Appendix 3

Safety Risk HAZID Workshop

Abbreviations

BLEVE	Boiling Liquid Expanding Vapor Explosion
BOG	Boil Off Gas
DOI	Declaration of Intent
DNV	Det Norske Veritas
ESD	Emergency Shut Down
HAZID	Hazard Identification (workshop)
HC	Hydrocarbon
LNG	Liquefied Natural Gas
MES	Marine Evacuation System
PKP	Fire extinguishing agent
PMS	Preventive Maintenance System
PPE	Personal Protective Equipment
SMS	Safety Management System
USCG	United States Coast Guard
WSF	Washington State Ferries

Table of Contents *Page*

1 INTRODUCTION

DNV conducted a safety risk assessment, with stakeholder input, of the LNG-fueled passenger ferry vessels and terminals. As part of the safety risk assessment, a vessel and terminal safety HAZID workshop was held in Seattle on February 14, 2013 with local maritime experts. The purpose of the workshop was to identify local hazards related to the LNG-fuelled passenger ferry vessels and bunkering at the terminals and to assess how the hazards could influence risk.

The vessel and terminal safety HAZID workshop used a systematic approach to identify hazards and assess the associated risk. Existing safeguards and barriers were identified as well as needs for risk reducing measures.

Output of the vessel and terminal safety HAZID was used to establish relevant probability values for accidental incidents along the sailing route and at the terminal (an input to navigational risk modeling). The HAZID output is also useful for development of the first draft of an Operations Manual.

2 HAZID WORKSHOP

A Hazard Identification Study (HAZID) uses a systematic process to identify hazards in order to plan for, avoid, or mitigate their impacts. Hazard identification is an important step in risk assessment and risk management.

The vessel and terminal safety HAZID workshop was a key early step and provided risk assessors important local knowledge about hazards related to the LNG system in the ferries - hazards related to terminal operations and hazards related to bunkering.

2.1 Scope

The following incident types where considered during the workshop:

- LNG truck trailer approach
- Bunkering operations
  - Pre-cooling
  - Purging
  - Filling
  - Inerting
- LNG-fueled passenger ferry operations
  - Fires
  - LNG leaks
  - LNG venting
- Out of service / dry dock

The main safety issues examined were:

- LNG leakage and spills
- Rapid phase transition
- Incorrect operation
- Pressure build-up
- Communication
- Control and automation systems
- Natural gas emissions to air

2.2 Participants

A HAZID participant group was assembled of 32 local experts who were knowledgeable about the study area. Members of the team had experience in piloting, escorting, and conning vessels within WSF's ferry network and working on marine projects in the Seattle and coastal areas. The participants' experience covered a wide range of maritime background and detailed knowledge about the area. The participant group was appropriate to assess the hazards involved in navigation in the area.

Table 2-1 List of Vessel and Terminal Safety HAZID Participants

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2.3 Guidewords

The following guidewords were used to aid in the identification of hazards:

- Fire or explosion
  - in machinery spaces
  - in other areas
- Mechanical hazards
- Electrical hazards
- Thermal hazards
- Hazards generated by malfunctions
- Other hazards generated by materials and substances
- Hazards generated by erroneous human intervention
- Collisions
- Dropped objects
- Grounding
- Foundering
- Environmental hazards
- Pollution
- Occupational accidents
- Hazards generated by neglecting ergonomic principles

2.4 Photographs of a Bunkering Operation

For purposes of setting a common understanding, the following photographs were shared during the workshop. The bunkering operations shown in the pictures were conducted in Norway.

