning the environment, the majority of substances pose a low risk (67%), requiring risk control measures and ongoing monitoring. Additionally, 33% of substances pose moderate to high risks, requiring emergency procedures, such as Silver nitrate, xylene and Sodium periodate.

Regarding fire and explosion hazards, substances exhibit varying levels of risk, with 60% being moderate to high risk and 40% being low risk.

We notably distinguish two substances, xylene and sodium periodate, which significantly impact all three aspects (health, environment, fire/explosion). Additionally, substances such as butanol, methanol, nitric acid and hydrochloric acid pose high risks to health and fire hazards.

SEIRICH plays a crucial role in elucidating the differential impacts of each substance. It provides us with insights into how a substance may be hazardous to health but less hazardous to the environment, as seen with substances like methanol and nitric acid. Conversely, certain substances may pose significant environmental hazards despite posing lower risks to human health. This nuanced understanding enables the identification of risks more accurately, facilitating the implementation of tailored measures based on the specific effects of each substance across different domains. In essence, SEIRICH helps stakeholders make informed decisions by providing comprehensive insights into the multifaceted impacts of various substances.

Recommendation

After the assessment of the chemical risk, we can give some recommendation about the potential risks in the laboratory related of the use of these chamicals:

Pratical part

1- Training the workers

Before working with chemicals:

- **Be informed:** Always know the properties of the chemicals you'll be handling. Review the **Safety Data Sheet** or equivalent for each chemical before starting any experiment. The SDS details potential hazards, safe handling procedures, first aid measures, and disposal information.
- **Plan thework:** Before starting, carefully plan the worker experiment and identify any potential hazards. Consider if there are safer alternative chemicals he could use.
- **Personal Protective Equipment (PPE):** Using appropriate PPE like gloves, goggles, lab coats, and respirators as recommended in the SDS.

While working in the lab:

- **Work in a fume hood:** Using a fume hood when working with volatile or toxic chemicals. A fume hood helps remove hazardous fumes from breathing zone.
- **Never smell or taste chemicals:** Relying on the SDS for information about a chemical's odor, and never taste a chemical to identify it.
- **No eating, drinking, or applying cosmetics:** These activities can increase the risk of chemical ingestion.
- **Minimize skin contact:** Wearing appropriate gloves and avoid unnecessary contact with chemicals.
- **Keep work areas clean:** Clean up spills immediately and dispose of chemicals according to the SDS guidelines.
- **Label everything:** Clearly label all containers with the chemical name and any relevant hazard information.

Additional tips:

- **Work alone only when approved:** If possible, avoid working with hazardous chemicals alone.
- **Report spills and accidents:** Report any spills or accidents immediately to the supervisor and follow established procedures.
- **Be aware of emergency procedures:** Know the location of safety equipment, fire exits, and emergency eyewash stations.
- **Take safety training:** Complete any required laboratory safety training courses.

By following these recommendations, the worker can significantly reduce the risk of chemical exposure and injury in the laboratory.

Specific Chemical Hazards:

- ** flammables:** Be aware of flash points and ignition sources. Store flammables in approved safety cabinets.

- ** corrosives:** These can cause severe burns. Wear appropriate gloves, goggles, and face shields when handling them.
- ** toxins:** Some chemicals can be harmful through inhalation, ingestion, or skin absorption. Use a fume hood and be especially careful to avoid spills.
- ** carcinogens:** These chemicals can cause cancer. Minimize exposure and handle them with extra care.
- ** allergens:** Certain chemicals can trigger allergic reactions. Be aware of your individual sensitivities.

Safe Chemical Handling Techniques:

- **Never use unlabeled or poorly labeled containers.**
- **Work with the smallest amount of chemicals possible.**
- **Transfer chemicals in a well-ventilated area.**
- **Never return unused chemicals to their original container.** Dispose of them properly according to the SDS.
- **Wash your hands thoroughly after working with chemicals.**
- **Maintain good personal hygiene in the lab. Don't wear lab coats outside the lab.**

Laboratory Safety Resources:

- **The laboratory supervisor:** They should be first point of contact for any questions or concerns about chemical safety.
- **Safety Data Sheets (SDS):** These provide vital information about specific chemicals.
- **Laboratory safety manuals:** Many institutions have manuals outlining specific safety procedures for their facilities.
- **National safety organizations:** Organizations like the American Chemical Society (ACS) https://www.acs.org/ offer safety resources and training materials.

Chemical Risk Assessment:

- **Before starting any experiment, conduct a risk assessment.** Identify the hazards of the chemicals you'll be using, evaluate the potential for exposure, and consider control measures to minimize risk.

By following these additional tips and utilizing available resources, you can gain a deeper understanding of chemical risks and create a safer work environment in the laboratory.

General Conclusion

General conclusion

After having concrete results, we can say that the laboratory has a crucial place in the industry otherwise a big attention should be given to the chemical risk to which the workers are exposed doing their work related to the manipulation of dangerous chemical products.

The combination of the two selected methods (the first: EVRP qualitative method and the other a software method) helped us find concrete results about the chemical risk in industrial laboratories.

According to the results of SEIRICH, we noticed that the majority of substances used in the laboratory pose high to moderate health risk and low to moderate environmental impacts.

We also found that the majority of the substances used pose high to moderate fire and explosion hazards.

In the other hand, the results obtained from the EVRP applied helped us deduce that

- A lot of initiating events can occur by a dysfunction of an equipment of the laboratory (like leak of gas or liquid, disturbance in physical parameters while analysis)
- The substances used have serious final health issues such as:Chronic diseases Burns, Skin, digestive, and respiratory tract irritation, CMR, Disorders affecting the nervous system, Fatality for human

After interpreting and analyzing all the results of the two methods we found that some points should ameliorated for both the laboratory and the workers such as:

Training of the workers
A periodic inspection for tools and equipment
Timing of exposure
Choosing Personal Protective Equipment (PPE) & Collective Protective Equipment (CPE)
The standards and norms of working
Respecting the standards
Policy of storage
The recent version of SDS

At last, the most important thing is that the risk assessment should be repeated regularly, as it is based on expert judgment and the software must be updated to give precise results.

Annex