



HAZID Session Report

CO₂ Capture – BOD & Tender Specifications

AEB Amsterdam

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Abbreviations

Abbreviation	Definition
AEB	Afval Energie Bedrijf Amsterdam / Waste to Energy Company Amsterdam
AEC	Afval Energie Centrale / Waste to Energy Plant
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
HSE	Health, Safety and Environment
HSSE	Health, Safety, Security and Environment
ISO	International Organization for Standardization
JT	Joule-Thomson (effect)
MSDS	Material Safety Data Sheet
OCAP	Organic CO ₂ for Assimilation by Plants
PCC	Post Combustion CO ₂ Capture
PFD	Process Flow Diagrams
PPE	Personal Protective Equipment
SVHC	Substances of Very High Concern
ToR	Terms of Reference
TOC	Total Organic Carbon
ZZS	Zeer Zorgwekkende Stoffen

1 Introduction

This document sets out the results of the Hazard Identification (HAZID) Sessions for the AEB PCC Aurora Project.

The HAZID review covered the selected process functionality, specifications, and operability, and aimed to identify all major hazards and surface opportunities of alternative options towards an inherently safe design. In order to accomplish such, participants from key disciplines like Process, Electrical and HSE, and Operations have been selected to share their expert expertise for this project whilst providing a structured approach and setting.

1.1 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.

2. Methodology

2.1 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. 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 for which a recommendation is formulated are risk ranked based on the Risk Assessment Matrix enclosed in Terms Of Reference HAZID, doc.no. 416041-47990/G.06/003.

The hazards, causes, consequences, and actions have been noted in a dedicated HAZID Worksheet, see Appendix B.

The actions have been implemented in AEB's Post-combustion CO₂ Capture (PCC) Project action list and closed out or transferred to the next project phase if a solution cannot be found directly.

The HAZID study has been recorded in MS Excel.

3. Meeting Details

3.1 Timing and Location

The HAZID study for the AEB PCC Aurora Project is held according to the following schedule.

Date	Time	Location
31 May 2023	9:00 – 16:00 CEST	AEB Amsterdam
07 June 2023	9:00 – 16:00 CEST	AEB Amsterdam

3.2 Team Composition

Name	Function / Role	Company	Attendance	
			31-05-2023	07-06-2023
Karen van Gent	Facilitator	Worley	Full Time	Full Time
Amit Munshi	Scribe/Safety Engineer	Worley	Full Time	Full Time
Mario Geel	Project Manager	AEB	Full Time	Part Time
Jack Staak	Safety Engineer (SHEQ)	AEB	Full Time	Absent
Paul Stockman	Layouts/Piping	Worley	Full Time	Absent
Aditya Thattai	Engineering Manager/ Process Lead	Worley	Full Time	Full Time
David van Diepen	Process Engineer-Utilities	AEB	Full Time	Full Time
Max Kuhn	Process Engineer-Utilities	AEB	Full Time	Full Time
Mark Hagoort	Start-up & Commissioning Manager	AEB	Full Time	Full Time
Kees de Jong	Project Manager	Worley	Full Time	Full Time
Arjan Koch	Production Engineer	AEB	Full Time	Full Time
Joris vd Kamer	Process Engineer	AEB	Full Time	Absent
H van Gour	EIA Engineer	AEB	Full Time	Full Time

The Signed Attendance list is attached in Appendix A of this report.

3.3 Guidance Documents

The HAZID sessions utilized engineering drawings and documents describing the proposed design. The following drawings and documents were 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

The guidance documents for the HAZID sessions are enclosed in Appendix C to this report.

4. 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 6 incineration lines, each with its own FGC line) generating 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) as part of the AURORA project to capture 507 kt (kilotons) of CO₂ annually from about 38% (mass basis) of the total flue gases of the HRC and AEC units.

The captured CO₂ shall be in principle delivered in gaseous form to a backbone (OCAP) 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.





Figure 4-1 AEB waste incineration plant (source: internet/public domain)

The key elements of the AURORA project:

- CO₂ Capture Plant and a CO₂ Conditioning Unit, overall called *PCC plant* to deliver gaseous CO₂ to the OCAP Grid (backbone) or to an onsite 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, a CO₂ Conditioning Unit, a CO₂ liquefaction plant and the existing AEC and HRC installations.

