APPENDIX A MAJOR HAZARD FACILITIES UNIT MEETING NOTES

TETRA TECH COFFEY

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MINUTES

Minutes of: Major Hazard Facility Unit – 2024 briefing

Subject: Sumitomo Hydrogen Project

Chair: Tetra Tech Coffey

Held on: 14 February 2024 10 am – 11 am AEST

At: Microsoft Teams

Minutes by: Melinda Hofman

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Item	Particulars	Action
1	**Introductions and roles**	
2	**Purpose of the meeting** TTC provided an overview of the agenda for the meeting and the purpose of the changes to the MCU application and liaison with the Coordinator-General. MHFU explained its role and advised that hydrogen has been included in petroleum and gas legislation where it is being used as a fuel gas.	

Item	Particulars	Action

3	**Changes implemented in detailed design**
	TTC provided project outline and the need to amend the SDA approval to acknowledge the new plans and documents.
	TTC/JGC presented the design updates including:
	• Nitrogen generator added to continuously purge the electrolyser. The generator is north of the dry cooler.
	• Water treatment unit (RO plant) relocated with potable water feed and reject water discharge unchanged.
	• Dry cooler location changed to on ground in horizontal arrangement north of the electrolyser power unit.
	• Hydrogen mass inventory increased from 1 kg to 3.3 kg.
	• Fire and explosion analysis:
	  ○ Full electrolyser container volume assumed to be vacant space for modelling during FEED (1 kg).
	  ○ Vacant space in electrolyser container calculated based on vendor information and used in modelling for EPC (0.97 kg).
	  ○ Fire and explosion modelling results for EPC phase similar to FEED phase results.
	• Atmospheric vent dispersion study:
	  ○ Updated to reflect revised design.
	  ○ Release height increased to reflect actual vendor information.
	• HAZID updated to reflect changed components and inventory.
	• Addition of the emergency access gate to permit emergency services access to site.	

4	**Risk assessments**
	TTC advised that the pilot plant doesn't trigger registration as a major hazard facility and doesn't trigger Schedule 15 chemicals. The risk assessment was revisited following the design changes.
	JGC presented the updated HAZID study:
	• Additional 33 scenarios from EPC, resulting in 37 recommendations. The study consulted multiple teams (JGC, Summit Hydrogen Gladstone, RTA Yarwun, and Cummins, the electrolyser manufacturer and supplier).
	• Additional hazards included:
	  ○ Out-of-specification nitrogen purity creates flammable atmosphere in the electrolyser container.
	  ○ Nitrogen leak in electrolyser or nitrogen generator container causes asphyxiation.
	  ○ Nitrogen generator regulator fails and nitrogen bundle does not activate causing overpressure in the electrolyser container.
	  ○ Nitrogen generator regulator fails causing overpressure in the electrolyser container.
	  ○ Atmospheric conditions (cyclones, wind speeds, static discharge from lightning).
	  ○ Conventional safety hazards posed by new additions to the facility, e.g., working at height.
	JGC explained how the MHFU recommendations during FEED have been addressed:	

Item	Particulars	Action
	"Explosions in unvented containers, which have resulted in very high-pressure explosions and shrapnel damage. MHFU recommended installed of explosion (blast) vents to control pressures." • Minimised flange connections and potential sources of ignition to reduce likelihood of leaks and fire or explosion event • Gas detection is set below the flammability limit to detect any leaks at an early stage. If a leak is detected, electrolyser container ventilation rate will be increase and electrolyser will be shutdown. • These active controls reduce the risk to so far as is reasonably practicable. *"Cold hydrogen vents igniting due to static electricity. Consider static electricity sources in detailed design including site electrical facilities and thunderstorms associated with tropical storms and cyclones."* • Earthing and bonding controls have been incorporated into the design in accordance with applicable laws, regulations, and Australian standards. JGC has checked applicable laws to ensure proper earthing bundles can be sourced. • No equipment or personnel access will be allowed within the 50% LFL contour of the hydrogen release vent ensuring that the impact on the operators is eliminated in the event. MHFU noted it preferred passive controls as well as active controls. The MHFU advised it would insist on passive controls (explosion (blast) vents if the facility was near a residential area. Given the location of the facility MHFU wouldn't insist on explosion (blast) vents. MHFU advised that to align with workplace health and safety regulations, an unsafe atmosphere is 5% LFL. MHFU recommended that gas detectors are set at this level and the exclusion zone is based on this. MHFU advised that it didn't expect adopting 5% LFL to make a material difference but recommend using this to align with the workplace health and safety regulations. MHFU enquired what nitrogen was being used for in the process. JGC advised it was to ensure complete purging of the electrolyser to prevent a flammable atmosphere in the container. The gas will be produced by a nitrogen generator. MHFU advised that while nitrogen purging was controlling one hazard it is introducing another, i.e., asphyxiation. MHFU advised that incidents of people dying in low oxygen atmospheres is high in some industries, particularly where gas is used in confined spaces. MHFU recommended JGC review the controls in place to avoid incidents, e.g., confirmation of a safe atmosphere before people enter the area. JGC advised that portable detectors will be used for people entering the space. MHFU noted that the electrolyser container doesn't meet the definition of a confined space as the container is designed for entry but advised it wouldn't hurt to operate the electrolyser as if it is a confined space. Incorporate entry procedures to protect people. TTC enquired if MHFU preferred passive or active controls. MHFU advised that based on the hierarchy of controls, active controls, like engineering controls, limit the likelihood of an event but passive controls will avoid or reduce the consequence of an event. TTC sought clarification that MHFU was comfortable with the proposed active controls but recommend looking at passive controls. MHFU confirmed that was correct.	

Item	Particulars	Action

	JGC presented the updated fire and explosion analysis:
	• For explosions the hydrogen mass inventory is increased to 3.3 kg, but the stoichiometric ratio with air was reduced to 0.97 kg.
	• For the jet fires, changes include increased design solar radiation flux and change to using a Miller model.
	  ○ Public safety is not compromised as there is adequate separation from Hanson Road (nearest publicly accessible area)
	  ○ Pilot plant operation is not compromised as there is adequate separation from the pilot plant control room.
	  ○ RTA Yarwun alumina refinery safety and integrity is not compromised as the risk to the alumina refinery warehouse is tolerable.
	• As a result of the updates, adequate separation distances from all buildings and roads has been ensured.
	• Also updated the atmospheric vent study:
	  ○ Hydrogen vent dispersion radius increased but vent height increased to maintain safety.
	  ○ Oxygen vent dispersion radius increased but vent height increased to maintain safety.
	  ○ People will not be exposed to hydrogen or oxygen.	

5	**Questions / recommendations** MHFU advised that once submitted, the amendment will probably be sent to the unit for comment. MHFU confirmed it did not see any of the safety issues being an obstacle to approval. They will probably reiterate the nitrogen hazard being a higher concern to people due to what we experience in industry, a number of fatalities every year from people entering low oxygen atmosphere, less incidents with flammable gas. TTC advised it would share the meeting notes and asked if MHFU would confirm they accurately capture the MHFU's comments and recommendations. TTC advised the meeting notes would be attached to the amendment application. Meeting close.	TTC to provide meeting minutes. JGC to further investigate passive controls (explosion (blast) vents). JGC to model 5% LFL for hydrogen vent. JGC to further investigate nitrogen leaks and emissions and controls. MHFU to confirm the minutes are an accurate record of its comments and recommendations.

Attachments:

Major Hazard Facility Unit Presentation 14 February 2024

Close-out of Major Hazard Facility Unit comments presentation

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Gladstone Hydrogen Project

Major Hazard Facility Unit Presentation
14 February 2024

COMMERCIAL IN CONFIDENCE

Meeting objectives

- Brief MHFU on Gladstone Hydrogen Project updates
- Present updated safety assessment for the project
- Seek MHFU advice on adequacy of updated safety assessment

Project outline

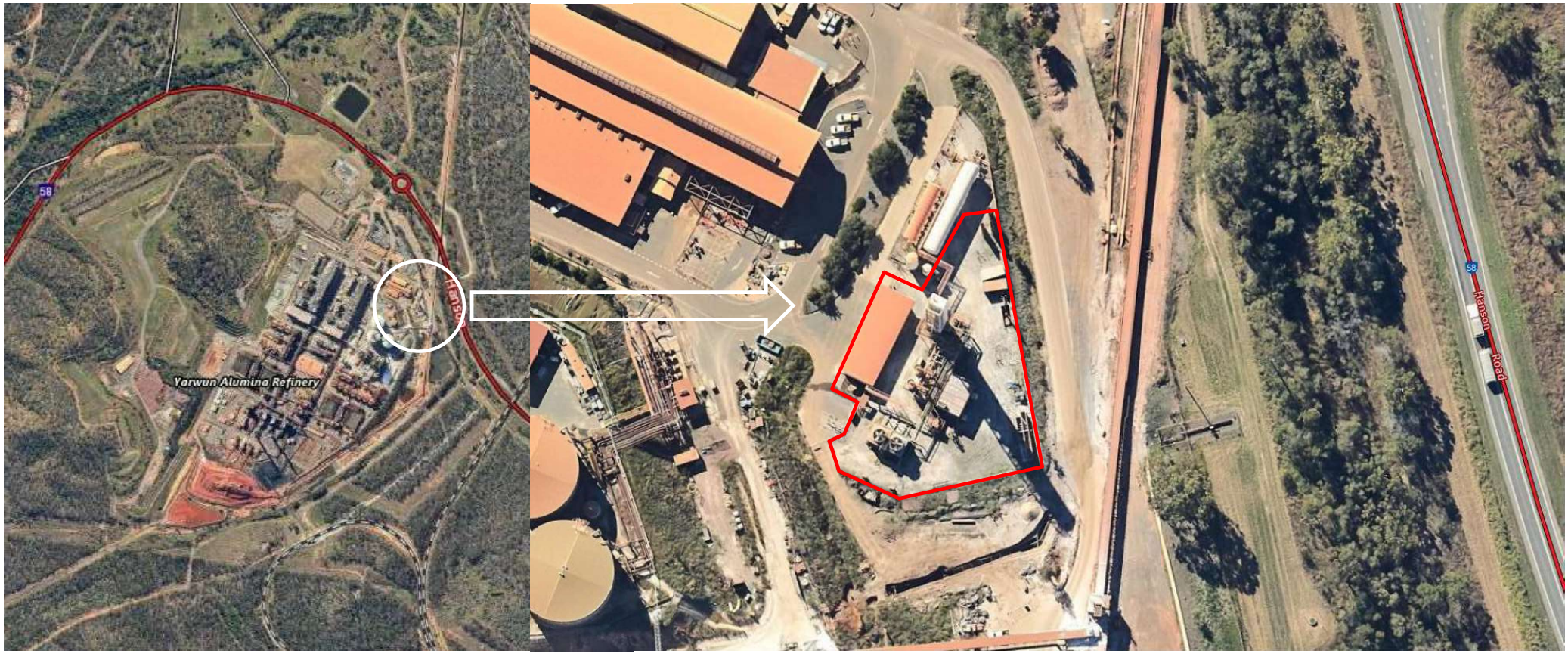
Proposed project

- Hydrogen production pilot plant using electrolysis
- 250 – 300 tpa (2.5 MW)
- H2 used in RTA Yarwun Alumina Refinery (calciner)
- H2 potentially used by third parties

Approvals

- Material Change of Use (MCU) issued in July 2022
- Environmental Authority P-EA-100235984 issued in July 2022
- EA P-EA-100235984 amended in May 2023 to update commencement date

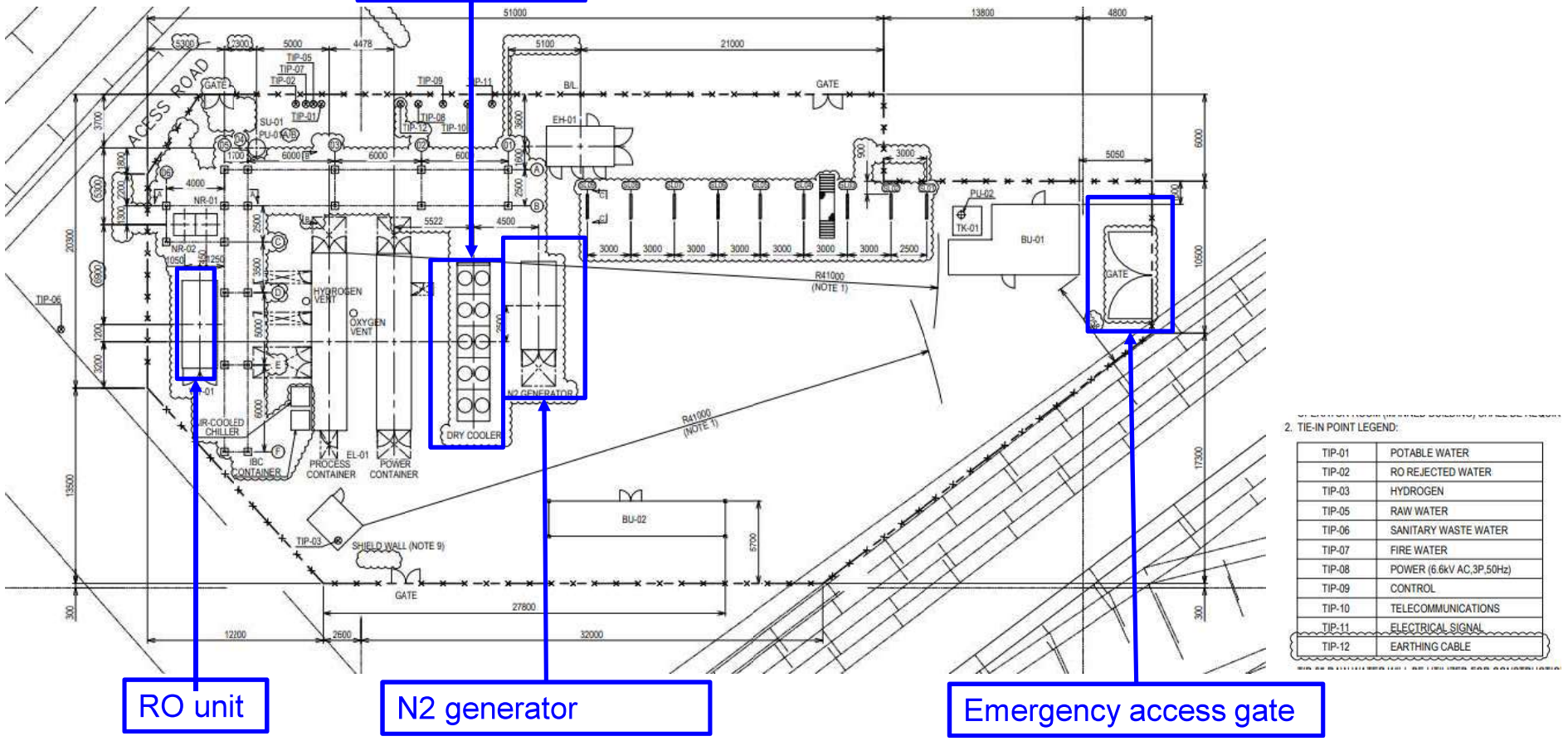
Project site
RTA Yarwun Alumina Refinery (former Air Liquide site)



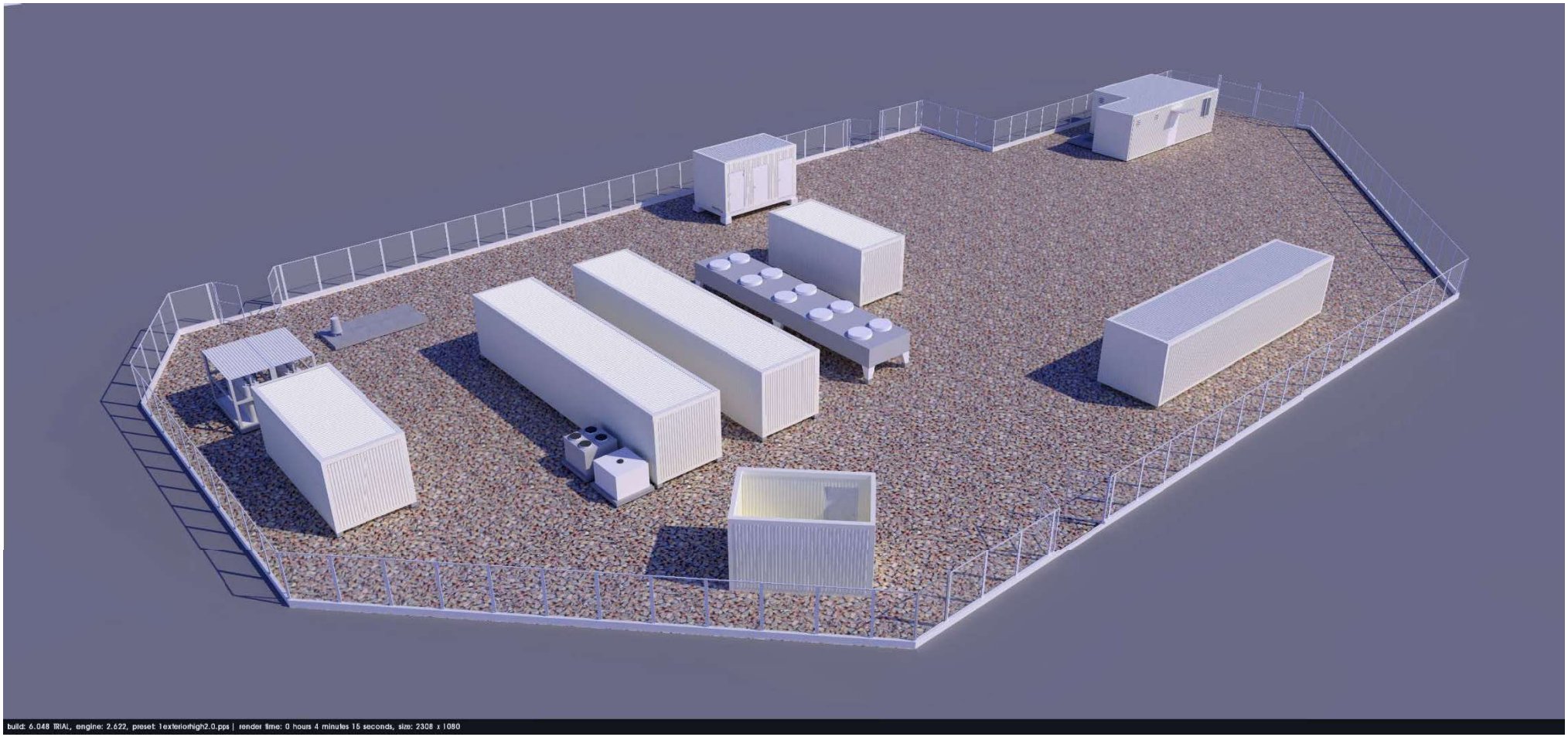
Updated design

- Nitrogen generator added to continuously purge system
- Water treatment unit (RO plant) relocated (potable water and reject water discharge unchanged)
- Dry cooler location changed (on ground in horizontal arrangement)
- Hydrogen (H2) mass inventory increased from 1 kg to 3.3 kg
- Fire and explosion analysis
  - Full electrolyser container volume assumed to be vacant space and used in modelling during FEED (1 kg)
  - Vacant space in electrolyser container calculated and used in modelling for EPC (0.97 kg)
  - Fire and explosion modelling results similar to FEED results
- Atmospheric vent dispersion study
  - Updated to reflect revised design
  - Release height increased to reflect actual vendor information
- HAZID updated to reflect changed components and inventory

