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Theme

Task Risk Assessment method study case: Desulfurization and Demercurization Unit at JV GAS IN AMENAS

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I also wish to thank all my teachers, as well as the administrative staff of my department, and everyone who contributed directly or indirectly to the completion of this work.

Dedication

I dedicate this work to:

My mother, source of tenderness and love, for her support throughout my studies.

My father, who has always supported me and has done everything possible to help me.

My brother and sister, whom I love very much.

My extended family.

My dear friends and colleagues.

Everyone who has contributed, directly or indirectly, to the completion of this work.

May God grant them health and prosperity.

MALAOUI Amdjed Seyfeddine

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List of Terms and Abbreviations

OECD: Organization for Economic Co-operation and Development.

HSE: health, safety and environment.

OHS: Occupational health and safety.

S&ST: Safety and Security at Work.

IA: IN AMENAS

ISO: International Organization for Standardization.

OHSAS: Occupational Health and Safety Assessment Series.

OSHA: Occupational Safety and Health Administration.

HITRA: Hazard Identification and Task Risk Assessment.

PTW: Permit To Work.

CPF: Central Processing Facility.

BP: British Petroleum.

Eni: Ente Nazionale Idrocarburi.

JV: Joint-venture.

Ops: Operations.

HSE MS: HSE Management System.

LNG: Liquefied natural gas.

LPG: Liquefied Petroleum Gas.

COW: Control of work.

COWS: Control Of Work System.

WMS: Work Management System.

ALARP: As Low As Reasonably Practicable.

IOGP: International Association of Oil and Gas Producers.

SWP: Safe Working Practice.

TRA: Task Risk Assessment.

ORA: Operations Risk Assessment.

ERA: Environmental Risk Assessment.

IGC: intake gas compression.

IACP: IN AMENAS Camp.

H_2S: Hydrogen sulphide.

Hg: Mercury.

CO_2: Carbon Dioxide.

H_2O: Water.

N_2: Nitrogen.

VRU: Vapour Recovery Unit.

URPG: unite de récupération de la phase gazeuse.

PSV: Pressure Security Valve.

HP: High Pressure.

LP: Low Pressure.

HC: Hydrocarbons.

HVAC: Heating Ventilation and Air Conditioning.

ESDV: Emergency Shutdown Valve.

C: Compressor.

V: Vessel.

E: Exchanger.

H: Heater.

PI: Pressure Indicator**.**

MP: Medium Pressure.

Ppm: Parts per million.

Sm3: Standard cubic meter.

TL: Team Leader.

SIMOPS: simultaneous operations.

PPE: Personal Protective Equipment.

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General Introduction

In the realm of industrial operations, particularly within the oil and gas sector, ensuring safety and mitigating risks are paramount concerns. Compliance with international standards like ISO 45001 and OHSAS 18001, as well as regulations from OSHA and EU-OSHA, is essential for creating a safe working environment. These standards mandate systematic risk assessment procedures and the adoption of the hierarchy of controls to manage workplace hazards effectively. Companies, especially in the petrochemical industry, are motivated to implement these regulations to reduce risks and ensure safety. Recognizing the high-risk nature of the petrochemical sector, which is strategic for Algeria, the Sonatrach oil group established a central Health, Safety, and Environment (HSE) department in 2002 to implement a new HSE management strategy aimed at preventing work-related accidents and illnesses. This approach, now termed 'health and safety at work,' replaces the older concept of 'hygiene, safety, and working conditions.

Given the vast number and variety of tasks carried out in the workplace, there is a correspondingly wide range of risks involved. For practical reasons, the extent of hazard and risk assessment in any particular case must be balanced against the type of risk, so that the greatest effort is devoted to the most severe risks. The hierarchy of risk management measures aims to reduce risks through the following steps: elimination, substitution, control, and mitigation. When conducting risk assessments, this hierarchy should be followed, giving the highest priority to the elimination of the risk or task first.

While the IA Ops Permit to Work (PTW) System effectively manages risks for non-routine tasks, routine operations like production monitoring and housekeeping rely on general risk assessments, training, and competency evaluations. However, for specialized processes like desulphurization and demercurization at the critical In Amenas gas plant, a more comprehensive risk management approach is required due to the complexities of hydrocarbon processing and presence of harmful contaminants. To address this, the Hazard Identification and Task Risk Assessment (TRA) framework has been strategically implemented. TRA enables systematic identification of potential hazards and evaluation of associated risks specific to these industrial processes. By adopting TRA, In Amenas can proactively mitigate risks, prevent incidents, minimize downtime, and safeguard workforce safety while ensuring regulatory compliance and equipment integrity in these crucial operations.

The structure of this thesis is divided into four chapters and organized as follows:

I. Presentation of the Tiguentourine «CPF» Gas Field: This chapter provides an overview of the Tiguentourine gas plant, including its location, significance, and their HSE policy.

II. Comprehensive Process Overview with Focus on Desulphurization and Demercurization Unit: This chapter outlines the entire gas treatment process at the plant, with detailed explanations of the desulphurization and demercurization units.

III. Task Risk Assessment: This chapter discusses the TRA methodology, outlining the method and procedures followed to apply this framework.

IV. Application of Task Risk Assessment, Results and Discussions: This chapter presents the application of TRA to the desulphurization and demercurization units. It includes a comprehensive analysis of the identified hazards, the results of the risk assessments, and a discussion of the findings, including their implications for the safety and efficiency of the gas plant's operations.

By exploring the application of TRA in a real-world industrial context, this thesis aims to provide a detailed examination of safety protocols and risk management strategies within the oil and gas sector. The insights gained from this research are intended to enhance the safety and operational efficiency at IA, while also serving as a valuable reference for other facilities facing similar challenges. This study underscores the importance of systematic risk assessment methodologies in promoting a safer and more efficient working environment in high-risk industries

Chapter I:

Presentation of the Tiguentourine «CPF» gas field

Introduction:

The operation of In Amenas is an association between the national company Sonatrach, BP Exploration (El Djazair) and Statoil North Africa Gas AS.

The project has been in production since April 2006 and has produced more than 67 million barrels oil equivalent in 2008. Currently, wet gas is extracted from wells in the field of Tiguentourine and is treated at the Central Treatment Facility (CPF) to remove water, the carbon dioxide, hydrogen sulphide, carbon monoxide and mercury so that the hydrocarbons meet commercial export standards. Then the gas is compressed, ready to be exported and the three products are sent to the main Sonatrach transport pipelines near Ohanet from where they are exported to markets Italian and Spanish markets.

The development of IA includes:

- collection systems, pipelines and associated facilities
- the IACPF,
- and of export facilities.

The contracted area of IA, as illustrated in Figure I-1, consists of the following four fields including proven hydrocarbon reservoirs:

- Tiguentourine (~ 2,581 km²);
- Hassi Farida (~ 243 km²);
- Ouan Taredert (~ 149 km²); and
- Hassi Ouan Abecheu (~ 121 km²)

Since September 2022, Eni's acquisition of BP's business in Algeria, particularly in the gas fields near In Amenas, has marked a major transition in the country's energy sector. As the main operator of the Tiguentourine gas field, Eni brings its expertise, technology and commitment to operational excellence to drive growth and sustainability in the region, redefining the Algerian energy landscape. See Figure I-1

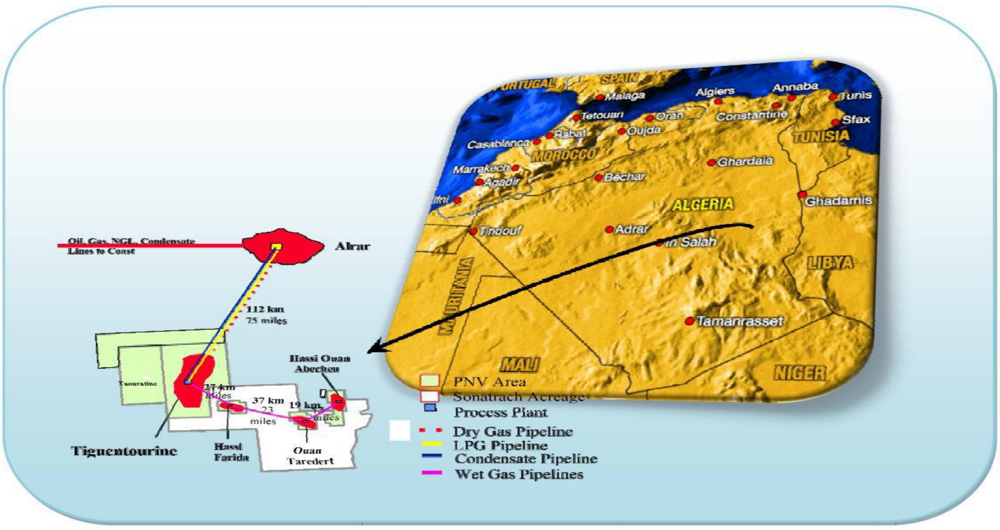


Figure I-1: Location of In Amenas field

I.1. Meteorological data:

The facilities and equipment of the In-Amenas Gas project are designed for the following environmental conditions:

Table I-1: Site meteorological data

Factors	Conditions
Temperature (max/min)	45°C / -5°
Relative Humidity (max/min)	98% / 30%
Average Annual Rainfall	110 mm
Wind Speed	50 m/s at a height of 10 m above ground level.
Prevailing winds	North-west
Elevation	600 meters above mean sea level
Ground temperature (Max/Min)	25°C / 15°C

I.2. The primary objectives of IA project are as follows:

I.2.1. Exploration and Production:

The JV focuses on exploration activities to identify and develop new gas reserves within the IA region. This involves the deployment of advanced technologies and techniques to optimize the production process and ensure efficient recovery of natural gas resources.

I.2.2. Field Development:

The partners collaborate to design and implement field development plans, including the construction and operation of necessary infrastructure such as production facilities, pipelines, and transportation systems. These initiatives aim to enhance the capacity for gas production, processing and export.

I.2.3. Operations and Maintenance:

The JV is responsible for the day-to-day operations and maintenance of the IA gas project. This includes ensuring safe and reliable operations, adhering to environmental and safety standards, and maximizing production efficiency.

I.2.4. International Gas Supply:

The project plays a crucial role in meeting both domestic and international gas supply requirements. The produced natural gas is processed, treated, and transported via pipelines, contributing to global energy security and diversification.

I.2.5. Technology and Innovation:

The JV places emphasis on leveraging advanced technologies and innovative practices to optimize production and reduce environmental impacts. This includes employing advanced reservoir management techniques, utilizing automation, and implementing sustainable practices throughout the project lifecycle.

The partnership between Sonatrach, Eni and Equinor brings together their extensive experience, technical capabilities and financial resources. It combines the strengths and expertise of each company to successfully develop and operate the IA gas project, creating value for all stakeholders involved while contributing to the energy needs of Algeria and the global gas market.

In the domain of natural gas treatment and utilization, effective coordination and collaboration are essential. The company's organizational structure showcases the interdependence of its divisions, enabling efficient gas treatment and exploitation. Within the company, various divisions work harmoniously towards a shared objective. Through close coordination and collaboration, these divisions ensure the seamless treatment and exploitation of natural gas.

I.3. HSSE Policy of IA:

✓ ***HSE Policy Statement:***

A respective commitment to HSE standards and continuous improvement of HSE performance for all JV activities.

This statement is intended to prevent against:

- Accidents
- Injuries
- Environmental damage

To achieve this, an HSE program has been drawn up, based on objectives and guided by principles to be respected.

✓ ***Several other statements are made in this context, including:***

- In Amenas' ethical commitment
- Policy statement on alcohol and drug abuse
- Search policy on entering/leaving operation sites
- HSE policy for road transport
- HSE Charter

I.4. IA's HSE Management System:

The development of In Amenas has included the implementation of a Health, Safety, and Environment Management System (HSE MS) for the duration of the project's operational phase. This HSE MS is intended to be applied to all IA activities, with a focus on the production of gas, condensate, and LPG. The HSE MS provides the framework for managing HSE issues within the company.

The foundation of IA's HSE MS includes national and international standards (ISO 14001/ISO 45001), existing legal requirements, industry practices, as well as industry guidance documents.

The environmental management system of In Amenas was established and initially certified ISO 14001 in 2007. It involves following procedures, ensuring compliance with standards, and implementing an environmental management system.

The environmental policy aims to minimize waste and generated emissions, ensure safe treatment for the environment, reduce environmental impact, control costs, comply with regulations, and enhance the company's image. Additionally, a significant number of controls related to hygiene and safety were defined, such as work control standards, which have been reviewed and included in the HSE MS.

The procedures and instructions of the HSE MS are controls aimed at reducing risks according to the following hierarchy:

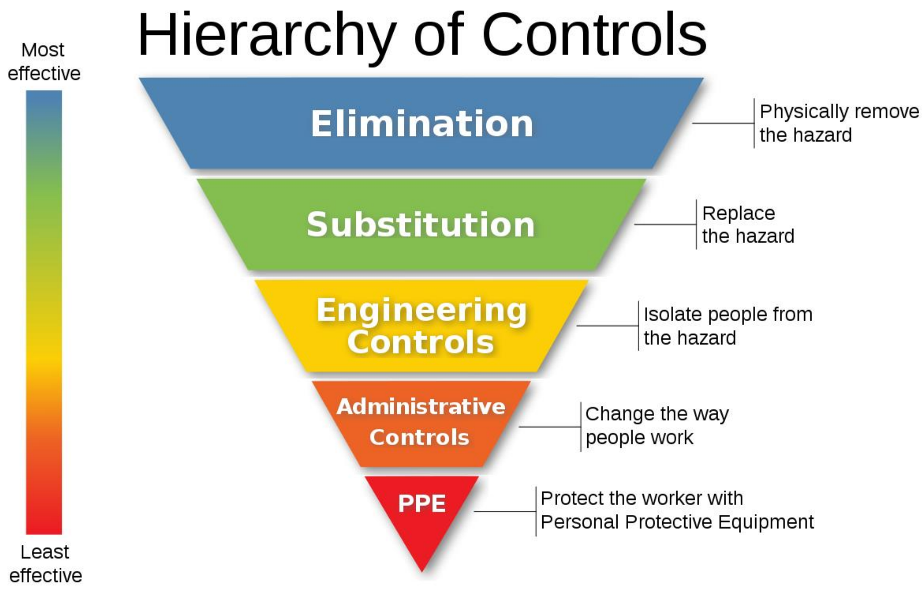


Figure I-2: Hierachy of Hazards Controls

I.4.1. Work Management System (COW):

It is a system tailored and approved by the IA management to control all site activities, leading to systematic identification and evaluation of risks according to the agreed hierarchy of controls through appropriate procedures and best practices.

The Work Management System (WMS) stipulates that all activities related to the Process Isolation, Electrical, Instrumentation, and Mechanical procedures of the PTW System, must be carried out to the standards specified by the Safe Isolation and Restoration procedure. This system is based on two essential keys, namely:

- **Procedures:**

Several procedures that provide guidance and requirements on how to ensure control and execution of activities in a safe manner.

- **Designated Personnel:**

These are trained and competent individuals from the joint venture (JV) who implement the requirements of these procedures.

