



Terms of Reference (TOR) HAZID

CO₂ Capture – BOD & Tender Specifications

AEB Amsterdam

Date: 19 Jan 2024

Report Document No. 416041-47990/G.06/003, Rev. B Final
AEB Document No.

Advisian
Worley Group

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Report Document No. 416041-47990/G.06/003, Rev. B Final

Document Title: Terms of Reference (TOR) HAZID

Document Subtitle: CO2 Capture – BOD & Tender Specifications

Rev	Description	Author	Review	Advisian approval	Revision date
A	For review	Amit Munshi	Karen van Gent	Kees de Jong	17/05/23
B	Final	Amit Munshi	Karen van Gent	Kees de Jong	19/01/2024

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Abbreviations

Abbreviation	Definition
AEB	Afval Energie Bedrijf / Waste to Energy Company
AEC	Afval Energie Centrale / Waste to Energy Unit
ATEX	Atmosphères Explosibles
ALARP	As Low As Reasonably Practicable
CEST	Central European Summer Time
EPC	Engineering Procurement and Construction
ESD	Emergency Shut Down
FEED	Front End Engineering Development
HAZID	Hazard Identification
HRC	Hoog Rendement Centrale / High Efficiency (Power) Station
HSE	Health, Safety and Environment
HSSE	Health, Safety, Security and Environment
ISO	International Organization for Standardization
MSDS	Material Safety Data Sheet
OCAP	Organic CO ₂ for Assimilation by Plants
PCC	Post Combustion CO ₂ Capture
PFD	Process Flow Diagrams
ToR	Terms of Reference

1 Introduction

This document sets out the Terms of Reference (TOR) to describe the proposed scope of work, overall methodology, organization, and schedule for the Hazard Identification (HAZID) review of the "Post-combustion CO₂ Capture (PCC)" project for AEB Amsterdam, as per details of the project mentioned below Section 3.

The objective of the HAZID is to identify potential major HSSE hazards in the project at an early stage.

1.1 Timing and Agenda

The HAZID is scheduled for 31st May 2023. The session will be executed in person at the AEB facility in Amsterdam as well as remotely via MS-Teams for the participants who are required to be on call or can't be present in person. Meeting will start at 9:00 h (CEST) and finish at a suitable point in the review around 16:00 h. During the session coffee breaks and lunch break (~12:00 h) will be taken. It is anticipated that a follow-up session is required to cover the entire project scope, which is yet to be scheduled.

Agenda 31/05/23 - 0900-16.00 CEST

- 1) Welcome & Introductions
- 2) Project Details
- 3) HAZID Methodology
- 4) Facility Hazards
- 5) Closeout

1.2 Team Composition

Name	Function / Role	Company	Presence
Karen van Gent	Facilitator	Worley	Full Time
Amit Munshi	Scribe/Safety Engineer	Worley	Full Time
Mario Geel	Project Manager	AEB	Full Time
Jan Jager	Safety Engineer (SHEQ)	AEB	Full Time/TBC
Paul Stockman	Layouts/Piping	Worley	Full Time
Aditya Thattai	Engineering Manager/ Process Lead	Worley	Full Time
David van Diepen	Process Engineer-Utilities	AEB	Full Time
Max Kuhn	Process Engineer-Utilities	AEB	Full Time
Mark Hagoort	Start-up & Commissioning Manager	AEB	Full Time
Kees de Jong	Project Manager	Worley	Full Time

2 HAZID Objectives

HAZID is a technique for early identification of potential hazards and threats.

The HAZID should be applied at the very outset of a new venture or during the early stages of development. The major benefit of a HAZID is that early identification and assessment of the critical HSSE hazards provides essential input to project development issues. This may lead to safer and more cost-effective design options being adopted.

The HAZID technique is:

- A means to identify and describe HSSE hazards and threats at the earliest practicable project stage.
- A meeting employing a highly experienced multi-discipline team using a structured brainstorming technique, based on a checklist of potential HSSE issues, to assess the applicability of potential hazards.
- A rapid identification and description process only, not a forum for trying to solve potential problems.