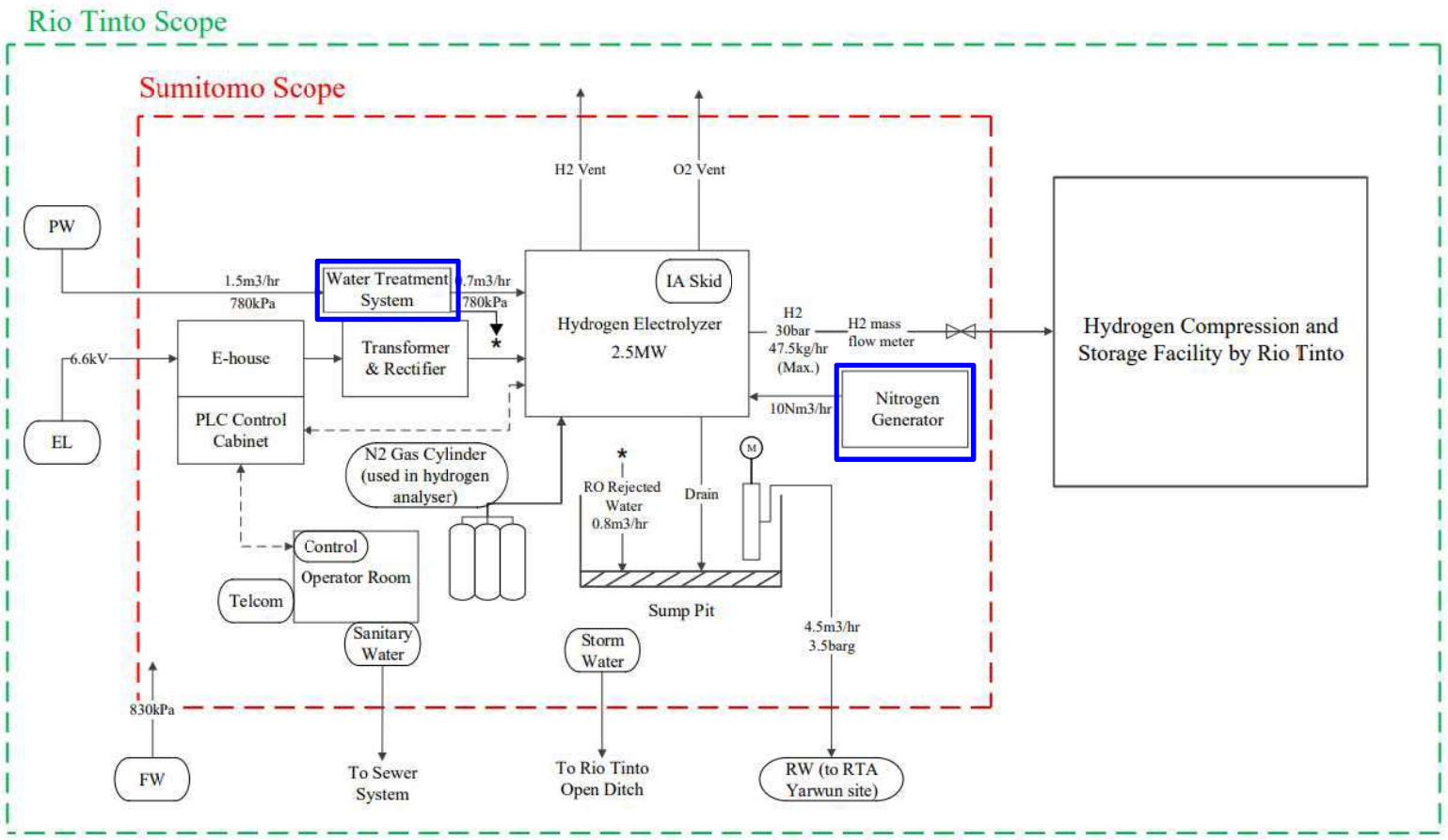
Updated site layout



Updated site layout



Updated system flow diagram



Term
PW: Potable Water
FW: Fire Water
RW: Raw Water
IA: Instrument Air
EL: Electrical Power
Control: Control Hard Wire

Telecom: Telecommunication Fiber Optic Cable

RO plant
To improve water quality provided to electrolyser by converting potable water to demineralized water with RO unit.

N2 Generator (using PSA)
To provide N2 gas for continuous purging to electrolyser system for maintaining inert (=safe) operating condition

Safety assessment

- Pilot plant does not trigger registration as a major hazard facility
- Pilot plant is not classified as a hazardous chemical facility under the threshold for Schedule 15 chemicals
- Safety assessment was prepared in 2022 to inform:
  - Design (plant integrity, proximity to Yarwun alumina refinery, and public safety)
  - Material change of use application (assessment considering State Code 21 Hazardous chemical facilities)
- Safety assessment was informed by:
  - HAZID study
  - Fire and explosion analysis
  - Atmospheric vent dispersion study
- The studies have been updated to incorporate the final design
- MHFU recommendations have been addressed in the design

Updated HAZID study

- Objective: Identify significant impacts and recommend measures to reduce risk
  - Major accident scenarios (safety, health, and environment)
  - Safeguards (prevention, control and mitigation)

- Facilities included in the study:
  - Electrolyser
  - Electrical house
  - Sump pit and pump
  - Water Treatment Package (WTP)
  - **Nitrogen generator**
  - **Dry cooler**

Updated HAZID study

- Additional 33 scenarios from EPC phase added to scenarios logged during FEED phase
- Additional 37 recommendations generated during the EPC HAZID study
- Additional hazards include:
  - Out of specification N2 purity creates flammable atmosphere in the electrolyser container
  - N2 leak in electrolyser or N2 generator container causes asphyxiation
  - N2 generator regulator fails and N2 bundle does not activate causing overpressure in the electrolyser container
  - N2 generator regulator fails causing overpressure in the electrolyser container
  - Atmospheric conditions (cyclones, wind speeds, static discharge from lightning)

MHFU recommendations during FEED

- ***"Explosions in unvented containers, which have resulted in very high-pressure explosions and shrapnel damage. MHFU recommended installed of explosion (blast) vents to control pressures."***

  Design control measures include:

  - Minimised flange connections and potential sources of ignition to reduce likelihood of leaks and fire and/or explosion event
  - Gas detection is set below the flammability limit to detect any leaks at an early stage. If a leak is detected, electrolyser container ventilation rate will be increase and electrolyser will stop operating

- ***"Cold hydrogen vents igniting due to static electricity. Consider static electricity sources in detailed design including site electrical facilities and thunderstorms associated with tropical storms and cyclones."***

  - Earthing and bonding controls have been incorporated into the design in accordance with applicable laws, regulations and Australian Standards
  - No equipment or personnel access will be allowed within the 50% LFL contour of the H2 release vent

Fire and explosion assessment

- Objective: Assess very high and high fire and explosion hazards

- Scenarios considered:
  - HAZID No. 1 Release of inventory, hydrogen leak inside container
  - HAZID No. 2 Release of inventory, hydrogen leak outside container
  - HAZID No. 8 Overpressure, increased hydrogen operating pressure

- Modelling undertaken:
  - Jet fire
  - Explosion (overpressure)

Updated fire and explosion modelling parameters

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Explosion modelling parameters

Parameter		FEED Phase	EPC Phase
Meteorological Conditions	Design solar radiation flux	0.5 kW / m^2	**1.2 kW / m^2**
	Hydrogen Mass Inventory	1.0 kg	**3.3 kg**
	Process Room Volume	59.7 m3	**49.4 m3**
	Process Room Vacancy Ratio	100 %	**77.6 %**
	Flammable Gas Volume and Mass Inventory in Stoichiometric Ratio with Air	39.6 m3	**38.3 m3 (49.4 m3 x 77.6 %)**
		1.0 kg	**0.97 kg**

Jet fire modelling parameters

Parameter		FEED Phase	EPC Phase
Meteorological Conditions	Design solar radiation flux	0.5 kW / m^2	**1.2 kW / m^2**
Jet Fire Condition	Model	Cone Model	**Miller Model**

Fire and explosion assessment results

- Public safety is not compromised
  - Adequate separation from Hanson Road (nearest publicly accessible area)
- Pilot plant operation is not compromised
  - Adequate separation from pilot plant control room
- RTA Yarwun alumina refinery safety and integrity
  - Alumina refinery warehouse risk tolerable
  - Safety assessments have been updated using vendor data
  - Plant has been designed to comply with relevant Queensland and Australian standards and guidelines

Updated jet fire modelling
Electrolyser (flame length 1.5/F)

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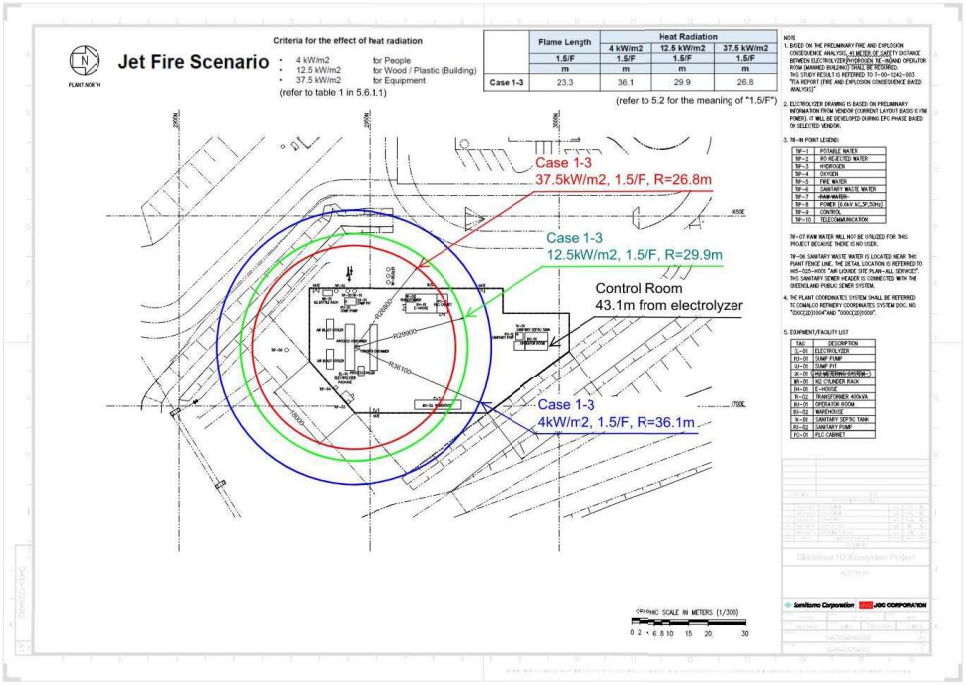
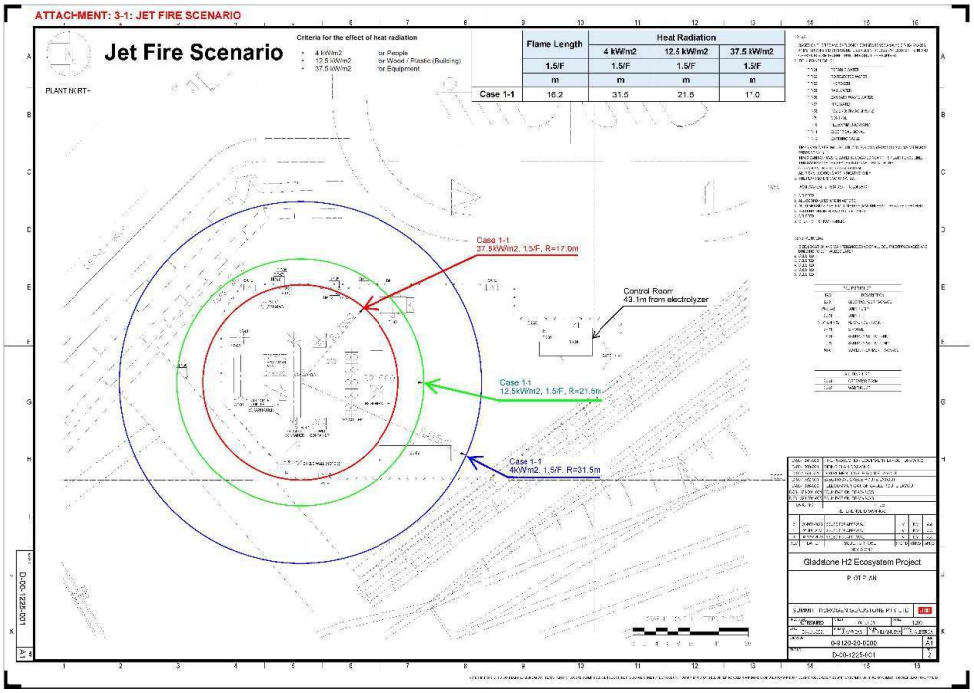
FEED design (Figure 10 in Planning Report)



EPC design



Updated jet fire modelling
Electrolyser (flame length 5/D)

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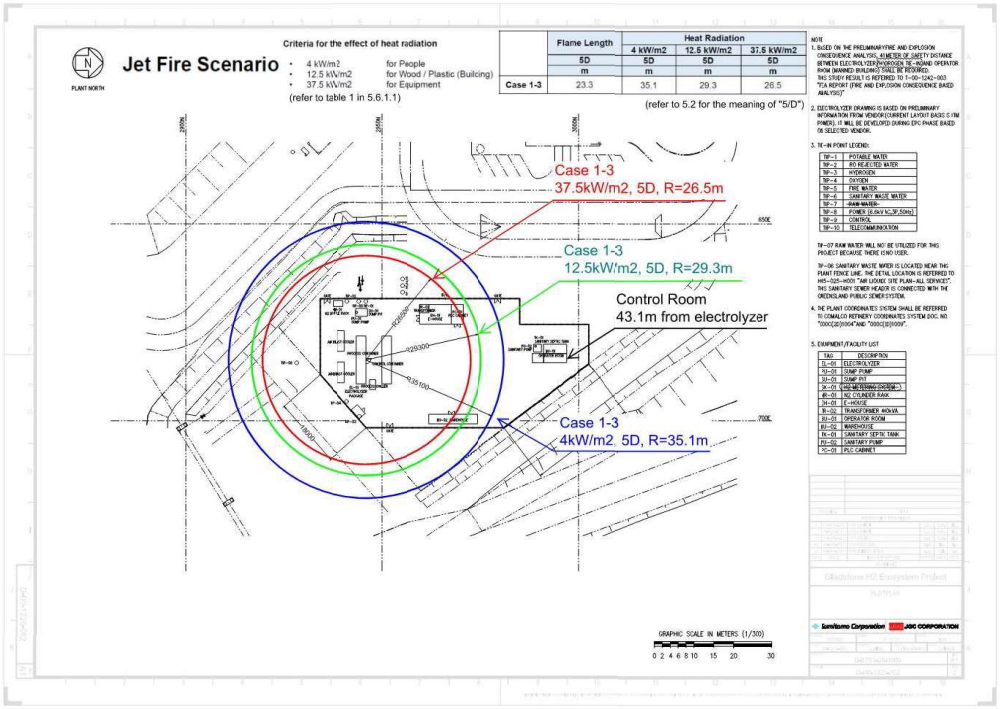
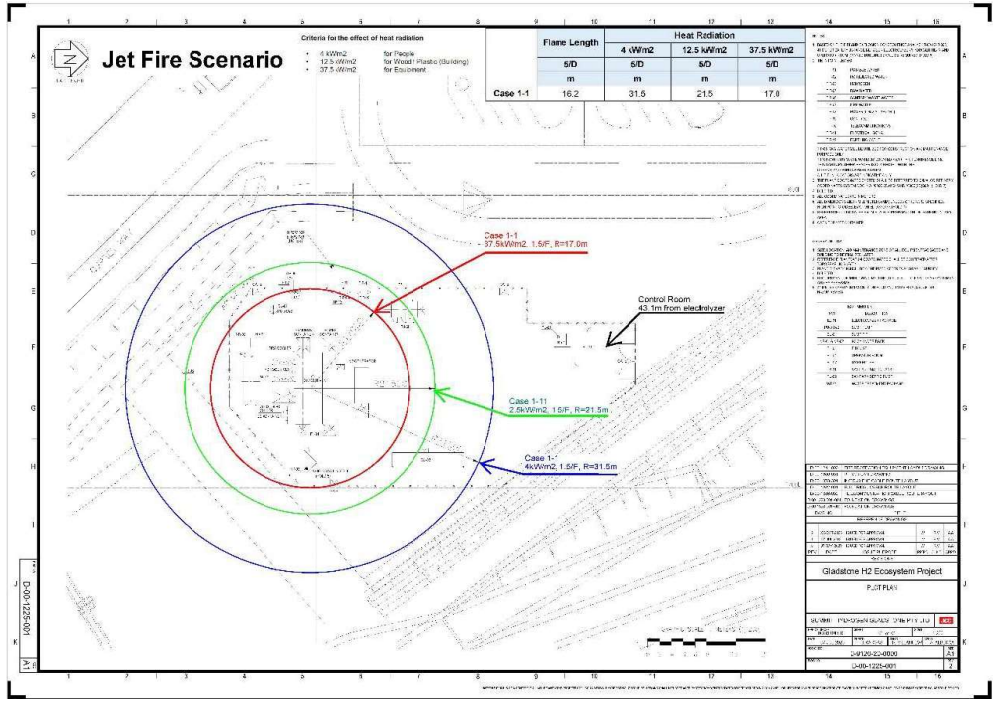
FEED design (Figure 11 in Planning Report)



