Global Centre for MARITIME DECARBONISATION

APPENDIX A & APPENDIX B: HAZID LOGS

1.1 Pilot Concept 2 Risk Result

1.1.1 HAZID Results

The HAZID study's results (i.e. hazards, hazardous events, causes, consequences, preventive & mitigating measures, recommendations and responsibility) were documented in the HAZID Log. Workshop participants reviewed all the content documented in the HAZID Log, including the proposed risk rating.

1.1.2 Risk Results

The HAZID was conducted based on arrangement drawings and documents, and design philosophies available at the time of the HAZID workshop. It is strongly recommended that any significant future changes to the design or operation which may impact the hazard and risk levels should be reassessed.

All results of the HAZID study (i.e. hazards, hazardous events, causes, consequences, preventive & mitigating measures, recommendations, and responsibility) were documented in the HAZID Log presented in Appendix A

to Appendix H of this report. In total, ninety-three (93) hazardous events were identified, where seventy (70) hazardous events were categorised as medium risk, and six (6) hazardous events were categorised as acceptable or low risk. The remaining seventeen (17) events were not ranked because no risk was identified.

No hazardous events were categorised as high risk.

The risk summarisation of Pilot concept 2 are as shown in Table 7.8.

Table 7.8: Pilot Concept 2 Risk Summarisation

Risk Ranking	Pilot Concept 2 STS LAC to ABV at Raffles Reserved Anchorage	
	Operation Risk	Location Risk
Low	3	3
Medium	33	37
High	0	0
Not Risk Ranked	4	13

1.1.3 HAZID Recommendations

One hundred and two (102) HAZID recommendations were made during the HAZID workshop for Pilot concept 2. Recommendations are further summarised in Table 7.9 and Table 7.10. All further details can be found in the HAZID Log in Appendix A to H.

Table 7.9 : HAZID Recommendations Pilot Concept 2 (Operational Risk)

No.	Hazard ID	Hazardous event / Consequences	Recommendation/ follow-up action
1	1.1	Compatibility assessment - Failing to follow procedures/ standards prior to operation	Conduct compatibility assessment (LAC/ ABV) (all parties are involved in developing compatibility assessment; all operational modes, including SIMOPs identified and addressed), in addition to bunkering infrastructure, berthing and fendering
2			Potential hose misalignment between manifolds is to be covered as part of the compatibility assessment
3			Review established requirements for compatibility assessment for ammonia application
4			Check on ammonia composition
5			Establish ship to ship checklist for ammonia transfer
6			Identify relevant PPE for ammonia application
7			Automatic and linked ESD (two different sets of ESD for loading and unloading to be considered)
8			Establish operating limits and weather windows for ammonia bunkering application
9			Certify crane for crew transfer
10			Establish emergency response, escape, and evacuation procedures in case of an ammonia release
11			Establish a custody transfer procedure for ammonia transfer
12			Master meter for ammonia transfer to be considered
13			Sampling procedures for liquid and vapour return shall be established, including available technology, verification, and personnel training. It is proposed at the sending ship side (CGA can be referred for associated procedure)

14			Provide required competence and training to personnel
15	**1.2**	Mooring assessment - Failing to follow procedures/ standards prior to operation	Perform a mooring assessment for the site location (possibly OPTIMOOR), including mooring compatibility
16			Consider introducing PERC (Powered Emergency Release Coupling)
17	**1.3**	STS procedures and organization - Failing to follow procedures/ standards prior to operation	Establish an associated procedure for the ammonia transfer operation

No.	Hazard ID	Hazardous event / Consequences	Recommendation/ follow-up action
18			Establish a joint plan of operations (JPO) (LAC/ ABV) for the ammonia transfer operation
19			STS vessel-specific safety management plan should be provided
20			Vessel-specific STS Plan to be approved by Flag
21	2.1	Failing to follow procedures prior to operation: - Pre-arrival checklist - Tests and notices - Communication - The Pilot and Master meeting prior to the approach	Update all established checklists for ammonia application
22	4.1	Failing to follow procedures: - Testing communication - Checklists onboard	Update all established bunkering/transfer procedures for ammonia application
23			Establish a procedure for hose drying and inerting
24			If inerting is introduced, nitrogen banks will be provided on the ship. Purged gas can be sent to ammonia neutralising unit/ GCU/ boiler
25	4.5	Human error – Vessel separation detection (VSD) connection failure	Consider VSD; provide required competence and training to operate VSD; including required checks
26	4.9	Human error - Incomplete PERC system set-up	Consider PERC (if not included initially)
27	4.12	Human error – Lack of competence/ training	Provision of competence and training to personnel is required for personnel involved in ammonia operations
28	5.1	Breakaway - Breakaway, vessel separation	Consider a dry drip tray for ammonia spill containment and draining
29			The capacity of the water spray system (including shoreside and terminal) is to be defined based on ammonia spilt vs water amount required. The water spray system is considered efficient for limited liquid ammonia spill only; The leak is considered neutralised by a large amount of water. A dry drip tray, or foam / DCP system, can be considered for extensive spill mitigation
30			Emergency response procedures to include ammonia transfer

31			Include a procedure for hose recovery in case of ESD2 from a daughter vessel
33			Escort tugs are to be kept on standby for the duration of the operation
34	**5.2 / 5.8**	Leak - Ammonia leakage from transfer hose (connection to manifold)	Placement of gas detectors to consider light and heavy toxic cloud behaviour
35			Consider a spill containment system for a pressurised ammonia release capable of containing the spill for multiple release directions
36			Thermal detection inside the bund

No.	Hazard ID	Hazardous event / Consequences	Recommendation / follow-up action
37			Fixed gas detection fitted on the vessels
38			Identify means for ammonia water solutions disposal; at some ports, release to the sea is permitted; to define in consultation with local authority for allowable toxic concentration for release to the sea
39			Identify the required capacity of the fire water system
40			Due to the exothermic reaction of ammonia with water, identify the spill amount that the water spray system can neutralise; for a larger release, part of the spill will be dissolved, remaining will be quickly vapourised travelling downwind. See hazard ID 5.1 for alternative solutions
41			Consider remote monitoring CCTV
42	5.3/ 5.8	Leak - Ammonia leakage from the cargo manifold	Closure of vent inlets to safe areas/ rooms
43			Provision of toxic detectors in HVACs
45			Double-door arrangements for accommodation and safe rooms
46			Mechanical shielding for flanged connections
47	5.7	External leak - Spill of ammonia into the water	Hose periodic testing and inspection before transfer
48			Hose rigged as per best industry practices
49	5.9	Damage - Piping thermal expansion or contraction	Include tightening of the flanged connections
50	5.10	Damage - Stress corrosion cracking	Assess material compatibility with ammonia
51	5.11	Arrangement - Bunker station arrangement	For future bunker vessel/ carrier design, a semi-open or closed bunker station design with provided mechanical ventilation is considered. Discuss the QRA effect on dispersion results associated with a leak at the bunker station
52	5.15	Fire/ explosion - Fire/ explosion in the manifold area	Identify potential ignition sources based on operations conducted by neighbouring jetties, including passing vessels (bunker vessel, bunker barge as a potential ignition source to consider for the QRA application)

53	**5.17**	Overpressure storage tank	Investigate to what extent humidity will affect ammonia gas dispersion
54			A flag may request dispersion analysis for the risk of toxic gas ingress to ventilation in the accommodation area
55			Consider a liquid level detector to be installed in the vent mast
56			Vent mast arrangement should be designed to prohibit water ingress from, e.g. rain or sea spray

No	Hazard ID	Hazardous event / Consequences	Recommendation / follow-up action
57			Investigate the inclusion of a water spray system for the vent mast. Consider drainage/ containment of aqueous ammonia as well
58			Procedures for alarms and monitoring system testing and operation (including fault handling and sensor's by-passing) to be included in vessel's SMS; responsible personnel to familiarise with requirements
59	**5.18**	Overfilling storage tank	As per hazard ID 5.17: Procedures for alarms and monitoring system testing and operation (including fault handling and sensor's by-passing) to be included in vessel's SMS; responsible personnel to familiarise with requirements
60	**5.19**	Design - Tank design (LAC/ ABV)	More than 25mm of pipe must be welded
61			Water spray system on tank dome
62			Melting plugs
63	**5.20**	General SIMOP activities - Vessel ballasting, Vessel crane operations, Crew and visitors embarking/ disembarking, Disposal (garbage, sludge, sewage, blackwater etc.), Lifeboat or MOB boat drills/ handling, Firefighting drills, General cleaning and maintenance, Underwater service/ repairs, testing fin stabilisers, Hot work and maintenance, Helicopter operations, Power generation onboard, running engine and machinery (supply and receiving vessels), Cargo handling	Consider SIMOPS at the terminal
64			Consider SIMOPS on a case-to-case basis and required mitigating measures (as a basis, no SIMOPS leading to additional loss of containment scenarios are assumed)
65			No crew change during STS is recommended
66	**6.1/ 6.2/ 6.3**	Drain - Fail to drain (ammonia remains in transfer equipment/ not liquid-free)	Installation of adequate freshwater eyewash in the vicinity of manifold, break off in accommodation
67	**7.1**	Navigational hazards (grounding, collision, and contact) during departure/ manoeuvring from STS location, see Location Risk Assessment	EDP (Early Departure Procedure) should be considered after the completion of the cargo operation.
68	**8.1**	Toxic zone definition - Toxic gas in non-hazardous areas	Consider air humidity on ammonia gas behaviour and potential for ingress to non-hazardous areas

Table 7.10: HAZID Recommendations Pilot Concept 2 (Location Risk)

No	Hazard ID	Hazardous event / Consequences	Recommendation / follow-up action
1	1.4	Experience with this location. Used currently or in the past for STS – New locations may pose a higher risk than existing locations with solid experience	Personnel with the relevant STS experience to be selected for the pilot operation
2			Emergency procedures are to be established
3	1.5	Ship dimension limitations (Minimum under-keel clearance requirement/ Maximum arrival draft) - Grounding	Consider smaller size vessels for the pilot phase of the project
f 4	1.6	Safety and security zones - Activities close to the bunkering operation	Address the QRA potential overlap between toxic zones for ammonia and establish a safety zone for other STS locations
5			Consider the risk of ship collision imposed by passing vessels
6	1.7	Dedicated waiting area/ anchorage area - Conflict with other ship traffic	Local authority to consider additional anchorage points for vessels that must await completion of other STS operations at the dedicated anchorage point
7	1.8	Mandatory pilotage - Navigational accident during the approach, manoeuvring or departure in the waterway (e.g. grounding, collision or contact)	Dedicated pilotage of vessel types involved in ammonia bunkering will be carried out
8	1.10	Standby tug requirement (Fire Fighting, Rescue Services, Emergency towing or pushing up, Delivery of personnel or equipment, Guarding the vessel, Assisting with Pollution, and Other Services as Determined) - An emergency event during STS transfer	Investigate if additional requirements of tugs for emergency response are associated with ammonia leaks
9	1.12/ 3.2/ 3.3/ 3.4	Vessel Traffic Services VTS (Information Service (INS), Navigation Assistance Service (NAS), Traffic Organisation (TOS)) - Navigational accident (e.g. grounding, collision, or contact)	Consider navigational risk assessment during FEED
10	1.14	Mooring requirements (Mooring study, Bow direction, Weather restriction)	Exiting mooring arrangements should be assessed for all sizes of ships
11			Assess mooring requirements on each planned operation by involving STS Organisers or by Managers of both Vessels

12	**1.15**	Loss of position – Anchor dragging	Assess the required mooring anchor's capacity and redundancy
13			Consider the provision of the standby tug to prevent separation
14	**1.19**	All regulating bodies are identified, and requirements accounted for - Unsafe operations (by not following regulations)	Investigate additional local regulating body requirements associated with ammonia transfer operations, including limitation of toxic release to air or water
15			Restriction on toxicity (ppm) associated with water ammonia solution that can be disposed to sea

No	Hazard ID	Hazardous event / Consequences	Recommendation / follow-up action
16	**1.20**	All company-specific requirements accounted for - Unsafe operations (by not following company-specific procedures)	To be addressed in the FEED phase
17	**1.22**	Approval of operations - Lack of approval may cause increased risk to the public	Approval of operation is required by regulating body
18			Requirements for Vessel specific STS Plan approval by Flag to be verified with local authority
19	**2.9**	Operational weather limits, including abort criteria - Accidental release of Ammonia (loss of containment) due to insufficient or lack of weather limits	Identify abort criteria for an ammonia transfer operation
20	**2.10**	Visibility (daylight, fog, etc.) - Navigational accident (e.g. grounding, collision, or contact) due to lack of visibility	Visibility to be addressed by each Vessel's SMS and procedures
21	**2.11**	Electrical storm (thunderstorms) may affect cargo transfer operation	Identify abort criteria for an ammonia transfer operation
22	**2.12**	Waves - Wave from passing traffic	Identify abort criteria for wave height generated by passing traffic for the ammonia transfer operation
23	**2.13**	Environmental hazards (cold fronts, hurricanes, tsunamis, etc.) - Frequent changes in the wind (speed, direction)	Consider the risk of wind gusts for the site location and the definition of associated abort criteria. Include vessels' SMS and procedures
24			Consider stand-by tugs nearby
25	**3.1**	Fairway to STS location (Sufficient water depth and width. Aton sufficient, Critical waypoints or depths, Squat effects) - Navigational accident (e.g. grounding, collision or contact) due to narrow waters	During the FEED phase, address required space for manoeuvring, turning, etc., given multiple (simultaneous) operations in the area
26	**3.5**	Emergency unmooring – Unable to Unmoor	Consider measures to initiate unmooring if mooring systems become unavailable (Suggestion: quick release of axe)

27	**4.1/ 4.2**	Close vicinity / nearby traffic lanes Traffic amount and composition – Collision with ships in the area (passing, crossing, head-on, overtaking, being rammed while STS, etc.)	Assess the risk of ship collision for the STS location; establish the required Safety Zone
28			Ensure appropriate communication to the traffic in the area (VTS, NavCharts, Radio, NavWarning, etc.)

