European Maritime Safety Agency

Guidance on LNG Bunkering

to Port Authorities and Administrations

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EMSA

Cover Image
Courtesy: AGA

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Foreword

The European Maritime Safety Agency (EMSA) has been established under Regulation (EC) 1406/2002 (as amended) of the European Parliament and of the Council for the purpose of ensuring a high, uniform and effective level of maritime safety, maritime security, prevention of and response to pollution caused by ships as well as response to marine pollution caused by oil and gas installations.

Articles 1 and 2 (d) of the amended Founding Regulation foresee that the Agency shall assist the Commission in the performance of tasks assigned in legislative acts of the Union, including the ones in the field of prevention of pollution caused by ships. To that end, EMSA works on the development of mechanisms to support the implementation and uniform enforcement of Directive 2014/94/EU *on the deployment of an alternative fuels infrastructure* and in particular the development of the EMSA LNG Bunkering Guidance for Port Authorities and Administrations.

In the above context the present document is developed in the frame of the implementation of Directive 2014/94/EU respecting to LNG as a marine fuel and, in that frame, it is suggested as complementary to other reference documents (rules, standards and other guidance documents). No overlapping of existing requirements or industry guidance is intended and, should the main objective be summarised in one word, the EMSA Guidance aims at harmonization of requirements throughout ports in Europe, in good respect of safe and environmental bunkering operations with LNG fuelled ships.

Port Authorities are here seen as fundamental players in the middle of a two-fold driver for the development of LNG as fuel in Ports. On one hand the expected increase in demand from LNG fuelled ships and, on the other hand, the regulatory requirements set by Directive 2014/94/EU on the 'Deployment of an Alternative Fuel Infrastructure'. The International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code), entering into force on the 1st of January 2017 and the decision for the 0.50% global sulphur cap by IMO, on the international stage, have been the most recent key factors favouring certainty in the adoption of LNG as fuel for shipping. The Directive 2014/94/EU, provides legal certainty to all potential users that LNG will be widely available in EU ports by requiring Member States to put in place an appropriate number of refuelling points for LNG to enable LNG inland waterway vessels or seagoing ships to circulated throughout the EU TEN-T Core network by 31 December 2025.

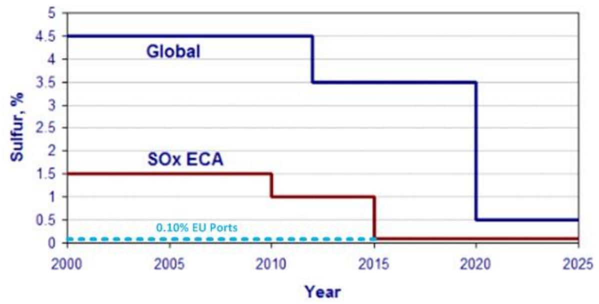
An increase in LNG bunkering activities is therefore foreseen, with more ports offering LNG bunkering, also as a competitive advantage. Functional and technical requirements have been developed, assisting LNG bunkering operations with a procedural framework and with technical provisions for LNG bunkering equipment. Notwithstanding industry preparations for LNG Bunkering it is important to provide Port Authorities with the necessary information and suggested good practice for this type of operation.

Several challenges have been addressed recently and solutions have been implemented on a significant number of small scale LNG bunkering installations/operations, involving LNG fuel trucks, barges and small scale fixed shore installations. Port Authorities have been fundamental to the development of LNG fuel offer in ports, working together with other stakeholders within a frame of sustainable development in maritime ports.

The procedures used to develop this document included consultation with different stakeholders, including port authorities, maritime administrations, terminal, gas suppliers and government representatives and with the LNG experts sub-group of the European Sustainable Shipping Forum (ESSF). Further to all consultations the work has been assisted by an online survey that allowed all participating ports and other stakeholders to contribute. The result is a document holding an ambivalent “informative” and “guidance” nature, aiming to provide Port Authorities/Administrations with the necessary advice and reference to guide their actions throughout the planning and operational stages of LNG bunkering.

Introduction

LNG as an alternative fuel for Shipping has been increasingly adopted as a strategy for environmental compliance, either sailing or at port. With an immediate significant impact on the reduction of Sulphur Oxides emissions (SOx), Particulate Matter (PM), and also of Nitrogen Oxides (NOx) the motivations for the use of LNG as fuel in maritime transport are today highly favoured by a relevant multi-layered regulatory frame. At international level MARPOL Annex VI defines gradual and tiered approaches to the reduction of both SOx and NOx, respectively through Regulations 14 and 13 (figures 1 and 2, below).



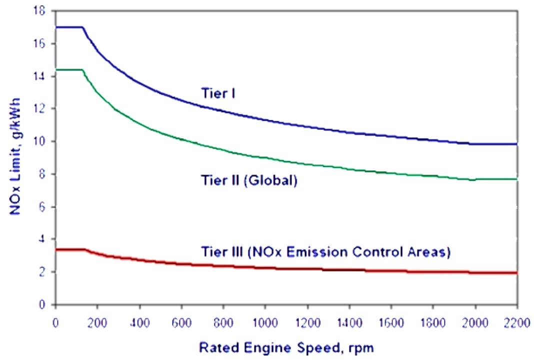


Fig.1 – SOx staged reduction (MARPOL Annex VI)

Fig.2 – NOx tiered reduction (MARPOL Annex VI)

On the Safety page the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code), entering into force on the 1st January 2017, establishes the requirements for safe design, construction, and operation, of LNG fuelled vessels. On the EU frame the Sulphur Directive (Dir. 2012/33/EU) and the Directive on the deployment of an Alternative Fuels Infrastructure (Dir. 2014/94/EU) establish the particular European framework for the development of LNG as an alternative fuel for shipping. The Sulphur Directive by including LNG as a possible Emission Abatement Method[1], and Directive 2014/94/EU by establishing the clear obligation for EU Member States to make LNG, as an alternative fuel for shipping, available at maritime ports[2] by the end of 2025 (for inland waterways ports the target objective is set for the end of 2030).

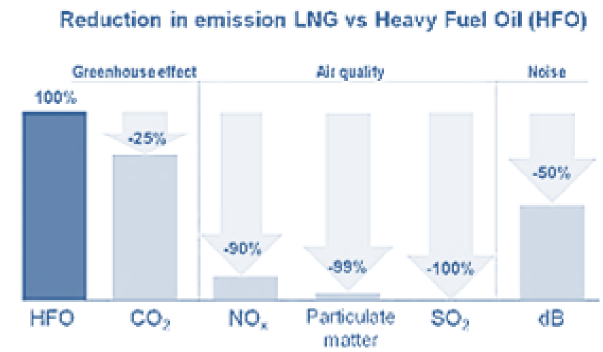


Fig.1 – MS Bergensfjord – LNG fuelled RO-PAX – LNG Fuelled vessels, from the outside, follow the exact same lines of traditionally fuelled vessels. LNG fuel is often, especially in passenger vessels, a feature not perceived from the outside. (courtesy of FJORDLINE)

Fig.2 – Potential reduction of air emissions (relative to use of HFO). The total elimination of Particulate Matter and Sulphur dioxide is the most relevant benefit, at local level, of a switch to LNG fuel.

[1] Reference is made to the provisions in the Sulphur Directive (Directive 2012/33/EU) allowing for the use of different Emission Abatement Methods, as defined by Article 4 c), subject to the criteria listed in Annex II of the Directive. In the letter of Article 4 c) *Member States shall allow the use of emission abatement methods by ships of all flags in their ports, territorial seas, exclusive economic zones and pollution control zones, as an alternative to using marine fuels that meet the low-sulphur requirements.*
It remains however to be noted that the criteria specified in the Sulphur Directive relates to the use of a mixture of BOG (*Boil Off Gas)* with HFO, by LNG carriers, at port, in order to meet the 0,10% EU sulphur cap in ports. Notwithstanding this LNG is used as an alternative fuel, representing a clear option for ships that, otherwise, would have to either use low-sulphur oil fuels or adopt a different Emission Abatement Method.

[2] Member States to put in place an appropriate number of refuelling points for LNG to enable LNG inland waterway vessels or seagoing ships to circulated throughout the EU TEN-T Core network by 31 December 2025 (List of ports available at: http://ec.europa.eu/transport/sites/transport/files/modes/maritime/ports/doc/2014_list_of_329_ports_june.pdf)

In the above context the development of LNG as an alternative fuel for shipping has been remarkably fast, with the involvement of ship operators, shipyards, Class Societies, different national competent authorities, including the obvious and fundamental active participation of Port Authorities. The technological steps given in the design of LNG fuelled vessels and LNG bunkering operations has been fast and keeping every stakeholder at the same pace in the development process is essential for a coherent, consistent and harmonized deployment of a safe LNG. The industry has been paramount in the whole process, adopting a good part of the LNG knowledge.[3]

LNG for shipping in a Nutshell

The table below summarizes the main technology aspects of LNG as fuel for shipping, with a brief indication of the main advantages and current challenges for this alternative fuel.

Table 1 – LNG for Shipping in a Nutshell, Technology, Advantages and Challenges

	Technology	Advantages	Challenges
Liquefied Natural Gas (LNG)	Natural Gas stored as a cryogenic liquid. The temperature required to condense natural gas depends on its precise composition, but it is typically between -120 and -170°C (-184 and –274°F). LNG carriers have used this alternative fuel for more than 40 years now, mainly as a result of conveniently making use of cargo vapours due to impossible 100% insulation effectiveness. Onboard storage of LNG is typically a challenge for ship design Engine concepts include gas-only engines, dual fuel 4-stroke and 2-stoke.	Environment. Environmental gains, both in GHG emissions and other relevant substances such as NOx, SOx and Particulate Matter. Availability. Increasing availability of Natural gas Sources. Energy Content. Energy density comparable to petrol and diesel fuels, extending range and reducing refuelling frequency Momentum. Significant number of first-mover initiatives with an increasing number of ships adopting LNG as fuel. Cost Effective. LNG achieves a higher reduction in volume than compressed natural gas (CNG) so that the (volumetric) energy density of LNG is 2.4 times greater than that of CNG or 60 percent that of diesel fuel.	GHG Impact. LNG is mostly composed of Methane (CH4) – comparative impact of CH4 on climate change is more than 25 times greater than CO2 over a 100-year period. Careful consideration needs to be given to any form of methane release throughout the Well-to-Wake chain of LNG (i.e. over the life cycle of the fuel). Capital Investment. Relatively high investment costs Bunkering. LNG bunkering infrastructure still in development. Safety. Safety concerns associated to Low flashpoint and cryogenic nature of LNG.

The full potential of LNG as Fuel for Shipping is yet to be explored. Many studies have been carried out to explore the technical and economic feasibility of this fuel and the results have shown promising conclusions leading to the inevitable assumption that further development of LNG ship fuel solutions will be seen in a very near future. Context driven aspects, such as fuel oil prices, are a possible “slowdown factor” for the adoption of LNG, nevertheless it is important to develop the tools and the understanding that LNG as fuel will be a reality which will grow in maritime transport. In the same inevitable way Ports will have to consider due facilitation of LNG, depending on specific technical (and business) feasibility, risk and safety, amongst other factors. The present guidance is proposed as an additional tool to assist Port Authorities to welcome LNG as fuel in a clear and safe manner.

Background

As mentioned above, LNG is today a technically feasible option as an alternative fuel for shipping. An increasing number of ships have adopted it, with an increasing number of newbuilds at the order book. The forecasts, despite any context related oil price variations, still present an interesting uptake in all major ship types.

[3] A good part of the responsibility for the consolidation of knowledge and experience transferability from LNG cargo to LNG as a fuel for shipping is to be given to the Society for Gas as a Marine Fuel (SGMF, a new non-governmental organisation (NGO) established to promote safety and industry best practice in the use of gas as a marine fuel.

Fuel engine technology; ship design; fuel tank containment systems; control & detection, amongst other, are some of the different areas where LNG fuelled vessels can differ from each other. The technological diversity however does, in all cases, introduce an increase in systems' complexity, and the low flashpoint nature of LNG highlights the Risk & safety concerns with a fuel that is not only physically so different from traditional oil fuels but that also brings additional operational challenges regarding its transport, delivery and use.

On the regulatory context, the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code), approved in its final draft version in June 2015, is due to enter in force on the 1st January 2017. It contains mandatory provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using low-flashpoint fuels, focusing initially on LNG. The Code addresses all areas that need special consideration for the usage of low-flashpoint fuels, taking a goal-based approach, with goals and functional requirements specified for each section forming the basis for the design, construction and operation of ships using this type of fuel.

LNG bunkering operations are however characterized by the interaction of multiple stakeholders and different regulatory contexts. This poses a challenge in different levels.

Whereas the IGF Code establish technical and functional requirements for LNG bunkering equipment and operations, its focus is mainly on the receiving vessel, and on its preparation for safe LNG bunkering operations. The bunkering interface is of course required to incorporate these requirements and be in line with them, ensuring consistency with other relevant regulatory instruments such as the ADR Convention or the Seveso Directive. Some functional requirements for bunkering have been included in the draft IGF Code but are mostly related to the receiving vessel, leaving the organization for bunkering, from the port side, outside of scope. Some important concepts are however included in the IGF, particularly in Chapter 18 where the "Person in Charge" (PIC) is defined, together with requirements on Check-lists and Communications, only to mention a few.

Recent Standards & Guidance Development for LNG Bunkering

There are currently different standards and guidance on LNG bunkering, either developed or under development. ISO has issued the ***Guidelines for systems and installations for supply of LNG as fuel to ships*** **(ISO/TS 18683:2015)**, early in 2015, and is currently working on the finalization of **ISO/DIS 20519** ***Specification for bunkering of gas fuelled ships.*** The last document is expected to bring a substantial set of functional requirements for LNG bunkering equipment and operations, including aspects such as bunker connectors, hoses, risk assessment, communications, safety distances, amongst many other aspects.

SGMF, also early in 2015, has launched their ***SGMF LNG Bunkering Safety Guidelines***, as the reflection from contribution of different industry stakeholders, with the objective to provide the LNG bunkering industry with the best practices in order to ensure that LNG fuelled ships are re-fuelled with high levels of safety, integrity and reliability. The LNG Bunkering Safety Guidelines include chapters on LNG Hazards (Leaks, Cryogenic, LNG Fire and Explosion), Safety Systems (Roles, People in Charge, Communications and Emergency Systems), Bunkering Procedures and Specific Safety Guidance for the different LNG bunkering modes.

IACS, the International Association of Classification Societies, has published[4] in June 2016 the **IACS *Recommendation on LNG bunkering* (Rec.142)**, a document which would later result in an update of the SGMF LNG Bunkering Safety Guidelines, in May 2017, with this later document incorporating both earlier SGMF work and the integral reproduction of Rec. 142.

Finally, the International Association of Ports and Harbours (IAPH) have developed specific **LNG bunker checklists (*IAPH LNG Bunker Check-Lists*)** for known LNG bunkering scenarios: ship-to-ship, shore-to-ship and truck-to-ship. These check-lists include specific requirements relevant for all parties involved in the LNG bunkering operations and are already in place in some ports where LNG bunkering operations are already in place.

Collectively, the above standards and guidelines represent the most significant set of references for LNG bunkering operations, today. Together with different national requirements and local/port regulations they are instruments for safe LNG bunkering operations, including provisions on risk &

[4] IACS – Rec.142 – Recommendation on LNG Bunkering
http://www.iacs.org.uk/publications/publications.aspx?pageid=4&sectionid=5

safety, bunkering/transfer equipment, training, bunkering procedures, amongst other aspects. Different bunkering modes are included and all stakeholders involved are featured with proposed good practice for safe operations addressing all parties. The receiving LNG-fuelled vessel, the LNG bunker barge/vessel; LNG truck; Terminal Operators, Person-in-Charge (PIC); they all find specific requirements which are relevant either to the equipment used in LNG bunkering operations, or to the procedures established as basis for the operation. Despite some variations in terminology, all existing guidance mentioned above is consistent with a common 3-phase approach, dividing LNG bunkering, in whichever mode, into 1) Pre-Bunkering; 2) Bunkering and 3) Post-Bunkering. An additional 4th phase can even be considered: the Planning (where feasibility, risk and other studies pertaining permitting and certification are developed).

The missing part, in the opinion of the ESSF and its subgroup of experts on LNG, is the guidance to Port Authorities/Administrations in the specific context of LNG bunkering planning, permitting and operations. Check-Lists and guidance, as mentioned above, give a good reference to the requirements for Ports to put in place; however this is only part of what is expected from competent port authorities. Byelaws, permitting, risk-based restrictions and tailor-made Emergency Response, amongst other aspects, are exclusive areas where Port Authorities/Administrations are given statutory powers and develop measures for good governance within the port area under their jurisdiction. Guidance to these competent authorities, on the different relevant aspects of LNG bunkering, is the objective of this document. The simple diagram presented in figure 1, below, (further developed in the definition of the Scope for the present guidance) presents the complete frame for LNG Bunkering where a triangle is completed between LNG Bunker supplier, Receiving Vessel and Port (competent) Authority.

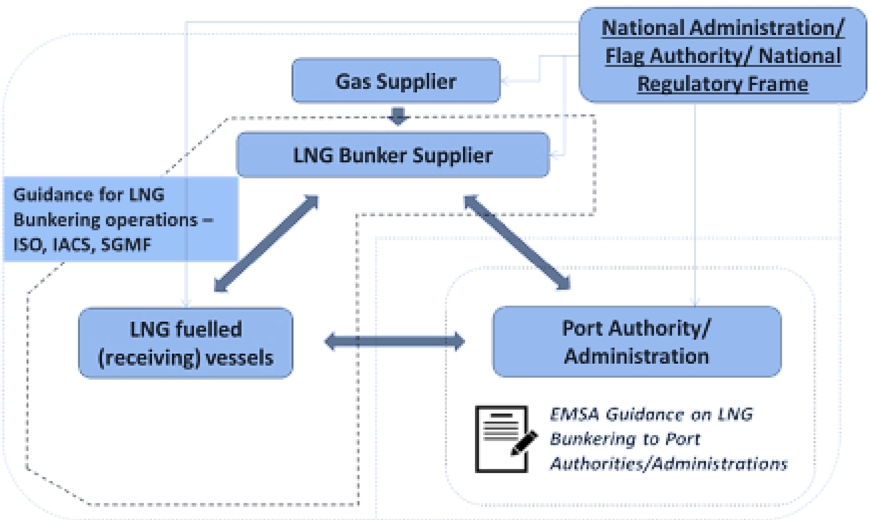


Fig.5 – LNG Bunkering main stakeholder triangle

EU Context

Directive 2014/94/EC *on the deployment of alternative fuels infrastructure*, part of the EU Clean Power for Transport package establishes a comprehensive set of requirement for an inter-modal development of an alternative fuel infrastructure. As defined by Directive 2014/94/EC, availability of LNG in EU core ports is scheduled for 31 December 2025 (maritime ports) and 31 December 2030 (inland ports), with the same document establishing an obligation for EU Member States to develop appropriate standards *containing detailed technical specifications for refuelling points for LNG for maritime and inland waterway transport*.

In the context of the Directive, EU Member States are currently developing their National Policy Frameworks, in line with the provisions of Article 3 of the same instrument, to be notified to the European Commission by 18 November 2016. Following the notification of these, down to the operational level and towards implementation, it is important that EU harmonization can be supported, not only by reference to higher level international documents, standards or guidelines, but also by having in place guidance to the lower level requirement definition, where local and port authorities are envisaged.

Despite the provisions of the Directive, in fact, LNG bunkering is already well advanced and taking place in several ports in Northern Europe, with first movers and pilot project initiatives where LNG fuelled vessels operation represent the largest share of the worldwide LNG fuelled fleet. Co-financing programs, such as the CEF[5], for studies, pilots and implementation works have been promoting and facilitating this development. It is now important to extract the main lessons learnt, specific experience-based advice and to address the most relevant challenges to harmonization, such as permitting procedures and training/qualification requirements for all those involved in the operation.

The Engineering solutions are already in place, demonstrated not only through the implementation of different LNG bunkering initiatives but also in several Feasibility Studies for prospective projects and ongoing implementation works. Not only it is possible to bunker LNG to a variety of different LNG fuelled vessels but also it is possible to do it safely and following a variety of different possible bunkering modes. The infrastructure is therefore expected to develop highlighting further the need to have a consistent minimum set of good practice references which, together with the existing standards and industry guidelines, can assist authorities in the different areas of LNG bunkering.

[5] CEF – Connecting Europe Facility is a policy aiming to realise a core transport network comprising nine major corridors, to be completed by 2030. The infrastructure package stipulates a need to update the current energy infrastructure and also identifies a need to improve gas infrastructure. As part of the CEF, this package identifies priority gas corridors and projects that can be considered potential projects of public interest and likely to need funding under CEF.