EPC design



Updated jet fire modelling

Electrolyser and hydrogen tie-in (flame length 5/D)

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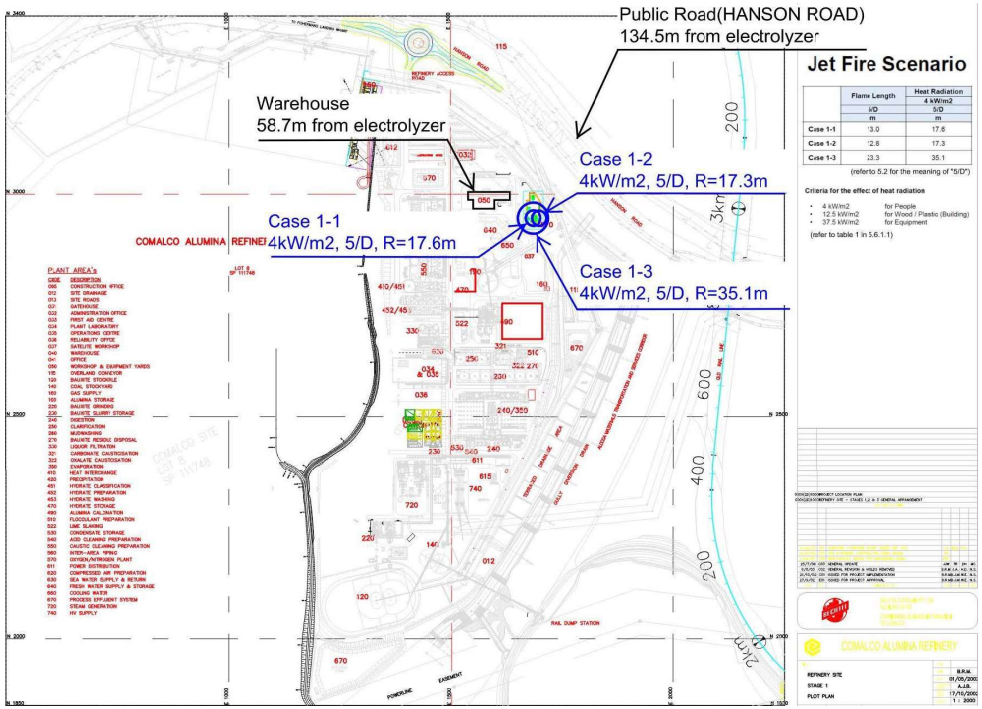
FEED design



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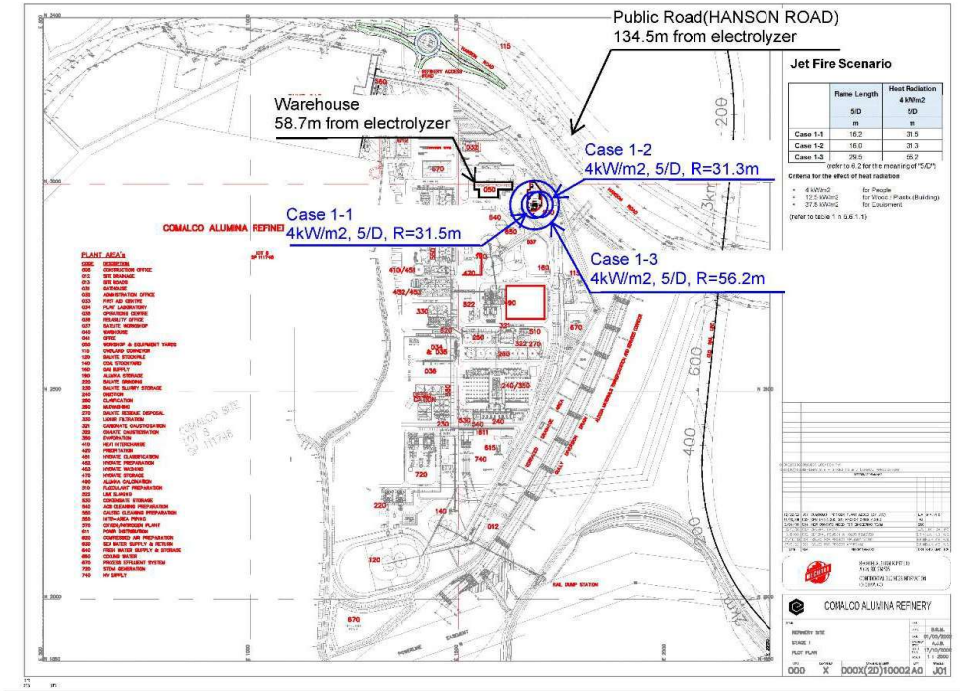
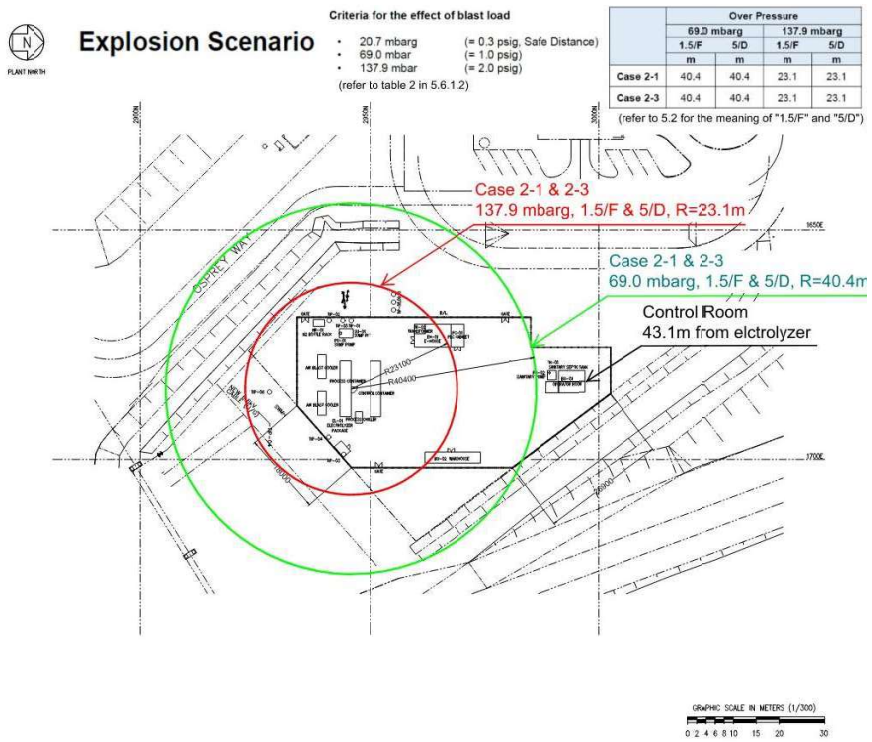
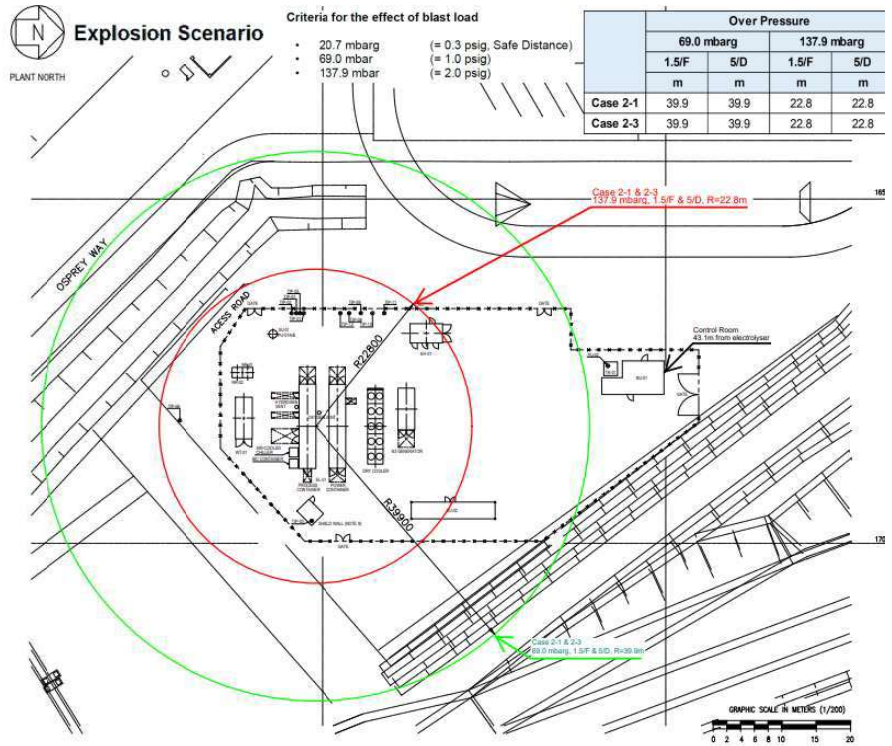


Updated explosion modelling Electrolyser

FEED design



EPC design



Updated explosion modelling
Electrolyser and hydrogen tie-in

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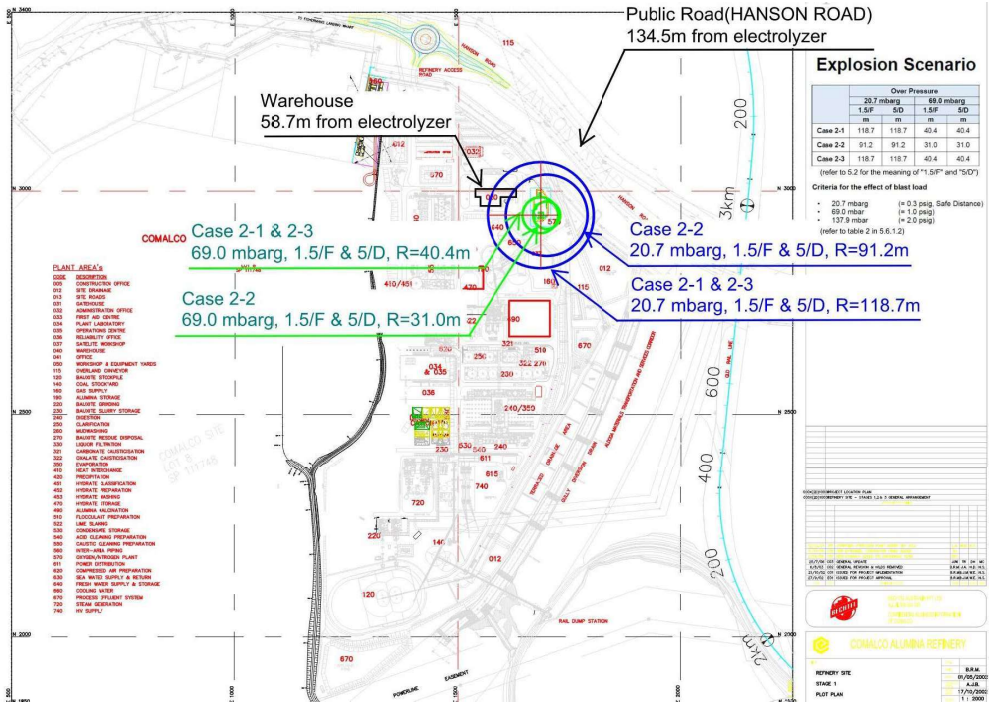
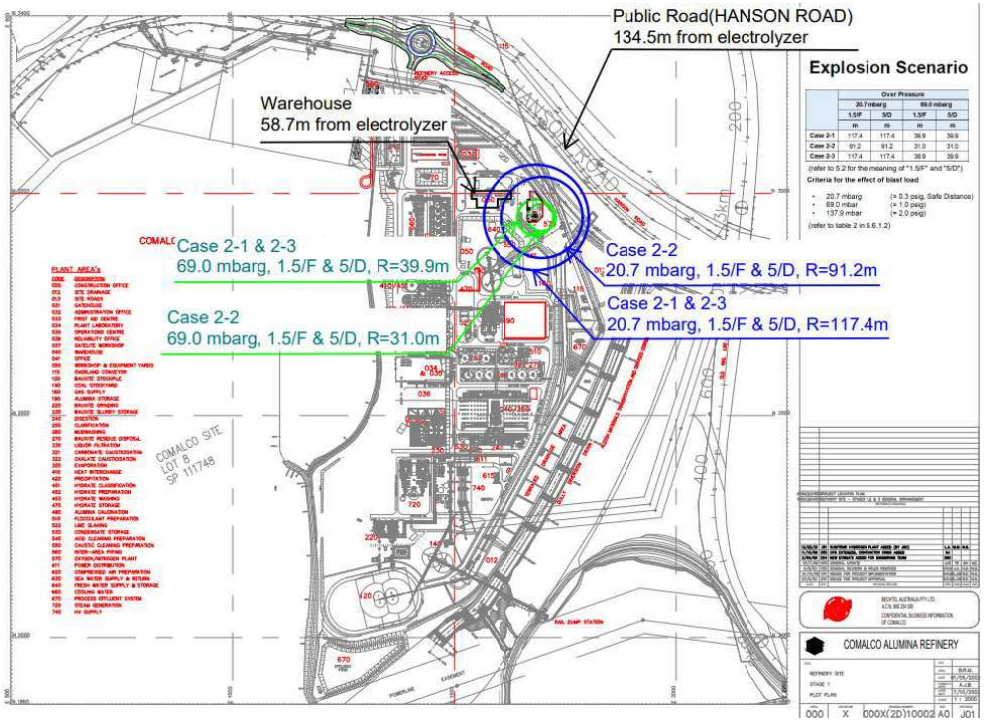
FEED design



EPC design



Atmospheric vent dispersion study

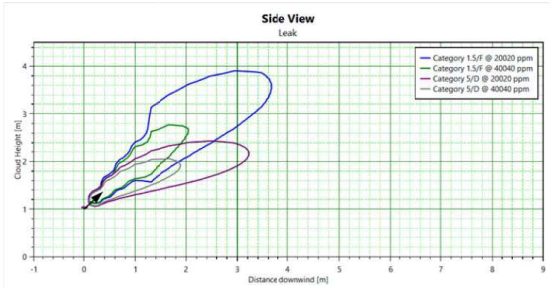
- Objective: Define the safe location of atmospheric release vents:
  - Hydrogen release vent
  - Oxygen release vent
- Criteria for safe location
  - Hydrogen dispersion
    - Equipment and building shall not be within 50% LFL (Lower Flammable Limit)
  - Oxygen dispersion
    - Operator access restricted due to 23.5% oxygen

Updated atmospheric vent dispersion study

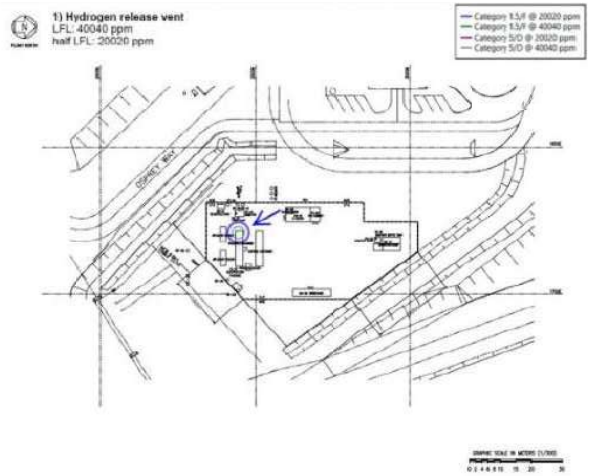
Hydrogen release vent

FEED design

LFL: 40040 ppm
half LFL: 20020 ppm



There shall not be allowed to locate any equipment and building within a radius of 3.7 m from the vent, 1 m height below the vent and 4 m height above the vent, that is 20020 ppm hydrogen dispersed area.