No	Hazard ID	Hazardous event / Consequences	Recommendation/ follow-up action
29	**4.3**	Distance to other STS locations in the vicinity (SIMOPS) - Simultaneous operations should be detailed in 'Operations risk assessment'	Investigate the QRA potential overlap and escalation risk due to SIMOPS at multiple anchorage points
30	**5.1/ 5.2**	Terminals or facilities nearby - Toxic vapour cloud that travels downwind towards the terminal or other operations nearby	Multiple anchorage points - the risk of escalation to be covered by the QRA
31	**5.3**	Populated areas/ private ship traffic – Potential ammonia spill may reach shorelines, with population, sensitive areas, etc.	Look into applicable regulations/restrictions for 3rd party (private) ships crossing the Raffles Reserved Anchorage area
32	**6.1/ 6.2**	Toxic emergency/ response services and units - Lack of toxic emergency units nearby may cause incidents to escalate	Review existing ERP activities for ammonia spill application
33			Investigate the required capacity of emergency/ support tugs and firefighting tugs to mitigate toxic gas dispersion. To be discussed with local authority on applicable requirements
34	**6.3**	Marine Pollution - Breach of bunker/ ammonia release due to collision	Perform environmental risk assessment due to ammonia spill caused by a ship collision

1.2 Pilot Concept 3 Risk Results

1.2.1 HAZID results

The HAZID study's results (i.e. hazards, hazardous events, causes, consequences, preventive & mitigating measures, recommendations and responsibilities) were documented in the HAZID Log. These, including the proposed risk rating, were reviewed by workshop participants.

1.2.2 Risk results

The HAZID was conducted based on arrangement drawings and documents, and design philosophies available at the time of the HAZID workshop. It is strongly recommended that any significant future changes to the design or operation which may impact the hazard and risk levels should be reassessed.

All results of the HAZID study (i.e., hazards, hazardous events, causes, consequences, preventive & mitigating measures, recommendations, and responsibilities) were documented in the HAZID Log presented in Appendices A to Appendix H of this report. In total, ninety-four (94) hazardous events were identified, where seventy-four (74) hazardous events were categorised as medium risk, and four (4) hazardous events were categorised as acceptable or low risk. The remaining sixteen (16) events were not ranked because no risk was identified. The risk summarisation of concept 3 are as shown in Table 7-11.

No hazardous events were categorised as high risk

The risk summarisation of Pilot Concept 3 are as shown in Table 7.11.

	Pilot Concept 3 STS ABV to APS at Raffles Reserved Anchorage

Risk Ranking	Operation Risk	Location Risk
Low	1	3
Medium	38	36
High	0	0
Not Risk Ranked	3	13

1.2.3 HAZID Recommendations

One Hundred and thirteen (113) HAZID recommendations were made during the HAZID workshop for Pilot Concept 3. Recommendations are further summarised in Table 7.12 and Table 7.13. All further details can be found in the HAZID Log in Appendices A to H.

Table 7.12: HAZID Recommendations Pilot Concept 3 (Operational Risk)

No.	Hazard ID	Guideword – Hazardous event	Recommendation / follow-up action
1	1.1	Compatibility assessment (between ships) - Failing to follow procedures / standards prior to operation	Conduct compatibility assessment (ABV / APS) (all parties are involved in developing compatibility assessment; all operational modes, including SIMOPs identified and addressed, in addition to bunkering infrastructure, berthing and fendering)
2			Potential hose misalignment between manifolds is to be covered as part of the compatibility assessment
3			Automatic ESD (ABV)
4			Linked ESD System (Ship-to-ship link)
5			For type A tank, reliquefication unit is to be provided to control tank pressure. For type C tank BOG management system is to be provided, including but not limited to a reliquefication unit, GCU / boilers are recommended to avoid opening of PRV. Alternatively, a tank design pressure of 18 bar (45 deg C) can be considered
6			Emergency response, escape, and evacuation procedures are to be established in case of an ammonia release
7			Required PPE is provided, including shower & eyewash stations
8			An ammonia release mitigation system (ARMS) should be provided for APS. ABV should as well consider the integration of ARMS. Any release of ammonia vapour on APS as part of regular operation should not exceed 30 ppm in toxic concentration
9			Material compatibility assessment
10			Ammonia sampling at ABV
11			A sampling procedure for liquid and vapour return shall be established, including available technology, verification, and personnel training. It is proposed at the sending ship side (CGA can be referred for associated

			procedure)
12			Established operating limits and weather windows for ammonia bunkering application
13			A custody transfer procedure for ammonia transfer is to be established
14			Master meter for ammonia transfer to be considered
15			Provide required competence and training to personnel

No.	Hazard ID	Guideword - Hazardous event	Recommendation / follow-up action
16	**1.2**	Mooring assessment - Failing to follow procedures/ standards prior to operation	Mooring compatibility assessment (anchorage point arrangement); fendering arrangement based on vessel size
17	**1.3**	Bunker procedures and organisation - Failing to follow procedures/standards prior to operation	Establish an associated procedure for the ammonia transfer operation
18			Establish a joint plan of operations (JPO) ABV/ APS for the ammonia transfer operation
19			Safety Management System (SMS) to include ammonia transfer operation
20	**2.1**	Failing to follow procedures prior to operation - Pre-arrival checklist - Tests and notices - Communication - The Pilot and Master meeting prior to the approach	Update all established checklists for ammonia application (ABV)
21	**4.1**	Failing to follow procedures: -Testing communication -Checklists onboard	Tank preparation procedure (air drying, purging) at APS before ammonia transfer
22			All established checklists should be reviewed for ammonia application (ABV)
23			Investigate means for vapour return handling (either on APS or ABV)
24	**4.5**	Human error - Vessel separation detection (VSD) connection failure	Consider VSD; provide required competence and training to operate VSD, including required checks
25	**4.9**	Human error - Insufficient cooldown of piping	Cold ammonia gas from the reliquefication unit can cool down pipes and remove nitrogen; that gas should further be sent to the ammonia catch system (APS)
26	**4.12**	Human error – Lack of competence / training	Provision of competence and training to personnel is required for personnel involved in ammonia operations

27	**5.1**	Breakaway - Breakaway, vessel separation	Consider a dry drip tray for ammonia spill containment and draining (ABV)
28			The capacity of the water spray system (including shoreside and terminal) is to be defined based on ammonia spilt vs water amount required. The water spray system is considered efficient for limited liquid ammonia spill only; the leak is considered neutralised by a large amount of water. For extensive spill mitigation, a dry drip tray or foam / DCP system can be considered (ABV)
29			The thermal sensor in the drip tray (APS design)
30			Gas detectors at the bunker station (APS design)
31			Include a procedure for hose recovery in case of ESD2 from a daughter vessel

No.	Hazard ID	Guideword - Hazardous event	Recommendation / follow-up action
32	5.2	Leak - Ammonia leakage from transfer hose, marine loading arm during cargo loading or offloading operation	Placement of gas detectors to consider light and heavy toxic cloud behaviour (ABV)
33			Consider a spill containment system for a pressurised ammonia release capable of containing the spill for multiple release directions (ABV)
34			Thermal detection inside the bund (ABV)
35			Fixed gas detection fitted on the vessels (ABV)
36			Automatic ESD (ABV)
37			Identify means for ammonia water solutions disposal; at some ports, release to the sea is permitted; to define in consultation with local authority for allowable toxic concentration for release to sea (ABV)
38			Identify the required capacity of the fire water system (ABV)
39			Due to the exothermic reaction of ammonia with water, identify the spill amount that the water spray system can neutralise; for a larger release, part of the spill will be dissolved, remaining will be quickly vapourised, travelling downwind. See hazard ID 5.1 for alternative solutions (ABV)
40	5.3	Leak - Ammonia leakage from cargo loading / offloading manifold	Closure of vent inlets to safe areas / rooms
41			Provision of toxic detectors in HVACs
42			Eyewash to personnel
43			Double-door arrangements for accommodation and safe rooms
44			Mechanical shielding for flanged connections (ABV)
45			Closure of vent inlets to safe areas / rooms (ABV)
46			Provision of toxic detectors in HVACs (ABV)
47			Eyewash to personnel (ABV)

48	**5.9**	Leak - Ammonia leakage from a pipe on a deck	Double-door arrangements for accommodation and safe rooms (ABV)
49			Mechanical shielding for flanged connections (ABV)
50			Based pipe routing is considered a double barrier if it goes close or passes to safe areas (APS)

No.	Hazard ID	Guideword - Hazardous event	Recommendation / follow-up action
51			Mechanical protection for piping is required if piping routing goes via areas with a present hazard of dropped objects (APS)
52			Consider the required capacity of mechanical protection based on the lifting operation conducted (APS)
53			Toxic gas detection in the inlet and safe areas must be considered if exposed to toxic release. Dispersion simulation can be conducted to assess potential exposure (APS / ABV)
54	5.13	Impact - Mechanical impact on piping, e.g. dropped object	Mechanical protection for piping on the main deck defines the required capacity for mechanical protection (APS)
55	5.14	Overpressure of the storage tank	Investigate to what extent humidity will affect NH_3 gas dispersion
56			A flag may request dispersion analysis for the risk of toxic gas ingress to ventilation in the accommodation area
57			Consider a liquid level detector to be installed in the vent mast
58			Vent mast arrangement should be designed to prohibit water ingress from, e.g. rain or sea spray
59			Investigate the inclusion of a water spray system for the vent mast. Consider drainage / containment of aqueous ammonia as well
60	5.15	Overfilling of the storage tank	Investigate ESD link logic to trigger a shutdown of ABV supply pumps and manifold valves
61	5.17	BOG management - Overpressure	Investigate the required capacity of the BOG management system on APS
62			Remotely operated valves as much as possible
63			Fully welded connections as much as possible

64	**5.18**	Leak - Leak inside TCS	Ammonia water solution disposal is to be defined by local authorities; otherwise, a drain tank should be made available on the ship
65	**5.19**	Design - Tank design (ABV)	More than 25mm of pipe must be welded
66			Water spray system on tank dome
67			Melting plugs

No.	Hazard ID	Guideword - Hazardous event	Recommendation / follow-up action
68	5.19	General SIMOP activities - Vessel ballasting, vessel crane operations, crew and visitors embarking / disembarking, disposal (garbage, sludge, sewage, blackwater etc.), lifeboat or man overboard (MOB) boat drills / handling, firefighting drills, general cleaning and maintenance, underwater service / repairs, testing fin stabilisers, hot work and maintenance, helicopter operations, power generation onboard, running engine and machinery (supply and receiving vessels), cargo handling	Consider SIMOPS at the terminal
69			No parallel operations with cargo operations (at the same anchorage point)
70			Consider SIMOPS on a case-by-case basis and required mitigating measures (as a basis, no SIMOPS leading to additional loss of containment scenarios are assumed)
71			MOPO - Matrix of Permitted Operations to be developed in conjunction with local authority and non-essential operations to be avoided
72			No crew change during STS is recommended
73	6.1	Drain - Fail to drain (ammonia remains in transfer equipment / not liquid-free)	As per hazard ID 4.1
74			Installation of adequate freshwater eyewash in the vicinity of manifold, break off in accommodation
75	6.2	Purge - Fail to purge (fail to maintain % content)	As per hazard ID 4.1
76			As per hazard ID 6.1, Installation of adequate freshwater eyewash in the vicinity of manifold, break off in accommodation
77			For APS purge gas to be sent to ARMS or back to the bunker vessel (not allowed to be vented)
78	7.1	Navigational hazards (grounding, collision and contact) during departure/ manoeuvring from STS location, see Location Risk Assessment	EDP (Early Departure Procedure) should be considered after the completion of the cargo operation

79	**8.1**	Toxic zone definition - Toxic gas in non-hazardous areas	Consider air humidity on ammonia gas behaviour and potential for ingress to non-hazardous areas (ABV)

Table 7.13: HAZID Recommendations Pilot Concept 3 (Location Risk)

No	Hazard ID	Hazardous event / Consequences	Recommendation / follow-up action
1	1.4	Experience with this location. Used currently or in the past for STS - New locations may pose a higher risk than existing locations with solid experience	Personnel with the relevant STS experience to be selected for the pilot operation
2			Emergency procedures are to be established
3	1.5	Ship dimension limitations (Minimum under-keel clearance requirement / Maximum arrival draft) - Grounding	Consider smaller-sized vessels for the pilot phase of the project
4	1.6	Safety and security zones - Activities close to the bunkering operation	Safety zone to be developed based on the results from QRA
5			Consider the risk of ship collision imposed by passing vessels
6	1.7	Dedicated waiting area / anchorage area – Conflict with other ship traffic	Local authority to consider anchorage locations for vessels that must await completion of other STS operations at the dedicated anchorage point
7	1.8	Mandatory pilotage - Navigational accident during approach, manoeuvring or departure in the waterway (e.g., grounding, collision, or contact)	Dedicated pilotage of vessel types involved in ammonia bunkering will be carried out
8	1.10	Standby tug requirement (firefighting, Rescue Services, emergency towing or pushing up, delivery of personnel or equipment, guarding the vessel, assisting with Pollution, and other services as determined) - An emergency event during STS transfer	Investigate if additional requirements of tugs for emergency response are associated with ammonia leaks