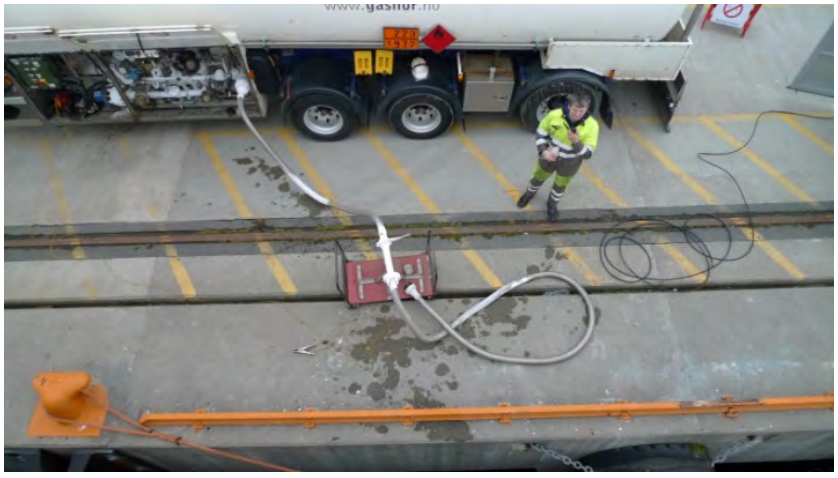

Figure 2-1 Supervision of bunkering

Figure 2-2 View of truck manifold and transfer hose during bunkering

Figure 2-3 Connection of bunkering hose to vessel inlet manifold

Figure 2-4 Supervision of LNG fuel transfer

Figure 2-5 View of exhaust stack and vent mast

3 HAZID FINDINGS

The HAZID was organized by LNG bunkering approaches and stages. LNG ferry operations, dry docking, and type information was provided. The following was captured during the workshop:

- Hazard or Threat
- Cause
- Consequence
- Existing Safeguards and Barriers
- Risk Reducing Measures

Each item was discussed and potential hazards identified, noting any segment-specific causes.

3.1 General Findings

The following issues were raised as part of general discussions across the various stages of the operation (bunkering, ferry operations and out of service / dry docking):

1. The largest risk from an LNG or gas release would most likely be from a spill during bunkering, due to not following procedures or from a hole in a transfer hose or piping.
2. Crew entrapment (during a fire or crew incident) on the vessel during bunkering would be a worst case scenario (blocked egress by an LNG truck trailer).
3. Ignition sources that are present during bunkering and LNG-fueled passenger ferry vessel operation need to be identified and treated during the planning phase of the ferry conversions.
4. Hazardous area zones on the ferry and in the terminals need to be defined for LNG operations.
5. Mitigating measures for fires on the vessel during operation due to electrical shorts, diesel leaks or from vehicles are currently in place.
6. During sailing, a leak in a LNG tank or gas piping will pose a potential fire and explosion hazard.
7. A LNG liquid leak around the cold box is foreseen as a credible event.
8. For the Eagle Harbor site (out of service / dry docking period) various dry dock events were discussed regarding pressure build-up in an LNG tank (venting/excess BOG), gas freeing of piping and components, hot work near proximity to gas/LNG spaces and working environment issues related to confined spaces.

3.2 HAZID Worksheets

The HAZID Worksheets below document the results and reflect the information gathered in the workshop. Information in [brackets] was added to the worksheets by comment after the workshop.