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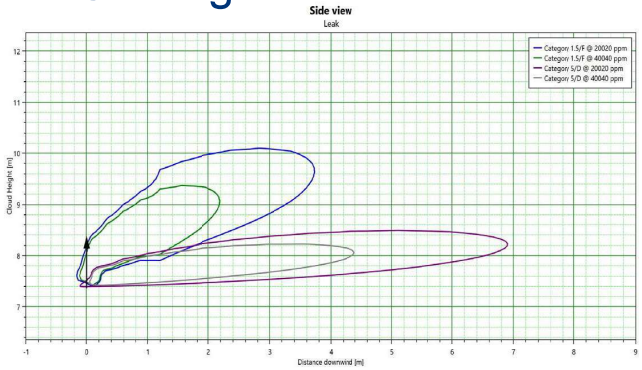
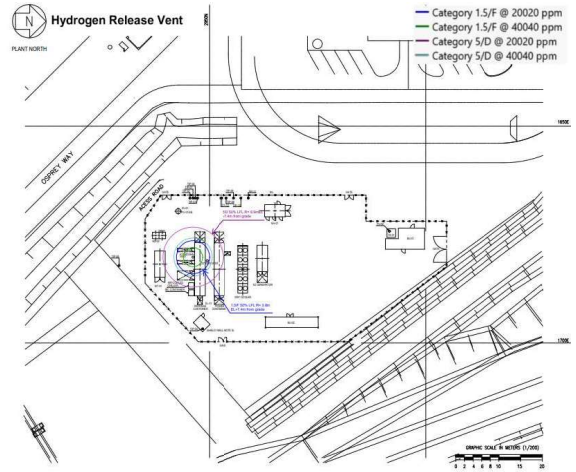




Dispersion radius increased but vent height increased to maintain safety

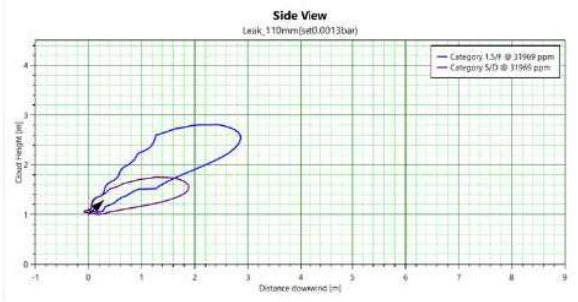
No equipment or buildings within the 50% LFL contour (20020 ppm) which is located:

- Within radius of 6.9 m from the vent
- 7.36 m height above grade

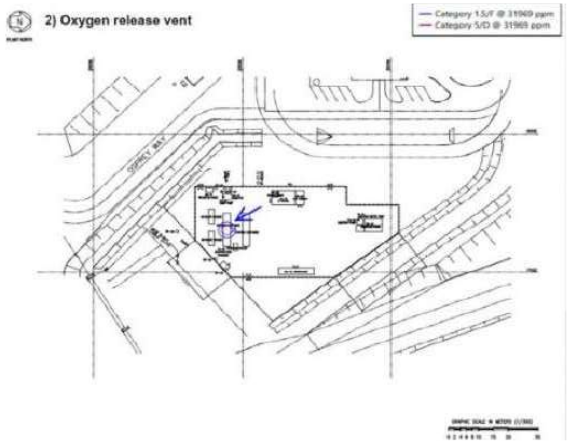
Updated atmospheric vent dispersion study

Oxygen release vent

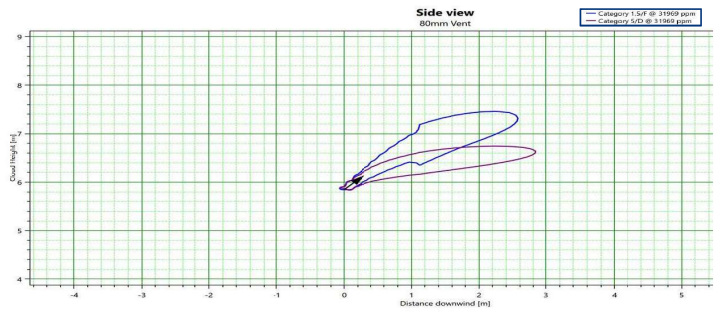
FEED design

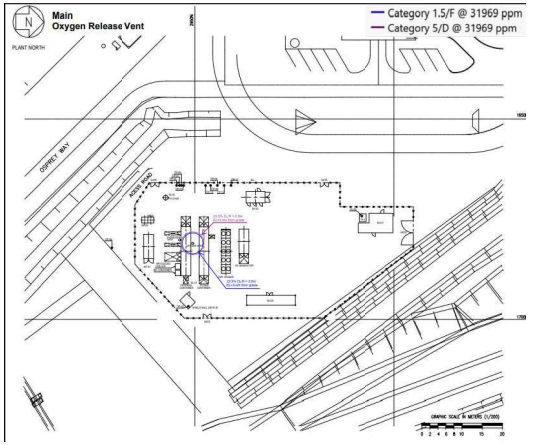


There shall not be allowed operator to access within a radius of 2.9 m from the vent, 1 m height below the vent and 2.9 m height above the vent, that is 31969 ppm oxygen dispersed area, where oxygen concentration is 23.5%.



EPC design





Dispersion radius increased but vent height increased to maintain safety

No operator access within 23.5% O2 concentration:

- Within radius of 2.9 m from the vent
- 7.5 m height above grade
- 5.9 m height above grade

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Thank you for your time and advice

Close-out of MHFU Recommendation

Gladstone H2 Ecosystem Project

A. MHFU Recommendation #1

- ***"Explosions in unvented containers, which have resulted in very high-pressure explosions and shrapnel damage. MHFU recommended installed of explosion (blast) vents to control pressures."***

B. Response

Understanding the hazard

1. Hazard Identification

No.	Guide word/Hazard	Cause	Consequence	Safeguard	Risk Category			Recommendation
					People	Asset	Env.	
H-1	Release of inventory	Hydrogen leak (Inside container)	Explosion/Fire	- Fire & Gas Detector - Air ventilation by HVAC - Emergency shut off in case of HVAC shut-down - Hazardous Area Classification and suitable selection for instrumentation and electrical items	High	High	Low	- Check the necessity of explosion-proof for electrical equipment in accordance with Rio Tinto's specification. - Evaluate enough separation distance between PEM Container and occupied buildings/area such as existing control room, maintenance workshop, parking. - Study the impact of fire and explosion on this scenario to the surrounding area especially for public road. - Protection against hydrogen permeations to be considered e.g. material selection of instrumentation

Understanding the hazard

2. Consequence Evaluation – Explosion Scenario

Explosion scenario

(Case 2-1) HAZID No. H-1: Release of inventory, Hydrogen leak (Inside container)
- Congested area inside Electrolyzer Container

(Case 2-2) HAZID No. H-2: Release of inventory, Hydrogen leak (Outside container)
- Congested area at shield wall surrounding Metering System

(Case 2-3) HAZID No. H-8: Overpressure, Increased hydrogen operating pressure due to process control deviation
- Congested area inside Electrolyzer Container

*For Explosion scenario, the HVAC ventilation in Electrolyzer Container is not considered in the modeling and calculation to evaluate the consequence conservatively according to GNMS0304 Mitigating process safety hazards on occupied buildings.

Understanding the hazard

2. Consequence Evaluation – Input Parameters

Vapor Cloud Explosion (Multi Energy Model) Condition

The end-point criteria for Vapor Cloud Explosion Scenario are summarized below for Case 2-1/2-3 and 2-2, respectively.

Applicable for Case 2-1 and 2-3:

Explosion Strength	:	7
H_2 Mass Inventory	:	3.3 kg
Process Room Volume	:	49.4 m^3
Process Room Vacancy Ratio	:	77.6 %
Flammable Gas Volume		38.3 m^3 (49.4 m^3 x 77.6%)
Mass Inventory in Stoichiometric Ratio with Air	:	0.97 kg

Inventory of flammable atmosphere in this pilot plant is relatively low compared to other industrial facilities with potential for explosion

Understanding the hazard

2. Consequence Evaluation – Explosion Criteria

Table 6.7 Damage Effects associated with Explosion Overpressures

Pressure (psig)	Level of Damage
0.02	Annoying noise (137 dB), if of low frequency (10-15 Hz)
0.03	Occasional breaking of large glass windows already under strain
0.04	Loud noise (143 dB). Sonic boom glass failure
0.1	Breakage of small windows under strain
0.15	Typical pressure for glass breakage
0.3	"Safe distance" (probability of 0.95 no serious damage beyond this value) Missile limit Some damage to house ceilings; 10% window glass broken
0.4	Limited minor structural damage
0.5-1.0	Large and small windows usually shattered
0.7	Minor damage to house structures
1.0	Partial demolition of houses, made uninhabitable
1-2	Corrugated asbestos shattered Corrugated steel or aluminum panels, fastenings fail, followed by buckling Wood panels (standard housing) fastening fail, panels blown in
1.3	Steel frame of clad building slightly distorted
2.0	Partial collapse of walls and roofs of houses
2-3	Concrete or cinder block walls, not reinforced, shattered
2.3	Lower limit of serious structural damage
2.5	50% destruction of brickwork of houses

*Diagnostic Features of Explosion Damage, 6th International Meeting on Forensic; CCPS (1994)

Understanding the hazard

2. Consequence Evaluation – Explosion Criteria

Severity Criteria are defined in Rio Tinto Standard, GNMS0304 Mitigating process safety hazards on occupied buildings, as below.

Table 6.8 Severity criteria

Severity Level	Overpressure	Thermal Radiation	Hypoxia [O_2 concentration]	Toxin Concentration[16]	Engulfment[17]
1	2kPa to 7kPa	2.5kW/m² to 5 kW/m²	14% to 17%	Between AEGL1 and AEGL2	Below 150mm
2	7kPa to 15kPa	5 kW/m² to 13 kW/m²	12% to 14%		150mm to 250mm
3 *	15kPa to 20kPa	13 kW/m² to 23 kW/m²	10% to 12%	Between AEGL2 and AEGL3	Above 250mm
4 *	20kPa to 35kPa	23 kW/m² to 35 kW/m²			
5 *	35kPa to 70 kPa	Above 35 kW/m²	10%	Above AEGL3	
6 *	Above 70kPa				

(0.3 to 1 psi)

(1 to 2 psi)

*GNMS0304 Mitigating process safety hazards on occupied buildings

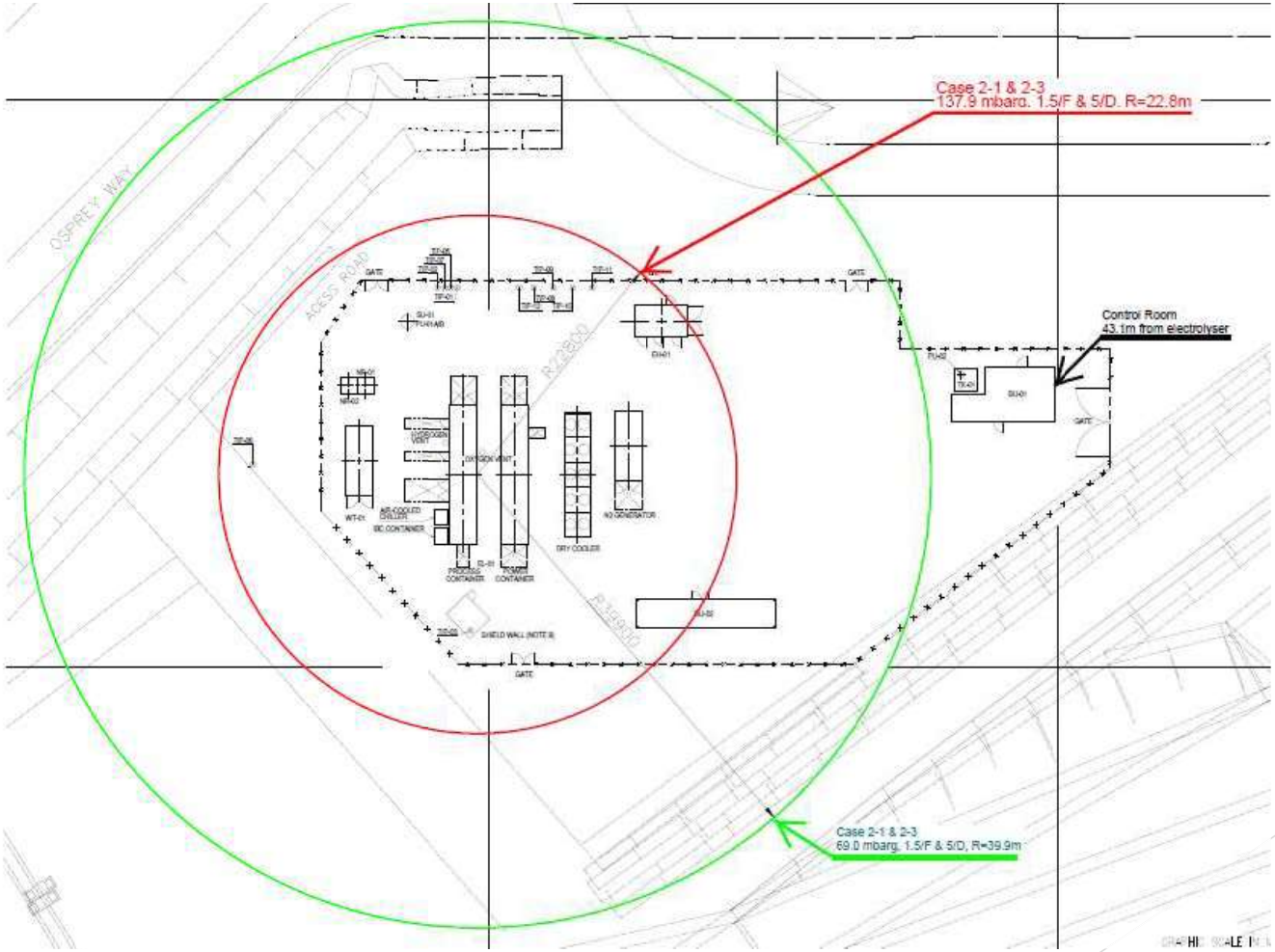
Table 6.9 Initial Acceptance Criteria - Consequence based analysis

Severity Level	Operations Building	Service Building, including Temporary / Portable Accommodation[1]	Administration Building and at the Site Boundary
1	Tolerable	Tolerable if risk management measures implemented to a level commensurate for green zone.	Tolerable if risk management measures implemented to a level commensurate for yellow zone
2	Tolerable if risk management measures implemented to a level commensurate for green zone.	Tolerable if risk management measures implemented to a level commensurate for yellow zone	Detailed analysis required or treated as not tolerable
3	Tolerable if risk management measures implemented to a level commensurate for yellow zone	Detailed analysis required or treated as not tolerable (Not tolerable for temporary / portable buildings)	Detailed analysis required or treated as not tolerable
4	Detailed analysis required or treated as not tolerable	Detailed analysis required or treated as not tolerable	Detailed analysis required or treated as not tolerable
5	Detailed analysis required or treated as not tolerable	Detailed analysis required or treated as not tolerable	Not Tolerable
6	Detailed analysis required or treated as not tolerable	Not Tolerable	Not Tolerable

* GNMS0304 Mitigating process safety hazards on occupied buildings

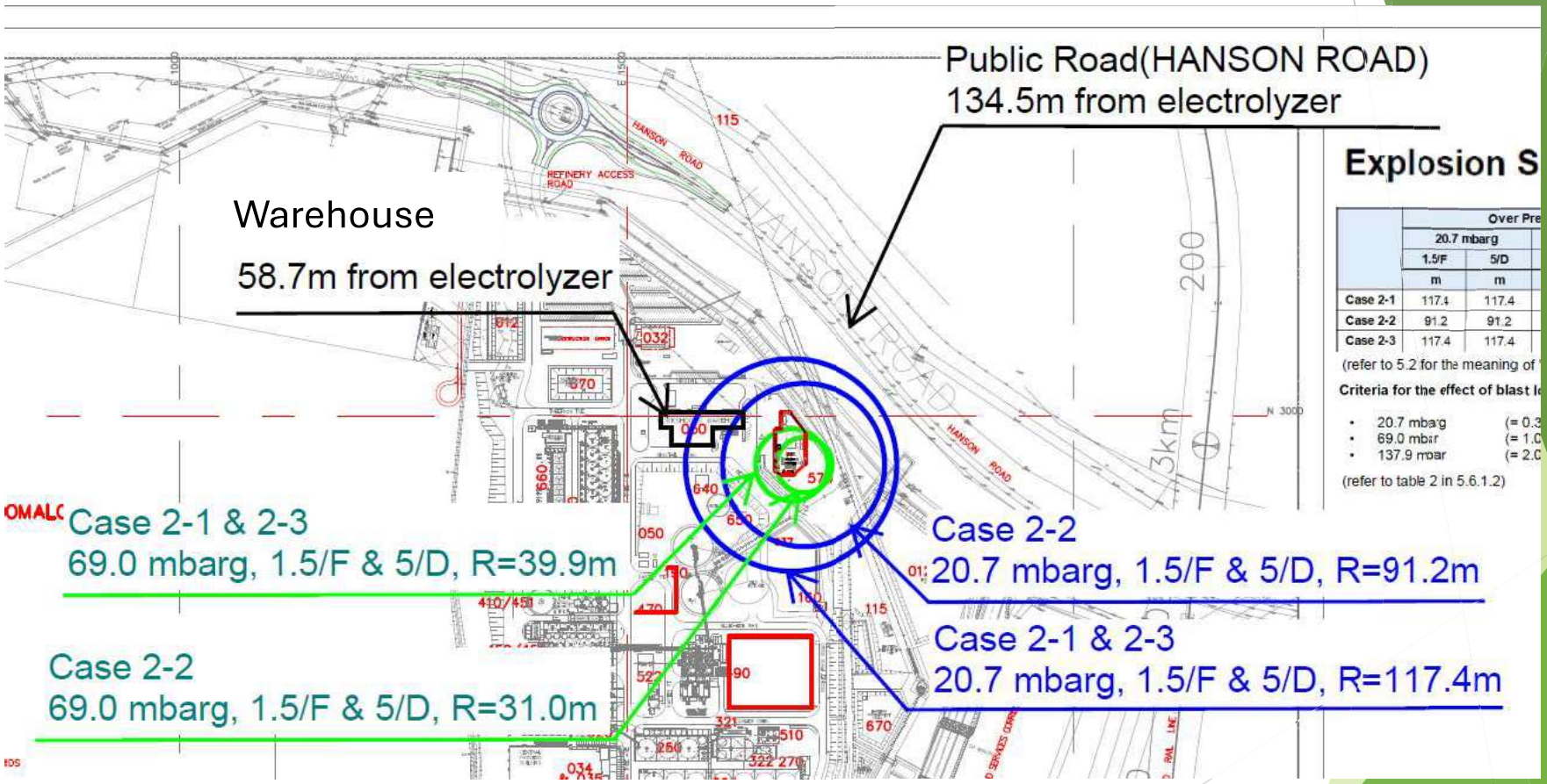
Understanding the hazard

2. Consequence Evaluation – Result



Understanding the hazard

2. Consequence Evaluation – Result



The pilot plant is located in an industrial facility and sufficiently far from critical public facilities such as churches, schools and commercial establishments.

