Our ref: SSI-9471-PA-99

Alexandra Lovell
HSE Manager
Australian Industrial Energy
PO Box 1070
Wollongong, NSW, 2500

6 October 2023

Subject: Hazard and Operability Study for Port Kembla Gas Terminal (SSI-9471)

Dear Ms. Lovell

I refer to your submission requesting review and approval of the Hazard and Operability Study for the Port Kembla Gas Terminal.

I note the Hazard and Operability Study has been prepared in accordance with DPE's HIPAP 8.

The Department has carefully reviewed the document and is satisfied that it meets the requirements under SSI 9471 Schedule 3, Condition 21(b).

Accordingly, as nominee of the Planning Secretary, I approve the Hazard and Operability Study (Rev 2, dated 16 June 2023), subject to the Applicant:

1. Implementing all actions and recommendations from the HAZOP studies in a timely and appropriate manner.
2. Submitting a HAZOP update report at the same time as the Safety Management System and Emergency Plan required under Schedule 3, Condition 23 providing:
    a. the HAZOP studies:
        i. covering the recommendations in Sections 5.1 and 5.2 of the FSRU HAZOP Peer Review (revision 0, dated 22 June 2023); and
        ii. resolving project holds or amendments which may have occurred since the original submissions, if any;
    b. confirmation that the automatic emergency shutdown system of the onshore receiving facility (ORF) aligns with item 1 of the FSS and FHA approval; and
    c. a status update on all actions and recommendations from all HAZOP studies submitted under the consent.

Please ensure you make the document publicly available on the project website at the earliest convenience.

If you wish to discuss the matter further, please contact Wayne Jones on (02) 6575 3406.

Yours sincerely

Stephen O'Donoghue
Director
Resource Assessments
as nominee of the Secretary

AUSTRALIAN INDUSTRIAL ENERGY

Port Kembla Gas Terminal Project

Detailed Design ORF HAZOP and FMEA Study Report

Document no. Rev 2: PKGT-WOR-ORF-SAF-RPT-0001
Worley Document no. Rev 2: 411010-00417-SR-REP-0002
16 June 2023

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PROJECT 411010-00417 - Port Kembla Gas Terminal Project - Detailed Design ORF HAZOP and FMEA Study Report

Rev	Description	Originator	Reviewer	Worley Approver	Revision Date	Customer Approver	Approval Date
Rev 0	Issued for Use	AS	TM	FL	06 Ju 2022		
		A. Stembridge	T. Millen	F. Losty			
Rev 0A	Re-Issued for Review	AS	TM	FL	24 Jan 2023		
		A. Stembridge	T. Millen	F. Losty			
Rev 1	Re-Issued for Use	AS	TM	FL	06 Apr 2023		
		A. Stembridge	T. Millen	F. Losty			
Rev 2	Re-Issued for Use				16 Jun 2023		
		A. Stembridge	T. Millen	F. Losty			

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Revision History

Revision 0

Location	Description
-	Issued for Use

Revision 1

Location	Description
General	Report updated to incorporate findings of additional HAZOP sessions held for the ORF utility systems and odourant storage and injection package. Report also includes findings of the FMEA conducted for the MLA hydraulics. Previously raised HAZOP actions have revised where applicable and list of FEED actions has been removed.
Section 4.2	Section added to detail FMEA methodology followed.
Section 5	Section restructured to detail the scope of each of the subsequent HAZOP / FMEA studies. Workshop study teams are listed.
Appendix A, Appendix D	Appendices updated to present minutes of the additional utility systems HAZOP review and new recommendations raised. Changes to the minutes are indicated in RED text. Action status in AIE tracking system is also indicated.
Appendix E	New Appendix added with additional utility systems HAZOP and fire water system re-HAZOP master drawings.
Appendix F, Appendix G	New Appendix added to present minutes of FMEA and FMEA master drawings.
Appendix H	Appendix removed.

Revision 2

Location	Description
General	Report updated to incorporate additional action (#141) raised during SIL Determination with Höegh.

1. Executive Summary

Australian Industrial Energy (AIE) are developing a Liquified Natural Gas (LNG) import terminal on the east coast of NSW to provide gas to industrial and wholesale customers. AIE is planning to supply up to 115PJ per annum, depending on seasonal demands and corresponding to approximately 75% of NSW gas demand.

LNG will be sourced from worldwide suppliers and transported by LNG carrier (LNGC) vessels to the Port Kembla LNG import terminal. The LNG will then be regasified on the Floating Storage and Regasification Unit (FSRU) for input into the NSW gas transmission network via the Port Kembla Pipeline (PKP). The project will be the first of its kind in NSW and provide a simple, flexible solution to the state's gas supply challenges.

This report documents the findings of the Hazard and Operability (HAZOP) studies and Failure Mode & Effects Analysis (FMEA) conducted as part of the detailed design phase of the Port Kembla Gas Terminal (PKGT) project. The objective of the studies were to identify possible deviations from normal operating conditions which could lead to hazardous situations, in order to minimise potential consequences by ensuring that adequate controls are in place for credible hazards.

An initial HAZOP study for the Onshore Receiving Facilities (ORF) located at the berth was carried out on the 8th – 10th February 2022 and were attended by representatives from Höegh, AIE, Arriscar, LogiCamms, and Jemena. The scope of these sessions included:

- FSRU gas unloading (ship-to-shore transfer) via unloading arms and onshore pipeline tie-in;
- Wharf utilities systems (firewater system, potable water etc.).

A total of ninety-five (95) recommendations were raised during the initial HAZOP study. It was noted that the close-out of the HAZOP recommendations had the potential to sufficiently change the design and was recommended that given the quantity and nature of the recommendations raised, requirements to reconvene and update HAZOP records were to be determined.

Further, during the initial sessions, it was agreed by the workshop team that a number of ORF utility systems required additional detail that was not available at the time and were to be subject to HAZOP at a later date. Additional HAZOP studies were carried out on the 17th and 29th November 2022 and the 14th December 2022 and were attended by representatives from AIE, Arriscar, and the vendor suppliers. The scope of these sessions included:

- Odourant storage and injection vendor package;
- Firewater system pumps vendor package;
- Instrument / utility air system vendor package; and
- ORF drain system.