HAZID has been developed specifically to reflect the importance of HSSE issues on the fundamental (and often non-HSSE related) decisions that are made at the inception of all development projects (e.g., design concept and location). HAZID is the first opportunity to collect experienced staff together to address, in a short timeframe, the issues surrounding a new venture or development.

The benefits of using HAZID include:

- Full recognition of the importance and interdependence of all HSSE aspects at the outset of the development.
- An opportunity to consider HSSE implications of alternative developments and process designs as part of the selection process between (competing) options.
- The potential to affect major changes to philosophy/ design at a very early stage before significant financial commitments are made.
- Identification of specific hazards and threats within a project life-cycle phase or process option.
- An inventory process for HSSE hazards and threats that provides a springboard for the development of the HSSE Risk Register.
- Identification of all the intended (continuous) emissions from the facility. This will focus design effort on the minimization of such emissions as well as compliance with company and third-party requirements.

3 Project Description and Scope

AEB Amsterdam is a waste processing company located in the Netherlands and currently owned by the City of Amsterdam. AEB is one of the largest waste processing plants in Western Europe processing over 1.4 million tonnes of waste every year. The AEB Amsterdam site has two waste incineration units namely the AEC (Afval Energie Centrale) and the HRC (Hoog-Rendement Centrale). Waste is incinerated in these two units (total 6X flue gas lines) to generate flue gases and heat which is subsequently used to generate electricity and supply heat to the district heating network.

AEB Amsterdam has the ambition to realize a post-combustion CO₂ capture (incl. CO₂ conditioning) plant (PCC Plant) to capture about 0.5 Mton of CO₂ annually (equivalent to 60t/h) from the flue gases of the HRC and AEC units. The captured CO₂ shall be in principle delivered in gaseous form to a backbone (OCAP pipeline) for further transport and possible storage/utilization. However, a CO₂ liquefaction plant shall/could also be installed to deliver liquid CO₂ to nearby greenhouses. For the previous phase of project development, various pre-FEED activities have been completed for the CO₂ capture project and AEB Amsterdam is currently in the tendering process for a FEED/EPC contract.



Figure 1 AEB waste incineration plant (source: internet/public domain)

The key elements of the complete CO₂ capture (incl. CO₂ conditioning) and liquefaction project consists of:

- CO₂ Capture Plant and a CO₂ Conditioning Unit, overall called *PCC plant* to deliver gaseous CO₂ to the OCAP Grid (backbone) or to the CO₂ Liquefaction Plant.
- CO₂ Liquefaction Plant including Liquefaction, Storage, Truck Loading and Evaporation to deliver either liquefied CO₂ to Greenhouses or gaseous CO₂ (regasification) back to the OCAP Grid.
- All physical interfaces between the new CO₂ Capture Plant and a CO₂ Conditioning Unit and the existing AEC and HRC installations.

The CO₂ capture project has been broken down into 15 work packages (WP) as listed below in Table 3-1 below.

Table 3-1 List of Work Packages

Work Package	Scope
WP1	CO ₂ Capture Plant
WP2	CO ₂ Conditioning Unit
WP3	CO ₂ Liquefaction Plant
WP4	Flue Gas Stack Tie-in
WP5	Primary Cooling Water Intake, Supply and Return
WP6	LP Steam Supply and LP Condensate Return
WP7	Industry Water & Potable Water Supply
WP8	Wastewater Unit and Discharge
WP9	Demin Water Unit and Supply
WP10	Fire Water Modifications
WP11	Fire Water and Rainwater Collection and Discharge
WP12	Heat Integration
WP13	Instrument Gas Supply
WP14	Electrical Power Supply
WP15	DCS & IPS Integration
WP16	Chemicals
WP17	Pre-Digging
WP18	Demolition
WP19	Site Preparation

Current WP definition is based on Project Understanding. WP Definition will be revised in view of Tendering Process after completion Contracting Strategy.