I.4.1.1. Objective:

The main objective of the Control of Work (COW) system is to:

- Ensure the safety of personnel, facilities, and equipment, and manage activities in a safe and efficient manner.
- Establish risk assessment standards to ensure that all hazards have been fully identified and all risks have been controlled and reduced to an acceptable level.

This system specifies the minimum acceptable standard for formal and informal risk assessments that must be conducted prior to all planned activities, to ensure that all risks and hazards have been eliminated and/or reduced to an acceptable level (ALARP - As Low As Reasonably Practicable). See Figure I-3.

I.4.1.2. Scope of COWS:

The Work Management (COW) system and the processes it describes apply to all IA Operations facilities and sites (Operations, Pipelines, Wells, Integrated Camps, Projects, Construction and TAR activities), unless an exemption has been authorised by the Operations Manager.

Companies who can demonstrate that their own Standards, Systems and Procedures meet and/or exceed the intent and minimum requirements of the IA Ops Work Management Standard (CoW), will be authorised by their responsible Area Owner (AO), in consultation with the responsible Area Authority (AA) to use their own procedures when working on site, provided that their work activities are carried out outside of the operating areas (CPF and Wells).

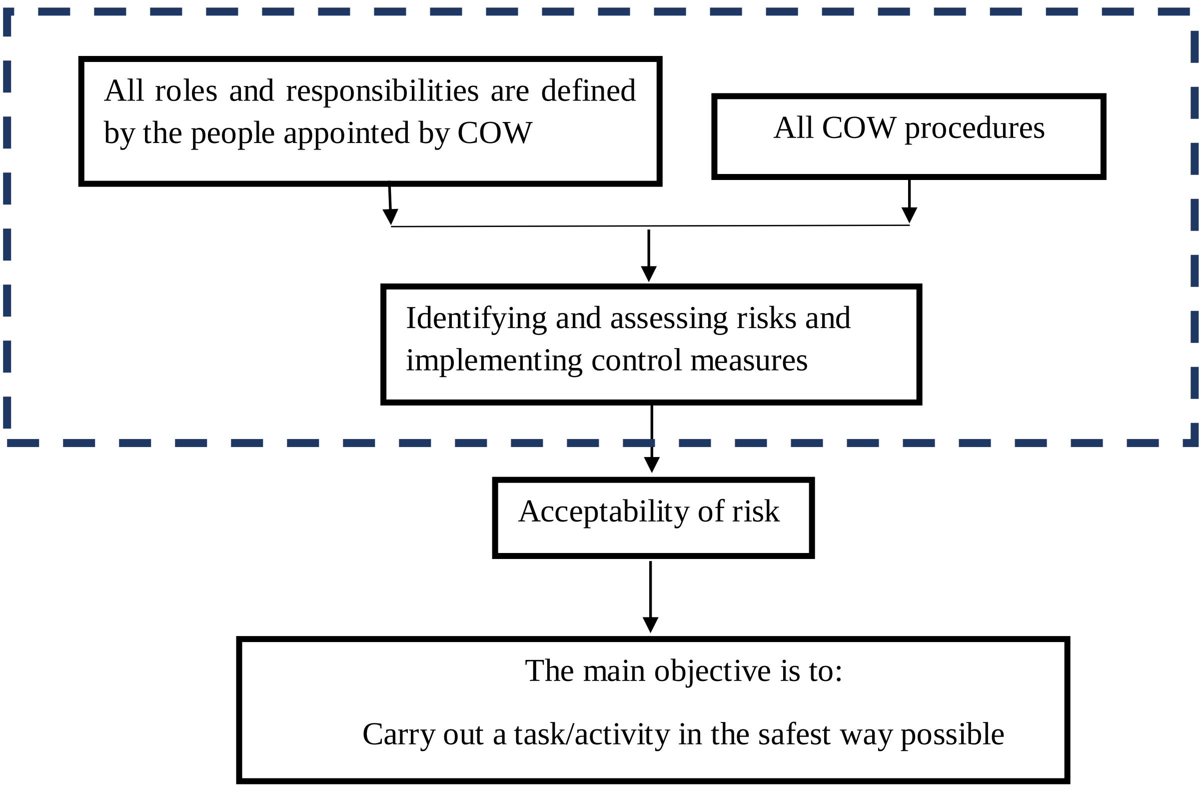


Figure I-3 : General principle of COW

I.4.2. Life Saving Rules:

The Safety of Life Rules, developed by the International Association of Oil and Gas Producers (IOGP), are a set of fundamental safety principles designed to prevent serious incidents and save lives in the oil and gas industry. These rules detail specific actions and behaviours that individuals must follow, whatever their role or workplace, in order to reduce risks and ensure their own safety and that of others. They serve as a universal industry standard, underlining the importance of consistent safety practices and fostering a culture of safety excellence. See Figure I-4.

IA has implemented IOGP Life-Saving Rules in the aim to protect the lives of all employees and contractors who are involved in work activities that have high potential incidents.

Adherence to the Life-Saving Rules represent a commitment by all IA employees and contractors to always follow these rules, at all times, without exception. They complement the embracing of IA's HSE goal "No accidents, no harm to people and no damage to the environment.

Key Messages of the Life-Saving Rules include the following:

- ✓ The Life-Saving Rules are here to ***keep you safe***;
- ✓ Comply with IA Life-Saving Rules is ***my responsibility***;
- ✓ I ***speak up and act*** whenever the Life-Saving Rules are ***broken***; and
- ✓ You have the ***support from your leaders to enforce compliance*** with IA Life-Saving Rules.

The Life-Saving Rules do not replace the need to adhere to IA HSE Policy and any other HSE Standards, they rather reinforce safety requirements for the most common work activities that have the highest potential to cause serious injuries and/or fatalities, and that require additional focus and strict adherence at all times. There are no exceptions!

Figure I-4: IOGP's Life Saving Rules

I.4.3. Work Permit System (PTW):

The IA Ops PTW System is a work planning and management system designed to protect personnel, facilities, equipment, and the environment, and to assist personnel working at IA Ops sites in working safely and efficiently, in compliance with IA Ops procedures and regulatory requirements.

I.4.3.1. Purpose of the Permit to Work System:

The purpose of the IA Ops PTW System Procedure is to provide processes to ensure the safety of personnel, facilities and equipment, and to define the methods of managing and coordinating work activities to enable all personnel (employees and contractors) to carry out their work safely and effectively at all IA Ops sites and facilities.

This procedure specifies the minimum acceptable standard of formal and informal risk analyses to be carried out prior to all planned work activities, to ensure that all risks and hazards have been eliminated and/or reduced to an acceptable level.

The results of the formal and informal risk analyses, including any necessary mitigation measures, must be documented and communicated to all personnel involved in the work before work commences. The PTW system procedure is the key tool for this process.

I.4.3.2. Scope of PTW:

The PTW System is applicable to all IA Ops sites and facilities, and must be complied with by all personnel (employees and contractors) at all times.

A Permit to Work (PTW) is imperative for any work or activity that involves working on energy systems, hot work, confined space entry and/or ground disturbance in areas where buried hazards may exist.

PTW authorisation is not required for certain specific routine and repetitive tasks. However, the person carrying out the task and the AA must consider the need to use a SWP (Safe Working Practice). A record of these tasks is kept jointly by the Area Owner and the AA for that site. A SWP cannot be used for a task that clearly requires a full PTW.

I.4.3.3. Forms and associated certificates:

The IA Ops PTW System has two (2) main PTW forms, namely:

- Hot Work Permit
- Cold Work Permit
- The PTW forms are accompanied by the following certificates:
  - Confined Space Entry
  - Mechanical/Process Isolation
  - Electrical Isolation
  - Ground Disturbance & Excavation

Certificates are to be used in conjunction with the PTW, and copies of the certificates should accompany the PTW copies.

I.4.4. IA's risk assessment and management:

Risk management is an ongoing process and is the cornerstone of all HSE elements.

- Hazards must be identified and the associated risks assessed for all activities on a regular basis.
- Appropriate measures must be taken to manage risks and prevent or reduce the impact of potential accidents or incidents.

The risk analysis process described in the IA procedure is a method of systematically examining an individual workstation (task), in order to identify hazards, assess risks and thus specify adequate protective measures to reduce the risk or hazard to an acceptable level. It is intended to be applied to any task for which the risks cannot otherwise be assessed in the same way.

Other types of Risk Analysis are also covered by this procedure, including Operations Risk Assessment (ORA) and Environmental Risk Assessment (ERA).

I.4.4.1. Levels of risk assessment:

There are two levels of risk assessment:

- **TRA Level 1:** A basic check by a Competent Person (Area Authority/Performing Authority) to assess if hazards are significant and manageable with a simple Safe Working Practice (SWP) or Permit to Work (PTW).
- **TRA Level 2:** A detailed analysis by the Competent Person (Area Owner/Authority) for new or complex tasks, requiring extra safety measures and supplementing the PTW.

Other Risk Assessments in IA Operations:

- **Operational Risk Assessment (ORA):** For using equipment/systems beyond design limits or when critical safety systems are inactive. Documented before use.
- **Environmental Risk Assessment (ERA):** For activities/products posing environmental risks, non-compliance with environmental procedures or ISO 14001, or to mitigate environmental impact.

The different levels of risk assessment are summarized in the figure bellow

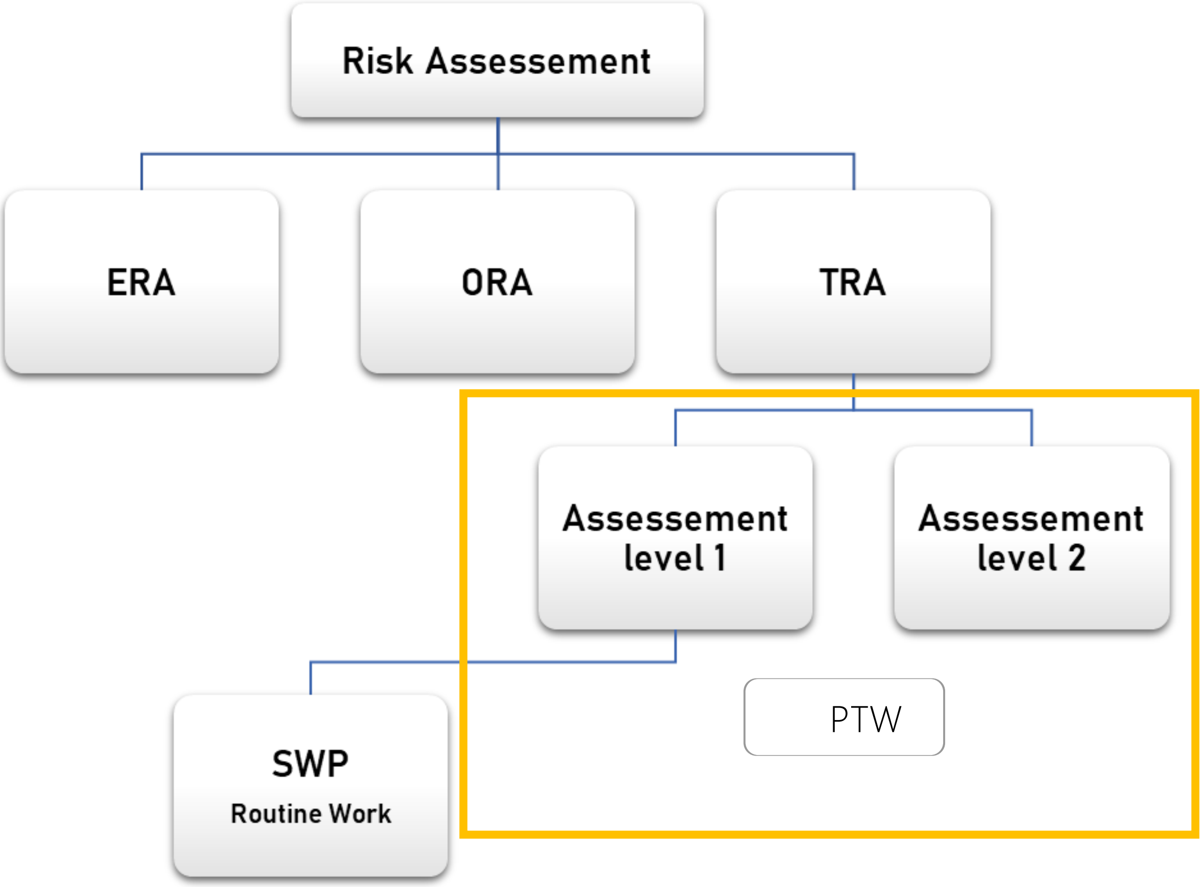


Figure I-5: Levels of Risk assessement

Chapter II:

Comprehensive Process Overview with Focus on Desulphurization and Demercurization Unit

Introduction:

In Chapter II, we delve into the operational intricacies of the Tiguentourine gas plant, focusing specifically on the desulphurization and demercurization unit. This unit plays a pivotal role in ensuring the purity and quality of the natural gas processed at the facility. By providing an overview of the gas plant's operations and emphasizing the importance of desulphurization and demercurization, this chapter sets the stage for a detailed exploration of the processes, technologies, and regulatory considerations associated with these critical units.

II.1. Natural gas treatment line

II.1.1. Purpose of natural gas processing

Natural gas processing consists of separating the constituents present at the well exit, such as water, acid gas and heavy hydrocarbons, to bring the gas up to transport or commercial specifications.

The distribution of treatments between the production and delivery sites is based on economic considerations. It is generally preferable to carry out only the following stages of treatment at the production site:

- The first stage separates any liquid fractions contained in the well effluent: liquid hydrocarbon fractions.
- The second stage, treatment of the wet gas, depends on the mode of transport adopted.

The natural gas and its various fractions can be transported in the form of:

- Compressed natural gas (transport by pipeline).
- Liquefied natural gas (LNG).
- Liquefied petroleum gas (LPG).
- Various chemicals (methanol, ammonia).

Certain components in the gas must be extracted, either for reasons imposed by the processing or transport stages, or to comply with commercial or regulatory specifications.

It is necessary to at least partially eliminate:

- ✓ Hydrogen sulphide (H_2S): toxic, corrosive and contains more than 2 ppm / Volume the acceptable content for transport specifications.
- ✓ Carbon dioxide (CO_2): corrosive especially with the existence of free water and the calorific value is zero. CO_2 content less than 2% mole (transport specifications).
- ✓ Mercury (Hg): prevents metal embrittlement by liquid and corrosion by amalgamation. Minimises mercury content <10 ng/Sm3.

- ✓ Water (H_2O): prevents the formation of hydrates, especially in the cold box, and protects equipment and transmission pipelines against corrosion and icing during the winter season.
- ✓ Hydrocarbons: which condense in transmission networks.
- ✓ Nitrogen (N_2): of zero thermal value.

The treatment carried out to obtain transport specifications may be accompanied by fractionation to obtain a liquid comprising LPG (propane and butane) and possibly ethane. When it is advantageous to recover this fraction separately.