The CO₂ capture project has been broken down into 19 work packages (WP) as listed below in Table 4-1 below.

Table 4-1 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

Work Package	Scope
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

The current WP definition is based on the present Project understanding. The WP definition will be revised in view of Tendering Process after completion of the Contracting Strategy by AEB.

5. Results

The HAZID recordings can be found in Appendix B. A total of 65 recommendations have been made reflected in section 5.1 below.

5.1 Recommendations

No.	Recommendations	Action Party
1	CO ₂ Personal Gas detectors should be provided to staff to carry in the field. Fixed CO ₂ Gas Detection System(s) shall be designed as part of the project.	AEB/EPC Contractor
2	Take ice formation risks into account during design of the installation. Related operational work procedures to be developed.	AEB/EPC Contractor
3	Logistics Plan to be made with attention to proper lining, safety signs, vehicle routing and lighting around the roads with low visibility conditions.	AEB
4	Heavy rain scenario to be considered for the design of the new sewer system of the new PCC plant.	AEB/EPC Contractor
5	Design shall ensure that loss of power shall not lead to hazardous consequences. Solutions such as fail-safe design, use of emergency/UPS power etc. to be considered.	AEB/EPC Contractor
6	Emergency Response procedures to be developed/updated for high CO ₂ leakage scenarios.	AEB
7	Waternet QRA & BEN QRA to be reviewed to assess the potential impact and safety risks for e.g., the scenarios of nearby biogas tank explosion/ wood gasifier factory fire.	AEB
8	Traffic Plan to be updated to reduce the impact from the scenario of "Unloading of bulk chemicals from truck for HRC and AEC". QRA for truck unloading operations to be shared with the neighbours as well.	AEB
9	Manage the interface (including process control and safety systems) with OCAP	AEB
10	Sourcing Strategy to be developed for all the consumables & spares availability.	AEB
11	Investigate if the existing warehouse is sufficiently sized to include new spares, if not, proper action should be initiated.	AEB
12	Process should be designed to reduce ammonia emissions	AEB/EPC Contractor
13	Consider reducing ammonia in the existing process (De-NO _x).	AEB

No.	Recommendations	Action Party
14	Consider pilot project to test various solvents including SVHC (Dutch: ZZS) content, ammonia in flue gas, wastewater contamination and CO ₂ quality.	AEB/EPC Contractor
15	Consider bringing back the CO ₂ stream including hot air back into the stack as it is included in the permit.	AEB/EPC Contractor
16	Analyse the wastewater stream and consider designing the wastewater treatment to handle ammonia after looking into various options. Optimize De-NOx. Online monitoring for ammonia and mercury to be considered.	AEB/EPC Contractor
17	Consider sampling the wastewater stream to prevent sending wastewater to municipal sewage treatment potentially violating the permit. Consider a retention tank in design.	AEB/EPC Contractor
18	Add chlorine inline measurement in the PCC cooling water inlet downstream the anti-biofouling system.	AEB/EPC Contractor
19	Good House Keeping and proper maintenance on filters and water separators. Integration into monitoring plan should be considered.	AEB
20	Waste Streams must be formally approved by Acceptation Teams.	AEB
21	Construction activities to be planned whilst taking breeding season of birds into account. Consult ecological expert.	AEB/EPC Contractor
22	Consider use of quick release coupling for loading/Unloading operation.	AEB/EPC Contractor
23	Local Control panel station should be installed in the PCC plant	AEB/EPC Contractor
24	Well defined operating window aligned with AEB's internal Operating, Control & Alarm philosophy.	AEB/EPC Contractor
25	Investigate the best solution to prevent failure of louvre dampers and/or mitigate failure cases.	AEB/EPC Contractor
26	Tracing needs to be in operation during the power failure.	AEB/EPC Contractor
27	Align PCC plant's maintenance philosophy of PCC plant with AEB's present maintenance philosophy for the existing operations	AEB/EPC Contractor
28	Well defined maintenance and spare part work instructions to be prepared including PO orders in the ERP system.	AEB/EPC Contractor
29	Engineer an isolation method to keep the availability of PCC high.	AEB/EPC Contractor
30	A maintenance review session on P&ID level to be organised prior to the HAZOP session.	AEB/EPC Contractor