Understanding the hazard

2. Consequence Evaluation – Summary of Results

All concern areas, buildings, and facilities have enough separation distance from Electrolyzer Container and Metering System as per the criteria provided.

Based on the Jet Fire and Vapor Cloud Explosion results shown in Tables 7.1 and 7.2, respectively, it is confirmed that the control room and public road have adequate separation distances from the identified hazards as listed in Section 4.

In addition, the warehouse and facilities owned by Rio Tinto were given an evaluation of Severity Level 1, which is categorized tolerable as per RTA STD, GNMS0304 Mitigating process safety hazards on occupied buildings.

Based on the above evaluation, risk associated to explosion of process container is in **Tolerable level**.

Due Diligence

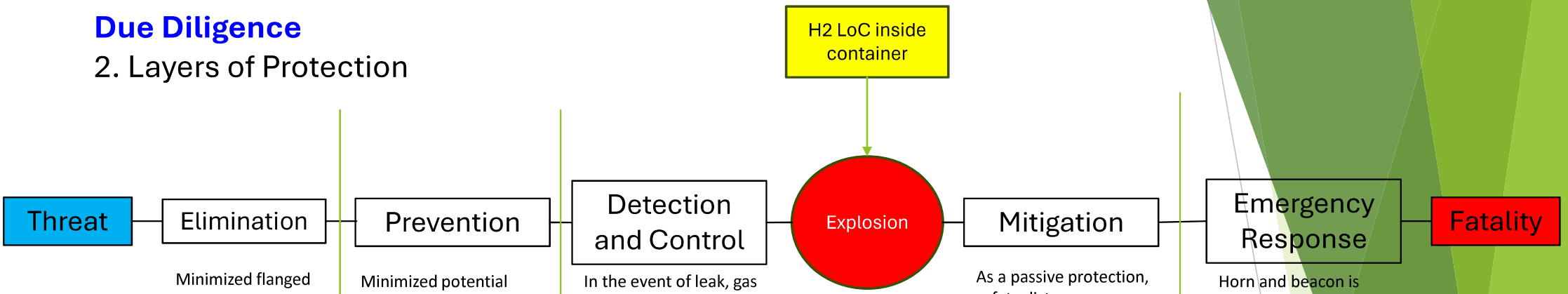
1. Defining SFAIRP

SFAIRP is a framework aiming to ensure that all “reasonably practicable” precautions are put in place to manage safety. It is threshold test for safety risk management in safety legislation in many jurisdictions.

A key aspect of SFAIRP is that there is no lower limit of risk that is automatically considered tolerable. Risk is considered tolerable if, and only if, there are no further practicable risk reduction measures available for implementation.

Due Diligence

2. Layers of Protection



Minimized flanged connections

Minimized potential sources of ignition reducing the likelihood of fire and/or explosion event

- Hazardous area classification is carefully implemented following applicable AS

In the event of leak, gas detection is provided set at a level below the flammability limit to ensure that leak is detected at early stage of release

During confirmed gas detection, the following actions are implemented:

- Ventilation rate is 600Nm3/hr in normal operation and will be intensified to 1,000Nm3/hr once hydrogen leakage is detected
- Electrolyzer stops the operation to prevent any further hydrogen production that may leak inside the container

As a passive protection, safety distances are carefully considered towards manned buildings inside the H2 generation facility, buildings in the nearby industrial facility (RTA), and public road.

Explosion hatch, a potential mitigation measure, has been carefully checked for suitability.

Horn and beacon is provided at the onset of release, for the operator to be aware of the incident and follow the established emergency response

Manning plan is lower than usual for industrial facility. The operator/s, being carefully selected, is expected to be trained for H2 hazards.

Escape path and emergency lighting will be provided in the facility.

Fire fighting operation, post explosion, can be performed as emergency access of fire truck is provided in the facility

Due Diligence

2. Layers of Protection – Evaluation of Explosion Hatch

- Explosion hatch is considered as a passive, mitigation control, for an explosion scenario, that can prevent catastrophic damage and loss of life
- Explosion hatch, however, does not extinguish the flame and may lead to post-explosion fires. This requires exclusion zones in the vicinity of the vent portal to protect personnel. There must be no other equipment or people in the zone during normal operation of the system.
- Specific to the project, explosion hatch will be mainly for the protection of apparatus (reducing the damage to the Electrolyzer itself) rather than operator protection as it was demonstrated that safety distances has been properly implemented in the design of the facility. The container may remain intact due to the provision of explosion hatch but equipment inside are still expected to be damaged by the explosion.
- Explosion relief panels are economical solution but unfortunately, they are often used incorrectly and thus become a danger to the process plant and the personnel operating it.
- If explosion hatch will be installed at the top of the container (which is most likely to eliminate the hazard of direct impact to nearby equipment), maintenance of the explosion hatch will pose additional hazard which is working at height.

Due Diligence

2. Layers of Protection - Summary

- Flammable material inventory in the pilot plant is relatively low compared to other industrial facility with potential for explosion event
- Given the robust emergency ventilation rate (2x5000 m3/h), the most frequent leakages within the container and their associated hydrogen release rates can be effectively diluted below the deflagration concentration level. It's worth noting that, according to NFPA 2, leaks less than 0.1 percent of the component flow areas represent 95 percent of the leakage frequency.
- The considered normal and emergency ventilation system, ignition controls – zone rated equipment (a prevention measure causing a significant reduction in ignition probability), gas detection, emergency shutdown/depressurization, and HVAC ramp-up collectively ensure that the risk of explosion is primarily prevented, rather than relying on an approach to mitigate the severity of explosion consequences.
- Explosion hatch might be able to prevent catastrophic damage and loss of life but there are concerns on mis-use and potential additional hazards posed by the maintenance of this control measure.
- Pilot plant is located in an industrial facility and sufficiently far from critical public facilities such as churches, schools and commercial establishments.

Due Diligence

3. Conclusion

Considering that the hazard has been evaluated to be properly addressed by active control measures (i.e., preventing the explosion from happening) and if explosion happens, sufficient safety distance (passive control) is provided to critical facilities, it is considered that the risk is tolerable.

And although explosion hatches, a potential additional passive protection may be employed as an additional mitigation measure, considering the low inventory of flammable material and the remote and controlled location of the pilot plant which is sufficiently far from critical public places, it is considered that this passive protection is not warranted for the scenario and the risk associated to the event is considered tolerable, so far as is reasonably practicable (SFAIRP).

C. MHFU Recommendation #2

- ***"Cold hydrogen vents igniting due to static electricity. Consider static electricity sources in detailed design including site electrical facilities and thunderstorms associated with tropical storms and cyclones."***

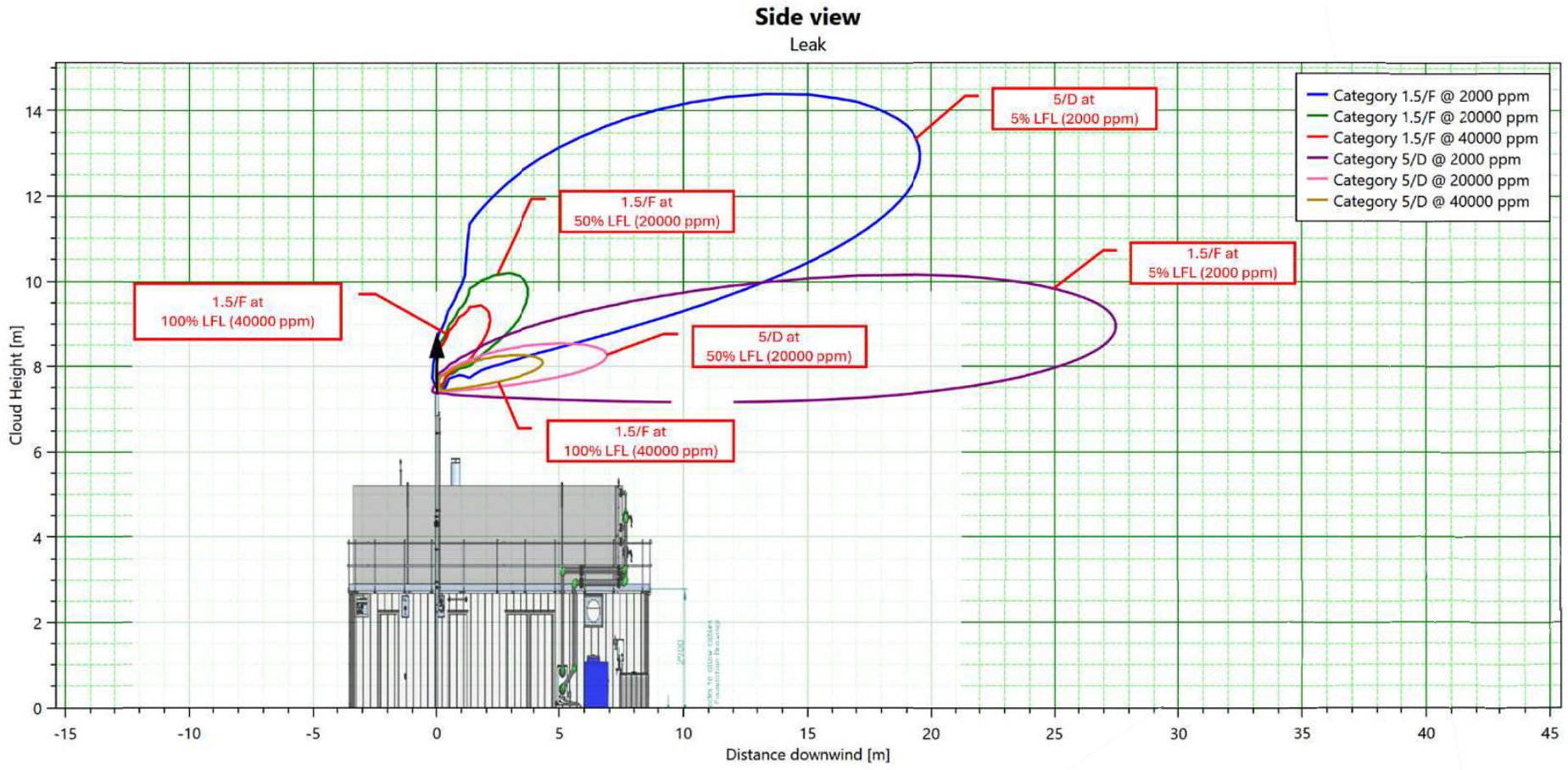
D. Response

- Earthing and bonding controls have been incorporated into the design in accordance with applicable law, regulation and Australian Standard

- No equipment or personnel access will be allowed within the 50% LFL contour of the H2 release vent

  MHFU commented, during preliminary discussion, that safe design considers 5% LFL for hydrogen release

- Provided below is the LFL, ½ LFL and 5% LFL contours from hydrogen release in the H2 vent



Due Diligence

Conclusion

It has been demonstrated, through the simulation of H2 release from the vent, that the gas cloud at 5% LFL, is not touching any platform or area that is accessible to the operators.

APPENDIX B EPC HAZID STUDY

SUMMIT HYDROGEN GLADSTONE PTY LTD	JOB No. 0-9120-20	DOC. No. T-00-1242-005	Rev. 1
	DATE 04 - APR - 2024	SHEET 1 OF 28	
	PREP'D	R.Osdon	R.O
	CHK'D	M.Manalo	M.M
	APP'D	M.Manalo	M.M
	RPEQ sign off	~~Required~~	Not required

EPC HAZID STUDY REPORT

RPEQ ☐ Squad Review Only ☐ Review ☐ Approval Single or Multiple Areas of Engineer (AoE)		
AoE 1		
AoE Discipline	RPEQ No.	Date
☐ with comment	☐ without comment	
AoE 2		
AoE Discipline	RPEQ No.	Date
☐ with comment	☐ without comment	
AoE 3		
AoE Discipline	RPEQ No.	Date
☐ with comment	☐ without comment	
AoE 4		
AoE Discipline	RPEQ No.	Date
☐ with comment	☐ without comment	
Individual RPEQ Disclaimer:		
The above signatory RPEQs are only responsible for Professional Engineering Service matters relating to their registered Area of Engineering. Compliance of the complete document is responsibility of the Document Approver		
☑ Acknowledged by JGC Responsible Manager* * as defined in Project Execution Plan		

For FA (mandatory)	
Owner has	
[ ] A:	Approved without comment
[ ] B:	Approved with minor comment, proceed to Next Status
[ ] R:	Not Approved subject to Resubmission at same status
[ ] F:	Not subject to review, Resubmission not required
For FC/FI/AB (not mandatory)	
Owner has	
[ ] C1:	Reviewed without comment
[ ] C2:	Reviewed with comment
DATE:	BY:
Gladstone H2 Ecosystem Project	

Gladstone H2 Ecosystem Project

FOR CONSTRUCTION

REV.	Date	Page	DESCRIPTION	PRE'D	CHK'D	APP'D
0	22 FEB 2024	All	For Approval (FA)	R.Osdon	M.Manalo	M.Manalo
1	04 APR 2024	All	For Construction (FC)	R.Osdon	M.Manalo	M.Manalo

Contents

1 INTRODUCTION

1.1 Scope

This document summarizes the methodology, key findings, and results of the HAZID (Hazard Identification) study for Gladstone H2 Ecosystem Project.

The HAZID Study is part of the "Safety in Design" approach which aims to prevent injuries and disease by considering hazards as early as possible in the planning and design process.

1.2 Objectives

The EPC HAZID study was conducted to systematically review the planned activities, identify significant credible impacts, and recommend measures to reduce risk in the facility. Principally, the objectives are to:

- Identify major hazards related to safety, health, and environment at a plant/unit level (high level identification)
- Determine the safeguards such as prevention, control and mitigation measures already incorporated in the design
- Propose recommendations for risk reduction

1.3 Definition

Project Name :	Gladstone H2 Ecosystem Project (GH2E Project)
Construction site :	Yarwun Alumina Refinery of Rio Tinto, Gladstone, Queensland, Australia
Owner :	Summit Hydrogen Gladstone Pty Ltd
JGC :	JGC Corporation Oceania Pty Ltd
RTA :	Off-taker of plant product, Rio Tinto Aluminum Limited
Purchaser :	Purchaser of JGC's item
Vendor :	Supplier of JGC's item
Subcontractor :	Engineering or Construction Company subcontracted under JGC
Inspector :	Owner / JGC Inspector or Third Party Inspector

1.4 Abbreviations

The following abbreviations shall be applied for this project.

ALARP	As Low As Reasonably Practicable
EPC	Engineering, Procurement and Construction
FEA	Fire and Explosion consequence-based Analysis
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HSE	Health, Safety and Environment
HVAC	Heating, Ventilation and Air-Conditioning
SIL	Safety Integrity Level
UPS	Uninterruptible Power Source

1.5 Order of Precedence

In the event conflicting requirements are identified, the following order is to apply, in decreasing order of precedence.

- Local Codes & Regulations
- Project Specifications
- Australian Standards
- International Standards
- RTA Standards

2 STANDARD CODE AND REGULATIONS

The standard code and regulations listed in the following tables are applicable to this document.

2.1 Australian Codes, Regulations and Standards

Code / Doc. No.	Description
N/A	

2.2 International Codes and Standards

Code / Doc. No.	Description
N/A	

2.3 Referenced Project Documents

Code / Doc. No.	Description
S-00-1240-001	GENERAL PHILOSOPHY FOR HSE DESIGN
T-00-1242-003	FEA REPORT (FIRE AND EXPLOSION CONSEQUENCE BASED ANALYSIS) AND ATMOSPHERIC VENT DISPERSION
D-00-1225-001	PLOT PLAN
S-00-1224-001	EQUIPMENT LIST
D-00-1223-001	PROCESS FLOW DIAGRAM FOR ELECTROLYZER PACKAGE
D-00-1225-102	PIPING AND INSTRUMENTATION DIAGRAM FOR HYDROGEN FACILITY
V-215A-104-A-DGN-013	PIPING AND INSTRUMENTATION DIAGRAM – WATER TREATMENT PACKAGE
V-215A-101-A-DGN-040	MATERIAL SAFETY DATA SHEETS – ELECTROLYZER PACKAGE

2.4 Referenced RTA Specifications & Standards

Code / Doc. No.	Description
N/A	

3 METHODOLOGY

EPC HAZID study was conducted through a workshop consisting of multi-disciplinary personnel with knowledge of the project by brainstorming method using guidewords.

3.1 Facility Scope

The scope of EPC HAZID study covers the following facilities:

- Electrolyzer (PEM) including Nitrogen Dilution as part of Product Safety Action
- E-House and Transformer
- Sump pump / pit
- Water Treatment Package (WTP)

Confirmation of FEED HAZID information was also done by the EPC HAZID team.

3.2 Guide Words

Selected guide words used during FEED stage were also used during EPC HAZID workshop.

