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1. PROJECT OVERVIEW

Provide an overview of the ammonia pipeline project, including key details such as:

- Pipeline route: Outline the route of the pipeline can be found in the overview below (see Figure 1)
- Ammonia transportation: Ammonia will be transported through the pipeline in Liquid form at ambient temperatures and under pressure (25barg). The parameters of the pipeline are defined in Table 1-1
- Project scope: The ammonia pipeline will transport ammonia from the ammonia production facility located north of Arandis, to the North port in Walvis Bay. The ammonia pipeline will pass through Farm 58, portion 8 and have a Tie-In at this location. The diameter of the pipeline will be 8". The pipeline will be mainly underground and partly aboveground. Sectioning valves will be installed over the length of the pipeline to ensure a section of the valves can be safely shutdown in case of an emergency.



Figure 1-1. Locality map

Table 1-1. Parameters of the ammonia pipeline

Parameter	Unit	Ammonia pipeline
Transported fluid	-	Ammonia
Operating pressure at inlet	Bar(g)	25-50barg
Operating temperature at Inlet	°C	5-25°C
Design pressure	Bar(g)	60
Design temperature	°C	0 / 60
Nominal design diameter	inches	8
Wall thickness	mm	TBC
Material	-	Carbon steel
Line pipe type	-	SAW
Material grade	-	API 5L X52
Specified minimum yield stress	MPa	360
Insulation layer	mm	0 (no insulation)
Corrosion allowance	mm	1.5
Design Code	ASME B31.4	
Depth of cover	Min 300 mm, max 1000mm	

2. RISK ASSESSMENT OBJECTIVES

- Identify high risk factors
- Identify sensitive receptors including workforce
- Mitigation measures and strategies
- Emergency Response and Contingency Planning

3. HIGH RISK IDENTIFICATION

3.1 HIGH-RISK AREAS TO CONSIDER:

The following high-risk areas should be evaluated for potential impacts on human health, safety, and the environment:

1. Pipeline Integrity and Failure
 - o Potential for leaks, ruptures, or pipeline corrosion leading to ammonia release.
2. Ammonia Release/Leakage
 - o Ammonia releases due to equipment failure, natural disasters, or operational errors.
3. Health and Safety Impacts on Workers
 - o Exposure to ammonia during pipeline commissioning, maintenance, and emergency situations.

4. Environmental Impacts
 - Ammonia leakage affecting surrounding ecosystems, water bodies, or soil.
5. Fire or Explosion Risks
 - Risks arising from ammonia exposure to ignition sources, leading to fire or explosion.
6. Transportation and Installation
 - Risk of accidents during the transport, handling, and installation of ammonia in pipeline construction.
7. Emergency Response and Contingency
 - Delayed or inadequate response to ammonia spills, leaks, or accidents.

4. SENSITIVE RECEPTORS IDENTIFICATION AND IMPACT ASSESSMENT

Identify the receptors (e.g., people, animals, water bodies, vegetation) within proximity to the pipeline and assess the potential impacts on each. The safety distances expressed in the table below will be confirmed during the QRA that is part of the engineering process of the pipeline. These may include:

4.1 SENSITIVE RECEPTORS TABLE

Receptor	Pipeline	Risk/Impact Foreseen	Mitigation Measures
Residential Areas	0-500 meters	Exposure to toxic ammonia vapor in the event of a leak or rupture.	- Installation of ammonia detection systems.
		Fire or explosion risks if ammonia is exposed to ignition sources.	- Buffer zones around residential areas.
		Health issues such as respiratory distress or poisoning.	- Emergency response planning (evacuation routes, shelters).
Schools/Daycare Centers	0-500 meters	Acute exposure to ammonia vapor, especially in the case of high winds.	- Public awareness programs.
		Health risks for children or staff due to ammonia exposure.	- Installation of remote shut-off valves and leak detection systems.
Agricultural Land	0-2 km	Ammonia leaks affecting crops or livestock, leading to contamination.	- Ammonia containment systems around high-risk zones.
		Soil and water contamination from ammonia leaks.	- Regular inspections and maintenance of the pipeline.
Water Bodies	0-2 km	Ammonia contamination of surface or groundwater.	- Spill containment measures and emergency plans for water

5. RISK EVALUATION

5.1 RISK LIKELIHOOD AND CONSEQUENCE MATRIX

Risk evaluation involves determining the likelihood and potential consequences of identified risks. The following matrix can be used to rank risks:

Likelihood	Consequence	Risk Level	Action Required
Rare	Minor	Low	Monitor and review periodically
Possible	Moderate	Medium	Implement control measures and review periodically
Likely	Severe	High	Immediate corrective actions required

5.2 KEY RISK SCENARIOS

Consider the most significant risks based on likelihood and consequence:

Ammonia Leak or Rupture

Likelihood: Rare (due to aging infrastructure, accidents, or third-party interference. This risk can be mitigated by proper maintenance, fencing, leak detection and surveillance)

Consequence: Severe (toxic exposure to nearby populations, environmental contamination)

Pipeline Corrosion

Likelihood: Rare (if proper corrosion control measures are in place)

Consequence: Moderate (localized leaks and soil contamination)

Explosion or Fire Due to Ammonia Exposure

Likelihood: Rare (due to proper safety measures and narrow explosion limits of ammonia)

Consequence: Severe (severe impact on public health and infrastructure)

Health Impacts on Workers

Likelihood: Possible (Workers will need to be trained and where the proper PPE)

Consequence: Moderate (respiratory problems or injuries)

Wildlife and Ecosystem Contamination

Likelihood: Possible (due to leaks near sensitive ecosystems)

Consequence: Moderate to Severe (impact on wildlife, soil, and water)

6. IMPLEMENTED MITIGATIONS AND STRATEGIES

During the Front-end engineering design (FEED) study of the pipeline the risk associated with the pipelines will be evaluated and mitigation measures will be defined and implemented.