II.1.2. Finished product specifications:

Table II-1: Typical commercial gas specifications

Export gas characteristics	Specifications
Water content	≤ 50ppm volume
Gross calorific value	9100 ≤ PCS ≤ 9500 Kcal/cm3 at 15°C and 1 bar
Hydrocarbon dew point	Must not be lower than -2°C between 1-70 bar
CO2 (carbon dioxide)	Must not be more than 2% mol
H2S (Hydrogen sulphide)	Must not exceed 2mg/m3
Mercaptans	Must not exceed 15mg/m3
Total inert gases He and N2	Must not exceed 6.5% mol
Hg (Mercury)	Must not exceed 10ng/Sm3

- **Residual gas:** Methane (CH_4) = 89% and Ethane (C_2H_6) = 8%.

Table II-2: Typical commercial LPG specifications.

LPG characteristics	Specifications
C2 light fraction content	1.32 < < 3.380/0 mol
Heavy fraction content Cs	0.03 0.82% mol
Density	< 0.560
Reid vapour pressure TVR at 37.80C	< IO.OKg/m2
H2S content (hydrogen sulphide)	< Ippm
Volatile sulphur content	< 0.03% mol

- **LPG:** Propane (C_3H_8) = 69% and Butane (C_4H_{10}) = 26%.

Table II-3: Typical commercial condensate specifications.

Condensate characteristics	Specifications
Sulphur content	< 0.005% Weight
Salt content	Nil 0/0 Weight
Density	0.7022 < d 150C < 0.7201
Reid vapour pressure TVR at 37.80C	< O.850Kg/m
Basic Sediment Water (BSW)	Traces % volume
Coloration	> 16 Say-bolt

- **Condensate:** Heptanes and more (C_7+) = 67%, Butanes (C_4) = 4%, Pentanes (C_5) = 8%, Hexanes (C_6) = 18%.

  When finished products (dry gas, LPG and condensate) are marketed, the specifications are more stringent.

II.2. Description of the installation to be studied (CPF):

II.2.1. System description:

The existing In Amenas central processing facility has a peak capacity of 29.85 million standard m³/day of produced gas and receives fluids from the gathering system in a multi-line condensate trap that performs an initial separation of gas and liquid.

The separated fluids are processed in each of the three production trains which produce dry gas, blended liquefied petroleum gas (LPG) and stabilised condensate products for export. On an annualised basis, the central processing facility produces an average of 27.5 million standard m³/day of dry gas, 2,630 tonnes/day of LPG and 4,460 tonnes/day of stable condensate.

The central processing facility receives production from the main lines and separates the multi-phase mixture into natural gas, liquefied petroleum gas (LPG), C5+ condensate and produced water.

The processing programme includes treatment to remove carbon dioxide (CO_2) and water, cryogenic turboexpander treatment to recover LPG and meet gas export specifications, and liquid fractionation to separate liquid products. The facility is arranged in three parallel processing trains, each with the capacity to process 33% of the total feed to the central processing facility, and common gas and liquids export systems to transport the products to the final delivery point on the Sonatrach system.

II.2.1.1. Reception facilities:

The CPF central treatment unit is fed from an inlet manifold, this inlet manifold is a 42' diameter header which collects the fluid from each trunk-lines and delivers the flow to the slug-catcher 00-V-051A/B and 00-V-052A/B, the load is shared equally in each side A/B where the first separation of the wet gas into three phases (gas, liquid hydrocarbons and water) takes place.

The slug catcher is also used for temporary storage of liquids and to calm transient flows of water and liquid hydrocarbons accumulated in the collection system pipes. The old slug catcher operates at the plant's inlet pressure of 70 bar, and following the start-up of the IGC inlet compressors, the two slug catcher units now operate at a pressure of between 32 and 38 bar.

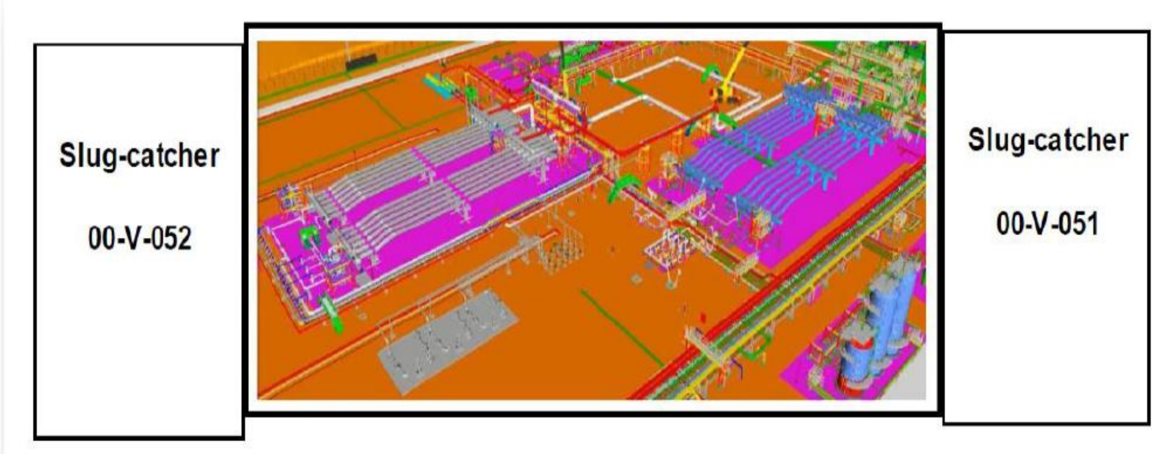


Figure II-1: The two slug-catchers, the old one (00-V-051) and the new one (00-V-052).

The inlet flow to the slug catcher is a mixed flow of multiple phases of gas and liquid, the gas entrained in the separation tubes is discharged at the high point and the liquid at the low point, after separation the vapour leaving the two slug-catchers is combined and sent to the

new IGC intake gas compression system (boosting) and the water and hydrocarbons are separated in the lower part of the slug catcher.

The flow of liquid hydrocarbons to the inlet pre-flash separator of each train 01/02/03-V-211.

To recover the condensate trapped in the water, the water produced is discharged under level control into the new 00-V-281 storage tank, which is added to the compression project.

Figure II-2: Separation of the three phases in the slug-catcher

II.2.1.2. New IGC intake gas compression system (boosting):

Boosting was introduced to compensate for the gradual drop in well pressure (from 72 bar before the IACP to 41 bar today). The system consists of two units (15 and 16).

The wet gas from the slug-catcher is collected in the two suction tanks 15-V-071 and 16-V-071, which feed the two multi-stage centrifugal compressors, each designed for 50% capacity, which are driven by gas turbines to increase the gas pressure from 33.8 bar (suction) to 71 bar. The gas discharged by the compressors is cooled by the air coolers and then sent to the three identical treatment trains.

II.2.1.3. Wet gas treatment line

- **Cooling and separation of inlet gas**

The pressure of the gas leaving the slug-catcher for the gas treatment train is normally controlled at 71.3 bar. During the summer months, the temperature of the gas can reach 82°C, so it is cooled to a temperature of 60°C in inlet air cooler 01-E-101. In winter, when the ambient temperature is as low as -5°C, the gas temperature can drop to 25°C, and inlet air cooler 01-E-101 is bypassed to prevent hydrate formation.

The gas leaving air cooler 01-E-101 is combined with the gas from air cooler 01-E-262 of the hydrocarbon vapour recovery unit (VRU) and enters inlet separator 01-V-101. This flask separates the liquid hydrocarbons and the water and directs them respectively to the liquid hydrocarbon inlet pre-flash separator 01-V-211 and the produced water separator 01-V-281, under level control.

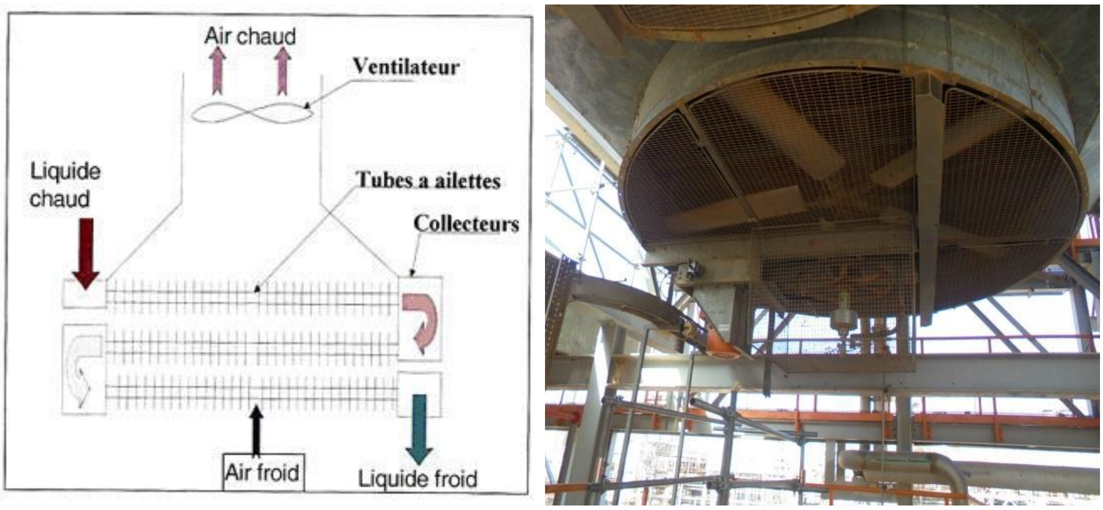


Figure II-3: Operating principle of an air-cooled heat exchanger.

Desulphurisation and demercurisation:

Desulphurization and demercurization are crucial processes in the refining and processing of natural gas and petroleum products. These processes aim to remove sulfur and mercury compounds, respectively, which are harmful to both the environment and industrial equipment. Effective removal of these contaminants ensures compliance with environmental regulations, protects infrastructure, and enhances the quality of the final products.

- **Types of Desulphurization and Demercurization**

  - ***Desulphurization Methods:***

- Hydrodesulfurization (HDS): Uses hydrogen gas to remove sulfur from petroleum products, forming hydrogen sulfide.
- Adsorption: Employs absorbents like zinc oxide, activated carbon, and metal oxides to capture sulfur compounds from gas or liquid streams.
- Gas Treating Processes: Utilize chemical solvents such as amine solutions to remove hydrogen sulfide from natural gas.

  - ***Demercurization Methods:***

- Adsorption: Uses absorbents like activated carbon, metal sulfides, and specialized adsorbents to capture mercury from gas or liquid streams.
- Chemical Reactions: Involves reagents that react with mercury to form stable, non-volatile compounds.
- Distillation and Condensation: Physical separation techniques to remove mercury, particularly in gas processing.

- **Desulphurization Using Absorbents**

  - ***Definition:***

Desulphurization using absorbents involves the removal of sulfur compounds from natural gas or petroleum products through the use of solid materials that selectively capture sulfur compounds. These absorbents typically include materials like zinc oxide, activated carbon, and metal oxides, which can effectively remove hydrogen sulfide (H_2S) and other sulfur compounds.

✓ ***Process:***

The process generally involves passing the gas or liquid stream containing sulfur compounds through a bed of absorbent material. The sulfur compounds react with the absorbent, forming a solid compound that remains on the absorbent material, thus removing sulfur from the stream. For example, zinc oxide reacts with hydrogen sulfide to form zinc sulfide and water, effectively reducing the sulfur content.

✓ ***Applications:***

This method is widely used in various industries, including natural gas processing, petroleum refining, and chemical manufacturing. It is particularly useful in situations where the use of chemical solvents is impractical or where additional liquid handling equipment would complicate the process.

✓ ***Example Absorbents:***

- Zinc Oxide (ZnO): Commonly used in the Claus process for desulphurizing natural gas. It reacts with hydrogen sulfide to form zinc sulfide.
- Activated Carbon: Used for the adsorption of organic sulfur compounds such as mercaptans and thiophenes.
- Metal Oxides: Other metal oxides like iron oxide can also be used, often supported on substrates to enhance their effectiveness and capacity.

➢ **Demercurization Using Absorbents**

✓ ***Definition:***

Demercurization using absorbents involves the removal of mercury from natural gas or petroleum products by passing the contaminated stream through materials that selectively capture mercury. This method is crucial in protecting equipment and ensuring compliance with environmental regulations.

✓ ***Process:***

The gas or liquid stream containing mercury is passed through a bed of absorbent material designed to capture mercury. The absorbents, which often include materials like activated carbon or specialized metal sulfides, bind with mercury, forming stable compounds that remain on the absorbent material.

✓ ***Applications:***

This method is particularly important in the liquefied natural gas (LNG) industry and in natural gas processing, where mercury can cause severe damage to aluminum heat exchangers. The process is also used in petrochemical and refining industries to ensure the quality of products and the safety of operations.

✓ ***Example Absorbents:***

- Activated Carbon: Often impregnated with sulfur or iodine to enhance mercury adsorption capacity.
- Metal Sulfides: Such as copper sulfide, which react with mercury to form mercury sulfide, a stable compound that remains on the absorbent.
- Specialized Adsorbents: Engineered materials specifically designed to target mercury in gas and liquid streams.

➢ **Importance of Desulfurization**

✓ ***Health and Safety:***

- Toxicity: H_2S is highly toxic and can be lethal at concentrations above 100 ppm. Even at lower concentrations, it poses serious health risks, including respiratory problems and irritation.
- Safety Hazard: The presence of H_2S in natural gas can lead to dangerous conditions for workers in the gas processing industry. Effective removal is essential to prevent accidents and ensure a safe working environment.

✓ ***Corrosion Prevention:***

- Material Degradation: H_2S is a corrosive gas that can cause significant damage to pipelines, storage tanks, and processing equipment. The corrosion can lead to leaks, equipment failures, and costly repairs.
- Infrastructure Longevity: By removing H_2S, the integrity and lifespan of the infrastructure are preserved, reducing maintenance costs and enhancing operational reliability.

✓ ***Environmental Compliance:***

- Regulatory Standards: Emissions of H_2S are subject to strict environmental regulations due to its contribution to acid rain and environmental degradation. Failure to comply with these regulations can result in severe penalties and environmental harm.
- Community Impact: Removing H_2S reduces the risk of harmful emissions that can affect surrounding communities, improving air quality and public health.

➢ **Importance of Demercurization**

✓ ***Equipment Protection:***

- Amalgamation: Mercury can form amalgams with metals, causing severe damage to processing equipment. This can result in unexpected equipment failures, costly downtime, and safety hazards.

- Contamination Prevention: Mercury contamination can spread through the processing system, affecting various components and leading to widespread damage.

✓ ***Health and Environmental Impact:***

- Toxicity: Mercury is a potent neurotoxin that poses significant health risks to humans and wildlife. Exposure can lead to serious health issues, including neurological damage and developmental defects in children.
- Environmental Contamination: Mercury can contaminate water bodies and soil, causing long-term environmental damage. Its persistence and ability to bioaccumulate make it a major environmental pollutant.

✓ ***Product Quality:***

- Specification Compliance: Natural gas with high mercury content does not meet quality standards required for safe distribution and use. Removing mercury ensures the gas complies with industry specifications.
- Marketability: High-quality, contaminant-free natural gas is more marketable and can command better prices in the global energy market.

Gas H_2S Absorber 0X-V-1110:

The majority, 75%, of the incoming natural gas stream enters the Gas H2S Absorber unit to reduce the concentration of hydrogen sulfide (H2S) from 5.0 parts per million by volume (ppmv) down to 1.4 ppmv. The total design feed flow rate to this treatment train is 9.9 million standard cubic meters per day (Sm3/day) of natural gas at high pressure.