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
Transfer Operations						
1 LNG Truck Tanker Terminal Approach						
1.1	Crew entrapment on the vessel in a worst case scenario (blocked egress)	Fire Crew incident (truck blocking escape way)	[Crew injury or death]	Life rescue boats	Evaluate to have a second mean of egress or access to the ship Extra access from the other end the ship Evaluate a Marine Evacuation System (MES) to a smaller vessel	
1.2	Electrical components on the station shore and vessel side	[Equipment malfunction or improper installation]	Ignition, fire		Specify Explosion proof or intrinsically safe components De-energize the system in case of a gas leak to ensure the hazardous zone Ensure proper grounding via an isolating flange on the bunker hose.	
1.3	Operational failure	Insufficient [or improper] lighting		Cargo light on the tower	Install Intrinsically safe lighting in bunkering area Sufficient lighting on the total bunkering system, lines, vent mast on the vessel	DNV working on PHAST calculations for LNG/Gas leakage Truck area in the shadow of the cargo light
1.4	Spillage of LNG	Substantial differences in the tilt of the apron due to tide	Impact on truck and truck personnel - a high tide may cause a leak to flow down towards the truck (Bridge ramp is higher than the ship transfer apron)	Planned drip trays	Have piping or hoses cross over the bridge, making it possible for the truck to bunker away from the bridge Evaluate a drain over the side of the bridge Evaluate a water hose in the vicinity of the bunkering area Evaluate a double walled bunker hose Evaluate the effect of LNG spillage on the bridge structure	The deck covering material on the bridge is concrete. All the electronics controlling the bridge will be in close proximity to the truck and bunker station. Have not yet decided if there will be a mobile LNG transfer pump or if a pump will be integrated on the truck
1.5	Spillage of LNG	Not sufficient drip trays Wear and tear of hose.	[Ignition, fire]	Drip trays	Aluminum or stainless steel drip trays Maintenance inspection Move the bridge halfway up the span Tray is a trough/gutter protecting the deck from the bunker station to truck	Deck is concrete All the electronics controlling movement on the bridge is in close proximity to the truck and bunker station

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
1.6	Backing the truck up on the apron	Maneuvering	Hitting the bridge side/other nearby obstacles/personnel injury		Have piping or hoses across the bridge Back-up siting personnel (spotter) Back-up cameras and proximity alarms Guiding line/light for the truck	WSF to evaluate the practices for Diesel supply trucks and utilize these as an initial guideline
1.7	Proximity of unauthorized personnel	Insufficient marking of bunkering and transfer area	Safety or Security violation	[Signs posted at terminals]	Physical, temporary barriers (fences), marking and signs (area restriction)	Evaluate to have crew member standing to keep people away
1.8	External ignition source	Bad weather (lightning strike) Plane passing (mainly small aircrafts)	Ignition, fire	[Regular weather updates provided by U.S. Coast Guard and WSF Operation Center]	Notice to the FAA (Federal Aviation Authority) during refueling	DNV working on PHAST calculations for LNG/Gas leakage. Need to calculate the dispersion height in case of a gas release during bunkering.
1.9	Large LNG release	Catastrophic breach of the truck	Overflow of drip trays. Damage to the vessel deck and vehicle bridge Ignition, fire		Calculate the plume size (height) in modeling software (PHAST)	Very low probability of this event to occur
1.10	Large LNG release, fire propagation	Truck fire	Damage to material, equipment and surroundings Personnel injury and/or fatalities	[Fueling only at night and most fueling locations are away from population densities]	Install baffles or other measures on the vehicle bridge with the purpose of directing the LNG away from the ship on case of a large spill and a potential fire. The purpose being to ensure that the LNG or fire of the truck does not damage the bridge or the vessel. Ensure notification of local fire departments and U.S. Coast Guard advanced notification center prior to truck transfers Ensure possible means of notification are incorporated into future procedures	The closest fire department (manned) is anything between 1 miles to 4 miles away from the planned bunkering stations
1.12	Wrong/insufficient maintenance of external pump	Pump not integrated on the truck or ship - responsibility not clearly defined	Dysfunctional pump	[Regular preventive maintenance performed]	Clearly specified maintenance procedures and responsibility Validate the concepts of operations in prior to initiating them	