9	**1.12**	Vessel Traffic Services VTS (Information Service (INS), Navigation Assistance Service (NAS), Traffic Organisational (TOS)) – Navigational accident (e.g. grounding, collision, or contact)	Consider navigational risk assessment during FEED
10	**1.14**	Mooring requirements (mooring study, Bow direction, weather restriction)	Existing mooring arrangements should be assessed for all sizes of ships

No	Hazard ID	Hazardous event / Consequences	Recommendation/ follow-up action
11			Assess mooring requirements on each planned operation by involving STS Organisers or by Managers of both Vessels
12	1.15	Loss of position – Anchor dragging	Assess the required mooring anchor's capacity and redundancy
13			Consider the provision of the standby tug to prevent separation
14	1.19	All regulating bodies are identified And requirements accounted for – Unsafe operations (by not following regulations)	Investigate additional local regulating body requirements associated with ammonia transfer operations, including limitation of toxic release to air or water
15			Restriction on toxicity (ppm) associated with water ammonia solution that can be disposed to sea
16	1.20	All company-specific requirements accounted for - Unsafe operations (by not following company-specific procedures)	To be addressed in the FEED phase
17	1.22	Approval of operations - Lack of approval may cause increased risk to the public	Approval of operation is required by regulating body
18			Requirements for vessel-specific STS Plan approval by Flag to be verified with local authority
19	2.9	Operational weather limits, including abort criteria - Accidental release of Ammonia (loss of containment) due to insufficient or lack of weather limits	Identify abort criteria for an ammonia transfer operation
20	2.10	Visibility (daylight, fog, etc.) - Navigational accident (e.g. grounding, collision, or contact) due to lack of visibility	Visibility to be addressed by each vessel's SMS and procedures

21	**2.11**	Electrical storm (thunderstorms) - Electrical storms (thunderstorms) may affect cargo transfer operation	Identify abort criteria for the ammonia transfer operation
22	**2.12**	Waves - Wave from passing traffic	Identify abort criteria for wave height generated by passing traffic for an ammonia transfer operation

23	**2.13**	Other environmental hazards (cold fronts, hurricanes, tsunamis, etc.) – Frequent changes in the wind (speed, direction)	Consider the risk of wind gusts for the site location and the definition of associated abort criteria. Include vessels' SMS and procedures
24			Consider stand-by tugs in close proximity
25	**3.1/3.2**	Fairway to STS location (sufficient water depth and width; aton sufficient, critical waypoints or depths, squat effects) – Navigational accident (e.g., grounding, collision, or contact) due to narrow waters	During the FEED phase, address required space for manoeuvring, turning, etc., given multiple (simultaneous) operations in the area
26	**3.5**	Emergency unmooring – Unable to unmoor	Consider measures to initiate unmooring if mooring systems become unavailable (Suggestion: quick release of axe)
27	**4.1/4.2**	Close vicinity / nearby traffic lanes Traffic amount and composition - Collision with ships in the area (passing, crossing, head-on, overtaking, being rammed while STS, etc.)	Assess the risk of ship collision for the STS location; establish the required Safety Zone
28			Ensure appropriate communication to the traffic in the area (VTS, NavCharts, Radio, NavWarning etc.)
29	**4.3**	Distance to other STS locations in the vicinity (SIMOPS) - Simultaneous operations should be detailed in 'Operations risk assessment'	Investigate the QRA potential overlap and escalation risk due to SIMOPS at multiple anchorage points
30	**5.1/5.2**	Terminals or facilities nearby - Toxic vapour cloud that travels downwind towards the terminal or other operations nearby	Multiple anchorage points - the risk of escalation to be covered by QRA
31	**5.3**	Populated areas/ private ship traffic – Potential ammonia spill may reach shorelines, with population, sensitive areas, etc.	Look into applicable regulations / restrictions for 3rd party (private) ships crossing the Raffles Reserved Anchorage area
32	**6.1/6.2**	Toxic emergency / response services and units - Lack of toxic emergency units nearby may cause incidents to escalate	Review existing ERP activities for ammonia spill application
33			Investigate the required capacity of emergency / support tugs and firefighting tugs to mitigate toxic gas dispersion. To be discussed with local authority on applicable requirements
34	**6.3**	Marine pollution – Breach of bunker / ammonia release due to collision	Perform environmental risk assessment due to ammonia spill caused by a ship collision

APPENDIX A-1 OPERATION RISK ASSESSMENT – LAC TO ABV AMMONIA TRANSFER AT RAFFLES RESERVED ANCHORAGE HAZID LOG

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
Node 1 Prior to operations											
1.1	Compatibility assessment	- Failing to follow procedures/standards prior to operation	- Commercial pressure - Human error - Lack of company standards	- Misalignment - Ship contact damages - Excessive forces on manifolds - Possibility to exceed operating envelop of equipment - Mooring issues	- Established STS recommendation following SIGTTO guidelines	SAFE	3	3	M	- Conduct compatibility assessment (LAC/ ABV) (all parties are involved in developing compatibility assessment; all operational modes, incl. SIMOPs identified and addressed). In addition to bunkering infrastructure, berthing and fendering - Potential hose misalignment between manifolds is to be covered as part of the compatibility assessment - Review established requirements for compatibility assessment for ammonia application. - Check on ammonia composition - Establish ship to ship checklist for ammonia transfer - Identify relevant PPE for ammonia application - Automatic and linked ESD (two different sets of ESD for loading and unloading to be considered) - Established operating limits and weather windows for ammonia bunkering application - Certify crane for crew transfer - Emergency response, escape, and evacuation procedures are to be established in case of an ammonia release - A custody transfer procedure for ammonia transfer is to be established. - Master meter for ammonia transfer to be considered - A sampling procedure for liquid and vapour return shall be established, including available technology, verification, and personnel training. It is proposed at the sending ship side (CGA can be referred for associated procedure) - Provide required competence and training to personnel	-As a basis, existing LAC/ABV design to be considered for the QRA application
1.2	Mooring assessment	- Failing to follow procedures/standards prior to operation	- Commercial pressure - Human error - Lack of company standards	- Ship drift away, drift grounding - Contact damage - Disrupt operations	- ESD	SAFE	2	3	M	- Perform a mooring assessment for the site location (possibly OPTIMOOR), incl. mooring compatibility - Consider introducing PERC (Powered Emergency Release Coupling)	
1.3	STS procedures and organization	- Failing to follow procedures/standards prior to operation	- Commercial pressure - Human error - Lack of company standards	- Loss of containment		SAFE	2	3	M	- Establish an associated procedure for the ammonia transfer operation - Establish a joint plan of operations (JPO) (LAC/ABV) for the ammonia transfer operation. - STS vessel-specific safety management plan should be provided - Vessel-specific STS Plan to be approved by Flag	
Node 2 Prior to arrival											
2.1	- Pre-arrival checklist, tests and notice - Communication - The Pilot and Master meeting prior to the approach	Failing to follow procedures prior to operation	- Failing to follow procedures may lead to incidents	- Loss of containment during operations	- Established checklists for LAC/ABV preparation activities, pre-arrival, equipment checklist, berthing checklist for the vessel, etc.	SAFE	2	3	M	-Update all established checklists for ammonia application.	
Node 3 Arrival (Inc. Mooring)											
3.1	- Navigational hazards	Navigational hazard is location specific, thus covered in Location Risk Assessment									
3.2	- Mooring between LAC //Jetty//ABV	Mooring hazards are location specific, thus covered in Location Risk Assessment									

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
Node 4 Pre-transfer											
4.1	- Testing communication - Checklists onboard	Failing to follow procedures	- Failing to follow procedures may lead to incidents	- Potential spillage during ammonia transfer	- Established transfer/ bunkering procedures	SAFE	2	3	M	- Update all established bunkering/transfer procedures for ammonia application - Establish a procedure for hose drying and inerting - If inerting is introduced, nitrogen banks will be provided on the ship. Purged gas can be sent to ammonia neutralising unit/ GCU/ or boiler	
4.2	Human error	Coupling/ loading arm/ hose connection failure	- Incorrect connection or locking	- Potential ammonia leaks		SAFE	1	4	M		
4.4	Human error	ESD link connection error	- Incorrectly plugged or plug connection damaged/ dirty	- Fail to function on demand - Potential ammonia leaks	- ESD test	SAFE	1	4	M		
4.5	Human error	Vessel separation detection (VSD) connection failure	- Incorrectly plugged or plug connection damaged/dirty - Wrongly placed	- Fail to function on demand - Potential ammonia leaks	- Part of the checklist/ procedure to ensure the connection is in place - System is function tested before operation - Compatibility analysis - Supervised operation - The listing angle of 2 degrees is considered for VSD	SAFE	1	4	M	- Consider VDS; provide required competence and training to operate VDS, including required checks	
4.6	Electric isolation	Electric isolation	- Wear and tear - No insulation flange	- An ignition source, sparks	- Electric isolation between connected vessels in compliance with the ISGOTT and SIGTTO “Liquefied Gas Handling Principles on Ships and in Terminals”.	QUA	1	3	L		
4.7	Human error	Forgot to reset the ESD systems after testing	- Failing to follow procedures	- Fail to function on demand - Potential ammonia leaks	- Established transfer procedures - Training and competence of personnel						If ESD is not resettled, not possible to operate any valve or pump, and no risk of leakage exists
4.8	Human error	Insufficient cooldown of piping	- Failing to follow procedures	- Pipeline damage	- Established transfer procedures - Training and competence of personnel	ASS	1	3	L		-Pipe cooling with cold ammonia to be considered for the QRA application
4.9	Human error	Incomplete PERC system set-up	- Failing to follow procedures	- PERC fail to function on demand - Ammonia spill	- Consider PERC with fail-safe function, active interlock	SAFE	1	4	M	- Consider PERC (if not included initially)	
4.10	Human error	Incomplete leak test	- Failing to follow procedures	- Leakages during operation	- Established transfer procedures	SAFE	1	4	M		
4.11	Utility failure	Fail to quantify/measure the quantity of fuel transferred	- Technical failure	- No health/ safety risk	- According to established industry standards requirements	QUA	1	3	L		
4.12	Human error	Human error	- Lack of experience with handling ammonia	- Leakages during operation		SAFE	2	4	M	- Provision of competence and personnel training is required for ammonia operations personnel	
Node 5 Transfer of Ammonia											
Cargo manifold											

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
5.1	Breakaway	Breakaway, vessel separation	- Excessive relative motion between ships beyond the operational window - Mooring failure	- Equipment/asset damage/operational delay - Personnel injuries	- Marine loading arm /Hose ERS - ESD system with two-stage alarm and shutdown system. The first stage (ESD1) shall initiate the shutdown of the transfer operations and close valves, and the second stage (ESD2) shall activate the PERCs. - Water curtain/ water spray system at the ship side and the Terminal - Drip tray 50% filled with water to dissolved ammonia if spilt	SAFE	2	4	M	- Consider a dry drip tray for ammonia spill containment and draining - The capacity of the water spray system (incl. shoreside and terminal) is to be defined based on ammonia spilt vs water amount required. The water spray system is considered efficient for limited liquid ammonia spill only; the leak is considered neutralized by a large amount of water. A dry drip tray, or foam / DCP system, can be considered for extensive spill mitigation - Emergency response procedures to include ammonia transfer. - Include a procedure for hose recovery in case of ESD2 from a daughter vessel - As per hazard ID 4.5 - Escort tugs are to be kept on standby for the duration of the operation	To be considered for the QRA application
5.2	Leak	Ammonia leakage from transfer hose (connection to manifold)	- Design, fabrication or installation error - Abnormal operating condition (exceeding design limits) due to equipment malfunction or operator error - Material defect - Excessive relative motion between ships beyond the operational window of the marine loading arms - Drift-off	- Toxic spill - Toxic gas dispersion due to evaporated spill - Personnel injuries; cold burns - Potential for damage of hull structure exposed - Potential for ignited toxic release if a strong ignition source is reached	- Manual ESD activation points are provided to rapidly shut down the cargo transfer system. The ESD can be initiated both locally and remotely - ESD system with two-stage alarm and shutdown system. The first stage (ESD1) shall initiate the shutdown of the transfer operations and close valves, and the second stage (ESD2) shall activate the PERCs. - Water curtains/spray - Pressure/leak testing - Bund for loading arm with a sump (small pit) installed with suction head	SAFE	2	4	M	- Placement of gas detectors to consider light and heavy toxic cloud behaviour - Consider a spill containment system for a pressurized ammonia release capable of containing the spill for multiple release directions -Thermal detection inside the bund - Fixed gas detection fitted on the vessels - Automatic ESD (as per hazard ID 1.1) - Linked ESD (as per hazard ID 1.1) - Identify means for ammonia water solutions disposal; at some ports, release to the sea is permitted; to define in consultation with local authority for allowable toxic concentration for release to the sea - Identify the required capacity of the fire water system - Due to the exothermic reaction of ammonia with water, identify the spill amount that the water spray system can neutralize; for a larger release, part of the spill will be dissolved, remaining will be quickly vapourised travelling downwind. See hazard ID 5.1 for alternative solutions - Consider remote monitoring CCTV	To be considered for the QRA application
5.3	Leak	Ammonia leakage from the cargo manifold	- As per hazard ID 5.2	- As per hazard ID 5.2	- Duty person for leak detection - Manually activated ESD - Water spray system - Drip trays in manifold area - ERP - Eyewash to personnel	SAFE	2	4	M	- As per hazard ID 5.2 - Closure of vent inlets to safe areas/ rooms - Provision of toxic detectors in HVACs - Double-door arrangements for accommodation and safe rooms - Mechanical shielding for flanged connections	To be considered for the QRA application
5.4	Trapped liquid	The trapped liquid between the bunker valve and the tank valve	- Intended or unintended activation of ESD	- Ammonia trapped between valves. When trapped liquid ammonia is heated, the result is high pressure which can cause equipment or gasket failure. - Equipment/ system damage -Ammonia leak	- Pressure relief valve on each segment - Depressurization of the segment after the transfer	SAFE	2	3	M		