A full record of the HAZOP minutes is provided in Appendix B, with modifications made to the original HAZOP records during the additional session held on the 17th and 29th November 2022 indicated in RED. In addition to previously unreviewed scope, and vendor package details, these markups reflect the following changes:

- Removal of permanent pigging facilities at the ORF [1];
- Removal of the facility diesel storage and distribution system [2].

A post desktop review of the minutes was conducted to reflect the removal of nitrogen injection to the pipeline at Cringilla [3]. Modifications to the original HAZOP records based on these changes are indicated in BLUE.

An additional forty-five (45) recommendations (#96-140) were raised during the subsequent workshops held for the ORF utility systems. In addition to raising new actions, the changes in scope associated with the vendor designs invalidated or superseded thirty two (32) of the actions raised within the initial HAZOP and impacted the scope of an additional four (4). A subsequent action (#141) was raised during SIL Determination worksheets with Höegh on the 6th June 2023 [4]. This relates to potential surge issues on the FSRU downstream of the HIPPS valve, due to rapid closure of ship to shore manifold valves, and it was noted that the HAZOP incorrectly claimed surge studies as a safeguard, when none had been undertaken. Modifications made to the HAZOP records based on the outcomes of this meeting are indicated in GREEN. A complete list of actions is provided in in Appendix A, together with commentary relating to the validity of actions, where relevant. These actions have been added to the AIE action tracking system 'Noggin' for closure and approval.

This report previously documented remaining open recommendations raised during the Front End Engineering Design (FEED) phase of the project [5] which have since been all closed and approved in 'Noggin'.

Due to the nature of the MLA hydraulic system, Failure Mode & Effects Analysis (FMEA) review was carried out for this system (rather than HAZOP) on the 29th November 2022. The resulting FMEA minutes are provided in Appendix F. No recommendations were raised for during the FMEA.

Systems on board the FSRU vessel itself (including LNG loading, storage and regasification) have not been subject to HAZOP review by this project. The FSRU regasification system designed by Wärtsilä Gas Solutions (WGS) has been subject to HAZOP by others and the findings are contained in the existing DNV HAZOP for the FSRU [6]. AIE have confirmed the LNG loading, storage, gas metering and other package utilities on board the FSRU will not be subject to HAZOP. However, a Hazard Identification (HAZID) study for these systems has been carried out and the findings are contained within a separate study report [7].

2. Introduction

This report summarises the findings of the HAZOP and FMEA studies carried out as part of the detailed design phase of the PKGT project which have been conducted to identify all hazard, maintainability and operability issues related to the project.

2.1 Study Scope

The scope of the HAZOP studies and FMEA covered the following facilities:

1. FSRU gas unloading (ship-to-shore transfer) via unloading arms and onshore pipeline tie-in;
2. Wharf facilities including but not limited to utilities, odourant injection, and the PKP tie-in facilities.

Specific scope items that have been reviewed are listed in Section 5.

2.2 Study Scope Exclusions

The HAZOP scope excluded the following:

- Port Kembla Pipeline - which being designed, constructed and commissioned by Jemena. A Pipeline Safety Management Study (SMS) has also been carried out for the Jemena PKP [10] by others in accordance with the Australian Standard for Pipelines – Gas and Liquid Petroleum (AS 2885) and concluded that no unusual threats that cannot be controlled through the current design process were identified. The scope of the SMS covers the entirety of the new lateral pipeline route from the PKGT to the existing EGP. The SMS has been reviewed by NSW Department of Planning and Environment and confirmed the study was conducted appropriately by all relevant stakeholders, in line with the requirements of AS 2885 [11]. The PKP has also been subject to HAZOP (by others) on 1st June, and 23rd, 28th, 20th July 2021 and the findings are contained within a separate study report [12].
- FSRU process systems - including LNG ship-to-ship loading, storage and regasification. The FSRU regasification system designed by Wärtsilä Gas Solutions (WGS) has been subject to HAZOP, and the findings are contained within the existing DNV HAZOP for the FSRU [6]. Note that the Regasification system HAZOP considered up to TP-006 (indicated on drawing MB601.61, refer Appendix D), and did not include the gas metering unit, pressure and temperature instrumentation, and High Pressure (HP) manifold with Emergency Shutdown (ESD) valves downstream. AIE have confirmed the LNG loading, storage, gas metering and other package utilities on board the FSRU will not be subject to HAZOP. However, a HAZID study for these systems has been carried out and the findings are contained within a separate study report [7].

2.3 Acronyms and abbreviations

In this document, the following acronyms and abbreviations apply.

Table 2-1: Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AG	Above Ground

Acronym/Abbreviation	Definition
AIE	Australian Industrial Energy
AIP	Australian Industrial Power
BOG	Boil-off Gas
CCS	Cargo Containment System
CS	Carbon Steel
DD	Detailed Design
DN	Nominal Diameter
dP	Differential Pressure
DNV	Det Norske Veritas
EGP	Eastern Gas Pipeline
ESD	Emergency Shutdown
FEED	Front End Engineering Design
FMEA	Failure Modes & Effects Analysis
FSRU	Floating Storage Regasification Unit
GC	Gas Chromatograph
HAZID	Hazard Identification Study
HAZOP	Hazard and Operability Study
HIPPS	High-Integrity Pressure Protection System
HP	High Pressure
KGMS	Kembla Grange Metering Station
LCV	Level Control Valve
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
LOC	Loss of Containment
MIJ	Monolithic Insulating Joint
MLA	Marine Loading Arm
NRV	Non-return Valve
NSW	New South Wales
ORF	Onshore Receiving Facility
PANSW	Port Authority NSW
PCV	Pressure Control Valve
PJ	Petajoule

Acronym/Abbreviation	Definition
PKCT	Port Kembla Coal Terminal
PKGT	Port Kembla Gas Terminal
PKP	Port Kembla Pipeline
PSD	Process Shutdown
RO	Restriction Orifice
RPZ	Reduced Pressure Zone
SCADA	Supervisory Control and Data Acquisition
SIL	Safety Integrity Level
SOP	Standard Operating Procedure
SS	Stainless Steel
TOR	Terms of Reference
WGS	Wärtsilä Gas Solutions

3. Project Description

The project consists of four key components, summarised below:

- LNGC
- FSRU
- Berth and wharf facilities – wharf topside facilities (also referred as the onshore receiving facility)
- Natural Gas pipeline – the Port Kembla Pipeline (PKP)

Note, the scope of the HAZOP is limited to the onshore receiving facility however this has direct interfaces with both the FSRU and the PKP. As such, these three components are summarised below.