- Process Hazard
  Release of inventory, Overpressure, High/Low temperature, Wrong composition

- Fire and Explosions:
  Stored flammables/inventory, Sources of ignition, Fire protection, Escape

- Operation Hazards:
  Operation personnel, Start-up and shut-down, By-pass operation, Utilities and their supply, Adjoining construction work

- Maintenance Hazards:
  Maintenance personnel, Maintenance requirements

- Others:
  Location, Climate, Geology/Subsoil, Environment, etc.

3.3 Risk Matrix

After the identification of potential hazards, an evaluation of the risk was performed by assessing the severity and likelihood of the scenario.

Risk was assessed for the categories “People” (risk category P), “Asset/Production Loss” (risk category A) and “Environment” (risk category E). The risk matrix in Appendix A was used to define the risk level.

3.4 Recommendation

If the team is not satisfied with the level of protection or otherwise perceives a need for further analysis, recommendations for further action were proposed during the workshop based on participants‘ consideration and agreement.

4 WORKSHOP DETAILS

4.1 Workshop Administration

The EPC HAZID study was conducted on 15th to 17th of January 2024, remotely through teleconferencing, with online participants from Manila, Japan, Australia and Belgium. Planned timetable is summarized in Appendix-B.

Identification of hazards, existing safeguards, and potential recommendations were conducted during the online discussions. Preliminary risk ranking was conducted by Contractor per Appendix-A and reviewed by Owner.

Summarized discussions during the workshop were recorded on the worksheet enclosed in Appendix-E.

During the EPC HAZID study workshop, three scenarios for the location and arrangement of the dry cooler were reviewed (See Section 4.4). After the workshop, a meeting was held with the team to finalize the location and arrangement of the dry cooler. It was decided that the dry cooler would be placed at the ground level with a horizontal arrangement. Any hazards for the three plot plan scenarios that were reviewed during the EPC HAZID study were re-assessed to see if they were still applicable, and the results of this re-assessment were noted in the worksheet in Appendix along with remarks.

4.2 Workshop Organization

4.2.1 General

The workshop attendees consisted of multi-disciplinary personnel with knowledge of the project comprised by the following:

- Owner's Representatives
- JGC's Representatives (including Project Engineer, Technical HSE Engineer, Equipment Package Engineers, Process Engineer and others as required)
- Electrolyzer Package Vendor
- RTA's Representatives

The exact composition of the team and attendances are shown in Appendix-C.

4.2.2 Roles and Responsibilities

The following sections describe the roles and responsibilities of the attendees:

4.2.3 Facilitator

The Facilitator ensures that all objectives and requirements provided in this procedure are considered for the studies.

The Facilitator is responsible for conducting and facilitating the study workshops. He must ensure that the discussions are progressive and that all required members participate. At the end of the study, the Facilitator shall be responsible for issuing the HAZID study reports per each area.

4.2.4 Scribe

The Scribe is responsible for taking notes and completing the worksheets during the study session.

4.2.5 Contractor Project Engineers

The Project Engineers will make available documents/materials utilized in the workshop. They are responsible for the action follow-up to close out the comments/recommendations raised in the session.

4.2.6 Contractor HSE Engineers

Participant coordination and workshop preparation (e.g., workshop invitation, meeting room arrangement and material preparation) will be done by HSE Engineer before the session. He will manage the whole sessions and schedules during the session as a contractor representative. He is responsible to summarize the worksheets and follow-up sheets after the session, and distributes them to the contractor persons in charge for action close out.

4.2.7 Other Contractor Engineers

Other Contractor Engineers are responsible for providing comments based on their knowledge and experience to identify any issues that should be discussed by the whole team. They have the authority to make appropriate decision and also responsible to assist the team in revolving issues by suggesting countermeasures to overcome the problems and assist the team at a consensus.

4.3 Reference Documents

The references used during the HAZID session were the most up to date information available at the time of the HAZID session. However, it is noted that these references might be subject to change during the project and are not per definition the final documents approved by Owner.

- D-00-1225-001 Plot plan
- D-00-1223-001 Process Flow Diagram for Hydrogen Production Facility
- D-00-1225-102 P&ID for Hydrogen Production Facility
- Explanatory Material for Nitrogen Generator
- Safety Data Sheets for Water Treatment Package and Electrolyzer Package
- Final Report of Cummins Product Safety Action

4.4 Study Cases

During FEED HAZID, location of dry cooler on ground was considered (Case 0).

Additionally, during EPC HAZID study, three scenarios for the dry cooler location are evaluated which are enumerated as follows:

- Case 1 (Base)
  Dry cooler on top of process container (vertical arrangement)

- Case 2 (Alternative)
  Dry cooler on top of process container (horizontal arrangement)

- Case 3 (Alternative)
  Dry cooler on separate elevated structure (horizontal arrangement)

As mentioned in Section 4.1, post-workshop, the dry cooler with horizontal arrangement was placed to be located on ground.

5 STUDY RESULT

Discussions during the workshop were recorded on the worksheet in Appendix-E. These worksheets include the identified accident scenarios (cause), the potential consequences, the available safeguards, the risk evaluation (ranking) and the recommendations to improve design and operation.

In the worksheets, FEED HAZID scenarios revalidated during the EPC phase are numbered from 1 to 40 with prefix “H-”. Additional scenarios identified during the EPC phase are numbered starting from Log. No. 41 preceded by prefix “HZ-”.

Additional of 33 scenarios from EPC was added to scenarios logged during FEED Phase for a total of 73 scenarios.

As mentioned in Section 4.1, after the HAZID workshop, dry cooler (horizontal arrangement) was selected. Re-assessment of the applicable hazards because of this selection are also enclosed in Appendix-E together with remarks. Recommendations which are not applicable to this selection are marked with strikethroughs on the worksheet in Appendix-E.

Recommendations captured during the workshop are in Appendix-D, including which ones still apply after selecting the dry cooler location and arrangement. Recommendations no longer applicable are marked with a strikethrough.

Additional 36 recommendations are generated during the EPC HAZID study bringing the total of 35 from FEED Phase to 71 during EPC Phase. This is considering the selection of the dry cooler location and arrangement. Recommendations related to the non-selected configurations of the dry cooler are marked in strikethrough.

The following tables show the number of scenarios for risk category and risk level as the risk ranking results.

<Risk category P, People>

Case	TOTAL (Ranked risk No.)	Very High	High	Medium
Plot Plan Case 1	45	0	25	13
Plot Plan Case 2	46	0	25	14
Plot Plan Case 3	47	0	26	14

<Risk category A, Asset/Production Loss >

Case	TOTAL (Ranked risk No.)	Very High	High	Medium
Plot Plan Case 1	35	0	19	6
Plot Plan Case 2	35	0	19	6
Plot Plan Case 3	36	0	20	6

<Risk category E, Environment >

Case	TOTAL (Ranked risk No.)	Very High	High	Medium
Plot Plan Case 1	35	0	0	17
Plot Plan Case 2	35	0	0	17
Plot Plan Case 3	36	0	0	18

APPENDIX-A: RISK MATRIX

				Severity				
				1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
			People	Slight Injury (Medical Time Injury (MTI), e.g., requiring first aid treatment. Able to continue working)	Minor Injury (Loss Time Injury (LTI) up to a week, e.g., temporary partial disability) -> Medical Attention required (e.g., doctor visit).	Major Injury (Loss Time Injury (LTI) greater than 1 week, e.g., permanent partial disability) -> Hospital admission or recovery time is greater than 1 week.	Single Fatality Or permanent total disability. Severe mental trauma resulting in inability to work.	Multiple Fatalities Or Permanent Total Disabilities Multiple persons with sever metnal trauma resulting in inability to work.
			Asset / Production Loss	Slight Damage / Loss <5% of the annual revenue budget (for production loss) and up to AUD 0.2M (for Asset)	Minor Damage / Loss <10% of the annual revenue budget (for production loss) and up to AUD 1M (for Asset)	Local Damage / Loss <20% of the annual revenue budget (for production loss) and up to AUD 5M (for Asset)	Major Damage / Loss <30% of the annual revenue budget (for production loss) and up to AUD 10M (for Asset)	Extensive Damage / Loss >30% of the annual revenue budget (for production loss) and greater than AUD 10M (for Asset)
			Environment	Slight Impact Localised or confined contamination or damage which is reversible or can be cleaned easily and without any long lasting effects. Reversible with normal practices within 24 hours. Heritage impact negigible.	Minor Impact Environmental contamination or damage requiring professional remediation. Reversible short term impact (typically 1-4 weeks). Heritage impact negligible or no direct impact to cultural features.	Moderate Impact Destruction of public or private property, environmental contamination. Localised and confined. Reversible medium term recovery (typically 1-6 months). Heritage impact to cultural features of significance.	Major Impact Unconfined environmental contamination or damage to culturally significant property. Long term action/recovery required (typically 1-10 years). Residual damage. Heritage impacts within a site boundary resulting in impacts to cultural features.	Massive Impact Permanent or large scale contamination of environment, destruction of culturally significant property. Potential for impact to grow over time in both a spatial and degree sense (eg. biomagnification) Requires long-term recovery (typically 10+ years). Major residual damage. Specialist response required. Heritage impacts within a site boundary resulting in loss of cutural features of high significance and/or national heritage values.
			Reputation	Slight Impact Minor public and internal commentary across limited platforms (eg. media, social media).	Minor Impact Community and stakeholders dissatisfied or sceptical about OWNER's motives or actions but continue to engage and collaborate, complaints easily resolved without escalation. Some internal and external (eg media, social media or regulator) scrutiny or complaints. Minor medium-term impact on stakeholder relationships.	Moderate Impact Multiple complaints and negative feedback Stakeholders begin to distance themselves from OWNER. Community becomes passive to OWNER's engagement and messages. Parliamentary questions/Ministerial directive. Negative public and internal commentary across multiple platforms (eg media, social media).	Major Impact Stakeholders withdraw from participating in OWNER's activities. Difficulty attracting and retaining staff. Loss of community confidence. High profile, public, State or national adverse reaction. Ongoing negative public and internal commentary across multiple platforms (eg. media, social media). Sustained Government/ regulator investigation.	Massive Impact Long term, extensive damage to OWNER's reputation resulting in the resignation of the Minister, Commissioner and/or senior members of staff. Extensive and ongoing negative public and internal commentary across multiple platforms (eg media, social media). Complete loss of public confidence.
Likelihood (Probability)	E Almost Certain	Happens several times per year at location (Is expected to occur in most circumstances)	> 90%	E1	E2	E3	E4	E5
	D Likely	Happens several times per year in company (Is expected to occur often)	>65%	D1	D2	D3	D4	D5
	C Possible	Incident has occurred in company (Is expected to occur at least once)	> 20%	C1	C2	C3	C4	C5
	B Unlikely	Heard of incident in industry (Is expected to occur at some time)	< 20%	B1	B2	B3	B4	B5
	A Rare	Never heard of in industry (Event would only be expected to occur in exceptional circumstances)	<5%	A1	A2	A3	A4	A5

Low Medium High Very High

APPENDIX-B: EPC HAZID TIMETABLE

Schedule is driven by guidewords then per Unit in order to have a more comprehensive review of the plant working as a system and not just per unit.

Agenda	Duration	Day 1									
		Manila		Tokyo/Yokohama		Brisbane		Melbourne		Oevel	
		Start	End	Start	End	Start	End	Start	End	Start	End
Introduction of Methodology / Agenda	15	14:00	14:15	15:00	15:15	16:00	16:15	17:00	17:15	7:00	7:15
Process Overview (w/ Additional Units)	15	14:15	14:30	15:15	15:30	16:15	16:30	17:15	17:30	7:15	7:30
Plot Plan Overview	10	14:30	14:40	15:30	15:40	16:30	16:40	17:30	17:40	7:30	7:40
Interface with Outside Plant	20	14:40	15:00	15:40	16:00	16:40	17:00	17:40	18:00	7:40	8:00
Break	15	15:00	15:15	16:00	16:15	17:00	17:15	18:00	18:15	8:00	8:15
Process Hazards	60	15:15	16:15	16:15	17:15	17:15	18:15	18:15	19:15	8:15	9:15
Break	15	16:15	16:30	17:15	17:30	18:15	18:30	19:15	19:30	9:15	9:30
Fire and Explosions	30	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	9:30	10:00
	180										

Agenda	Duration	Day 2									
		Manila		Tokyo/Yokohama		Brisbane		Melbourne		Oevel	
		Start	End	Start	End	Start	End	Start	End	Start	End
Fire and Explosions (continued)	30	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	7:00	7:30
Operation Hazards	30	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00	7:30	8:00
Break	15	15:00	15:15	16:00	16:15	17:00	17:15	18:00	18:15	8:00	8:15
Operation Hazards	30	15:15	15:45	16:15	16:45	17:15	17:45	18:15	18:45	8:15	8:45
Break	15	15:45	16:00	16:45	17:00	17:45	18:00	18:45	19:00	8:45	9:00
Maintenance Hazards	60	16:00	17:00	17:00	18:00	18:00	19:00	19:00	20:00	9:00	10:00
	180										

Agenda	Duration	Day 3									
		Manila		Tokyo/Yokohama		Brisbane		Melbourne		Oevel	
		Start	End	Start	End	Start	End	Start	End	Start	End
Location, Climate, Geology / Subsoil	60	14:00	15:00	15:00	16:00	16:00	17:00	17:00	18:00	7:00	8:00
Break	15	15:00	15:15	16:00	16:15	17:00	17:15	18:00	18:15	8:00	8:15
Environmental Hazards	60	15:15	16:15	16:15	17:15	17:15	18:15	18:15	19:15	8:15	9:15
Break	15	16:15	16:30	17:15	17:30	18:15	18:30	19:15	19:30	9:15	9:30
Recap	30	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	9:30	10:00
	180										

APPENDIX-C: ATTENDEE LIST

Name	Company	Role	HAZID Role	Online Attendance		
				15-Jan	16-Jan	17-Jan
Marvin Manalo	JGC	Lead Technical Safety Engineer	Facilitator	X	X	X
Reinette Osdon	JGC	Technical Safety Engineer	Scribe	X	X	X
Shunsuke Mochida	JGC	Project Manager	Design Engineer (Balance of Plant)	X	X	X
Ariston Alberca	JGC	Engineering Manager	Design Engineer (Balance of Plant)	X	X	X
Shunsuke Kawabata	JGC	Lead Package Equipment Engineer	Design Engineer (Equipment Packages)	X	X	X
Meriel Maniquiz	JGC	Lead Process Engineer	Process Engineer	X	X	X
Junnel Vargas	JGC	Lead Piping Engineer	Design Engineer (Piping)	X	X	
Daisy Pineda	JGC	Lead Instrument Engineer	Instrument Engineer			X
Eileen Marie Velez	JGC	Package Equipment Engineer	Design Engineer (WTP)	X	X	X
Carlo Castillo	JGC	Project Engineer	Design Engineer (Balance of Plant)	X	X	X
Eugene Tupas	JGC	Project Engineer	Design Engineer (Balance of Plant)	X	X	
Ghia Luwalhati	JGC	Technical Safety Engineer	Safety Engineer	X	X	X
Jackie Lou Marti	JGC	Project Engineer	Design Engineer (Balance of Plant)	X	X	X
Liezl June Chan	JGC	Process Engineer	Process Engineer	X		
Rey Anthony Dee	JGC	Process Technical Adviser	Process Engineer		X	
Koji Kanamaru	SHG	Hydrogen Business Development (Americas, Oceania and EMEACIS)	GH2E Owner Representative	X	X	X
Miro Moss	SHG	Project Development Manager	GH2E Owner Representative	X	X	X
Noboru Yoshino	SHG	Assistant General Manager	GH2E Owner Representative	X	X	X
Yuki Sato	SHG	Senior Project Coordinator	GH2E Owner Representative	X	X	X
Astrid Bealing	GPA	Senior Process Engineer	Process Engineer		X	X
Christopher Olive	GPA	Process Engineer	Process Engineer	X	X	X
Gaurang Joshi	GPA	Senior Project Manager	Design Engineer	X	X	X
Rinkesh Shah	GPA	Project Engineer	Design Engineer	X	X	X

Name	Company	Role	HAZID Role	Online Attendance		
				15-Jan	16-Jan	17-Jan
Terry Weier	GPA	Electrical Instrumentation and Control Technical Officer	Electrical Instrumentation and Control	X	X	X
Tara Mevissen	GPA	GPA Representative	GPA Representative		X	X
Jason Vella	RTA	Mechanical Project Engineer	RTA Representative	X	X	X
Steven Fogarty	RTA	Process Engineer	RTA Representative	X	X	X
Johan Standaert	Cummins	Engineering Manager	Electrolyzer Package Vendor Representative	X	X	X
Siby Joseph	Cummins	Design Engineer	Electrolyzer Package Vendor Representative	X	X	X
Ruben Govaerts	Cummins	Design Engineer	Electrolyzer Package Vendor Representative	X	X	
Alejandrina Bermudez Salvati	Cummins	Design Engineer	Electrolyzer Package Vendor Representative	X	X	X
Elena Panova	Cummins	Design Engineer	Electrolyzer Package Vendor Representative	X		

Note: X = Present

APPENDIX-D: RECOMMENDATION LIST

The following table summarizes the recommendations from the HAZID workshop.