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
5.5	Backflow	Backflow of NH_3 into the N_2 system	- Valve failure	- Exposure to the crew (when opening up for maintenance etc.) - Damage to the nitrogen system - Toxic hazard - Fire/ explosion if a strong ignition source is present	- Required to have double block and bleed valves on connections to the nitrogen system	SAFE	2	3	M		- Piping is not purged with nitrogen; instead filled with ammonia gas. If not used for transfer and by keeping on open valve system will be naturally depressurised
5.6	Wrong flow	The flow of NH_3 to other bunkering stations	- Valve failure	- Toxic hazard - Fire/ explosion if a strong ignition source is present	- Double valve segregation	SAFE	2	3	M		
5.7	External leak	-Spill of ammonia into the water	- Hose rupture	-Rapid formation of toxic cloud	- Water spray system on the ship side	ENV	1	4	M	- Hose periodic testing and inspection before transfer - Hose rigged as per best industry practices	- Release of the QRA modelling 6m above sea level is anticipated
5.8	External leakage on single piping between bunker station and storage tank	- Technical failure - External hazards	- Design, fabrication or installation error - Wear and tear - Mechanical damage, dropped objects	- Spillage on deck	- Water spray system on the ship side	SAFE	1	4	M	- As per hazard ID 5.2 & 5.3	To be considered for the QRA application
5.9	Damage	Piping thermal expansion or contraction	- Extreme temperatures of the fuel and high ambient temperatures	- Pipe leak or rupture	- PRV - Heat stress analysis	SAFE	1	4	M	- Include tightening of the flanged connections	
5.10	Damage	Stress corrosion cracking	- Design fault, incorrect material properties	- Pipeline damage	- Material selection part of The IGC code (clause 17.1.2) - Condition monitoring on the piping inspections	SAFE	1	4	M	- Assess material compatibility with ammonia	
5.11	Arrangement	Bunker station arrangement	- Insufficient ventilation		- Open (natural ventilation)	SAFE	1	4	M	- For future bunker vessel/ carrier design, a semi-open or closed bunker station design with provided mechanical ventilation is considered. Discuss in the QRA the effect on dispersion results associated with a leak at the bunker station	
5.14	Impact	Mechanical impact on piping, e.g. dropped object	- Lifting activity - Dropped objects	- Rupture of pipe - Release of NH_3 - Toxic hazard - Fire/explosion if a strong ignition source is present	- No crane operations in parallel with cargo operations	SAFE	1	4	M		To be considered for the QRA application
5.15	Fire/explosion	Fire/ explosion in the manifold area	- Toxic gas release reaching the strong ignition source	- Ignited leak - Flash fire	- The manifold area is located in a hazardous zone; ex-rated equipment's no ignition sources are allowed	SAFE	1	4	M	- Identify potential ignition sources based on operations conducted by neighbouring jetties, including passing vessels. (Bunker vessel, bunker barge as a potential ignition source to consider for the QRA application)	To be considered for the QRA application
5.16	Fire/explosion	Heat transfer to ammonia cargo transfer station from fire	- Fire/ explosion in other areas	- Overpressure the release of toxic gas	- PRV set at 18 bar - Water spray to cool down manifold piping	SAFE	1	4	M		To be considered for the QRA application
Cargo containment and vent systems											

No.	Guideword	Hazard/ event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
5.17	Overpressure	Overpressure	- Opening of PSVs due to pressure increase in the cargo tanks	- Toxic gas dispersion on the upper deck area. - Consequently, the potential for injuries, fatalities, asset damage or accident escalation to adjacent areas.	- Cargo tank pressure monitoring and control system - BOG management (ensuring that reliquefication system capacity is based on maximum BOG generation) - Gas detection system for the vent mast - N_2 purging connection for the vent masts - Gas detection system for the air intakes for the accommodation - Compatibility assessment to exclude a probability of hazardous zone overlap and ventilation intakes exposure to a toxic gas - The drain valve on the vent is activated after rainy condition - Vapour return connection between two vessels	SAFE	1	4	M	- Investigate to what extent humidity will affect ammonia gas dispersion. - A flag may request dispersion analysis for the risk of toxic gas ingress to ventilation in the accommodation area - Consider a liquid level detector to be installed in the vent mast - Vent mast arrangement should be designed to prohibit water ingress from, e.g. rain or sea spray - Investigate the inclusion of a water spray system for the vent mast. Consider drainage/ containment of aqueous ammonia as well - Procedures for alarms and monitoring system testing and operation (including fault handling and sensor's by-passing) to be included in Vessel's SMS; responsible personnel to familiarise with requirements	To be considered for the QRA application
5.18	Overfilling	Overfilling	- Overfilling of cargo tanks during ammonia transfer	- Toxic liquid out of vent mast. - Consequently, the potential for injuries, fatalities, asset damage or accident escalation to adjacent areas.	- Tank level monitoring and limits w/shutdown - An agreed amount of Ammonia to be transferred - "Run-down" procedures - Stop cargo loading operation or reduce operation rate - Cargo tank pressure monitoring and control system - High and high high-level alarm in the tank	SAFE	2	4	M	- As per hazard ID 5.17: Procedures for alarms and monitoring system testing and operation (including fault handling and sensor's by-passing) to be included in Vessel's SMS; responsible personnel to familiarise with requirements	To be considered for the QRA application, i.e. Release via vent mast due to tank overfilling scenario
5.19	Design	Tank design (LAC/ABV)	- Insufficient design	- Continuous ammonia release		SAFE	1	4	M	- More than 25mm of pipe must be welded - Water spray system on tank dome - Melting plugs	
SIMOPs											

5.20	General SIMOP activities	- Vessel ballasting - Vessel crane operations - Crew and visitors embarking/ disembarking - Disposal (garbage, sludge, sewage, blackwater etc.) - Lifeboat or MOB boat drills/ handling - Firefighting drills - General cleaning and maintenance - Underwater service/ repairs - Testing fin stabilisers - Hot work and maintenance - Helicopter operations - Power generation onboard, running engine and machinery (supply and receiving vessels) -Cargo handling	- SIMOPs	- Toxic release, the potential for fire or explosion - Consequently, the potential for injuries, fatalities, asset damage or accident escalation to adjacent areas	- No SIMOP executed in parallel	SAFE	1	4	M	- Consider SIMOPS at the terminal - Consider SIMOPS on a case-to-case basis and required mitigating measures (as a basis, no SIMOPS leading to additional loss of containment scenarios are assumed) - No crew change during STS is recommended - Limited SIMOPS are to be agreed upon by all parties before transfer	Some operations are usually allowed during LPG STS: - Ballasting of both Vessels is an essential part of operations, as this may considerably affect mooring and hose connection - Periodic Mooring adjustment - Personnel transfer by service boat between two vessels

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
Node 6 Post-Transfer											
6.1	Drain	Fail to drain (ammonia remains in transfer equipment/not liquid-free)	- Fail to follow procedures - Technical error	- Toxic condition in transfer equipment while disconnection (gas or trapped liquid) - Exposure of flammable material to crew	- PPE - Emergency Preparedness - Procedures adapted to vessel compatibility - Pressure relief valve - Procedure for connection liquid-free status verification established -Procedure for connection liquid-free status verification established	SAFE	2	3	M	- As per hazard ID 4.1 - Installation of adequate freshwater eyewash in the vicinity of manifold, break off in accommodation	
6.2	Purge	Fail to purge (fail to maintain % content)	- Fail to follow procedures - Technical error	- Toxic condition in transfer equipment while disconnection (gas or trapped liquid) - Exposure of flammable material to crew	- Work procedures for draining, purging, inerting - Training and competence of personnel - PPE - Emergency Preparedness - Procedures adapted to vessel compatibility - Purging with hot gas to remove all ammonia to the tank (ship side).	SAFE	2	3	M	- As per hazard ID 4.1 - As per hazard ID 6.1, Installation of adequate freshwater eyewash in the vicinity of manifold, break off in accommodation	
6.3	Disconnection	Toxic condition	- As per hazard ID 6.1 and 6.2	- As per hazard ID 6.1 and 6.2		SAFE	2	3	M	- As per hazard ID 6.1 and 6.2	
Node 7 Unmooring and departure											
7.1		Navigational hazards (grounding, collision and contact) during departure/manourvering from STS location, see Location Risk Assessment	-	-	-					- EDP (Early Departure Procedure) should be considered after the completion of the cargo operation.	
Node 8 Other hazards											
8.1	Toxic zone definition	-Toxic gas in non-hazardous areas	- Toxic zone is defined as insufficient	- Toxic gas in non-hazardous areas	- Defined toxic zones according to applicable requirements	SAFE	2	3	M	- Consider air humidity on ammonia gas behaviour and potential for ingress to non-hazardous areas	

APPENDIX A-2 LOCATION RISK ASSESSMENT – LAC TO ABV AMMONIA TRANSFER AT RAFFLES RESERVED ANCHORAGE HAZID LOG

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
1. Local establishment, regulations and requirements											
1.1	Fish farms/ fishery or aquaculture establishments	Conflict with fish farms/ aquaculture establishments	- Other activities may hinder or cause hazards for the STS operation, or vice versa	- Ammonia spill (toxic hazard) - Potential for fire/explosion - Operational restrictions - Operational delays	- No commercial fishing activities						- Not applicable; thus, no risk rating is provided
1.2	Ballast water	Ballast water restrictions			- No restrictions for ballast water exchange in that area						- No ballast water restrictions; thus, no risk rating is provided
1.3	Military areas	Conflict with military areas	- Other activities may hinder or cause hazards for the STS operation, or vice versa	- Ammonia spill (toxic hazard) due to potential collision impact between vessels - Impact due to military activities - Operational restrictions - Operational delays	- No military areas						- Not applicable; thus, no risk rating is provided
1.4	Experience with this location Used currently or in the past for transhipment	New locations may pose a higher risk than existing locations with solid experience	- Loss of containment due to lack of experience	- Loss of containment - Ammonia spill (toxic hazard)	- Area has been used for typical transfer activities (not ammonia specific)	SAFE	2	3	M	- For the pilot phase, pilotage, testing, and personnel training to be provided - Emergency procedures are to be established	
1.5	Ship dimension limitations: - Minimum under-keel clearance requirement - Maximum arrival draft	Grounding	- Violation of clearance or draft requirements	- Ammonia spill (toxic hazard) - Asset damage - Delay in operation	- Grounding is not considered likely for anchorage location	SAFE	2	3	M	- Consider smaller size vessels for the pilot phase of the project	
1.6	Safety and security zones	Activities close to the bunkering operation	- Other activities may hinder or cause hazards for the STS bunkering operation, or vice versa	- Operational restrictions - Operational delays	- An average 150m safety zone is required for LPG and LNG cargo	SAFE	2	3	M	- Address the QRA potential overlap between toxic zones for ammonia and establish a safety zone for other STS locations - Consider the risk of ship collision imposed by passing vessels	
1.7	Dedicated waiting area/ anchorage area	Conflict with other ship traffic	- Geography/ landscape/ depth	- Drift grounding - Contact or collision with other ships	- Entry procedures mean no entrance until allowed	SAFE	1	4	M	- Local authority to consider additional anchorage points for vessels that must await completion of other STS operations at the dedicated anchorage point	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
1.8	Mandatory pilotage	A navigational accident during the approach, manourvering or departure in the waterway (e.g. grounding, collision or contact)	- Human error - Lack of pilotage	- The credible consequence is severe ship damage and damage to ballast bottom or wing tanks (i.e. no Ammonia spill) - Worst case consequence: Penetration of ship hull (inner and outer) and penetration of cargo containment Uncontrolled escape/outflow of Ammonia, pool formation, gas dispersion and rapid phase transition (RPT) Potential for ignition and pool fire, with significant heat intensity		SAFE	2	3	M	- Dedicated pilotage of vessel types involved in ammonia bunkering to be carried out	
1.9	Escort tug requirement	A navigational accident during the approach, manourvering or departure in the waterway (e.g. grounding, collision or contact)	- Human error - Lack of tugs	- Severe ship damage - Loss of containment - Toxic hazard - Fire/explosion	- No escort tugs are assumed to be used for STS						- Not applicable; thus, no risk rating is provided
1.10	Standby tug requirement - Fire Fighting; - Rescue Services; - Emergency towing or pushing up; - Delivery of personnel or equipment; - Guarding the vessel; - Assisting with Pollution; - Other Services as determined	Emergency event during STS transfer	- Human error - Technical Error	- Severe ship damage - Loss of containment - Toxic hazard - Fire/explosion		SAFE	1	4	M	- Investigate if additional requirements of tugs for emergency response are associated with ammonia leaks	
1.11	IMO routing measures (e.g. Traffic Separation Scheme, deep water route, etc.)	Navigational accident (e.g. grounding, collision or contact)	- Human error - Lack of TTS	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- Local authority guidelines requirements are followed, and depth is sufficient	SAFE	1	3	L		
1.12	Vessel Traffic Services VTS - Information Service (INS) - Navigation Assistance Service (NAS) - Traffic Organisation (TOS)	Navigational accident (e.g. grounding, collision or contact)	- Human error - Lack of VTS	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- Vessel separation traffic VST service - Ship traffic data	SAFE	1	3	L	- Consider navigational risk assessment during FEED	
1.13	Speed restrictions	Navigational accident (e.g. grounding, collision or contact)	- Human error - Technical error	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- See Hazard ID 1.12	SAFE	1	3	L	- See Hazard ID 1.12	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
1.14	Mooring requirements - Mooring study - Bow direction - Weather restriction	Drift grounding	- Technical Error - Environmental forces	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- For mooring and unmooring will occur one activity at a time	SAFE	2	3	M	- Exiting mooring arrangement should be assessed for all sizes of ships - Assess mooring requirements on each planned operation by involving STS Organisers or by Managers of both Vessels	
1.15	Loss of position	Anchor Dragging	- Seabed condition	- Vessel separation	- Personnel watching and radar monitoring, navigation systems - The engine is on standby which can start immediately	SAFE	2	3	M	- Assess the required mooring anchor's capacity and redundancy - Consider the provision of the standby tug to prevent separation	
1.16	Underwater pipelines, cables	Anchor damaging pipelines	- Technical (accidental dropped anchor) or human error (dropped anchor over pipeline)	- Pipeline damage and loss of pipeline containment	- No pipeline or cables identified						- Not applicable; thus, no risk rating is provided
1.17	Environmental sensitive areas	Ammonia spill in environmentally sensitive areas	- Technical or human error	- In small spills, most of the Ammonia will vaporise before reaching the water due to heat transfer with the air - For large spills, air cannot transfer enough heat to vaporise much Ammonia, so almost all of the spill will likely end up in a pool. The spilt Ammonia will undergo several physical processes simultaneously (pool formation, spread and boil-off) - Ammonia spills are much less severe for the environment compared to oil spill							- Not applicable; thus, no risk rating is provided
1.18	Airports nearby	Conflict with the airport nearby	- Location of airport	- Ships may be obstacles for flights arriving/ departing - Ship lights may conflict with runway lights arrangement	- No airport nearby						- Not applicable; thus, no risk rating is provided
1.19	All regulating bodies identified,and requirements accounted for	Unsafe operations (by not following regulations)	- Requirements not identified or insufficient	- Ammonia spill (toxic hazard) - Operational delays (requirements identified late in the process)		REG	2	3	M	- Investigate additional local regulating body requirements associated with ammonia transfer operations, including limiting the toxic release to air or water - Restriction on toxicity (ppm) associated with water ammonia solution that can be disposed to sea	
1.20	All company-specific requirements accounted for	Unsafe operations (by not following company-specific procedures)	- Requirements not identified or insufficient	- Ammonia spill (toxic hazard) - Operational delays (requirements identified late in the process)		DEL	2	3	M	- To be addressed in the FEED phase	
1.21	All stakeholders informed	Lack of information among stakeholders	- Stakeholders not identified	- Operational delays - Ammonia spill - Potential for fire/ explosion		DEL	2	3	M		
1.22	Approval of operations	Lack of approval may cause increased risk to the public	- Lack of regulating body	- Ammonia spill - Potential for fire/ explosion		REG	2	3	M	- Approval of operation is required by regulating body - Requirements for Vessel specific STS Plan approval by Flag to be verified with local authority	
2. Exposure of location too, or shelter, prevailing environmental conditions including, where appropriate, met ocean analysis											

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
2.1	Overall swell height, period and direction Sea characteristics	Large swells	- Environmental	- This may cause excessive strain on the transfer hoses - Suspension of operation - Activation of PERC - Mooring Line failure	- Environmental assessment has been conducted for prior operations in the bay - The area is rather congested, so no swell is anticipated						Not applicable; thus, no risk rating is provided
2.2	Prevailing wind direction Wind force averages	Strong wind may cause drift-off, separation or drift grounding	- Environmental	- This may cause excessive strain on the transfer hoses. - Suspension of operation - Activation of PERC - Mooring Line failure	- Monsoon season maximum wind speed anticipated around 4-5 and higher - Weather limitations established for the draft and commissioning at the jetty	DEL	2	3	M		
2.3	Tide	Strong tides/currents may cause drift-off, separation or drift grounding	- Environmental	- This may cause excessive strain on the transfer hoses. - Suspension of operation - Activation of PERC - Mooring line failure	- No tide hazard	DEL	2	3	M		
2.4	Current	Accidental release of Ammonia (loss of containment) due to currents	- Strong tides/ currents may cause drift-off, separation or drift grounding	- This may cause excessive strain on the transfer hoses. - Suspension of operation - Activation of PERC - Mooring line failure	- A protected, sheltered area						Not applicable; thus, no risk rating is provided
2.5	The seabed (holding ground)	Drift grounding due to poor holding ground	- Strong wind, strong currents and harder sea bottom may cause drift grounding - The vessel anchor is not holding on to the holding ground - Failure of anchor chain	- Severe ship damage - Loss of containment - Toxic release - Fire/ explosion	- Sea bed (holding ground) clay and sand	SAFE	2	3	M		
2.6	Stability of seabed, such as sand waves forming	Grounding due to changes in seabed	- Strong wind, strong currents and harder sea bottom may cause drift grounding - The vessel anchor is not holding on to the holding ground - Failure of anchor chain	- Severe ship damage - Loss of containment - Toxic release - Fire/ explosion							Not applicable; thus, no risk rating is provided
2.9	Operational weather limits, including abort criteria	Accidental release of Ammonia (loss of containment) due to insufficient or lack of weather limits	- Incidents due to weather criteria not being followed	- Ammonia spill		DEL	2	3	M	- Identify abort criteria for the ammonia transfer operation	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
2.10	Visibility (daylight, fog, etc.)	Navigational accident (e.g. grounding, collision or contact) due to lack of visibility	- Visibility may hinder navigation	- Ship damage - Operational restrictions or delays	- Permanent full-scale Navigational watch	DEL	2	3	M	- Visibility to be addressed each Vessels SMS and procedures	Not applicable; thus, no risk rating is provided
2.11	Electrical storms (thunderstorms)	Electrical storms (thunderstorms) may affect cargo transfer operation	- Environmental hazards	- Ammonia spill (fire/ explosion) - Operational restrictions - Operational delays		DEL	2	3	M	- Identify abort criteria for the ammonia transfer operation	
2.12	Waves	Wave from passing traffic	- Passing traffic nearby the anchorage point	- May cause excessive strain on the transfer hoses.		DEL	2	3	M	- Identify abort criteria for wave height generated by passing traffic for an ammonia transfer operation	
2.13	Other environmental hazards (cold fronts, hurricanes, tsunamis, etc.)	Frequent changes in the wind (speed, direction)	- Environmental hazards	- Ammonia spill (fire/ explosion) - Operational restrictions - Operational delays	- No hurricane, tsunami, or cold fonts	DEL	2	3	M	- Consider the risk of wind gusts for the site location and definition of associated abort criteria. Include vessels' SMS and procedures - Consider stand-by tugs nearby	
3. Navigational hazards in the vicinity of the location											
3.1	Fairway to STS location: - Sufficient water depth and width - Aton sufficient - Critical waypoints or depths - Squat effects	Navigational accident (e.g. grounding, collision or contact) due to narrow waters	- Human error	- Experience has shown that the double-bottom structure of the Ammonia carrier can accept severe grounding damage without affecting the integrity of the cargo containment system (however, a double-bottom is not required with a C-type Ammonia tank)		SAFE	3	4	M	- During the FEED phase, address required space for maneuvering, turning, etc., given multiple (simultaneous) operations in the area	
3.2	STS location / Space for manourvering in port/ terminal - Turning circles - Operational water zones Critical depths or coastal areas, rocks	- Ship grounding, collision or contact accident due to lack of manourvering space	- Human error			SAFE	3	4	M	- As per hazard ID 3.1	
3.3	Mooring at location	Mooring LAC	- Technical error - Human error	- Insufficient mooring - Contact damage between ships -Drift away	- Fenders - Established guidelines (STS transfer guide for petroleum SIGTTO) to be followed	SAFE	2	4	M	- As per Operations' risk hazard ID 1.2	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
3.4	Mooring at location	Mooring ABV	- Technical error - Human error	- Insufficient mooring - Contact damage between ships -Drift away	- Fenders - Established guidelines (STS transfer guide for petroleum SIGTTO) to be followed	SAFE	2	4	M	- As per Operations' risk hazard ID 1.2	
3.5	Emergency unmooring	Unable to unmoor	- Technical error - Human error	- Asset damage/ loss - Injuries/ fatalities		SAFE	2	4	M	- Consider measures to initiate unmooring if mooring systems become unavailable (Suggestion: quick release of axe)	
4. Ship traffic density in the vicinity of the location, including the presence of other STS activities											
4.1	Close vicinity/ nearby traffic lanes Traffic amount and composition	- Collision with ships in the area (passing, crossing, head-on, overtaking, being rammed while STS, etc.)	- Technical or human error	- Impact with larger ships will cause increased impact energies and damage potential		SAFE	3	4	M	- Assess the risk of ship collision for the STS location; establish the required Safety Zone - Ensure appropriate communication to the traffic in the area (VTS, NavCharts, Radio, NavWarning etc.)	
4.2	Fishing activities and pleasure crafts interfering with the STS operation	Fishing activities and pleasure crafts interfering with the STS operation	- Intentional or lack of awareness of safety zone			SAFE	2	3	M	- As per hazard ID 4.1	
4.3	Distance to other STS locations in the vicinity (SIMOPS)	- Simultaneous operations should be detailed in 'Operations risk assessment'				SAFE	2	3	M	- Investigate the QRA potential overlap and escalation risk due to SIMOPS at multiple anchorage points	
5. Spill and dispersion trajectories and potential impacts											
5.1	Terminals or facilities nearby	Toxic vapour cloud that travels downwind towards the terminal or other operations nearby	- Accidental release of Ammonia	- Toxic hazard - Potential for ignition somewhere within the terminal		SAFE	2	3	M	- Multiple anchorage points - the risk of escalation to be covered by the QRA	
5.2	Terminals or facilities nearby	Fire/explosion or emergency situation at the terminal or other operation areas nearby	- Flammable cargo handling activities - Bunkering operation/ vessel represents an additional source of ignition	- Potential for escalation to bunkering operation		SAFE	2	3	M	See Hazard ID 5.1	
5.3	Populated areas/private ship traffic	- Potential Ammonia spill may reach shorelines, with population, sensitive areas, etc.	- Technical/ human error	- Toxic hazard	- No populated area in the vicinity	SAFE	2	3	M	- Relevant port authorities should look into applicable regulations/ restrictions for 3rd party (private) ships crossing the Raffles Reserved Anchorage area	
6. Requirement for and availability of any additional spill response resources at the location											
6.1	Toxic emergency/ response services and units	- Lack of toxic emergency units nearby may cause incidents to escalate	- Lack of emergency units	- Escalation of events		SAFE	1	4	M	- Review existing ERP activities for ammonia spill application - Investigate the required capacity of emergency/ support tugs and firefighting tugs to mitigate toxic gas dispersion. To be discussed with local authority on applicable requirements	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
6.2	Towing/ tug emergency	- Lack of towing emergency units nearby may cause incidents to escalate	- Lack of emergency units	- Escalation of events		SAFE	1	4	M	- As per hazard ID 6.1	
6.3	Marine Pollution	- Breach of bunker/ ammonia release due to collision	- Collision Impact	- Ammonia spill into the water	- Ammonia internal transfer between tanks reviews damage control. - Listing and DE ballasting	SAFE	1	4	M	- Perform environmental risk assessment due to ammonia spill caused by a ship collision	
7. Other											
7.1	Shore logistical daily support (tugs, support crafts, etc.)	Lack of shore logistical daily support (tugs, support crafts, etc.)	- Lack of logistical support may affect operations (safety, delays etc.)	- Operational delays	- Shore support required for operations is identified and arranged prior Vessel's arrival at the STS location	SAFE	2	3	M		
7.2	STS Superintendents subcontracted	Lack of experience and competence	- Lack of training and competence (qualification of personnel)	- Ammonia spill (toxic hazard)		SAFE	1	4	M	- As per Operations' risk hazard ID 4.12	
7.3	Security threats in the area	Security threats	- War, sabotage, and terrorism risks	- Ammonia spill (toxic hazard)							- Not Applicable
7.4	Radio/ rele-communication coverage	Lack of radio/ telecommunication coverage	- Lack of tele-communication capacity	- Ammonia spill (toxic hazard)							- Not Applicable
7.5	Time	The time window for operation and slot requirements	- Multiple activities at the terminal	- Stress and potential human failures	- Established operations schemes	SAFE	2	3	M		

APPENDIX B-1 OPERATION RISK ASSESSMENT - ABV TO APS AMMONIA TRANSFER AT RAFFLES RESERVED ANCHORAGE HAZID LOG

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
Node 1 Prior to operations											
1.1	Compatibility assessment (between ships)	Failing to follow procedures/ standards prior to operation	- Commercial pressure - Human error - Lack of company standards	- Misalignment - Ship contact damages - Excessive forces on manifolds - Possibility to exceed operating envelop of equipment - Mooring issues -Loss of containment	- Class rules and LNG bunkering requirements (IGF/ IGC) can be used as a reference for bunkering transfer and associated requirements (APS) - Ammonia composition is checked based on the quality certificate.	SAFE	3	3	M	- Conduct compatibility assessment (ABV/ APS) (all parties are involved in developing compatibility assessment; all operational modes, including SIMOPs identified and addressed). In addition to bunkering infrastructure, berthing and fendering - Potential hose misalignment between manifolds is to be covered as part of the compatibility assessment - Automatic ESD (ABV) - Linked ESD System (Ship to ship link) - A tank reliquefication unit is to be provided to control tank pressure. For thank type C BOG management system to be provided, including but not limited to a reliquefication unit, GCU/boilers are recommended to avoid opening of PRV. Alternatively, a tank design pressure of 18 bar (45 deg C) can be considered - Emergency response, escape, and evacuation procedures are to be established in case of an ammonia release - Required PPE is provided, including shower & eyewash stations - An ammonia release mitigation system (ARMS) should be provided for APS. ABV should as well consider the integration of ARMS. Any release of ammonia vapour on APS as part of regular operation should not exceed 30 ppm in toxic concentration - Material compatibility assessment - Ammonia sampling at ABV - A sampling procedure for liquid and vapour return shall be established, including available technology, verification, and personnel training. It is proposed at the sending ship side (CGA can be referred for associated procedure) - Established operating limits and weather windows for ammonia bunkering application - A custody transfer procedure for ammonia transfer is to be established. - Master meter for ammonia transfer to be considered - Provide required competence and training to personnel	-For the QRA APS ammonia fuel supply system design fully compliant with IGC and DNV Ammonia Ships Rules is assumed 'General remark. The presented concept of an ammonia transfer (bunkering) system is based on traditional/ LPG/ LNG fuels transfer. Due to the toxic nature of ammonia, suggest looking at a different transfer philosophy approach: use smaller diameter hose(s) of 2-3" with higher flow speed in the transfer link. There are multiple benefits to such a system: - Smaller and lighter hoses make it less possible to sustain mechanical damage - Hose connections are simpler, quicker, and safer - Handling hoses is much easier - A significant advantage in the safety aspect: in cases of hose burst amount of residual ammonia in the hose (which is the primary quantity of ammonia spilt) is much smaller in comparison to a bigger diameter hose - Depending on the size of the bunker parcel, 1, 2 or 3 hoses can be used simultaneously (all are fixed on one bunker boom/ arm), which adds to the flexibility and redundancy of the transfer system
1.2	Mooring assessment	Failing to follow procedures/ standards prior to operation	- Commercial pressure - Human error - Lack of company standards	- Ship drift away, drift grounding - Contact damage - Disrupt operations	- ESD and PERC (Powered Emergency Release Coupling)	SAFE	2	3	M	- Mooring compatibility assessment (anchorage point arrangement). Fendering arrangement based on vessel size	
1.3	Bunker procedures and organisation	Failing to follow procedures/ standards prior to operation	- Commercial pressure - Human error - Lack of company standards	- Loss of containment		SAFE	2	3	M	- Establish an associated procedure for the ammonia transfer operation - Establish a joint plan of operations ABV/ APS for the ammonia transfer operation - Safety Management System (SMS) to include ammonia transfer operation	
Node 2 Prior to arrival											
2.1	- Pre-arrival checklist, bunkering and notice - Communication - The Pilot and Master meeting prior to the approach	Failing to follow procedures prior to operation	- Failing to follow procedures may lead to incidents	- Loss of containment during operations	- Established check bunkering for ABV/ APS preparation activities, pre-arrival, equipment checklist, berthing checklist for the vessel, etc.	SAFE	2	3	M	- Update all established checklists for ammonia application (ABV)	- APS is assumed to have dedicated procedures in place for ammonia
Node 3 Arrival (Including mooring)											

No.	Guideword	Hazard/ event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
3.1	- Navigational hazards	Navigational hazards are location specific, thus covered in Location Risk Assessment									
3.2	- Mooring between ABV/ APS	Mooring hazards are location specific, thus covered in Location Risk Assessment									
Node 4 Pre-transfer											
4.1	- Testing communication - Checklists bunkering onboard	Failing to follow procedures	- Failing to follow procedures may lead to incidents	- Potential spillage during bunkering transfer	- Bunkering transfer/ bunkering procedures - Gas sampling (Inside the tank) - Safety management system and safety checklist.	SAFE	2	3	M	- Tank preparation procedure (air drying, purging) at APS before ammonia transfer - All established checklists should be reviewed for ammonia application (ABV) - Investigate means for vapour return handling (either on APS or ABV)	
4.2	Human error	Coupling/ loading arm/ hose connection failure	- Incorrect connection or locking	- Potential Ammonia leaks	- Bunkering transfer/ bunkering procedures	SAFE	2	4	M		
4.4	Human error	ESD link connection error	- Incorrectly plugged or plug connection damaged/ dirty	- Fail to function on demand, potential ammonia leaks	- ESD test	SAFE	1	4	M		
4.5	Human error	Vessel separation detection (VSD) connection failure	- Incorrectly plugged or plug connection damaged/ dirty - Wrongly placed	- Fail to function on demand, Potential ammonia leaks	- Part of the checklist/procedure to ensure the connection is in place - System is function tested before operation - Compatibility analysis - Supervised operation - ESD2 is initiated in case of excessive forces on the loading arm (to be confirmed)	SAFE	1	4	M	- Consider VSD; provide required competence and training to operate VDS, including required checks	
4.6	Electric isolation	Electric isolation	- Wear and tear - No insulation flange	- Ignition source, sparks	- Electric isolation between connected vessels in compliance with the ISGOTT and SIGTTO “Liquefied Gas Handling Principles on Ships and in Terminals”	SAFE	1	4	M		
4.7	Utility failure	Fail to quantify/ measure the quantity of fuel transferred	- Technical failure	- No health/ safety risk	- Established related industry standards requirements	QUA	1	3	L		
4.8	Human error	Forgot to reset the ESD systems after testing	- Failing to follow procedures	- Fail to function on demand Potential ammonia leaks	- Bunkering transfer procedures - Training and competence of personnel	SAFE	1	4	M		
4.9	Human error	Insufficient cooldown of piping	- Failing to follow procedures	- Pipeline damage	- Bunkering transfer procedures - Training and competence of personnel	SAFE	1	4	M	- Cold ammonia gas from the reliquefication unit can be used to cool down pipes and remove nitrogen that gas should be sent to the ammonia catch system (APS)	

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
4.10	Human error	Incomplete PERC system set-up	- Failing to follow procedures	- PERC fail to function on demand (potential damage to bunkering hoses in case of vessel separation) - Ammonia spill	- PERC with fail-safe function, interlock until active	SAFE	1	4	M		
4.11	Human error	Incomplete leak test	- Failing to follow procedures	- Leakages during operation	- Bunkering procedures	SAFE	1	4	M		
4.12	Human error	Human error	- Lack of experience with handling ammonia	- Leakages during operation		SAFE	2	4	M	- Provision of competence and personnel training is required for ammonia operations personnel.	
Node 5 Transfer of Ammonia											
Bunker manifold											
5.1	Breakaway	Breakaway, vessel separation	- Excessive relative motion between ships beyond the operational window - Mooring failure	- Equipment/asset damage/operational delay - Personnel injuries	- Marine loading arm /Hose ERS - ESD system with two-stage alarm and shutdown system. The first stage (ESD1) shall initiate the shutdown of the transfer operations and close valves, and the second stage (ESD2) shall activate the PERCs. - Water curtain/ water spray system at the ship side and the Terminal - Drip tray 50% filled with water to dissolve ammonia if spilt - Dry breakaway decoupling (APS design) - Gas detectors for semi-enclosed bunker station arrangement (APS design) - For the semi-enclosed bunker, the station provided mechanical ventilation (APS design) - Water spray system for bunker satiation to mitigate the toxic gas release. - Automatic ESD system on gas detection (APS design)	SAFE	2	4	M	- Consider a dry drip tray for ammonia spill containment and draining (ABV). - The capacity of the water spray system (incl. shoreside and terminal) is to be defined based on ammonia spilt vs water amount required. The water spray system is considered efficient for limited liquid ammonia spill only; the leak is considered neutralized by a large amount of water. For extensive spill mitigation, a dry drip tray or foam / DCP system can be considered (ABV) - A thermal sensor in the drip tray (APS design) - Gas detectors at the bunker station (APS design) - Include a procedure for hose recovery in case of ESD2 from a daughter vessel	-To be assessed in the QRA

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
5.2	Leak	Ammonia leakage from transfer hose, marine loading arm during cargo loading or offloading operation	- Design, fabrication or installation error - Abnormal operating condition (exceeding design limits) due to equipment malfunction or operator error - Material defect - Excessive relative motion between ships beyond the operational window of the marine loading arms - Drift-off	- Toxic spill - Toxic gas dispersion due to evaporated spill - Personnel injuries; cold burns - Potential for damage of hull structure exposed to a cryogenic spill - Potential for ignited toxic release if a strong ignition source is reached	- Manual ESD activation points at ABV are provided to rapidly shut down the cargo transfer system. The ESD can be initiated both locally and remotely - ESD system with two-stage alarm and shutdown system. The first stage (ESD1) shall initiate the shutdown of the transfer operations and close valves, and the second stage (ESD2) shall activate The PERCs (ABV) - Water curtains/ spray (ABV) - Pressure/ leak testing (ABV) - Bund for loading arm with a sump (small pit) installed with suction head (ABV) - Dry breakaway decoupling (APS design) - Gas detectors for semi-enclosed bunker station arrangement (APS design) - For the semi-enclosed bunker, the station provided mechanical ventilation (APS design) - Mechanical shielding for flange connection (APS design) - Automatic ESD system on gas detection (APS design)	SAFE	2	4	M	- Placement of gas detectors to consider light and heavy toxic cloud behaviour (ABV) - Consider a spill containment system for a pressurised ammonia release capable of containing the spill for multiple release directions (ABV) -Thermal detection inside the bund (ABV) - Fixed gas detection fitted on the vessels (ABV) - Automatic ESD (ABV) - Identify means for ammonia water solutions disposal; at some ports, release to the sea is permitted; to define in consultation with local authority for allowable toxic concentration for release to sea (ABV) - Identify the required capacity of the fire water system (ABV) - Due to the exothermic reaction of ammonia with water, identify the spill amount that the water spray system can neutralise; for a larger release, part of the spill will be dissolved, remaining will be quickly vapourised travelling downwind. See hazard ID 5.1 for alternative solutions (ABV)	-To be assessed in the QRA
5.3	Leak	Ammonia leakage from cargo loading/offloading manifold	- Design, fabrication or installation error - Abnormal operating condition (exceeding design limits) due to equipment malfunction or operator error - Material defect	- Toxic spill - Toxic gas dispersion due to evaporated spill -Personnel injuries; cold burns - Potential for damage of hull structure exposed - Potential for ignited toxic release if a strong ignition source is reached	- Duty person for leak detection (ABV) - Manually activated ESD (ABV) - Water spray system (ABV) - Drip tray 50% filled with water to dissolve ammonia if spilt (ABV) - Gas detectors for semi-enclosed bunker station arrangement (APS design) - For the semi-enclosed bunker, the station provided mechanical ventilation (APS design) - Mechanical shielding for flange connection (APS design) - Automatic ESD system on gas detection (APS design) - Dry drip tray with liquid sensors (APS design)	SAFE	2	4	M	- As per hazard ID 5.2 - Closure of vent inlets to safe areas/ rooms - Provision of toxic detectors in HVACs - Eyewash to personnel - Double-door arrangements for accommodation and safe rooms - Mechanical shielding for flanged connections (ABV)	-To be assessed in the QRA
5.3	Trapped liquid	The trapped liquid between the bunker valve and the tank valve	- Intended or unintended activation of ESD	- Ammonia trapped between valves. When trapped liquid ammonia is heated, the result is high pressure which can cause equipment or gasket failure. - Equipment/ system damage - Ammonia leak	- PRV is provided for each piping segment; the trapped liquid is sent either to the fuel tank or ammonia release mitigation system ARMS. (APS design) - The design pressure for the ammonia system required 18 bar - Depressurisation of the segment after the transfer (ABV)	SAFE	1	4	M		- All ammonia gas released as part of a standard operation must be sent to ARMS; only tank vapour is released via PRV

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
5.4	Backflow	Backflow of NH_3 into the the N_2 system	- Valve failure	- Exposure to the crew (when opening up for maintenance etc.) - Damage to the nitrogen system - Toxic hazard - Fire/ explosion if a strong ignition source is present	- Required to have double block and bleed valves on connections to the nitrogen system	SAFE	1	4	M		
5.5	Wrong flow	The flow of NH_3 to other bunkering stations	- Valve failure	- Toxic hazard - Fire/ explosion if a strong ignition source is present	- Double valve segregation - Additional valve beside the double valve segregation barrier (APS Design)	SAFE	1	4	M		
5.6	Damage	Piping thermal expansion or contraction	- Extreme temperatures of the fuel and high ambient temperatures	- Pipe leak or rupture	- PRV - Heat stress analysis	SAFE	1	4	M		
5.7	Damage	Stress corrosion cracking	- Design fault, incorrect material properties		- Material selection part of the IGC code (clause 17.1.2) and DNV ammonia ship rules (APS Design) - Piping inspections and condition monitoring	SAFE	1	4	M		
5.8	Arrangement	Bunkering station arrangement	- Insufficient ventilation		- See Hazard ID 5.1	SAFE	1	4	M		-To be assessed in the QRA
5.9	Leak	Ammonia leakage from a pipe on a deck	- Design, fabrication or installation error - Abnormal operating condition (exceeding design limits) due to equipment malfunction or operator error - Material defect	- Toxic spill - Toxic gas dispersion due to evaporated spill - Personnel injuries; cold burns - Potential for damage of hull structure exposed to a cryogenic spill - Potential for ignited toxic release if a strong ignition source is reached	- Water spray system on the ship side - Single wall pipe fully welded (APS design)	SAFE	1	4	M	- As per hazard ID 5.2 - Closure of vent inlets to safe areas/rooms (ABV) - Provision of toxic detectors in HVACs (ABV) - Eyewash to personnel (ABV) - Double-door arrangements for accommodation and safe rooms (ABV) - Mechanical shielding for flanged connections (ABV) - Based pipe routing is considered a double barrier if it goes close or passes to safe areas (APS) - Mechanical protection for piping is required if piping routing goes via areas with a present hazard of dropped objects (APS) - Consider the required capacity of mechanical protection based on the lifting operation conducted (APS) - Toxic gas detection in the inlet and safe areas must be considered if exposed to toxic release. Dispersion simulation can be conducted to assess potential exposure (APS/ ABV)	-To be assessed in the QRA
5.10	Fire/explosion	Fire/ explosion in the manifold area	- Toxic gas release accounting for a strong ignition source	- Ignited leak - Flash fire	- The Manifold area is located in a hazardous zone, and ex-rated equipment's no ignition sources are allowed (ABV) - The fixed and portable dry-powered system at the bunker station (APS Design)	SAFE	1	4	M		
5.11	Fire/explosion	Heat transfer to the bunkering station from the fire	- Fire/ explosion in other areas	- Overpressure the release of toxic gas	- The fixed and portable dry-powered system at the bunker station (APS Design) - Passive fire protection at bunkering station A60 insulation adjacent to the machinery system	SAFE	1	4	M		
5.12	External leak	Spill of ammonia into the water	- Hose rupture	- Rapid formation of toxic cloud	- Water spray system at ship's side for vapour mitigation	ENV	1	4	M		-To be assessed in the QRA

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
5.13	Impact	Mechanical impact on piping, e.g. dropped object	- Lifting activity - Dropped objects	- Rupture of pipe - Release of NH3 - Toxic hazard - Fire/ explosion if a strong ignition source is present	- No crane operations in parallel with cargo operations (ABV)	SAFE	1	4	M	- Mechanical protection for piping on the main deck; define the required capacity for mechanical protection (APS)	-To be assessed in the QRA
Cargo containment and vent systems											
5.14	Overpressure	Overpressure	- Heat ingress - Ammonia supplied at different conditions (P, T)	- Opening of PSVs due to pressure increase in the cargo tanks / Fuel Tank -Toxic gas release	- High-pressure alarm - BOG management system GCU, Reliquification unit - Control venting - Tank design pressure - Installation of Harbour setters in port to increase MARVS (Maximum allowable relief valve setting)	SAFE	1	4	M	- Investigate to what extent humidity will affect NH_3 gas dispersion - A flag may request dispersion analysis for the risk of toxic gas ingress to ventilation in the accommodation area - Consider a liquid level detector to be installed in the vent mast - Vent mast arrangement should be designed to prohibit water ingress from , e.g. rain or sea spray - Investigate the inclusion of a water spray system for the vent mast. Consider drainage/ containment of aqueous ammonia as well	-To be assessed in the QRA
5.15	Overfilling	Overfilling	- Overfilling of fuel tanks during transfer	- Toxic liquid out of vent mast Consequently, the potential for injuries, fatalities, asset damage or accident escalation to adjacent areas	- High and independent High-level alarm to close the bunkering valve and stop transfer pumps - The agreed amount of Ammonia to be transferred	SAFE	2	4	M	- Investigate ESD link logic to trigger the shutdown of ABV supply pumps and manifold valves	-To be assessed in the QRA
5.17	BOG management	Overpressure	- Generation of BOG in the ammonia transfer (especially in the initial stage)	- Unintended release of gas via vent mast - Increase tank pressure	- See Hazard ID 5.14	SAFE	1	4	M	- Investigate the required capacity of the BOG management system on APS	
5.18	Leak	Leak inside TCS	- Design, fabrication or installation error - Abnormal operating condition (exceeding design limits) due to equipment malfunction or operator error - Material defect	- Toxic gas out of vent mast	- Gas detection inside TCS will trigger the shutdown of the tank valve - Liquid leakage detection will trigger the shutdown of the tank valve - Trigger catastrophe ventilation 45 ach - Mechanical shielding on the flanged connection inside the TCS - Fully welded connection to the tank up to the first valve - The alarm on the open deck if gas is detected in TCS or spaces that are ventilated to that area. - A toxic zone is defined as the minimum distance in the event of a toxic release - A water curtain on the door to TCS - An airlock if TCS goes into another enclosed space	SAFE	1	4	M	- Remotely operated valves as much as possible - Fully welded connections as much as possible - Ammonia water solution disposal is to be defined by local authorities; otherwise, a drain tank should be made available on the ship	

5.19	Design	Tank design (ABV)	- Insufficient design	- Continuous release		SAFE	1	5	M	- More than 25mm of pipe must be welded - Water spray system on tank dome - Melting plugs	

No.	Guideword	Hazard/event	Potential causes	Potential consequence	Existing or planned safety measures	T	P	C	R	Recommendations (and responsible)	Notes
SIMOPs											
5.20	General SIMOP activities	- Vessel ballasting - Vessel crane operations - Crew and visitors embarking/ disembarking - Disposal (garbage, sludge, sewage, blackwater etc.) - Lifeboat or MOB boat drills/ handling - Firefighting drills - General cleaning and maintenance - Underwater service/repairs - Testing fin stabilizers - Hot work and maintenance - Helicopter operations - Power generation onboard, running engine and machinery (supply and receiving vessels) -Cargo handling	- SIMOPs	- Potential for fire (jet, pool or flash fire) or explosion. Consequently, the potential for injuries, fatalities, asset damage or accident escalation to adjacent areas	- No SIMOPS will occur during bunkering	SAFE	1	4	M	- Consider SIMOPS at the terminal - No parallel operations with cargo operations (at the same anchorage point) - Consider SIMOPS on a case-to-case basis and required mitigating measures (as a basis, no SIMOPS leading to additional loss of containment scenarios are assumed) -MOPO - Matrix of Permitted Operations to be developed in conjunction with local authority and non-essential operations to be avoided - No crew change during STS is recommended	
Node 6 Post-Transfer											
6.1	Drain	Fail to drain (ammonia remains in transfer equipment/not liquid-free)	- Fail to follow procedures - Technical error	- Toxic condition in transfer equipment while disconnection (gas or trapped liquid) - Exposure of flammable material to crew	- PPE - Emergency Preparedness - Procedures adapted to vessel compatibility - Pressure relief valve - Draining of lines after completion of transfer operations -Procedure for connection liquid-free status verification established	SAFE	2	3	M	- As per hazard ID 4.1 - Installation of adequate freshwater eyewash in the vicinity of manifold, break off in accommodation	
6.2	Purge	Fail to purge (fail to maintain % content)	- Fail to follow procedures - Technical error	- Toxic condition in transfer equipment while disconnection (gas or trapped liquid) - Exposure of flammable material to crew	- Work procedures for draining, purging, inerting - Training and competence of personnel - PPE - Emergency Preparedness - Procedures adapted to vessel compatibility - Purging with hot gas to remove all ammonia to the tank (ship side)	SAFE	2	3	M	- As per hazard ID 4.1 - As per hazard ID, 6.1 Installation of adequate freshwater eyewash in the vicinity of manifold, break off in accommodation - For APS purge gas to be sent to AMRS or back to the bunker vessel (not allowed to be vented)	
6.3	Disconnection	Toxic condition	- As per hazard ID 6.1 and 6.2	- As per hazard ID 6.1 and 6.2	- Sampling of gas for toxic content after purging	SAFE	2	3	M	-As per hazard ID 6.1 and 6.2	
Node 7 Unmooring and departure											
7.1		Navigational hazards (grounding, collision and contact) during departure/manourvering from STS location, see Location Risk Assessment	-	-	-					- EDP (Early Departure Procedure) should be considered after the completion of the cargo operation.	
Node 8 Other hazards											

8.1	Toxic zone definition	-Toxic gas in non-hazardous areas	- Toxic zone is defined as insufficient	- Toxic gas in non-hazardous areas		SAFE	2	4	M	- Consider air humidity on ammonia gas behaviour and potential for ingress to non-hazardous areas (ABV)	

APPENDIX B-2 LOCATION RISK ASSESSMENT – ABV TO APS AMMONIA TRANSFER AT RAFFLES RESERVED ANCHORAGE HAZID LOG

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
1. Local establishment, regulations and requirements											
1.1	Fish farms/ fishery or aquaculture establishments	Conflict with fish farms/ aquaculture establishments	- Other activities may hinder or cause hazards for The STS operation, or vice versa	- Ammonia spill (toxic hazard) - Potential for fire/explosion - Operational restrictions - Operational delays	- No commercial fishing activities						- Not applicable; thus, no risk rating is provided
1.2	Ballast water	Ballast water restrictions			- No restrictions for ballast water exchange in that area						- No ballast water restrictions; thus, no risk rating is provided
1.3	Military areas	Conflict with military areas	- Other activities may hinder or cause hazards for STS operation, or vice versa	- Ammonia spill (toxic hazard) due to potential collision impact between vessels -Impact due to military activities - Operational restrictions - Operational delays	- No military areas						- Not applicable; thus, no risk rating is provided
1.4	Experience with this location Used currently or in the past for transhipment	New locations may pose a higher risk than existing locations with solid experience	- Loss of containment due to lack of experience	- Loss of containment Ammonia spill (toxic hazard)	- Area has been used for typical transfer activities (not ammonia specific)	SAFE	2	3	M	- Personnel with the relevant STS experience to be selected for the pilot operation - Emergency procedures are to be established	
1.5	Ship dimension limitations: - Minimum under-keel clearance requirement - Maximum arrival draft	Grounding	- Violation of clearance or draft requirements	- Ammonia spill (toxic hazard) Asset damage Delay in operation	- Grounding is not considered likely for anchorage location	SAFE	2	3	M	- Consider smaller size vessels for the pilot phase of the project	
1.6	Safety and security zones	Activities close to the bunkering operation	- Other activities may hinder or cause hazards for the STS bunkering operation, or vice versa	- Operational restrictions - Operational delays	- An average 150m safety zone is required for LPG and LNG cargo.	SAFE	2	3	M	- Address the QRA potential overlap between toxic zones for ammonia and establish a safety zone for other STS locations - Consider the risk of ship collision imposed by passing vessels	
1.7	Dedicated waiting area/anchorage area	Conflict with other ship traffic	- Geography/landscape/ depth	- Drift grounding - Contact or collision with other ships	- Entry procedures mean no entrance until allowed.	SAFE	1	4	M	- Local authority to consider additional anchorage points for vessels that must await completion of other STS operations at the dedicated anchorage point	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
1.8	Mandatory pilotage	A navigational accident during the approach, manourvering or departure in the waterway (e.g., grounding, collision or contact)	- Human error - Lack of pilotage	- The credible consequence is severe ship damage and damage to ballast bottom or wing tanks (i.e., no Ammonia spill) - Worst case consequence: Penetration of ship hull (inner and outer) and penetration of cargo containment. Uncontrolled escape/outflow of Ammonia, pool formation, gas dispersion and rapid phase transition (RPT). Potential for ignition and pool fire, with significant heat intensity		SAFE	2	3	M	- Dedicated pilotage of vessel types involved in ammonia bunkering to be carried out	
1.9	Escort tug requirement	A navigational accident during the approach, manourvering or departure in the waterway (e.g., grounding, collision or contact)	- Human error - Lack of tugs	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- No escort tugs are assumed to be used for STS						- Not applicable; thus, no risk rating is provided
1.10	Standby tug requirement - Fire Fighting - Rescue Services; - Emergency towing or pushing up - Delivery of personnel or equipment - Guarding the vessel - Assisting with Pollution - Other Services as Determined	Emergency event during STS transfer	- Human error - Technical Error	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion		SAFE	1	4	M	- Investigate if additional requirements of tugs for emergency response are associated with ammonia leaks	
1.11	IMO routing measures (e.g., Traffic Separation Scheme, deep water route, etc.)	Navigational accident (e.g., grounding, collision or contact)	- Human error - Lack of TTS	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- Local authority guidelines requirements are followed, and depth is sufficient	SAFE	1	3	L		

1.12	Vessel Traffic Services VTS - Information Service (INS) - Navigation Assistance Service (NAS) - Traffic Organisation (TOS)	Navigational accident (e.g., grounding, collision or contact)	- Human error - Lack of VTS	- Severe ship damage - Loss of containment - Toxic hazard - Fire/explosion	-Vessel separation traffic VST service - Ship traffic data	SAFE	1	3	L	- Consider navigational risk assessment during FEED	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
1.13	Speed restrictions	Navigational accident (e.g., grounding, collision or contact)	- Human error - Technical error	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- See Hazard ID 1.12	SAFE	1	3	L	- See Hazard ID 1.12	
1.14	Mooring requirements - Mooring study - Bow direction - Weather restriction	Drift grounding	- Technical Error - Environmental forces	- Severe ship damage - Loss of containment - Toxic hazard - Fire/ explosion	- For mooring and un-mooring will occur one activity at a time	SAFE	2	3	M	- Exiting mooring arrangement should be assessed for all sizes of ships - Assess mooring requirements on each planned operation by involving STS Organisers or by Managers of both Vessels	
1.15	Loss of position	Anchor dragging	-Seabed condition	-Vessel separation	- Personnel watching and radar monitoring, navigation systems. - The engine is on standby which can start immediately	SAFE	2	3	M	- Assess the required mooring anchor's capacity and redundancy. - Consider the provision of the standby tug to prevent separation.	
1.16	Underwater pipelines, cables	Anchor damaging pipelines	-Technical (accidental dropped anchor) or human error (dropped anchor over pipeline)	Pipeline damage and loss of pipeline containment	- No pipeline or cables identified in the area of operations						- Not applicable; thus, no risk rating is provided
1.17	Environmental sensitive areas	Ammonia spill in environmentally sensitive areas	-Technical or human error	- In small spills, most of the Ammonia will vaporise before reaching the water due to heat transfer with the air - For large spills, air cannot transfer enough heat to vaporise much Ammonia, so almost all of the spill will likely end up in a pool. The spilt Ammonia will undergo several physical processes simultaneously (pool formation, spread and boil-off) - Ammonia spills are much less severe for the environment compared to an oil spill							- Not applicable; thus, no risk rating is provided
1.18	Airports nearby	Conflict with the airport nearby	Location of airport	- Ships may be obstacles for flights arriving/ departing - Ship lights may conflict with runway lights arrangement	- No airport nearby						- Not applicable; thus, no risk rating is provided
1.19	All regulating bodies identified, and requirements accounted for	Unsafe operations (by not following regulations)	Requirements not identified or insufficient	- Ammonia spill (toxic hazard) - Operational delays (requirements identified late in the process)		REG	2	3	M	- Investigate additional local regulating body requirements associated with ammonia transfer operations, including limitation of toxic release to air or water - Restriction on toxicity (ppm) associated with water ammonia solution that can be disposed to sea	

1.20	All company-specific requirements accounted for	Unsafe operations (by not following company-specific procedures)	Requirements not identified or insufficient	- Ammonia spill (toxic hazard) - Operational delays (requirements identified late in the process)		DEL	2	3	M	- To be addressed in the FEED phase	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
1.21	All stakeholders informed	Lack of information among stakeholders	Stakeholders not identified	- Operational delays - Ammonia spill - Potential for fire/explosion		DEL	2	3	M		
1.22	Approval of operations	Lack of approval may cause increased risk to the public	Lack of regulating body	-Ammonia spill - Potential for fire/explosion		REG	2	3	M	-Approval of operation is required by regulating body - Requirements for Vessel specific STS Plan approval by Flag to be verified with local authority	
2. Exposure of location too, or shelter, prevailing environmental conditions including, where appropriate, met ocean analysis											
2.1	Overall swell height, period and direction Sea characteristics	Large swells	Environmental	- This may cause excessive strain on the transfer hoses. - Suspension of operation - Activation of PERC - Mooring Line failure	- Environmental assessment has been conducted for prior operations in the bay - The area is rather congested, so no swell is anticipated						Not applicable; thus, no risk rating is provided
2.2	Prevailing wind direction Wind force averages	Strong wind may cause drift-off, separation or drift grounding	Environmental	- This may cause excessive strain on the transfer hoses. - Suspension of operation - Activation of PERC - Mooring Line failure	- Monsoon season maximum wind speed anticipated around 4-5 and higher -Weather limitations established for the draft and commissioning at the jetty	DEL	2	3	M		
2.3	Tide	Strong tides/currents may cause drift-off, separation or drift grounding	Environmental	- This may cause excessive strain on the transfer hoses. - Suspension of operation - Activation of PERC - Mooring Line failure	- No tide hazard	DEL	2	3	M		
2.4	Current	Accidental release of Ammonia (loss of containment) due to currents	Strong tides/currents may cause drift-off, separation or drift grounding	- This may cause excessive strain on the transfer hoses. - Suspension of operation - Activation of PERC - Mooring Line failure	- A protected, sheltered area						Not applicable; thus, no risk rating is provided
2.5	The seabed (holding ground)	Drift grounding due to poor holding ground	- Strong wind, strong currents, and rocky sea bottom may cause drift grounding - The vessel anchor is not holding on to the holding ground. - Failure of anchor chain	- Severe ship damage - Loss of containment -Toxic release - Fire/explosion	- Sea bed (holding ground) clay and sand						- No anchors were used. Not applicable; thus, no risk rating is provided
2.6	Stability of seabed, such as sand waves forming	Grounding due to changes in seabed	- Strong wind, strong currents and harder sea bottom may cause drift grounding - The vessel anchor is not holding on to the holding ground - Failure of anchor chain	- Severe ship damage - Loss of containment -Toxic release - Fire/ explosion							Not applicable; thus, no risk rating is provided

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
2.9	Operational weather limits, incl. abort criteria	Accidental release of Ammonia (loss of containment) due to insufficient or lack of weather limits	- Incidents due to weather criteria not being followed	Ammonia spill		DEL	2	3	M	-Identify abort criteria for an ammonia transfer operation	
2.10	Visibility (daylight, fog, etc.)	Navigational accident (e.g. grounding, collision or contact) due to lack of visibility	Visibility may hinder navigation	- Ship damage - Operational restrictions or delays	-Permanent full-scale Navigational watch	DEL	2	3	M	-Visibility to be addressed each Vessels SMS and procedures	
2.11	Electrical storms (thunderstorms)	Electrical storms (thunderstorms) may affect cargo transfer operation	Environmental hazards	- Ammonia spill (fire/explosion) - Operational restrictions - Operational delays		DEL	2	3	M	-Identify abort criteria for an ammonia transfer operation	
2.12	Waves	Wave from passing traffic	Passing traffic nearby the anchorage point	- May cause excessive strain on the transfer hoses.		DEL	2	3	M	-Identify abort criteria for wave height generated by passing traffic for the ammonia transfer operation	
2.13	Other environmental hazards (cold fronts, hurricanes, tsunamis, etc.)	Frequent changes in the wind (speed, direction)	Environmental hazards	- Ammonia spill (fire/explosion) - Operational restrictions - Operational delays	-No hurricane, tsunami, or cold fonts	DEL	2	3	M	-Consider the risk of wind gusts for the site location and definition of associated abort criteria. Include vessels' SMS and procedures. -Consider stand-by tugs nearby	
3. Navigational hazards in the vicinity of the location											
3.1	Fairway to STS location: - Sufficient water depth and width - Aton sufficient - Critical waypoints or depths - Squat effects	Navigational accident (e.g. grounding, collision or contact) due to narrow waters	Human error	- Experience has shown that the double bottom structure of The Ammonia carrier can accept severe grounding damage without affecting the integrity of the cargo containment system (however, double- the bottom is not required with a C-type Ammonia tank)		SAFE	3	4	M	- During the FEED phase, address required space for manourvering, turning, etc., given multiple (simultaneous) operations in the area	
3.2	STS location / Space for manourvering in port/ terminal - Turning circles - Operational water zones Critical depths or coastal areas, rocks	- Ship grounding, collision or contact accident due to lack of manourvering space	Human error			SAFE	3	4	M	-As per hazard ID 3.1	
3.3	Mooring at location	Mooring LAC	- Technical Error - Human error	- Insufficient mooring - Contact damage between ships -Drift away	- Fenders - Established guidelines (STS transfer guide for petroleum SIGTTO) to be followed	SAFE	2	3	M	- As per Operations' risk hazard ID 1.2	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
3.4	Mooring at location	Mooring ABV	- Technical Error - Human error	- Insufficient mooring - Contact damage between ships -Drift away	- Fenders - Established guidelines (STS transfer guide for petroleum SIGTTO) to be followed	SAFE	2	3	M	- As per Operations' risk hazard ID 1.2	
3.5	Emergency unmooring	Unable to unmoor	- Technical Error - Human error	-Asset damage/ loss -Injuries/ fatalities		SAFE	2	3	M	- Consider measures to initiate unmooring if mooring systems become unavailable (Suggestion: quick release of axe)	
4. Ship traffic density in the vicinity of the location, including the presence of other STS activities											
4.1	Close vicinity/nearby traffic lanes Traffic amount and composition	- Collision with ships in the area (passing, crossing, head-on, overtaking, being rammed while STS, etc.)	Technical or human error	- Impact with larger ships will cause increased impact energies and damage potential		SAFE	3	4	M	-Assess the risk of ship collision for the STS location; establish the required Safety Zone - Ensure appropriate communication to the traffic in the area (VTS, NavCharts, Radio, NavWarning etc.)	
4.2	Fishing activities and pleasure crafts interfering with the STS operation	Fishing activities and pleasure crafts interfering with the STS operation	Intentional or lack of awareness of safety zone			SAFE	2	3	M	- As per hazard ID 4.1	
4.3	Distance to other STS locations in the vicinity (SIMOPS)	- Simultaneous operations should be detailed in 'Operations risk assessment.'				SAFE	2	3	M	- Investigate the QRA potential overlap and escalation risk due to SIMOPS at multiple anchorage points.	
5. Spill and dispersion trajectories and potential impacts											
5.1	Terminals or facilities nearby	Toxic vapour cloud that travels downwind towards the terminal or other operations nearby	Accidental release of Ammonia	Toxic hazard Potential for ignition somewhere within the terminal		SAFE	2	3	M	- Multiple anchorage points - the risk of escalation to be covered by the QRA	
5.2	Terminals or facilities nearby	Fire/explosion or emergency situation at the terminal or other operation areas nearby	-Flammable cargo handling activities -Bunkering operation/vessel represents an additional source of ignition	Potential for escalation to bunkering operation		SAFE	2	3	M	See Hazard ID 5.1	
5.3	Populated areas/private ship traffic	- Potential Ammonia spill may reach shorelines, with population, sensitive areas, etc.	Technical/human error	Toxic hazard	- No populated area in the vicinity	SAFE	2	3	M	- Look into applicable regulations/restrictions for 3rd party (private) ships crossing the Raffles Reserved Anchorage area.	
6. Requirement for and availability of any additional spill response resources at the location											
6.1	Toxic emergency/ response services and units	- Lack of toxic emergency units nearby may cause incidents to escalate	- Lack of emergency units	Escalation of events		SAFE	1	4	M	- Review existing ERP activities for ammonia spill application. - Investigate the required capacity of emergency/support tugs and firefighting tugs to mitigate toxic gas dispersion. To be discussed with local authority on applicable requirements.	

ID	Guideword(s)	Hazard/ hazardous event	Cause	Consequence	Safety Measures	T	P	C	R	Recommendations	Notes
6.2	Towing/tug emergency	- Lack of towing emergency units nearby may cause incidents to escalate	- Lack of emergency units	Escalation of events		SAFE	1	4	M	-As per hazard ID 6.1	
6.3	Marine Pollution	- Breach of bunker/ammonia release due to collision	Collision Impact	Ammonia spill into the water	- Ammonia internal transfer between tanks reviews damage control. - Listing and DE ballasting	SAFE	1	4	M	- Perform environmental risk assessment due to ammonia spill caused by a ship collision	
7. Other											
7.1	Shore logistical daily support (tugs, support crafts, etc.)	Lack of shore logistical daily support (tugs, support crafts, etc.)	- Lack of logistical support may affect operations (safety, delays etc.)	- Operational delays	-Shore support required for operations is identified and arranged before vessels arrive at the STS location	SAFE	2	3	M		
7.2	STS Superintendents subcontracted	Lack of experience and competence	- Lack of training and competence (qualification of personnel)	Ammonia spill (toxic hazard)		SAFE	1	4	M	-As per Operations' risk hazard ID 4.12	
7.3	Security threats in the area	Security threats	- War, sabotage, and terrorism risks	Ammonia spill (toxic hazard)							-Not Applicable
7.4	Radio/Tele-communication coverage	Lack of radio/ telecommunication coverage	- Lack of tele-communication capacity	Ammonia spill (toxic hazard)							-Not Applicable
7.5	Time	The time window for operation and slot requirements	Multiple activities at the terminal	Stress and potential human failures	-Established operations schemes	SAFE	2	3	M		