3.1 FSRU

The FSRU selected for the Port Kembla LNG Import Terminal Project is the Höegh Galleon (previously referred as SN2220) which is an ocean-going vessel approximately 297 metres in length and about 43 metres in breadth [13]. It is a DNV Class vessel subject to the relevant Rules for Classification [14, 15] and has a total capacity of about 170,000 m^3 or equivalent to approximately 4 PJs of gas. This equates to approximately 10 -12 days of natural gas supply for the whole of NSW.

The FSRU is a double-hulled vessel with a cargo area which consists of four cargo tanks suitable for carrying LNG at low temperatures (about -160°C) and at atmospheric pressure. There are also two high pressure manifolds located on the vessel that are required to export the natural gas produced via the regasification process into the pipeline (refer Figure 3-1).

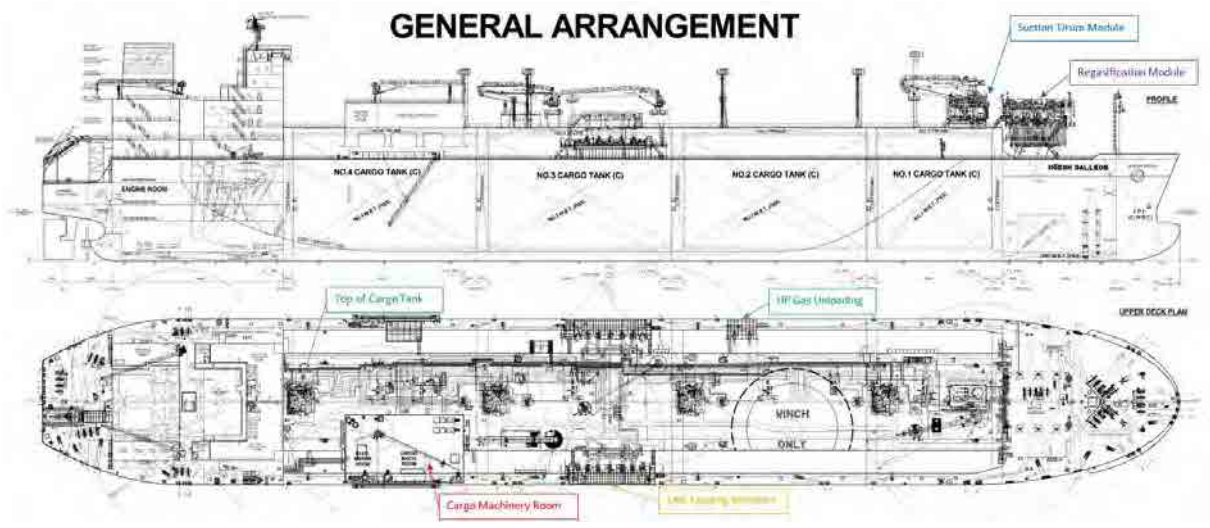

Figure 3-1: FSRU General Arrangement

The FSRU, for the term of the project and subject to any maintenance requirements or Port Authority directions, would be moored at the berth and wharf facilities. The purpose of the FSRU is to receive LNG from regularly scheduled LNGC visiting Port Kembla.

LNGC will tether alongside the FSRU for 24–36 hours while they transfer their LNG cargo, still under atmospheric pressure, into the cargo holds of the FSRU. Once the transfer is completed the LNGC will leave the port subject to suitable navigational conditions.

The FSRU has three key functional elements being: facilities to receive LNG from LNGC; facilities to store LNG; and facilities to convert LNG to high pressure gas and send it into the gas pipeline.

Purpose built cryogenic flexible hoses will be used to transfer LNG from visiting LNGC to the FSRU. It is expected that the FSRU itself will have five hoses which will include four for receiving LNG and one for maintaining a balance of vapour gas between ships.

The vessel cargo tanks are designed with a primary and secondary barrier to protect the cargo tanks and mitigate loss of containment. Cargo tanks which store the LNG in the FSRU are purpose built. The Cargo Containment System (CCS) is a GTT Mark III membrane type which consists of a primary barrier and a complete secondary barrier, further supported by insulation and intervening spaces. These cargo tanks are designed to achieve two outcomes:

- to insulate and contain LNG cargo at cryogenic temperatures (-160°C); and
- to prevent leakages and isolate the cargo from the hull structure.

The vessel hull structure is a double hull construction which also provides mechanical protection of the cargo tanks.

Boil-off gas (BOG) management facilities are also in place to capture any trace amounts of vaporised gas that is generated from LNG in the storage tanks. This BOG is used to fuel the on-board generators for the operation of pumps and other equipment used on-board.

The regasification unit located on board the FSRU is located toward the bow the vessel. The regasification module contains all necessary pumps, motors, heat exchangers, instrumentation, control and emergency shutdown systems to ensure safe operation of the unit can occur. LNG is pumped from the cargo tanks into a suction drum and then through a series of heat exchangers, which utilise seawater as a source of natural heat differential to warm and vapourise the LNG.