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
2 Preparations						
2.1	Human error during bunkering operations	Lack of clear procedural interface between gas vendor, ship personnel and fire department. Crew change Lack of training or repetitive training	Mis-operation	[Thorough and detailed bunkering procedures]	Have joint written and agreed upon bunkering procedures with chosen vendor and fire department Joint training and common drills Share written procedures and emergency manual with fire department Separate bunkering and crew change operations (Don't allow crew change, vendors, non-essential personal within the identified safety zone) Ensure check lists, communication in place	
2.2	Mal-functioning or mal-operation of fire fighting equipment	Fire fighting equipment and sprinkler system not checked			Incorporate maintenance of firefighting equipment into PMS	
2.4	Lack of proper PPE	Insufficient availability			Training and development of processes and procedures for implementation Incorporate into pre-bunkering check-list	
2.6	Human fatigue	Night time operations	Mis-operation		Have designated fueling crew for all bunkering operations Perform bunkering operations during daylight hours if possible	
2.7	Improper or lack of repetitive training	Lack of funds, insufficient personnel, lack of training facilities	May incur cost for additional duties and training		Incorporate crew training practices and frequency of training into company practices	
2.8	Insufficient power to the fire system pump	Black out, engines not operable/available			Redundant power by generator	
2.9	Misunderstanding, miscommunication, mis-operation				Common terminology and technical language	
2.10	Lack of clear authority for when a bunkering operation should be terminated				Establish a pre-bunkering brief, check list and chart of authority	
2.11	No/limited access to international connection for firefighting equipment				Evaluate additional shore connection point on shore terminal	

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
2.12	Lack of safe and functioning communication channels			Engine room has intrinsically safe communication equipment	Back-up communication system that are intrinsically safe Having spare on board	
2.13	Lack of sufficient Nitrogen onboard for inerting operations				Detailed demand study and calculations Regular supply of Nitrogen Store back-up supply of Nitrogen bottles onshore Include check of nitrogen pressure level in the pre-bunker check-list	
2.14	Lack/ non-functional PKP system/equipment			Portable fire extinguisher	Frequent maintenance of the system incorporated into the PMS	
2.15	Vessel drift-off	Harsh weather, lack of inspection of mooring	LNG spillage		Having a crew standby during bunkering Double-up mooring lines Clearly define weather limits for bunkering Weather monitoring during the total bunkering operations and pre operations (forecast) Add tide and current limitations to the bunkering procedures (terminal dependent)	
2.16	Insufficient crew with proper qualification available to keep vessel moored or maneuver the ship away if necessary				Ensure a dedicated bunkering crew for bunkering operations See 2.15	
2.17	Unable to deploy the chemical powder firefighting system				See 2.14	
3 Signed Agreement Between Bunker Parties						
3.1	Parties signing declaration of inspection that are not familiar with the systems				Signed Declaration of inspection (DOI). See 2.6	
3.2	Impurities in the LNG received				Set up sampling procedures Vendor to provide gas sample upon delivery Establish proper communication procedures with LNG supplier on documentation of received quality and quantity prior to the bunkering operations. Include these procedures in the pre-bunkering check-list.	

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4 Hazardous Area Zone						
4.1	No clear distance established around the vessel, the pier and the bunkering truck				Need to determine gas hazardous zones for all critical areas according to industry practice	
4.2	Lack of standardisation of piers				Perform an assessment of the requirements for the piers related to LNG bunkering and incorporate changes into the route manual	
4.3	Maintain integrity of intrinsically safe equipment				Regular Maintenance in PMS	
4.4	Fire affecting the whole pier (including hydraulic system of the pier)			Lock pins holding the pier bridge stationary	Fire proofing of the pier	
4.5	Lack of access to the emergency generator rooms due to proximity of the LNG tanks due to an emergency				Evaluate location and potential of alternative location of the emergency generator	
4.6	Emergency generator can potentially represent an ignition source due to its location				Reconfigure current design wrt access and safe location of emergency generator (gas tight room, etc.)	
4.7	Consequences spreading to the community around the bunkering area	Large release of bunkering			Establish zones of concern (size of gas plume)	
4.8	LNG leakage on the transfer lines from the bunker station on the ship to the LNG tanks	LNG release			Maintain continuous inspections of the lines Gas detectors in cold box	
4.9	Valves failing within the coldbox	LNG release		Valves are auto sequenced (fail safe to close/open)	Response procedures Inspection and maintenance procedures (in PMS)	
4.10	Loss of ventilation from the engine room and the coldbox				Evaluate the need for alternate ventilation	