The PURASPECT™ 100 process efficiently removes H_2S from gas streams using an axial flow reactor, where H_2S irreversibly binds to the PURASPECT™ absorbent material. This absorbent does not contain any impregnated compounds, ensuring no release of chemicals. Once partially sulfided, the bed can also remove mercury from the gas stream. The process operates without the need for additional chemicals, meeting product specifications without any hydrocarbon losses. It only requires an inert gas for purging during start-up and shutdown operations. With minimal service requirements, the process is easy to operate and robust against variations in flow rates and impurity levels.

Chemically reacting with PURASPEC absorbent, H_2S forms a sulphide:

$$MO + H_2S \longrightarrow MS + H_2O$$

This sulphur is permanently incorporated into the absorbent structure alongside H_2O and CO_2 production:

$$MS_2 + Hg \longrightarrow MS + HgS$$

Additionally, the absorbent can remove COS and mercury. Pressure monitoring in the H_2S Absorber bed ensures efficient operation, detecting potential scale and debris accumulation.

Successful operation hinges on achieving product specifications, necessitating a well-designed process system and timely replacement of consumed absorbent. Systems are typically designed based on predictable sulphur absorption capacities, allowing for planned absorbent replacement.

Monitoring and planning absorbent replacement involve regular gas sample analyses and calculating the total weight of sulphur removed by the absorbent bed.

The gas enters the H2S Absorber through a series of valves to control pressure, including double block and bleed arrangements and a butterfly valve. It then passes through a nozzle and a distributor with small holes for even distribution. Inside the absorber, the gas flows through beds of ceramic balls and a Puraspec 1038 catalyst to remove H2S. The cleaned gas exits through an outlet with valves and monitoring equipment, including a pressure gauge and an H2S analyzer. Safety features include a Pressure Safety Valve to prevent over-pressurization, set to release excess pressure to a flare system. The absorber is designed to operate continuously for a year, maintaining H2S levels within specified limits.

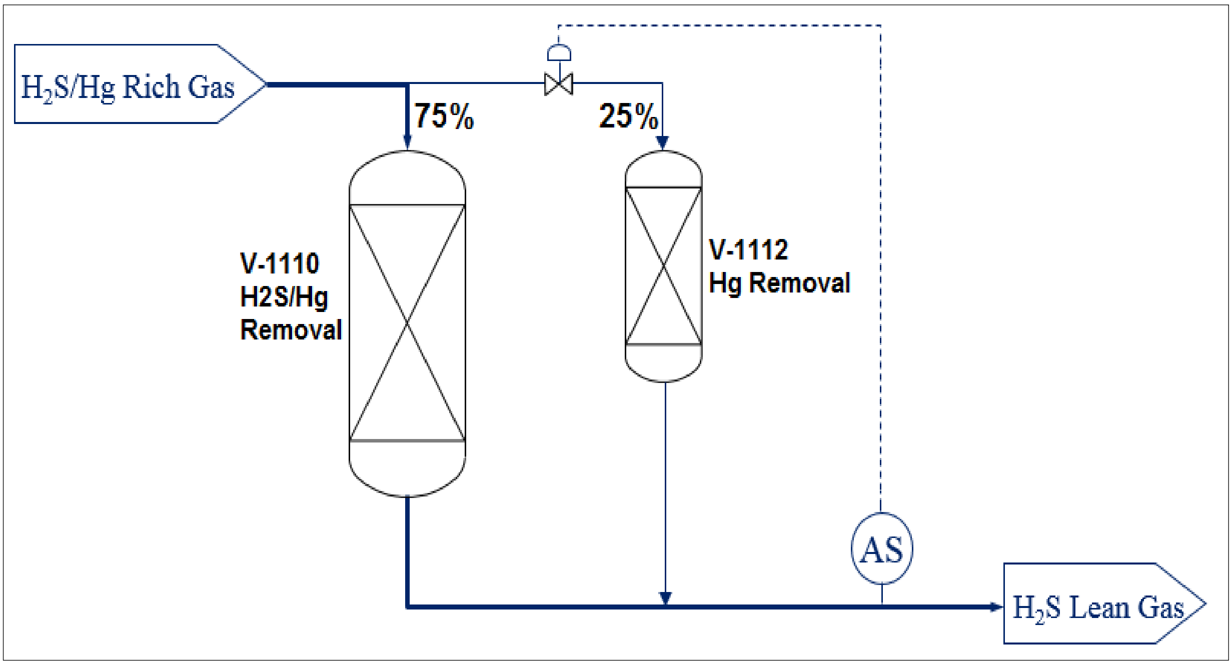


Figure II-4: Schematic diagram of H2S and Hg absorbers.

Figure II-5: H2S and Hg absrobers.

Mercury Absorber 0X-V-1112

The remaining 25% of the feed gas stream, amounting to 9.9 million standard cubic meters per day (Sm3/day) of natural gas at high pressure, enters the Mercury Absorber unit. This unit aims to reduce the mercury (Hg) levels from 0.2 micrograms per normal cubic meter (µg/Nm3) down to less than 10 nanograms per standard cubic meter (ng/Sm3).

In the Mercury Absorber, mercury irreversibly binds to the PURASPECT™ absorbent material, preventing any downstream equipment contamination. The mercury removal bed does not contain any impregnated compounds. For the absorbent to be active, it must be in a sulfided form, which is achieved during the initial operation due to trace amounts of hydrogen sulfide (H_2S) present in the natural gas stream.

Similar to the H_2S removal process, no additional chemicals are required for mercury removal. The process is chemically selective, meeting product specifications without incurring any hydrocarbon losses. The only requirement is the use of an inert gas for bed purging during start-up and shutdown operations.

$$MS_2 + Hg \longrightarrow MS + HgS$$

The process, which is easy to operate, requires periodic mercury analysis. Initially, annual inlet and outlet checks monitor the saturation front progress, and ongoing bed pressure drop monitoring detects scale and debris accumulation. Regular monitoring of the feed stream is recommended, with samples taken downstream of the Mercury vessel to ensure good reactor performance and prevent mercury breakthrough. Proper sampling techniques are crucial to avoid errors. Potassium permanganate absorption is used for detection via atomic absorption methods. The gas enters the Mercury Absorber through an inlet butterfly valve and a 24” gas inlet nozzle, distributed evenly by an inlet distributor with 1380 holes arranged in staggered rows.

As the gas enters the reactor, it first passes through a bed of ceramic balls, then through a bed of Puraspec 1157 catalyst. There are sample collection nozzles on the side. The catalyst is held in place by beds of ceramic balls and a stainless-steel screen. The gas exits through an outlet collector with vertical slots and drain ports, designed to manage pressure drop. A pressure gauge monitors the system pressure. A nitrogen connection for purging is installed at the outlet, with a double block and bleed arrangement. Two Pressure Safety Valves prevent over-pressurization, set to relieve excess pressure to the HP Flare header, with one valve in service and the other on standby. There are provisions for draining the absorber for maintenance and for sampling the gas as needed. The absorber is designed to operate continuously for at least three years, maintaining mercury levels within specified limits.

Equipment Descriptions:

Gas H_2S Absorber 0X-V-1110:

Description:

Type:	Vertical Vessel with 77.0 m3 bed of Puraspec 1038
Size :	4000mm x 5830mm T-T
Design Conditions:	78 barg; 100ºC/-29ºC
Materials:	Carbon Steel body, 18%Cr-8%Ni stainless steel internals.
Insulation:	None

The Gas H_2S Absorber is designed to reduce the H_2S level from 5.0 ppmv down to 1.4 ppmv for the Residue Gas specification. The H_2S Absorber is designed to operate continuously for a period of at least one year whilst maintaining the outlet Hydrogen Sulphide at or below specified levels.

The Gas H_2S Absorber is equipped with the following devices to facilitate local monitoring of process parameters:

- ✓ Pressure gauge 01-PI-1151 in the gas outlet line
- ✓ Two side nozzles to collect samples

The Gas H_2S Absorber can be drained to the Closed Wet HC Drain system via a drain connection located on the gas outlet line.

A 24” diameter manway is provided on the shell of the Absorber to facilitate access for internal inspection or maintenance. An 8” inclined nozzle with a flange has been provided on the bottom end of the shell of the Absorber, to facilitate unloading of the catalyst.

A nitrogen connection with dual isolation valves is provided on the outlet of the Absorber to inert the Absorber before the introduction of hydrocarbon gases into the system. The nitrogen is disconnected by the removable spool provided before the introduction of hydrocarbon into the Absorber.

Control Systems

There are no automatic controls directly associated with the Gas H2S Absorber.

Pressure Safety Valves

The Gas H_2S Absorber is protected against overpressure in the event of a fire by pressure safety valve 01-PSV-1191, which is set to relieve to the HP Flare at the vessel design pressure of 78 barg.

Mercury Absorber 0X-V-1112

Description

Type: Vertical Vessel with 20 m3 bed of Puraspec 1157

Size : 2750mm x 3330mm T-T

Design Conditions: 78 barg; 100ºC/-29ºC

Materials: Carbon Steel body, 18%Cr-8%Ni stainless steel internals.

Insulation: None

The Mercury Absorber is designed to reduce the Mercury content of the gas from 0.2 micrograms/Sm3 down to less than 10 ng/Sm3. The Mercury Absorber is designed to operate continuously for a period of at least three year whilst maintaining the outlet Mercury at or below specified levels.

The Mercury Absorber is equipped with the following devices to facilitate local monitoring of process parameters:

- ✓ Pressure gauge 01-PI-1150 in the gas outlet line

The Mercury Absorber can be drained to the Closed Wet HC Drain system via a drain connection located on the gas outlet line.

A 24” diameter manway is provided on the shell of the Absorber to facilitate access for internal inspection or maintenance. An 8” inclined nozzle with a flange has been provided on the bottom end of the shell of the Absorber, to facilitate unloading of the catalyst.

A nitrogen connection with dual isolation valves is provided on the outlet of the Absorber to inert the Absorber before the introduction of hydrocarbon gases into the system. The nitrogen is disconnected by the removable spool provided before the introduction of hydrocarbon into the Absorber.

Control Systems

There are no automatic controls directly associated with the Mercury Absorber.

Pressure Safety Valves

The Mercury Absorber is protected against overpressure in the event of a fire by pressure safety valves 01-PSV-1190A/B, which is set to relieve to the HP Flare at the vessel design pressure of 78 barg. During normal operation only one of 01-PSV-1190A/B is placed in service, allowing maintenance or testing of either safety valve to be carried out.

- **CO_2 removal unit**

  - **Purpose:** Remove CO2 from gas to meet product specifications by circulating and regenerating amine solvent.

  Gas from H2S absorbers is processed, mixed with bypass gas, and sent to dehydration.

- **Gas dehydration**

  - **Purpose:** Remove water from feed gas to meet product specifications and treatment requirements.

- **Condensate stabilization**

  Liquid hydrocarbons are preheated (in winter), separated into ethane/lighter and propane/heavier components, with the bottom product sent to the debutanizer.

- **Vapour recovery unit**

  Purpose: Collect and compress gases from the condensate stabilizer and inlet condensate separator for delivery to the wet gas treatment system.

- **Residual gas compression and export**

  - **Purpose**: Compress residual gas to export pressure, count gas accurately, and transport it to Sonatrach's pipeline.
  - **Alternative**: Provides an LPG export route when needed.

- **LPG storage and export**

  Purpose: Store and export on-spec/off-spec LPG, remove H2S, and transfer LPG via pipeline.

- **Condensate storage and export**

  Purpose: Store and export on-spec/off-spec condensate, with buffer capacity for reprocessing.

II.3. The main hazards associated with operating activities

The main concern relates to the potential hazards posed by the ignition of flammable hydrocarbon of flammable hydrocarbons, as described in the previous section. Hazard identification studies have indicated that CPF's operating systems containing significant hydrocarbon significant stocks of hydrocarbons, particularly those used at high pressure represent the main sources of potential danger; danger zones have been defined as shown in Figure 10.

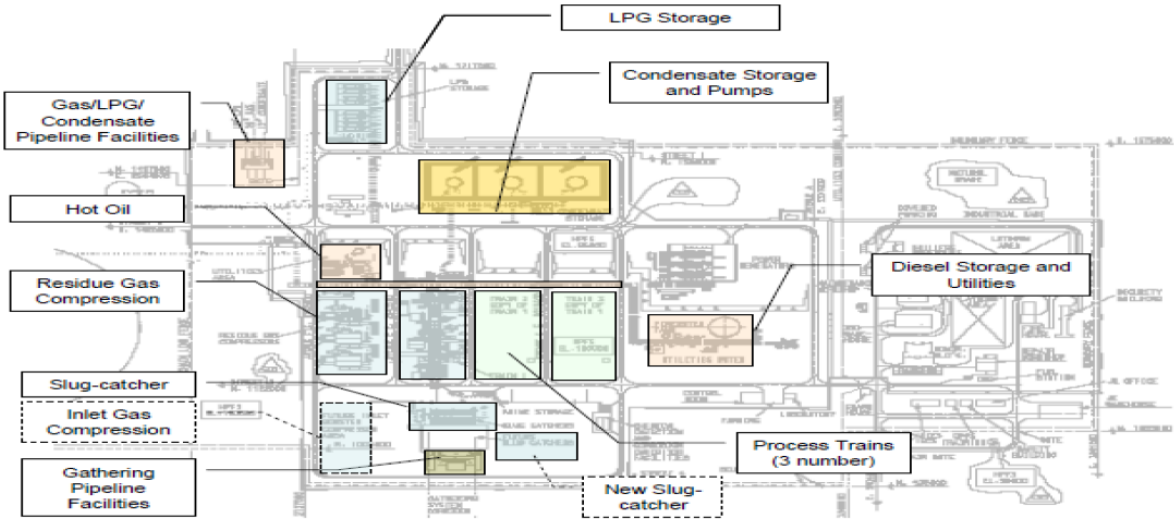


Figure II-6: CPF danger zones (or fire zones) defined for the CPF.

Conclusion:

In Chapter II, we have explored the critical role of the desulphurization and demercurization unit within the Tiguentourine gas plant. By delving into the operational intricacies and technological innovations of these units, we have gained insights into their significance in ensuring the purity and compliance of processed natural gas. Moving forward, the Tiguentourine gas plant remains committed to upholding the highest standards of environmental stewardship and safety, while continuously striving for operational excellence and innovation in desulphurization and demercurization processes.

Chapter III:
Task Risk Assessment

Introduction:

The number and variety of tasks carried out in the work place is very large, and there is a correspondingly wide range of risks involved. This means that, for practical reasons, the extent of hazard and risk assessment in any particular case has to be balanced against the type of risk, so that the greatest effort is devoted to the most severe risks.

The Hierarchy of Risk Management measures shall reduce the risks through the following steps:

- Elimination
- Substitution
- Control
- Mitigation

When conducting Risk Assessments, the hierarchy above should be followed giving the highest priority to elimination of the risk/task first.

The IA Ops Permit to Work (PTW) System shall be used to manage work, identify hazards, and control the risks.