No.	Recommendations	Action Party
31	Integrate PCC plant in the existing Emergency Plan and communicate with Fire Brigade.	AEB/EPC Contractor
32	Consider using lined steel & discuss with insurance company.	AEB/EPC Contractor
33	Consider other coolant than ammonia for the chiller.	AEB/EPC Contractor
34	Material Selection study to be executed.	AEB/EPC Contractor
35	Design, Handling (loading/unloading) and Operational requirements related to amine storage and transport to be reviewed in the HAZOP session.	AEB/EPC Contractor
36	Design, Handling (loading/unloading) and Operational requirements related to sulphuric acid storage and transport to be reviewed in the HAZOP session	AEB/EPC Contractor
37	CO ₂ gas detectors to be provided in the areas where CO ₂ leakage may be expected.	AEB/EPC Contractor
38	Ensure proper ventilation is provided for the indoor areas (e.g., acoustic enclosures).	AEB/EPC Contractor
39	Organise technical alignment meetings with Offtaker (OCAP)	AEB/EPC Contractor
40	Control philosophy for flue gas fan & louvre dampers to be reviewed during HAZOP session.	AEB/EPC Contractor
41	Investigate if flushing of the system is needed after drainage of the amine solution.	AEB/EPC Contractor
42	Material to be selected for CO ₂ looking into JT effect.	AEB/EPC Contractor
43	Acceptance including testing requirements procedure for Amine should be prepared.	AEB/EPC Contractor
44	Solvent Management Plan to be investigated.	AEB/EPC Contractor
45	Add a TOC measurement in the flue gas condensate line.	AEB/EPC Contractor
46	Design the drains such that (also at start up, shutdown and maintenance) medium is properly recovered.	AEB/EPC Contractor
47	Make reservation for storage and dosing of auxiliary chemicals.	AEB/EPC Contractor
48	Every instrument, valve and operable equipment has to be accessible and visible without the need of any additional temporary measures (like ladders etc.).	AEB/EPC Contractor
49	Accessibility of louvre dampers in the flue gas ducts should be reviewed in detail.	AEB/EPC Contractor
50	Make sure that there is enough space to install cranes for maintenance	AEB/EPC Contractor
51	Ensure the passage height under pipe bridges is sufficient.	AEB/EPC Contractor

No.	Recommendations	Action Party
52	Erect a first line maintenance station for the operators including LOTOTO near the PCC plant.	AEB/EPC Contractor
53	Safety Effect Calculations for safe location to atmosphere of the vents to be performed.	AEB/EPC Contractor
54	Health risks of amine to be further investigated and define impact for plant design.	AEB/EPC Contractor
55	Select solvent based on health, safety requirements.	AEB/EPC Contractor
56	Bow-tie analysis to be performed for safe use of selected solvent.	AEB/EPC Contractor
57	Define the necessary PPE for safe working with amine.	AEB/EPC Contractor
58	Plant installed outdoor (ensuring proper ventilation) to be kept in mind when applying for Building Permit.	AEB/EPC Contractor
59	CO ₂ Compressor will be installed in an acoustic enclosure. Conditional access to be considered for this enclosed space.	AEB/EPC Contractor
60	Formation of carcinogenic degradation products of amines need to be minimized by proper process design.	AEB/EPC Contractor
61	Requirement of Safety Shower and Eye Wash for diphtheriae to be checked for areas where exposure to amine is expected.	AEB/EPC Contractor
62	Check if expansion of CO ₂ from 23bar to atmospheric pressure may trigger a hazardous situation leading to cold burns	AEB/EPC Contractor
63	Ensure noise requirements are met by the Vendor	AEB/EPC Contractor
64	Evaluate the design of the nitrogen system if it is considered indoor.	AEB/EPC Contractor
65	Consider "man down" function on the portaphone system.	AEB/EPC Contractor

6. Action Follow-up

Each action has a unique number and shall be managed by the assigned Action Party. Agreed solutions will be recorded in the Project Action List (416041-47990/G.06/007)

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



Appendix A

HAZID Worksheet



Appendix B

Study Documents



Appendix C

Attendance List