3.2 Berth and Wharf Facilities

Once in a gaseous form, the gas is exported, under pressure, through 2 x 12” Marine Loading Arms (MLAs) at the Onshore Receiving Facility (ORF). The loading arms connect to a common manifold. Odourant is injected into the natural gas prior to input into the PKP. The odourant selected for use is known as Spotleak 1005 and is stored onsite in two 500L semi bulk containers (SBC) housed within a shipping container. The container contains internal bunding and is self-bunded. The shipping container will also contain the injection packages. Odourant will be injected into the natural gas at a rate between 0.6 – 6 L/hr and a concentration of 9mg/Sm^3. The SBC’s will be loaded into the shipping container onsite using forklifts, with the long side of the container adjacent to the road being open and accessible via forklift (i.e. shipping container will not be fully enclosed during these activities).

Additional utility systems in place at the wharf include:

- Firewater system – comprising 2 x 1537m^3 freshwater storage tanks, providing water to hydrants, tower monitors etc. via 3 x 50% diesel fire water pumps.
- Instrument air system – comprising 2 x 100% air compressors, dryers, and instrument air receiver.
- Potable water system, including safety showers.
- Drain systems.

3.3 Port Kembla Pipeline

The PKP will be approximately 11.5km in length and will tie-in to the Eastern Gas Pipeline (EGP) at an end of line facility near the Kembla Grange Metering Station (KGMS). The EGP is part of the existing gas transmission network. The PKP route is presented in Figure 3-2.

Figure 3-2: PKGT Pipeline Route based on MOD4 to SSI 9471

3.4 ORF Surrounding Land Use

The FSRU will be moored at Berth 101 in Port Kembla. Berth 101 is located in the Port Kembla Inner Harbour area between the existing Port Kembla Coal Terminal (PKCT) coal berth (B102) to the north, and "The Cut" shipping channel to the south. The land adjoining Berth 101 to the east is currently managed by NSW Ports.

Excavation and dredging will be required in order to establish the berth and wharf facilities to support the side-by-side configuration of the FSRU and LNG carriers without limiting the existing navigability of the Inner Harbour.

The surrounding land use is primarily categorised as industrial. There are no significant commercial spaces that routinely have large number of people present. The road to the east of berth 101 is a public road managed by NSW Ports. Public access to the Port Kembla Inner harbour is not permitted and is under the control of the Port Authority NSW (PANSW). The closest residential areas are approximately 2km to the north and south of the berth 101 site.

Proposed developments located within the Inner Harbour include a bulk liquids terminal and a Soybean Processing and Biodiesel Facility located near berth 103 and berth 104. Australian Industrial Power (AIP) have also proposed for a gas-fired power station to be constructed adjacent to the PKGT.

There is also a cruise ship terminal (berth 106) within the Inner Harbour, approximately 550m from the FSRU, which is used 2 to 5 times a year.

Port Kembla Inner Harbour has numerous other berths and associated industrial facilities.

4. Study Methodologies

This section outlines the methodologies followed for the HAZOP studies and the FMEA review.

4.1 HAZOP Methodology

HAZOP is a systematic examination of process hazards and potential operational problems. The aim is to identify potential hazards (consequences) and operating concerns that may result from unexpected deviations from the intended design or operation.

The studies were completed with a group representing a range of engineering disciplines, and site engineering and operations representatives (refer Section 4). The purpose is to stimulate ideas and thought to ensure all possible hazards and operability issues are identified This ensures that proposed modifications can be appropriately made to the design and/or operating procedures.

The HAZOP review was undertaken as a facilitated workshop using the process and guidewords, that follow the Worley HAZOP Study Standard [16]. An outline of the process is provided in Figure 4-1 and the HAZOP guidewords used are contained within Appendix C. Prior to the review of each node, the responsible engineer provided a summary description of the node, including design intent, and operating parameters.

The HAZOP study was recorded using PHA Pro 8™ software. The minutes were shared with all attendees to review during the study. The minutes of the study are included in Appendix B.

HAZOP worksheets were prepopulated where possible with applicable hazards identified in the PGKT FEED HAZOP study [3], existing DNV HAZOP for the FSRU Regasification System [6] and PKP [10]. Updates to the minutes resulting from subsequent sessions (i.e. workshop 2) are shown in RED text.

Note: Although the HAZOP technique is a comprehensive hazard identification tool, it cannot provide assurance that all hazards (major and minor) will be identified.