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
4.11	Lack of physical infrastructure to exclude unauthorized personnel or people from the Haz zone	Lack of marking, physical barriers around the haz areas			See above	
5 Initial pre-cooling of lines and equipment						
5.1	Lack of pre-cooling procedures or capabilities to pre-cool lines and equipment				Establish procedures	LNG truck tanker design not concluded yet
5.2	Pressure build-up during the pre-cooling sequence	BOG		Ensure material of hose and lines are cryogenic and pressure tested	Implement safety procedures for the specific process	
5.3	Lack of ownership of equipment				Identify and define ownership and responsibility of the specific equipment	
5.4	Damage to equipment due to lack of pre-cooling or lack of ability to ramp up the flow rate in the start process				Frequency controlled pump.	
5.5	Insufficient time for pre-cooling of the process				Ensure the pre-cooling schedule is adapted to bunkering timeline	Pre-cooling schedule will be included in the total bunkering process
6 Grounding and connection of bunker hose						
6.1	Ground fault arcing - unclear ground practices				Provide isolated flanges on LNG pipe connection	
6.3	Incomplete hose connection (not sufficiently tightened)				Include system double check of connection points in bunkering procedure Provide dry break away/quick connection couplings for the bunker hose which are easy to connect/dis-connect and limit spills.	
6.4	Incompatibility between the truck and vessel connections	Lack of proper standards			Clear and standardized connections (e.g. according to ISO guidelines)	Evaluate to have connection pieces for different hose types
6.5	Lack of maintenance procedures and life cycle requirements	Wear and tear of hose, lack of inspection and pressure testing	Hose rupture		Incorporate regulators requirements into procedures	

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
6.6	People using unauthorized tools in the hazardous zones		Introduction of new ignition sources		Intrinsically safe tools and equipment to be applied under all operations inside the hazardous zone Evaluate color coded tools and marking of equipment	
6.7	Mix-up of filling lines				Check-list to ensure no mix-up of vapor return and filling lines Evaluate color coded tools and marking of equipment	
7 Inerting of Filling Lines						
7.1	Insufficient Nitrogen onboard for inerting				Nitrogen pressure gauge check Nitrogen bottles are replaced by a specialized provider	
7.2	Insufficient time for inerting	Moisture	Moist residuals in the lines		Establish appropriate time spans for inerting Performance testing	
7.3	Insufficient supply of Nitrogen to chemical powder system			Have separate Nitrogen system	Have spare Nitrogen batteries available onboard Nitrogen pressure gauge check Nitrogen bottles are replaced by a specialized provider	
8 Purging the Filling Lines						
8.1	Sequence of purging the filling lines is unclear				Establish appropriate procedures	
8.2	Unclear use of vapor return line				Establish appropriate procedures	For information: Teekay requires a vapor return line for their supply system due to the placement of the LNG tanks on top of vessel (don’t have enough pressure on the truck to work against the static head)
9 Filling Sequence						
9.1	Heat in the liquid transfer line			Introduce a small amount of LNG in addition to the purging	Establish appropriate procedures	
9.2	Overfilling of the tank				Testing protocol and pre transfer check of equipment and alarms	
9.3	Filling the wrong tank				See above for coding of equipment	

