Best Practices

Liquefied Natural Gas (LNG) Bunkering

July 2025

IRCLASS
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Liquefied Natural Gas (LNG) Bunkering
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Contents

Introduction

With the advent of Liquefied Natural Gas (LNG) as fuel, the number of LNG fuelled vessels in service has risen. There are challenges in operating vessels fuelled with LNG as LNG is stored at cryogenic temperatures (-163ºC) and its vapour has wide flammability limits. This presents challenges and hazards not limited to ship design, construction and operation but also with respect to specific operations such as bunkering.

Classification Society Rules are focused on the design, construction, testing and surveys of ship and herequipment. Therefore, it may be well acknowledged that Bunkering Operations of LNG ashore do not fall under the ambit of Classification matters, other than to ships involved in the bunkering operations.

This document has been developed to provide practical insights for performing the bunkering operations of LNG while maintaining an acceptable level of safety.

Additionally, it may be noted that compliance may be required with applicable statutory and legal requirements of the local area within which the LNG bunkering operations are envisaged to be performed. Stakeholders are therefore advised to consult local authorities prior planning such operations.

It may be noted that these best practices may not be exhaustive and are to be updated periodically as necessary and as experience is continually gained.

Section 1

Application

1.1 Introduction and General

1.1.1 This document provides recommendations for the responsibilities, procedures and equipment required for LNG bunkering operations and provide harmonized minimum baseline recommendations for bunkering risk assessment (Section 6 and Annex A), equipment and operations.

1.1.2 This document does not consider commercial aspects of the bunker transfer such as measurement of quantity or quality of LNG.

1.1.3 Mobile facilities such as road tankers, rail tank cars and portable tanks, piping, hoses, pumps and valves should be constructed and conform to applicable standard recognized by national and/or regional standard bodies, for handling LNG.

1.1.4 All components of the LNG transfer system are to be constructed to meet or exceed requirements as specified in the IGC/ IGF Code.

1.2 Purpose

1.2.1 The purpose of these Best Practices is mainly to define and cover the additional risks associated with bunkering LNG and to propose a methodology to deal with those additional risks in order to provide a similar level of safety as is achieved for traditional oil fuel bunkering operations.

1.2.2 This document is intended to complement the requirements of the existing applicable guidelines and regulations, such as port and terminal checklists, operator's procedures, industry guidelines and local regulations. This document aims to cover the following items:

.1 The responsibility of different parties involved in the LNG transfer
.2 The LNG bunkering process
.3 SIMOPS
.4 Safety distances
.5 QRA and HAZID

1.3 LNG Properties

1.3.1 The key properties of LNG are summarized as shown below:

Item	**Value (typical)**
Chemical Formula	CH_4
Boiling Point at atmospheric pressure	-163°C
Density (at boiling point at atmospheric pressure)	425 – 470 kg/m^3
Critical Temperature	-82.6°C
Critical Pressure	4.59 MPa
Lower Heating Value	45 MJ/kg
Autoignition Temperature (Methane)	540°C
Methane Number	>80

1.4 LNG Bunkering Process and Best Practices Structure

1.4.1 LNG bunkering is the process of transferring LNG fuel to a ship from a bunkering facility.

1.4.2 The sequence for a bunkering operation carried out between two parties for the first time is described in Figure 1.4.2; the cross-references indicate the applicable sections of this document.

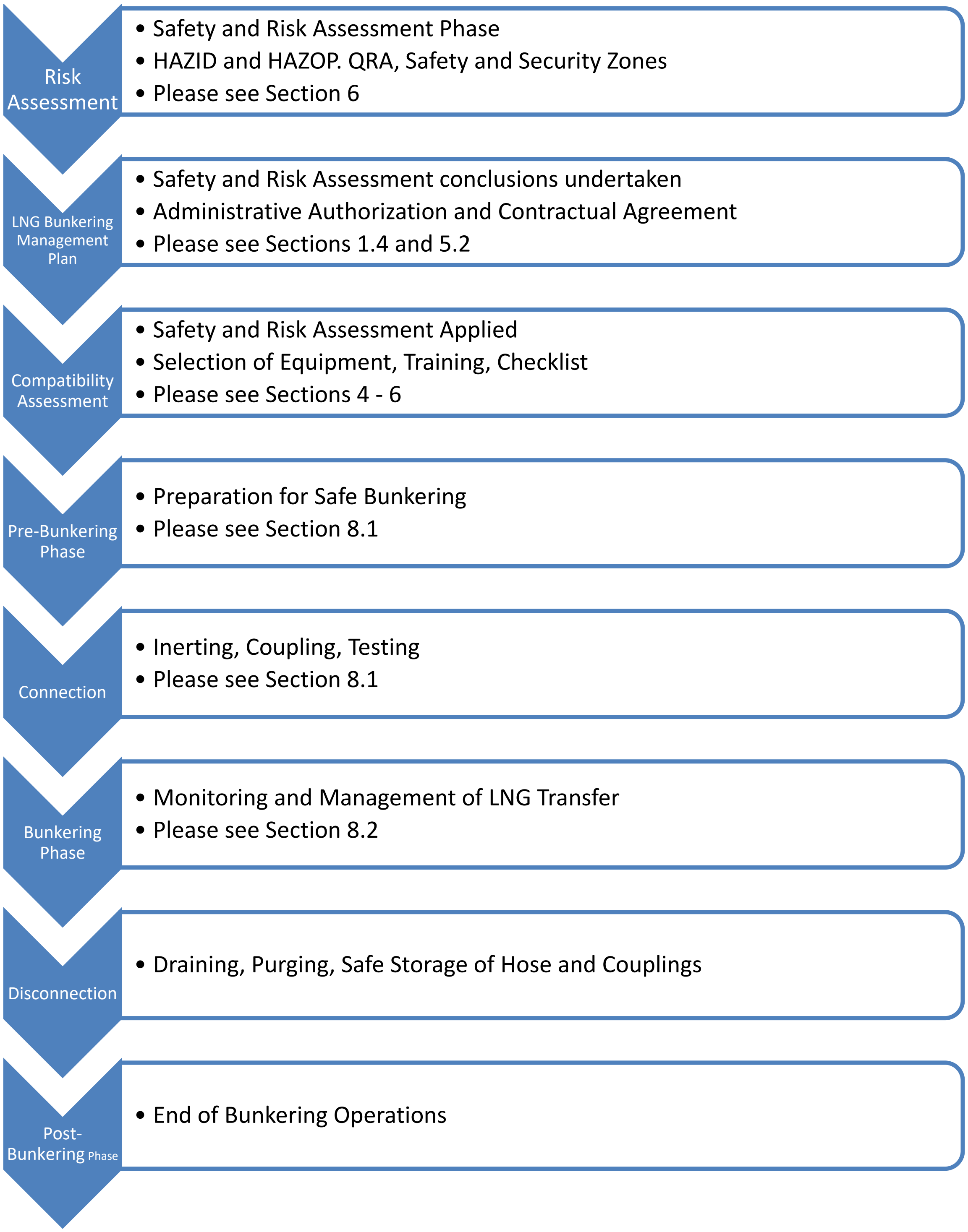

Figure 1.4.2: Activities involved in Bunkering Operation

1.5 LNG Bunker Management Plan (LBMP)

1.5.1 An LNG bunker management plan should be established in order for the parties involved to agree technically and commercially on methodology, flow rate, temperature, pressure of the delivery of LNG and receiving tank. This plan gathers together all the information, certificates, procedures, and checklist(s) necessary for an effective and safe LNG Bunkering operation.

1.5.2 The LNG Bunker Management Plan should be referenced as part of the safety management system of the RSO.

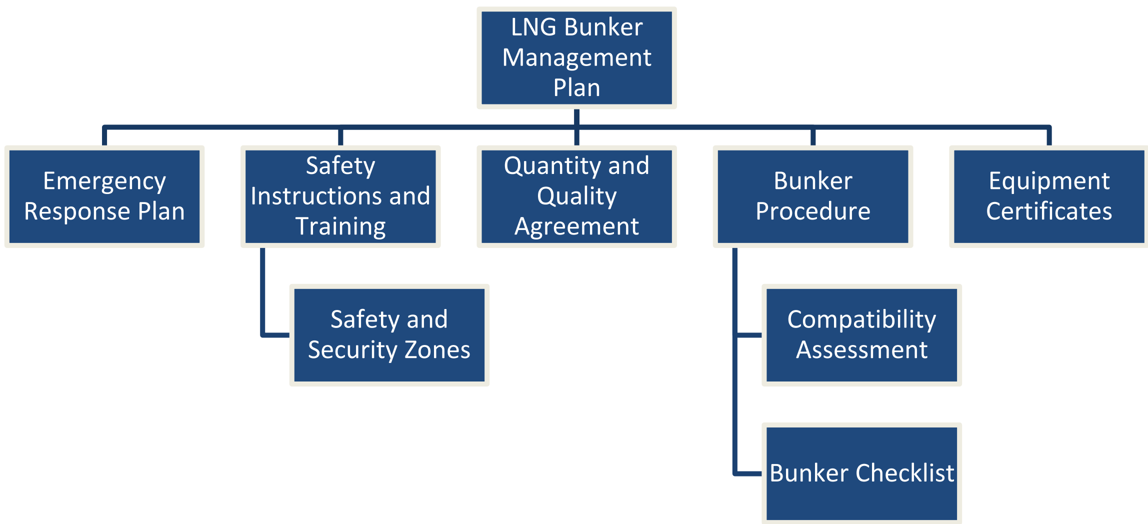

Figure 1.5.2: LNG Bunker Management Plan

Section 2

Definitions, Applicable Standards and Rules

2.1 Terms and Definitions

2.1.1 Types A or B or Membrane Tanks

Types A or B or Membrane tanks are as defined in:

- IGC Code, regulations 4.21, 4.22 and 4.24; and
- IGF Code, regulations 6.4.15.1, 6.4.15.2 and 6.4.15.4

2.1.2 Bunkering Facility Organization (BFO)

This is the organization in charge of the operation of the bunkering facility.

2.1.3 Breakaway Coupling (BRC) and Emergency Release Coupling (ERC)

A BRC or ERC is a safety coupling located in the LNG transfer system (at one end of the transfer system, either the receiving ship end or the bunkering facility end, or in the middle of the transfer system), which separates at a predetermined section at a determined break-load or relative separation distance, each separated section containing a self-closing shut-off valve, which seals automatically.

BRC activation is by breaking of shear pins/studs, requiring higher force. BRC has limited control over disconnection and is generally used in hose-to-hose connections for protecting against accidental pull-aways. Whereas, ERC activation is by collar release mechanism by cable, hydraulics etc., requiring potentially less force with controlled release for tow-away protection on loading arms. In essence, both types of couplings offer safety and spill prevention.

2.1.4 Bunkering facility

A bunkering facility is normally composed of an LNG storage and a LNG transfer installation. A bunkering facility may be (a stationary shore-based installation or a mobile facility, i.e. a LNG bunker ship or barge or a tank truck).

A bunkering facility may be designed with a vapour return line and associated equipment to manage the returned vapour.

2.1.5 Dry disconnect

This applies when the transfer system between two vessels or a vessel and a port facility is disconnected as part of normal operations. The objective is that no LNG or LNG Vapour should be released into the atmosphere. If this objective cannot be achieved, the amount released can be reduced to negligible amounts consistent with safety. Dry disconnect can be achieved by:

- Draining and inerting process before the disconnection; or
- Use of dry connect / disconnect coupling.

2.1.6 Emergency Shut-Down (ESD)

These are systems installed as part of the LNG transfer system that are designed to stop the flow of LNG and or prevent damage to the transfer system in an emergency. The ESD may consist of two parts, they are:

- ESD - stage 1, is a system that shuts the LNG transfer process down in a controlled manner when it receives inputs from one or more of the following: transfer personnel, high- or low-level

LNG tank pressure alarms, cables or other means designed to detect excessive movement between transfer vessels or vessel and an LNG bunkering facility, or other alarms.

- ESD - stage 2, is a system that activates decoupling of the transfer system between the transfer vessels or between a vessel and an LNG bunkering facility. The decoupling mechanism contains quick acting valves designed to contain the contents of the LNG transfer line (dry break) during decoupling.

2.1.7 Emergency Release Coupling (ERC)

The ERC is normally linked to the ESD system where this may be referred to as ESD2 as per SIGTTO *"ESD arrangements and linked ship/shore systems for liquefied gas carriers"*. An emergency release coupling is activated:

- By excessive forces applied to the predetermined section, or
- By manual or automated control, in case of emergency.

2.1.8 Emergency Release System (ERS)

A system that provides a positive means of quick release of the transfer system and safe isolation of receiving vessel from the supply source. This system includes the BRC or ERC.

2.1.9 Flash Gas

LNG vapour instantly generated during fuel transfer due to the warmer temperature of the receiving ship tanks, sudden pressure drop or friction.

2.1.10 HAZOP

A structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment or prevent efficient operation. A HAZOP is a qualitative technique based on guidewords and is carried out by a multi-disciplinary team of experts during a set of meetings.

2.1.11 HAZID
Hazard identification exercise, There are a number of recognized methods for the formal identification of hazards. For example: a brainstorming exercise using checklists where the potential hazards in an operation are identified and gathered in a risk register. These hazards will then be assessed and managed as required.

2.1.12 Hazardous zones

Bunkering-related hazardous zone means any hazardous area zone 1 or zone 2 defined for:

- Bunkering Receiving Ship in accordance with IGF Code, regulation 12.5
- Bunkering Ship in accordance with IGC Code, regulation 1.2.24 and where gas may be present as a result of the bunkering operation; and;
- Bunkering Shore facility or truck in accordance with IEC 60079-10-1

2.1.13 IAPH
International Association of Ports and Harbours

2.1.14 IGC Code
International Code of Safety for Construction and Equipment of Ships carrying Liquefied Gases in Bulk.

2.1.15 IGF Code
International Code of Safety for Ships using Gases or other Low-Flashpoint Fuels. IGF Code refers to Resolution MSC.391(95) as amended.

2.1.16 LNG Bunkering
The process of transferring LNG to be used as fuel on board the receiving ship

2.1.17 Vapour Return Line
A vapour return line is a connection between the bunkering facility and the receiving ship to allow excess vapour generated during the bunkering operation to be returned to the bunkering facility and remove any need to vent to atmosphere. It is used to control the pressure in the receiving tank due to the liquid transfer, flash gas and boil-off gas generation

2.1.18 LNG transfer system
A system consisting of all equipment contained between the manifold used to deliver LNG bunker (and to handle LNG vapour return) and the manifold receiving the LNG (and delivering LNG vapour return) including but not limited to:

- Loading arms and supporting structures,
- LNG articulated rigid piping,
- Hoses, swivels, valves, couplings
- Emergency Release Coupling (ERC),
- Insulating flanges,
- Quick connect / disconnect couplings (QC/DC),
- Handling system and its control / monitoring system,
- Communication system,
- ESD Ship/Shore Link or Ship/Ship Link used to connect the supplying and receiving ESD systems.

It can also include the compressors or blowers intended for the Vapour Management system where provided depending on the design of the transfer system. However, liquefaction systems used to maintain pressure in the bunker vessel tanks are not to be considered as part of the LNG transfer system.

2.1.19 MARVS
Maximum Allowable Relief Valve Setting

2.1.20 MSC
Maritime Safety Committee of the IMO

2.1.21 Person in Charge (PIC)
The Person in Charge (PIC) is a person who is responsible for the overall management of the bunkering operation. The PIC may also be referred to as Person in Overall Advisory Control (POAC).

2.1.22 PPE
Personal Protective Equipment.

2.1.23 Qualitative Risk Assessment
A risk assessment method using relative measure of risk value based on ranking or separation into descriptive categories such as low, medium, high; not important, important, very important; or on a scale, for example from 1 to 10 or 1 to 5.

2.1.24 Quantitative Risk Assessment (QRA)

This is a formalized statistical risk assessment method for calculating a numerical risk level for comparison with defined regulatory risk criteria.

2.1.25 Receiving Ship (RS)

Receiving ship is the ship that receives LNG fuel.

2.1.26 Receiving Ship Operator (RSO)

The receiving ship operator (RSO) is the company responsible for the operation of the receiving ship, in particular during the bunkering operations.

2.1.27 Risk

A combination of the likelihood of an event and the consequences if the event occurs.

2.1.28 Risk matrix

A risk matrix is a tool for displaying combinations of likelihood and consequence, used as the basis for ranking of the hazards with view to their prioritization. Multiple consequence categories can be included: impact on people, assets, environment and reputation.

2.1.29 Safety zone

The safety zone is a zone around the bunkering facility, the bunkering station of the receiving ship and the LNG transfer system. The purpose of the zone is to set an area that is put in place during LNG bunkering and within which only essential authorized and qualified personnel are allowed and potential ignition sources are controlled.

2.1.30 Security zone

The Security Zone is the area around the bunkering facility and receiving ship where ship traffic and other activities are monitored (and controlled) to prevent entry and provide a 'stand-off' distance during the bunkering operation; this will be larger than the safety zone. The security zone may also be referred to as the "exclusion zone". The security zone is site dependent and is often determined by the Port Authorities.

2.1.31 SIGTTO
Society of International Gas Tanker and Terminal Operators.

2.1.32 Simultaneous Operations (SIMOPS)

Carrying out LNG bunkering operations concurrently with any other transfers between ship and shore (or between ships if ship-to-ship bunkering method is used). This includes loading or unloading cargo operations, dangerous goods loading or unloading and any kind of other goods loading or unloading (i.e. stores and provisions), passenger embarkation/disembarkation, chemical and other low flash product handling, bunkering of fuels other than LNG, and any other activity that can impact or distract from bunkering operations (e.g. cargo movements on board, heli-ops, etc.).

Special attention is to be paid to any of the above activities occurring within the bunkering safety zone as well as any on-board testing that may impact on the bunker operation.

2.1.33 STCW Code
IMO Code for Seafarers' Training, Certification and Watchkeeping.

2.1.34 Independent Type A, B, C and Membrane Tank

These tank types are defined in the IGC and IGF Codes.

2.2 Standards and Rules

1. IGC Code
2. IGF Code
3. STCW Code
4. IRS Rules and Regulations for the Construction and Classification of Steel Ships, Part 5, Chapters 4 and 35.
5. ISO 23306: 2020 – Specification of Natural Gas as Fuel for Marine Applications
6. EN 1160:1996 - General characteristics of liquefied natural gas
7. EN 1473:2021 - Design of onshore installations
8. EN 16904: 2016 - Design and testing of marine transfer systems. Design and testing of transfer arms

9. EN 1474 – 2:2020 – Design and testing of marine transfer systems. Design and testing of transfer hoses
10. EN 1474 – 3:2009 – Design and testing of marine transfer systems. Offshore transfer systems
11. EN 12308:1998 – Suitability testing of gaskets designed for flanged joints used on LNG piping
12. EN 12838:2000 – Suitability testing of LNG sampling systems
13. EN 13645:2002 – Design of onshore installations with a storage capacity between 5t and 200t
14. EN ISO 28460:2010 – Ship-to-shore interface and port operations
15. ISO 16903:2015 – Characteristics of LNG influencing design and material selection
16. ISO 18683:2021 – Guidelines for systems and installations for supply of LNG as fuel to ships
17. CSA Z276 – Standard for production, storage and handling of LNG in Canada
18. ISO 20519:2021 – Specification for bunkering of gas fuelled ships
19. ISO 21593:2019 – Ships and marine technology: Technical requirements for dry-disconnect/connect couplings for bunkering liquefied natural gas
20. CTAC – Recommendations for LNG Unmanned Barge Policy Letter
21. API RP 2003 – Protection against Ignitions arising out of Static, Lightning and Stray Currents
22. IACS Recommendation 142
23. ISO/IEC Guide – Risk Management - Vocabulary
24. ISO 31000:2018 – Risk Management - Principles and Guideline
25. ISO 31010:2019 - Risk Management - Guidelines on principles and implementation of risk management
26. ISO 16901:2022 – Guidance on performing risk assessments in the design of onshore LNG installations including the ship/shore interface
27. SGMF – FP07-01_LNG as Marine Fuel: Safety and Operational Guidelines - Bunkering
28. IEC 60079 series of standards
29. IEC 60092 – 502 - Electrical installations in ships - Tankers - Special features
30. EN ISO 80079 – 36:2016 Non electric equipment for use in potentially explosive atmospheres
31. SIGTTO - ESD arrangements and linked ship/shore systems for liquefied gas carriers
32. USCG (CG-OES) Policy Letter No. 01-15: Guidelines for Liquefied Natural Gas Fuel Transfer Operations and Training of Personnel on Vessels using Natural Gas as Fuel
33. USCG (CG-OES) Policy Letter No. 02-15: Guidelines Related to Vessels and Waterfront Facilities Conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations
34. NFPA 52 – Vehicular Gaseous Fuel Systems Code
35. NFPA 59A - Standard for the Production, Storage, and Handling of LNG
36. 49 CFR 193 - Liquefied Natural Gas Facilities: Federal Safety Standards (DOT)
37. OISD STD-245-2018 – Standards on Safety of LNG Bunkering Facilities at Ports for Large Ships, Coastal Shipping and Inland Waterways Terminal
38. OCIMF - Guidelines for the Handling, Storage, Use, Maintenance and Testing of STS Hoses (First edition May 2021)

Section 3

Bunkering Methods

3.1 Description of typical ship bunkering arrangements

3.1.1 Three methods of bunker supply are detailed in the following sections.

3.1.2 The duration of the bunkering will depend mainly on the transfer rate from the bunkering facility; different pump sizes or pressurised supply can be selected depending on the specific needs. Other parameters influencing the duration include testing procedures, flash gas handling, purging and draining method and pre- and post-bunkering procedures.

3.2 Ship to Ship LNG Bunkering

3.2.1 LNG bunker ships are a common solution when there is a significant volume of LNG to be transferred. Current fuel storage tank capacities of LNG bunker ships, in operation and under construction, are in the range of a few hundred to several thousand cubic meters. Majority of LNG fuel transfer is expected to be performed by ship to ship (STS) operations, for which the OCIMF - Guidelines for the Handling, Storage, Use, Maintenance and Testing of STS Hoses may be referred.

3.3 Truck to Ship LNG Bunkering

3.3.1 LNG bunkering operations are carried out from standardized trucks (typically about 40 cubic meter capacity). Multiple trucks may be required to bunker a single ship, depending on the required bunker volume.

3.3.2 The LNG bunkering operation duration is dependent on the transfer capacity of the truck which is relatively small. Depending on the shore side arrangement it may be possible to increase the bunker rate to some extent by simultaneous bunkering from multiple trucks via a common manifold or using a permanently installed buffer station on the quay side.

3.3.3 This LNG bunkering method is recognized to be flexible as it offers the possibility for many different ships to be bunkered in different port locations. Depending on the port arrangement it may be possible to park the trucks close to the bunker station on the receiving ship allowing short hoses to be used, this potentially reduces the heat flux into the LNG, minimizes the pressure drop and also reduces the size of a potential spill if the hose is damaged.

3.4 Terminal to Ship LNG Bunkering

3.4.1 LNG bunkering takes place from the Terminal through a rigid cryogenic pipe and flexible hose or loading arm for final connection with the ship. The LNG storage tanks should generally be as close as possible to the bunkering terminal.

3.4.2 It is expected that this type of facility will be manned such that there will be shore side personnel able to manually activate the ESD and stop the bunker transfer in case of an emergency.

3.5 Examples of Ship Bunkering Arrangements

Possible ship bunkering options are given in Table 1 below with corresponding arrangements.

Table 1: Bunkering Options and Arrangements

		Bunkering Facility				
		Type C tank			Type A or Type B or Membrane Tank	
		Bunker Ship	Tank Truck	Shore-based Facility	Bunker Ship	Shore-based facility
Receiving Ship	Type C tank	Fig. 3.5.1	Fig. 3.5.4	(*)	(*)	Fig. 3.5.5
	Type A or Type B or Membrane Tank	Fig. 3.5.2	(*)	(*)	Fig. 3.5.3	(*)
(*) This arrangement is possible but not shown. Note: For small scale bunker supply using Type C tanks, the LNG supply pressure may be generated by pump (as shown in the figures below) or by a Pressure Build Up unit.						

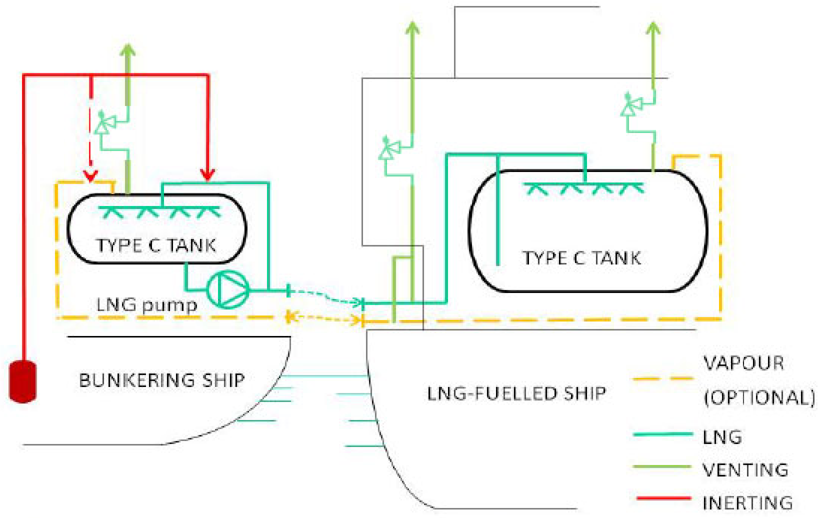

Figure 3.5.1: Ship-to-ship bunkering - typical arrangement of bunkering ship and LNG fuelled ship with type C tank

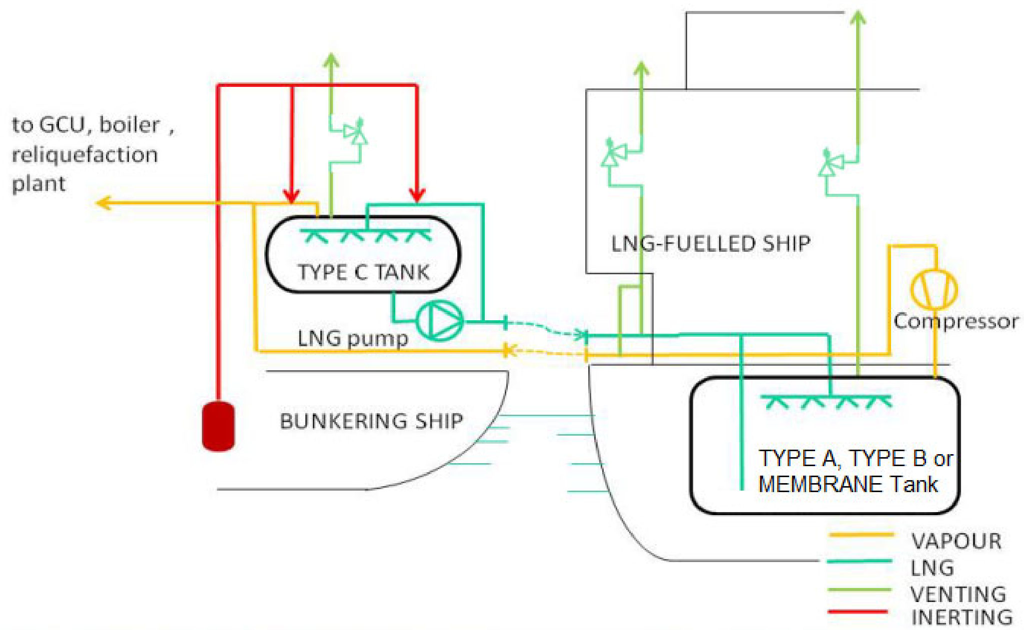

Figure 3.5.2: Ship-to-ship bunkering - typical arrangement of bunkering ship with type C tank and LNG fuelled ship with Type A or Type B or Membrane Tank

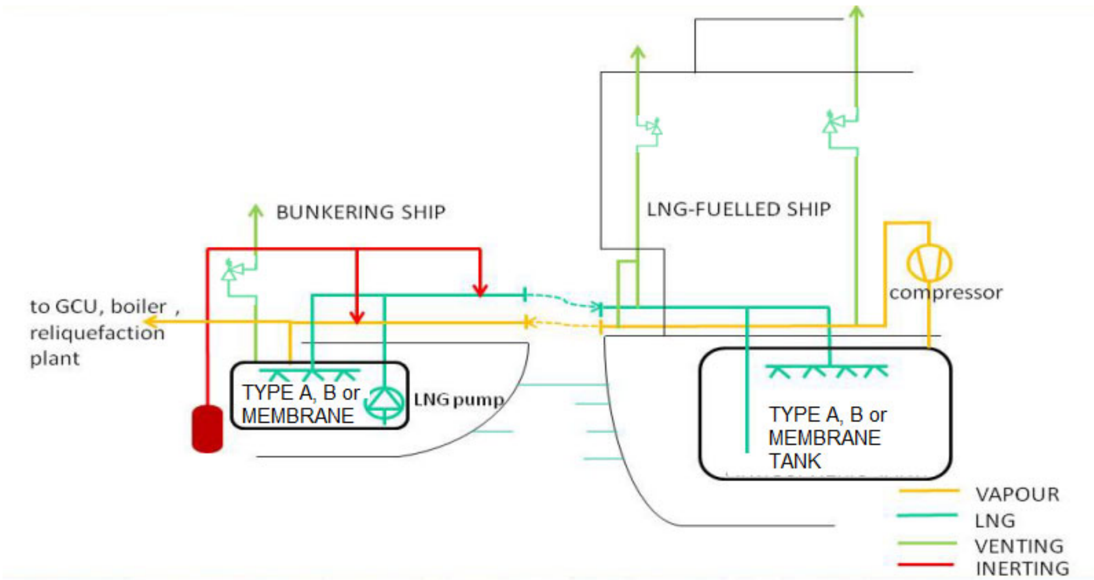

Figure 3.5.3: Ship-to-ship bunkering - typical arrangement of bunkering ship and LNG fuelled ship with Type A or Type B or Membrane Tank

Note: Compressor is optional, only necessary if free flow is not possible. Normally there is no need for a compressor if the bunker ship uses Independent Type A or Type B or Membrane tanks or uses type C tanks operated at very low pressure (using discharge pump and not PBU). It is only required in cases where there is likely to be large quantities of flash gas generated during bunkering and the pressure gradient between the bunker ship and receiving ship does not allow free flow of vapour.

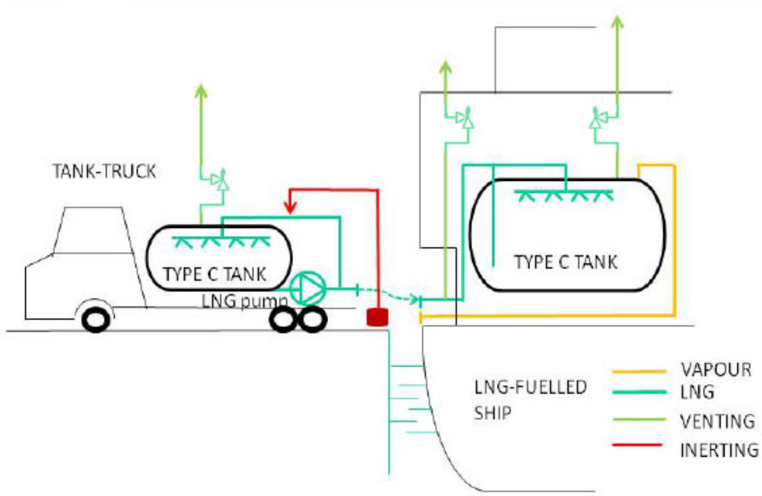

Figure 3.5.4: Truck-to-ship bunkering - typical arrangement of tank truck with type C tank and LNG fuelled ship with Type C tank

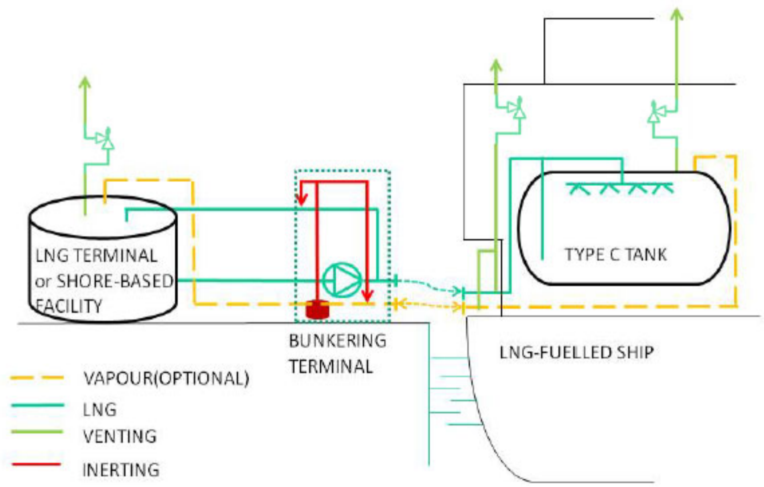

Figure 3.5.5: Terminal-to-ship bunkering - typical arrangement of Bunkering Terminal with type C tank and LNG fuelled ship with Type C tank

Section 4

Responsibilities during LNG Bunkering

4.1 Responsibilities during Planning Stage

The involvement of Port, National and/ or other jurisdictional authorities, LNG supplier and receiving ship in the planning of a bunkering operation are detailed below.

4.1.1 Port, National Authority and Flag Administration responsibilities

Decisions and requirements for LNG bunkering should be based on a risk analysis carried out in advance of each bunkering operation. The Port authority and/or national or other authority with jurisdiction should consider:

- Overall responsibility for the good governance and framework for LNG bunker operations in the port
- Applicability of an accreditation scheme for LNG bunker operators in the ports under their authority,
- Acceptability of the location of bunkering facilities, (bunkering may be limited to specific locations within the port/anchorage),
- Approval of the risk acceptance criteria,
- Restrictions on bunkering operations such as simultaneous operations,
- Shore side contingency plans, emergency response systems,
- General procedures for traffic control and restrictions,
- Whether additional requirements should be applied.

4.1.2 Receiving ship operator (RSO) and bunkering facility organisation (BFO) responsibilities

Before setting up a ship bunkering operation, the receiving ship operator (RSO) and bunkering facility organization (BFO) should perform the actions listed below

Table 2: Receiving ship operator (RSO) and bunkering facility organization (BFO) responsibilities

Sr. no	Activity	Performed by		Remarks
		BFO	RSO	
1	Review the applicable International, National and Local Regulations, Port bylaws, industry guidelines, standards, checklists, and Classification Societies Rules and Guidelines.	✓	✓	Prior to the operation.
2	Identify all documents, information, analysis, procedures, licences, accreditations, etc. required by Authorities.	✓	✓	Prior to the operation.
3	Check that the bunkering equipment is certified by the relevant Classification Society (on-board equipment) or by relevant Authorities (on-shore equipment).	✓		Prior to the operation.
4	Check that the receiving ship and the bunkering facility are compatible.	✓	✓	This action should be carried out jointly by RSO and BFO.
5	Develop a specific LNG bunkering procedure for the concerned ship and bunkering facility based on preselected LNG bunkering guideline.	✓	✓	The LNG bunkering procedure should take into account any instructions and check-lists issued by the Port. This procedure should be developed jointly by RSO and BFO

6	Perform the bunkering risk assessment (as part of an initial in-depth study).	✓	✓	Normally required by the Port Authorities and Flag authorities. Bunkering risk assessment study should involve RSO and BFO
7	Develop an emergency response plan and bunkering safety instructions.	✓	✓	This action should be carried out jointly by RSO and BFO with local authorities, fire brigade and hospital premises involvement
8	Ensure that all bunkering personnel are adequately trained.	✓	✓	
9	Develop bunkering plans and procedures reflecting the status of the facility	✓		
10	Prepare, compile and share the LNG bunkering management plan with stakeholders		✓	

In addition, the safety instructions for LNG bunkering may contain technical, RSO and BFO company-internal and operational regulations. The safety instructions should identify conditions under which bunkering will be stopped and in each case the actions required/conditions to be reinstated before the bunkering operation can be restarted.

4.1.3.2 Emergency Response Plan

An Emergency Response Plan should be prepared to address hazards, and firefighting techniques for controlling, mitigating and elimination of a gas cloud fire, jet fire and/or a LNG pool fire.

The Emergency Response Plan should cover all emergency situations identified in the LNG Bunkering Operations Risk Assessment and may designate responsibilities for local authorities, hospitals, local fire brigades, PIC, Master and selected personnel from the bunkering facility. As a minimum, the following situations should be covered where appropriate:

4.2 Responsibilities during bunkering operations

The involvement of port, national and/or other LNG supplier, receiving ship and specific individuals in the different phases of LNG bunkering are indicated below. In some situations, there may be no port authority with direct responsibility for oversight of the bunkering operation (for example when the port/terminal is owned and managed by the BFO or RSO) in those cases the responsibilities listed in 4.1.1 and 4.2.1 should be adopted by either the BFO or the RSO.

4.2.1 Port Authorities General Responsibilities

Port Authority regulations and procedures may impose requirements or criteria for:

- Accreditation of the BFO,
- Qualification of the PIC,
- Mooring of the receiving ship and bunker facility, industry standards may be referenced (e.g. OCIMF Effective Mooring 4th Edition 2019),
- Immobilisation / braking of the tank truck,
- Establishment of a Safety zone / Security zone in way of the bunkering area,
- Simultaneous operations,
- Spatial planning and approval of bunker locations,
- Enforcement,
- Use of checklists,

- Environmental protection (Releases of LNG, LNG Vapour, purging),
- Approval of safety and emergency response plans,
- Bunkering risk assessment, and
- Conditions in which LNG bunkering operations are allowed: weather conditions, sea state, wind speed and visibility.

4.2.2 LNG Bunkering Facilities Organization (BFO) responsibilities

The LNG Bunkering Facilities Organization should be responsible for the operation of the LNG bunkering installations including:

- Planning of the specific operation (liaising with the RSO),
- Operation of the facility in line with plans and procedures; and
- Maintenance of the bunkering equipment.

4.2.3 Receiving ship operator (RSO)

Receiving ship operator has responsibilities for bunkering operation including:

- Informing the BFO and the Port Authority in advance for necessary preparation of the bunkering operation; and
- Attending the pre-bunkering meeting to ensure compliance with local requirements for equipment, quantity and flow rate of LNG to be bunkered, and coordination of crew and safety communication systems and procedures

4.2.4 Master

The master of the receiving ship retains overall control for the safe operation of the ship throughout the bunkering operation. If the bunkering operation deviates from the planned and agreed process the master retains the right to terminate the process.

The master has overall responsibility for the following aspects of the bunkering operation. However, these tasks may be delegated to the PIC or other responsible crew member but the overall responsibility should be retained by the master:

- Approving the quantity of LNG to be bunkered
- Approving the composition, temperature and delivery pressure of LNG that is available from the bunkering facility operator. (Aspects of this may have been agreed prior to the bunkering operation as part of the LNG supply contract)
- Ensuring that the approved safe bunkering process is followed including compliance with any environmental protection requirements required by international, national or local port regulations
- Agreeing in writing the transfer procedure, including cooling down and if necessary, gassing up; the maximum transfer rate at all stages and volume to be transferred
- Completing and signing the bunkering checklist

4.2.5 Person in Charge (PIC)

A person in charge of the bunkering operation (PIC) should be agreed by the receiving ship and the bunkering facility. It is noted that in case of ship-to-ship transfer the role of PIC should be undertaken by either the Master or Chief Engineer of the receiving ship, or the Master of the bunker ship, for other bunker transfer methods a person of equivalent authority should be selected. In the case of distinct Master and PIC, the division of responsibilities between the two parties should be agreed before commencing bunkering operations.

The PIC should have an appropriate level of competence and be accepted to operate in the bunkering location. This may require authorisation or certification to act as PIC for bunkering operations, issued by the Port Authority or other Authority with jurisdiction over the bunkering location. The PIC should have adequate education, training and authorisation to ensure safe bunkering operations.

The PIC should be responsible for the bunkering operation and for the personnel involved, in all aspects of the bunkering operation, in particular safety, until completion.

The PIC should ensure that:

- Relevant approved procedures are properly applied; and
- Safety standards are complied with, in particular within the hazardous zone and safety zone.

To achieve this, the PIC should be responsible for:

- Ensuring that company specific operating procedures are followed, and that the operation is conducted in compliance with all applicable port regulatory requirements;
- Ensuring that all required reports are made to the appropriate Authorities;
- Conducting a pre-operation safety meeting with the responsible officers of both the bunkering facility and the receiving ship;
- Ensuring that all bunkering documentation is completed (checklists, bunker delivery note, etc.);
- Agreeing the mooring arrangement and where applicable nominated Mooring Master during the operation
- Ensuring all safeguards and risk prevention measures are in place prior to initiating the fuel flow;
- Being familiar with the results of the location risk assessment and ensuring that all specific risk mitigation means are in place and operating (water curtain, fire protection, etc.);
- The activation of Emergency Procedures related to the bunkering system operation;
- Ensuring operation will remain within the accepted environmental window for the duration of bunkering;
- Ensuring safe procedures are followed and the connection of liquid and vapour transfer hoses and associated ERS is successfully completed;
- Ensuring the safe procedures are followed and purging and leak testing of the bunkering system prior to transfer is successfully completed;
- Monitoring fuel transfer and discharge rates including vapour management;
- Monitoring climatic conditions including lightning strikes throughout operation
- Monitoring mooring arrangement integrity (in communication with mooring master);
- Monitoring communications throughout the operation;
- Ensuring that safe procedures are followed for drainage and purging of the bunkering system prior to disconnection;
- Supervising disconnection of liquid and vapour hoses/pipes;
- Supervising unmooring and separation of ships or in the case of truck bunkering, departure of the truck; and
- Supervising deployment/return of fenders and/or additional support utility to the bunker ship.

4.3 Crew and Personnel Training and LNG Awareness

4.3.1 General LNG bunkering operational training

The RSO is responsible for ensuring that the personnel on board the receiving ship involved in the bunkering operation should be suitably trained and certified by a recognised organisation, to fulfil requirements according to STCW.7/Circ.23 “Interim guidance on training for seafarers on board ships using gases or other low flashpoint fuels and STCW.7/Add.1”.

Reference is also made to Resolution MSC.396(95) – (adopted on 11 June 2015) on AMENDMENTS TO THE INTERNATIONAL CONVENTION ON STANDARDS OF TRAINING, CERTIFICATION AND WATCHKEEPING FOR SEAFARERS (STCW), 1978, AS AMENDED and corresponding sections to Parts A and B of the 1978 STCW Convention containing training and qualifications of personnel that work on ships subject to the IGF Code.

The BFO is responsible for ensuring that all bunkering facility personnel involved with the bunkering operations are suitably trained and certified as required by the regulations governing the bunkering method.

- For ship-to-ship bunkering these are the requirements of STCW Regulation V/1-1 – “Mandatory minimum requirements for the training and qualifications of masters, officers and ratings on oil and chemical tankers” and equivalent requirements as provided by the governing authority for the inland waterway where the vessel is operating.

- For truck-to-ship or shore-based terminal-to-ship bunkering these are the requirements of the local authorities governing activities within the port area. The personnel to be trained include but are not limited to personnel involved in LNG bunkering, personnel from authorities and emergency response services.

The person in charge (PIC) is to be trained in all aspects involving LNG. For the introduction of LNG bunkering operations within Port, sufficient training courses should be introduced in order to provide adequate competency to the role of PIC. This is especially the case with the development of novel bunkering systems or methods. The responsibility for verifying that the PIC is adequately trained falls on the RSO and BFO, the responsibility for certifying the PIC may be taken by the port authority.

4.3.2 Specific LNG bunkering safety training

Each bunkering method introduces different hazards. Specific training should be developed, based on the different possible failure scenarios and external events identified during the risk assessment study. Specific safety instructions as defined in 4.1.3.1 should be prepared based on the conclusions and outputs of the LNG Bunkering Risk Assessment.

The specific LNG Bunkering safety training should cover at least:

- Sudden change of ambient / sea conditions
- Loss of power (receiving ship or bunkering facility),
- Loss of monitoring / control / safety systems (ESD),
- Loss of communication,
- Abnormal operating parameters, and
- Rapid situation assessment technique with focus of restabilising unstable situations.

Section 5

Technical Requirements for LNG Bunkering Systems

5.1 General

The LNG transfer system should be designed and the bunkering procedure carried out so as to avoid the release of LNG or natural gas. The transfer system should be designed such that leakage from the system cannot cause danger to personnel, the receiving ship, the bunkering facility or the environment when the system is well maintained and properly used. Where any spillage of LNG can occur provisions should be taken to protect personnel, ship's structure and equipment. The consequences of other LNG fuel-related hazards should be limited to a minimum through the arrangement of the transfer system and the corresponding equipment.

Specific means should be provided to purge the lines efficiently without release of natural gas with all purged gasses either retained by the receiving ship or returned to the bunkering facility.

Accidental leakage from the LNG liquid and/or natural gas transfer systems including the connections with the receiving ship bunkering manifold and with the bunkering facility should be detected by appropriate means.

5.2 LNG Bunker Management Plan

A bunker management plan should be developed to allow for easy availability of all relevant documentation for communication between the receiving vessel and the BFO and if applicable the terminal and/or third parties.

The Bunker Management plan should be stored and maintained by both RSO and BFO. For onboard bunkering this should include the following aspects:

- Description of LNG, its handling hazards as a liquid and vapour, including toxicity and low flashpoint, necessary safety equipment, personal protection equipment (PPE) and description of first aid measures
- Description of the dangers of asphyxiation from inert gas on the ship
- Bunkering safety instructions and emergency response plan
- Description of the bunker facility LNG tank measurement and instrumentation system for level, pressure, and temperature control
- Definition of the operating envelope for which safe LNG bunkering operations can be undertaken in reference to temperature, pressure, maximum flow, weather and mooring restrictions etc.
- A procedure for the avoidance of stratification and potential rollover, including comparison of the relative temperature and density of the remaining LNG in the receiving tank and that in the bunker provider tank and action to be taken to promote mixing during bunkering
- The description of all risk mitigation measures to comply with during LNG bunkering
- The description of the hazardous areas, safety zone, and security zone and a description of the requirements in the zones to be complied with by the receiving vessel, the bunkering facilities, and if applicable the terminal and third parties
- Descriptions and diagrams of the bunker facility LNG bunkering system, including, but not limited to, the following as applicable:

- Recirculating and vapour return line system
- LNG fuel tank cooling down procedure
- Procedure for controlling the pressure of the receiving tank before and during bunkering
- LNG fuel tank pressure relief valve
- Ventilation and inlet/outlet location
- Inerting system and components
- Boil-off gas compressor or liquefaction system
- Gas detection system including locations of detectors and alarms
- List of alarms or safety indication systems linked to the gas fuel installation
- LNG transfer line and connectors
- • Emergency Shutdown System description
- • Communication systems and controls protocol

In addition to the above list of description and schematic drawings, the LNG BMP should include:

- Documents/reports on periodic inspections of the BFO LNG installation (components), and safety equipment.
- A checklist to verify that the ship's crew have received proper training for bunkering LNG.
- Bunkering safety instructions and safety management plan, (see below).

5.2.1 Bunkering Safety Instructions

RSO and BFO specific safety instructions should be prepared by both parties based on the conclusions and outputs of the LNG Bunkering Operations Risk Assessment (see Section 6).

The specific LNG Bunkering safety instructions should cover at least:

- Sudden change of ambient / sea conditions,
- Breaching of safety and security zones,
- Loss of power (receiving ship or bunkering facility),
- Loss of monitoring / control / safety systems (ESD),
- Impact due to lightning strikes,
- Loss of communication, and
- Abnormal operating parameters.

- LNG leakage and spill on the receiving ship, on the bunkering facility or in the water body (sea, river, inland waterway) from the LNG transfer system
- Gas detection
- Fire in the bunkering area
- Unexpected movement of the vessel due to failure or loosening of mooring lines
- Unexpected moving of the truck tanker
- Unexpected venting on the receiving ship or on the bunkering facility
- Loss of power

5.3 Loading Arms and Hoses Arrangements

5.3.1 Transfer installation

Arrangements should be made for:

- Purging and inerting the bunkering lines (or between designated ESD valves for systems with long LNG transfer lines) prior to the LNG transfer,

- Draining, purging and inerting the transfer system after completion of the LNG transfer.

LNG and vapour transfer systems (loading arm and/or flexible hose) should be fit for marine LNG bunkering operations. Design should be according to Tables 1 and 2 in ISO 18683:2021. The hoses and loading arms should be specially designed and constructed for the transfer products (LNG and Nitrogen) with a minimum temperature of -196^{o}C.

Pressure relief devices should be provided so that the hose or loading arm is not over-pressurised (for example if the ERS is activated). Means should be provided to safely drain and collect the LNG trapped between isolating valves.

Hoses, loading arms and parts of the ship manifold should be designed for loads which may be experienced during operation such as self-weight (including fully loaded), loads due to relative motion between receiving ship and bunker supplier, and loads due to any lifting equipment used to handle the hose. The loading arms and parts of the ships manifold may also need to be designed to support the weight of an emergency release coupling.

Care should be taken when choosing the transfer system particularly with regards to:

- Potential movements between the receiving ship and the bunkering facility,
- Operating envelope of transfer system,
- Minimum bending radius allowed for hoses
- ESD system functionality
- Means of purging and draining the transfer lines,
- Material selection and structural support
- Type of connectors
- Electrical insulation
- Continuity of earthing system
- System design to address potential surge pressures developed during an ESD
- Flash gas handling system, and
- Arrangements for pressure relief

5.3.2 Hoses

Hoses should comply with appropriate recognized standards such as EN 1474-2, EN 12434 or BS 4089. Hoses must be constructed from materials compatible with LNG. In normal practice, composite type of flexible hoses, constructed from multiple layers of materials and designed to safely and efficiently transfer LNG at extremely low temperatures, are used.

Transfer hose manufacturer's instructions, regarding testing and number of temperature and pressure operating cycles before removal from service, should be strictly followed.

Depending on which party owns the bunkering hose, a document should be included in the LNG Bunker management plan and a copy kept by the receiving ship containing the following information as applicable:

- Hose identification number
- Manufacturer's name
- Date of Manufacture
- Date of initial entry into service
- Diameter
- Minimum Bend Radius
- Working Temperature range
- Maximum Allowable Working Pressure
- Factory Test Pressure
- Materials of Construction
- Electrostatic properties and conductivity
- Initial test certificate and all subsequent test reports and certificates

Hoses should be handled with care. They should not be dragged over abrasive surfaces or sharp edges/corners

Hoses should be subjected to hydrostatic testing as a minimum once in a year, if any defects appear during this inspection, the hose should be replaced. In addition, the manufacturer of these hoses may lay down requirements relating to service life, inspection and maintenance. The manufacturer's instructions should be followed. Periodic visual inspection of the hoses both internally and externally is required; in fact, prior to and after every operation to ensure the fitness of the hoses for the current and future operations.

5.3.3 Lifting and supporting devices

The lifting devices, where fitted, should be of suitable capacity to handle the LNG transfer hoses and associated equipment.

Hoses should be suitably supported in such a way that the allowable bending radius is satisfied. They should normally not lie directly on the ground and should be arranged with enough slack to allow for all possible movements between the receiving ship and the bunkering facility.

Lifting and supporting devices should be suitably electrically insulated and should not impair the operation of any emergency release coupling or other safety devices.

5.4 Couplings and Flanges

5.4.1 General

The use of dry disconnect couplings is recommended for day-to-day bunkering operations using small hose diameters that will require several connections and disconnections.

5.4.2 Standard

Dry disconnect/connect couplings should conform to ISO 21593:2019. However, couplings used for LNG Bunkering operation should be designed according to the requirements in ISO EN 16904:2016 and 1474-3 or any other applicable standards may also be accepted.

5.4.3 Isolation flange

The bunker transfer system should contain an isolation flange of a non-electrically conductive material to prevent stray currents between the bunkering facility and the receiving ship. The isolation flange is generally fitted at the receiving ship end of the transfer system.

5.4.4 Spool piece

When spool pieces are used to connect to different sizes and geometries of connectors, they should be installed and tested as part of the preparation for bunkering. The leak testing would be applicable to ensure that the arrangement including spool piece is fully inerted and gas tight before transfer.

5.5 Leakage

The following safety devices should be provided, as a minimum, in an enclosed or semi enclosed bunker station (on the receiving ship) or discharging station (of the bunker facility):

- Gas detectors in suitable location(s) taking into consideration the rate of dispersion of cold vapour in the space, or temperature detection sensor(s), installed in the drip trays, or any combination to immediately detect leakage.
- CCTV is recommended to observe the bunkering operation from the bridge or operation control room. The CCTV should provide images of the bunker connection and also if possible the bunker hose such that movements of transfer system during bunkering are visible. CCTV is particularly recommended for enclosed bunker stations. Where CCTV is not provided, a permanent watch should be maintained from a safe location.

Gas detectors should be connected to the ESD system for monitoring leakage detection on the receiving ship.

Consideration may be given to the use of thermal imaging equipment or other suitable technology for leakage detection, especially in semi-enclosed bunkering stations.

A gas dispersion analysis will aid in identifying the critical locations and the extent of the LEL range where gas detectors should be fitted to enable early detection of any leakage.

5.6 ESD Systems

The bunkering facility and receiving ship should be fitted with a linked ESD system such that any activation of the ESD systems should be implemented simultaneously on both bunkering facility and receiving ship. Any pumps and vapour return compressors should be designed with consideration to surge pressure in the event of ESD activation.

The bunkering line should be designed and arranged to withstand the surge pressure that may result from the activation of the emergency release coupling and quick closing of ESD valves.

On ESD activation, manifold valves on the receiving ship and bunkering facility and any pump or compressor associated with the bunkering operation are to be shut down except where this would result in a more hazardous situation (see Table 3).

An ESD activation should not lead to LNG being trapped in a pipe between closed valves. An automatic system is to be provided that is designed to extract the LNG to a safe location without release to the environment.

If not demonstrated to be required at a higher value due to pressure surge considerations, a suitably selected closing time up to 5 seconds should be selected, depending on the pipe size and bunkering rate from the trigger of the alarm to full closure of the ESD valves, in accordance with the IGF Code.

The emergency shutdown system ESD should be suitable for the capacity of the installation. The minimum alarms and safety actions required for the transfer system are given in Table 3 below:

Table 3: Alarms and Safety actions required for the transfer system

Parameter/Alarm Trigger	**Alarm**	**Action[1]**
Low Pressure in the supply tank	✓	✓
Sudden Pressure Drop at the Transfer Pump	✓	✓
High Level in Receiving Tank	✓	✓
High Pressure in Receiving Tank	✓	✓
LNG leakage in Bunkering Station	✓	✓
LNG leakage in bunker station (gas detection/low temperature detection)	20% of LEL	Alert at 20% LEL. ESD activation at 40% LEL.
Manual activation of shutdown from either the receiving ship or the bunker facility (ESD1)	✓	✓
Manual activation of the emergency release coupling from either the ship to be bunkered or the bunkering installation (ESD2)	✓	✓
Safe Working Envelope of the Loading Arm exceeded	✓	✓
Fire Detection (on either the ship or bunkering facility)	✓	✓
Electrical Power Failure (For the LNG transfer system)	✓	✓
Notes: 1: Alert is to be made at both the delivery and receiving ends of the transfer system to clearly identify the reasons for the ESD activation.		

2: Where the parameter that triggers the ESD is such that closure of vapour connection valves and shut down of vapour return compressors would increase the potential hazard (for example a receiving tank high level alarm) these are to remain open/active where appropriate.

Alarm should be both audio and visual.

The manual activation position for the ESD system should be outside the bunker station and should have a clear view of the manifold area (the 'clear view' may be provided via CCTV).

LNG bunker transfer should not be resumed until the transfer system and associated safety systems (fire detection, etc.) are returned to normal operation condition.

All electrical components of the emergency release coupling actuator and of the ESD systems that are considered as provided by the ship side should be type approved/certified by IRS or the ship's Classification Society. When the ESD hardware and components are part of the onshore facility they should be designed and tested according to the industry standards.

5.7 Emergency Release Coupling

5.7.1 General

Transfer hoses may be fitted with a Breakaway Release Coupling. The BRC should be subjected to a type test to confirm the values of axial and shear forces at which it automatically separates.

Transfer arms should be fitted with an Emergency Release Coupling (ERC) designed to minimize the release of LNG on emergency disconnection.

The ERC may be designed for:

- Manual or automatic activation, and
- Activation as a result of excessive forces i.e. automatic disconnection in case the safe working envelope of the transfer system is exceeded.

For a BRC and an ERC, the tightness of the self-closing shut-off valves after separation should be checked.

The ERC should be designed and installed so that, in the worst allowable conditions for current, waves and wind declared in the bunkering conditions, it will not be subjected to excessive axial and shear forces likely to result in the loss of tightness or opening of the coupling. When the Safe working envelope of the transfer system is exceeded, the ERC system should be triggered.

Means should be provided in order to avoid a pressure surge in the bunker hose after release of the ERC when the connecting end of the hose is fitted with a dry disconnect coupling type.

Full operating instructions, testing and inspection schedules, necessary records and any limitations of all emergency release systems should be detailed in the ship's operating manuals.

5.7.2 ERC Activation

Where manual activation type ERC is fitted, the means of remotely operating the ERC should be positioned in a suitability protected area both on bunkering facility and receiving ship allowing visual monitoring of the bunkering system operation. A physical ESD link should bond the two parties. This does not apply to a dry breakaway coupling as this is a passive component which cannot be remotely activated.

5.7.3 Hose Handling after ERC Release

An integrated hose/support handling system should be in place, capable of handling and controlling the bunker transfer hoses after release of the ERC. In addition, it should be capable of absorbing all shock loadings imposed by the release of ERC during maximum capacity transfer conditions.

The system should ensure that, as far as practicable, upon release the hoses, couplings and supports do not contact the metal structure of the ship and bunkering facility, thereby reducing the risk of sparking at the contact point, injury to personnel or mechanical damage.

5.8 Communication Systems

A communication system with back-up should be provided between the bunkering facility and the receiving ship.

The components of the communication system located in hazardous and safety zones should be type approved according to IEC 60079.

5.9 Bunkering Transfer Rate

The LNG transfer rate from the BFO should be adjusted, taking into consideration:

- Initial flow rate
- Maximum allowable flow rate of the bunker station manifold
- Flow rate for topping up operations for the fuel tank
- Management of the flash gas generated during bunkering
- Temperature of the LNG supplied from the bunkering facility
- Temperature of the LNG remaining in the receiving ship tank, and
- Pressure in both bunkering facility tank and receiving ship tank

Adequate provisions should be made for the management of the LNG Vapour generated during the bunkering operation, without release to the atmosphere.

The maximum LNG velocity in the piping system should not exceed 12 m/sec under the rated equipment capacity in order to avoid the generation of static electricity, additional heat, and consecutive boil off gas due to nonlinear flow.

5.10 Vapour Return Line

Vapour return line(s) may be used in order to control the pressure in the receiving tank or to reduce the time required for bunkering (refer to Section 8.2.4.6). This is particularly applicable to Type A, prismatic Type B or Membrane tanks. The most relevant factors that will affect the amount of flash gas generation in a typical bunkering operation are as follows:

- Cool down of the transfer system
- Difference in the conditions prevailing between the bunkering facility tanks and the receiving tanks (particularly the temperature of the receiving tank)
- Transfer rates (ramp up, full flow, ramp down/topping up)
- Heat gain in pipe line between bunkering facility tank and receiving ship tank
- Pumping energy

5.11 Lighting

Lighting should illuminate the bunker station area, and if installed in a hazardous area should be compliant with applicable hazardous area equipment requirements. Lighting should adequately illuminate the bunkering operation work area especially:

- LNG bunker hose(s),
- Connection and couplings on both receiving ship and bunkering facility
- ESD system call points
- Communication systems
- Fire-fighting equipment
- Passage ways / gangways intended to be used by the personnel in charge of the bunkering operation, and
- Vent mast(s)

Section 6

LNG Bunkering Operations Risk Assessment

6.1 General

A bunkering operations risk assessment should be undertaken in accordance with ISO 18683:2021. This technical specification is specific to the supply of LNG as fuel to ships and refers to recognised standards that provide detailed guidance on the use and application of risk assessment.

The objectives of the bunkering operations risk assessment are to:

- Demonstrate that risks to people and the environment have been identified and eliminated where possible, and if not, mitigated as necessary, and
- Provide insight and information to help set the required safety zone and security zone around the bunkering operation

In order to meet these objectives, as a minimum, the bunkering operations risk assessment should cover the following operations:

- Preparations before and on ship's arrival, approach and mooring
- Preparation, testing and connection of equipment
- LNG transfer and boil-off gas management
- Completion of bunker transfer and disconnection of equipment
- Simultaneous operations (SIMOPS)

6.2 Risk Assessment Approach

6.2.1 Qualitative Risk Assessment

A Qualitative Risk Assessment (QualRA) should be undertaken prior to introduction of a new bunkering operation procedure that follows the guidance in this document.

Provided the bunkering operation is one of the three standard bunkering scenarios below, and guidance in this document is followed, i.e. there are no deviations from the functional requirements, then the qualitative approach is sufficient to meet the objectives of the bunkering operations risk assessment.

Standard bunkering is characterised by three bunkering scenarios:

- Shore-to-ship (that is, LNG transfer from an onshore facility to a LNG fuelled ship)
- Truck-to-ship (that is, LNG transfer from a road truck to a LNG fuelled ship)
- Ship-to-ship (that is, LNG transfer from a ship, such as a bunker barge, to a LNG fuelled ship)

6.2.2 Quantitative Risk Assessment

As a supplement to the Qualitative Risk Analysis, a Quantitative Risk Assessment (QRA) should be required where:

- bunkering is not of a standard type
- design, arrangements and operations differ from the guidance given in this document; and
- bunkering is undertaken alongside other transfer operations (SIMOPS),

A QRA is also appropriate where further insight is required to: judge the overall level of risk (since this is not typically provided by a Qualitative Risk Analysis); appraise design options and mitigation alternatives; and/or to support a reduced safety zone and/or security zone.

The requirement for a QRA (in addition to a Qualitative Risk Analysis) is normally determined by the Administration or Port Authority based on the conclusions and outcomes of the Qualitative Risk Analysis and accepted by the concerned parties.

The Quantitative Risk Analysis should also, in addition to gas dispersion analyses consider – thermal radiation and explosion shock wave.

6.2.3 Risk Assessment Scope for LNG Bunkering

As a minimum the risk assessment should detail:

- How the bunkering operation could potentially cause harm. That is, systematic identification of potential accidents/incidents that could result in fatality or injury or damage to the environment
- The severity of harm. That is, the worst-case consequences of the accidents/incidents identified above in terms of single, multiple fatalities, severe injuries etc. and environmental damage caused
- The likelihood of harm. That is, the probability or frequency with which the worst-case consequences might occur;
- Risk – which is a combination of likelihood and severity
- How the functional requirements are met.

In addition, the risk assessment should help identify the scenarios to be used to determine the safety zone; and as a minimum, consider SIMOPS within the safety zone.

Qualitative Risk Analysis and QRA approaches should be selected using recognized standards or established best practices. A typical approach is described in ISO18683: 2021. These approaches or similarly established approaches should be used provided they cover items (a) to (e) above.

The risk assessment should be carried out by a team of suitably qualified and experienced experts with collective knowledge of, and expertise of risk assessment application; engineering design; emergency response, and bunkering operations.

6.2.4 Risk Acceptance Criteria

Examples of qualitative and quantitative risk criteria are outlined in ISO 18683:2021. In addition, guidance on selection of appropriate criteria may be given by government organisations. Furthermore, many industry organisations, such as the international oil companies, have specific risk criteria extensively used to demonstrate safe onshore and offshore operations to governments and regulators.

Although criteria from different sources may appear similar, it is important to note that there are no universally agreed risk criteria: there are differences between governments, regulators and organisations. Therefore, prior to the commencement of the risk assessment, risk criteria should be agreed with appropriate stakeholders, IRS, the port and regulatory authorities, the Administration and the ship operator.

6.3 Risk Assessment for SIMOPS

Where it is proposed to carry out bunkering operations concurrently with other operations that may impact or be impacted by the bunkering then further risk assessment should be carried out to demonstrate that the required level of safety can be maintained. The other operations may include but may not be limited to:

- Cargo handling
- Ballasting operations
- Passenger embarking / disembarking
- Dangerous goods loading / unloading and any kind of other goods loading or unloading (i.e. stores and provisions)
- Chemical products handling
- Other low-flash point products handling
- Bunkering of fuels other than LNG

Simultaneous operations should be investigated for any of the above activities occurring within the safety zone calculated as described in Section 7.

Any simultaneous shipboard technical operations such as testing of systems that might affect the stability of the receiving ship, for example, changes to the mooring situation, testing of power generations systems or fire-fighting systems, are not to be carried out during LNG bunkering operations.

Section 7

Safety and Security Zones

7.1 General

A safety zone and a security zone should be established around the bunkering operation by evaluating the hazardous area zones as elaborated in Section 7.2. These zones are in addition to the established practice of setting hazardous area classification zones that will be required around areas with potential for explosive atmospheres such as the bunkering connections

Both the safety and security zones should be enforced and monitored at all times during bunkering, at all other times these zones may not be enforced.

The purpose of the safety zone is to set an area within which only essential personnel are allowed and potential ignition sources are controlled. Essential personnel are those required to monitor and control the bunkering operation. Similarly, the purpose of the security zone is to set an area within which ship/ port traffic is monitored and controlled.

Together, the safety and security zones help further minimise the likelihood of a fuel release and its possible ignition and help protect individuals and property via physical separation.

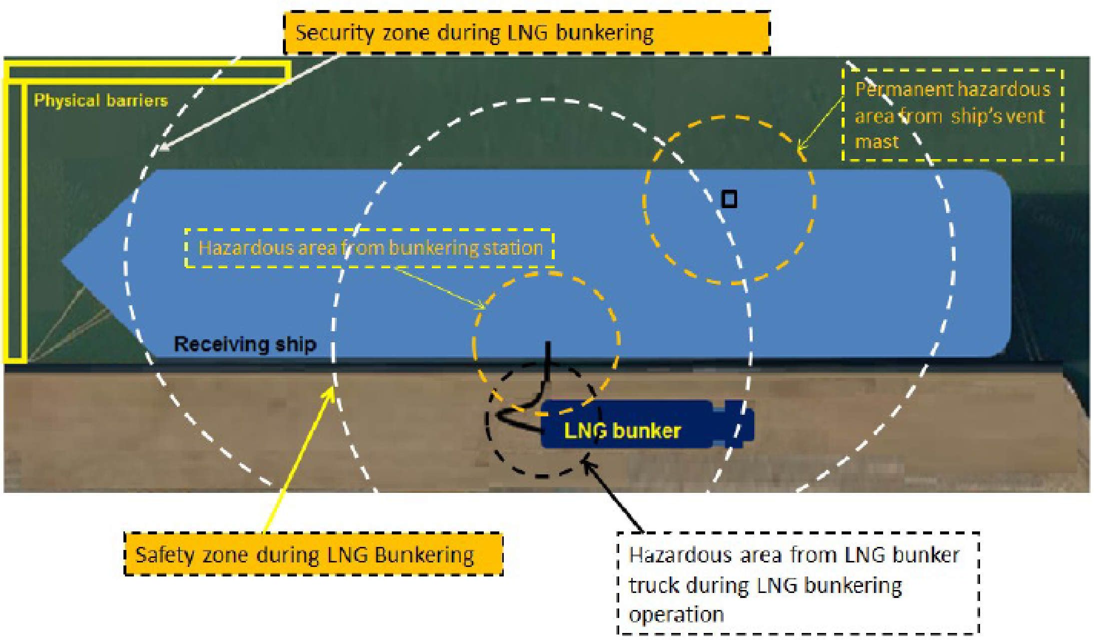

Figure 7.1 Schematic of Safety and Security Zone

7.2 Hazardous Area Classification

Bunkering-related hazardous areas means any hazardous area zone 1 and zone 2 defined for:

- The receiving ship in accordance with IGF Code, regulation 12.5,
- The bunkering ship in accordance with IGC Code, regulation 1.2.24, and

Example minimum hazardous zone sizes include:

- Areas on open deck, or semi-enclosed spaces on deck, within 3 m of any gas tank outlet, gas or vapour outlet, bunker / supply manifold valve, other gas valve, gas pipe flange and gas tank openings for pressure release,
- Areas on the open deck within spillage coamings surrounding gas bunker / supply manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck,
- Semi-enclosed bunkering stations, and
- Areas within 1.5 m surrounding spaces listed above.

The bunkering-related hazardous area also includes areas around the truck, LNG bunker vessel or shore-based bunkering facility. Depending on the outcomes of the risk assessment and the specific details of the bunkering process (equipment and transfer flow rates and pressures) the size of these areas may be increased.

In the hazardous area, only electrical equipment certified in accordance with IEC 60079 is permitted. Other electrical equipment should be de-energised prior to the bunkering operations. Attention is drawn to the following equipment, which is not intrinsically safe and should therefore be disabled, except if otherwise justified:

- The radar equipment, which may emit high power densities
- Other electrical equipment of the ship, such as radio equipment and satellite communication equipment, when they may cause arcing.

7.3 Safety Zones

In the safety zone, the following restrictions normally apply during the bunkering operations, except if otherwise justified by the safety analysis or agreed by the Local Port Authorities or National Administration:

- Smoking is not permitted.
- Naked lights, flashlights, mobile phones, laptops, tablets, cameras (except thermal imaging cameras of a certified type) and other non-certified portable electrical equipment are strictly prohibited.
- Cranes and other lifting appliances not essential to the bunkering operation are not to be operated.
- No vehicle (except the tank truck) should be present in the safety zone
- No ship or craft should normally enter the safety zone, except if duly authorised by the Port Authorities.
- Other possible sources of ignition should be identified and eliminated
- Access to the safety zone is restricted to the authorised staff, provided they are fitted with personal protective equipment (PPE) provided as below:
    - Fire Retardant Clothing
    - Coverall suitable for handling LNG (to be used when connecting and disconnecting hoses or loading arms)
    - Gloves suitable for handling of LNG (to be used when connecting and disconnecting hoses or loading arms or sampling (if required by the flag administration or national authority))
    - Safety Shoes
    - Hardhat
    - Safety Glasses
    - Portable Gas Detector

7.3.1 Determination of the safety zone distance

There are two different approaches which are outlined in the following paragraphs.

7.3.1.1 Deterministic approach

The safety zone should be set based upon the flammable extent of a maximum credible release scenario. In ISO 18683:2021, this approach to setting the safety zone is referred to as the 'deterministic approach'. Specific requirements for the determination of the safety zone may be set by national and local authorities.

The flammable extent is the distance at which the lower flammable limit (LFL) is reached as the vapour/gas (from the released fuel) disperses in the atmosphere. For LNG, the LFL is approximately 5% in air.

As a minimum, the following information should be taken into account in the maximum credible release scenario:

- The physical properties of the released LNG
- Weather conditions at the bunkering location; wind speed, humidity, air temperature and the temperature of the surface upon which the fuel leaks. The chosen conditions should reflect the worst-case conditions that result in the greatest distance to LFL
- Roughness of the surface over which the vapour/gas disperses, (i.e. land or water).
- Structures and physical features that that could significantly increase or decrease dispersion distances.
- Release rate, release orientation, available inventory and rate of vapour generation.

In addition, release height is to be considered as this can significantly affect the extent of the calculated safety zone. The vertical extent of the safety zone may require special consideration, especially in cases where persons can be at elevated positions, such as located in cabins many metres above the bunker station.

Large objects, such as buildings and ships, and topography, such as cliffs and sloping ground, can constrain or direct dispersion. This should be recognised in setting the safety zone. Failure to do this can result in inappropriate safety zones that include areas that would not be affected by any release of natural gas or exclude areas that would be affected if there was a release. Advanced modelling techniques, such as computational fluid dynamics (CFD) should be utilized to justify the zone's shape and extent.

Regardless of the technique(s) used in setting the safety zone it should be applied by a suitably qualified and experienced individual.

ISO 18683:2021 provides two examples of a maximum credible release scenario, where the one resulting in the greatest LFL extent is used to set the safety zone:

- A release of the 'trapped inventory' between emergency shutdown valves in the liquid bunkering line (i.e. bunker hose), and
- 'continuous release' from an instrument connection where emergency valves do not close to isolate the release and delivery pressure is maintained

To set the safety zone either:

- The ISO 18683:2021 release cases as described above should be used (i.e. ‘a’ and ‘b’), or
- A maximum credible release scenario should be used that has been identified and justified using the risk assessment method described in ISO 18683:2021. This option allows for consideration of mitigation measures and other factors specific to the bunkering operation.

7.3.1.2 Quantitative Risk Analysis

An alternative approach to setting the safety zone should use quantitative risk assessment (QRA) whereby consideration is given within a predefined scenario to a representative set of potential releases and the likelihood with which they occur. This approach is often referred to as the “probabilistic” or “risk based” approach.

Notwithstanding, the outcome of the QRA, the Safety Zone should at least extend beyond the hazardous areas and/or the minimum distance defined by the authorities from any part of the bunkering installation.

A key feature of QRA is that it accounts for both the consequence and likelihood of releases and can consider the location of people, the probability of ignition, and the effectiveness of mitigation measures and other emergency actions. As such, it can provide increased understanding of those releases that contribute most to the risk, and this can be useful in identifying and testing the suitability of mitigation measures and optimizing zone extent. If this approach is selected, then it is important that appropriate risk criteria are used.

7.4 Security Zones

A security zone should be set based upon ship/ port operations. In setting the zone, consideration should be given to activities and installations that could endanger the bunkering operation or exacerbate an emergency situation. For example, consideration of the following is required when setting the security zone:

- Other ship/ ship movements
- Surrounding road traffic, industrial plants, factories and public facilities
- Crane and other loading/unloading operations
- Construction and maintenance works
- Utilities and telecommunication activities and infrastructure

It is likely that most or all of the above factors are considered in the risk assessment described in this document. Therefore, to help inform setting of the zone, reference should be made to this risk assessment.

Section 8

Requirements for LNG Bunkering Operations

8.1 Pre-Bunkering Phase

8.1.1 General

The pre-bunkering phase starts from the first communication between receiving ship and bunkering facility for ordering a bunker of LNG and ends with the physical connection of the bunker line to the bunker station.

8.1.2 Goal

The goal of the pre-bunkering phase is the preparation and the completion of a safe connection between the transfer systems of the bunkering facility and the receiving ship.

8.1.3 Functional Requirements

The following functional requirements should be considered during the pre-bunkering phase:

- The risk assessment has been conducted and the findings have been implemented
- A LNG Bunker Management Plan has been established and is applicable to the ship.
- A compatibility check demonstrates that the safety and bunkering systems of the bunkering facility and the ship to be bunkered match
- The relevant authorities have been informed regarding the LNG bunkering operation.
- The permission for the transfer operation is available from the relevant authority
- The boundary conditions such as transfer rate, vapour handling and loading limit have been agreed between the supplier and the ship to be bunkered
- The fuel tank(s) to be bunkered are in a state of readiness for bunkering
- Initial checks of the bunkering and safety system are conducted to ensure a safe transfer of LNG during the bunkering phase.

8.1.4 General Requirements

8.1.4.1 Personnel on Duty

During the transfer operation, personnel in the safety zone should be limited to essential staff only. All staff engaged in duties or working in the vicinity of the operations should wear appropriate personal protective equipment (PPE) and an individual portable gas detector and thermal imaging camera as required by the LNG Bunker Management Plan.

8.1.4.2 Compatibility Assessment

A compatibility assessment of the bunkering facility and receiving ship should be undertaken prior to confirming the bunkering operation to identify any aspects that require particular management.

The compatibility assessment should be undertaken with the assistance of an appropriate checklist to be completed and agreed by Master(s) and PIC prior to engaging in the bunkering operation.

As a minimum, compatibility of the following equipment and installation should be checked prior to engaging further in any LNG bunkering operation:

- Communication system (hardware, software if any and language) between the PIC, ship's crew and BFO personnel

- ESD system
- Bunker connection
- Emergency release system (ERS) or coupling (ERC)
- Vapour return line when appropriate
- Nitrogen lines availability and connection
- Mooring equipment
- Bunker Station location
- Transfer system sizing and loading on manifold
- Location of ERS
- Closure speed of valves
- HAZOP results as applicable

8.1.5 Preparation for Bunker Transfer

8.1.5.1 Environmental Conditions

The environmental conditions (weather (especially lightening), sea state, temperature, and visibility limitation such as fog or mist) should be acceptable in terms of safety for all the parties involved.

8.1.5.2 Mooring

8.1.5.2.1 Mooring Condition of Receiving Ship

The ship should be securely moored to the bunker supplier to prevent excessive relative movement during the bunkering operation. The effect of swell due to ships passing in the waterway, channel or port area should also be considered.

8.1.5.2.2 Mooring condition of bunker ship

For ship-to-ship bunkering the bunker ship should be securely moored according to the result of the compatibility check, so that excessive movements and overstressing of the bunkering connections can be avoided. Refer to 8.1.7.3 below. For the mooring of the bunker ship the limiting conditions should be considered such as weather, tide, strong wind, waves and current.

8.1.5.2.3 Parking condition of LNG Truck(s)

The LNG Trucks should be securely parked, to prevent unintended movements.

All ignition sources linked to the truck are to be managed in accordance with the bunkering management plan/procedure taking into account Hazardous areas and Safety Zones. Any situation whereby this requirement cannot be met, special consideration must be provided (i.e. non-standard) to ensure the risk of ignition is managed to ALARP.

In any case, the truck(s) engine(s) should not be running during connection and disconnection of the transfer system.

The LNG truck(s) should be electrically earthed.

If multiple trucks are utilized in the bunkering operation, then they must be suitably located so that an incident with one truck does not affect the safety of the other trucks and the ship.

8.1.5.3 Communication

Communication should be satisfactorily established between the bunkering facility and the receiving ship prior to any transfer operation. If they are to be used, visible signals should be agreed by and clear to all the personnel involved in the LNG bunkering operation.

In case of communication failure, bunkering operations should be stopped and not resumed until communication is re-established.

8.1.5.4 Agreement of Transfer Conditions

The following should be agreed before commencing the bunker transfer:

- Transfer time, temperature and pressure of the delivered LNG, pressure inside the receiving ship tank, delivery line measurement, vapour return line measurement (if any) should be agreed and checked prior to engaging in any LNG Bunkering Operation.
- The maximum LNG temperature ranges that the receiving ship can handle should be stated by the receiving ship.
- Liquid levels, temperature and pressure for the LNG bunker tanks of the receiving ship should be checked and noted on the bunkering checklist.
- The maximum loading level and transfer rate, including cool down and topping up should be agreed upon. This includes the pressure capacity of pumps and relieving devices in the connected transfer system. The filling limit of the receiving tank depends on MARVS (as per IGC / IGF codes) and accounts for the possible expansion of cold LNG.

The agreed transfer conditions should be included in the LNG Bunker Management Plan.

8.1.5.5 Individual Safety Equipment in Place

All personnel involved in the LNG bunkering operation should properly wear adequate Personal Protective Equipment (PPE) (please also see section 7.3). It should be ensured that all the PPEs have been checked for compliance and are ready and suitable for use.

8.1.5.6 Protection of the hull plate, shell side and ship structure

Protection from cryogenic brittle fracture of the receiving ship deck and structure caused by leakage of LNG should be provided as per IGF code requirements.

When appropriate, one or more of the following protective measures may be utilized:

- A water curtain may be installed to protect the ship’s hull
- A cover of suitable material grade to withstand LNG temperatures may be installed underneath the transfer hose to protect deck plating.
- A drip tray of suitable material grade to withstand LNG temperatures may be fitted below the pipe coupling to collect LNG spill.

It is recommended that spill protection is also provided for the BFO equipment, this may be governed by local regulations for truck-to-ship bunkering and shore-based facilities.

8.1.5.7 Safety Zone requirements and mark out

- The boundaries of the safety zone associated with bunker station and BFO connection should be clearly marked out
- Any non-EX equipment installed in hazardous areas and/or in safety zone, such as the bunker station, should be electrically isolated before the bunkering operation commences and throughout the bunkering process until such time as the area is free of any gas leak hazard. Any such arrangement where there is non-Ex rated equipment installed in a hazardous zone should be subject to special consideration by IRS.
- Radio communications equipment not needed during bunkering and cell phones should be switched off as appropriate

8.1.5.8 Electric Isolation

A single isolation flange should be provided, in each arm or hose of the transfer system, between the receiving ship manifold and the bunker pipeline. The installation should not permit shorting out of this insulation for example by, leaving the flange resting in stainless steel drip tray. This flange prevents galvanic current flow between the receiving ship and the bunkering facility. Steel to steel contact between receiving ship and bunkering facility e.g. via mooring lines, ladders, gangways, chains for fender support etc. should be avoided through the use of insulation. Bunker hoses/ pipes should be supported and isolated to prevent electrical contact with the receiving ship.

When bunkering from trucks, the truck should be grounded to an earthing point at the quay to prevent static electricity build up. Where approval has been given for the bunkering truck to be parked on the deck of the ship then the truck should be grounded to the receiving ship.

Ship-shore bonding cables/ straps should not be used unless required by national or local regulations.

If national or local regulations require a bonding cable/strap to be used, the circuit continuity should be made via a ‘certified safe’ switch (e.g. one housed inside a flame proof enclosure) and the connection on board the receiving ship should be in a location remote safe area from the hazardous area. The switch should not be closed until the bonding cable/strap has been connected, and it should be opened prior to disconnection of the bonding strap.

8.1.5.9 ERS

Simulated testing of all types of coupling having the function of ERC within the ERS should be performed according to a recognised standard. Testing records should be retained with the bunkering operator or organisation responsible for such equipment ready for immediate inspection by authorities. Any transfer /support system should be proved operational (if necessary, by inspection of marine loading arm or supported hose) and be confirmed as part of the pre-transfer checklist.

Testing of the system prior to each bunkering operation should prove all components are satisfactory, with the exception of actually releasing the ERC. The system used to link the ERS system with the ships’ ESD1 trip circuit should be tested and proved operational.

8.1.5.10 Emergency Release Coupling

The disconnection can be triggered manually or automatically. In either case, activation of the ERS system should trigger activation of the ESD (ESD1) before release of the ERC (ESD2).

Where applicable, step-by-step operating instructions should be permanently affixed to the ERC equipment and all personnel involved in its operations should be trained and made familiar with its correct use. Additionally, clear procedures should be in place identifying the process for authorisation to remotely activate the ERC.

In the event of ESD2 activation, i.e. ERC sudden release triggered due to emergency event or overstress on the transfer line induced by ship movement, the backlashing hoses can damage hull structure and injure personnel in the absence of an appropriate supporting arrangement. This supporting arrangement, if fitted, should not prevent the correct operation of the ERC, any relative motion between the receiving ship and the bunkering facility should act directly on the ERC to ensure its correct operation if the event of vessel drift or unexpected truck movement.

Routine inspection and testing of the release equipment is required, responsibility for this testing will depend on agreements between the BFO and RSO.

8.1.5.11 ESD Testing

The bunkering facility and receiving ship should both test their emergency shutdown systems not more than 24 hours before bunkering operations commence. The PIC should then be advised of the successful completion of these tests. These tests should be documented in accordance with the bunkering procedure.

8.1.5.12 Visual inspection of bunker hose or arm before physical connection

Bunker hoses and connecting systems should be visually examined for wear and tear, physical damage and cleanliness. If any defects are found during this inspection, the bunkering operation is cancelled until the transfer hose is replaced.

8.1.5.13 Liquid and gas leakage detection systems activated

The gas detection system as described in Section 5.5 should be activated. Sensors to detect leakage should be installed in the bunker station below the drip tray and their temperature calibration(s) should be checked. Their function should also be tested.

8.1.5.14 Preparation of the transfer system

The piping at the bunkering facility should be inerted and cooled down (as far as practicable) prior to the connection with the ship to be bunkered. If this operation may cause any specific hazards when connecting to the transfer line it should be carried out after the connection has been carried out. The specific cooling down procedure for the transfer system in terms of cooling down rate should be observed with special care regarding the potential for induced thermal stresses and damage and leaks that may occur. Connections to the bunkering facility and the receiving ship should be visually checked and if necessary retightened. During this operation there should be no release of any LNG or natural gas.

8.1.6 Pre-Bunkering Checklist

The LNG Bunker Management Plan should include a checklist to be used during LNG bunkering operation by all involved personnel. This checklist should be elaborated once the full agreement on: procedures to apply, equipment to be used, quantity and quality of LNG to bunker, and training is obtained by all involved parties.

Checklists such as those developed by IAPH should be considered for use (please also see Annex B).

8.1.7 Connection of the Transfer System

8.1.7.1 Connecting

Equipment utilised with the transfer system such as couplings and hoses should be approved and tested both before and after installation. For emergency release coupling requirements (ERC), see Section 5.6.

The transfer system should be connected such that all the forces acting during the transfer operation are within the operating range.

8.1.7.2 Condition of Flange and Sealing Surfaces prior to connection

During connecting of the transfer system, humidity at the flange mating surfaces should be avoided and it should be ensured that all mating surfaces are clean. When necessary, compressed air should be used for cleaning the contact surface of flanges and seals before physical connection and clamping of the couplings. Heating of the connections to dry them prior to connecting may be considered in some circumstances.

8.1.7.3 Minimum Bending Radius of Hose

Hoses should be suitably supported in a manner that the minimum acceptable bending radius according to the qualification standard of the hose is not exceeded. Equipment utilised with the transfer system such as hose rests, saddles, and guidance systems (as applicable) should be approved and tested.

A LNG transfer hose should normally not lie directly on the deck plate and should be isolated from the deck. As a minimum, suitable protection such as wooden boards should also be provided to avoid damage from friction on the quay.

The hose arrangement should be so designed with enough slack to allow for all possible movements between the receiving ship and the bunkering facility.

8.1.7.4 Transfer Line Purging

After connection of the transfer system, it should be purged to ensure that no oxygen or humidity remains in the transfer system. Nitrogen should be used for purging of any parts of the system that will be cooled to cryogenic temperatures during the bunkering operation.

Attention is drawn to quantity of the inert gas used for purging / inerting, which may result in high inert gas content in the LNG tank of the receiving ship, which may affect the proper operation of engines. A typical purging sequence of the transfer line involves the injection of five times the volume of the bunker line. The volume of inert gas required may be minimised by the design of the transfer system (i.e. using shorter lengths of hose).

8.1.7.5 Transfer Line Pressure Testing

During inerting of the transfer system, the leak test according to the bunkering procedure should be carried out. As a minimum, a leak test of the connection points and flanges in the system from the bunkering facility up to the ESD valve on the receiving ship should be performed prior to any transfer operation.

8.2 Bunkering Phase

8.2.1 Definition

The bunkering phase begins after the physical connection between the bunkering facility and the receiving ship's bunker station has been safely completed with the opening of the LNG transfer valve from the bunker ship, the truck tanker or the onshore bunkering facility.

It continues with the cooling down of the transfer line followed by the LNG bunker transfer and ends at the end of the topping up phase and the closure of the LNG valve from the bunkering facility.

8.2.2 Goal

Transfer of the required quantity of LNG without release of LNG and/ or natural gas to the surrounding environment in a safe and efficient operation.

8.2.3 Functional requirements

- During the whole transfer process, a suitable ESD and ERS system should be provided for the transfer system.
- After connection of the transfer system, a suitable cooling down procedure should be carried out in accordance with the specification of the transfer system and the receiving tank supplier requirements.
- Flash gas or boil-off gas will not be released to atmosphere during normal transfer operations.

- Bunker lines, transfer system and tank condition should be continuously monitored for the duration of the transfer operation.

8.2.4 General Requirements

8.2.4.1 ERS

The ERS control signals and actuators should be checked and tested and should be ready for use.

The mechanical release mechanism of the ERS system should be proven operational and ready for use before fuel bunkering operation commences.

8.2.4.2 ESD Connection Testing

It should be ensured that a linked ESD system connected, tested and ready for use is available.

There are two phases of testing: Warm ESD testing and Cold ESD testing.

8.2.4.2.1 Warm ESD Testing

For Warm ESD Testing, the ESD system should be tested following completion of manifold connection and ESD link. The testing should take place between the receiving ship and the bunkering facility prior to commencement of operation (warm ESD1) to confirm that the systems are compatible and correctly connected. The initiation of the warm ESD1 signal should be done from either one of the receiving ship or the bunkering facility.

8.2.4.3 Cool down of transfer system

As far as practicable, cooling down of the transfer lines should be carried out according to the requirements of the transfer system and according to the bunkering procedure with special care regarding the potential leaks that may occur as components shrink as they are cooled. Connections to the bunkering facility and the receiving ship should be monitored and, if necessary, tightened.

If a pump is used to deliver the required pressure for the tank to be filled, it is necessary to cool it to operating temperature before starting. This is done by filling the pump circuit with liquid from the tank.

8.2.4.3.1 Cold ESD Testing

Following the successful completion of cool down operation the cold test should be carried out as far as practicable to ensure that the ESD valves operate correctly in cold conditions before initiating the main LNG bunker transfer.

8.2.4.4 Main Bunker Transfer

After proper cooling down of the transfer system and a stable condition of the system the transfer rate can be increased to the agreed amount according to the bunkering procedure. The transfer process should be continuously monitored with regard to the operating limits of the system.

If there are any deviations from the operation limits of the system, the transfer of LNG should be immediately stopped.

8.2.4.5 Monitoring Pressure and Temperature

Receiving tank pressure and temperature should be monitored and controlled during the bunkering process to prevent over pressurisation and subsequent release of LNG or natural gas through the tank pressure relief valve and the vent mast.

8.2.4.6 Vapour Management

The vapour management methodology will vary depending on tank type, system type and system condition, but should be agreed on during the compatibility check. For Type A or Type B or Membrane tanks, a vapour return line may be used but also other systems like reliquefaction units or pressurised auxiliary systems can also be used to regulate the pressure of the return vapour.

If the receiving tank is a Type C tank, the above remains valid. An alternative practise of LNG bunkering widely used, especially in a truck-to-ship bunkering situation or when no vapour return line is available, is to spray LNG into the top of the receiving tank through diffusers in order to cool the vapour space. As a result, the tank pressure will be reduced and therefore the pressure increase due to flash gas can be contained and managed for the duration of the LNG bunkering.

8.2.4.7 Topping up of the Tank

The topping up of the tank should be carefully examined by the Person in Charge and/or the Chief Engineer monitoring the filling up of the LNG tank(s). The LNG fuel transfer flow rate should be slowed with an appropriate declining value when the receiving tank LNG level approaches the agreed loading limit. The loading limit of the tank and the tank pressure should be paid special attention by the PIC during this operational step. The opening of the tank’s Pressure Relief Valve (PRV) due to overpressure in tank, for example following overfilling, should be avoided.

8.2.4.8 Selection of Measuring Equipment

The impact on the safety of the transfer system by any equipment used for the measurement of LNG quantity during the bunkering operation should be considered. The measurement method selected, and the equipment used (flow meters, etc.), should minimise disruption to the flow of LNG to prevent pressure surge, excess flash gas generation, or pressure losses in the transfer system.

8.3 Bunkering Completion Phase

8.3.1 Definition

The post bunkering phase begins once the bunker transfer (final topping up phase) has been completed and the bunkering facility LNG delivering valve has been closed. It ends once the receiving ship and bunkering facility have safely separated, and all required documentation has been completed.

8.3.2 Goal

This phase should secure a safe separation of the transfer systems of the receiving ship and bunkering facility without release of LNG or LNG Vapour to the surrounding environment.

8.3.3 Functional Requirements

The following functional requirements should be considered during the Post Bunkering Phase:

- The draining, purging and inerting sequences as described in 8.3.4 below for the different bunkering cases are fulfilled without release of natural gas to the atmosphere.
- The securing and safe storage of transfer system equipment is ensured
- The unmooring operation and separation of ship(s) is completed safely.

8.3.4 Draining, Purging and Inerting Sequence

This part of the process is intended to ensure that the transfer system is in a safe condition before separation, the couplings should not be separated unless there is an inert atmosphere on both sides of the coupling.

The details of this process will be design dependent but should include the following steps:

- Shut down of the supply.
- Safe isolation of the supply.
- Draining of any remaining LNG out of the transfer system.
- Purging of natural gas from the transfer system
- Safe separation of the transfer system coupling(s).
- Safe storage of the transfer system equipment in a manner that the introduction of moisture or oxygen into the system is prohibited.

8.3.4.1 LNG Bunkering from Truck to Ship

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the receiving ship tank.

8.3.4.2 LNG Bunkering from Ship to Ship

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the bunker ship tank.

8.3.4.3 LNG Bunkering from Terminal

The process of purging and inerting will follow the general outline described above, all purged gasses are generally returned to the shore facility.

8.3.5 Post Bunkering Documentation

Upon completion of bunkering operations, the checklist in the LNG bunkering management plan (as described in the pre-bunkering section above) should be completed to document that the operation has been concluded in accordance with the agreed safe procedure. The vessel PIC should receive and sign a Bunker Delivery Note for the fuel delivered, the details of the bunker delivery note are specified in the annex to part C-1 of IGF Code. The bunker delivery note may need to be accompanied by any other document (s) (for e.g. proof of sustainability certificate (as per a recognized International Certification Scheme)) as may be required by the relevant statutory authorities/ flag Administration.

Annex A: Guidance on HAZID and HAZOP for LNG Bunkering Operations

This annex presents the minimum scope for the HAZID and HAZOP related to LNG Bunkering

A.1 HAZID

A.1.1 Objective

The principal objectives of the HAZID should identify:

- Hazards and how they can be realised (i.e. the accident scenarios)
- The consequences that may result
- Existing measures/safeguards that minimise leaks, ignition and potential consequences, and maximise spill containment; and
- Recommendations to eliminate or minimise risks

A.1.2 Scope

As a minimum the HAZID should include the scope as described in Section 6. It should be complemented with an HAZOP (Hazard and Operability) assessment after all safeguards have been implemented.

A.1.3 HAZID Process

The HAZID process should be carried out in accordance with a recognised technique using experienced subject matter experts. It is recommended that professional guidance is sought to ensure that the process is carried out to an adequate and appropriate level of detail.

The outcomes of the HAZID include hazard rankings and recommendations for additional safeguards and analysis. This may include detailed analysis or studies to establish that the measure in place meet the acceptance criteria agreed by the Administration.

A.1.4 Technique

To facilitate the HAZID process, the bunkering process may be divided into smaller steps each of which are then addressed systematically:

It is recommended that the following list is used to structure the HAZID exercise for LNG bunkering

- Preparation (compatibility, testing, mooring)
- Connection
- Inerting of relevant pipe sections
- Cooling down
- Transfer start
- Transfer at nominal flow
- Transfer stop including topping-up
- Draining and purging
- Inerting
- Disconnection
- Debriefing
- Security

A.1.5 Guidewords

The following guidewords may be used to help the HAZID Process:

Leakage	Boil-off gas management during bunkering	Potential fire and explosion
Rupture	Control failure	Excessive transfer rate
Corrosion	ESD valves control failure	Hydraulic Power Unit failure
Impact	ERC actuator failure	Communication failure
Fire/Explosion	ERC spring failure causing not closing	Black out
Structural integrity	Loss of containment (piping, valves)	Relative motions of vessels
Mechanical failure	Hose damage	SIMOPS
Control/electrical failure	Hose rupture	Unexpected venting
Human error	Major structural damage	Harsh weather
Manufacturing defects	Gas leak	Lightning Strikes
Material selection	Gas dispersion	Cryogenic Leaks
Flange or connector failure	Gas in air intake	Cooling down operation wrong

A.2 HAZOP

A.2.1 Definition

The HAZOP study is a structured and methodical examination of a planned process or operation in order to identify causes and consequences from a deviation to ensure the ability of equipment to perform in accordance with the design intent. It aims to ensure that appropriate safeguards are in place to help prevent accidents. Guidewords are used in combination with process conditions to systematically consider all credible deviations from normal conditions.

A.2.2 Process

The HAZOP should be realised with a focus on the LNG bunkering, storage and delivery to the engines. The operational modes for the receiving ship to be considered are:

- Start-up
- Normal Operations
- Normal Shutdown, and
- Emergency Shutdown

A.2.3 Scope

The HAZOP should review the following cases but not limited to:

- Joining together of the emergency shutdown systems of the Bunkering Facility, Receiving Ship and transfer system
- Emergency procedures in the event of abnormal operations
- Leakage from hoses
- Overpressure of the LNG Tank
- Emergency unmooring
- Emergency venting of LNG or Vapour
- Additional Protection for Ship’s hull in case of fuel leakage at the manifold
- Emergency shut down and quick release protocol
- Requirements for external assistance such as tugs

- Loss of power

The following should be analysed:

- Connection
- Inerting of piping
- Cooling down
- Transfer start
- Transfer at nominal flow
- Transfer stop including topping-up
- Draining
- Inerting
- Disconnection
- Fatigue, stress and human errors

It is recommended that emergency disconnection at the receiving ship's manifold should be addressed by the bunkering operations risk assessment in order for any potential impact of the system within the receiving ship's bunker station lay-out to be identified and additional mitigation or support utilities to be incorporated as appropriate.

Both HAZID and HAZOP processes will produce a list of recommendations and an action plan. These action plans will address each recommendation developed and provide a means for tracking the hazards for assessment and implementation.

Annex B: Checklists for LNG Bunkering

Please refer to the checklists published by the World Ports Sustainability Program as available on their website:

https://sustainableworldports.org/clean-marine-fuels/lng-bunkering/bunker-checklists/

Annex C: Sample Bunker Delivery Note

LNG Bunker Delivery Note

Ship Name: ____________________
IMO Number: ____________________

1. LNG Properties

Methane Number **	-	________
Lower Calorific Value	MJ/kg	________
Higher Calorific Value	MJ/kg	________
Wobbe Indices W_s/W_i	MJ/m^3	________
Density	Kg/m^3	________
Pressure	MPa (abs)	________
LNG Temperature of Delivery	ºC	________
LNG Temperature in Fuel Storage Tank(s)	ºC	________
Pressure in Storage tanks	MPa (abs)	________

** Preferably above 70 and referring to the used methane number calculation method in DIN EN 16726. This does not necessarily reflect the methane number that goes into the engine

2. LNG Composition

Methane (CH_4)**	% (kg/kg)	_______
Ethane (C_2H_6)	% (kg/kg)	_______
Propane (C_3H_8)	% (kg/kg)	_______
Iso-Butane (C_4H_{10})	% (kg/kg)	_______
N-Butane (C_4H_{10})	% (kg/kg)	_______
Pentane (C_5H_{12})	% (kg/kg)	_______
Hexane (C_6H_{14})	% (kg/kg)	_______
Heptane(C_7H_{16})	% (kg/kg)	_______
Nitrogen(N_2)	% (kg/kg)	_______
Sulphur (S)	% (kg/kg)	_______

negligible<5ppm hydrogen sulphide, hydrogen, ammonia, chlorine, fluorine, water

3. Net Quantity Delivered

Net Total Delivered ______________ Tonnes ____________ MJ ____________ m^3
Net Liquid Delivery ______________ GJ

4. Signature

Supplier:
Name & Contact Details
Signature
Port/Anchorage
Date & Time
Signatory on behalf of Receiver
Signature of Receiver