Guidance Map

The table below presents this Guidance map, with the structure

Table 2 – Guidance Map

Part	Section	Title	Key Contents
A. General	1	Scope and Applicability	Scope and Application of the Guidelines
	2	LNG as Fuel	LNG as fuel LNG Bunkering modes Introduction to Equipment
	3	Environment	Good Environmental practice in LNG Bunkering
B. Governance	4	Regulatory Frame	Rules, regulations and standards Guidelines - Overview Check-lists
	5	Ports	Port governance principles Good governance and framework for LNG bunker operations in the port Drivers for LNG Bunkering options
	6	Feasibility	Feasibility studies Evaluation and support to prospective projects
	7	Permitting	Permitting Procedure Bunkering Location Selection Information management
C Risk & Safety	8	Risk	LNG Hazards Risk Criteria Risk Assessment Evaluation
	9	Control Zones	Safety Distances & Control Zones
D Organization	10	Process Map & Organization	LNG Bunkering Process Responsibilities
	11	SIMOPS	Simultaneous Operations
E Bunkering	12	Bunkering	LNG Bunkering Procedure Pre-bunkering Check-Lists Weather & Operational Envelopes Authorization Procedure Communications Lighting, Mooring and Access Control & Overview Traffic control Post-bunkering checks Purging and Inerting
	13	Incident Reporting	LNG release reporting Incident reporting procedure Near Misses
F Emergency	14	Emergency Preparedness & Response	Emergency, Preparedness and Response for different stages of the LNG Bunkering Process Approval of Emergency Response Plans Shore side contingency Plans
D Certification	15	Certification, Accreditation	Compatibility Assessment Accreditation Certification
	16	Qualification and Training	Qualification for personnel involved in LNG Bunkering Training

List of Abbreviations

ACDS	Advisory Committee on Dangerous Substances
ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways.
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road is a 1957 United Nations treaty that governs transnational transport of hazardous materials.
ALARP	"As Low As Reasonably Possible"
AIR	Acceptable Individual Risk
BFO	Bunker Facility Organisation
BOG	Boil-Off Gas
CCNR	Central Commission for Navigation in the Rhine
DWT	Deadweight tonnage
EAM	Emission Abatement Method
EC	European Commission
ECA	Emission Control Area
EEDI	Energy Efficiency Design Index
EMCIP	European Maritime Casualties Information Platform
EMSA	European Maritime Safety Agency
EPR	Emergency, Preparedness & Response
ERC	Emergency Release Couplings
ERS	Emergency Release System
ESD	Emergency Shutdown System
EU	European Union
FMEA	Failure Modes and Effects Analysis
FSU	Floating Storage Unit
GT	Gross Tonnage
HAZID	Hazard Identification
HAZOP	
HCRD	Hydrocarbon Release Database
HFO	Heavy Fuel Oil
HSE	Health & Safety Executive
IACS	International Association of Classification Societies
IAPH	International Association of Ports and Harbours
IMO	International Maritime Organization
ISGOTT	International Safety Guide for Oil Tankers and Terminals
ISO	International Standardization Organization
LCV	Level Control Valve
LDT	Light Displacement Tonnes
LEL	Lower Explosive Limit

LFL	Lower Flammability Limit
LNG	Liquefied Natural Gas
LNGBMP	LNG Bunkering Management Plan
LOC	Loss of Containment
LOD	Line of Defence
LSIR	Location-Specific Individual Risk
MARPOL	International Convention for the Prevention of Pollution from Ships
MARVS	Maximum Allowable Relief Valve Setting
MGO	Marine Gasoil
NG	Natural Gas
P&ID	Piping & Instrumentation Diagram
PAA	Port Authorities & Administrations (used throughout the document for simplification in the text)
PLC	Programmable Logic Controller
PIV	Person in Charge
PPE	Personal Protective Equipment
PSC	Port State Control
PSCO	Port State Control Officer
PTS	Port-to-Ship (in some references: Terminal (Pipeline)-to-Ship)
QRA	Quantitative Risk Assessment
QualRA	Qualitative Risk Assessment (ISO/TS 18683)
QCDC	Quick Connect/Disconnect Coupling
RA	Risk Assessment
RO	Recognised Organisation
RP	Recommended Practice
SECA	Sulphur Emission Control Areas
SGMF	Society for Gas as a Marine Fuel
SIGTTO	Society of International Gas Tanker and Terminal Operators
SIMOPS	Simultaneous Operations
SoC	Statement of Compliance
SSL	Ship Shore Link
STCW	IMO Code for Seafarers' Training, Certification and Watchkeeping
STS	Ship-to-Ship
SWIFT	Structured What-If Checklist (SWIFT) technique
TTS	Truck-to-Ship
UEL	Upper Explosive Limit
UFL	Upper Flammability Limit
UNECE	United Nations Economic Commission for Europe
WPCI	World Ports Climate Initiative

Instructions Guidance

The *EMSA Guidance on LNG Bunkering to Port Authorities/Administrations*, hereafter referred to as "EMSA Guidance" offers, simultaneously, a reference to guide Port Authorities/Administrations (PAAs) through the relevant stages of LNG Bunkering Planning and Operations and, at the same time, an informative source on the different. The EMSA Guidance is divided into 4 (four) main Sections and 17 (seventeen) sub-sections as presented in the Guidance Map. The table below presents the main objectives and practical aspects that can be found in each of the fifteen sub-sections.

Table 3 – EMSA Guidance on LNG Bunkering – Sections insight

Part	Section		Key Contents
A. **General**	**1**	Scope and Applicability	• Scope and Applicability of the EMSA Guidance are defined, especially in the context of other guidelines, standards and references of good practice in the context of LNG Bunkering. • List of Terms / Definitions with references.
	2	LNG as Fuel	• Informative section on the characteristics of LNG as fuel for shipping. • LNG Bunkering options and other possible operations with LNG as fuel
	3	Environment	• Overall benefits of LNG as fuel, remarkably on the reduction of GHG/CO2 emissions, are highly dependent on the adequate understanding of methane emission's environmental impact. • Apart from the informative aspects the present section defines best practice guidance to avoid mitigate the risk of natural gas emissions during LNG bunkering operations.
B. **Governance**	**4**	Regulatory Frame	• List of the main relevant instruments for LNG as fuel for shipping, with a particular focus to those where references to Bunkering can be found. • Description of the main references and applicability of different instruments on LNG Bunkering. • Best practice for the formulation of Port Regulations in the context of LNG bunkering.
	5	Ports	• LNG Bunkering is here regarded in the context of Ports Good Governance. Different Port management principles are considered and their particular aspects are, again, used to frame the specific case of LNG Bunkering. • In essence, sub-section 5 addresses the main aspects of Ports Good Governance, making the parallel with the LNG Bunkering development, from Planning to Operations.
	6	Feasibility	• A Feasibility Study incorporates a large number of aspects that are relevant for the development of LNG Fuel infrastructure. The elements which are relevant to Ports should be, on top of those directly related to the bunkering interface, also distribution links within Port Area, LNG small scale storage and others. • Only technical and operational aspects are included. Economic feasibility outside the scope of this document
	7	Permitting	• Sub-section intended to provide best practice in permitting processes for LNG Bunkering. • Included flow-chart with reference permitting process.
C **Risk & Safety**	**8**	Risk	• Part on LNG Risk / Safety including information on LNG safety hazards, risk assessment options, HAZID, HAZOP and related concepts. Not extensive and mostly referring to existing references on LNG and Natural Gas. • Best practice guidance on how to assess/evaluate Risk Assessment Reports. List of relevant elements/contents for a

			Risk Study on LNG Bunkering. • Risk Criteria – Existing Risk Criteria applicable to LNG Bunkering.
	9	Control Zones	• Best practice in the approval and definition of Control Zones, in particular of Safety Zone and Hazardous Zone. • Examples of best practice application in the definition of Control Zones.
D. **Organization**	**10**	Process Map & Organization	• The core process of LNG Bunkering operation is defined, with consideration for different LNG Bunkering concepts. • Definition of Responsibilities.
	11	SIMOPS	• Proposal for a procedure to facilitate Simultaneous Operations during LNG bunkering.
E. **Bunkering**	**12**	Bunkering	• Bunkering process, with outline of the relevant events in bunkering, supported in a demonstration of an LNG transfer operation between two pressurized tanks (type-C) • Definition of the main technical concepts in the bunkering operation. • Outline of the necessary actions, from a Port Authority perspective, to be taken before, during and after LNG bunkering operation is authorized. • Procedures in Communications, Approval of Bunkering Operation, Implementation of Safety Controls, Verification
	13	Incident Reporting	• Definition of best-practice procedure for LNG Bunkering incident and near-miss reporting. • Check list / template provided with the essential elements suggested for LNG bunkering incident, or near-miss, reporting.
F. **Emergency**	**14**	Emergency Preparedness & Response	• Best practice in Emergency, Preparedness and Response in the case of LNG related incidents, addressing all hazards listed in sub-section 8. • Emergency Plan for LNG Bunkering.
G **Certification**	**15**	Certification & Accreditation	• Definition and differentiation of the different concepts. • Certification of LNG Bunkering equipment. Identification of relevant certification processes
	16	Qualification Training	• Qualification for the necessary competencies to operate in LNG bunkering • Training for and on LNG Bunkering. In addition to the competences and qualification requirements. Training program for the Port Authority on LNG Bunkering supervision and Emergency response

The objectives inside each section, as above described, is to provide PAAs with Information and Guidance on LNG Bunkering. Firstly, Information on the aspects already covered by other instruments (regulations, standards, industry guidelines), such as technical requirements for design, LNG bunkering concepts, modes and procedures for safe LNG transfer. Secondly, by providing Guidance to Port Authorities and Administrations in developing of the necessary control mechanisms, allowing for the safe development of LNG bunkering in EU Ports.

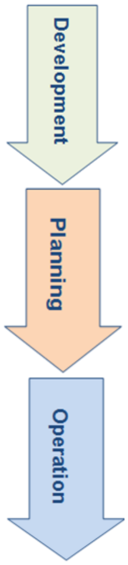
The Guidance is structured in 4 (four) parts and 15 (fifteen) sections, following the natural sequence of the LNG bunkering Process. Each section contains Information and Guidance in a distinguishable manner through the format of the text and structure given to each sub-section. Figure 6, in the next page shows the difference in text section format between more informative part and the good[6] practice guidance provided to PAAs by this Guidance.

[6] The word ‘best’ is generally not used in the onshore/offshore industries. This is because the goal is to encourage good practices that meet the legal requirements. The word ‘best’ implies exceeding the legal requirements (it also implies there is nothing better). For many reasons (often cost) ‘best’ cannot be adopted although ‘good’ practices can and are more likely to be adopted.

Labels are provided on the side of the document, dividing further the Guidance into the 9 (nine) labels as presented in tables 2 and 4. The labels provided for an intuitive division where the titles and sections are divided according to the sequence in LNG Bunkering.

Table 3 – EMSA Guidance on LNG Bunkering – Sections insight

Part	Section	Title	Labels
A. General	1	Scope and Applicability	GENERAL
	2	LNG as Fuel	
	3	Environment	
B. Governance	4	Regulatory Frame	GOVERNANCE
	5	Ports	
	6	Feasibility	
	7	Permitting	
C. Risk & Safety	8	Risk	RISK
	9	Control Zones	
D. Organization	10	Process Map & Organization	ORGANIZATION
	11	SIMOPS	
E. Bunkering	12	Bunkering	BUNKERING
	13	Incident Reporting	
F. Emergency	14	Emergency Preparedness & Response	EMERGENCY
G. Certification	15	Certification	CERTIFICATION
	16	Qualification & Training	



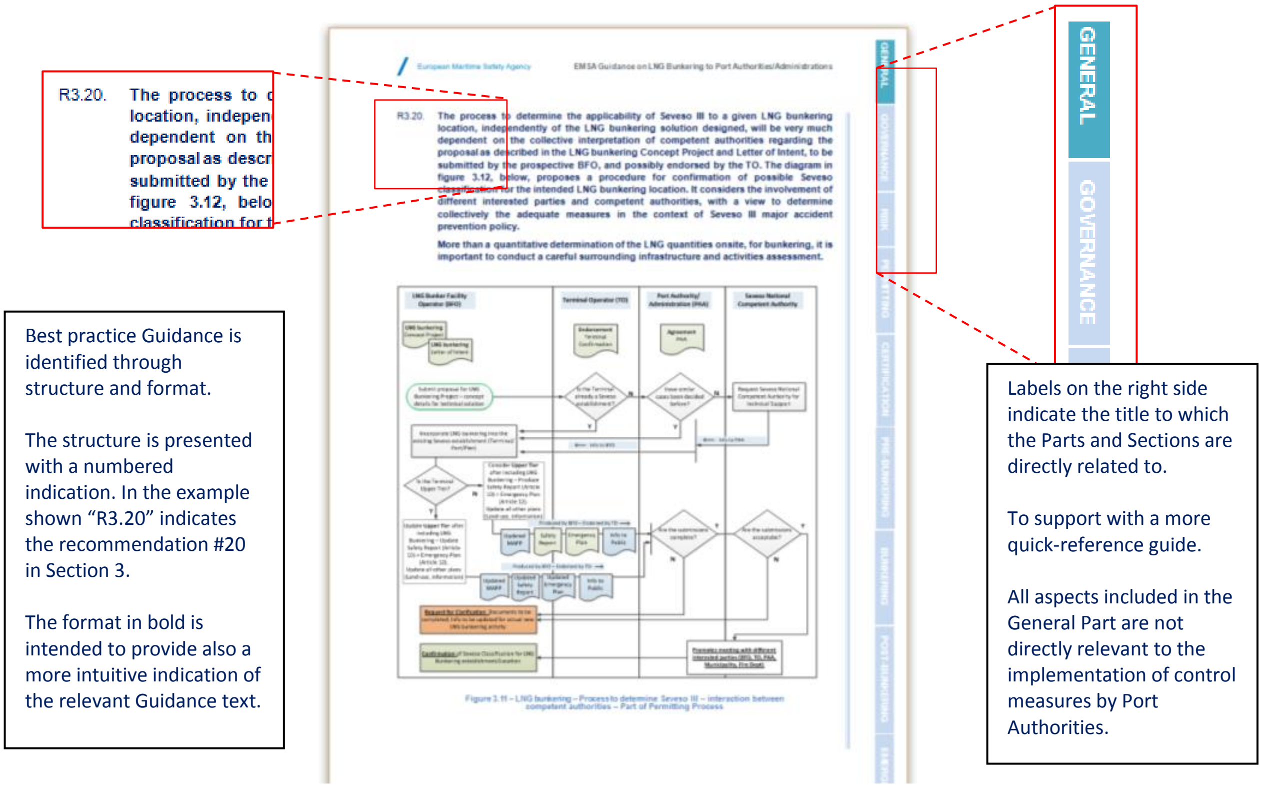


Fig.6 – EMSA Guidance – Visual presentation of Best Practice recommendations

1. Scope, Applicability & Definitions

This Guidance sets best practice control measures for LNG bunkering, and small scale LNG storage, relevant to Port Authorities-Administrations in their role on permitting, evaluating, approving, certifying, controlling, overviewing, documenting and providing/coordinating response in case of emergency.

1.1 Scope

The scope of this Guidance is limited to LNG bunkering[7], covering the following elements[8]:

Regulations

- High level instrument at EU and international levels, relevant for LNG bunkering.
- Standards
- Guidelines
- Industry best practice
- Port Regulations

Operations

- Control Zones
- Safety Distance approval
- Simultaneous Operations (SIMOPS)
- Mooring of the receiving ship and bunker facility.
- Check-lists
- Operational Envelopes (weather conditions, sea state, wind speed and visibility)
- General Procedures for Port Authorities.

Permitting

- Spatial planning
- Approval of bunker locations.
- Definition of simplified
- Overall responsibility for the good governance and framework for LNG bunker operations in the port.

Risk & Safety

- LNG Bunkering Risk Assessment
- Definition of Risk Acceptance Criteria
- Evaluation of Risk Assessment reports – Best practice for the evaluation of Risk Assessment report.

Emergency

- Approval of safety and emergency response plans
- Emergency Preparedness & Response Plan
- Shore side contingency plans, emergency response systems.
- Definition of emergency procedures for the different types of LNG Bunkering.
- Best practice in response to LNG Hazards.

Quality Management

- Several elements considered relevant to ensure the quality of the LNG bunkering process, from a PAA perspective.
- Check-lists updated to include relevant indications for PAAs.
- Incident Reporting.
- Port Bye laws. Best practice in setting up port specific requirements.

Certification

- Accreditation of the Bunker Facility Operator (BFO),
- Qualification of the Person in Charge.
- Applicability of an accreditation scheme for LNG bunker operators in the ports under their authority.
- Certification of LNG bunker barges, non-IGC bunker vessels

Training

- Training Matrix with identification of multiple training requirements in the Bunkering Interface.
- Competencies, Qualifications and Training for LNG Bunkering.
- Qualification for the PIC
- Training Certification

[7] Elements related to LNG as cargo, LNG terminals or other LNG wider value chain are excluded from the scope of this Guidance.

[8] Scope for the EMSA Guidance based on a gap analysis of existing references, in the context of the EU LNG Study, LOT1,

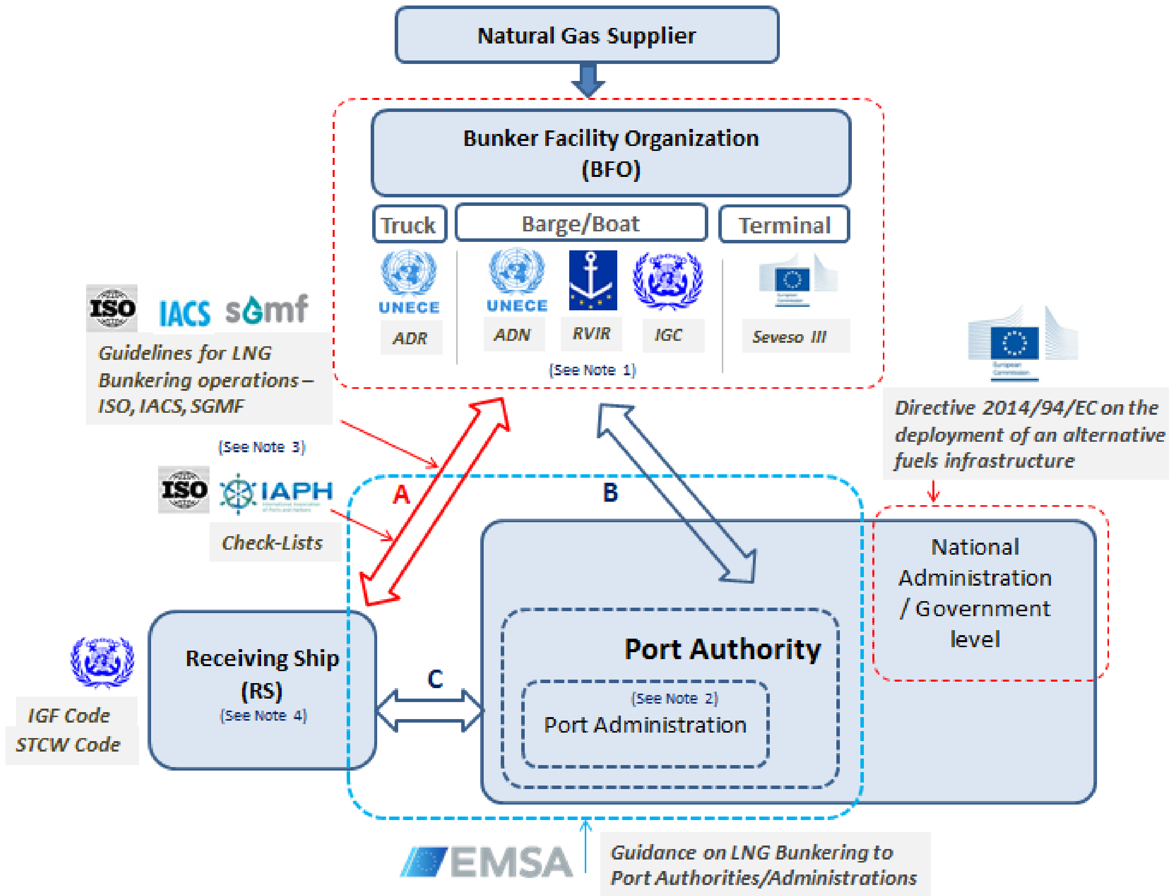
1.2 Applicability

The EMSA Guidance applies to Port Authorities/Administrations (PAAs) when involved in LNG Bunkering within their areas of port jurisdiction, either during the exploratory and planning phases or, at later stages of development, already in the context of actual LNG Bunkering operations.

The EMSA Guidance is applicable in a complimentary way to existing Standards, Guidelines and Industry Best Practice instruments, aiming to provide best practice recommendations to PAAs wherever their action is relevant, in control, evaluation, or even in guidance on the several different aspects of LNG bunkering.

The EMSA Guidance is applicable to the control of LNG bunkering operations by PAA in EU Core Ports, wherever EU law is applicable. It is applicable for:

- Different LNG Bunkering methods, Fuelling with LNG at berth and Shore-side LNG electricity production
- Different ship types and
- Different locations (in port, off shore and terminal) worldwide.



Notes:

1. Regulatory frame applicable to LNG bunker barges/boats/ships will depend on their area of operation. If below 500GT and not engaged in international voyages, in principle, IGC does not apply (unless enforced by national legislation). ADN agreement applies, to all LNG barges/boats/ships of contracting parties, engaged in the inland waterway transport of LNG.
2. Port Administration is, in the context of the EMSA Guidance, a holder of administrative responsibility; possibly with partial delegated authority (this can typically be the case of a private Port or of a landlord Port (mostly responsible for leasing the land). Different local, regional or national context should here be taken into account.
3. The Guidelines from ISO, IACS and SGMF offer guidance and establish requirements that cover Functional Requirements for LNG bunkering equipment, responsibilities of RS and BFO, Risk Assessment principles, amongst other aspects relevant for interaction (A) above.
4. Receiving Ship is assumed to be either an IGF Code vessel (if constructed, or converted to LNG fuel, after 1st January 2017). Before that date the IMO Interim Guidelines apply (Res. IMO MSC.285(86) *Interim guidelines on safety for natural gas-fuelled engine installations in ships (2009)*).

Fig.1.1 – Applicability of the EMSA Guidance in the current context of LNG Bunkering

1.3 Objectives

The objectives defined for the EMSA Guidance on LNG Bunkering are to assist Port Authorities/Administrations with:

- The necessary elements to develop a harmonized procedure for the evaluation, control and through-life assessment of LNG bunkering projects.
- Definition of a unified set of first principles for permitting and approval, including a common risk assessment evaluation approach and common suggested risk acceptance criteria for the bunkering of gas as fuel in the respective.
- Implement harmonized bunkering procedures in EU ports to reduce the potential confusion caused by having to comply with different rules and regulations in different ports.
- Clear suggested definition for the responsibilities of the different involved parties including landside and waterside authorities regarding the bunkering of LNG, both in in case of normal operation and in case of malfunction or emergency.
- Definition of a procedure to allow evaluation, control and authorization of SIMOPS with LNG bunkering.
- Proposal for a harmonized approach to the approval of Control Zones in different bunkering scenarios, through the implementation of a concept of “meaningful protection”. In addition to a deterministic or probabilistic approach, it is suggested to include a context-based approach where the determination of Control Zones is driven mostly by the presence of elements meriting protection in the vicinity of the LNG bunkering location.

1.4 Terms & Definitions

The terms used in this guidance document have the same meaning as those defined in the Regulation and in the IMO guidelines with the following additional definitions which apply for the purposes of this guidance document only:

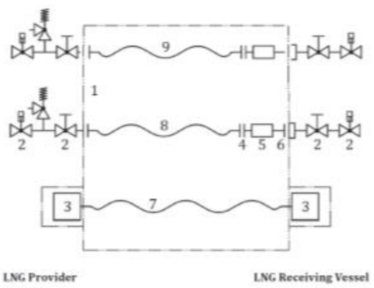
Term	Definition
Accreditation	**Accreditation** is the formal declaration by a neutral third party that the certification program is administered in a way that meets the relevant norms or standards of certification program (such as ISO/IEC accreditation standards[9]). Many nations have established specific bodies responsible for third-party independent accreditation. Those that haven't, such as the US, have seen the accreditation services provided by typically non-for profit organizations, typically specialized in a given industry area (e.g. American National Standards Institute (ANSI)). The accreditation hierarchy is overseen by the International Accreditation Forum (IAF) and the European Accreditation Forum (EA). Both forums approve and accredit the National Accreditation Body in each country that has arrangements in place to operate an NAB. The list of approved NABs can be found at www.iaf.nu. Accreditation can also have a particularly relevant role in Training. Qualification of LNG bunkering professionals may be required through the completion of 'accredited' training programs or courses. Accreditation of Training is typically provided by Accredited Training Organizations (ATOs) In the context of LNG Bunkering, **Accreditation** assures users of the competence and impartiality of the body accredited, responsible for the **certification** of LNG bunkering systems and equipment, processes and training. Note: Certification and Accreditation are terms often used interchangeably but they are not synonyms. See also 'Certification.
Alternative Fuel	**'Alternative Fuels', as per Directive 2014/94,** means fuels or power sources which serve, at least partly, as a substitute for fossil oil sources in the energy supply to transport and which have the potential to contribute to its decarbonisation and enhance the environmental performance of the transport sector. LNG is an Alternative Fuel.
Atmospheric tanks	Atmospheric tanks mean tanks of the types A or B or membrane tanks 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.
Authorization	**Authorization** is the formal expression of the competent authorities in form of an agreed official permission, giving indication for the start of the LNG Bunkering Operation. The definition of the starting point should, in itself, be also an agreed point between all the parties and the competent authorities.
Boiling liquid expanding vapour explosion (BLEVE)	Sudden release of the content of a vessel containing a pressurized flammable liquid followed by a fireball A Boiling Liquid Expanding Vapour Explosion is an explosion caused by the rupture of a tank containing a pressurised liquid above its boiling point (It does not have to be a flammable liquid). A fireball would result (most probably) if the liquid was flammable.
Breakaway Coupling (BRC)	A breakaway coupling or emergency release coupling (ERC) is a coupling located in the LNG transfer system (at one end of the transfer system, either the receiving ship end or the bunker facility end, or in the middle of the transfer system), which separates at a predetermined section when required, each separated section containing a self-closing shut-off valve, which seals automatically

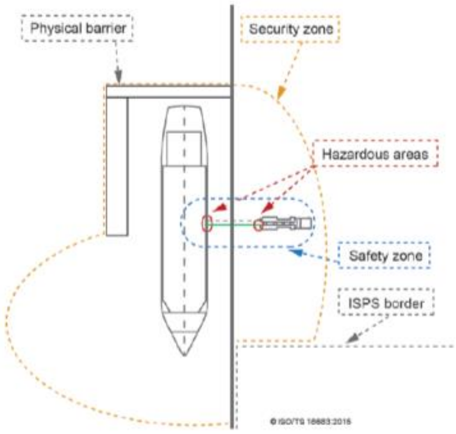
[9] Many accreditation bodies operate according to processes developed by the International Organization for Standardization (ISO) as specified in ISO/IEC 17011.[2] Accredited entities in specific sectors must provide evidence to the accreditation body that they conform to other standards in the same series:
ISO/IEC 17020: "General criteria for the operation of various types of bodies performing inspection" (2012)
ISO/IEC 17021: "Conformity assessment. Requirements for bodies providing audit and certification of management systems" (2011)
ISO/IEC 17024: "Conformity Assessment. General requirements for bodies operating certification of persons" (2012)
ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories" (2005)

Term	Definition
Bunkering	General Definition Regulation (EU) 2017/352). *Provision of solid, liquid or gaseous fuel or of any other energy source used for the propulsion of the waterborne vessel as well as for general and specific energy provision on board of the waterborne vessel whilst at berth* LNG Bunkering LNG fuel transfer operation to a vessel. For the purposes of this standard it refers to the embarkation of LNG only. In the context of this document, bunkering relates to the transfer of LNG from a bunkering facility to a receiving vessel, taking place over a well-defined period of time where the beginning, transfer and end of operations follow a particular specified and documented procedure. NOTE(s) For the supply of LNG directly to a generator onboard see the definition of "Feeding" For the supply of electricity from close by LNG mobile power units see the definition of "Shore-side LNG electricity"
Bunkering by ISO LNG container units	Supply of LNG fuel by mobile LNG tanks/containers that are lifted onto the receiving vessel and connected to the fuel system on board
Bunkering Facility	In the context of this document, this is the ship/facility interface where LNG bunkering is intended to take place or is taking place The term may be used for any of the bunker scenarios terminal-to-ship, truck-to-ship or ship-to-ship. (see disambiguation with "Bunkering Location" and Bunkering Infrastructure) From IACS Rec.142 and revised SGMF Guidelines: *A bunkering facility is a LNG storage and transfer installation, which can be:* • *a stationary shore-based installation or* • *a mobile facility, including LNG bunker ship (or barge) or a tank truck.* *Shore based facilities and LNG bunker ships may be designed to handle LNG vapour return.*
Bunkering Facility Organisation (BFO)	This is the organisation in charge of the operation of the bunkering facility
Bunkering Location	Location where LNG bunkering operation
Bunkering Vessel	Bunkering vessels (vessels used to transport LNG to a vessel using LNG as a fuel) shall comply with this standard and be approved by its Flag State or be Classed by a Classification Society that is a member of IACS, indicating that it meets, at a minimum, the applicable requirements of the IGC Code, this standard, and applicable Flag State requirements.
Certification	**Certification** refers to the confirmation of certain characteristics of given equipment, in its whole or any of its parts, of a procedure, operation or personnel, often requiring a confirmation of conformity against an existing standard or regulation. In the context of LNG Bunkering, **Certification** refers primarily to the LNG fuel systems, equipment and personnel. Can be applicable to systems with different complexities, provided rules, standards and regulations exist for conformity evaluation. Note: Certification and Accreditation are terms often used interchangeably but they are not synonyms. See also 'Accreditation'.
Classed or Classification	A process in which the design and condition of a vessel is evaluated to determine its compliance with International Maritime Organization Conventions and Codes and suitability for its intended service. This process is conducted by Classification Societies in compliance with class rules.

Term	Definition
Classification Society	Is a non-governmental organization that establishes and maintains technical standards for the construction and operation of ships and offshore structures. They also validate that construction is according to these standards and carry out regular surveys in service to ensure compliance with the standards.
Concept Project	
Consequence	Outcome of an event
Drip-free coupling	A coupling that automatically closes at both separation points of the joints when it is disconnected. A drip-free coupling avoids any spill of liquid or vapour or limits it to a minimum. Another term that may be used is "dry-disconnect".
Dry Break Away Coupling	A dry break-away coupling is a particular application of a dry disconnect mechanism coupling which separates at a predetermined section at a set breaking load and in which each separated section contains a self-closing shut-off valve which seals automatically When activated, a dry break-away coupling avoids any spill of liquid or vapour or limits it to a minimum. A dry break-away coupling shall provide two functionalities: • A separation function that is triggered in sufficient time before reaching the load limit on the bunker connection to separate the line between the supply side and the receiving vessel. • A closing function to close the line at both separation points to prevent the spill of liquid or vapour.
Emergency release coupling (ERC)	See "Breakaway Coupling – BRC"
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. system that allows a quick disconnection of the supply side from the receiving vessel in an emergency Includes Emergency Breakaway Coupling (ERC)
Emergency Shut Down (ESD)	An emergency shut-down (ESD) is a method or a system that safely and effectively stops the transfer of LNG (and vapour as applicable) between the LNG bunkering facility and the receiving ship in the event of an emergency during the bunkering operation. The control systems involved in the ESD, which is a linked system to allow both parties (on board receiving ship and the bunkering facility) to shut down the transfer in an emergency situation, can be activated automatically or manually. These are systems installed as part of the LNG transfer system and 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: • 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 levels LNG tank alarms, cables or other means designed to detect excessive movement between transfer vessels or vessel and an LNG port 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 port facility. The decoupling mechanism contains quick acting valves designed to contain the contents of the LNG transfer line (dry break) during decoupling.
Feasibility Study	A **Feasibility Study** is an analysis of how successfully a project can be completed, accounting for factors that affect it such as economic, technological, legal and scheduling factors. A feasibility study tests the viability of a given LNG Bunkering or

Term	Definition
	small scale LNG storage project. The goal of a feasibility study is to place emphasis on potential problems that could occur if this project is pursued and determine if, after all significant factors are considered, the project should be pursued. Feasibility studies also allow a business to address where and how it will operate, potential obstacles, competition and the funding needed to get the business up and running.
Hazard	Potential source of harm. The hazard, or danger, is intrinsic to the product. Regulation (EC) No 765/2008 on General Risk Assessment Methodology
Hazardous area	area in which a flammable gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of apparatus
HAZID	**Hazard identification (HazID)** study is the method of identifying hazards to prevent and reduce any adverse impact that could cause injury to personnel, damage or loss of property, environment and production, or become a liability. HazID is a component of risk assessment and management. It is used to determine the adverse effects of exposure to hazards and plan necessary actions to mitigate such risks.
HAZOP	**Hazard and Operability (HAZOP)** is a structured and systematic examination of a complex planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment. HAZOP is a well-known and well documented study. HAZOP is used as part of a Quantitative Risk Assessment (QRA) or as a standalone analysis. HAZOP is a more detailed review technique than HAZID.
Holding Time	Time of the pressure increase in the inner tank measured from a starting pressure of 0 bar at the corresponding boiling point of liquefied natural gas (LNG) (−164° C) up to the maximum allowable working pressure (MAWP) of the inner tank
Impact assessment	assessment of how consequences (fires, explosions, etc.) affect people, assets, the environment, etc.
Inerting	placing tanks, piping and machinery in a non-flammable atmosphere by displacing oxygen
International Safety Management Code	An IMO code that provides an international standard for the safe management and operation of ships, and for pollution prevention. Operators of ship's subject to the International Safety Management Code are required to enact a management system (ISM) that meets the code and have their compliance with the ISM audited, first by the Company (internal audit) and then each 2.5 to 3 years by the Flag State Maritime Administration to verify the fulfilment and effectiveness of their Safety Management System.
International Standard	An International Standard provides rules, guidelines or characteristics for activities or for their results, aimed at achieving the optimum degree of order in a given context. It can take many forms. Apart from product standards, other examples include: test methods, codes of practice, guideline standards and management systems standards.

Term	Definition
Letter of Intent	Letter that should be issued by the BFO, for possible endorsement by other stakeholders and competent authorities, to be submitted to the PAA for initial appreciation of a prospective LNG bunkering concept design project, intended location, amongst other initial aspects of an initial
LNG Bunkering Management Plan	As defined in IACS Recommendation 142 *LNG Bunkering Guidelines,* Section 1.5.
LNG Fuelling	Supply of LNG, from shore, at berth, or vessel/barge, directly to the LNG consumers onboard the Receiving Ship. The LNG is here supplied through a mobile unit which is otherwise
LNG transfer system (ISO 20519)	For the purposes of this document the LNG transfer system consists of all equipment contained between the bunkering manifold flange on the facility or vessel providing LNG fuel and the bunkering manifold flange on the receiving LNG fuelled vessel including but not limited to; Ship to ship transfer arms, LNG articulated rigid piping and hoses, Emergency Release Coupling (ERC), insulating flanges and quick connector/disconnect couplings (QC/DC) In addition the ESD Ship/Shore Link or Ship/Ship link used to connect the supplying and receiving ESD systems. The components are arranged in the following manner:  1 Scope boundary 2 Automatic and manual ESD 3 ESD junction box 4 Insulation flange 5 Emergency release coupling 6 QC/DC – Quick Connect/ 7 Ship/shore or ship/ship ESD link 8 Loading system (systems include- : vessel to vessel transfer arms, 9 Vapour return system
Lower Flammable Limit (LFL)	Means the concentration of flammable gas or vapour in air below which there is insufficient amount of substance to support and propagate combustion.
Operational Envelope	**Operational Envelope (OE) refers to a limited range of parameters in which operations will result in safe and acceptable equipment performance.** It can result from a quantitative analysis or from a comparable qualitative evaluation. OEs can relate to weather and environmental conditions and usually take into account some degree of safety with regards the limit state of equipment, materials, amongst other aspects.
Permitting	**Permitting** refers, in the context of LNG Bunkering, to an official and documented authorization to build, implement or operate. There are several different types of permits (environmental permit, building permit, etc) depending on which instruments are used to assess a given project. The 'permit holder' is subject to a list of obligations designed to allow demonstration of compliance with regulations and standards relevant for the permitting processes.
Qualification	**Qualification** is a term that relates to a given individual, referring to a successful completion of a given educational or training program and, in specific terms, to passing an examination or assessment, especially one conferring status as a recognized practitioner of a profession or activity. When an individual passes an certain examination following a course provided by an approved ATO – they can demonstrate their knowledge of the subject matter contained within the course material of that qualification.
Receiving Vessel	vessels used to transport LNG to a vessel using LNG as a fuel) shall comply with this standard and be approved by its Flag State or be Classed by a Classification Society

Term	Definition
	that is a member of IACS, indicating that it meets, at a minimum, the applicable requirements of the IGC Code, this standard, and applicable Flag State requirements.
Restriction	**Restriction** represents a limitation, either on the utilization of specified equipment or system, or in the implementation of a given procedure, as far as LNG Bunkering is concerned.
Risk	Combination of the probability of occurrence of a hazard generating harm in a given scenario and the severity of that harm
Risk level	Degree of risk, which may be 'serious', 'high', 'medium' or 'low'. When different levels of risks in different scenarios have been identified "the risk" of the product is given by the highest risk.
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 cargo operations (including lightering operations if applicable), ballasting operations, passenger embarkation/disembarkation, loading of provisions, etc.
Technical Specification	(ISO terminology) A Technical Specification addresses work still under technical development, or where it is believed that there will be a future, but not immediate, possibility of agreement on an International Standard. A Technical Specification is published for immediate use, but it also provides a means to obtain feedback. The aim is that it will eventually be transformed and republished as an International Standard.
Technical Standard	For the purposes of this document, Technical Standards are standards that prescribe requirements for one or more of the following; operations, equipment design/fabrications, or testing methodology.
Temporary Intermediate (onsite) Storage	Limited duration storage of LNG in any point of the distribution chain, between the LNG Loading Terminal and the transfer/bunkering operation. The duration is not defined but it is suggested that the approximate holding time of an LNG trailer tank can be used as reference which, for the purpose of this Guidance, will be a period of 24 hours
Zoning	LNG Bunkering Operations, like other activities within the port area involving handling of hazardous substances or cargo, use the concept of safety/security zones in order to create a layered arrangement of scalable and controlled zones with different objectives. The figure below, taken from the draft ISO/DIS 20519:2016 [1]. *Draft Specification for bunkering of gas fuelled ships*, provides one possible arrangement for convenient generic indication of the possible zones involved in LNG Bunkering. 

Term	Definition
	Safety Zone. Area that is present during bunkering and within which only essential personnel are allowed and potential ignition sources are controlled. This further minimises the low likelihood of an LNG release and its possible ignition. It also helps protect individuals and property via physical separation should a release occur. Reference is made to [1], [2] and [3]. **Security Zone**. Zone required during LNG Bunkering, subject to the criteria of the competent authority that is established on a wider perimeter in order to allow control of access, road traffic and other port activities in the vicinity of the LNG bunkering operation location. It may consider the location for the bunkering but also other relevant considerations, such as the access or waiting points for LNG trucks, or even other physical elements from a fixed installation. **Hazardous Zone.** Zone set in accordance with IEC 60079-10-1 (or similar) with a purpose to minimise the likelihood of ignition from electrical equipment [4]. As such, the hazardous zone primarily restricts the type of electrical equipment allowed within prescribed distances (e.g. 4.5 m) from the line/hose connections on the ship and bunker supply. [1]. ISO/TS 18683:2015. (15-Jan. 2015). Guidelines for systems and installations for supply of LNG as fuel to ships. Technical Specification. [2]. Society for Gas as a Marine Fuel (SGMF). (2015). Gas as a marine fuel, safety guidelines, Bunkering. Version 1.0, February 2015. [3]. ISO/DIS 20519:2016. Ships and marine technology – Specification for bunkering of gas fuelled ships. (Draft International Standard). [4]. IEC 60079-10-1. (2015). Explosive atmospheres – Part 10-1: Classification of areas - Explosive gas atmospheres.

2. LNG as Fuel

The present section is focused on the aspects that make today LNG as fuel a viable technical option for ships, from the very own fuel characteristics, to the value chain, different bunkering options and concepts. LNG characteristics are presented with a focus on its physical properties. The LNG value chain is then broadly addressed with a view to identify the main general transformation and distribution links from LNG production to LNG transfer into an LNG fuelled ship.

In addition, LNG Bunkering is defined, with different options presented as to how LNG fuel chain can be designed within a Port Area. How the LNG/NG arrives to the Port, how it is stored or processed, distributed, and finally how it is transferred/bunkered to an LNG Fuelled Ship.

Along with the informative content of this section some recommendations are included, in section 2.8, on how PAAs should integrate basic LNG bunkering options and elements contributing to the overall design of LNG bunkering solutions affecting the Port area.

2.1 LNG as Fuel – General Aspects

LNG as fuel for shipping, as an emerging market segment, is already shaping new ship design, technical options and operations. Mostly driven by first-front demand and higher risk-taking funding/investment initiative, LNG bunkering has incorporated increasingly complex and customized solutions. This is the case for ship design, with more ambitious LNG fuel systems, capacity and technology wise, but also for operations where the need to have Simultaneous Operations, along with LNG bunkering, is one of the essential elements for the viability of LNG fuel option for some types of ships (e.g. containerships or RO-PAX ferries). The market has developed recently, even in the verge of a particular context driven by increasingly lower oil fuel prices [22]. More LNG fuelled projects are developing and, in parallel, LNG bunkering options being characterized by an increasing higher-capacity portfolio of solutions.

Figures 2.1 to 2.8 show examples of significant ships or relevant LNG bunkering options which are considered as well representative of LNG as fuel for shipping.

Fig 2.1 – MS BIT Viking – First ship converted to LNG power. [19]. The conversion involved installation of new dual fuel engines and LNG fuel system

The vessel is outfitted with an LNG fuel system comprising two LNG storage tanks with combined storage capacity of 1,000m3.

The storage tanks are located on the vessel's deck. This also allows the bunkering of LNG at a rate of 430m3 an hour

Fig.2.2 – Artistic impression of the Shell LNG bunker vessel[10].

This specialized ship will have a capacity of 6,500m3 and will be capable of fuelling 1,000m3 of LNG per hour.

As the market for LNG as Fuel increases in demand and LNG fuelled ships grow in LNG fuel capacity, the demand for LNG bunker barges will also naturally increase, with much higher capacities and available bunker rates when compared to LNG Trucks.

[10] EU co-funded project – ReaLNG – TEN-T Motorways of the Sea - https://ec.europa.eu/inea/sites/inea/files/fiche_2014-eu-tm-0095-w_final.pdf

Fig.2.3 and 2.4 – MV Viking Grace. With a dedicated LNG bunker vessel (AGA Seagas[11]), alongside in LNG bunkering operation.

To note the LNG fuel tanks on the stern of the ship. The binomial "Receiving-Bunkering ships" is here seen as a clear indication of an LNG bunkering market in early stage of development. In the presented case the Seagas bunker vessel is dedicated to LNG supply to the Viking Grace. With a very significant number of successful operations conducted, the presented case is the example of a customized LNG bunkering solution has resulted in an exemplar safety case.

Fig.2.5 – Skangas Coralius[12].

Bunker vessel with a cargo capacity of 5,800 m3 and is 99.6 meters long. She holds a Finnish/Swedish Ice Class 1A and is classed "**LNG gas carrier IGC type 2G -165°C, 500 kg/m3**" Larger volumes of LNG are transferred at high rates with Coralius representing a new paradigm in flexibility for higher and diversified LNG bunkering demands.

Fig.2.6 – Truck-to-Ship LNG bunkering.

By far the most common method used today, representing an option that has allowed flexible operations and experience to build up. Notwithstanding adequate for limited LNG quantities[13] truck-to-ship LNG bunkering is unable to respond to higher demands in capacity or LNG transfer rates. As ships become more demanding for higher LNG volumes the transition to LNG bunker vessels or fixed LNG bunkering facilities will naturally take place.

Fig.2.7 and 2.8 – Truck-to-Ship LNG bunkering/feeding.

Variations of typical LNG truck-to-ship bunkering have also been developed, remarkably on what is called in the present guidance of LNG "feeding", as presented in these two images, one artistic impression and another one, on the right, of actual operation. With LNG feeding the ship, otherwise with no LNG storage capacity on board, receives LNG directly from a truck trailer to consumption onboard. This allows the ships environmental profile at berth to be significantly improved, consuming cleaner burning natural gas, instead of oil fuels in port generators.

[11] EU co-funded project – Fjalir - https://ec.europa.eu/inea/sites/inea/files/download/project_fiches/sweden/fichenew_2011se92148p_final_1.pdf

[12] EU co-funded project – Pilot LNG (part of the Zero Vision Tool) - http://www.zerovisiontool.com/pilotlng

[13] LNG trailer trucks are typically limited to around 25ton of LNG (around 50m^3)

Fig.2.9 – Fixed LNG bunkering facility, with small-scale LNG storage tank.

Having presented mobile LNG bunkering facilities, in Fig 2.9, above, a fixed LNG bunkering location is shown, with type-C LNG tank.EU TEN-T co-financed pilot fixed LNG bunkering installation of 200 tonnes/445m3 tank capacity Max Flow rate delivery of 200m3/hour. (source: Fjordline)

Fig.2.10 – LNG shore-side energy

Even though not an LNG bunkering typical scenario, LNG fuelled electricity supply is also included in the context of this document. It involves typically mobile units such as the one presented – power barge supplying electricity from gas dual-fuel generators onboard, directly to the cruise vessel alongside in a close position. (source: Aida)

Even though outside the scope of this document, the LNG bunkering market development is an important aspect that PAAs will have to consider. On one hand the number of ships that can be expected in a near future to be built, converted, or prepared for LNG as fuel.

Currently it is possible to obtain information on the prospects of LNG as fuel from different sources, not only on the number of ships built and operating on LNG but also on the infrastructure development. These two aspects are often regarded as interdependent and should, from a practical point of view also be considered as relevant information elements to PAAs evaluating, promoting or assessing a prospective LNG bunkering facility project.

The number of LNG fuelled ships, in operation and on order is presented in figure 2.11, whilst figure 2.12 shows the areas of operation, based on AIS information, where LNG fuelled ships operate today.

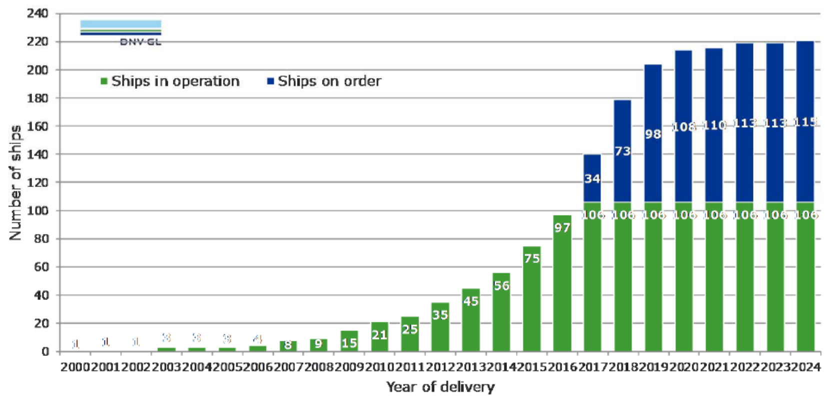


Figure 2.11 – LNG fuelled ships, in operation and on order [23]

Figure 2.12 – LNG fuelled ships, in operation – areas of operation by AIS information – update May 2017 - [23]

It does not go unnoticed from figure 2.11 that LNG-fuelled ships in operation and on order have reached a maximum growing rate between 2014 and 2016, having recently stabilized mainly due to a reduction in oil fuel price driving shipowners to either delay the decision to convert to LNG or to choose another technical option for compliance with emission regulations [13]. The future is however uncertain and, for the purpose of the present document, the important aspect to retain is that LNG as fuel will be an increasingly generalized option adopted in shipping. This reflects in the diversification of the LNG as an off-grid fuel solution for maritime transport

An important aspect for the development of LNG as fuel is the infrastructure. The small-scale developments are therefore important in the definition of LNG bunkering facility projects and, consequently, for the sizing and specification of the adequate LNG bunkering solutions within a port.

An adequate overview of the LNG small-scale infrastructure is therefore important to PAAs. The GIE small-scale LNG map provides the LNG industry and interested parties with an overview of the available, under construction and planned small-scale LNG infrastructure and services in Europe (http://www.gie.eu/index.php/maps-data/gle-sslng-map).

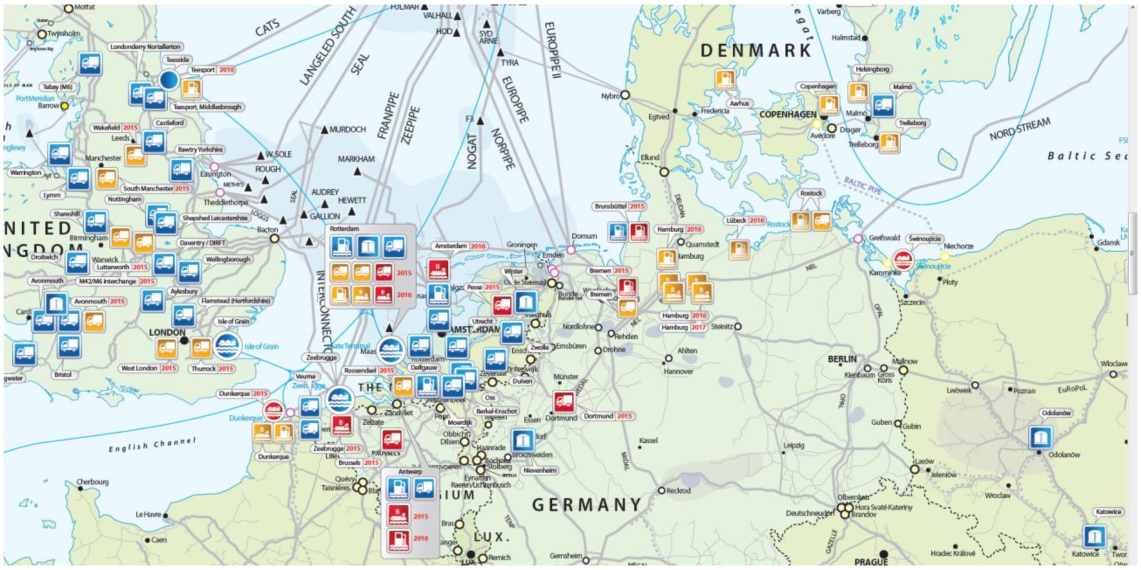


Figure 2.13 – Detail of the LNG Small Scale infrastructure map in Europe - [23]

The GLE small-scale LNG map provides the following information:

LNG import terminals offering new LNG services
Reloading: Transfer of LNG from the LNG reservoirs of the terminal into a vessel
Transhipment: Direct transfer of LNG from one vessel into another
Loading of bunker ships: LNG is loaded on bunkering ships which supply to LNG-fuelled ships or LNG bunkering facilities for vessels
Truck loading: LNG is loaded on tank trucks which transport LNG in smaller quantities
Rail loading: LNG is loaded on rail tanks which transport LNG in smaller quantities
LNG small-scale liquefaction plants:
LNG is produced in small scale liquefaction plants to respond to peak shaving demand or make available natural gas to regions where it is not economically or technically feasible to build new pipelines.
LNG bunkering facilities for vessels:
This stationary facility allows ships to bunker LNG to be used as fuel for the vessel
LNG bunker ship:
This ship supplies LNG directly to LNG-fuelled ships or to LNG bunkering facilities for vessels.
LNG refuelling stations for trucks
This facility allows trucks to fill LNG to be used as fuel.
LNG satellite storage:
They enable to store LNG in small quantities in areas where there is no high pressure pipeline. LNG is delivered mainly by trucks (but also by small LNG ships) to these satellite plants where it is then stored and regasified into the natural gas distribution networks or used by an end user.

2.2 LNG Characteristics

LNG (liquefied natural gas) is the name given to natural gas that has been converted to liquid form by being cooled to a very low temperature. To attain a liquid phase, the temperature must be lower than the critical temperature (-82°C in the case of methane). LNG is typically stored at near-atmospheric pressure at close to its atmospheric boiling point (-160°C). In liquid form, natural gas occupies 600 times less volume that in a gaseous state, making it easier to transport over long distances and enabling a large storage capacity to be achieved in a relatively small space.

The main characteristics and hazardous properties of liquefied and gaseous natural gas are summarised in table 2.1 and discussed in the paragraphs below.

2.2.1 Composition

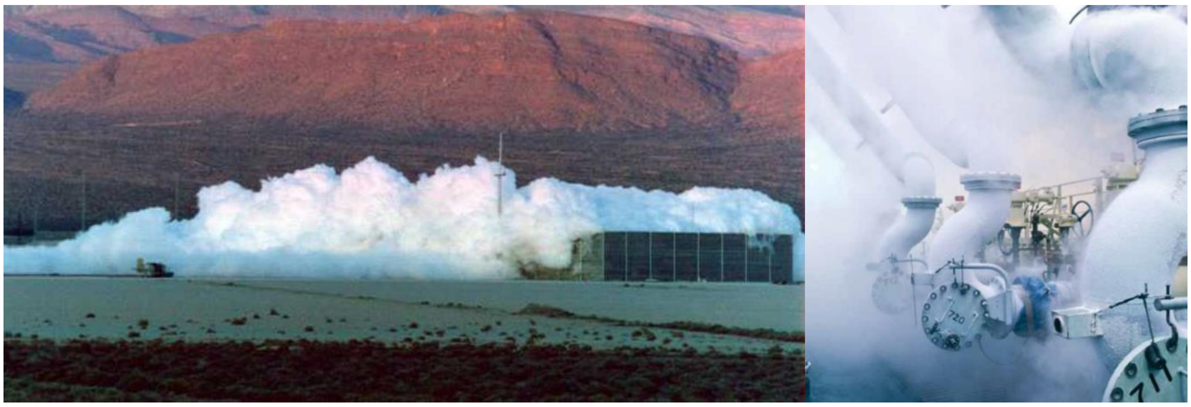
LNG is typically a mixture of hydrocarbons consisting mainly of methane with smaller fractions of *inter alia* ethane, propane and nitrogen. The LNG imported to Europe typically consists of methane (90 weight percent) and ethane (10 weight percent). Components such as water vapour, carbon dioxide and heavier hydrocarbons have already been removed from the LNG [13].

When the LNG is vaporised, it is methane that is first released as vapour. This is due the difference in atmospheric boiling point between methane and ethane. More precisely, the vapour will consist almost entirely of pure methane as long as no more than around 70% of the liquid has been vaporised.

2.2.2 Physicochemical Properties

Methane is a colourless and almost odourless gas. When LNG is released into the environment, cold vapours are formed that result in condensation of the water vapour present in the air. This phenomenon means that LNG vapour is visible at low temperature due to the mist created.

The cold vapours formed by the vaporising of LNG are initially heavier than air and disperse close to the ground. As they mix with the ambient air, the cold LNG vapours gradually heat up and will behave neutrally at temperatures of around -110°C, eventually becoming lighter than air under normal pressure and temperature conditions. At ambient temperature and pressure, natural gas has a density of around 0.72 kg/m^3.



Figures 2.13 and 2.14 – LNG cloud formation and progression (on the left) opposed to the condensation cloud formation around LNG piping due to water vapour condensation in the air surrounding the cryogenic cold piping system.

Understanding the dispersion behaviour of **LNG clouds**, following an accidental release is a determining factor to design adequate Control/Safety Zones and safeguard systems for LNG bunkering. Clouds are asphyxiating due to oxygen depletion and explosive interval will be present in the limiting boundaries of the cloud.

Condensation cloud formation around LNG piping, hoses, and manifolds is the result of water condensation surrounding cryogenic temperature elements of the LNG bunkering interface. The less insulated the bunkering lines are, and the more humid the surrounding atmosphere, the more condensate cloud formation and frost cap around piping will be generated.

2.2.3 Hazardous Properties

LNG vapour in air is flammable within specific concentration limits. As LNG vapour consists mainly of methane, the flammability limits of methane (4.5 – 16.5 vol. %) are generally used to estimate the size of the flammable clouds formed after an incidental release of LNG.

It should also be noted that free natural gas clouds, once ignited, burn at a relatively low speed, which means that only relatively small overpressures are likely to occur in an open environment (≤ 50 mbarg) [25]. Only if the flammable natural gas cloud formed is confined or is present in an installation with a high obstacle density may higher overpressures possibly occur in the surrounding area.

A pool fire or jet fire that occurs after an incidental release of LNG is characterised by a bright flame (little soot formation) and high radiation intensity (typically: 200 – 300kW/m²). The effects of an LNG fire on nearby people or installations are therefore greater than those of fires that occur after an incidental release of conventional fuels such as petrol or diesel.

Finally, it should be noted that direct contact with LNG (as a cryogenic liquid) can result in serious freezing injuries. If LNG comes into contact with steel, the steel will embrittle due to the low temperature and a steel structure may fracture. Stainless steel retains its ductility at low temperatures and is therefore more resistant to contact with cryogenic liquids.

Table 2.1 – LNG Physicochemical properties

Properties	Notes	Value
Physical State	Cryogenic liquid under special PVT conditions	**cryogenic liquid**
Boiling Temperature at 1 bar [°C]	This is the temperature at which the vapour pressure of the material equals ambient pressure. Pure substances boil at specified pressure at a defined temperature. This temperature stays constant under continued addition of heat until all material is vaporised. Mixtures usually have a boiling range.	**-161**
Density at 15°C [kg/m3]	Density at (-160°C,1 bar)	**448**
Lower Heating Value [MJ/kg] At (-162°C and 1 bar)	LHV gives a measure of the energy density by mass of the fuel. This parameter impacts on storage space in conjunction with density but can also provide an indication of the amount of heat released in a fire in conjunction with heat of evaporation. LNG has an LHV of 50 MJ/kg which 15 to 20% higher than that of HFO and MGO. Thus approximately the same LNG fuel by weight must be bunkered to obtain the same energy on board. With respect to fire, the higher LHV of LNG implies that more heat will be released per mass of fuel as compared to MGO and HFO.	**50**
Vapour Density air=1	This parameter is interesting in order to gauge whether a vapour is likely to sink and accumulate in low areas or rise and accumulate in high areas. Methanol vapour density is very close to that of air, so it is near to neutral in buoyancy. The vapour density of anhydrous ethanol is 1.6, which is heavier than air. As LNG is at ambient conditions gaseous, but stored at less than -160°C the vapour density discussion is more complex. Should a spillage occur the cold vapours may initially be heavier than air until they have warmed up sufficiently? Liquid density of LNG at -160°C and 1 bar is 448 kg/m^3. At 1 bar abs and -162°C pure methane is in subcooled condition. Gas density of pure methane at 0°C and 1 bar (normal conditions) is 0.71 kg/m3 (superheated condition).	**0.55**
Flash Point (TCC) [°C]	Flash point is the lowest temperature at which a liquid gives off enough vapour at the surface to form an ignitable mixture in air. Flash point is one of the valid indicators of the fire hazard posed by the fuel. The flashpoint of LNG at -175°C is much lower than any oil fuel, and even much lower than other low flashpoint fuels such as methanol (12ºC) or even ethanol (17ºC). The challenge is therefore not to avoid formation of vapour due to heating of LNG but rather to manage, contain and, ultimately, use the generated vapour.	**-175**
Auto Ignition Temperature [°C]	The auto ignition temperature is defined as "the temperature at which a material self-ignites without any obvious sources of ignition, such as a spark or flame. It is a function of the concentration of the vapour, the material in contact and the size of the containment.	**540**
Flammability Limits [by % Vol of Mixture]	Flammability limits give the range between the lowest and highest concentrations of vapour in air that will burn or explode [v]. Methanol's flammability limits are wider than those of ethanol, LNG, and MGO	**4.5 – 16.5**
Min. ignition energy at 25°C [mJ]	This is the lowest amount of energy required for ignition. This parameter is highly variable and dependent on temperature, amount of fuel and the type of fuel. Methanol, ethanol, and LNG all have minimum ignition energy below 1 mJ at 25°C, whereas for MGO it is 20 mJ.	**0.29**
Flame temperature (ºC)	Temperature attained to lean burning LNG pool fire	**1875**

2.3 LNG Value Chain

From Natural Gas source to final consumers the LNG value chain can assume different shapes and be designed in different ways, depending on the needs for a variety of end-users. Figure 2.15 below shows a very simplified representation of a generic value chain, distinguishing between two different types of consumers: 1) LNG and 2) NG consumers. These typically represent the transport and domestic/industrial users, respectively. The chain is characterized by the liquefaction and re-gasification points where NG transforms into LNG and vice-versa. The need for LNG is associated with 2 (two) essential needs: a) the need to transport NG through long distances or b) the need to provide NG for mobile users. Since LNG occupies 600 times less volume than NG it is also convenient for storage wherever limited space is available. This is obviously the case for ships, and other mobile units, but can also be the case for land-side developments, off-grid, potentially close to shore where LNG use may be convenient.

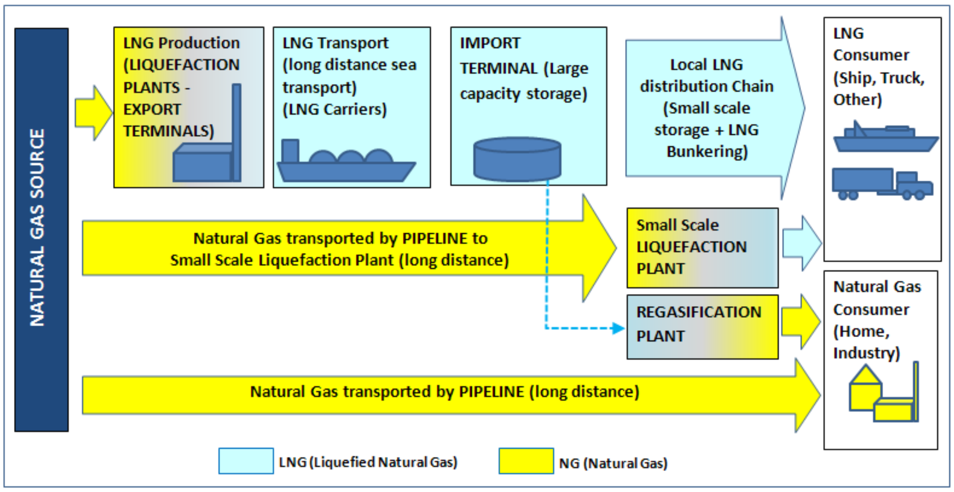


Figure 2.15 – LNG Value Chain

There are several aspects to be carefully considered when designing an LNG chain, but one main rule applies: The more interfaces, liquefaction plants, distribution links, the more likely it will be to have LNG accidental or operational releases. In liquefaction plants LNG compressors are likely to have small LNG leaks leading to undesired methane emissions. In addition to the potential environmental impact it is also important to have safety into consideration, remarkably where the more transitions in phase and interface operations will represent also a potentially higher risk of accidental releases.

Finally, it is important to note that a significant part of the LNG value chain can be contained within the boundaries of a Port and, especially if a multi-modal hub[14] is also included, it will very likely be seen the co-existence of different stakeholders in the port area. Port rules and local regulations should not only have this notion into account but also realize the different regulatory frameworks that may be relevant for different parts of the LNG chain. Fixed LNG bunkering facilities and mobile units may coexist, giving the exact expression to the versatility of LNG as fuel.

The LNG value chain, from an import grid or natural gas network distribution, can be further decomposed into different supply routes. Figure 2.16 exemplifies a possible representation of different supply routes. Different stages are considered which can be generically taken as the example from the figure: 1) Supply; 2) Transport; 3) Local storage or production and 4) Bunkering. We are only taking LNG fuelled vessels as the consumers in the diagram represented. In reality, however, this would be a multi-consumer environment that would be able to access LNG/NG from any point in the LNG chain.

LNG Bunkering, as an end-service within the LNG Value Chain will dictate, through demand, the shape of the local storage/production, whether trucks suffice, on a regular or spot delivery for bunker, or even whether local storage needs to be considered. Demand in terms of capacity (in total or per operation) will have to be considered, in this sense, at a very early stage. A careful consideration to the LNG Value Chain end, will avoid undesired operational losses, inadequate solutions and, ultimately, safety.

[14] The tendency to have multi-modal hubs where LNG is supplied to different transport mode units will be potentiated by the TEN-T network, where EU core ports also represent relevant multi-modal nodes in the network. The possibility

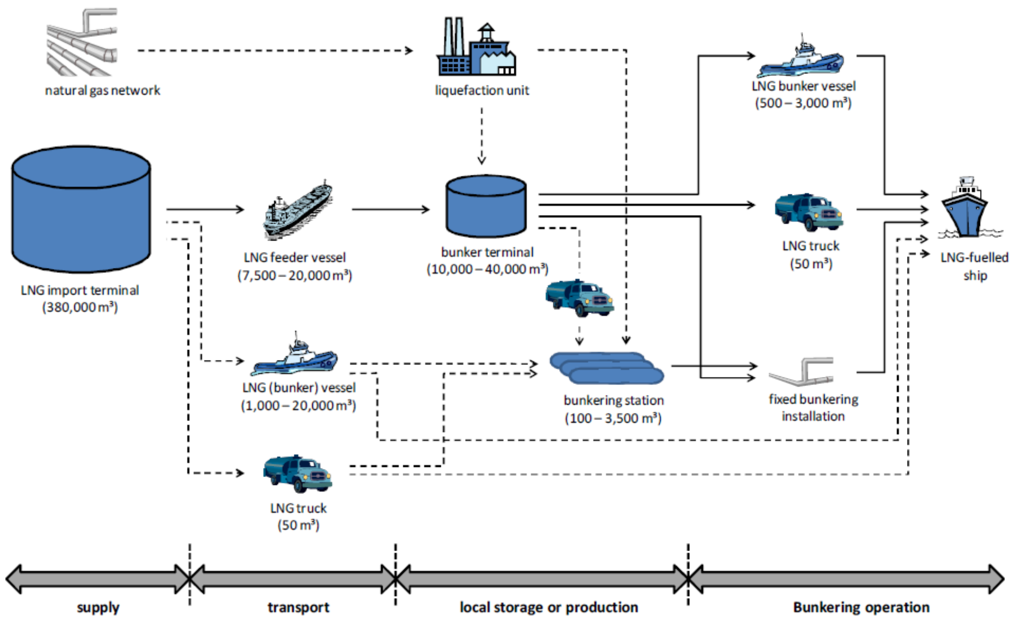


Figure 2.16 – Schematic representation of the different supply routes for the delivery of LNG as a ship fuel [21]

2.3.1 Elements affecting the LNG Value Chain

The following elements are considered as determinant in the shape and requirements for an LNG Value Chain:

- Consumer characteristics (location(s), consumption profile, cost vs. feasibility)
- Gas availability requirement
- Supply (location(s), suitability, cost)
- Receiving terminals (need for break-bulk, location, type, sizes, investment cost)
- Shipping (vessels available, charter rate, fuel consumption)
- Boil-off gas (BOG) handling
- Distance for LNG distribution (will dictate the distribution/transport mode for LNG) – the longer the distance for LNG distribution the higher should be the investment in insulation and, potentially, also the need for intermediate storage, liquefaction and refrigeration.
- LNG truck-trail loading in points where LNG road-rail mobile units load LNG for break-bulk distribution.
- LNG transhipment[15] from larger scale LNG carriers to medium-smaller LNG feeder vessels or even LNG bunker vessels or barges.
- How far apart are end users/consumers from LNG Import Terminal? This will dictate how smaller scale LNG bunkering will develop and how will distribution of LNG be done to avoid losses and to minimize the number of transformation points.

2.3.2 Scale of LNG developments and facilities

In the context of this Guidance the scale of an LNG development/facility is often mentioned, in particular with reference to “small scale” LNG facilities. In the absence of exact criteria that would help to determine a separation between small, medium and large scale LNG developments, this Guidance establishes, as an indicative reference the single criteria approach, using for classification the LNG storage capacity of a given LNG facility. The whole scope of this Guidance is contained in the Small scale interval, with LNG storage capacities involved, either in pressurized or atmospheric tanks well below 10,000m^3.

[15] Transhipment – operation technically similar to simultaneous unloading and loading - can be used to divide a large cargo into smaller ones (break-bulking), or to optimise the LNG tanker fleet between the sellers and buyers of a cargo (ship swap). Transhipment may also be called "Ship-to-Ship" (STS), even if STS usually refers to offshore cargo transfer through flexible hoses between side-by-side vessels.

Transhipment is not covered by this Guidance as it deals with LNG as cargo, even if it may represent the break-bulk of cargo into smaller feeder vessels. Some of these feeder vessels may however be involved themselves in the delivery of LNG broken bulk to LNG bunkering providers,

Table 2.2 – Scale of LNG developments and facilities (single criteria: storage capacity)

LNG Scale	LNG Storage capacities typically involved	Operations
Large	> 100,000 m^3	Liquefaction plant: A large-scale LNG operation typically includes production trains with single capacities between 1 and 6 MTPA (million metric tonnes per annum), and they can include multiple trains. Large liquefaction sites are always located in coastal areas since the only practical method of large-scale transportation is using LNG carriers, with capacities ranging from approximately 120,000 m3 (54,000 tonnes) for older vessels to up to as much as 267,000 m3 (120,000 tonnes) for the largest Q-max vessels. Receiving terminal: Conventional receiving terminals (LNG hubs) in the large-scale LNG chain are also located by the coast so that LNG carriers can arrive and unload the cargo. Main hubs include LNG storage facilities, typically in the range of 120,000 m3 or larger, designed to receive at least the full capacity of the allocated LNG carrier. The LNG is regasified at the hub, and the main distribution channel for the consumers is normally a national, high-pressure, natural gas pipeline.
Medium	10,000 to 100,000 m^3	A medium-size LNG logistics chain includes terminal up to 100,000 m3 in size, which are supplied by small-scale LNG carriers, starting from sizes of 1000 m3 to up to around 40,000 m3. Here again, the vessel size and loading frequency play an important role in determining storage capacity. Medium-scale liquefaction is not so common today, due to the challenge with high, specific production costs. In any case, these will probably play a larger role in the future for decentralised solutions, to which extending the large-scale logistic chain would not be feasible.
Small	< 10,000 m^3	A small-scale LNG logistics chain is comprised of LNG distribution to local users. In practice, this means highway truck transportation or small sea-going vessel distribution to the end-user's local LNG tanks, which can be from the smallest container sizes of 20 m3 to up to a set of pressurised steel tanks with total capacities of up to a few thousands of cubic metres. Small-scale liquefaction is becoming popular due to the liquefaction of biogas and other smaller pockets of stranded gas. Small-scale liquefaction can be modularised and, to some extent, standardised. The systems are similar to the re-liquefaction process used in large terminals to handle the BOG (boil-off gas

2.4 LNG Bunkering

2.4.1 Definition

Regulation 2017/352 provides the more general definition, used in the context of this Guidance. Adapting that definition for the case of LNG bunkering the following definition is provided:

Provision of liquefied natural gas (LNG), to be used as fuel, used for the propulsion of the LNG fuelled waterborne vessel as well as for general and specific energy provision on board of the waterborne vessel whilst at berth

LNG Bunkering is in fact a particular type of operation where LNG fuel is transferred from a given distribution source to a LNG fuelled ship. It involves the participation of different stakeholders, from the ship-side, LNG supplier, ports, safety personnel, administrations and policy makers. In addition to the supply of the LNG fuel itself, also the operation of supplying LNG sourced energy to the waterborne vessel, whilst at berth, is included in the present Guidance document.

2.4.2 LNG Bunkering Supply Mode

One of the main challenges with LNG Bunkering is the interfaces created during LNG delivery moment. These challenges can be either of a regulatory or technical nature, but not only. In fact, on top of particular standards and technological needs for LNG as a marine fuel to be bunkered safely, it is important to acknowledge the relevance of harmonization. The creation of interface environments in LNG bunkering raises the concern about how different regulatory frames ('land side' vs 'ship side', 'road' vs 'port', 'road' vs 'ship-side', etc.). Ideally regulations and requirements should tend towards harmonization and non-conflicting regimes, but this is not always the case. On top of this the interface can also unveil potential training discrepancies, equipment mismatches and other factors that can, ultimately, influence Safety and affect the Environment with unnecessary methane emissions. The minimization of risk to life and property, and the mitigation of gas release are the fundamental drivers to make the LNG chain inside the port area as lean and simple as technically possible.

From a PAA perspective in the definition of an LNG Bunkering concept the main elements that are considered for the present questionnaire are:

a) How the LNG arrives to the port are;
b) Whether it is intermediately stored within the port and
c) How is the LNG delivered to the receiving vessel?

Different options are possible by the combination of replies to these questions. Table 2.17, below, includes a combination of different supply elements.

Many different combinations are possible. With these different combinations there are different regulatory instruments; at national, regional or international level which also concur (these are explored in Section 4). The identification of potential conflicting requirements will also be relevant for the outlining of guidelines that may be able to resolve them, clarifying, streamlining and identifying possibly adjusted procedures.

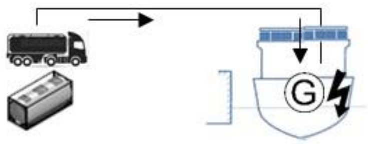
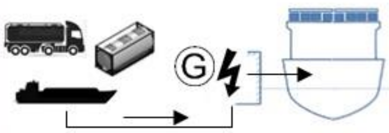
Table 2.17 – LNG fuel supply options inside the Port area (table 1)

Delivery to Port LNG Source (how LNG is brought to the Port)	On-site Storage (Is LNG stored within the port area?)	Bunkering (how LNG is delivered to the receiving vessel)	Mode (Code indicating the sequence: Delivery/Intermediate Storage/Bunker)
1. Truck	A. Yes	1. Truck	1A1
		2. Barge/vessel	1A2
		3. Pipeline	1A3
	B. No	3. Truck	1B1
2. Ship/Barge	A. Yes	1. Truck	2A1
		2. Barge/vessel	2A2
		3. Pipeline	2A3
	B. No	2. Barge/vessel	2B2
3. Pipeline For Natural Gas pipelines – reliquefaction required. For LNG pipelines (short insulated lines) – reliquefaction not required.	A. Yes	1. Truck	3A1
		2. Barge/vessel	3A2
		3. Pipeline	3A3
	B. No	1. Pipeline Relevant in the cases where LNG terminal is in close-by location and LNG can be transferred via short-distance piping lines.	3B1

Also featured in the present Guidance the Special Modes presented in table 2.18 where, in fact, no transfer of fuel occurs in the interface (in S4 the transfer is of a containerized unit and in S5 or S6 the transfer is not of the LNG fuel but of LNG-sourced electricity). The definition used for LNG bunkering in the context of this Guidance allows these options to be also considered.

The concept followed is here that of the presence of LNG as a hazardous substance in the vicinity of the receiving LNG vessel. Whether the transfer operation occurs in the interface or not is only important for the detailed technical guidance. At the level of Risk & Safety and concept of operations the presence of LNG in the proximity of the LNG fuel receiving vessel.

Table 2.18 – LNG fuel supply options inside the Port area (table 2)

Special Modes		
4. Container 	LNG fuel ISO container units directly plugged into dedicated modular Fuel System units.	S4
5. LNG Shore fuel supply 	LNG Truck or Modular LNG ISO Container with shore-to-ship connection directly feeding the LNG fuel system for harbour LNG fuelled generator.	S5
6. LNG Shore electricity supply 	LNG Truck, Modular LNG ISO Container or LNG barge with feeding shore-side electrical generator for shore-side electricity supply.	S6

Having codified the LNG supply options in the previous tables it is now further detailed how these options can influence the concept of operations inside the Port, which aspects can be challenging from PAAs perspective and, also, how these can possibly influence the Spatial Planning of the Port as an important responsibility of PAAs when accommodating for LNG bunkering in the port services portfolio.

Table 2.19 – LNG fuel supply options inside the Port area (table 2)

LNG Supply Mode (Code from Tables 2.17 and 2.18)	Description	Observations/ Conditioning Factors
1A1	1. LNG is brought to the Port area by truck. 2. Storage in pressurized or atmospheric tanks, inside the port. 3. LNG is then loaded for TTS bunkering on a spot demand basis. Final movement of LNG inside the port by wheels. 4. Bunkering by Truck-to-Ship from the storage and loading site. 5. Intermediate storage facilities used as buffer spot between supply of LNG and bunkering demand. **Nr. of LNG transfers inside the port**: **3**	• Number of trucks to keep storage capacity can be significant, depending on the demand. • Relevant if Port Area is large and LNG between storage and Receiving Ship is not viable by pipeline. • Reduced LNG bunkering capacity (each truck will be able to deliver approximately 25ton of LNG (in slightly less than an hour) – see section 2.6 for more detailed information. • Any potential variation-increase in bunkering demand would lead to an increase in the number of truck movements in the port area, both loading-on and loading-off.

LNG Supply Mode (Code from Tables 2.17 and 2.18)	Description	Observations/ Conditioning Factors
1A2	1. LNG is brought to the Port area by truck. 2. Storage in pressurized or atmospheric tanks, inside the port. 3. LNG is then loaded for STS bunkering. Final movement of LNG inside the port area by ship/barge. 4. Bunkering by Ship-to-Ship from the storage and loading site. **Nr. of LNG transfers inside the port**: **3**	• Loading-on by trucks and loading-off by vessel is a very unlikely option accounting for the inflow/outflow balance. With very different capacities between truck LNG trailers and waterborne LNG transport (50m3 against 500 to 5000m3, respectively)
1A3	1. LNG is brought to the Port area by truck. 2. Storage in pressurized or atmospheric tanks, inside the port. 3. LNG is then transferred to the bunkering facility by pipeline onto a manifold, rigid arm or bunkering hose. **Nr. of LNG transfers inside the port**: **2**	• Loading of onsite storage facilities by truck is a very limited option to bring LNG fuel into the port area. • For higher demands in LNG volumes it will represent a rather intense LNG tuck traffic into the port area with a consequently high rate of loading operations. • Limited pipeline length by need to reduce pressure increase in the line due to heat influx along the transfer pipeline (even if insulated)
1B1	1. Truck-to-Ship (TTS) directly to ship. LNG is brought to the Port in the same truck that will bunker the receiving vessel. 2. No fixed storage of LNG. **Nr. of LNG transfers inside the port**: **1**	• This is perhaps the most common method for LNG bunkering today, despite the very limited capacity and LNG bunkering rates available from TTS solutions (around 50-200m3 and 40-60m3/h). • Despite the low capacity and bunker rates this is an option that allows flexibility and response to spot-demand.
2A1	1. LNG comes to the port by ship/barge, typically an LNG feeder vessel of higher capacity serving the intermediate logistical link between larger LNG import terminals and smaller LNG bunker facilities. 2. LNG is loaded from the intermediate storage tanks onto LNG trucks for bunkering at designated location(s) inside the port. **Nr. of LNG transfers inside the port**: **3**	• This represents an option that would allow high capacity and loading rates onto an intermediate storage tank within the Port, breaking this into smaller volumes for loading LNG trucks (or even multi-costumer hub), adding value to the port in terms of multi-service portfolio. • Different LNG Bunkering operator can be involved if multi-operator loading from the storage site is allowed. • Different designated LNG bunkering locations could be served allowing for flexible LNG bunkering response.
2A2	1. LNG comes to the port by ship/barge, typically an LNG feeder vessel of higher capacity serving the intermediate logistical link between larger LNG import terminals and smaller LNG bunker facilities. 2. LNG is loaded from the intermediate storage tanks onto smaller LNG bunker barges for bunkering at designated location(s) inside the port. **Nr. of LNG transfers inside the port**: **1**	• This represents an option that would allow high capacity and loading rates onto an intermediate storage tank within the Port. • Different LNG Bunkering operator can be involved if multi-operator loading from the storage site is allowed. • Different designated LNG bunkering locations could be served allowing for flexible LNG bunkering response.

LNG Supply Mode (Code from Tables 2.17 and 2.18)	Description	Observations/ Conditioning Factors
2A3	1. LNG comes to the port by ship/barge, typically an LNG feeder vessel of higher capacity serving the intermediate logistical link between larger LNG import terminals and smaller LNG bunker facilities. 2. LNG is transferred from storage tank location to bunkering facility by pipeline, either underground or above ground supports. **Nr. of LNG transfers inside the port**: **2**	• This is an inflexible method because the bunkering location must be close to the LNG storage tank(s) (≤250 m) [21]. Also, there may be conflicts with other activities taking place on the quay (i.e. loading/unloading of ships). • It is mainly indicated for situations with high bunker frequencies and small bunker volumes (e.g. supplying service vessels or scheduled ferry services).
2B2	1. LNG comes to the port area in the LNG bunker vessel/barge directly to bunker a waterborne receiving vessel, either at anchor or at berth. 2. No intermediate storage in the port area. **Nr. of LNG transfers inside the port**: **1**	• This method is mainly used for large bunker volumes (100 to 20,000 m^3) and high bunker frequencies, with the bunker vessel being supplied from a large import terminal or medium-sized bunker terminal. Bunkering can take place at the quay where the ship is berthed or at a specific anchorage in port or out at sea. The capacity of the bunker vessel and the bunkering rate applied must be tailored to the fuel needs of the ships being supplied [21]. • This is a flexible method with which high bunkering rates can be achieved. The downsides are the high costs (initial investment and use) and possible interference with through traffic in the port. • It is important that careful nautical analysis is made for the LNG bunkering location. • For some ships bunkering by the outside may represent significant operational advantages, allowing the quay side for other possible operations.
3A1	1. LNG can be derived from pipeline into the Port area in 2 different ways: a. Natural Gas pipeline into re-liquefaction unit inside the port area. b. LNG pipeline from outside the Port area, from close-by LNG Import Terminal outside the port. 2. LNG stored in intermediate onsite pressure/atmospheric tanks within the port area. 3. LNG loaded into LNG trailer trucks, for later bunkering at designated bunkering location. **Nr. of LNG transfers inside the port**: **2**	• This represents an option that would allow high capacity and loading rates onto an intermediate storage tank within the Port, breaking this into smaller volumes for loading LNG trucks (or even multi-costumer hub), adding value to the port in terms of multi-service portfolio. • Different LNG Bunkering operator can be involved if multi-operator loading from the storage site is allowed. • Different designated LNG bunkering locations could be served allowing for flexible LNG bunkering response.

LNG Supply Mode (Code from Tables 2.17 and 2.18)	**Description**	**Observations/ Conditioning Factors**
3A2	1. LNG can be derived from pipeline into the Port area in 2 different ways: a. Natural Gas pipeline into re-liquefaction unit inside the port area. b. LNG pipeline from outside the Port area, from close-by LNG Import Terminal outside the port. 2. LNG stored in intermediate onsite pressure/atmospheric tanks within the port area. 3. LNG loaded into LNG bunker vessel/barge, for later bunkering at designated bunkering location. **Nr. of LNG transfers inside the port**: **2**	• LNG bunkering via bunker vessel/barge is a solution for high capacity and high transfer rates. • Having a re-liquefaction facility onsite would allow flexibility in the production of LNG that would potentially be favourable to adjust the offer to the demand in peak demand periods. • This represents an option that would allow high capacity and loading rates onto an intermediate storage tank within the Port, breaking this into smaller volumes for loading LNG trucks (or even multi-costumer hub), adding value to the port in terms of multi-service portfolio.
3A3	1. LNG can be derived from pipeline into the Port area in 2 different ways: a. Natural Gas pipeline into re-liquefaction unit inside the port area. b. LNG pipeline from outside the Port area, from close-by LNG Import Terminal outside the port. 2. LNG stored in intermediate onsite pressure/atmospheric tanks within the port area. 3. Transfer for bunkering location by LNG pipeline (short distance run) **Nr. of LNG transfers inside the port**: **1**	• This is an inflexible method because the bunkering location must be close to the LNG storage tank(s) (≤250 m) [21]. Also, there may be conflicts with other activities taking place on the quay (i.e. loading/unloading of ships). • The layout of de LNG pipeline will have an impact on spatial planning, dictating important local construction measures. • Typical solution indicated for high bunkering rates and volumes.
3B1	1. In the case featured there is no intermediate onsite storage. LNG would come to the port area in liquid form, via special insulated pipeline. **Nr. of LNG transfers inside the port**: **1**	• This is an inflexible method because not only the bunkering location must be close to the LNG storage tank(s) (≤250 m) [21]. • Bringing LNG into the port area by special insulated line would also mean that the LNG production would have to be very close to the port, representing several challenges in spatial planning. • Should the LNG be sourced from another ship or barge berthed at a different quay, the challenges would be similar, in particular with the layout for the special pipelines.

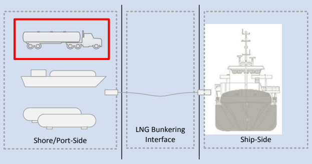
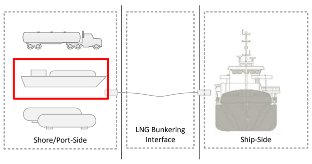
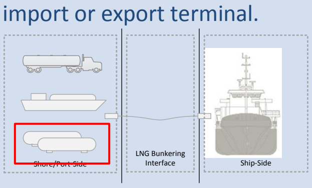
LNG Supply Mode (Code from Tables 2.17 and 2.18)	**Description**	**Observations/ Conditioning Factors**
S4	1. LNG fuel is here transferred to the receiving waterborne vessel via portable tanks. 2. LNG portable tanks can be embarked loaded-in or rolled-in, if transferred in suspension by crane or embarked directly via truck, respectively. **Nr. of LNG transfers inside the port**: **0** (LNG transfer occurs inside the ship)	• The present Guidance includes bunkering by portable tanks within its scope.[16] • It will be important for the port to differentiate the handling of these containerized units from other containerized cargo. • The differentiation mentioned above should encompass: i. Bunkering location ii. Possible intermediate storage location for LNG portable tanks (safe area in the quay side) iii. Possible limitations in the loading/rolling in operation accounting for other operations.
S5	1. LNG can be supplied to an LNG fuelled waterborne vessel whilst at berth, directly <u>from an LNG trailer tank, ISO portable container or even barge</u> to an LNG fuel burning unit onboard. 2. The LNG would, in this case, be fed through an Evaporator onboard onto the gas fuelled unit (engine, boiler…) at the exact consumption rate of that unit. 3. The LNG truck, portable tank or barges are used in this option as LNG temporary storage unit for the receiving ship whilst at berth.	• This operation is mentioned throughout the Guidance as “LNG fuelling” but, in fact, it consists of a bunkering operation scoped within the definition presented in 2.4.1. • The challenges presented to this type of operation are similar to the LNG fuel transfer operation, with the additional concern that the LNG storage stands outside, close to the vessel in a location that is, otherwise, not a fuel storage location. • The interesting aspect of this option is that ships can improve their environmental performance whilst at berth without having to invest in onboard LNG storage or complex fuel systems. • The challenge is that, whilst LNG fuel storage spaces onboard are regulated by the IGF Code, it is not the same case outside the ship and, therefore, also outside the scope of the IGF Code.
S6	1. In this case, electrical energy is supplied to the receiving vessel, not LNG. 2. LNG fuel is used by power generation units, or small-scale power plants, that will provide electrical shore-side energy to the receiving vessel.	• This operation is by far the one the most different from typical LNG bunkering operation and, in fact, LNG is never transferred to the receiving vessel. • The most relevant aspect to take into account, this special situation S6 is the fact that a small LNG power plant is close to the receiving vessel, either alongside or in the vicinity of the receiving vessel. • It represents an important application of LNG energy, adding value to the Ports environmental performance and, also, allowing ships to meet air emissions requirements whilst at birth.

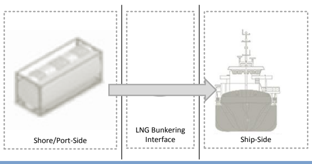
[16] This is not the same approach followed in all LNG bunkering references where LNG fuel portable tanks are dealt as hazardous materials handling operations. In the context of the definition presented in 2.4.1 of the present Guidance this is considered bunkering. Important note to make is that there is no correct way of classifying this, but aligning requirements for loading in and rolling in portable LNG containers should be in line with IGF Code requirements for these tanks onboard. Since the IGF Code deals with fuel, and not cargo, the operation of loading or rolling LNG fuel tanks, followed by their safe stowage and connection is here featured as an LNG bunkering option.

2.5 LNG Bunkering Modes

Delivering LNG fuel to a ship can be done in different ways, following different methods, depending on different logistic and operational factors. Various LNG bunkering methods are available, with Truck-to-Ship (TTS) being the most commonly used. Today's choice for TTS method has been a result of different aspects and difficulties that concur in the development of the business case for bunkering LNG as a marine fuel. On one hand the operational flexibility and limited infrastructure requirements for TTS and, on the other hand, relatively low initial investment to establish business readiness, have driven the option for this LNG bunkering method. The table below covers the relevant possible methods of bunkering LNG fuelled vessels.

Table 2.20 – LNG bunkering methods

Method	Typical Volumes (V) and Bunker Rates (Q) [21]	Advantages	Disadvantages
Truck-to-Ship - TTS LNG truck connected to the receiving ship on the quayside, using a flexible hose, assisted typically by a hose-handling manual cantilever crane. 	V ≈ 50-100m3 Q ≈ 40-60m3/h	• Operational Flexibility • Limited Infrastructure requirements • Possibility to adjust delivered volumes (nr. of trucks) to different client needs. • Possibility to adapt to different safety requirements. • Possibility to serve different LNG fuel users on point-to-point delivery	• Limited capacity of trucks: approximately 40-80 m3 is likely to dictate multi-truck operation. • Limited flow-rates (900-1200l/hr) • Significant impact on other operations involving passengers and/or cargo. • Limited movement on the quay-side, mostly influenced by the presence of the bunker truck(s). • Exposure to roadside eventual limitations (permitting, physical limitations, traffic related, etc.)
Ship-to-Ship - STS LNG is delivered to the receiving vessels by another ship, boat or barge, moored alongside on the opposite side to the quay. LNG delivery hose is handled by the bunker 	V ≈ 100-6500m3 Q ≈ 500-1000m3/h	• Generally does not interfere with cargo/passenger handling operations. Simultaneous Operations (SIMOPS) concept is favoured. • Most favourable option for LNG bunkering, especially for ships with a short port turnaround time. • Larger delivery capacity and higher rates than TTS method. • Operational flexibility – bunkering can take place alongside, with receiving vessel moored, at anchor or at station.	• Initial investment costs involving design, procurement, construction and operation of an LNG fuelled vessel/barge. • Significant impact in life-cycle cost figures for the specific LNG bunker business. • Limited size for bunker vessel, conditioned by port limitations.
Terminal (Port)-to-Ship - PTS LNG is either bunkered directly from a small storage unit (LNG tank) of LNG fuel, small station, or from an import or export terminal. 	V ≈ 500-20000m3 Q ≈ 1000-2000m3/h	• Possibility to deliver larger LNG volumes, at higher rates. • Good option for ports with stable, long-term bunkering demand.	• From operational perspective it may be difficult to get the LNG fuelled receiving vessel to the Terminal. • Proximity of larger LNG terminal may not be easy to guarantee. • Calculation of available LNG for delivery, in small storage tanks, can be difficult unless pre-established contract exist

Method	Typical Volumes (V) and Bunker Rates (Q) [21]	Advantages	Disadvantages
ISO Container-to-Ship LNG can also be delivered to the receiving vessel by embarkation of ISO containerized LNG tanks. If the receiving vessel is pre-fitted with LNG connections the fuel can then be used.  	Typical capacity: ISO 20ft: 20,5m3 ISO 40ft: 43,5m3	• Absence of interface bunkering operations • Simplification by exempting operations from hoses and other operational aspects. • Potential advantages from intermodal possibilities. • leveraging of intermodal transportation	• Connections onboard need to comply with strict construction regulations. • Limited volumes available in 20-40 m^3 containers. • Only suitable for a limited type of ships. • Requires pre-installation of LNG fuel installation.

Depending on the LNG quantity needed and potential time constraints for the operation it is possible that different LNG bunkering modes are more applicable to different needs, from different ship types, operational profiles and LNG fuel onboard storage capacities. Very likely larger ships, that potentially make use of LNG for longer voyages, will naturally require larger bunker volumes and, inevitably higher bunker rates. This is very likely the potential LNG bunkering characteristics for Very Large Container Ships, who stay at berth for the shortest time interval possible whilst potentially requiring the largest volumes of LNG bunkering. A suitable LNG bunkering method should therefore be provided for such needs. In addition to the capacity challenge

Table 2.21 – Typical LNG bunkering per different generic ship type [21]

Vessel Type (Receiving vessel)	Bunker Quantity	Rate	Duration	Hoses or arm diameter (pol)	Adequate Bunkering Mode
Service vessels, tugboats, patrol boats and fishing boats	50 m^3	60 m^3/h	45 min	2x2” or 1x3”	TTS
Small Ro-Ro and Ro-Pax vessels	400 m^3	400 m^3/h	1 hr	2x4” or 1x6”	TTS/ STS
Large Ro-Ro and Ro-Pax vessels	800 m^3	400 m^3/h	2 hr	2x4” or 1x6”	STS
Small cargo, container and freight vessels	2,000 – 3,000 m^3	1,000 m^3/h	2 to 3 hr	2x8” or 1x12”	STS
Large freight vessels	4,000 m^3	1,000 m^3/h	4 hr	2x8” or 1x12”	STS
Large tankers, bulk carriers and container ships	10,000 m^3	2,500 m^3/h	4 hr	2x10”	STS/ PTS
Very large container ships and oil tankers	20,000 m^3	3,000 m^3/h	7 hr	2x12”	STS/ PTS

All LNG bunkering modes share several fundamental aspects of concern that need to be carefully addressed in order to have safe and successful operations:

- Risk Analysis and Safety Management, intrinsically different depending on the method chosen for bunkering.
- Permitting, which will be needed for the different operations, from the relevant competent authorities
- Training of all personnel involved, both onboard and ashore.

2.6 LNG Bunkering Equipment, Ships and Infrastructure

As identified in the previous sections, LNG bunkering can assume very different shapes in terms of LNG supply chain and LNG bunkering mode. This will relate to the particular aspects of bunkering location, receiving LNG vessel characteristics and BFO service portfolio. Inherent to the different bunkering options and modes it is possible to consider different equipment, ships and infrastructure elements that compose the different LNG bunkering solutions. Table 2.22, below, includes these relevant elements with an indicative description for information.

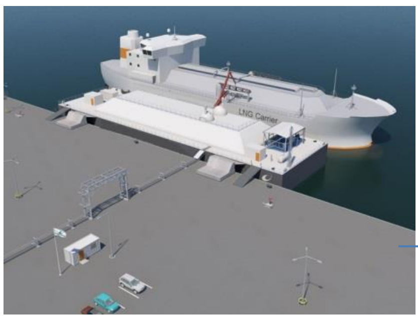
Table 2.22 – LNG Bunkering relevant Equipment and Infrastructures [21]

Equipment (Equipment/Ship/Infrastructure)	**Description**
1. LNG Feeder Vessels  	LNG feeder vessels are small to medium-sized LNG carriers used for regional transport of LNG with a view to its use as ship fuel or the industrial use of natural gas in remote places. LNG feeder vessels currently in operation or under construction are double-hulled gas carriers with a capacity of 7,500-30,000 m³ [21]. The size and main dimensions of the vessels will depend on market demand and the physical limitations of the intended unloading location, such as dimensions of the berthing site and draught at the jetty. The figures below show some examples of LNG feeder vessels with different capacities. LNG feeder vessels can be loaded at large LNG import terminals. Loading takes place via fixed cryogenic pipes and flexible hoses or fixed arms at the typical rate of 1,000-6,000 m³/h (depending on the size of the feeder vessel) [21]. The LNG vapour displaced from the ship's cargo tanks is returned to the terminal via a vapour return line. Unloading of the vessel at a bunker terminal or bunkering station is also done using fixed cryogenic pipes and flexible hoses or fixed arms. The LNG is pumped to the terminal by the submersible pumps fitted in the ship's cargo tanks at a typical rate of 1,000 - 6,000 m³/h **Figure 2.17 and 2.18 – LNG Feeder vessels – "Coral Methane" (7,500 m3) and "FKLAB L2" project (16,500m3) [21]**
2. LNG Bunker Vessel   	LNG bunker vessels are small LNG ships used for the direct supply of LNG fuel to ships inside or outside a port. During bunkering, the LNG is pumped from the bunker vessel's cargo tanks directly into the fuel tanks of the ship being supplied. LNG bunker vessels are identical in design to LNG feeder vessels and typically have a capacity of 500- 20,000 m³. LNG bunker vessels represent today a key role in the ability of LNG bunkering to grow in capacity whilst avoiding the difficulties of shore side/ quay operation. Bunkering from the opposite side to the quay will allow to design bunkering an port operation in a more flexible **Figure 2.19, 2.20 and 2.21 (top to bottom) – LNG bunker vessels – "Coralius" (5,800 m3), AGA "Seagas" (187m3) and "FKLAB L2" project (16,500m3) [21]** Small LNG bunker vessels (500 – 3,000 m³) are usually equipped with one or two cargo tanks. These are mainly cylindrical cargo tanks with a design

pressure of 3 to 4 barg (IMO type C tank) and an individual tank capacity of 500 - 2,000 m³ of LNG.
LNG bunker vessels can be loaded at small to medium-sized bunker terminals or large LNG import terminals. Loading takes place via fixed cryogenic pipes and flexible hoses or fixed loading arms at a rate of 200-3,000 m³/h (depending on the size of the bunker vessel).
Bunkering is done using flexible hoses or fixed arms at a rate of 60-3,000 m³/h depending on the size of the fuel tanks on the receiving vessel. [21].

Rules applicable to LNG bunker vessels are typically IGC Code unless the bunker vessel is operating only in inland waterways, outside the scope of IMO IGC Code applicability. Here the applicable instruments would be defined at National Administration level. In the EU context the ADN agreement, Directive 2016/1629 or RVIR regulation would apply.
Details of certification elements required for barges included in Section 15 of the present Guidance.

LNG Bunker Barge



LNG Bunker Barges are, essentially, the non-propelled version of LNG bunker vessels. All types of different LNG capacities and containment systems are possible, with a growing number of designs being developed.

Mobility of these barges is subject to push-pull tug arrangements or to any other external propelling unit that deliver the barge the ability to be moved around the port area, responding to different LNG bunkering needs in potential different LNG bunkering locations.

The use of a tug or external unit for mobility represents, on one hand, a clear flexible option that allows moving different floating units with one propelling craft. On the other hand, it may represent a challenge for manoeuvrability in higher traffic waterways.

Barges can have integral LNG tanks or, as in the cases presented in the figures to the left, tanks above main deck.
Whilst rules have been developed for LNG bunker vessels, mostly derived from IGC and IGF Codes, barges seem not to have a dedicated of of rules that apply directly to the carriage LNG fuel and bunkering services[17]. This may impose a challenge in the harmonization of these floating craft that should be taken into consideration by PAAs.

Details of certification elements required for barges included in Section 15 of the present Guidance.

Figure 2.22, 2.23, 2.24 and 2.25 – LNG bunker barges – top to bottom 1) barge with 2 (two) type-C tanks above deck; 2) Transport barge with ISO 40' LNG containers; 3) LNG bunker barge with membrane tank, equipped with rigid LNG transfer arm and 4) LNG Bunker barge, here seen as a berthing interface, similar to a floating storage unit (FSU) for LNG bunkering service.

[17] In general, barges intended for the carriage of liquefied gases in bulk are to comply with the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)* as appropriate, or other national standard, as applicable to the non-propelled status of the vessel.

A special certificate attesting to the degree of compliance with the above codes or national standard may be issued upon request.

For manned barges, consideration is to be given for full compliance with the code. In all cases, it is the Owner's responsibility to determine the requirements of flag Administration and port Administration.

LNG IMO Tanks/Containment Systems

For the cargo tanks used on gas carriers, a distinction is generally made between non-self-supporting tanks (atmospheric membrane tanks) and self-supporting tanks (actual pressure tanks). The self-supporting cargo tanks are subdivided into three classes according to their strength. The same classification (IMO Classification) is used for LNG fuelled ships, to define the LNG fuel tanks.

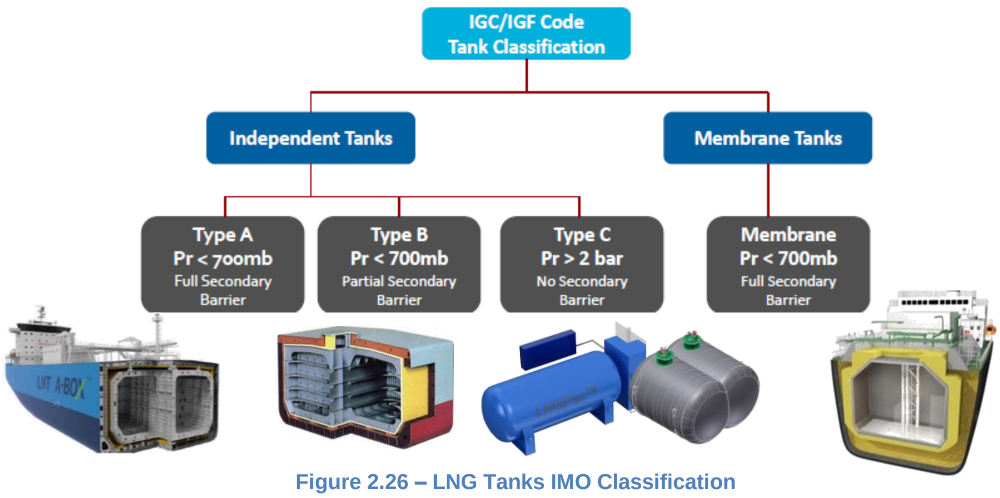


Figure 2.26 – LNG Tanks IMO Classification

IMO TYPE A TANK

These are prismatic cargo tanks with a low design pressure (< 0.7 barg). The material used in the construction of these tanks offers insufficient resistance to crack propagation, so that for safety reasons a second shell (tank wall) has to be provided to contain any leaks. This second shell can also be formed by parts of the ship (e.g. inner hull) provided that these are capable of resisting the low temperature of the cargo.

IMO TYPE B TANK

These are prismatic or spherical cargo tanks with a low design pressure (< 0.7 barg), for which a great deal of attention has been paid in the design phase to detailed stress analyses (inter alia in relation to fatigue and crack propagation).

Spherical Moss-Rosenberg tanks are the best known example of this type of tank.

Because of the improved design, a type B cargo tank only needs to have a partial second shell, fitted on the underside of the tank in the form of a drip tray.

IMO TYPE C TANK

These are spherical, cylindrical or bilobe pressure tanks with a design pressure greater than 2 barg. The tanks are designed and built according to the conventional pressure vessel codes and, as a result, can be subjected to accurate stress analyses. Moreover, in the design phase much attention is paid to eliminating possible stresses in the tank material. For these reasons, type C cargo tanks do not require a second shell.

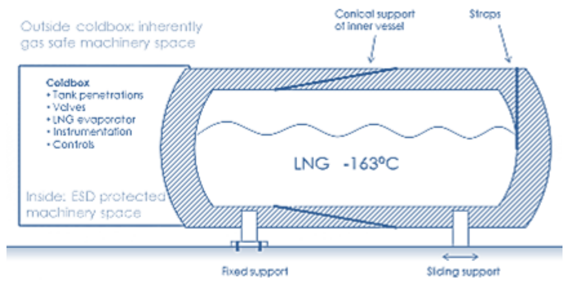


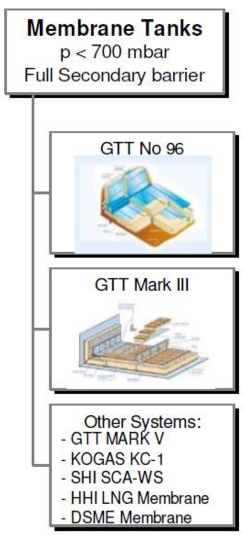
Figure 2.27 – LNG Type-C Tank

For ships in which the cargo is transported in a cooled and partially pressurised state, the cargo tanks and associated apparatus are typically designed for a working pressure of 4 to 6 barg and a vacuum of 0.5 bar.

The cargo tanks are typically insulated with polystyrene or polyurethane panels attached to the tank wall.

Membrane Tank

The inner surface of the insulation is exposed to the cargo. - Membrane tank – Membrane tanks are not-self-supporting tanks which consist of a thin layer (membrane) supported through insulation by the adjacent hull structure.



Despite the fact that membrane tanks are today widely used in LNG cargo tankers, the application of these technologies for LNG as Fuel is still without much expression.

Membrane tanks, as in Type A or B, optimize holding time by improved insulation.

Figure 2.28 – Membrane Tanks. Different technologies.

LNG Trucks

Regional transport and local distribution of LNG can also be performed using LNG trucks provided that the distance between the loading and unloading locations is not too great (max. 500 km) and the consumption of the local consumer is small.

The capacity of LNG trucks varies from 35 to 56 m³ for conventional trucks and up to 80 m³ for a truck/trailer combination. As an alternative to trucks, ISO tank containers with a capacity of 21 m³ (20" container) or 45 m³ (40" container) can also be used.
In some countries there may be a restriction on the maximum authorised mass (MAM)[18] of trucks used for domestic transport.

In terms of cargo tank design, LNG trucks can be divided into two types [21]:

- Trucks with a single-walled cargo tank made of stainless steel, insulated with insulating rigid polyurethane panels and fitted with a thin aluminium or stainless-steel protective cover[19];
- Trucks with a double-walled vacuum-insulated cargo tank comprising an inner tank made of aluminium or stainless steel and an outer tank of carbon steel. The space between the inner and outer tanks is a vacuum and is further insulated with perlite, glass wool or a super-insulating foil.

Figure 2.29 and 2.30 – LNG trucks in bunkering operation – From the top, LNG truck bunkering with second truck-trailer for Nitrogen/Inert Gas supply. Below 2 (two) LNG trucks bunkering back-to-back via common 2-way manifold derivation.

The cargo tank of an LNG truck typically has a design pressure of 5 to 6 barg and is equipped with a redundant overpressure protection system with two safety valves [21]
The main specifications of LNG trucks are presented below. The pressure and temperature of the LNG in the truck during transportation is typically between 0 and 3 barg (-160°C and -142°C).

Table 2.23 – General specifications of LNG trucks [21]

Volume	35 - 56 m³ (14 - 23 tonnes of LNG)
Maximum Filling %	Max. 90%
Design pressure (test pressure)	5-6 barg (9 barg)
Set pressure of safety valves	typically 5-6 barg

LNG trucks can be loaded at large LNG import terminals or medium sized bunker terminals at a rate of 50 - 100 m³/h. The LNG is pumped from the LNG storage tanks into the truck using a submersible pump via a fixed cryogenic pipe and a flexible (un)loading hose. The displaced LNG vapour is returned to the storage tanks via a vapour return line.

Unloading of LNG trucks at a bunker terminal or local bunkering station is also done using a flexible hose (2-3") and a fixed cryogenic pipe at a typical rate of 40 to 60 m³/h. The LNG can be transferred using a pump fitted on the truck or by raising the pressure in the truck using a pressure build-up coil or a connection to an external nitrogen or natural gas network.

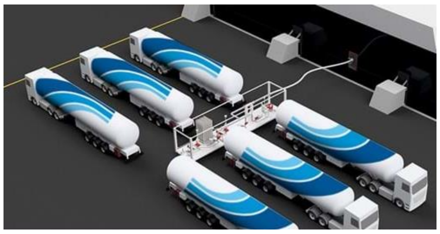
[18] Maximum authorised mass (MAM) means the weight of a vehicle or trailer including the maximum load that can be carried safely when it's being used on the road.

This is also known as gross vehicle weight (GVW) or permissible maximum weight. It will be listed in the owner's manual and is normally shown on a plate or sticker fitted to the vehicle.

The plate or sticker may also show a gross train weight (GTW), also sometimes called gross combination weight (GCW). This is the total weight of the tractor unit plus trailer plus load.

[19] The use of single-wall trucks for domestic transportation of LNG is not allowed in some countries due to concerns about the fire safety of these trucks given the flammable nature of the insulating material.

LNG Truck Common Bunkering Manifold



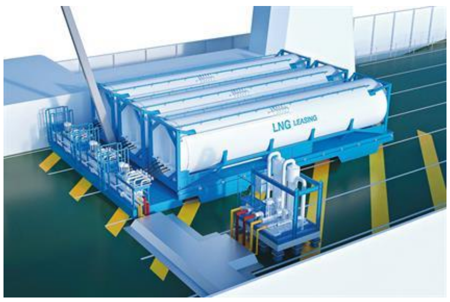
As LNG bunkering demand increases, the capacity of LNG truck (both in terms of volumes or LNG transfer rates) becomes insufficient. To continue using LNG trucks for TTS bunkering, the option found to increase volumes and transfer rates and optimize LNG bunker delivery operation times includes today common manifold structures as the one presented in the figure to the left.

Figure 2.30 and 2.31 – LNG trucks in common manifold bunkering operation

The option for common manifolds has been first featured in IACS Rec. 142 where it is mentioned: *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.*

Adequate and detailed operating procedures are important for safety of the operation. All the steps (preparation, pre-bunkering, bunkering, post-bunkering should be carefully detailed and explained. The risks and safety of the whole operation should be carefully assessed, not only in terms of HAZID and HAZOP analysis for the LNG bunkering operation, but also on the implications for the LNG bunkering location.

ISO LNG Tanks



ISO LNG Tanks are elements with the potential to play an important role in the LNG fuel value chain, not only as cargo but also as fuel.
With the following typical capacities:

- ISO 20ft: 20,5m3
- ISO 40ft: 43,5m3

With the possibility of portable fuel tanks to be used as LNG fuel units included in the IGF Code[20], it is possible to consider the use of these elements as fuel storage for ships converted to LNG as fuel that did not make use of the hull internal volume to place fixed LNG fuel storage.
A normal tank container intended for transporting LNG cannot, however, be used directly as a portable fuel tank since it does not fulfil all the requirements for marine LNG fuel tanks. Modifications relating to remote monitoring and safety systems, IMO type C tank requirements, and leakage & spill protection are a few items that need to be specifically considered for marine fuel tanks. The list below identifies the characteristics of LNG portable fuel tanks that need to be considered, on top of those required for LNG cargo ISO tanks.

Standard ISO frame
Compliance with transportation regulations (IMDG, TPED, ADR, RID, CSC among others)
Compliance with rules for use as LNG fuel tank on board ships:
IMO Type-C tank
Water spraying system
Tank safety relief valves designed for fire case
Connection to external vent mast
LNG leakage detection and protection
Class approved equipment & design
Stainless steel outer shell
Dry disconnect quick couplings
Connections at end for connecting to ship
Connection to automation system on the ship
Connection to safety systems on the ship

Only the first two requirements are required for ISO LNG tanks

Remaining aspects to be covered for LNG portable tanks.

Figure 2.32, 2.33 2.34 – ISO LNG fuel tanks – From top to bottom: 1) 20ft ISO LNG and 2) 40ft ISO LNG. Bottom figure is the artistic representation of the LNG FuelPac ISO concept from Wartsila with ISO portable tanks, "plug-in" common manifold and evaporator on deck.

[20] IGF Code Section

Rigid/Mechanical arms

Whilst smaller diameter 2 to 3" LNG hoses are easily handled by hand, larger diameters are far more difficult to handle. The use of dedicated, or general purpose, cranes have therefore been of great assistance in the operation of LNG hoses for connection with the LNG receiving vessel.

In addition to the support of LNG hoses weight during bunkering, other aspects are important drivers for the use of mechanical rigid LNG bunkering arms:

i. Safety of the whole LNG bunkering operation
ii. Precision in the connect/disconnect procedure
iii. Optimization of bunkering duration
iv. Possibility to deliver LNG bunker connection at different heights

Full rigid arms are provided with rigid insulated pipe sections through which LNG is pumped through to the receiving vessel. Swivel joints allow the necessary motion in the intended degrees of movement, whilst pneumatic/hydraulic assisted mechanisms provide the motion and binary forces for the mechanic arm.

Typical installations for such arms would be LNG bunkering fixed stations or LNG bunker vessels.

Figure 2.35 and 2.36 – From top to bottom: 1) Mechanical arm for hose handling with dedicated saddle articulated points and 2) Example of a full articulated mechanical LNG bunker arm.

LNG bunkering stations

Local jetties can be equipped with a small-scale LNG bunkering station that is used to supply specific end users (e.g. service vessels or ferries). The storage capacity of such bunkering stations is typically 100 to 3,500 m³ [21]. Bunkering takes place by means of a fixed bunkering installation (i.e. a cryogenic pipe and loading arm or flexible hose) from the stationary LNG storage tanks at a rate of 50 - 500 m³/h depending on the size of the vessel being supplied.

Such stations are generally supplied by small LNG ships (capacity: 500 to 3,000 m³) or LNG trucks that bring the LNG from a nearby LNG bunker terminal or from a large LNG import terminal [21]. A possible alternative to supplying LNG by ship or truck is to build a small-scale liquefaction unit with a capacity of 5,000 to 20,000 tpa in the immediate vicinity of the station.

The figures to the left show some examples of small-scale LNG stations.

Whereas the two figures on the top are demonstrative of small-scale fixed LNG bunkering stations, the one on the bottom is intended to demonstrate what can be achieved through a temporary installation of an LNG trailer, on a semi-fixed installation. It is important that PAAs are aware that even if this situation is not a fixed installation, similar concerns should be considered. The use of LNG trailer trucks in semi-fixed LNG bunkering installations should not represent a way to avoid more stringent regulatory requirements for fixed small scale LNG bunkering sites.

Figure 2.37, 2.38 and 2.39 – Two on the top representing fixed LNG bunkering installations, both with 3 horizontal pressure tanks. The one below representing an LNG trailer installed temporarily, with concrete defences and

The storage tanks used at a local LNG bunkering station are typically cylindrical tanks with a volume of 100 to 1,000 m³. More specifically, they are double-walled vacuum insulated pressure tanks set up either horizontally or vertically. The degree of filling of the tanks must not exceed 95% under any circumstances, in line with ADR requirements.

The LNG is stored in the tanks at a pressure of 0 to 4 barg and a temperature of -160°C to -138°C. Because the tanks are vacuum-insulated, little heat is lost through the tank wall and the tank pressure will only rise very gradually during long periods when no LNG is withdrawn. The tanks are also fitted with an ambient air vaporiser to keep the tank pressure at the desired level as well as a redundant overpressure protection system with two safety valves.

The figure below shows a schematic representation of a vacuum-insulated LNG tank.

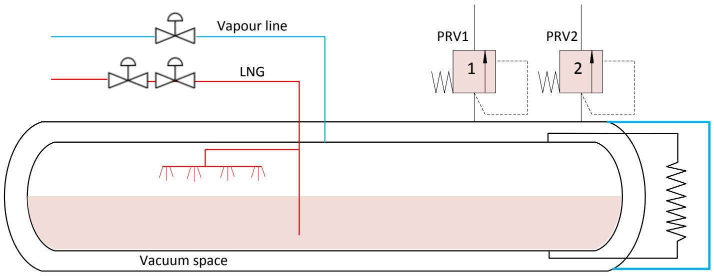


Figure 2.40 – LNG storage pressure tank [21]

The characteristics dimensions of such tanks are given in the table below [21]:

Table 2.24 – Typical characteristic dimensions for LNG storage pressure tanks [21]

Tank Volume	100m³	250m³	500m³	700m³
Diameter	3.5	4.3	5	5.5
Length	16.5	23	30	35
Max. connection (mm) [inches]	(100) [4]	(150) [6]	(150) [6]	(200) [8]

The ship bunkering installation is similar to the installation used to unload LNG ships, namely a fixed cryogenic pipe and a flexible hose or loading arm. The flow rates applied when bunkering vessels using a fixed installation are typically 50 to 500 m³/h depending on the size of the ship being supplied

Fixed LNG bunkering stations can be loaded both from ships or trucks:

Loading from LNG ships:
LNG ships unloaded at a bunkering station have a typical capacity of 500 to 3,000 m3 and unloading takes place via a fixed arm or a flexible hose at a rate of 200- 1,000 m³/h. The diameter of the unloading arm or hose used for this purpose is 4” to 8”. The LNG is transferred to the storage tank via a cryogenic unloading pipe with a diameter of 4” or 10”. The unloading pipes must be kept as short as possible (<250 m) to minimise boil-off gas losses and associated pressure increase in the LNG line.

Loading from LNG ships:
The LNG trucks used to supply the station are generally unloaded at a rate of 40 - 60 m³/h using a flexible unloading hose (3”) and a cryogenic LNG pipe (3”/4”). The LNG can be transferred using a pump fitted on the truck or by raising the pressure in the truck using a pressure build-up coil.

Liquefaction units

Building a small to medium-sized liquefaction unit is a possible alternative to shipping in LNG to bunker terminals and bunkering stations. Such liquefaction units have a production capacity of 5,000 to 20,000 tpa (for bunkering stations) and 40,000 to 300,000 tpa (for bunker terminals).
Medium-sized liquefaction units typically have a production capacity of 270 to 2,000 m^3 of LNG per day, which implies a natural gas consumption of 7,200 to 54,000 m^3 (n)/h.
Small liquefaction units typically have a production capacity of 35 to 135 m^3 of LNG per day, which implies a natural gas consumption of 900 to 3,600 m^3(n)/h.

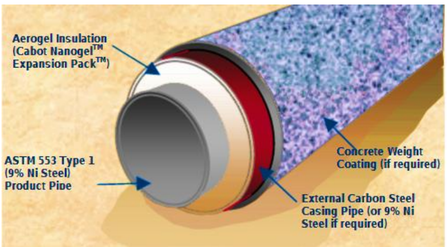
Figure 2.41 – Small liquefaction unit [21]

For LNG liquefaction units with a capacity of 5,000 – 300,000 tpa, the following process cycles are mainly used [21]:

- an open cycle with turboexpander;
- a closed one- or two-stage cycle with nitrogen refrigerant;
- a closed one- or two-stage cycle with mixed refrigerant.

LNG (re)-liquefaction plants are important infrastructure elements that allow both production of LNG onsite and Boil-Off Gas management through re-liquefaction.

LNG pipeline (fixed installations)



LNG pipelines are increasingly important elements in the context of LNG bunkering. They allow the LNG fuel to be transferred from the storage location (pressure or atmospheric tanks) into the LNG bunkering location. Even though they are not very common for

The total length of the pipelines is limited to the efficiency of the insulation and, in principle, should not be longer than 250m [21]. This will depend on many aspects which are mostly local-dependent and whether the LNG distribution system has the ability to manage BOG generated during transfer.

The LNG pipeline layout design can consider different routing solutions, either by aerial route with supports or lay along a special trench, designed to keep the LNG pipeline offset from the risks associated to vehicle circulation hazards/accidents.

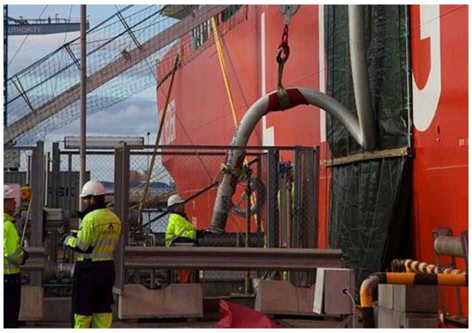
LNG pipelines are then able to feed either local numbering manifolds or directly into mechanical articulated arms as the one presented in this table, above.

Whenever LNG pipelines are routed, aerial, over ground or underground, crossing public domain spaces, careful consideration must be paid to Safety with special dedicated measures and barriers to mitigate the risk of hazardous events affecting the pipeline.

Inerting arrangements to be part of the LNG bunkering station. LNG pipeline to be permanently inerted outside LNG bunkering operation.

Figure 2.42 and 2.43 – underground LNG pipeline cross-sectional representation, highlighting the insulation layer and, below, LNG pipeline above ground (to be noted the apparent large diameter mostly due to insulation. Outer layer for physical protection and to avoid moisture frost formation.

LNG hoses



LNG bunkering hoses are important elements in the LNG bunkering operation. Typically in composite multi-layer thermoplastic, LNG hoses are to be designed and certified according to the following standards:

- EN 1474-2 - Design and testing of marine transfer systems. Design and testing of transfer hoses
- EN 13766:2010 – Thermoplastic multi-layer (non-vulcanized) hoses and hose assemblies for the transfer of liquid petroleum gas and liquefied natural gas – Specification

Typically, the bunker hose is expected to be provided by the supplier. It should be suitably long and flexible, such that the hose can remain connected to both the supplier's manifold and the receiving ship's manifold during normal relative movements expected from wind, waves, draft changes, current, and surges from passing vessels. Typically, bunker hoses are constructed of composite materials and are flexible to allow for relative movements. The supplier should provide a bunker connection at the hose end that will match the receiving ship's connection. Although industry standardization has not yet been implemented, ISO/TS 18683:2015 references relevant standards.

Additionally, the hose should be capable of releasing without damage or significant spills if the relative position or movement of the receiving ship exceeds the limits. LNG bunker hoses are typically fitted with connections that are of the quick connect type and remain sealed until the connection (drip-free type) is made. The receiver's end of the hose also will usually be fitted with an emergency release system (ERS), such as a drip-free, breakaway coupling that gives way before excessive pull causes the hose to break or other damage to occur.

This type of coupling uses spring loaded shutoff valves to seal the break and stop any LNG or vapour release. Quick connect and break-away couplings are readily available in the market and minimize the possibility of LNG leakage and gas escape.

Cranes, loose gear, supports, etc., are to be provided for hose handling and bunkering operations and are to be designed, arranged and surveyed in accordance with the applicable requirements of the ABS Guide for Certification of Lifting Appliances.
iii) Hose supports or cradles are to be used where necessary to keep hose bends within the design limits, as per manufacturer's recommendations.
iv) Fixed LNG bunker transfer systems are to be designed and tested in accordance with recognized standards such as EN1474-3 (offshore transfer system) and/or EN1474-2 (transfer hoses). LNG bunker transfer systems and hoses are to be arranged to provide sufficient flexibility over the range of expected relative vessel motions.

Hoses can also be part of hybrid flexible/rigid/mechanical systems, such as the one presented to the left. ERC and connector to be also fitted at the end.

Figure 2.44, 2.45 and 2.46 – examples of flexible LNG bunkering hose applications. Top to bottom: 1) Bunkering of the MV Viking Grace with bunker hose handled from the bunker vessel side; 2) LNG bunkering hose suspended from crane line, noting the attention to the hose suspension point where pressure is distributed along the saddle curvature; 3) example of a hybrid rigid-flexible LNG bunkering line arrangement.

Emergency Release System (ERS)

The present Guidance refers to ERS, ERC and ESD in the terms presented in EN ISO 20519, where ERS is defined as a system comprised of two sub-systems/elements that allow the main functional requirement of quick/dry disconnect during bunkering operation, as a consequence of an emergency

Emergency Release System (ERS)
(EN ISO 20519, Section 4.3)
General Functional requirements for ERS include ERC and ESD systems. The approach in the standard is to consider both ERC and ESD as sub-components of the system.

Emergency Release Coupling (ERC)
(EN ISO 20519, Paragraph 4.3.2)
Coupling designed to allow hose separation when desired, as a consequence of a faulty, alarm or hazardous condition n LNG bunkering.

Emergency Shut-Down (ESD)
(EN ISO 20519, Section 4.3.9)
ESD systems to comply with minimum requirements in EN ISO 20519, Paragraph 4.3.9 (referring to SIGTTO document titled "ESD Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carriers, SIGTTO First Edition 2009"

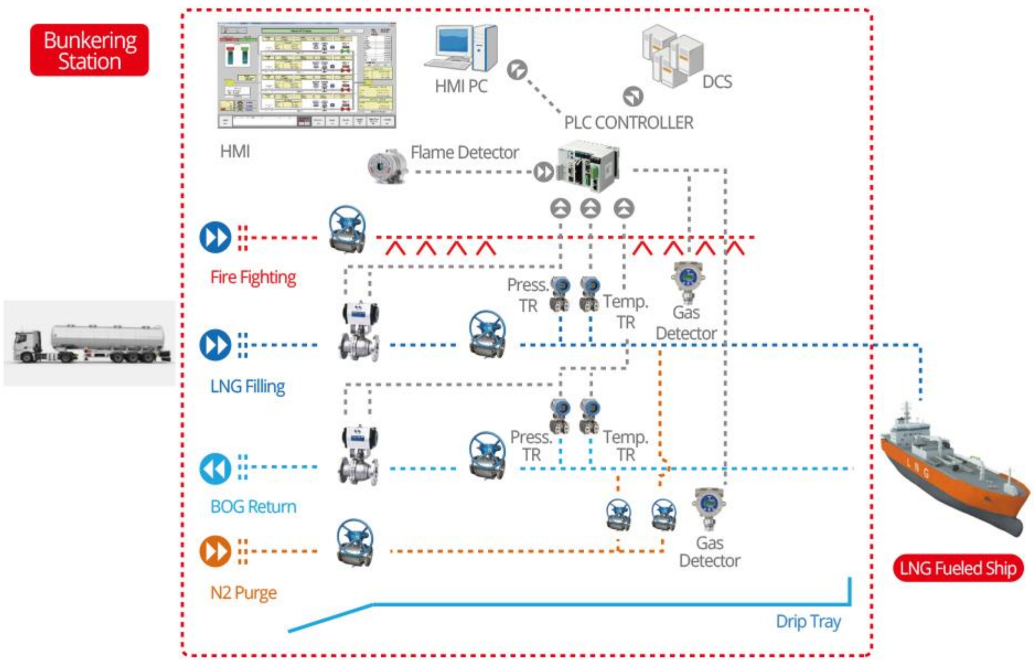
Emergency Shut-Down (ESD)

An emergency shut-down (ESD) is a method or a system that safely and effectively stops the transfer of LNG (and vapour as applicable) between the LNG bunkering facility and the receiving ship in the event of an emergency during the bunkering operation. The control systems involved in the ESD, which is a linked system to allow both parties (on board receiving ship and the bunkering facility) to shut down the transfer in an emergency situation, can be activated automatically or manually.

The ESD may consist of two parts:

- 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 levels LNG tank alarms, cables or other means designed to detect excessive movement between transfer vessels or vessel and an LNG port 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 port facility. The decoupling mechanism contains quick acting valves designed to contain the contents of the LNG transfer line (dry break) during decoupling.

The figure below presents a possible integrated diagram for an ESD, for the specific case of TTS LNG bunkering.



Typical reasons for activation of the ESD include the following:

- Gas detection
- Fire detection
- Manual activation from either the supplier or receiver
- Excessive ship movement
- Power failure
- High level in receiving tank
- Abnormal pressure in transfer system
- High tank pressure
- Excessive stress in LNG bunker arm

Other causes as determined by system designers and regulatory organizations

Figure 2.47 – ESD local command switchboard and alarm indicator [26]

<u>ESD systems to comply with minimum requirements in EN ISO 20519, Paragraph 4.3.9 (referring to SIGTTO document titled "ESD Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carriers, SIGTTO First Edition 2009".</u>

Emergency Release Coupling (ERC)

A breakaway coupling or emergency release coupling (ERC) is a coupling located in the LNG transfer system (at one end of the transfer system, either the receiving ship end or the bunker facility end, or in the middle of the transfer system), which separates at a predetermined section when required, each separated section containing a self-closing shut-off valve, which seals automatically.

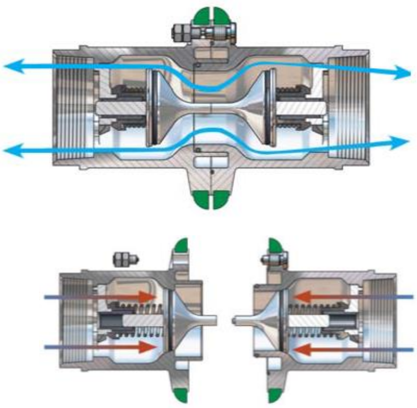


Figure 2.48 and 2.49 – ERC model drawing representation, with halves tight together, during normal operation and, below, after emergency release for dry breakaway.

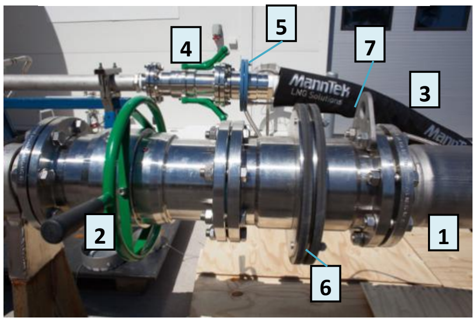


Figure 2.50 – complete bunkering arrangement at connection in Bunkering Station.

1. **LNG bunkering line**
2. Main Quick-Connect/ Dry Disconnect coupling (QC/DC)
3. Vapour return line
4. Return QC/DC
5. ERC main line
6. ERC Vapour Return
7. Pad-eye for LNG bunkering hose crane handling

<u>ESD systems to comply with minimum requirements in EN ISO 20519, Paragraph 4.3.9 (referring to SIGTTO document titled "ESD Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carriers, SIGTTO First Edition 2009".</u>

Dry Quick-Connect/ Disconnect Coupling

Dry Quick Connect/Disconnect couplings (Dry QC/DC) are a specific type of couplings that allow easy connection/disconnection without the use of manual intensive operation (such as tightening bolts), whilst including self-containing stop valves at the female and male ends to avoid spillage of hose and receiving line LNG content that may possibly be contained in the lines (if not inerted).

Figure 2.51 – LNG Dry QC/DC coupling.

The coupling consists of a Nozzle (male) and a receptacle (female). The nozzle allows quick connection and disconnection of the fuel supply hose to the receptacle, mounted on the LNG manifold. Connectors used shall be designed to operate as quick connect/disconnect couplings. Couplings, in nominal sizes up to 6", for flows up to 650 m3/h, and maximum flow rates of 10 m/s.

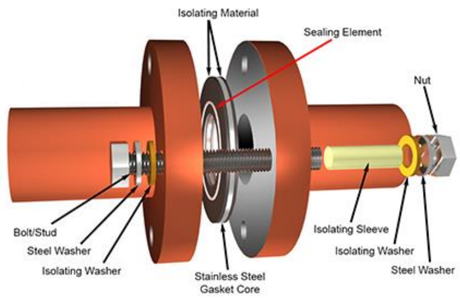
The advantages of standard quick connectors are as follows [27]:

1. avoid mix-up and use of any connector designed for other fluids or gasses through the safety of a unique standard geometry;
2. allow for a quick and easy mechanical solution with efficient and safe connection specially designed for cryogenic LNG;
3. avoid company standards that will normally be protected by property rights and may be limited to contracts and brand distributors, which normally results in less competition and hamper public procurement;
4. prevent the safety risk of fitting additional adaptors and gaskets to convert between different company standards and the risk of using parts not adequate for cryogenic fluids;
5. avoid the temptation to make or modify adaptors, to fix something on short notice, with possible limited access to the right material and manufacturing equipment;
6. eliminate the need for manual bolting and manual re-tightening after down-cooling to cryogenic temperatures;
7. avoid leaks (methane slip) and problems due to uneven tightening and any accident if wrong studs accidentally have been used;
8. avoid torsion problems as the connectors have swivel features and thus torsion problems that may arise on flanges do not exist; and
9. ensure conformant operation and safety training for all personnel involved in bunkering on a world-wide basis

ESD systems to comply with minimum functional requirements in EN ISO 20519, Paragraph 4.3.
NOTE: Until the adoption of an International Standard for Dry QC/DC couplings the Best Practice to follow is:

- **Ensure compliance of the couplings with the Functional Requirements in EN ISO 20519.**
- **consult with Classification Society on the best options to optimize LNG bunkering compatibility with receiving vessel.**
- **Liaise with Industry Association (such as SGMF) or other in order to get the best**

Isolation Flange



Vessels transferring or receiving low flashpoint flammable liquids, such as LNG, need to take additional precautions against ignition resulting from electrical arcing.
Two causes of arcing are

- Static electricity build-up in the LNG bunker hose
- Differences in potential between the ship and bunker supplier's facility, including the quay or pier, trucks, bunker vessels, etc.

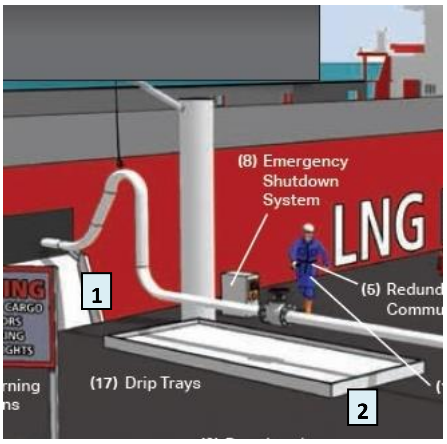
The use of electric bonding cables, for LNG bunkering, is not advised [3], [5], [26].

Figure 2.52 – Expanded elements – Electric Isolation Flange

An effective way of preventing arcing is to isolate the ship and the bunker supplier using an isolating (insulating) flange fitted at one end of the bunker hose only, in addition to an electrically continuous bunker hose. The isolating flange, an example of which is shown in Figure 4, prevents arcs from passing between the ship and facility even if there is a difference in potential. Furthermore, because the hose is electrically continuous and one end is grounded to either the ship or the bunker supplier, static electricity will effectively be dissipated.

An alternative method is to use one short section of insulating hose without any isolating flanges, but with the rest of the bunker hose string electrically continuous. To ensure that the ship is completely isolated from the supplier, it may be necessary to isolate mooring lines, gangways, cranes, and any other physical connections. This is typically done by using rope tails on mooring lines, insulating rubber feet on the end of gangways, and prohibiting the use of certain equipment that would otherwise pose an unacceptable risk of arcing.