4 HAZID Methodology

During the HAZID a checklist of applicable hazards is assessed, the used checklist is based on the HAZID Worksheet. During the review, via guidewords hazards are identified through a brainstorming session. The hazards are identified for the entire life cycle of the facility, meaning construction, commissioning, operation, and demolition. However, emphasis lies on the operational phase of the facility.

For these hazards, the likely causes are identified, and consequences are listed without taking safeguards into account. These hazards are risk ranked based on the Risk Assessment Matrix (**Appendix A**). Finally, in case safeguards are known these are noted and mitigating measures to be implemented in the design are proposed if assumed necessary.

The hazards, causes, consequences, and actions are noted in the HAZID Worksheet, see **Appendix B**.

The actions are implemented in the AEB's post-combustion CO₂ capture project action list and closed out or transferred to the next project phase if a solution cannot be found directly.

The HAZID study will be recorded in Excel.

5 Study Documents

HAZID utilizes drawings and documents which describe the proposed design. The following drawings and documents are available for the HAZID.

No.	Title	Document Number	Revision
1	Overall Plot Plan Post Combustion Carbon Capture Plant	416041-47990/L.01/001	B
2	Block Flow Diagram	416041-47990/B.01/001	B
3	PFD - Flue Gas Pre-Treatment Unit	416041-47990/P.01/001	A
4	PFD - CO ₂ Absorption Unit	416041-47990/P.01/002	A
5	PFD - Regeneration Unit	416041-47990/P.01/003	A
6	PFD - Solvent Reclaiming, Drain & Storage	416041-47990/P.01/004	A
7	PFD - CO ₂ Conditioning Unit	416041-47990/P.01/005	A
8	PFD - Capture & Conditioning - Utilities	416041-47990/P.01/007	A
9	PFD Overview CO ₂ Liquefaction Plant	416041-47990-P-01-010	A
10	PFD Overall Utility Flow - CO ₂ Liquefaction	416041-47990-P-01-011	A
11	PFD Flue Gas Stack Tie-In	416041-47990-P-01-012	A
12	PFD CW Supply & Return	416041-47990-P-01-013	A
13	PFD LP Steam Supply & Condensate Return	416041-47990-P-01-014	A
14	PFD Industry & Potable Water Supply	416041-47990-P-01-015	A
15	PFD Wastewater Treatment Plant	416041-47990-P-01-016	A
16	PFD Demin Water Plant	416041-47990-P-01-017	A
17	PFD Chemicals Supply *	416041-47990-P-01-018	A
18	PFD Instrument Gas *	416041-47990-P-01-019	A
19	PFD Surface Water Collection/Discharge *	416041-47990-P-01-020	A
20	PFD Firewater *	416041-47990-P-01-021	A

(*) Inclusion into Worley/Advisian Scope yet to be confirmed

6 HAZID Report

During the study comments and recommendations will be collected and summarized in HAZID worksheets.

After the study a HAZID report will be prepared. The report will include as a minimum:

- Scope
- Objectives
- Team, place, and date
- Method and guidewords
- Summary of recommendations, including action parties
- HAZID worksheets
- Listing of considered documents

The HAZID report will be distributed to all HAZID participants and assigned action parties, so they can follow-up the recommendations.

7 Action Follow-up

Each action will be assigned a unique number and be managed by the assigned Process Lead. Agreed solutions will be recorded in a Project Action List

All response documentation shall have a full auditable trail on how each HAZID recommendation has been addressed.



Appendix A Risk Matrix

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect					
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					



Appendix B

HAZID Worksheet

Code	UNIT	Description of Hazard, Project Risk or Issue	Scenario	Worst credible consequence	HSSE RAM Risk				Barriers / Safeguards / Mitigations	Recommendations/ Actions	Responsible	Due before	Resolution
					P	A	C	E					