During the engineering studies of the pipelines, that have commenced on 12 February 2025, CMB.TECH together with its engineering partner will perform a risk assessment of the installation.

During the engineering work the following safety deliverables will be prepared for the pipeline:

- PFD's/P&ID's
- Material Safety Data Sheets.
- Emissions, Effluent and Waste Schedule.
- Noise Study.
- Hazardous Area Classification File.
- Fire Zone (FPZ) Layouts (showing Passive Fire Protection).
- Fire and Gas Hazard Analysis.
- Fire Protection Design Criteria Plans (process buildings).
- Safety Equipment Summary for emergency safety showers, eye wash stations, portable fire extinguishers, escape sets, fire protection etc.
- Pipeline risk assessment
- Hydraulic Transient Analysis Report
- Typical highway and water crossings
- Geohazard Assessment and Design Report (if applicable)
- Cathodic Protection Philosophy
- Coating Selection Report
- Leak detection definition
- Block valve installation philosophy

To ensure a proper and safe design the following measures will be taken during the engineering and construction phases of the project.

Measure	Type	Description of measure
Mechanical design according to ASME B31.4	Preventive measure	The American Society of Mechanical engineers have developed design codes for pipelines that are suitable oil and gas applications. Using these standards will ensure a proper design of the Pipelines installation

HAZID review	Preventive measure	A HAZID review is a qualitative risk analysis technique used to identify potential hazards and threats in a process. It is typically conducted in a workshop setting and aims to alert management to any threats and hazards as early as possible. The identified hazards are classified based on their probability of occurrence and the severity of their consequences
ENVID review	Preventive measure	A ENVID focuses on identifying environmental aspects that arise from the interaction between a facility and its surroundings. The goal is to plan for, avoid, or mitigate potential environmental impacts.
QRA by an independent 3 rd party	Preventive measure	A QRA is a structured process used to identify, analyse, and quantify risks in numerical terms. It determines the probability of hazardous events occurring and their potential consequences.
HAZOP / LOPA by an independent 3 rd party	Preventive measure	A HAZOP review is a structured and systematic examination of a complex system, typically a process facility, to identify potential hazards and operability issues that could affect safety and efficiency
Material selection review	Preventive measure	a systematic process used to identify the most suitable materials for a specific application, considering various factors such as mechanical properties, cost, availability, and environmental impact

6.1 OPERATIONAL RISKS AND MITIGATIONS:

The main risk with an ammonia pipeline is the possibility of released ammonia. Several possible causes can be listed as followed:

H&S Risk- Cause	Mitigation in place
Construction failures (welds or flange connections)	The ASME B31.3 and ASME B31.8 describes test and inspection requirements that will allow us to check the quality of the construction. And validate if the installation is constructed in a safe way. (E.g. Non-destructive testing, Post weld heat treatment, ...)

External corrosion	- Make sure that corrosive air can't harm the core material of the pipe. Suitable coating (marine coating) will be applicable, the use of correct insulation which will maintain safe operation conditions on one hand and will protect the core pipe by creating a barrier. - Deciding on a underground and aboveground has also an impact on safety and health. A buried pipe will have measures in place, like a proper coating and cathodic protection
Human or animal interactions	- Safety distances: the QRA will define safety distances. Deviations on routing will be conducted according to the results of the QRA. Especially in the proximity of residential area's these safety distance will be an important topic. - Sectioning of the pipe route: Use smaller "block- in" sections in areas where the presence of humans is more likely. - Aboveground pipeline- parts where human presence is possible, will be fenced off to indicate no trespassing is allowed. Also, above ground valve stations will be fenced off - Along the routing an underground will be indicated with aboveground and below ground signalisation, UG signalisations is mainly used to warn excavating construction workers that they are approaching a pipeline.
Aging pipeline	- Lengthen the lifespan by a Constant monitoring by fiber optic and Frequent inspections and maintenance of the pipeline. This can be conducted by intelligent pigging, fly-over with drones, maintaining valves by testing them on regular basis as specified in the ASME B31.3 and company specifications.

7. EMERGENCY RESPONSE AND CONTINGENCY PLANNING

An emergency response and contingency planning will be incorporated at a later stage. This emergency response plan will include the response to ammonia-related emergencies such as Spill Response, Evacuation Plans, Emergency contact information.

International Standards and codes applied to the emergency response and contingency plan includes the following:

European Union Regulations and Standards

- Seveso III Directive – For controlling major accident hazards involving dangerous substances.
- EN 689 – Workplace exposure assessments.

International Standards

- ISO 45001 – Occupational Health and Safety Management Systems
- ISO 31000 – Risk Management
- ISO 22320 – Emergency Management
- NFPA 55 – Compressed Gases and Cryogenic Fluids Code

8. CONCLUSION

CMB.TECH is planning to design and construct an ammonia pipeline that will run from Arandis to the North port in Walvis Bay. The key risk scenarios outlined in this report are mostly rated medium which requires the implementation of control measures and periodical review. Wildlife and ecosystem have a high key risk and the mitigations in place involve ASME B31.3 and ASME B31.8 describing test and inspection requirements that will allow quality checks. Additionally, an Occupational Health and Safety (OHS) and an emergency response plan will be developed according to the highest international standards and codes during the coming engineering phase. CMB.TECH will further define the risk associated with this pipeline and define the mitigating measures in depth.