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
9.4	Running the LNG tank empty				Establish procedures	Cross-connection of the tanks is possible
9.5	Valve leakage in the cold box				Monitoring, maintenance and inspection procedures	
9.6	Leakage during filling				Monitoring, maintenance and inspection procedures Sufficient drip trays and drain	
9.8	Unintentional closing of the valves				Maintenance and inspection procedures	
9.9	Hose rupture	Pinching of the hose Wear and tear			Maintenance and inspection procedures Manufacture appropriate guards for protection of the hose	
9.10	Communication failure				See above bunkering procedures	
9.11	Failure of the automatic control system				Redundancy, ESD	
9.12	Hold-up/interruption of the filling				Evaluate effect on the system and establish proper procedures for ramping the bunkering	
9.13	Freezing/inoperable valves				Do a valve check in prior to the bunkering	
9.15	Over pressurization of the LNG tank	Failure of the safety valves			Maintenance of the safety valves Provide an alarm for failure of the safety valves	
9.16	Mal-functioning of the liquid level gauge				Maintenance Failure notification Redundant gauges Provide ultrasound gauging	

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
9.17	Ship board power failure			Uninterrupted Power Supply (UPS) Independant ESD system Emergency generator support	Regular periodic testing of the UPS and ESD	Normally the vessel is on shore power
9.18	Improper calibration of measuring and detection equipment	Wrong reading/signals	Equipment or operation failure		Proper calibration procedures according to vendor recommendation	
9.19	Truck fire and BLEVE				Immediate notification to local firefighting Emergency evacuation of the vessel	
9.20	Fire in terminal building				Immediate notification to local firefighting Emergency evacuation of the vessel	
9.21	Fire in dolphins				Immediate notification to local firefighting Emergency evacuation of the vessel	
9.22	Fire in the galley			Engage firefighting systems in the galley Engagement of the fire screen doors and ventilation shut down for passenger spaces	Immediate notification to local firefighting Notify the USCG Emergency evacuation of the vessel	No passengers or crew in the galley during bunkering
9.23	Damage to steel wires (mooring)	Bunker hose contact with the mooring lines, apron is laying on the wires	Crew injury from handling		Use stainless wires, rubber mat protection of mooring lines	
10 Stripping the Liquid Line						
10.1	Traces of LNG left in the filling lines	Lack of sufficient time for pressure build-up and LNG stripping back into the tanks			Establish procedures for stripping	

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
10.2	Rain out of LNG upon venting of the lines	Trapped LNG in the lines	Rain out on deck, potential for structural damage and personnel injury		Ensure that design of vent mast has an outlet directing the flow away from the vessel	
11 Inerting the Transfer Lines						
11.1	Unable to inert the gas transfer lines				See above for N_2 supply	
12 Disconnecting and Ready for Operations						
12.1	Gas release	Trapped gas in the lines / insufficient inerting	Ignition, explosion, fire		Establish sufficient time for purging	
12.2	LNG traces in the bunker hose		Personnel injury due to exposure		Establish sufficient time for purging	
13 LNG Fueled Ferry Operation (Sailing)						
13.1	Fire on the ship during operation				See fire above Include reference to what HAZARD	
13.2	Fire in cars or gasoline tanks during sailing			Fire sprinklers and system on all the car decks	See fire above Include reference to what HAZARD	Gasoline and electric cars
13.3	Unclear procedures in the event of a leakage in the system				Establish appropriate procedures	
13.4	Smoking				Establish appropriate smoking policies Mark non-smoking areas	
13.5	LNG liquid leak in the cold box				Drip trays and ventilation Evaluate considerations for shut down of operations Maintenance of gas detectors Evaluate effect of down time and costs	
13.6	Gas release in passenger spaces or ventilation system				Isolation, casing and double barriers	Very low probability