Some activities, for example, contain tasks which are normally carried out without the need for a permit. Routine operating tasks, production monitoring, housekeeping, catering and cleaning, etc., are examples. In this type of work, risk is usually assessed and managed through a periodic general analysis of job or task requirements or SWP, training needs of personnel and competency assessments. The risks are then minimised by ensuring that people are trained and competent for the tasks they are required to do. Special types of risk can also be assessed by means such as chemical exposure surveys or manual handling surveys, which apply across a broad range of tasks.

In cases where the hazards are more severe, the permit to work system alone may not provide a sufficiently detailed assessment of risk. Here, a more structured method, using a team approach, may be necessary. Typical examples might include entry into confined spaces, isolation of high-pressure systems, hot work in difficult locations, complex lifting tasks, etc.

The process of risk assessments described in this procedure is a method for systematically examining an individual work assignment (task), to identify the hazards, evaluate the risks and specify appropriate safeguards to reduce the risk to ALARP. It is intended for application to any task for which the risks cannot otherwise be adequately assessed by the more general methods outlined above.

Additional types of Risk Assessment are also covered in this Procedure; these are Operations Risk Assessment (ORA) and Environmental Risk Assessment (ERA). Task Risk Assessments (TRA) will normally be initiated by a Work Request, or by an application for a PTW. The assessment must be carried out prior to the commencement of the work activity, regardless of whether a PTW is required.

III.1. Levels of Task Risk Assessment (TRA):

Level 1 TRA – is an informal, broad overview of the task by a Competent Person, usually the person responsible for ensuring the work is completed safely (Area Authority and/or Performing Authority), to determine whether the hazards involved are significant, and if so, whether the risks will be controlled adequately, in this case, either a Safe Working Practice (SWP) or PTW would be used/completed.

Level 2 TRA - is a formal qualitative assessment which is required only when the Competent Person (Area Owner/Authority) determines that the task is new, or complex, and that additional safeguards and controls are required to minimise the risks. Once completed, the TRA would support the PTW for the work activity.

Additional IA Ops Risk Assessments - not Task based:

An Operation Risk Assessment (ORA) shall be completed whenever a piece of equipment or operating system is operated outside its design parameters or where a key safety system is not functioning or is inhibited.

When completing the ORA and before its implementation, the ORA Team Leader must consider if the ORA should be submitted through the In Amenas Management of Change process.

An Environmental Risk Assessment (ERA) shall be used when the activity or products to be used within IA Operations, Projects or Drilling may have an Environmental Risk or when Environmental procedures, or ISO 14001 standards cannot be met.

III.2. Regulatory framework

- ✓ Algerian legislation, in particular:
  - Law 83-13 of 2 July 1983 on accidents at work and occupational illnesses.
  - Law 85-05 of 16 February 1985 on health protection and promotion
  - Law 88-07 of 26 January 1988 on hygiene, safety and occupational medicine.
  - Executive Decree No. 91-05 of 19/01/1991 on general protection requirements applicable to health and safety in the workplace.
  - Executive Decree No. 96-209 of 05 June 1996 laying down the composition, organization and operation of the national occupational health, safety and medicine council. Executive Decree No 97-424 of 11 November 1997 laying down the conditions for application of Title V of Law 83-13 of 02 July 83 relating to the prevention of accidents at work and occupational illnesses by the CNAS.

- Executive Decree No. 15-09 of 14 January 2015 setting the conditions for approving hazard studies specific to the hydrocarbons sector and their content (Article 10, relating to the Safety Management System SGS).

- ✓ SONATRACH Group HSE Policy of 12 May 2004;
- ✓ Sonatrach Group HSE Management System Standards;
- ✓ Sonatrach Group Work Permit System Standards;
- ✓ Sonatrach Group's Accident and Incident Investigation Standards;
- ✓ Procedure for developing and managing E&P procedures;
- ✓ ISO 9001 version 2008 - quality management system;
- ✓ ISO 45001 - occupational health and safety management systems (OHSMS)
- ✓ OHSAS 18001 version 2007 - occupational health and safety management system.

III.3. Roles and responsibilities:

The **IA Operations Manager** shall be responsible for this procedure being followed, and shall be required to approve all operation Risk Assessments.

The **IA Area Owners (AO – Appointed division chefs)** shall be responsible for ensuring that this procedure shall be used as part of the control of Work system. The Area Owner (AO) in consultation with the Area Authority (AA) shall approve all Risk Assessments within their designated area of ownership.

The AO is also responsible for ensuring Safe Working Practices are used and followed and that AA's are competent in the use of this procedure.

The **Area Authority (AA)** shall be responsible for ensuring that the Task Risk Assessment Form along with other appropriate Permits & Certificates are completed in accordance with IA Ops Procedures.

The Area Authority shall also be responsible for ensuring that all control measures identified in this process are put in place before and during all work activities.

The **Performing Authority (PA)** shall be responsible for the preparation of all Task Risk Assessment (level 1 and 2) process and understand the controls and requirements that come from this process and communicate these to everyone involved in the task/work..

The **HSE Division** shall provide expert or technical inputs into the Task Risk Assessment process for Level 2 Task Risk Assessment (see team structure below).

The **Technical Authority (TA)** shall provide expert or technical input into the Task Risk & Operations Risk Assessment process.

The **HSE Division chef** shall provide assurance by reviewing the effectiveness of this process on an annual basis, and shall approve all Operations Risk Assessments in consultation with the Ops Manager and the Area Owner.

❖ The Level 2 TRA Leader (Performing Authority)

The main responsibilities of the Level 2 TRA Leader are:

- Lead the Team in performing the Level 2 TRA
- Ensure that the TRA Team visit the worksite as required
- Take full responsibility for completion of TRA, including signatures and filing
- Ensure that all TRA Team members actively participate and that they have the opportunity to contribute to the TRA

❖ The Level 2 TRA Team Members shall:

Actively participate in the TRA process

Assist in identifying the Hazards, Risks and Controls required to complete the task safely

Ensure through open discussion that all team members agree that the risks have been reduced to as low as reasonably practicable (ALARP)

- **Personnel conducting the Work:**

All staff that shall use the PTW System shall be trained in the basic understanding of the Task Risk Assessment process, and may be asked to participate as a PA and/or TRA Team Member. They will also be responsible for making themselves aware of the controls and requirements of the Permits, Certificates and Task Risk Assessments which have been completed for any work they are involved in. They must stop work if conditions change, actively participate in the Tool Box or pre-job safety meeting and identify any lessons learned during the job.

III.4. Detailed TRA Procedure & Approvals:

III.4.1. Level 1 TRA process:

Once the task has been defined, the person to be in charge of the work must ensure that an appropriate Area Authority (AA) has been briefed on the scope of the task. The Area Authority (AA) must determine whether any significant hazards are likely to be involved, using his own knowledge/experience.

Where the risks are considered to be significant, the Area Authority (AA) must decide whether they can be controlled adequately by existing means, PTW or SWP; taking into account the safeguards required by any relevant Procedures, and the competence of the Performing Authority (PA).

If he is satisfied with the safeguards available, the Area Authority (AA) shall then endorse the PTW or SWP, to record his decision and to indicate that work can proceed, once the safeguards and controls have been implemented.

However, if the Area Authority (AA) is not completely assured that the risks will be adequately controlled by these measures, he must inform the Area Owner (AO) of the work and initiate a Level 2 TRA.

III.4.2. Level 2 TRA process:

A Level 2 TRA must be carried out where, as a result of Level 1 TRA, the Area Authority (AA) and/or Area Owner (AO), and/or performing authority (PA) believes that significant risks exist which will not be adequately controlled without additional safeguards.

The reasons for this view might include, for example:

- The task is new and unfamiliar;
- It is physically impossible to comply fully with the standards in a relevant local procedure, HSE Practice or other recognized source of guidance;
- Previously used safeguards may not be reasonably practicable in this case.

Mandatory level 2 TRA:

<u>A mandatory Level 2 TRA shall be completed for:</u>

- Potential to affect the integrity of operations
- Hot Work/Spark Potential activities in hazardous areas
- Complex Process, Mechanical and/or Electrical Isolations
- Confined Space Entry activities
- Excavation/Ground Disturbance
- Non-Routine Conventional Lifts/Complex Lifts
- Scaffold erection or dismantling (simple scaffolds will be based on judgement of AA/AO/PA depending on work area)
- Work on flare systems
- Tasks which are unfamiliar, or which involve unfamiliar methods or technologies
- Non-routine venting/draining/cleaning of equipment containing hazardous chemicals

The objective of the Level 2 TRA is to use onsite knowledge and experience in a structured manner to examine the hazards from first principles, and to devise a set of safeguards that shall ensure an acceptable level of risk. If necessary, expertise from external organizations/vendors can be brought in to assist with the risk assessment.

III.4.2.1. Appointment of level 2 TRA team leader & team:

The Level 2 TRA must be carried out by a team composed of competent persons who have knowledge and experience relevant to the task and who will be part of the work activity.

Appointment of level 2 TRA team leader:

The appointment of the Level 2 TRA TL shall be done by Line Manager of the Performing Authority (PA), in consultation with the Area Owner (AO) who has overall responsibility for the task that is to be completed.

The TRA must be approved by the responsible Area Owner (AO) who is trained to TRA Level 2.

Appointment of the level 2 TRA team members:

The Level 2 TRA TL shall select the TRA Team based upon the task to be completed; SIMOPS, and the knowledge required of the equipment, location and isolations etc. Depending on the complexity and size of the task involved, a typical team for plant operations, for example might include the following people:

- Shift Engineer Exploitation
- Performing Authority (the person supervising the activity)
- HSE Division representative
- Technical Authority

The Level 2 TRA Team may be supplemented by other members of the workforce or persons from out-with the site who may have specialist knowledge or experience which could help with the assessment.

The Level 2 TRA TL shall record the names of the team members, indicating their area/s of expertise and/or knowledge, which shall assist with the risk assessment.

The Level 2 TRA TL shall make proper arrangements for the group to meet in an arranged venue/meeting room, work together. It is important to ensure, for example, that there is adequate space for examination of drawings and that sufficient time is allocated to allow a rational decision to be reached.

III.4.2.2. Identification of hazards:

- The team shall define tasks and hazards associated with covered work.
- At least one member of the team shall visit the job site to see the physical layout of the area and potential job site hazards to be addressed in the Level 2 TRA. Particular attention should be given to adjacent facility and equipment, process-related hazards, and any Simultaneous Operations (SIMOPS) activities taking place or planned to take place which can affect the activity under assessment.
- The Leader of the Level 2 TRA Team shall list each covered task on the form. Any additional tasks can be listed at the team's discretion; however, all tasks listed shall be assessed in accordance with this procedure.

- Once the members are all familiar with the covered tasks to be performed, the team shall list the known or potential hazards associated with each defined task. The Leader of the Level 2 TRA team shall facilitate this group discussion. The following aspects of the tasks shall be considered when identifying hazards:
    - Characteristics of the facility and systems directly involved (e.g. pressure, noise, temperature, stability, voltage, H_2S, toxic chemicals, foam, wax, sludge)
    - Sensitivity of the location within the facility or job site caused by proximity of other critical assets or systems, (e.g. Heating, Ventilation and Air Conditioning (HVAC) intakes, flare header, control room, Natural Gas Liquid (NGL) separator, risers, Emergency Shutdown Valve (ESDV), structural support members, tankage)
    - Critical activities necessary to perform the task (e.g. lifting, draining fluid, inerting, isolation, flushing, entry into confined spaces, working at heights, transport of materials, equipment and wastes, use of power tools, hot work, grinding, bolting, use of cables and hoses)
    - Possibility of interaction between simultaneous activities within the permit covered task or other unrelated tasks taking place nearby (SIMOPS)
        - If there is a SIMOPS issue and the work cannot be rescheduled, hazards introduced from the SIMOPS shall be assessed on the Level 2 TRA form
- The Leader of the Level 2 TRA team shall make sure that each team member is given adequate opportunity to express their views.
- The Leader of the Level 2 TRA team may designate another team member to document hazards on the Level 2 TRA form.
- Hazards identified at the time of the job which are not associated with the permit covered tasks such as environmental factors (i.e. weather) that change from day to day shall be evaluated by the PTW process or can be added to the field copy of the TRA form if a Level 2 assessment is warranted by the workforce
- Hazards that are listed and addressed on the Level 2 TRA Form are not required to be included on the PTW form.

- Hazards that are listed and addressed on associated permits are not required to be included on the Level 2 TRA Form.

III.4.2.3. Evaluation of risks

Once the members are all familiar with the scope of the task to be carried out, the team should list all the significant hazards. This should be done during group discussion, with the team leader making sure that each team member is given adequate opportunity to express his/her views.

The risks created by each hazard identified shall be evaluated according to:

(a) The potential severity of the hazard effects, should anything go wrong

(b) The probability of the hazard being realized.

The TRA & ORA Risk Matrix shows one means of making these evaluations, which helps to focus attention on the most serious risks. Other approaches can be equally valid, provided they are used consistently.

The effectiveness of the assessment will depend entirely on the team's ability to identify and evaluate all significant hazards associated with the task. The main input should come from the competency, knowledge and experience of the team members.

III.4.2.4. Identification of Hazard Effects

- Each hazard shall be evaluated to determine the Hazard Effect and appropriate Hazard Effect level (A, B, C, D, E) using Table II-1- Hazard Effect Table.
- Consideration should also be given to the possibility of cumulative effects from the interaction of several different hazards.
- This initial identification of hazard effects shall be done with the assumption that there are no control measures or mitigations in place except for the normal PPE required by the PPE Matrix. The evaluation of hazard effects with control measures and mitigations in place shall be done during the determination of residual risk.

<u>Information/Note:</u> The initial assessment of risk shall be determined on the basis that no specific control measures exist except for the normal PPE required by the PPE matrix and:

• The worst reasonably credible severity of the hazard effects, should anything go wrong.

• The probability of the hazard being realized and resulting in the specified hazard effect

This is in order that the full risk potential may be recognized. The effectiveness of the assessment depends entirely on the team's ability to identify and evaluate all known hazards associated with the task.

Table III-1: Hazards Effect (HE) Table

Hazard Effect Level	Health and Safety	Environment	Privilege to Operate	Equipment Damage, Business Value Lost
A	Multiple Fatalities	>1000 bbl (fluids) > 10,000 lb (Flammable Gases) > 200,000 lb (Flammable Liquids) > 200,000 lb (gas/vapors/solids)	Public outrage Regional or prolonged media coverage or severe national coverage Actual or threatened loss of License to Operate for Likely to lead to change of regulations	$100m -$0.5 billion
B	Fatal Permanent Disability	100 < 1000 bbl (fluids) 1000 < 10,000 lb (Flammable Gases) 20,000 < 200,000 lb (Flammable Liquids) 20,000 < 200,000 lb (gas/vapors/solids)	Localized or limited "interest group" outrage Significant enforcement action agatnst Asset	$5m - $100m
C	DAFWC Hospitalization Temporary Disability	1 < 100 bbl (fluids) 100 < 1000 lb (Flammable Gases) 2000 < 20,000 lb (Flammable Liquids) 4000 < 20, lb (gaslvapors/solids)	Prolonged local media attention	$500k - $5m
D	No DAFWC No Hospitalization OSHA recordable	0.1 < 1 bbl (fluids) 10<10015 (Flammable Gases) 200 < 2,000 lb (Flammable Liquids) 400 < 4000 lb (gas/vail)rs/solids)	Short tem local media coverage Fines other to Asset	$50k - $500k
E	Simple First Aid	< 0.1 bbl (fluids) lb (Flammable Gases) <200 lb (Flammable Liquids) <400 lb (other hazardous vapors/solids)	Short term complaints from neighbors	<$50k

III.4.2.5. Determination of Probabilities and Initial Risk Level

For each identified Hazard Effect and associated Hazard Effect Level, the Probability (High – Medium - Low) of the Hazard Effect happening shall be selected from Figure III-2 Hazard Effect – Probability Matrix.

The following guidelines should be used for assigning probabilities:

H	Likely	Event will likely occur more than once per quarter. (FREQUENT)
M	Somewhat Likely	Event will likely to occur at least once per year but less than quarterly (PROBABLE)
L	Very Unlikely	Event likely to occur less than once per year (OCCASSIONAL)

Assignment of probabilities for initial and residual risk assessments shall be by consensus of the assessment team. The team should consider any site, district, region, IA, contractor or industry reference information available alone with the combined experience of the team or any internal/external experts consulted. Examples of reference information that can be utilized are as follows:

- Previous executions of same or similar job
- IA Incident databases and reports
- IA Near miss databases and reports
- Contractor vetting database
- API or other industry safety incident data
- Workforce experience with this scope of work
- Previous risk assessments

The initial Risk Level shall be determined from Figure III-2 and the risk level represents the product of the Hazard Effect Level and the Probability of the Hazard Effect being realized. The risk levels are: Low (L), Medium (M), High (H).

	A	B	C	D	E
PROBABILITY					
High (H) Event likely to occur more than once per quarter (FREQUENT) **H**	15	14	13	9	4
Medium (M) Event likely to occur at least once per year but less than quarterly (PROBABLE) **M**	12	11	10	5	3
Low (L) Event likely to occur less than once per year (OCCASSIONAL) **L**	8	7	6	2	1

Figure III-2: Hazard Effect vs. Probability Risk Matrix

Table III-2: Approval Level Matrix

Residual Risk Level		Minimum Level of Approval
High (H)	13 to 7	Task **cannot** commence due to unacceptable Residual Risk. RA TL to report back to Area Owner who Shall determine action required with Ops Manager & HSE Manager.
Medium (M)	6	RA TL to report back to Area Owner who Shall determine if task can commence or if additional control measures are required to further reduce residual risk.
Low (L)	5 to 1	Acceptable Residual Risk; Task can commence with Area Owner approval.

III.4.2.6. Identification of Control Measures and Mitigations

While identifying control measures and mitigations for hazards, consideration should be given to the following:

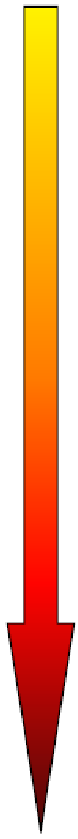
- Task
- People involved
- Tools, equipment, PPE, and materials to be used
- Working environment

The team shall work through the list of hazards to specify the methods needed to control each of their associated risks. Control measures over and above the normal PPE as required by the PPE Matrix shall be recorded as the team considers control measures necessary to achieve ALARP. The Hazard Effect - Probability Risk Matrix should be used as a guide for this purpose. The hierarchy of controls discussed below should be used as a guide so that a full range of options are considered.

When specifying Risk Control Measures, any associated hazards associated with controls to be implemented shall be identified and addressed in the assessment.

The hierarchy of controls is a sequence of options which offer a number of ways to approach the hazard control process. One representation of this hierarchy can be summarized and illustrated as follows:

Most Effective



Eliminate the hazard
Eliminate a hazard and completely eliminate the associated risk, i.e., conduct task else where, conduct the task during facility turn-a-rounds

If a hazard cannot be eliminated, continue to substitution:

Substitute the hazard with a lesser risk
Substitute something else (a substance, process, or practice) that has less potential to cause harm

If the hazard cannot be eliminated or substituted, continue to engineering controls:

Engineering controls
Use engineering controls to remove a hazard or place a barrier between the workforce and the hazard

If the hazard cannot be mitigated with engineering controls, continue to isolation methods:

Isolate the hazard
Contain the work environment or work process to interrupt the path between the workforce and the risk, e.g., insert blind flange, guards or barriers, set up temporary or permanent enclosures

If isolation methods are not feasible, use administrative controls:

Administrative controls
Reduce the risk by through training assuring competency of the workforce, the use of specialist personnel, changing rosters, close supervision, establish policies/standards or procedures such as permit policies

If this is not practical, then:

Personal protection equipment
When you can't reduce the risk in any other way, use personal protective equipment (e.g. gloves, goggles,) as a last resort

Least Effective

III.4.2.7. Determination of Residual Risk

Information/Note: The Residual Hazard Effect generally remains the same as the Initial Hazard Effect when mitigations such as PPE, administrative controls, and isolation are put in place, e.g. hearing protection mitigates a noise hazard but the initial and residual hazard effect of noise are the same. The Residual Hazard Effect may change from the Initial Hazard Effect when engineering, substitution and elimination mitigations are used, e.g. an initial hazard effect for electrical shock mitigated with a lockout can be eliminated as a residual hazard effect.

The team shall work to re-evaluate the hazard assuming that the identified control measures and mitigations are in place by repeating the process of determining the Hazard Effects, Hazard Effect Levels, Probabilities, and Risk Levels.

Once the team has reached agreement that the risks are considered to be As Low As Reasonably Practical (ALARP), the Hazard Effect Level, Probability, and Risk Level shall be recorded on the Level 2 TRA form in the residual risk columns.

After the residual risk level for each identified hazard has been recorded, the highest risk level shall determine the minimum level of approval for the Level 2 TRA based on Table 3 - Approval Level Matrix.

If the Residual Risk Level is in the High zone (7 – 13), the risk is unacceptable and the task cannot be performed without the implementation of further, more rigorous risk control measures to reduce the Risk Level to a lower level

Information/Note: When evaluating Residual Risk, consideration should also be given to the possibility of cumulative effects from the interaction of several different hazards.

If the team concludes they need additional team members to assist in the TRA, the task shall be suspended. The TRA Leader shall then request the participation by a subject matter expert as a team member.

As a final check, the team should ask itself the following questions about the proposed task:

- Was the hierarchy of risk control measures followed?
- Have all necessary risk control measures been identified?
- Is there a need for engineering change to eliminate or reduce risk?
- Is there a need to shutdown the facility in order to perform the work?
- Is the residual risk acceptable?

If the team determines that the residual risks are ALARP for the tasks to be performed, the team members shall sign the Level 2 Risk Assessment form indicating their completion of the Level 2 TRA.

III.4.2.8. Specification of Work Monitoring Requirements

Even though all work is to be monitored by the Performing Authority, if special monitoring over and above the norm is required, the Level 2 TRA Team shall

- Determine the requirements (if any) for additional monitoring for the execution of the tasks.
- Specify the frequency of additional monitoring, e.g., once per hour or monitoring at specific critical phases or job tasks.
- Document the additional monitoring requirements on the Level 2 TRA form.

III.4.2.9. Approval of Level 2 TRA

If the highest Residual Risk Level is Low, the Leader of the Level 2 TRA team shall approve the Level 2 TRA.

If the highest Residual Risk Level is Medium, the Leader of the Level 2 TRA team shall submit the Level 2 Risk Assessment form to the appropriate Terminal Manager or O&M Team Leader for approval.

If the highest Residual Risk Level is High, the Leader of the Level 2 TRA team shall submit the Level 2 Risk Assessment form to the District Operations Manager for approval using proper protocol with the Terminal Manager/O&M Team Leader and District Operations Manager if applicable.

If the approver accepts the level of risk, he/she shall approve the Level 2 Risk Assessment in writing to the Leader of the Level 2 TRA team.

If the approver does not accept the level of risk, he/she shall work with the Level 2 TRA team and other appropriate personnel to either change the tasks or modify equipment to reduce the Residual Risk Level.

After approval of the Level 2 Risk Assessment, the Leader of the Level 2 TRA team shall either make the completed Level 2 Risk Assessment form available to the Asset Operator or follow District procedures to file the TRA for future use.

III.4.2.10. Implementation of Control Measures

The AO shall verify that the identified risk control measures are implemented and communicated to the workforce.

III.4.2.11. Workforce Acceptance

The workforce shall sign the PTW form to verify they understand the scope of work, hazards identified and associated control measures.

III.4.2.12. Additional Hazards and Changes to TRA

- ***Additional Hazards Identified***

For additional hazards identified after approval, a Level 2 TRA Leader shall document the hazards on the TRA form in the section titled "Changes and Additional Hazards and/or Risk Control Measures". The additional hazards shall be evaluated and approved in accordance with this procedure.

- ***Changes to Level 2 TRA***

For changes to page 1 or 2 of the TRA form after approval, a Level 2 TRA Leader shall document the changes on the form and the changes shall be evaluated and approved in accordance with this procedure. Changes can include additional tasks, control measures, monitoring requirements or general comments identified after the original TRA was approved.

III.4.2.13. Use of a Previously Developed Level 2 TRA

A previously developed Level 2 TRA that is stored as an electronic file can be printed and used as a template for development of a current up-to-date TRA. The development and completion of the TRA shall be in accordance with this procedure

Electronic Level 2 TRAs that are associated with SPs shall be referenced in the SP using the TRA title and also linked to the electronic file.

III.4.2.14. Revision of a Level 2 TRA

The TRA Leader shall request a revision to the electronic version of the TRA to incorporate changes and additions made to the field copy when the changes and additions are expected to be present each time the job is performed.

If changes are not typically expected to be present each time the job is performed, the electronic version of the TRA does not need to be revised.

III.5. Specification of safeguards:

Typical safeguards can be classified as follows:

Table III-3: Safeguards Specifications

Safeguards	Typical examples
1. Physical	Removal of pipe work or fuses Insert spade or blank flange Lock valve Place mechanical barrier Use locked enclosure Keep people at a distance Eliminate or substitute toxic substances Substitute noisy machinery Use mechanical handling equipment, etc.
2. Procedural	Test for pressure build-up or leaks Test for toxic atmosphere or flammable gas Procedure for control of simultaneous or adjacent work Prohibition of hot work Equipment lock-out Develop contingency plan, etc.
3. Human	Use of independent specialist personnel Regular or constant monitoring of the task Clear instructions and warnings to workforce Clear definition of roles and responsibilities during the task Adequate supervision Ensure competency of personnel by special training for manual handling, use of machinery, etc.
4. Time	Limit duration of the task Use time-saving measures such as hot bolting, good work-site preparation and planning for movement of materials, tools, etc.
5. Contingency	Control: Emergency shutdown, deluge and blow down Systems, reduction of inventory, etc. Mitigation: Emergency response system, water curtain, provision of PPE, rescue equipment, etc.

The team should specify safeguards in all these categories, to the extent that they are appropriate. Particular emphasis, though, must be placed on physical or procedural safeguards which prevent or reduce risk, and contingency arrangements to control or mitigate the consequences if anything does go wrong.

Chapter IV:

Task Risk Assessment Application

IV.1. Conducting a Task Risk Assessment on the desulphirization and demercurization unit:

Task title:

"Unloading of the absorbent from the H2S and Mg absorbers"

The focus of this task is to apply the Task Risk Assessment (TRA) method to the desulphurization and demercurization unit at the In Amenas gas plant. This unit is critical for removing harmful contaminants like hydrogen sulfide (H2S) and mercury (Hg) from natural gas. Due to the high toxicity and corrosive nature of these substances, a detailed and systematic risk assessment is essential.

The Permit to Work (PTW) system which is level 1 risk assessment typically manages routine and some non-routine tasks, but it is insufficient for handling the complexities of desulphurization and demercurization. The processes involved here include significant hazards that require a more comprehensive approach, which TRA provides.

One critical aspect of this task is the replacement of absorbent materials in the H2S and Hg absorbers. After about a year of operation, the absorbents become saturated with H2S and Hg and need to be changed. This replacement task poses significant risks to workers because the spent absorbent becomes pyrophoric, meaning it can spontaneously ignite when exposed to air. This creates serious safety challenges and requires specific procedures and job steps to manage.

Handling and unloading the pyrophoric spent absorbent necessitate meticulous hazard identification and risk assessment. These activities involve several job steps, each with its own set of hazards that do not fall under the standard PTW system. Therefore, a dedicated TRA is essential to ensure all risks are properly identified and mitigated.

Applying TRA allows us to systematically address these risks, ensuring that all potential hazards are comprehensively managed. This proactive risk management approach not only enhances safety and operational efficiency but also protects the workforce and environment while ensuring compliance with regulatory standards. Such thorough assessments are vital for managing the high-risk operations at the In Amenas gas plant. The results of the application of the TRA method are represented in the tables below.

Task description :

First, we inert the vessel to control the oxygen levels and prevent contact with the absorbent. Next, we perform positive isolation to stop the vessel's operation and isolate it from the facility. We then remove the top elbow diffuser to open the vessel, ensuring AGT 1 is present at all times to monitor LEL and oxygen levels. We start the unloading process by installing a vacuum and unloading from the top manway. If the absorbent is free-flowing, we switch to the bottom manway. The remaining puraspec is then removed from the bottom mesh, requiring a worker to enter the vessel. Finally, we remove the mesh and the ceramic balls.

Table IV-1 : Hazard Effect Rating vs Probability with Residual Risk

HAZARD EFFECT RATING					
PERSONAL INJURY	**Fatality**	**Likely Permanent Disability**	**Hospital Stay**	**DAFWC, Medical Treatment**	**Simple First Aid**
PROPERTY DAMAGE	**Major Loss> $5 million**	**Significant Damage Loss $0.5 - $ 5 million**	**Moderate Damage Loss $100 to $ 500 K**	**Minor Damage Loss $10 K to $100 K**	**Minor Damage Loss <$10K**
HEALTH IMPACT	**Fatal**	**Chronic - Unfit to work for remainder of working life, but not Fatal**	**Acute - Hospital stay and long-term Medication and/or Treatment required**	**Moderate - Initial Medical Treatment, but no lasting effect**	**Minor - Temporary discomfort**
	A	**B**	**C**	**D**	**E**
PROBABILITY					
High (H) Event likely to occur more than once per quarter (FREQUENT) **H**	15	14	13	9	4
Medium (M) Event likely to occur at least once per year but less than quarterly (PROBABLE) **M**	12	11	10	5	3
Low (L) Event likely to occur less than once per year (OCCASSIONAL) **L**	8	7	6	2	1
IA RESIDUAL RISK	**13+**	**7 to 12**	**6**	**2 to 5**	**1**
Action Required	Task **cannot** commence; unacceptable Residual Risk. RA TL to report back to Area Owner who shall determine action required with Ops Manager & HSE Manager.	Task **cannot** commence; unacceptable Residual Risk. RA TL to report back to Area Owner who shall determine action required with Ops Manager & HSE Manager.	RA TL to report back to Area Owner who shall determine if task can commence or if additional control measures are required to further reduce residual risk.	Acceptable Residual Risk; Task can commence with Area Owner approval.	Acceptable Residual Risk; Task can commence with Area Owner approval.

IV.2. Task Risk Assessment results:

IV.2.1. Task Risk Assessment for the H2S and Mg Absorber V-1110:

To realize task risk assessment **table IV-2** was created in order to represents the TRA results for the V-1110, for more details about hazard identification see Appendix No

Table IV-2: TRA results for the V-1110

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			HE	P	R
1	N2 purge applied to the vessel	- N2 liquid - Spark potential - High pressure - Gas release: CH and H2S - High flow - Noise - TAR SIMOPS	- Fatality - Personal injury - Skin burn - Asphyxiation - Fire & explosion - Property damage	**A**	**L**	**8**	- Conduct Toolbox talk for all involved personnel. - N2 hazards and used hoses to be fully inspected and certified. - Adequate PPE to be worn during the activity (hearing protection, gloves) - Continuous authorised gas tester 3. - Weep-check must be installed - Provide a Nitrogen certificate with high purity.	EXPL Eng Linde gas PA HSE AGT3	**D**	**L**	**2**
2	V-1110 positive isolation	- Lifting Operations - Working at height - Dropped objects - Manual handling - Pyrophoric materials - Spark potential - Slip, trip & fall - Pressure	- Fatality - Property damage - Personal injury - Fire/Explosion - Pyrophoric reaction - Gas Release and/or possible	**A**	**L**	**8**	- LEL measurement by AGT 1 to be conducted commencement of positive isolation (less than 80%LEL). - Only one side will be under isolation while the other must be maintained close (avoid air circulation). - Nitrogen will maintain connected in case of pyrophoric - warm up, injection Will conducted. - Temperature monitoring of the vessel, use IR thermometer (if the temperature	MNT PA EXP ENG AGT 1 Linde gas PA	**D**	**L**	**2**

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	R		
				HE	P	R			HE	P	R
							in the inerted space increases 3°C in 15 minutes, work must stop) . - AGT1 to be on standby during activities. - Tow barricades in place: One for lifting exposed area, other for normal activities. - Area on the platform must be and well-sealed, tools also to well arranged. - Lift Plan to be andapproved prior to Lifting Operations. - Competent & Certified Crane Operator to be utilised, - Use good manual technics - Safety net to installed - Scaffolding to be installed at a - height Of m10 and the middle rail at 60cm after manway removal. - Area at platform to be well sealed and tools well arranged (Use box tools) - Safety signs and barriers to be erected				
3	- PURASPEC unloading using TECHNIVAC vacuum machine (no confined space entry) and top manway removal - If the Puraspec becomes 'Free Flowing' we will move operations to the 'Port Flo' at the bottom (side) manway.	- Ignition sources - Static electricity - Vehicle movement - N2 presence - Manual handling - Lifting operation - Dropped objects - Working at height - Pyrophoric materials - Noise/vibration - Dust - Trapped Pressure - Presence of Hydrocarbon	- Fatality - Property damage - Personal injury - Fire - Pyrophoric reaction - Asphyxiation - Spill (environment impact) - Intoxication - Hydrocarbon release	**A**	**L**	**8**	- Tow barricades in place: One for lifting exposed area. other for normal activities. - LEL measurement must be less than 1 % LEL within a distance upper than 1.5 m from nitrogen jet area (Stop if it is more). - Adequate hard guard body and adequate length (handrail I .5 m) must limit the mouth (opening) of top man way. - Competent Operators to wear Airline SCBA sets and wear PPE (Safety harness, Nitrile Gloves, Disposable	MNT PA EXP ENG AGT 1 Linde gas PA HSE intervention	**D**	**L**	**2**

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			**HE**	P	R
	- A vacuum lance will be used from outside to remove as much Puraspec as possible						Coveralls). - AGT3 1 Authorised Gas Tester to be on site during all activities. - AGT3 Continuous Gas Testing to be specified on PTW. - LEL in N2 gas detectors to be used. Unloading operation will not proceed until LEL levels have been achieved. - Set-up an adequate liner at Puraspec discharge drums of equipment. - Temperature monitoring of the vessel, use IR thermometer (if the temperature in the inerted space increases 30C in 15 minutes, work must stop). - use of anti-static electricity hoses. - use an earthling wire on the flexible of vacuum machine to ensure no static electricity - specific cartridge musk must be worn (during drums sealing) - Earplugs should be wom when the vacuum functioning. - Create Two permits for transport the drums, one in CPF & the second permit Gard house CPF to JK YARD - Continuous temperature monitoring for each refiled drum with the unloaded Puraspec **after 10min**. - Ensure that All unloaded PURASPEC drums are well sealed and moved to JK yard storage area at each end of the shift. - Permanent Monitor of wind condition. - Inspect Wood palette before any use				

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			**HE**	P	R
							and eliminate the broken ones. - Ensure a good storage of used Puraspec drums in CPF and JK Yard. - Tarpaulin to be used in case of spread of contaminated Puraspec. - All electrical equipment must be inspected and ATEX certified - Weep-check must be installed				
4	Unloading of the remaining Puraspec on the bottom Mesh surface (agglomerated Puraspec).	- Confined space Entry - Lack of air - Ignition sources (Static electricity, tools) - Manual handling - Dropped objects - Working at Height - Pyrophoric Materials - Dust - Trapped Pressure - Presence of Hydrocarbon - Hg presence - Chemical product - Connected nitrogen flexible. - Heat stress	- Fatality - Personal injury - Fire - Pyrophoric reaction - Asphyxiation - Hg Intoxication	**A**	**L**	**8**	- **All nitrogen connections will be disconnected before CSE entry.** - Wear the BA for entering the CS, use BA emergency kit. - Keep the top and side manway open to ensure adequate aeration. - The task will not proceed with BA if the Oxygen Content (%) is less than **19** and **> 20.8%**. - Housekeeping and Area at platform to be well sealed and tools well arranged (use a box tools). - Wear Hg cartridge with full face mask during unloading operations. - All persons wearing BA must rotate often to avoid the risk of fatigue. - In the event that the temperature increases by more than **3°C** in **15 minutes**, stop the work and consider N2 injection. - Nitrogen will be maintained in place available for use during CSE in case of Pyrophoric warm up, injection will be conducted. - Use the original wired flexible of vacuum	MNT PA EXP ENG AGT 1 Linde gas PA HSE intervention	**D**	**L**	**2**

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			**HE**	P	R
							machine to ensure no static electricity. - Continuous temperature monitoring for each refiled drum with the unloaded Puraspec after 10min. - Adequate PPE to be worn during all activity. - All electrical equipment must be inspected and ATEX				
5	- Remove the mesh and unloading of ceramic balls	- Confines Space Entry (CSE) hazards - Manual Handling - Vehicle movement - Dropped objects - Working at height - Noise/vibration - Insufficient lighting - Biological hazards - Electricity	- Fatality and/or Personnel Injury - Asphyxiation - Environment impact	**A**	**L**	**8**	- AGT 1 to ensure gas measurennent before CS entry and continuous gas monitoring by AGT3 - Nitrogen must be stopped. - Enough ventilation and lightening for confined space entry - Adequate PPE to be worn (chemical coverall, specific gloves, Cartridge mask) - Stand by man with Radio - use adequate lighting for Confined space - Use good manual handling	**MNT PA AGT 1, AGT3**	**D**	**L**	**2**

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			**HE**	P	R
	- Vessel Loading from the bottom Manway & the top Man way door	- Lifting Operations - Dropped Objects - Chemical product - Working at height - Spark potential - Noise	- Serious Injury - Fatality - Fire & explosion - Property damaged - Spill	**A**	**L**	**8**	- Appropriate respiratory protection will be worn - Lifting plan to be out for task. - Tow barricades in place: One for lifting exposed area, other for normal activities. - Adequate hard guard body an adequate length (handrail 1.5 m) must limit the mouth (opening) of top man way. - Set-up an adequate liner at Puraspec discharge drums of Technivac equipment. - Puraspec dust and empty drums to managed with management waste procedure. - Standby man with radio to control space activities. - Rescue plan at worksite.	**EXP/PA**	**D**	**L**	**2**

IV.2.2. Task Risk Assessment for the H2S and Mg Absorber V-1112:

To realize task risk assessment **table IV-3** was created in order to represents the TRA results for the V-1112, for more details about hazard identification see Appendix No

Table IV-3: TRA results for the V-1112

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			HE	P	R
1	N2 purge applied to the vessel	- N2 liquid - Spark potential - High pressure - Gas release: CH and H2S - High flow - Noise - TAR SIMOPS	- Fatality - Personal injury - Skin burn - Asphyxiation - Fire & explosion - Property damage	**A**	**L**	**8**	- Conduct Toolbox talk for all involved personnel. - N2 hazards and used hoses to be fully inspected and certified. - Adequate PPE to be worn during the activity (hearing protection, gloves) - Continuous authorised gas tester 3. - Weep-check must be installed - Provide a Nitrogen certificate with high purity.	EXPL Eng Linde gas PA HSE AGT1	**D**	**L**	**2**
2	0*-V-1112 positive isolation Top elbow/diffuser removal	- Lifting Operations - Working at height - Dropped object - Manual handling - N2 presence - Pyrophoric materials - Ignition sources - Inert atmosphere - Hydrocarbon presence	- Fatality - Property damage - Personal injury - Fire - N2 High pressure - Pyrophoric reaction - Asphyxiation				- The task will not be carried out unless the LEL is **<10%** in air at a distance of **one metre** of top many way, while inside N2 the LEL less than **<80%.** - Ensure no nitrogen pressure prior opening of the top blind man-way. - While the removal of the top blind, all others blinds/valves must be kept close. - Permanent temperature monitor, using an infrared thermometer. - Nitrogen will be maintained connected for injection in case of pyrophoric warm up. - In the event that the temperature increases by more than **3°C** in **15**	MNT PA EXP ENG AGT 1 Linde gas PA			

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			**HE**	P	R
				A	**L**	**8**	**minutes**, stop the work and consider N2 injection. - Ensure integrity of hoses and fittings. - Area at platform must be well sealed and tools well arranged (use a box tools). - Only certified and tested lifting equipment to be used. - Safety signs and Barriers to be erected - Only authorised personnel to be within the area where lifting operation is taking place. - Taglines to be used to control the load while lifted. - Use good manual handling. - Initial gas testing AGT1 and flagman with personal gas detector AGT3 to control potential ignition sources. - Ensure communication between PA's - Weep-check must be installed.		**D**	**L**	**2**
3	- PURASPEC unloading using TECHNIVAC vacuum machine (no confined space entry). - If the Puraspec becomes 'Free Flowing' we will move operations to the 'Port Flo' at the bottom (side)	- Ignition sources - Static electricity - Vehicle movement - N2 presence - Manual handling - Lifting operation - Dropped objects - Working at height - Pyrophoric materials - Noise/vibration - Dust - Trapped Pressure - Presence of Hydrocarbon	- Fatality - Property damage - Personal injury - Fire - Pyrophoric reaction - Asphyxiation - Environment impact - Hg Intoxication	**A**	**L**	**8**	- The task will not be carried out unless the LEL is **<10%** in air at a distance of **<u>one metre</u>**, while inside N2 at man-way, the LEL less than **<80%.** - Permanent N2 purging during the task, ensure positive pressure more than atmospheric pressure. - Personnel working on the V-1112 platform to wear BA during the Puraspec unloading. - Personnel working on the top to wear a safety harness during all the activity. - Housekeeping and Area at platform to be well sealed and tools well arranged	MNT PA EXP ENG AGT 1 Linde gas PA HSE intervention	**D**	**L**	**2**

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			**HE**	P	R
	manway. - A vacuum lance will be used from outside to remove as much Puraspec as possible	- Hg presence					(use a box tools). - Wear Hg cartridge with full-face mask during unloading operations. - All persons wearing BA must rotate often to avoid the risk of fatigue. - In the event that the temperature increases by more than **3°C** in **15 minutes**, stop the work and consider N2 injection. - Continuous temperature monitoring for each refiled drum with the unloaded Puraspec **after 10min**. - Continuous gas level 1 monitoring to be applied during the task. - Ensure that All unloaded PURASPEC drums are well sealed and moved to JK yard storage area at each end of the shift. - At the end of each unloading operation, all open manways must be closed and V-1112 must be kept under positive N2 pressure. - Permanent Monitor of wind condition. - Use the original wired flexible of vacuum machine to ensure no static electricity. - Inspect Wood palette before any use and eliminate the broken ones. - Ensure a good storage of used Puraspec drums in CPF and JK Yard. - Adequate PPE to be worn during all activity. - Tarpaulin to be used in case of spread of contaminated Puraspec. - All electrical equipment must be				

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk R		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible			
				HE	P	R			HE	P	R
							inspected and ATEX certified - Weep-check must be installed				
4	Unloading of the remaining Puraspec on the bottom Mesh surface (agglomerated Puraspec).	- Confined space Entry - Lack of air - Ignition sources (Static electricity, tools) - Manual handling - Dropped objects - Working at Height - Pyrophoric Materials - Dust - Trapped Pressure - Presence of Hydrocarbon - Hg presence - Chemical product - Connected nitrogen flexible. - Heat stress	- Fatality - Personal injury - Fire - Pyrophoric reaction - Asphyxiation - Hg Intoxication	**A**	**L**	**8**	- **All nitrogen connections will be disconnected before CSE entry.** - Wear the BA for entering the CS, use BA emergency kit. - Keep the top and side manway open to ensure adequate aeration. - The task will not proceed with BA if the Oxygen Content (%) is less than **19** and **> 20.8%**. - Housekeeping and Area at platform to be well sealed and tools well arranged (use a box tools). - Wear Hg cartridge with full face mask during unloading operations. - All persons wearing BA must rotate often to avoid the risk of fatigue. - In the event that the temperature increases by more than **3°C** in **15 minutes**, stop the work and consider N2 injection. - Nitrogen will be maintained in place available for use during CSE in case of Pyrophoric warm up, injection will be conducted. - Use the original wired flexible of vacuum machine to ensure no static electricity. - Continuous temperature monitoring for	MNT PA EXP ENG AGT 1 Linde gas PA HSE intervention	**D**	**L**	**2**

N°	Job steps	Hazard Identified	Hazard Effect	Risk Evaluation			Control Measures	Action	Residual Risk		
		Use the checklist as a guide and be specific	Type of Injury/ Equipment damage or Environmental Impact	Refer to the evaluation form			**Required** (Include existing and proposed)	Person Responsible	**R**		
				HE	P	R			**HE**	P	R
							each refiled drum with the unloaded Puraspec after 10min. - Adequate PPE to be worn during all activity. - All electrical equipment must be inspected and ATEX				
5	- Remove the mesh and unloading of ceramic balls	- Confines Space Entry (CSE) hazards - Manual Handling - Vehicle movement - Dropped objects - Working at height - Noise/vibration - Hg presence	- Fatality and/or Personnel Injury - Asphyxiation - Environment impact - Hg Intoxication	**A**	**L**	**8**	- When middle Manway is removed, a safety harness attached to yoyo must be worn and secured to a suitable anchor point, to prevent potential falls into vessel. - Only trained personnel will be entering the vessel - Standby man with radio to control confine space activities - Continuous gas monitoring will be in place - Hg measurement must be conducted before CSE - Specific PPE in reference to CSE procedure (appendix 3) must be worn - All nitrogen connections will be disconnected. - Tarpaulin to be used in case of spread of contaminated Puraspec. - Good technics of manual handling	**MNT PA AGT 1**	**D**	**L**	**2**

❖ Results interpretation:

The detailed hazard identification and risk assessment using the TRA methodology for the desulphurization and demercurization units at the In Amenas gas plant reveal significant safety and operational challenges. Hydrogen sulfide (H2S) exposure presents a high risk (severity: Fatality, probability: Low) due to its toxicity and corrosiveness, necessitating robust safety measures like continuous monitoring, effective ventilation systems, and the use of personal protective equipment (PPE). Fire and explosion risks from handling flammable hydrocarbons are rated as medium risk (severity: Fatality, probability: Low), and include the additional hazard of pyrophoric reactions from contaminated absorbent materials. These materials can spontaneously ignite when exposed to air, highlighting the need for strict safety protocols, regular equipment inspections, and preventive measures to manage and store these absorbents safely. Worker training and awareness programs are crucial to maintaining a high level of preparedness and response capability.