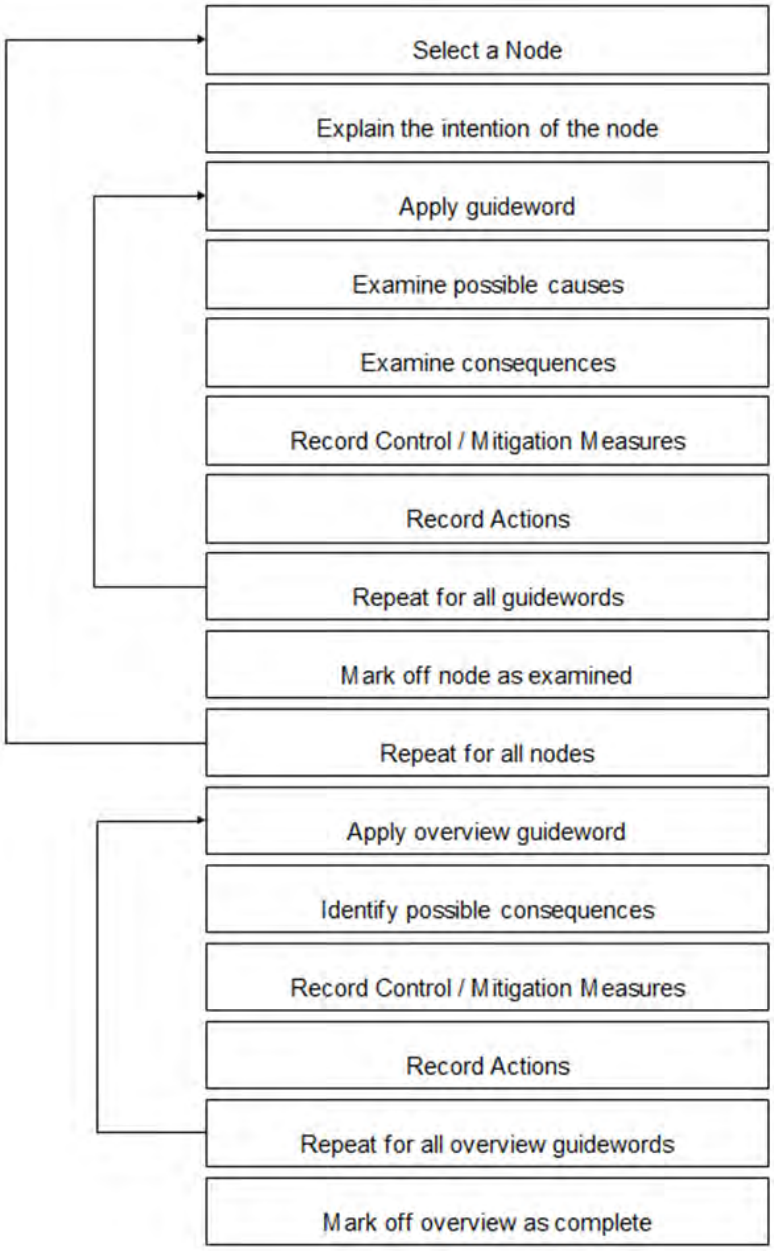

Figure 4-1: HAZOP Study Process [16]

4.2 FMEA Methodology

FMEA is a method in which an item or a process is broken down into elements and, for each element in turn, failure modes and effects are identified and analyzed. This is to identify any required improvements by eliminating adverse effects or reducing their likelihood or severity.

For each element, the following is documented:

- The function, or performance requirement.
- Potential failure mode, causes, and consequences.
- Existing controls, including means to detect failure, and to mitigate against failure.
- Additional actions to be undertaken.

The FMEA was undertaken using process outlined in Figure 4-2, that follow International Standard IEC 60812:2018 for Failure Modes and Effect Analysis [17]. Note that the workshop was not intended to assess failure criticality.

The FMEA study was recorded using Microsoft Excel software. The minutes were shared with all attendees to review during the study. The minutes of the study are included in Appendix F.

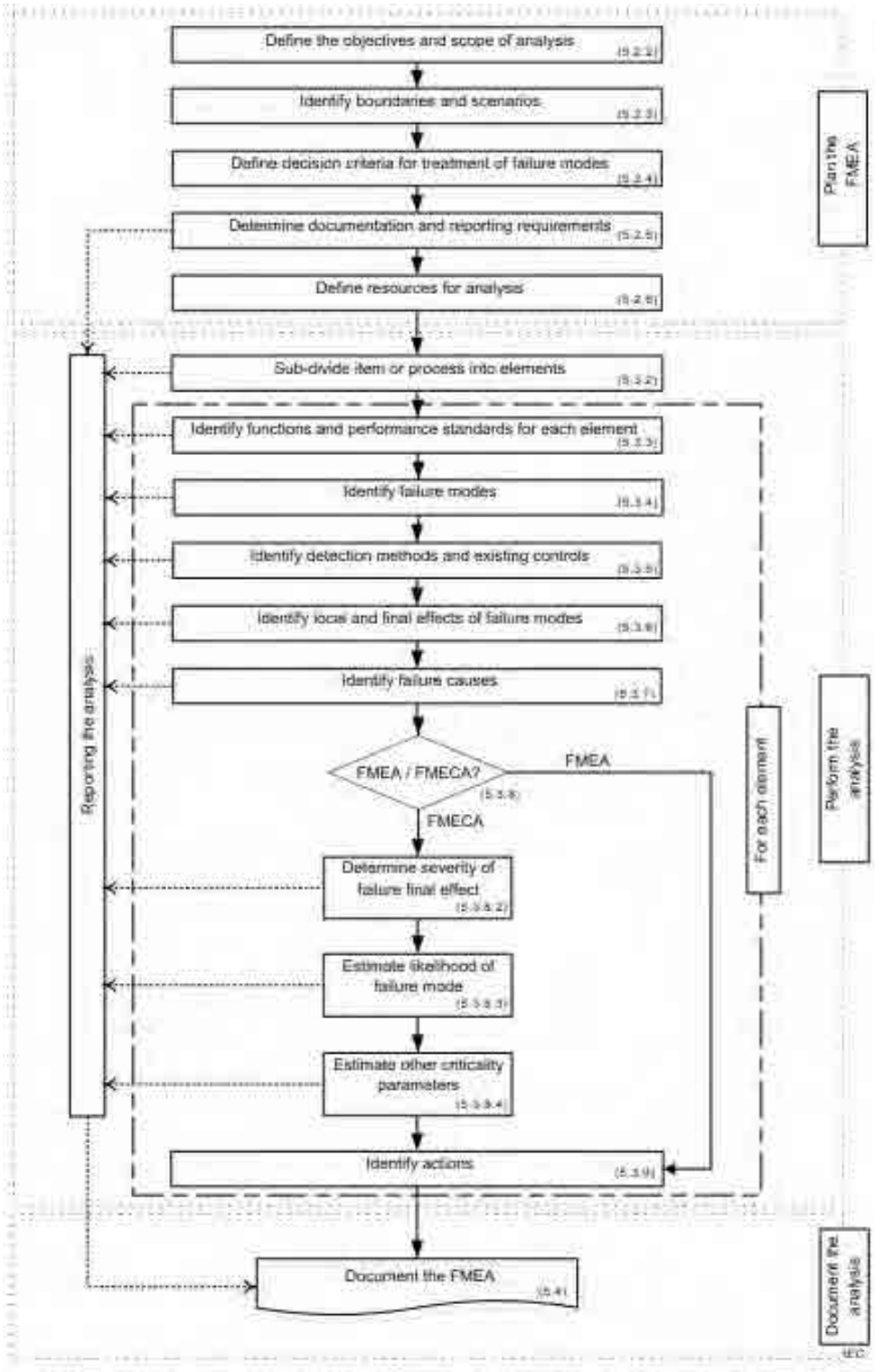

Figure 4-2: FMEA Process [17]

5. Meeting Details

This section presents the details of each workshop session held in the detailed design phase of the PKGT Project, in terms of attendees and nodes (scope). The following sessions were undertaken:

- Initial HAZOP
- ORF Utilities HAZOP
- MLA Hydraulics FMEA

Each workshop team consisted of a range of experienced personnel from various engineering, project and operations groups and sessions were facilitated by a suitably qualified and experienced person independent from the project.