ID	HAZARD OR CRITICAL ISSUE	CAUSE	POSSIBLE CONSEQUENCE	EXISTING SAFEGUARDS AND BARRIERS	RISK REDUCING MEASURES OR PROCEDURES	COMMENTS
13.7	LNG tank loosening	Fatigue in tank supports or structure failure			Proper design according to international/class code	
13.8	Unauthorized entering of the tank and coldbox area				Restricted access areas around the tank and coldbox	
13.9	Black out and potential loss of propulsion		Loss of gas supply to the engine		See above emergency generators	
14 Out of Service / Dry Dock						
14.1	Gas freeing of the total system	Dry dock requirements	Need to be towed from the site of gas freeing to the dry dock site		Establish procedures and practices for gas freeing Determine requirements for ship yards	Recertification of the LNG tanks before dry dock leave
14.2	Long term lay-up	Casualty repair	Pressure build-up in the LNG tank, excess BOG		Establish procedures and practices for gas freeing upon a lay-up. Define upper limits of operating parameters for gas freeing.	
14.3	Gas freeing of a portion of the system	Maintenance and hot work on parts of the system			Establish procedures and practices for gas freeing for parts of the system Evaluate if there are differences in requirements for the different parts of the system	
14.4	Hot work in near proximity to gas/LNG spaces	Maintenance, sand blasting, welding			Establish procedures and practices for gas freeing Determine requirements for ship yards	
14.5	Unidentified confined spaces	Space limitation	Unable to evacuate people from confined spaces		Define and evaluate confined spaces	

4 HAZID CONCLUSIONS

The key observations from the Vessel and Terminal Safety HAZID are as follows:

1. The largest risk for an LNG or gas release would be a spillage during a bunkering operation due to failure to follow procedures or because of a leaking transfer hose or piping. Development of bunkering procedures and extensive personnel training is necessary to mitigate these types of events. Involvement and training of local emergency response teams would be of high importance.
2. LNG liquid leaks during bunkering are foreseen as a credible event and can pose damage to structures and create a fire hazard. Well known design measures from other industry applications exist to safeguard and mitigate potential escalation. Education and training of local emergency response teams would be of outmost importance in order to deal with various LNG scenarios.
3. During bunkering, crew entrapment poses a serious threat, and a review of alternate or secondary means of egress and access should be evaluated. WSF needs to determine the minimum number of personnel required, and limit the number of employees performing a fueling operation.
4. Hazardous areas and zones will need to be identified to clearly understand areas of concern with respect to ignition sources and impact to off-site personnel.
5. LNG/gas fires pose a new threat to WSF and updated fire suppression systems will need to be designed to cater for this threat. International rules and regulations for these types of systems exist and are in continuous development.
6. WSF will need to establish appropriate procedures to deal with leaks from a LNG tank or gas piping. Proper operational inspection, maintenance and suppression procedures will have to be developed. Even though smoking is not allowed on the WSF network, it was suggested to revisit current smoking policies and mark clearly all non-smoking areas.
7. For any dry docking activity, WSF will need to investigate and establish requirements and procedures on how to deal with various dry dock events such as pressure build-up in the LNG tank (venting/excess BOG), gas freeing of piping and components, hot work near proximity to gas/LNG spaces and working environment issues related to confined spaces.
8. The Masters and Mates usually sail on one given route on all rotations and special crew with knowledge of all routes are at hand if needed. This reduces the risk of errors due to lack of local knowledge. In addition, Masters and Mates are required to be familiar with the routes and equipment through experience and training before being assigned Master or Mate duties.

Det Norske Veritas:

DNV is a global provider of knowledge for managing risk. Today, safe and responsible business conduct is both a license to operate and a competitive advantage. Our core competence is to identify, assess, and advise on risk management, and so turn risks into rewards for our customers. From our leading position in certification, classification, verification, and training, we develop and apply standards and best practices. This helps our customers to safely and responsibly improve their business performance.

Our technology expertise, industry knowledge, and risk management approach, has been used to successfully manage numerous high-profile projects around the world.

DNV is an independent organisation with dedicated risk professionals in more than 100 countries. Our purpose is to safeguard life, property and the environment. DNV serves a range of industries, with a special focus on the maritime and energy sectors. Since 1864, DNV has balanced the needs of business and society based on our independence and integrity. Today, we have a global presence with a network of 300 offices in 100 countries, with headquarters in Oslo, Norway.

Global impact for a safe and sustainable future: