Rio Tinto

Summit Hydrogen Gladstone

Yarwun Hydrogen Calcination Pilot Demonstration Program[1]

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Lessons Learnt Report no.2 (July 2024 – Sept 2024)

Rio Tinto Aluminium Limited[2]
Summit Hydrogen Gladstone[3]

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[1] https://www.riotinto.com/sustainability/climate-change/yarwun-hydrogen-calcination-pilot
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1.0 Project background

The alumina refining industry in Australia emits approximately 14.9 Mt of CO_2-e per annum, or 3% of Australia's Greenhouse Gas emissions. Calciners, which use high temperatures to extract chemically bound water from alumina crystals, traditionally use fossil fuels for process heat and contribute 25% of emissions from alumina refining.[4]

Hydrogen calcination technology has the potential to abate about 25% of emissions from Gladstone refineries. At current production levels, full implementation of this technology at Yarwun has the potential to reduce emissions by 500kt CO_2e per annum.

Rio Tinto and Summit Hydrogen Gladstone (SHG), a subsidiary of Sumitomo Corporation, aim to jointly deliver a project that will demonstrate the production of hydrogen and operation of hydrogen fuelled calcination for process heating at Rio Tinto's Yarwun alumina refinery.

The objective of the project is to prove the hydrogen calcination technology is technically viable for alumina refineries.

The project aims to validate the use of hydrogen for calcination process within an operating refinery and develop the systems, processes, and skills to manage hydrogen onsite and integrate this into existing infrastructure. The project also aims to accelerate the development and commercialisation of hydrogen calcination technology and if successful, will also support the establishment of the Gladstone hydrogen industry.

Hydrogen will be produced via a 2.5 MW electrolyser and it will then be compressed to more than 200 barg. Approximately 4,000 kg of hydrogen will be stored, and when required for a trial run at the K1 Calciner unit, it will be let-down from approximately 200 barg to 10 barg which is the delivery pressure for firing at the hydrogen burners. This delivery configuration (i.e., compression-storage-let-down) was selected to achieve the necessary full-scale hydrogen flowrates and durations needed for testing while keeping the electrolyser size to a minimum.

The project will be delivered in two concurrent work packages:

- Work Package 1 will be delivered by SHG and involves the installation of a 2.5 MW polymer electrolyte membrane hydrogen electrolyser and associated equipment with a production capacity of 250 to 300 tonnes per annum of hydrogen on site at the Yarwun refinery
- Work Package 2 will be delivered by Rio Tinto and involves:
    - The design and installation of full-scale hydrogen burners and a steam recycle loop at Rio Tinto's Yarwun refinery.
    - The installation of 4 tonnes of hydrogen storage, which is required to store enough hydrogen to operate the calciner for 2 hours using 100% hydrogen fuel. This is considered the minimum

[4] https://arena.gov.au/knowledge-bank/a-roadmap-for-decarbonising-australian-alumina-refining/

operating window required to simulate and de-risk full scale operation of hydrogen calcination technology.

2.0 Executive summary

This second lessons learnt report covers learnings from both Rio Tinto and SHG, around process safety and risk mitigation during construction stages, specification of metering equipment and the importance of early compliance checks with local regulations as well as engaging third party specialist contractors.

Key learnings include:

- The use of a Safety Critical Task Analysis (SCTA) is recommended for high-risk projects.

- The impact of brownfield construction within an operating site can potentially introduce both safety and business production risks. Risks were mitigated by securing an adjacent easement corridor and establishing a safe and secure access route for Sumitomo's construction workforce.

- 2017 Qld Regulation (Petroleum and Gas (Production and Safety) Act 2004 (Qld)[5]) requires hydrogen measurement accuracy of ±1%. An external flow meter with flanged connection is required and this necessitated changes to the piping design to comply with ASME B31.12 (Hydrogen Piping and Pipelines) and associated hazardous area assessments. The flow meter was relocated within a shield wall to mitigate potential jet releases.

- The project has also experienced delays due to coordination issues with sub-vendors, impacting civil design and government approvals. Early subcontractor engagement can help align design paths. Incorporating design flexibility and considering skilled local labour availability can also help manage timelines more effectively.

3.0 Key learnings

3.1 Safety Critical Task Analysis

Category: Risk

As part of the safety assurance process for this project, an external specialist was engaged to facilitate a workshop to assess the impact of human errors to process safety risk.

The Safety Critical Task Analysis (SCTA) workshop consisted of three distinct stages:

- critical task selection

[5] Petroleum and Gas (Production and Safety) Act 2004 - Queensland Legislation - Queensland Government

- task prioritisation and screening to identify potential for high consequence events
- critical task analysis to identify single-point human failures.

The SHERPA software uses hierarchical task analysis (Figure 1) to map how operators will likely perform a given task and breaks these into individual constituent parts. The negative consequences of any human failure will be modelled with the use of performance influencing factors (PIFs) to identify causal factors and potential interventions to reduce probability of risk.

The analysis of the critical tasks did not identify any obvious single point human failures that would, by themselves, lead to any major unwanted events sequence (e.g. loss of containment from hydrogen transfer pipework etc). The analysis did however identify opportunities for maximising human reliability during all foreseeable operating conditions, by providing specific recommendations which may both:

a) optimise performance influencing factors; and
b) reduce human contribution to risk

Implication for future projects: To mitigate against risk of human failures on process safety critical tasks, and in particular, procedures which involve introducing new, high consequence hazards to a facility, the use of SCTA as part of the overall process safety assurance should be considered.

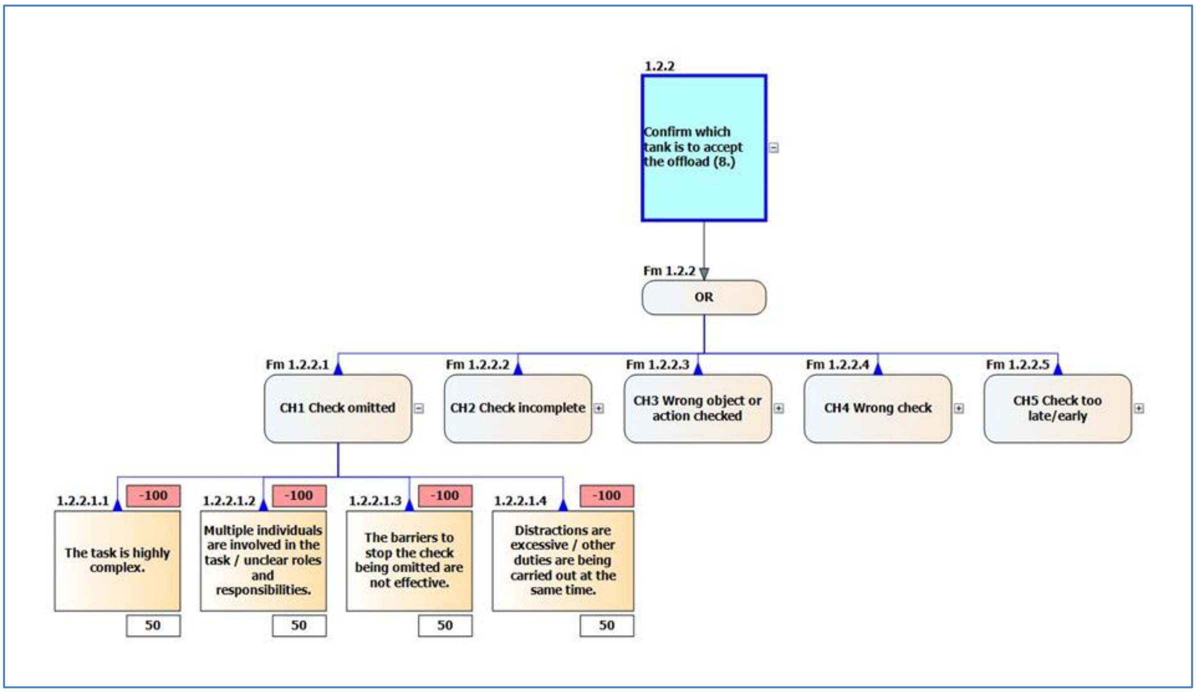

Figure 1: Performance Influencing Factors (PIF) analysis

3.2 Construction Access - Mitigating Business Risk to Operating Site

Category: Project Management

The impact of brownfield construction within the battery limit of an operating site can potentially introduce both safety and business production risks, given the significant ramp-up of new personnel and equipment of a third-party workforce. The project team has constructed a temporary site access road and fenced gate area to allow Sumitomo and its principal turnkey contractor to independently access the new leased area for electrolyser plant construction, while minimising risk of incursions or interactions between the construction team and the operating refinery. Following comprehensive stakeholder engagement, the construction road was custom-built across a services corridor with temporary access permits in place to allow safe transportation of project personnel without any disruption of traffic or other personnel movements within the refinery.

A risk assessment was carried out to identify control measures as well as on-going interface management, including emergency response between both Rio Tinto and Sumitomo's respective workforce. From a regulatory perspective, this included the appointment of Sumitomo's nominated construction contractor as the Principal Contractor under Queensland's Work Health and Safety Regulation 2011.

Implication for future projects: A dedicated access/egress or physical separation into a construction site may both reduce risk of incidents and appoint single point of accountability and ownership of Health, Safety, Security and Environment (HSSE) site policies during execution phase.

3.3 Performance Measurement: Custody transfer metering

Category: Technical

2017 Qld Regulation (Petroleum and Gas (Production and Safety) Act 2004 (Qld)[6] requires the measurement accuracy of hydrogen metering instrument to be +/- 1%. The project team initially considered that hydrogen metering unit inside the electrolyser could be utilised for custody transfer metering, however the standard metering unit provided by the electrolyser vendor did not comply with Qld regulations *Petroleum and Gas (Production and Safety) Act 2004 (Qld)*; This necessitated an external flow meter to be installed that can measure within the tolerance. A new flow meter was added to the balance of plant piping, modifying the plant piping design to accommodate.

Implication for future projects: Engagement and compliance check of instruments with local regulations for hydrogen should be considered at early stage.

3.4 Flow Meter Joints

Category: Technical

[6] Petroleum and Gas (Production and Safety) Act 2004 - Queensland Legislation - Queensland Government

Despite the preference for welded joints to prevent hydrogen leaks, the principal turnkey contractor was constrained to use flanged-end flow meters. These meters, supplied by hydrogen flow meter vendors, necessitate the use of gaskets for connection. While gaskets can potentially lead to hydrogen leaks due to the molecule's small size, welding flanges could also damage the highly sensitive instruments, compromising measurement accuracy.

To accommodate flanged end connections, the piping design was revised to adhere to ASME B31.12[7] standards for hydrogen systems. A concurrent hazardous area assessment, conducted in accordance with AS 60079, identified a new location for the flow meter within a shielded wall. This strategic placement mitigates the risk of jet releases from the flange.

Hazardous area calculations confirmed that the anticipated release grade would remain secondary, with a potential escalation to primary. This assessment was based on the venting frequency, which is projected to stay below the acceptable threshold of 10 hours per year as outlined in AS 60079.

Implication for future projects: Early compliance checks and vendor liaison to determine design specifications will help minimise the chances of needing to modify the design.

3.5 Piling delay: Coordination with Principal Turnkey contractor and engagement of piling sub-contractor

Category: Project Management

The project experienced some delays related to the coordination of sub-vendor management and the finalization of critical packages. Due to the complexity of the inputs required from both the vendor and the principal turnkey contractor, there was an impact on the timeline for civil design, which in turn delayed the government building approvals. This sequence of events led to a later-than-expected engagement of the piling contractor, whose availability window was then extended by approximately three months from the initial plan.

It is noted that, while the recommended alternative piling subcontractors and technologies outlined in the geotechnical report were not pursued, these may present additional flexibility in similar future situations.

Implications for future projects:

For future projects, it may be beneficial to explore earlier engagement with subcontractors, ensuring that critical design paths and milestones are aligned more closely with vendor inputs. Considering the high volume of upcoming projects in this region, incorporating design flexibility—such as alternative foundation solutions—may prove advantageous in preventing delays and accommodating local resource availability.

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[7] ASME B31.12 is applicable to **piping and pipelines handling gaseous hydrogen** and gaseous hydrogen mixtures and to piping in liquid hydrogen service. This Code is applicable up to and including the joint connecting the piping to associated pressure vessels and equipment but not to the vessels and equipment themselves

The importance of skilled local labour will also be a key factor to consider in managing future project timelines.

4.0 Conclusion

In conclusion, the project highlighted several key lessons learned across various domains. The Safety Critical Task Analysis (SCTA) underscored the importance of identifying and mitigating human errors to enhance process safety, recommending the integration of SCTA in future safety assurance processes. Construction access management demonstrated the value of dedicated access routes to minimize operational disruptions and enhance safety. Technical evaluations, such as those for custody transfer and flow meter joints, emphasized the necessity of early compliance checks and vendor engagement to ensure regulatory adherence. Lastly, the coordination with subcontractors revealed the need for early engagement and flexible design strategies to mitigate delays and optimize project timelines. These insights collectively provide a robust framework for improving safety, compliance, and efficiency in future projects.