A full list of the HAZOP / FMEA nodes is provided in Table 5-1. Noting the workshop did not assess the nodes that are shaded grey for the following reasons:

- Node 5 - relates to the temporary pig launcher operation. It was confirmed be Jemena that the launcher conforms to a standard Jemena design and operation will be done with appropriate risk assessment by Jemena.
- Node 10 - during initial HAZOP sessions, it was agreed to be a low priority scope for assessment, and was deferred to be include in the review of the remaining scope. Subsequent to this, nitrogen supply and reticulation removed from scope at the ORF (refer PKGT-AIE-PMT-CON-CHRQ-0012).
- Node 14 - excluded, noting that HAZID studies have been conducted for the project and the findings are contained within a separate study report [7]. The HAZID guidewords cover issues that otherwise would be recorded in the overview node.

In order to ensure team consensus on the recording on HAZOP minutes, the workshop sessions were run with the minutes displayed on a shared screen within Teams. P&IDs were also displayed on the shared screen as part of the node introduction, and as required throughout, however all attendees were provided with their own copies of the drawings for reference in the meeting.

Table 5-1: HAZOP (and FMEA) Nodes*

Node	Description
1	FSRU gas unloading to ORF inlet (MLA's to XV-064001/2)
2*	MLA Hydraulic System
3	ORF pipework (XV-064001/2 to PKP)
4A.	Odourant Storage & Injection
4B.	Odourant Package Activated Carbon Scrubber System
5	Pig Launcher Operation
6	Fire water system (U/S of Pump)
7	Fire water system (D/S of Pump)
8	Instrument / Utility Air Compressor & Dryer Vendor Package
9	Instrument / Utility Air Distribution System

Node	Description
10	Bottled Nitrogen System
11	Diesel Fuel Supply
12	Potable Water
13	Drain System
14	Overview

5.1 Initial HAZOP

The initial HAZOP study carried out as part of the detailed design phase of the PKGT Project was held via Microsoft Teams over three sessions on the 8 – 10th February 2022. This session covered Nodes 1, 3, 6, 7, 9, 11, and 12. Drawings associated with each node, date of review and responsible engineering company are listed in Table 5-2, with marked up P&IDs provided in Appendix D.

Table 5-2: Initial HAZOP Workshop Scope

Node	Description	Drawing Number(s)	Rev.	Resp. Eng.	Date of Review		
					8-Feb	9-Feb	10-Feb
1	FSRU gas unloading to ORF inlet (MLA's to XV-064001/2)	MB601.61	0	AIE / Jemena	✓	✓	-
		PKGT-EMC-BTH-PIP-PID-0001	3				
		GAS-554-DW-PD-001	D				
3	ORF pipework (XV-064001/2 to PKP)	GAS-554-DW-PD-001	D	Jemena	-	✓	-
		GAS-554-DW-PD-002	D_RL				
6	Fire water system (U/S of Pump)	PKGT-LOG-ORF-PRO-PAIA-0009	B	LogiCamms	-	✓	-
		PKGT-LOG-ORF-PRO-PAIA-0009	1_RL				
		PKGT-LOG-ORF-PRO-PAIA-0011	0				
7	Fire water system (D/S of Pump)	PKGT-LOG-ORF-PRO-PAIA-0009	B	LogiCamms	-	✓	-
		PKGT-LOG-ORF-PRO-PAIA-0010	B				
9	Instrument / Utility Air Distribution System	PKGT-LOG-ORF-PRO-PAIA-0006	B	LogiCamms	-	-	✓
		PKGT-LOG-ORF-PRO-PAIA-0012	B				
11	Diesel Fuel Supply	PKGT-LOG-ORF-PRO-PAIA-0008	B_RL	LogiCamms	-	-	✓
		PKGT-LOG-ORF-PRO-PAIA-0009	B				
12	Potable Water	PKGT-LOG-ORF-PRO-PAIA-0011	B	LogiCamms	-	-	✓

The following scope was noted in the HAZOP but not reflected on the drafted and issued P&IDs:

- A shutdown valve (SDV064003) has been marked up on the pipeline discharge from the ORF (refer P&ID GAS-554-DW-PD-002). The valve function, trip initiators and failure state were not detailed at the time of the markup, and were discussed within the HAZOP session.
- The firewater jockey pump (refer P&ID PKGT-LOG-ORF-PRO-PAIA-0009) is indicated as having a low pressure switch for operation. It was confirmed this will be a pressure transmitter with high and low setpoints for pump operation.
- The firewater ring main (refer P&ID PKGT-LOG-ORF-PRO-PAIA-0010) is noted to include a firewater hose reel near the odourant storage.

The initial HAZOP team is listed in Table 5-3.

Table 5-3: Initial HAZOP Workshop Study Team

Name	Role / Discipline	Company	08/02/22	09/02/22	10/02/22
Ole Nedrelid	Technical Manager	Höegh	✓	Part-time (N1 & N3)	-
Bjorn Haukedal	Technical Manager - Process	Höegh	✓	Part-time (N1 & N3)	-
Thomas Fiskaa	Technical Manager	Höegh	✓	-	-
Aleksander Kabas	MLA Package Engineer	Emco Wheaton	✓	Part-time (N1 & N3)	-
Vukan Vranjes	Project Manager	Emco Wheaton	✓	Part-time (N1 & N3)	-
Sharad Bhasin	Harbour Master	PANSW	-	-	✓
Sohan Fernando	MHF Senior Safety Analyst	SafeWork NSW	✓	-	-
Derrick Quinlivan	MHF Assistant State Inspector	SafeWork NSW	✓	-	-
Michael Peoples	Engineering Manager – Gas Projects (Process Rep.)	Jemena	✓	✓	Part-time (N11 & N12)
Lars Aarekol	Process Engineer	LogiCamms	✓	-	-
Dave Afshari	Fire Engineer	LogiCamms	✓	✓	-
Andrew Petch	Project Engineer	AIE	✓	Part-time (N1 & N3)	-
Kevin Bourke	Instrument, Control and Electrical Engineer	AIE	✓	✓	✓
David Miller	Operation Specialist – Process Engineer	AIE	✓	✓	✓
Alex Lovell	HSE Manager	AIE	✓	✓	✓
Joel Cubol	Environmental Adviser	AIE	Part-time	-	-
Gordon Treadwell	Risk Consultant	Arriscar	✓	✓	✓
Andrew Fergusson	Principal Safety & Risk Engineer	Worley	Part-time	-	-
Eva Simak	Project Engineer	Worley	Part-time	Part-time	Part-time
Troy Millen	Facilitator	Worley	✓	✓	✓
Alice Stembridge	Scribe	Worley	✓	✓	✓

Additional supporting documents used during the initial sessions held on the 8th - 10th February 2022 are listed in Table 5-4.

Table 5-4: Additional Supporting Documents

Document Number	Rev	Document Title
PKGT-LOG-ORF-PEQ-DGA-0001	A	Port Kembla Gas Terminal General Arrangement
GAS-554-PN-ME-001	D	Port Kembla Gas Terminal Start of Line Plot Plan
GAS-554-LJ-JJ-001_RL	B	Port Kembla Start of Line Facility Cause and Effect Matrix
PKGT-LOG-ORF-PRO-LIS-0003	A	Port Kembla Gast Terminal Wharf Topside Cause and Effect Matrix

5.2 ORF Utilities HAZOP

As previously documented, during the initial HAZOP studies It was agreed that a number of ORF utility systems (Nodes 2, 4, 8 and 13) required additional detail that was not available at the time and were to be subject to HAZOP at a later date. Therefore, additional HAZOP studies for the ORF remaining utility systems were held via Microsoft Teams and carried out on the 17th November 2022 for the instrument air package and odourant storage and injection systems (Node 4 and 8) and the 29th November 2022 for the ORF drainage systems (Node 13). Subsequent to the initial HAZOP study, the firewater pump configuration changed as a result of the selected vendor offering, most significantly moving from 2 x 100% duty firewater pumps, to 3 x 50% duty pumps. As such, a review of the fire water system (Node 6, 7 and 11) was held via Microsoft Teams on the 14th December 2022 to update relevant records to align with the vendor design.

Drawings associated with each node, date of review and responsible engineering company are listed in Table 5-5, with marked up P&IDs provided in in Appendix E. Updates to the HAZOP minutes provided in Appendix B made during the subsequent sessions are shown in RED text.

Table 5-5: ORF Utilities HAZOP Scope

Node	Description	Drawing Number(s)	Rev.	Resp. Eng.	Date of Review		
					17-Nov	29-Nov	14-Dec
4A.	Odourant Storage & Injection	PKGT-ICE-ORF-PRO-PID-0001	A	ICE	✓	-	-
		PKGT-ICE-ORF-PRO-PID-0002	A				
		GAS-554-DW-PD-002	1_RL				
4B.	Odourant Package Activated Carbon Scrubber System	PKGT-ICE-ORF-PRO-PID-0003	A	ICE	✓	-	-
6	Fire water system (U/S of Pump)	PKGT-LOG-ORF-PRO-PAIA-0009	1_RL	Allied Pumps / LogiCamms	-	-	✓
		PKGT-LOG-ORF-PRO-PAIA-0011	0				
7	Fire water system (D/S of Pump)	PKGT-LOG-ORF-PRO-PAIA-0009	1_RL	Allied Pumps / LogiCamms	-	-	✓
		PKGT-LOG-ORF-PRO-PAIA-0010	0				
		99093-3-P-01	1				
8	Instrument / Utility Air Compressor & Dryer Vendor Package	E12201-PID-001	A	Complete Air and Power Solutions	✓	-	-
		PKGT-LOG-ORF-PRO-PAIA-0004	0_RL				
		PKGT-LOG-ORF-PRO-PAIA-0006	0_RL				
11	Diesel Fuel Supply	PKGT-LOG-ORF-PRO-PAIA-0009	1_RL	LogiCamms	-	-	✓

The ORF utilities HAZOP teams are listed in Table 5-6.

Table 5-6: ORF Utilities HAZOP Study Teams

Name	Role / Discipline	Company	17/11/22	29/11/22	14/12/22
Lars Aarekol	Process Engineer	LogiCamms	✓	✓	-
Dave Afshari	Fire Engineer	LogiCamms	-	-	Part-time
Navid Neda	Project Manager	LogiCamms	✓	-	-
Brian Campbell	Technical Manager	ICE	✓	-	-
Mohsen Saki	Odourant System Design Engineer	ICE	✓	-	-
Kym Williams	Odourising Specialist	ICE	✓	-	-
Ash Reginald	ORF Delivery Manager	Complete Air and Power Solutions	✓	-	-
Guy Monkman	Instrument and Electrical Engineer	Gasco	✓	-	-
Arlyn Sharpe	Project Manager	Allied Pumps	-	-	✓
Stephen Slack	Sales Consultant	Allied Pumps	-	-	✓
Sheldon Simpson	Instrument and Electrical Superintendent	AIE	✓	-	-
David Miller	Operation Specialist – Process Engineer	AIE	✓	✓	✓
Alex Lovell	HSE Manager	AIE	✓	✓	✓
Peter Duplex	Head of Infrastructure Planning and Asset Optimisation	AIE	-	-	Part-time
Gordon Treadwell	Risk Consultant	Arriscar	✓	✓	✓
Troy Millen	Facilitator	Worley	✓	✓	✓
Amorita Combis	Scribe	Worley	✓	✓	✓

5.3 MLA Hydraulics FMEA

Due to the nature of the MLA hydraulic system (Node 2) FMEA review was carried out for this system (rather than HAZOP) on the 29th November 2022 via Microsoft.

Drawings associated with the node, and responsible engineering company are listed in Table 5-5, with marked up P&IDs provided in in Appendix G.

Table 5-7: FMEA Workshop Scope

Node	Description	Drawing Number(s)	Rev.	Resp. Eng.
2	MLA Hydraulic System	PKGT-ENC-BTH-PIP-PID-0001	3	Emco Wheaton
		PKGT-EMC-BTH-CIV-DWG-0002	B_RL	

The FMEA review team is listed in Table 5-8.

Table 5-8: FMEA Review Team

Name	Role / Discipline	Company
Aleksander Kabas	MLA Package Engineer	Emco Wheaton
Lars Aarekol	Process Engineer	LogiCamms
Yuri Tikhanov	Mechanical Engineer	AIE
Kevin Bourke	Instrument, Control and Electrical Engineer	AIE
David Miller	Operation Specialist – Process Engineer	AIE
Alex Lovell	HSE Manager	AIE
Gordon Treadwell	Risk Consultant	Arriscar
Troy Millen	Facilitator	Worley
Amorita Combis	Scribe	Worley

6. Key Findings and Recommendations

A full record of the HAZOP minutes is provided in Appendix B, with modifications made to the original HAZOP records during the additional session held on the 17th and 29th November 2022 indicated in RED. In addition to previously unreviewed scope, and vendor package details, these markups reflect the following changes:

- Removal of permanent pigging facilities at the ORF [1];
- Removal of the facility diesel storage and distribution system [2].

A post desktop review of the minutes was conducted to reflect the removal of nitrogen injection to the pipeline at Cringilla [3]. Modifications to the original HAZOP records based on these changes are indicated in BLUE.

The initial HAZOP raised a total of ninety-five (95) recommendations, with an additional forty-five (45) recommendations (#96-140) raised during the subsequent workshops held for the ORF utility systems. A subsequent action (#141) was raised during SIL Determination with Höegh on the 6th June 2023 [4]. This relates to potential surge issues on the FSRU downstream of the HIPPS valve, due to rapid closure of ship to shore manifold valves, and it was noted that the HAZOP incorrectly claimed surge studies as a safeguard, when none had been undertaken. Modifications made to the HAZOP records based on the outcomes of this meeting are indicated in GREEN. These actions have been added to the AIE action tracking system 'Noggin' for closure and approval.

In addition to raising new actions, the changes in scope associated with the vendor designs invalidated or superseded thirty two (32) of the actions raised within the original HAZOP sessions, and impacted the scope of an additional four (4). A complete list of actions is provided in in Appendix A, together with commentary relating to the validity of actions, where relevant. The status of the actions in 'Noggin' (i.e. in progress, completed - but not approved, or closed and approved) at the time of issue of Revision 1 of this report are also indicated for reference only. Where closure of an action results in a change in the design, the requirement for re-HAZOP will be identified as part of AIE's management of change process.

The recommendations will be tracked and closed out by the project. Due dates were assigned by AIE following the workshop and are documented in the HAZOP minutes. Assigned action parties and due dates for the initial HAZOP studies have been updated as indicated by AIE.

Twenty-one (21) recommendations were raised during the FEED phase of the project [3] which have since been all closed and approved in 'Noggin'.

7. References

1. PKGT Project Technical Basis, Document No. PKGT-AIE-STE-TEC-SPC-0001, Revision 0
2. PKGT Project Change Request – VE Utilities Scope Removal, Document No. PKGT-AIE-PMT-CON-CHRQ-0012, Revision 0
3. PKGT Project Change Request – Removal of BOC Nitrogen Injection, Document No. PKGT-AIE-PMT-CON-CHRQ-0013, Revision A
4. PKGT SIL Determination Study Report, Document No. PKGT-WOR-ORF-SAF-RPT-0002, Revision 1
5. PKGT FEED HAZID and HAZOP Studies Report, Document No. 401010-01496-SR-RPT-0003, Revision 0
6. Höegh 170K LNG FSRU (Hull No. SN2220) HAZOP Report for Regasification System, Document No. 1155RVGV-2, Revision A
7. PKGT HAZID Study Report, Document No. PKGT-WOR-ORF-SAF-RPT-0009, Revision 1
8. Port Kembla Gas Terminal Environmental Impact Statement Volume 1, November 2018 - https://ausindenergy.com/wp-content/uploads/2019/04/PKGT-EIS.pdf
9. PKGT Infrastructure Approval, Application SSI 9471
10. GPA Engineering, Project Marlin – Detailed Design SMS Report, Document No. GAS-556-RP-RM-002, Revision 2, July 2022
11. Letter from NSW Department of Planning and Environment to Alexandra Lovell (AIE), Subject: Safety Management Study for Port Kembla Gas Terminal (SSI-9471), Sept 2022
12. GPA Engineering, Project Marlin – EGP Reversal – Facilities Detailed Design HAZOP Report, Document No. GAS-599-RP-HZ-009, Revision A
13. SN2220 SHI Höegh 170,000 CBM LNG FSRU, General Arrangement, Doc No. PF10110, July 2019
14. DNV Rules of Classification – Part 5, Chapter 7 Liquified Gas Tankers, DNV-RU-SHIP-Pt5Ch7
15. DNV Rules of Classification – Part 6, Chapter 4 Cargo Operations, DNV-RU-SHIP-Pt6Ch4
16. Worley Hazard of Operability (HAZOP) Study Standard, Document No. MS-EP-STD-0098, Revision 3
17. IEC International Standard, Failure Modes and Effects Analysis (FMEA and FMECA), IEC 60812, Edition 3.0, August 2018