No.	Recommendation	Action by
H-1	- Evaluate enough separation distance between PEM Container and manned buildings/area such as existing control room, maintenance workshop, parking.	FEED Contractor
	- Study the impact of fire and explosion on this scenario to the surrounding area especially for public road.	FEED Contractor
	- Protection against hydrogen permeations to be considered e.g. material selection of instrumentation	EPC Contractor
H-2	- Study the impact of fire and explosion on this scenario to the surrounding area.	FEED Contractor
H-3	- Study the safe location of vent by dispersion analysis	EPC Contractor
H-4	- Provide a portable O2 meter in order for operators to enter a confined space.	EPC Contractor
	- Provide a manual and/or training for maintenance operator considering O2 piping and this scenario.	EPC Contractor
H-5	- Study the safe location of vent by dispersion analysis	EPC Contractor
H-6	- Check the necessity of fire protection system after Vendor selected	EPC Contractor
H-7	- Make sure that the surface drainage around the chemical injection point is designed to prevent pollution.	EPC Contractor
H-8	- Check the necessity of pressure relief valves and/or the emergency depressuring system with PEM Vendor.	EPC Contractor
	- Consider to conduct HAZOP and SIL workshop after Vendor's detail information such as P&ID is available at EPC Phase.	EPC Contractor
H-9	- Confirm with Vendor if this scenario is feasible or not.	EPC Contractor
	- Add an alarm to monitor oxygen pressure.	EPC Contractor
	- Check the necessity of emergency shut-down system automatically activated by high pressure alarm.	EPC Contractor
H-10	- Confirm necessity of personal protection according to outlet temp. based on Vendor info	EPC Contractor
H-11	N/A	N/A
H-12	- Check with vendor about impact on water electrolysis system in the scenario.	EPC Contractor
H-13	- Evaluate this scenario in HAZOP workshop after Vendor's detail information such as P&ID is available at EPC Phase.	EPC Contractor
H-14	- Evaluate this scenario in HAZOP and SIL workshop after Vendor's detail information such as P&ID is available at EPC Phase.	EPC Contractor
	- Oil free treatment such as chemical cleaning to be applied to O2 piping and fittings	EPC Contractor
	- Material selection for O2 piping not to provide a scale leading to spark or frictional ignition	EPC Contractor
H-15	- Make sure that the surface drainage around the transformer is designed to prevent escalation of fire.	EPC Contractor
H-16	N/A	N/A
H-17	N/A	N/A
H-18	N/A	N/A
H-19	N/A	N/A
H-20	- Check local fire fighting organizations	Facility Owner
H-21	N/A	N/A
H-22	N/A	N/A

No.	Recommendation	Action by
H-23	- Provide a portable safety shower for the maintenance activity, if ethylene glycol is used.	EPC Contractor
H-24	Refer to HAZID No. HZ-46 for the actions. (NOTE 1)	(NOTE 1)
H-25	N/A	N/A
H-26	- Confirm with Vendor UPS capacity enough to safely shut-down for Electrolyzer	EPC Contractor
	- Confirm if an alarm of HVAC stop or room high temp. or panel high temp. can be provided in order for operators to make a suitable response.	FEED Contractor
H-27	- Study the safe location of vent by dispersion analysis - Evaluate this scenario inside Electrolyzer package in HAZOP and SIL workshop after Vendor's detail information such as P&ID is available at EPC Phase.	EPC Contractor EPC Contractor
H-28	N/A	N/A
H-29	- According to the approved procedure, take appropriate measures for confined space entry. e.g. O2 meter, air blower, etc.	EPC Contractor
H-30	N/A	N/A
H-31	N/A	N/A
H-32	- Check the necessity of automatic emergency shutdown for PEM by the emergency shutdown signal from Rio Tinto's facility.	FEED Contractor
H-33	- Check the necessity of pressure relief valves and/or the emergency depressuring system with Vendor.	EPC Contractor
	- Ensure receiving the signal from Rio Tinto facility, or Establishment of communication system with Rio Tinto.	FEED Contractor
H-34	- Check the necessity of pressure low protection system with Vendor.	EPC Contractor
	- Ensure Rio Tinto receiving the signal from Hydrogen Facility, or Establishment of communication system with Rio Tinto.	FEED Contractor / Rio Tinto
H-35	N/A	N/A
H-36	N/A	N/A
H-37	N/A	N/A
H-38	N/A	N/A
H-39	N/A	N/A
H-40	- Provide a manual and/or training for construction and for operation.	EPC Contractor
	- Ensure proper housekeeping and fauna management.	EPC Contractor / Owner's Team
HZ-41	- Confirm if airflow is sufficient considering the nitrogen leak inside process container.	EPC Contractor
HZ-42	N/A	N/A
HZ-43	N/A	N/A
HZ-44	- Confirm the duration of N2 purging operation during start-up and shutdown conditions.	EPC Contractor
	- Ensure that N2 vent location considers N2 purging scenarios during start-up and shutdown.	EPC Contractor
HZ-45	N/A	N/A

No.	Recommendation	Action by
HZ-46	- Ensure that overpressure due to regulator failure is considered in the design of the electrolyzer.	EPC Contractor
	- Verify the necessity of N2 bundle as backup for N2 purging operation using N2 generator.	EPC Contractor
	- If N2 bundle is confirmed to be backup for N2 purging, verify that the N2 bundle inventory is still sufficient for the safe purging operation, considering that N2 from bundle is regularly for analyzer use.	EPC Contractor
	- To ensure alignment of recommendations in the HAZOP study.	EPC Contractor
HZ-47	N/A	N/A
HZ-48	- Review N2 purity loop using a LOPA Analysis to ensure safety requirements are met.	EPC Contractor
	- Consider provision of flame arrestor on the vent line.	EPC Contractor
HZ-49	N/A	N/A
HZ-50	N/A	N/A
HZ-51	N/A	N/A
HZ-52	- Review the definition of confined space as per Australian Standard (AS 2865) for all containers.	EPC Contractor
	- If applicable, ensure development of confined space entry procedure based on AS requirements.	EPC Contractor
HZ-53	- Ensure that the noise level at the fence line between GH2E and RTA to be max. 82 dBA during normal operation.	EPC Contractor
HZ-54	- Incorporate proper housekeeping in operating procedures of GH2E facility taking into account the dusty environment from the neighboring facility.	EPC Contractor
	- Ensure that proper housekeeping procedures will be adhered during operation.	Owner's Team
	- Ensure proper earthing and bonding controls are provided.	EPC Contractor
HZ-55	- Consider the safety of personnel conducting the inspection ~~*of dry cooler (e.g. working at* height~~). **(NOTE 2)**	EPC Contractor **(NOTE 2)**
	- Ensure compliance to Australian Standard during inspection.	EPC Contractor
	- Check QLD Code of Practice for managing risks of falls.	EPC Contractor
HZ-56	~~*- Ensure that foundation/structure is designed to handle the load of the electrolyzer and dry cooler (including fluid weight) on top of process container during cyclone event.*~~ **(NOTE 2)**	~~*EPC Contractor*~~ **(NOTE 2)**
	- For dry cooler ~~*mounted on separate structure*~~ **installed on grade**, ensure that the process conditions are still satisfied to deliver the required hydrogen quality. **(NOTE 2)**	EPC Contractor **(NOTE 2)**
HZ-57	- Incorporate RTA's cyclone readiness procedure in emergency response planning document for GH2E facility.	EPC Contractor
HZ-58	- Include information on appropriate PPE / clothing rated for H2 areas in the operation procedure.	EPC Contractor
	- Purchase and use of appropriate PPE / clothing rated for H2 areas.	Owner's Team
HZ-59	- Include statement on provision and use of box outside hazardous area for smart devices (smartphones / smartwatches).	EPC Contractor
	- Ensure implementation of protocol not to bring smart devices inside hazardous area.	Owner's Team
HZ-60	Ensure proper dust management procedure and adequate access as per AS 1657 will be in place especially in horizontally oriented dry cooler.	EPC Contractor
HZ-61	~~*- Conduct consequence analysis to ensure that there will be no impact to operator on the elevated structure* when flammable gas release is ignited from the H2 vent.*~~ **(NOTES 2, 3)**	~~*EPC Contractor*~~ **(NOTES 2, 3)**

No.	Recommendation	Action by
HZ-62	- Conduct risk assessment for functional safety requirements as per AS 61508 / IEC 62443.	EPC Contractor
	- Ensure that safety instrumented function related to remote shutdown shall have suitable SIL rating.	EPC Contractor
HZ-63	N/A	N/A
HZ-64	N/A	N/A
HZ-65	- Ensure that size of access gate is suitable for the transport device dimension.	EPC Contractor
HZ-66	- Include information on the leak testing procedure in the operation and maintenance manual.	EPC Contractor
	- Consider use of Helium during leak testing and general maintenance for Hydrogen equipment (i.e. flange)	EPC Contractor
HZ-67	N/A	N/A
HZ-68	- Ensure compliance of Safety Shower and Eye wash with AS 4775.	EPC Contractor
HZ-69	- Ensure that the potential release of high salinity of reject water to environment is covered in the operation manual.	EPC Contractor
HZ-70	N/A	N/A
HZ-71	- Ensure that piping and cable arrangement will be designed adequately to allow personnel access/movement to conduct operations and maintenance activities.	EPC Contractor
HZ-72	- Review location of gate and proximity of access to the building for proposed vehicle path.	EPC Contractor
	- Review clashes with piping and cable trays as shown in the vehicle turning in current design.	EPC Contractor
HZ-73	N/A	N/A

NOTE:

1. Additional recommendation during EPC HAZID Workshop to FEED Scenario.
2. Recommendation was updated post-workshop based on the selection of dry cooler (horizontal) on ground.
3. Recommendation for H_2 vent release hazard for dry cooler (horizontal) on ground is covered in HAZID Item No. H-3.

APPENDIX-E: HAZID WORKSHEET

0-9120-20-0000 EPC for Gladstone H2 Ecosystem Project
EPC HAZID Study Work Sheet
LEGEND:
Additional items during EPC Session (*)
~~*Deleted during EPC Workshop*~~
Post-workshop remarks
Logged during FEED Phase
Additional during FEED Phase
(*) Scenario Numbering: **H -** FEED HAZID **| HZ -** EPC HAZID

1/22/2024

No.	Guide word/Hazard	Cause	Consequence	Safeguard	Risk Ranking P	A	E	Recommendation	Action by	Remarks
	Process Hazard									
H-1	Release of inventory	Hydrogen leak (Inside container)	Explosion/Fire	- Fire & Gas Detector - Air ventilation by HVAC - Emergency shut off in case of HVAC shut-down *- Hazardous Area Classification and suitable selection for instrumentation and electrical items*	C5	C5	C1	~~- Check the necessity of explosion proof for electrical equipment in accordance with Rio Tinto's specification.~~ - Evaluate enough separation distance between PEM Container and manned buildings/area such as existing control room, maintenance workshop, parking. - Study the impact of fire and explosion on this scenario to the surrounding area especially for public road. - Protection against hydrogen permeations to be considered e.g. material selection *of instrumentation*	~~FEED Contractor~~ FEED Contractor FEED Contractor EPC Contractor	*Fire and Explosion Analysis (T-00-1242-003)* *Fire and Explosion Analysis (T-00-1242-003)*
H-2	Release of inventory	Hydrogen leak (Outside container) 30 barg	*Explosion/*Fire	*- Shield wall to prevent dispersion of leaked H2 gas* *- Fire & Gas Detector inside shield wall* *- Automatic Emergency Shut-down by F&G detection*	B4	B4	B1	~~- Check the necessity of fire protection system in accordance with Rio Tinto's specification.~~ - Study the impact of fire and explosion on this scenario to the surrounding area.	~~*NOTE 1~~ FEED Contractor	*Gas fire shall not be extinguished to avoid re-ignition and/or explosion. Emergency shut-down shall be prioritized over firefighting activities.*
H-3	*Release of inventory*	*Continuous Hydrogen release from H2 vent*	*Fire*	*- H2 Vent at safe location*	E1	E1	E1	*- Study the safe location of vent by dispersion analysis*	*EPC Contractor*	*Added Scenario*
H-4	Release of inventory	Oxygen leak (Inside container) *0barg*	- Danger to operator health by Hyperoxic condition in confined space *- Fire during mainteance*		C3	C1	C1	*- Provide* a portable O2 *meter in order for operators to enter* a confined space. *- Provide a manual and/or training for maintenance operator considering O2 piping and this scenario.*	*EPC Contractor* *EPC Contractor*	
H-5	Release of inventory	Continuous oxygen release *from O2 vent* (Outside container) *0barg*	Danger to the surrounding area by massive release of O2 e.g. Induction of fire at other process unit in Rio Tinto facility	- O2 Vent at safe location	E3	E3	E1	- Study the safe location of vent by dispersion analysis	EPC Contractor	

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Additional during FEED Phase
(*) Scenario Numbering: **H -** FEED HAZID **| HZ -** EPC HAZID

1/22/2024

No.	Guide word/Hazard	Cause	Consequence	Safeguard	Risk Ranking P	A	E	Recommendation	Action by	Remarks
H-6	Release of inventory	Ethylene glycol aqueous solution spill	Fire caused by ignition	- IBC container outside process container - Smoke detection inside process container to safe shutdown	C3	C3	C2	- Check the necessity of fire protection system after Vendor selected	EPC Contractor	~~*This is a potential scenario that may disappear depending on the result of the Vendor selection.*~~ **EPC Update: Ethylene glycol will still be used in the selected electrolyzer.
H-7	Release of inventory	Ethylene glycol aqueous solution spill	Wastewater pollution	- IBC container outside process container	C1	C1	C3	- *Make sure that the surface drainage around the chemical injection point is designed to prevent pollution.*	EPC Contractor	~~*This is a potential scenario that may disappear depending on the result of the Vendor selection.*~~ **EPC Update: Ethylene glycol will still be used in the selected electrolyzer.
HZ-41	Release of inventory	Nitrogen leak (inside process container)	Asphyxiation	- OTA (Oxygen through atmosphere) detectors resulting to emergency shutdown	C4	C1	C1	- Confirm if airflow is sufficient considering the nitrogen leak inside process container.	EPC Contractor	
HZ-42	Release of inventory	Nitrogen leak (inside process container)	Electrolyzer shutdown due to loss of pressure of nitrogen	- Electrolyzer shutdown	-	-	-			No risk ranking as this is associated to asset loss.
HZ-43	Release of inventory	Nitrogen leak (inside nitrogen container)	Asphyxiation	- OTA detectors resulting to emergency shutdown	C4	C1	C1			*The level of performance (rating) for the safety function of the OTA detector in the nitrogen container and safe shutdown will be determined during LOPA Study for N2 generation.
HZ-44	Release of inventory	Nitrogen leak (outside process container)	Asphyxiation	- N2 vent at safe location - Dry cooler on top of the process container: limited personnel access - Portable O2 detector to be used by maintenance operator	C4	C1	C1	- Confirm the duration of N2 purging operation during start-up and shutdown conditions. - Ensure that N2 vent location considers N2 purging scenarios during start-up and shutdown.	EPC Contractor EPC Contractor	
HZ-45	Release of inventory	Nitrogen leak (outside nitrogen container)	Asphyxiation	- N2 vent at safe location	C4	C1	C1			

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Post-workshop remarks
Logged during FEED Phase
Additional during FEED Phase
(*) Scenario Numbering: **H -** FEED HAZID **| HZ -** EPC HAZID

1/22/2024

No.	Guide word/Hazard	Cause	Consequence	Safeguard	Risk Ranking P	A	E	Recommendation	Action by	Remarks
HZ-46	Overpressure	Nitrogen source switching operation with N2 bundle regulator failure	Potential overpressure on the electrolyzer	- Double regulator per Australian standard	B1	B3	B1	- Ensure that overpressure due to regulator failure is considered in the design of the electrolyzer. - Verify the necessity of N2 bundle as backup for N2 purging operation using N2 generator. - If N2 bundle is confirmed to be backup for N2 purging, verify that the N2 bundle inventory is still sufficient for the safe purging operation, considering that N2 from bundle is regularly for analyzer use. - To ensure alignment of recommendations in the HAZOP study.	EPC Contractor EPC Contractor EPC Contractor EPC Contractor	
HZ-47	Overpressure	Nitrogen generator regulator failure	Overpressure on the electrolyzer (break tanks)	- Multiple measurements of pressure with multiple alarm steps and shut-off - PSV	B1	B3	B1			
H-8	Overpressure	Increased hydrogen operating pressure due to process control deviation	Overpressure exceeding design pressure, rupture, release of H2, fire and explosion	- Emergency Shut-down System	B5	B5	B1	- Check the necessity of pressure relief valves and/or the emergency depressuring system with PEM Vendor - Consider to conduct HAZOP and SIL workshop after Vendor's detail information such as P&ID is available at EPC Phase.	EPC Contractor EPC Contractor	
H-9	Overpressure	Increased oxygen operating pressure due to process control deviation, vent clogging	Permeation of oxygen to the hydrogen side, or formation of an explosive atmosphere due to membrane rapture, fire and explosion	- Pressure Transmitter	B5	B5	B1	- Confirm with Vendor if this scenario is feasible or not. - Add an alarm to monitor oxygen pressure. - Check the necessity of emergency shut-down system automatically activated by high pressure alarm.	EPC Contractor EPC Contractor EPC Contractor	
H-10	High temperature	Electrolyzer outlet of hydrogen/ oxygen line	Burn injury		-	-	-	- Confirm necessity of personal protection according to outlet temp. based on Vendor info	EPC Contractor	*(Reference) Max. Operating Temp.: Approx. 55~60degC*
H-11	Low temperature	Not applicable			-	-	-			

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Post-workshop remarks
Logged during FEED Phase
Additional during FEED Phase
(*) Scenario Numbering: **H -** FEED HAZID **| HZ -** EPC HAZID