Pressure release events due to over-pressurization or malfunctioning relief devices are high-risk (severity: Likely Permanent Disability, probability: Medium), necessitating effective pressure management systems and comprehensive training for operators on emergency procedures. High temperature operations pose a medium risk (severity: DAFWC Medical Treatment, probability: Medium) of heat stress or heat-related illnesses, indicating the need for current heat management practices and continuous monitoring of workplace temperatures. Noise exposure from high machinery levels results in a medium risk (severity: Hospital Stay, probability: Medium) of hearing loss or other auditory issues, necessitating hearing protection and regular noise monitoring. Chemical spills of acids, solvents, and other chemicals are medium-risk hazards (severity: Hospital Stay, probability: Medium) that underscore the importance of spill containment measures and emergency response plans. Ergonomic hazards from manual handling and repetitive tasks pose a medium risk (severity: DAFWC Medical Treatment, probability: Medium) of musculoskeletal injuries, indicating the need for ergonomic assessments and workplace adjustments.

Mercury exposure in the demercurization unit presents a medium risk (severity: Likely Permanent Disability, probability: Low) due to its neurotoxic effects, highlighting the need for continuous monitoring, stringent handling procedures, and regular health assessments.

Confined space entry poses significant risks, including oxygen deficiency, toxic atmosphere, and limited entry and exit points. These factors require stringent safety protocols, continuous atmospheric monitoring, and specialized training for workers to ensure safety during such operations. Working at night introduces additional risks due to reduced visibility, worker fatigue, and potential delays in emergency response. These factors can exacerbate existing hazards such as chemical exposure, equipment failure, and pressure release events. Enhanced lighting systems, fatigue management programs, and increased supervision are essential to mitigate these risks. Regular breaks, rotational shifts, and improved communication systems can help manage worker fatigue and ensure adherence to safety protocols.

❖ Recommendations

- **<u>Training and Competence:</u>** Enhance training programs for all personnel, particularly night shift workers, in using TRA and PTW systems, with regular refreshers and emergency drills to maintain high awareness and preparedness levels.

- **<u>Safety Culture:</u>** Foster a culture that encourages proactive hazard identification and reporting, implementing a reward system for teams demonstrating exceptional safety practices.

- **<u>Technological Investments:</u>** Invest in real-time monitoring technologies to promptly detect system performance and potential risks, deploying additional safety measures such as automated alerts for anomalies detected during night operations.

- **<u>Operational Adjustments:</u>** Implement fatigue management programs with scheduled breaks and rotational shifts to manage worker fatigue, increasing supervision and support during night shifts to ensure adherence to safety protocols, and improving lighting and visibility in all operational areas.

- **<u>Behavioral Safety Programs:</u>** Develop behavioral safety programs to encourage safe practices and awareness among workers, holding regular safety meetings and discussions on recent incidents and near-misses to help in learning and preventing future occurrences.

- **<u>Enhanced Communication Systems</u>:** Implement advanced communication systems to ensure effective and timely communication between workers, especially during night shifts, including emergency communication devices and regular check-ins.

- **<u>Risk Assessment Updates:</u>** Regularly update risk assessments to reflect changes in processes, equipment, or regulatory requirements, ensuring all potential hazards are identified and mitigated promptly.

- **<u>Collaborative Safety Initiatives:</u>** Encourage collaboration between different departments and teams to share best practices and safety innovations, with joint safety drills and exercises to enhance preparedness and foster a collective safety culture.

❖ Plan of action:

After conducting the TRA a plan of action was put together in order to further improve safety in this task. **The table IV-4** shows the solutions given to apply such improvements:

Table IV-4: the plan of action

Type of Solution	Action	Responsible
Technical	Design and purchase of an adjustable height cart to transport contaminated absorbent bags.	Purchasing Department
Technical	Specialized training for operators on handling procedures for pyrophoric absorbents.	Human Resources
Technical	Installation of H_2S and Hg detectors in work areas for continuous monitoring.	Safety Department
Technical	Implementation of an emergency plan specific to incidents involving pyrophoric substances.	Safety Department
Technical	Acquisition and distribution of additional personal protective equipment (PPE) for handling contaminated absorbents.	Purchasing Department
Technical	Provide proper training for workers on the use of equipment and PPE for handling pyrophoric materials and ensure adherence to proper procedures.	Human Resources
Organizational	Implement shift rotations to minimize prolonged exposure to toxic substances.	Human Resources
Organizational	Schedule regular breaks to allow operators to recover and relieve fatigue from handling hazardous substances.	Human Resources
Organizational	Enhance supervision and support during night operations to ensure compliance with safety protocols.	Human Resources
Organizational	Implement enhanced monitoring systems for night work, including frequent safety rounds.	Safety Department
Safety	Regularly update risk assessments to reflect changes in processes, equipment, or regulatory requirements.	HSE Department
Safety	Foster collaboration between departments to share best practices and innovations in safety.	Human Resources
Safety	Improve lighting in work areas to ensure optimal visibility during night operations.	Maintenance Department
Safety	Provide healthy snacks and beverages for night shift teams to maintain their energy and alertness.	Human Resources
Safety	Training on the use of PPE in confined spaces, and training about the dangers of H_2S and Hg, and working in inert spaces.	Human Resources

❖ Advantages and Inconveniences of TRA

➢ Advantages

- **Systematic Risk Identification:**
  - Comprehensive Coverage: Identifies a wide range of hazards.
  - Detail-Oriented: Ensures thorough hazard identification and risk assessment.
- **Proactive Risk Management:**

- Prevention Focus: Prevents accidents by identifying risks early.
- Mitigation Strategies: Develops effective strategies to manage and control risks.

- **Improved Safety Culture:**
  - Awareness and Training: Fosters a safety-conscious culture through extensive training.
  - Employee Involvement: Encourages proactive hazard identification among workers.
- **Enhanced Operational Efficiency:**
  - Downtime Reduction: Minimizes operational disruptions.
  - Maintenance Planning: Enables better maintenance planning and resource allocation.
- **Regulatory Compliance:**
  - Alignment with Standards: Ensures compliance with international safety standards.
  - Documentation and Reporting: Provides thorough documentation for audits and inspections.
- **Tailored Risk Controls:**
  - Hierarchy of Controls: Applies elimination, substitution, engineering controls, administrative controls, and PPE.
  - Task-Specific Measures: Develops specific controls for each task

➢ **Inconveniences**

- **Resource Intensive:**
  - Time-Consuming: Requires significant effort and attention to complete thoroughly.
  - High Costs: Involves substantial costs for training, hiring experts, and implementing controls.
- **Complexity:**
  - Technical Expertise: Needs high technical expertise and experience.
  - Complex Procedures: Can be challenging to manage, especially for smaller organizations.
- **Employee Resistance:**
  - Change Management: May face resistance from employees accustomed to existing practices.
  - Engagement Challenges: Ensuring active participation can be difficult.
- **Potential for Overlooked Risks:**
  - Human Error: Subject to human error, potentially overlooking certain risks.
  - Bias and Subjectivity: Effectiveness depends on the objectivity of assessors.
- **Maintenance of Updated Information:**
  - Continuous Monitoring: Requires ongoing monitoring and regular updates.

- Data Management: Managing extensive risk assessment data can be challenging.

- **Integration with Existing Systems:**
  - Compatibility Issues: Integrating with existing systems may present challenges.
  - Implementation Barriers: Ensuring effective implementation can be difficult.

Conclusion:

The interpretation of the results from the TRA methodology highlights the critical role of comprehensive risk assessments in enhancing safety and operational efficiency at the In Amenas gas plant. The probability of many of these hazards occurring is rated as low due to the effective implementation of existing safety measures, robust protocols, and preventive maintenance strategies. However, the gravity or severity of these hazards remains very high, underscoring the potential catastrophic consequences if they were to occur. This duality necessitates continuous vigilance and improvement to ensure that the likelihood remains low while the safety measures are strengthened to mitigate the high-severity impacts. By systematically identifying and mitigating risks, the plant can safeguard its personnel, equipment, and environment. Continuous improvement and adherence to international standards will ensure sustained safety performance and operational excellence, particularly in addressing the unique challenges posed by night operations and evolving industrial practices.

General conclusion

The application of the Hazard Identification and Task Risk Assessment (TRA) methodology in the desulphurization and demercurization units at the Tiguentourine gas plant demonstrates the significant benefits of a systematic approach to identifying and managing risks in high-risk industrial environments. By thoroughly identifying potential hazards and assessing the associated risks, TRA enables proactive risk management, which is crucial for preventing accidents, minimizing downtime, and ensuring the health and safety of the workforce. This thesis highlights the importance of adhering to international safety standards, such as ISO 45001 and OHSAS 18001, and regulatory frameworks like OSHA and EU-OSHA, which mandate systematic risk assessment procedures and the adoption of the hierarchy of controls. The proactive identification and mitigation of risks, facilitated by TRA, align with these standards and contribute to creating a safer working environment.

The IN AMENAS project, with its complex operations in desulphurization and demercurization, exemplifies the challenges of processing hydrocarbons and the critical role of TRA in addressing these challenges. The methodology's comprehensive framework ensures that both routine and non-routine tasks are assessed, and specific control measures are developed to manage identified risks effectively. This study specifically highlighted certain hazards and risks associated with the desulphurization and demercurization processes, such as the exposure to toxic gases like hydrogen sulfide ($H2S$) and mercury, the potential for fire and explosion due to pyrophoric reactions from contaminated absorbent materials, and the risks associated with high-temperature operations. By systematically evaluating these hazards, the study provided detailed insights into the severity and probability of these risks, offering tailored recommendations to mitigate them.

Additionally, the study underscored the importance of managing less obvious but equally significant risks, such as ergonomic hazards from manual handling tasks, noise exposure from machinery, and the dangers of confined space entries. These findings emphasize the necessity of a holistic approach to risk assessment that covers a wide spectrum of potential hazards. While TRA offers numerous advantages, such as improved safety culture, enhanced operational efficiency, and regulatory compliance, it also presents challenges, including being resource-intensive and complex. These challenges underscore the need for ongoing training, continuous monitoring, and active engagement of all employees to maintain an effective risk management system.

In conclusion, the systematic application of TRA in the Tiguentourine gas plant not only enhances safety and operational efficiency but also provides valuable insights into best practices for risk management in the oil and gas industry. The findings and recommendations from this study can serve as a reference for other facilities facing similar challenges, emphasizing the importance of systematic risk assessment methodologies in promoting a safer and more efficient working environment in high-risk industries.

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Appendices

Appendix 1: AGT

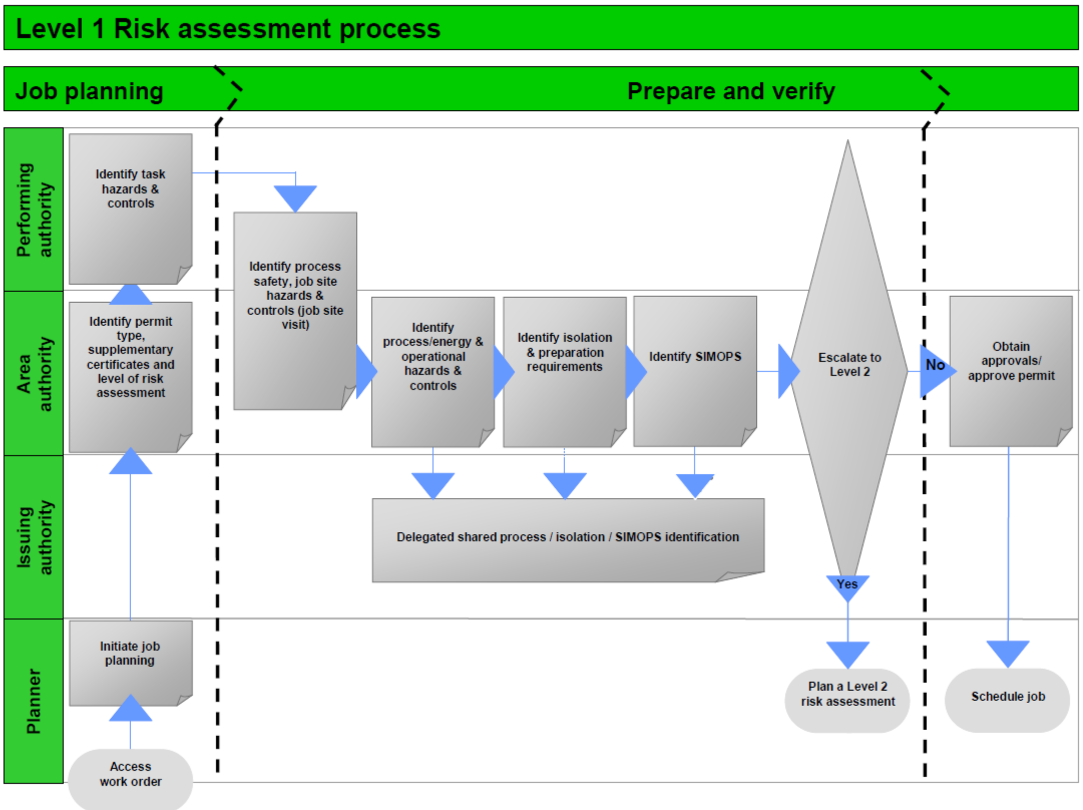
Authorised Gas Tester

An Authorised Gas Tester (AGT) is defined as a person who is trained, assessed as competent and authorised to use gas detector equipment- They Shall be authorised to test for the presence of flammable vapours, toxic gas and oxygen in suppolt of the permit or confined space entry.

An AGT's training should be provided by the manufacturer of the equipment (or a recognised agent) and should be valid for two years maximum (or frequency required by local legislation).

The AGT remains authorised, subject to the person using the gas tester equipment regularly or at least once every twelve months- Anyone not having used a gas detector in the previous twelve months Shall undergo refresher training in the form of supervised equipment re-familiarisation before carrying out gas testing.

Appendix 2: Level 1 Risk assessment process



Appendix 3: Level 2 Risk assessment process