1/22/2024

No.	Guide word/Hazard	Cause	Consequence	Safeguard	Risk Ranking P	A	E	Recommendation	Action by	Remarks
H-12	Wrong composition	Heat exchanger tube leak/rupture	Contamination/pollution of ethylene glycol aqueous solution into water electrolysis process		*	*	*	- Check with vendor about impact on water electrolysis system in the scenario.	EPC Contractor	~~*This is a potential scenario that may disappear depending on the result of the Vendor selection.*~~ **EPC Update: Ethylene glycol will still be used.
H-13	Wrong composition	Heat exchanger tube leak/rupture	Contamination/pollution of hydrogen and oxygen into cooling medium, damage to the cooling medium circulation pump due to cabitation, release of H2, fire and explosion	- Periodic inspection	C5	C5	C3	- Evaluate this scenario in HAZOP workshop after Vendor's detail information such as P&ID is available at EPC Phase.	EPC Contractor	
H-14	*Wrong composition*	*Increased hydrogen concentration in O2 line*	*Formation of explosive atmosphere in O2 line, fire and explosion*	*- H2 Analyzer(H/HH Alarm) at O2 outlet of electrolyzer* *- Shut-down of Electrolyser* *- Shut-down valve at the downstream facility*	B5	B5	B1	*- Evaluate this scenario in HAZOP and SIL workshop after Vendor's detail information such as P&ID is available at EPC Phase.* *- Oil free treatment such as chemical cleaning to be applied to O2 piping and fittings* *- Material selection for O2 piping not to provide a scale leading to spark or frictional ignition*	*EPC Contractor* *EPC Contractor* *EPC Contractor*	*Added Scenario during FEED*
HZ-48	Wrong composition	Nitrogen generator outlet purity not met	- Lack of N2 purity resulting to flammable atmosphere in the electrolyzer	- N2 purity check in the N2 generator system	C5	C5	C3	- Review N2 purity loop using a LOPA Analysis to ensure safety requirements are met. - Consider provision of flame arrestor on the vent line.	EPC Contractor EPC Contractor	
	Fire and Explosion									
H-15	Stored flammables/inventory	Heat input to insulating oil in transformer by fire in the surrounding area	Pool fire	*- High Temperature Alarm of oil in transformer* *- Fire Extinguisher*	C3	C3	C3	~~- Consider fire extinguishers and any alarm to alert high temperature of oil or fire.~~ *- Make sure that the surface drainage around the transformer is designed to prevent escalation of fire.*	~~*NOTE 1~~ EPC Contractor	~~*This is a potential scenario that may disappear depending on the result of the Vendor selection. (Dry type transformer)*~~ **EPC Update: Insulating oil will still be used.
H-16	Sources of ignition	Deterioration of electric cable	Ignition when flammable fluid leaks, fire and explosion	- Periodic inspection	A3	A3	A1			
H-17	Sources of ignition	Outdoor electrical equipment (instrumentation electrical equipment)	Ignition when flammable fluid leaks, fire and explosion	*- Hazardous Area Classification and suitable selection for instrumentation and electrical items*	-	-	-			
H-18	Sources of ignition	Automobile	Ignition when flammable fluid leaks, fire and explosion	*- Access control by fence* *- Safety distance from facility (Min. 8m for 1" H2 piping as per NFPA 55)*	A3	A3	A1	~~- Consider access control by fences, safety distance, etc.~~	~~FEED Contractor~~	
H-19	Sources of ignition	Sparks during maintenance	Ignition when flammable fluid leaks, fire and explosion	- Maintenance only at shutdown	-	-	-			
H-20	Fire protection				-	-	-	- Check local fire fighting organizations	Facility Owner	
H-21	Escape			*- Two directions of escape (Main gate and Sub gate)*	-	-	-	~~- Consider multiple entrances to the container~~ ~~- Consider Plotplan with access for fire engines~~ ~~- Provide Fire engine size information~~	~~EPC Contractor~~ ~~FEED Contractor~~ Facility Owner	

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EPC HAZID Study Work Sheet
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Post-workshop remarks
Logged during FEED Phase
Additional during FEED Phase
(*) Scenario Numbering: **H -** FEED HAZID **| HZ -** EPC HAZID

1/22/2024

No.	Guide word/Hazard	Cause	Consequence	Safeguard	Risk Ranking P	A	E	Recommendation	Action by	Remarks
	Operational Hazards									
H-22	Operation personnel	Not applicable			-	-	-			
H-23	Start-up and shut-down	Filling with ethylene glycol	Operator exposure due to misoperation		B3	B1	B3	- *Provide a portable safety shower for the maintenance activity, if ethylene glycol is used.*	*EPC Contractor*	~~*This is a potential scenario that may disappear depending on the result of the Vendor selection.*~~ **EPC Update: Ethylene glycol will still be used in the selected electrolyzer.
HZ-49	Start-up and shut-down	Failure of nitrogen generation	Failure to complete the purging on ramp down	- Low pressure trip on buffer vessel - Sufficient inventory on buffer vessel to complete the purging	C5	C5	C3			
H-24	By-pass operation	~~Not applicable~~			-	-	-	Refer to HAZID No. 46 for the actions.		Refer to HAZID No. 46 for the remarks.
H-25	Utilities and their supply	Power supply stop	Deviation of process control due to DCS failure	- UPS for 30 min. (not including N2 generator)	-	-	-			
H-26	Utilities and their supply	Power supply stop	Loss of ventilation function due to HVAC shutdown *of E-house*, instrumet/electrical room temperature raise and potential malfunction		A3	A3	A1	- *Confirm with Vendor* UPS capacity enough to safely shut-down *for Electrolyzer* - Confirm if an alarm of HVAC stop or room high temp. *or panel high temp.* can be provided in order for operators to make a suitable response.	*EPC Contractor* FEED Contractor	
HZ-50	Utilities and their supply	Power supply stoppage	Nitrogen generation stops resulting to incomplete purging	- Low pressure trip on buffer vessel - Sufficient inventory on buffer vessel to complete the purging	C5	C5	C3			
H-27	Utilities and their supply	Instrument air supply stop (air failure)	Deviation of process control due to instrumentation air outage, *On-off valve at O2 vent line to be opened, (Refer to the above No.5 scenario)*	*- O2 Vent at safe location*	E3	E3	E1	*- Study the safe location of vent by dispersion analysis* *- Evaluate this scenario inside Electrolyzer package in HAZOP and SIL workshop after Vendor's detail information such as P&ID is available at EPC Phase.*	*EPC Contractor* *EPC Contractor*	*All valves for N2 generator are powered electrically.
H-28	Adjoining construction work	Damage to existing underground gas pipeline	**According to "HYDRAULIC SERVICES SITE PLAN" (H05-025-H001_A.pdf) of existing facility, this scenario seems not credible.*		-	-	-	~~- Check the route before construction work.~~	~~EPC Contractor~~	
H-29	*Adjoining construction work*	*Confined space: Sump pit*	*Danger to operator health by suffocation condition in confined space*	*- Construction procedure and Permit system*	-	-	-	*- According to the approved procedure, take appropriate measures for confined space entry. e.g. O2 meter, air blower, etc.*	*EPC Contractor*	*Added Scenario during FEED*

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No.	Guide word/Hazard	Cause	Consequence	Safeguard	Risk Ranking P	A	E	Recommendation	Action by	Remarks
	Maintenance Hazards									
H-30	Maintenance personnel	Not applicable			-	-	-			
H-31	Maintenance requirements	Cell stack replacement (once every 10 years)	No safety issues		-	-	-			
HZ-51	Maintenance requirements	Nitrogen generator compressor and filter maintenance			-	-	-			To be revisited during HAZOP study
HZ-52	Maintenance requirements	Confined space for containers	Danger to operator health by suffocation condition in confined space		C2	-	-	- Review the definition of confined space as per Australian Standard (AS 2865) for all containers. - If applicable, ensure development of confined space entry procedure based on AS requirements.	EPC Contractor EPC Contractor	
	Others									
H-32	Location (Neighboring facilities)	Rio Tinto's facility	Damage to the PEM due to vibration generated during an emergency shut-down of the existing facility, fire and explosion		A5	A5	A1	- Check the necessity of automatic emergency shutdown for PEM by the emergency shutdown signal from Rio Tinto's facility.	*FEED Contractor*	
H-33	Location (Neighboring facilities)	Operation trouble *at the downsteam facility* (Rio Tinto side)	Damage due to overpressure, fire and explosion	- Emergency Shut-down System	B5	B5	B1	- Check the necessity of pressure relief valves and/or the emergency depressuring system with Vendor. - Ensure receiving the signal from *Rio Tinto* facility, or Establishment of communication system with Rio Tinto.	EPC Contractor *FEED Contractor*	
H-34	*Location (Neighboring facilities)*	*Operation trouble at hydrogen production that affects the downsteam facility (Rio Tinto side)*	*Damage due to underpressure (vacuum) cause by hydrogen compressor failing to stop.*	*- Emergency Shut-down System*	B5	B5	B1	*- Check the necessity of pressure low protection system with Vendor.* *- Ensure Rio Tinto receiving the signal from Hydrogen Facility, or Establishment of communication system with Rio Tinto.*	*EPC Contractor* *FEED Contractor /Rio Tinto*	*Added Scenario*
HZ-53	Location (Neighboring facilities)	Noise generating equipment	Potential high noise level on perimeter fence of GH2E		B3	-	-	- Ensure that the noise level at the fence line between GH2E and RTA to be max. 82 dBA during normal operation.	EPC Contractor	*Operation of RTA considers 12 hr shift / day.
H-35	Location (Transport)	Road	Traffic accident	*- Access control by fence*	-	-	-	~~- Check the frequency and impact of vehicles driving the nearby roads.~~	~~Facility Owner~~	
H-36	Climate	~~Thunder~~ Lightning	~~Lightning~~ Ignition of H2 vent release	- Lightning rod / earth - Limited equipment and personnel access based on dispersion study results	C5	C5	C3			*No equipment and personnel access installed around 50%LFL contour of H2 release.
H-37	Climate	Earthquake		- Seismic design for structure *according to BEDD*	-	-	-	~~- Check the impact of earthquake to PEM Vendor~~	~~EPC Contractor~~	
HZ-54	Climate	Dusty environment*	- Ignition, fire and explosion - Higher frequency of inspection for outdoor equipment which may increase slip/trip/fall incident		C5	C5	C3	- Incorporate proper housekeeping in operating procedures of GH2E facility taking into account the dusty environment from the neighboring facility. - Ensure that proper housekeeping procedures will be adhered during operation. - Ensure proper earthing and bonding controls are provided.	EPC Contractor Owner's Team EPC Contractor	*Alumina and background dust contributing to dusty environment

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HZ-55	Maintenance requirements	~~Access to dry cooler for~~ Working at heights during maintenance*	~~- Higher frequency of inspection for outdoor equipment which may increase~~ slip/trip/fall incident		~~C3~~	-	-	- Consider the safety of personnel conducting the inspection ~~of dry cooler (e.g. working~~ at height~~).~~ - Ensure compliance to Australian Standard during inspection.** - Check QLD Code of Practice for managing risks of falls.	EPC Contractor EPC Contractor EPC Contractor	~~*Dry cooler on top of process container (vertical/horizontal), dry cooler on separate elevated structure~~ **Check RTA's procedure for working at heights. **Post-HAZID Study Update:** * Specific recommendations for dry cooler at higher elevation are no longer applicable since the decision was made to install the cooler on the ground. However, general recommendations for managing risks of falls for accessing outdoor equipment during maintenance still apply.
HZ-60	Maintenance requirements	Dust accumulation on flat surface*	- Higher frequency of maintenance for outdoor equipment which may increase slip/trip/fall incident		C3	-	-	Ensure proper dust management procedure and adequate access as per AS 1657 will be in place especially in horizontally oriented dry cooler.	EPC Contractor	~~*Dry cooler on top of process container (horizontal) and dry cooler on separate elevated structure*~~ **Post-HAZID Study Update:** *Dry cooler on ground with horizontal orientation was selected.
HZ-56	Climate	Cyclone and high wind speeds	Potential damage to equipment ~~(*)~~		-	-	-	~~- Ensure that foundation/structure is designed to handle the load of the electrolyzer and dry cooler (including fluid weight) on top of process container during cyclone event. (*)~~ - For dry cooler ~~mounted on separate structure~~ installed on grade, ensure that the process conditions are still satisfied to deliver the required hydrogen quality. *(**)*	~~EPC Contractor~~ *EPC Contractor*	~~*Dry cooler on top of process container (vertical/horizontal)*~~ **Post-HAZID Study Update:** (*)Recommendation regarding design load for dry cooler on top of process container during cyclone event is not applicable anymore since dry cooler on ground with horizontal orientation was selected. (**) Recommendation is not deleted since process conditions still need to be satisfied to deliver the required hydrogen quality as a result of relocation to grade.

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HZ-57	Climate	Cyclone and high wind speeds	Potential loss of containment leading to fire/explosion	- Operation shutdown during cyclone events in Yarwun area - Structural design considering cyclone loads	C4	-	-	- Incorporate RTA's cyclone readiness procedure in emergency response planning document for GH2E facility.	EPC Contractor	
HZ-58	Climate	High static charges during winter	Potential ignition during incidental H2 release leading to fire and explosion	Operating procedure	B4	-	-	- Include information on appropriate PPE / clothing rated for H2 areas in the operation procedure. - Purchase and use of appropriate PPE / clothing rated for H2 areas.	EPC Contractor Owner's Team	
HZ-59	Operation hazard	Entry of non-hazardous rated items to hazardous area	Ignition, fire and explosion	Operating procedure	C5	C5	C3	- Include statement on provision and use of box outside hazardous area for smart devices (smartphones / smartwatches). - Ensure implementation of protocol not to bring smart devices inside hazardous area.	EPC Contractor Owner's Team	
~~*HZ-61*~~	~~*Release of inventory*~~	~~*H2 vent release*~~	~~*Ignition, fire and explosion*~~	~~*Vent to safe location*~~	~~*C5*~~	~~*C5*~~	~~*C3*~~	~~*- Conduct consequence analysis to ensure that there will be no impact to operator on the elevated structure* when flammable gas release is ignited from the H2 vent.*~~	~~*EPC Contractor*~~	~~**Dry cooler on separate elevated structure*~~ **Post-HAZID Study Update:** *Dry cooler installed on ground with horizontal orientation was selected. Hazard related to H2 vent release for dry cooler (horizontal) on ground is covered in HAZID Item No. H-3.

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H-38	Geology/Subsoil	Not applicable			-	-	-			
H-39	Environment	Wild animal (Kangaroo)	Damage on equipment	- *Access control by fence*	-	D3	-	~~- Provide access control by fences, etc.~~	~~FEED Contractor~~	
H-40	*Environment*	*Wild animal (Snake/Spider)*	*Poison leading to death*		C4	-	-	*- Provide a manual and/or training for construction and for operation.* - Ensure proper housekeeping and fauna management.	*EPC Contractor* EPC Contractor / Owner's Team	*<Reference>* *https://www.billabongsanctuary.com.au/coastal-taipan/* *https://www.reptilepark.com.au/redback-spider/* *Check the housekeeping and fauna management of RTA.
HZ-62	Security-related hazard	Cyberattack	- Stoppage of operation - H2 release, fire/explosion - Possible fatality	- Information security management plan	C5	C5	C3	- Conduct risk assessment for functional safety requirements as per AS 61508 / IEC 62443. - Ensure that safety instrumented function related to remote shutdown shall have suitable SIL rating.	EPC Contractor EPC Contractor	
HZ-63	Environment	Solar radiation	- Instrument and electrical cable damage	- Tray cover - Sunshade for instruments	-	-	-			
HZ-64	Environment	Vegetation growth (grass)	- Personnel trip especially near sump pit location	- Movable fence	C2	-	-			
HZ-65	Operation hazard	Entry of transport device for N2 bottle replacement	Damage to sump pit due to vehicle impact	- Movable fence	-	-	-	- Ensure that size of access gate is suitable for the transport device dimension.	EPC Contractor	
HZ-66	Maintenance requirements	Hydrogen facility	Undetected release during leak testing when using incorrect fluid medium		C5	C5	C3	- Include information on the leak testing procedure in the operation and maintenance manual. - Consider use of Helium during leak testing and general maintenance for Hydrogen equipment (i.e. flange)	EPC Contractor EPC Contractor	
HZ-67	Operation and Construction Hazard: Psychosocial hazard	Workplace interactions or behaviors (sexual harrassment, discrimination, drugs and alcohol use, etc.)	Negative impact on mental health of personnel	- Fit for work requirements, - HSE Management plan and policies	B2	-	-			

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HZ-68	Start-up and shut-down	Filling with WTP Antiscalant 135	Operator exposure due to misoperation	- Safety Shower and Eyewash	B3	-	B3	- Ensure compliance of Safety Shower and Eye wash with AS 4775.	EPC Contractor	
HZ-69	Start-up and shut-down	RO flushing operation	Possible release of high salinity of reject water to environment	- Standard operating procedure - Design of WTP	-	-	-	- Ensure that the potential release of high salinity of reject water to environment is covered in the operation manual.	EPC Contractor	
HZ-70	Wrong composition	Incorrect chemical used for antiscalant	- Damage to equipment	- Standard operating procedure	-	-	-			
HZ-71	Operation / maintenance hazard	Piping and cable layout	Personnel slips, trips and falls		C3	-	-	- Ensure that piping and cable arrangement will be designed adequately to allow personnel access/movement to conduct operations and maintenance activities.	EPC Contractor	
HZ-72	Fire and Explosion	Limited Access through Proposed Emergency Gate	Emergency vehicle cannot enter the facility	- Standard operating procedure	C4	-	-	- Review location of gate and proximity of access to the building for proposed vehicle path. - Review clashes with piping and cable trays as shown in the vehicle turning in current design.	EPC Contractor EPC Contractor	
HZ-73	Location	Terrain outside the facility	- Emergency response cannot be conducted - Damage to RTA facility	- Fence outside the GH2E facility where emergency vehicle access is expected	-	-	-			

*NOTE:
1 Deleted.~~Engineering service related to Fire Protection to be considered at next phase according to OWNER's request.~~