Drip Trays



To avoid LNG spillages in contact with decks or other exposed parts of the ship structure, from becoming structural failure hazardous events (with cryogenic cracking associated to carbon-steel embrittlement) two possible solutions may be possible:

1. Design for local cryogenic resistant structure
2. Use of stainless steel drip trays

Drip trays are in fact, today, the most commonly used solution to contain LNG leakage and prevent damage to the ship's structure, being featured in the IGF code as an actual requirement for the bunkering station. This includes the location below any flanged connection, typically fitted with spray shields, in the LNG piping system or where leakage may occur.

Drip trays should be sized to contain the maximum amount of leakage expected and made from suitable material, such as stainless steel. Cryogenic pipes and equipment are typically thermally insulated from the ship's structure to prevent the extreme cold from being transferred via conduction. These requirements are especially important at the bunker station because this is where LNG leaks or spills are most likely to occur.

Figure 2.53 and 2.54 – Drip-trays – protection against cryogenic related hazards that may represent risk of local girder structural failure.

2.7 General Good Practice by Port Authorities & Administrations

2.7.1 LNG as Fuel for Ports

R2.1. **From a general perspective it is important that PAAs incorporate the perspective that LNG as fuel is today a developing option for ship operators willing to improve ship's environmental performance, whilst maintaining a viable and profitable operation.**

R2.2. **PAAs should provide leadership and create and maintain administrative frameworks to facilitate the development of a safe and environmentally sound LNG bunkering projects and infrastructure, including mobile and fixed small-scale LNG bunkering and energy applications.**

R2.3. **Port Regulations should incorporate LNG bunkering, defining the relevant standards and minimum requirements to be met by Operators. All aspects related to the lifecycle of LNG bunkering activity should be clearly identified and defined, from initial proposal, permitting process, operation and emergency.**

R2.4. **It is important that PAAs define clearly the scope of responsibility for Operators when initiating and developing an LNG Bunkering Solution. In particular there should be clear requirements with regards to Quality Management system that includes LNG bunkering activities and objectives referring to relevant standards[21].**

R2.5. **With LNG bunkering being a relatively new port service, being added gradually to Port services portfolio, it is recommended that relevant instruments are developed to allow learning, experience and best practices to be shared amongst operators, with other ports and with other local stakeholders, directly or indirectly involved or affected by LNG bunkering.**

R2.6. **PAAs are advised to adopt an approach adequate to the different LNG bunkering lifecycle stage. Table 2.25, below, includes the best practice advisable approach for PAAs when assessing, evaluating**

2.7.2 LNG Supply Chain

R2.7. **The range of LNG bunkering options is today increasing as new technical solutions are brought to this specific market segment. More than rigid standardization in LNG bunkering it is important for PAAs to fully understand the supply chain proposed for a given LNG bunkering project, asking the initial questions:**

- **a. What is the LNG transport chain before arrival to Port under PAA jurisdiction/ administration?**
- **b. How does the LNG arrive to Port (Truck/Vessel/Barge/Pipeline)?**
- **c. Is intermediate storage considered in the port? If so, is it a fixed permanent or temporary solution?**
- **d. Are the storage and bunkering location in the same place? If not, how far apart? How is LNG transported/routed to the bunkering location**
- **e. Are there (re)-liquefaction facilities considered? If so, what is the production considered and associated storage?**
- **f. Will it be a single or multi-operator LNG bunkering chain?**
- **g. Is LNG truck loading also considered from on-site facilities?**
- **h. Which safety and environmental preliminary measures are being considered?**
- **i. How will Boil-Off Gas (BOG) be managed throughout the LNG chain in the Port? How will BOG be managed, in particular, during LNG bunkering/transfer to the receiving ship?**

[21] For the present Guidance the relevant standard for LNG bunkering Operation is EN ISO 20519 *Specification for bunkering of liquefied natural gas fuelled vessels,* with references, where relevant, to ISO/TS 18683 *Guidelines for systems and installations for supply of LNG as fuel to ships.*

(Annex 1 includes a Template for the Initial Assessment of Concept LNG Bunkering Projects)

R2.8. **The LNG supply chain should be made as simple as technically possible with the minimum number of interfaces and custody transfers as possible. This important goal should be instrumental in ensuring the necessary minimization of risks typically associated with LNG handling, transfer, purging, inerting and other typical LNG bunkering operations.**

R2.9. **LNG bunkering supply chain should be streamlined, designed and operated so as to prevent any uncontrolled release into the environment. The main factors to be considered for the design of LNG supply chains are:**

- **a. Distance between intended LNG bunkering location and the LNG source (Import Terminal or production facility).**
- **b. LNG bunkering demand (low-high interval) – Volumes and Bunker flowrates estimated for the operation.**
- **c. Environmental, Land use planning and societal aspects in the port and surrounding the port area.**
- **d. Waterways suitability.**
- **e. Other services, involving handling of hazardous substances.**
- **f. Other LNG services – potential for synergies in the Port Area.**

R2.10. **The success of the LNG bunkering operation will, amongst other aspects, depend on the ability of the LNG supply chain to cope with LNG demand variations, whilst maintaining safety levels. It is therefore advisable to have into consideration the differences for a given LNG bunkering project and facility on both low and high demand scenarios.**

2.7.3 LNG Bunkering operation – General aspects

R2.11. **The Bunkering Facility Operator should implement a management system to develop, maintain and, where proven necessary, improve, the LNG Bunkering facilities and service. The safety and reliability of LNG Bunkering Facilities should be ensured through adequate design, construction, maintenance, inspection and monitoring and through sound management.**

R2.12. **The LNG bunkering operator (BFO) has primary responsibility throughout the whole lifecycle of its systems for ensuring safety and for taking measures to prevent accidents and limit their consequences for human health and the environment. Furthermore, in case of accidents, all possible measures should be taken to limit such consequences.**

R2.13. **Potential releases, resulting from hazardous accidental events, from any point of the LNG supply chain, in the vicinity and inside the port area, should be considered in the recognized adequately in a recognized and reliable way, especially in environmentally sensitive or highly populated areas.**

R2.14. **Deterministic and/or probabilistic approaches can be used in evaluating LNG bunkering facilities and operation, and assessing impacts on human health and the environment.**

R2.15. **Appropriate measures should be taken in case of accidents. Emergency plans should be established by pipeline operators (internal emergency plans) and by authorities (external emergency plans) and should be tested and regularly updated. These plans should include descriptions of the measures necessary to control accidents and limit their consequences for human health and the environment.**

R2.16. **Land-use planning considerations should be taken into account both in the development of LNG bunkering facilities (e.g. to limit proximity to populated areas and other port activities already established) and in decisions concerning proposals for new**

developments/construction in the vicinity of existing LNG bunkering facilities. These considerations are applicable to every element of the LNG supply chain, distribution, intermediate storage and bunkering/transfer.

R2.17. **LNG Bunkering Operators and PAAs responsible for LNG bunkering facilities and location should review and, if necessary, develop and implement systems to reduce third-party interference, which is a main cause of accidents. This is, in particular, relevant for waterways access to LNG bunkering location, especially in higher nautical traffic areas,**

R2.18. **Information on the safety of LNG bunkering, the geographic position of LNG bunkering facilities, safety measures and the required behaviour in the event of an accident should be supplied to persons likely to be involved, directly or indirectly, in case of an LNG bunkering accident. General information should be made available to the public.**

2.7.4 LNG Bunkering equipment

R2.19. **LNG bunkering equipment, functional and technical requirements are outside the scope of the present Guidance[22]. PAAs should nevertheless be aware of the relevant applicable certification frame for each system and piece of equipment used in LNG bunkering. All equipment is required to be certified, following the provisions and technical requirements prescribed in the relevant applicable design codes and standards.**

R2.20. **PAAs should confirm regularly, following a specific inspection plan, if certificates are in place for the exact elements used in LNG bunkering. Section 15 in the present Guidance includes a list of indicative references that should be taken into account when confirming equipment certification.**

[22] Section 2.6, on LNG Bunkering equipment is only of informative nature, providing typical characteristics for different elements of the LNG bunkering operational scenario, including typical performance of some of these elements, not only in terms of LNG bunkering typical storage volumes but also with some aspects of the technologies involved. The relevant Codes, Standards and other regulations should be consulted for reference.

3. Environment

The impact of using LNG as fuel for transport can be regarded from 2 different perspectives: 1) the net benefits of LNG as a replacement of oil fuels, in terms of local air pollution (SOx, NOx and Particulate Matter) and 2) the higher GHG emission potential of Methane (higher constituent of LNG). On one hand these promising environmental benefits have already granted to LNG a front-run position as an alternative fuel[23], but, on the other hand, the concerns with regards to the actual GHG life-cycle benefits of Natural Gas, as LNG as fuel, are still today in discussion, deserving significant attention and underlining the need to develop adequate mitigating measures. The challenge is to potentiate the benefits of using LNG as fuel, whilst reducing the potential negative environmental effects from its use.

3.1 LNG as a Cleaner Alternative Fuel for Shipping

LNG does not contain sulphur, which results in (almost) no SO_x emissions and almost no PM-emissions. In addition, because LNG has a higher hydrogen-to-carbon ratio in comparison to conventional fuels, the specific CO_2 emissions are lower.

It is possible to obtain different potential gains, both in terms of GHG and the emission of other relevant substances, depending on which source of information you use. It is therefore important to identify and understand the conditions and assumptions contributing to the mentioned environmental benefits. Table 3.1, below, show the different potential emissions reductions which can be achieved by using LNG as an alternative fuel.

Table 3.1 – Environmental benefits from the use of LNG as Fuel by Ships.

Emission	Potential Reduction with LNG as Fuel (compared to HFO)	Observations
SOx	**95** to **100 % reduction**	- Compliance with sulphur regulations. - Some % of sulphur oxide emissions due to the use of pilot-oil fuels in dual-fuel operation. - Lean gas burn result in near-zero emission of sulphur-oxides.
NOx	**Between 40 and 80%** .	- Depending on Engine technology. - Lean Gas burn Otto Cycle (low-pressure injection) – compliant with IMO Tier III (80-85% NOx emission reduction) - Dual-Fuel Diesel Cycle (high-pressure injection) – not inherently Tier III compliant – will typically require additional NOx abatement device.
PM	**90-100%**	- Some % of PM emissions due to the use of pilot-oil fuels, in dual-fuel operation. - Lean gas burn result in near-zero emission of sulphur-oxides.
CO_2	**25-30%**	- Benefit for EEDI and EEOI indexes.
GHG (Well-to-Wake)	**0-25%**	- From a "well-to-wake" perspective the GHG benefits from LNG as fuel are only effective if methane emissions to the atmosphere are adequately controlled and minimized.

As it can be seen from the table above, the benefits from using LNG as fuel are indeed very significant with an almost complete reduction of sulphur oxide emissions and PM, and with a very significant reduction of NOx emissions. With regards to the reduction on direct combustion CO_2 emissions to the atmosphere, the figure (up to 30%) is also relevant but of lesser expression.

[23] Alternative fuels, as scoped and defined in Directive 2014/94

The following factors need to be taken into account when interpreting and discussing the potential benefits of LNG as fuel for shipping:

- Engine technology (dual-fuel, lean burn spark-ignited and Diesel-gas), with a special attention to pilot fuel percentages potentially used and their effect on the overall
- LNG quality and composition
- Life cycle analysis of LNG fuel, taking into account Natural Gas source, production, liquefaction, transportation/distribution chain and overall propulsive efficiency of a given ship

Even though LNG is, undisputedly, a cleaner alternative fuel to heavy, diesel and distillate oils, it is worth pointing out that it is still a fossil fuel. Exploration, processing and all the life cycle of natural gas throughout the possible fuel treatment, industrial and logistic processes and, finally, consumption, have to be taken into account in assessing LNG's actual environmental impact.

A disadvantage of LNG is the potential increase in methane emissions (CH_4). Methane slip, and other releases, can represent a serious problem, since methane has high global warming potential; methane leakages seriously affect the GHG reduction potential.

LNG as fuel can, therefore, represent a clear advantage with regards to local air quality improvement, with very significant expression in reduction of pollutant air emissions, but also the potential for methane emissions to the atmosphere, affecting thereon the GHG benefits from direct combustion CO_2 reduction

3.2 Well-to-Wake GHG Emissions of LNG

LNG can be regarded from a life cycle perspective and, in this particular case, it is important to note, not only the effects of producing LNG and transporting it over large distances by ship, but also the potential impact that methane emissions can have on LNG as fuel GHG reduction potential. This later approach is commonly known as "Well-to-Wake" analysis, as an adaptation of the approach already followed.

Important factors contributing to the WtW approach, contributing to LNG GHG footprint as ship fuel:

- CO2 emissions resulting from energy spent extracting, transforming, liquefying, transporting and distributing LNG
- CH4 emissions resulting either from methane release events throughout the LNG life cycle and logistic chain.

CO_2 emissions throughout the production and logistic chain are virtually impossible to avoid. They are in fact to be accounted for all fuels, not only LNG. Depending on the origin, type and age of liquefaction plants, distance travelled by LNG carrier vessels and, indeed, also on the smaller scale distribution footprint, the total actual GHG contribution will be different. LNG sourced from local natural gas production will therefore have a smaller carbon emission footprint than that sourced from a distant point in the globe. These considerations are however outside the scope of this Guidance.

Methane (CH_4) is another gas of particular interest from a life cycle, well-to-wake perspective. Being 20-25 times more powerful than CO_2 as a greenhouse gas during a 100 year time span, any release of methane to the atmosphere has the potential to reduce significantly the relevance of LNG as a shipping fuel.

Methane release can occur during all stages of the LNG life cycle. The particular case of methane emissions resulting from internal engine combustion is called "methane slip". Incomplete gas combustion, leading to the emission of small amounts of methane to the atmosphere, contributes negatively to the environmental impact of LNG. There has been significant pressure to optimize four-stroke dual-fuel engine technology with design improvements to minimize methane-slip. In modern two-stroke engines this problem has practically been eliminated.

Whilst addressing the life cycle approach applied to LNG as fuel for shipping, the following aspects are identified as having the potential to further improve the accuracy of WtW results:

- Upstream methane release estimates (production, liquefaction and distribution), having integrated up-to-date research in the industrial production/processing of LNG;
- Engine Technology – considering new and emerging dual-fuel engine technology on both two-stroke and four-stroke diesel engines, focusing on efficiency and methane slip mitigation/reduction.

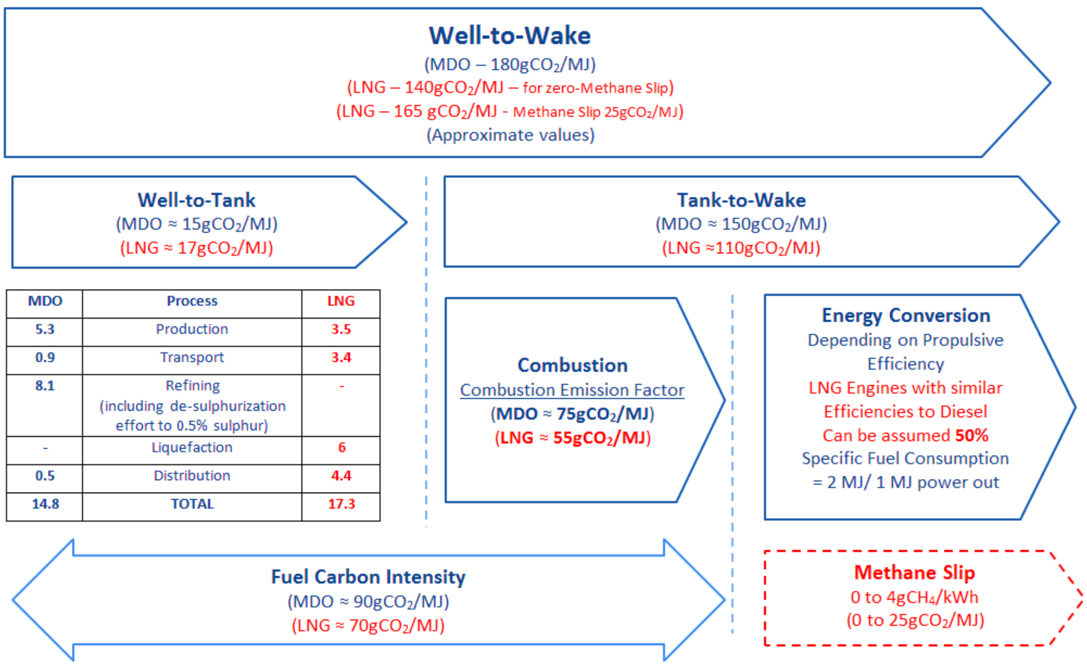
- Environmental impact of producing low-sulphur fuel oils (LSFOs) – identifying the relative GHG impact of oil fuel desulphurization, using the results as further evidence of the advantages of LNG
- Comparative new technologies other than LNG – in particular scrubbers, identifying the additional energy consumption of such systems as an argument for using LNG rather than fuel oils.

The carbon emission factor of LNG (actual CO_2 emissions from burning LNG as fuel) is approximately 25% less than marine diesel oil (see table below). This is the result of its lower carbon presence at molecular level.

Table 3.2 – Combustion Factors for Diesel, in comparison to LNG

Fuel	Combustion Emission Factor gCO2/MJ LHV	Percentage reduction %
Diesel	75	0
LNG	56.1	-25

The Well-to-Wake approach takes the analysis onto a more comprehensive scale, looking at each of the fuel's life cycle stages. The figure below presents a rough comparison between WtW values of LNG compared to those of MDO [28]. The main assumptions of the comparison are the carbon emission factors presented above, in t, an engine efficiency of 50% [28] as well as the methane slip reference value which takes into account more recent developments in 2-stroke, diesel cycle, low speed engines and 4-stroke higher speed dual fuel engines. The values that were used are rough and indicative that LNG causes approximately 20 per cent less CO_2 emissions than MDO (if methane slip is not considered). A more modest benefit of 10% would result if methane slip were to be considered, as shown in the diagram below.



Adapted from: M. Kofod & S.Hartman, T. Mundt "Review of Recent Well-to-Wake Greenhouse Gas Studies evaluating the use of LNG as a marine Fuel", submitted to IMO at MEPC67 as MEPC67/INF.15 by Germany

Figure 3.1 – Well-to-Wake break-down comparison MDO-LNG [28], [29].

In the particular context of the present Guidance the WtW considerations for CO_2 emissions from LNG as Fuel are relevant as a measure indication on how important are LNG handling, distribution, transfer and bunkering operations in the port area. Having an appropriate production and distribution architecture in place is also very important when considering the environmental footprint of LNG as fuel.

Environmental benefits of LNG suffer the potential risk of being outbalanced by a poor GHG performance if due consideration for the need to avoid methane emissions is not carefully and rigorously implemented throughout the whole LNG fuel value chain.

3.3 Methane Release Mitigation

3.3.1 Scope

For the purpose of the present Guidance the objective is to provide PAAs with a reference on best environmental practice in LNG bunkering, allowing and promoting the use of LNG as fuel as a beneficial measure to improve local air quality, whilst addressing the risk of potential negative GHG (methane) emissions.

The Well-to-Wake (WtW) considerations made in section 3.2 were important to express the need to carefully address any potential release of LNG/NG (under any form) to the atmosphere, as an event directly representing an environmental hazard, with direct negative impact as GHG emission.

The scope for the present Guidance is however not covering the full WtW width. Only the aspects related to LNG bunkering are covered (in all aspects from arrival to port until delivery to the receiving ship flange). **The use of LNG onboard is not covered in the present guidance**.

Methane Release Mitigation, the title of the present Section, is therefore defined as a set of technical and operational measures to reduce down to negligible amounts, in normal operational conditions, the release of NG[24]

Figure 3.2, below, indicates the scope of this Guidance for all considerations relative to methane release mitigation

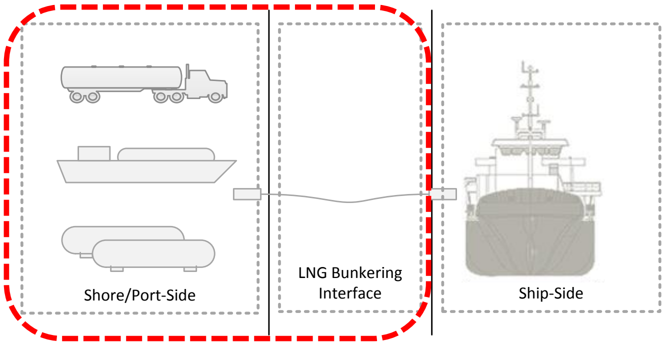


Figure 3.2 –Scope for best environmental practice consideration in the present Guidance (inside the red dashed box).

In addition to the scope definition in figure 3.2, it is furthermore **important to note**

- **Present section of the Guidance is concerned with the environmental aspects of LNG/NG release. Safety concerns are addressed in Section 8. No Safety related hazardous scenarios are addressed in this section.**
- **All environmental best practice considerations are valid, in the present section, for normal operational condition.**
- **In Emergency situations the release of LNG vapours to the atmosphere may be inevitable, through the opening of Pressure Relief Valves (PRVs).**
- **All emitted methane fractions should be quantifiable and reported (even if in emergency) as part of specific operator reporting obligations.**

The risk of methane release to the atmosphere is higher during LNG transfer operations (loading on/off an LNG truck, barge or bunkering transfer), and whenever adequate LNG vapour management operations are not in place. Improving the LNG distribution, handling and transfer/bunkering procedures, in addition to the safety benefits, will also result in a more sound environmental practice.

[24] Reduction of natural gas emissions down to negligible amounts can be interpreted as a reference to “zero operational methane emissions”.

For the purpose of developing best practice in the particular aspect of methane release mitigation the present Guidance decomposes figure 3.2 into 2 separate dimensions: 1) **LNG Bunkering Interface**, where mostly the interface operations are addressed, from flange to flange; hose connection to disconnection and 2) **Shore/Port Side** elements where, apart from bunkering transfer, also other aspects need to be considered regarding the small scale LNG development within the port area. These two dimensions are important for the development of a consolidated and practical best practice approach to the particular attention of PAAs.

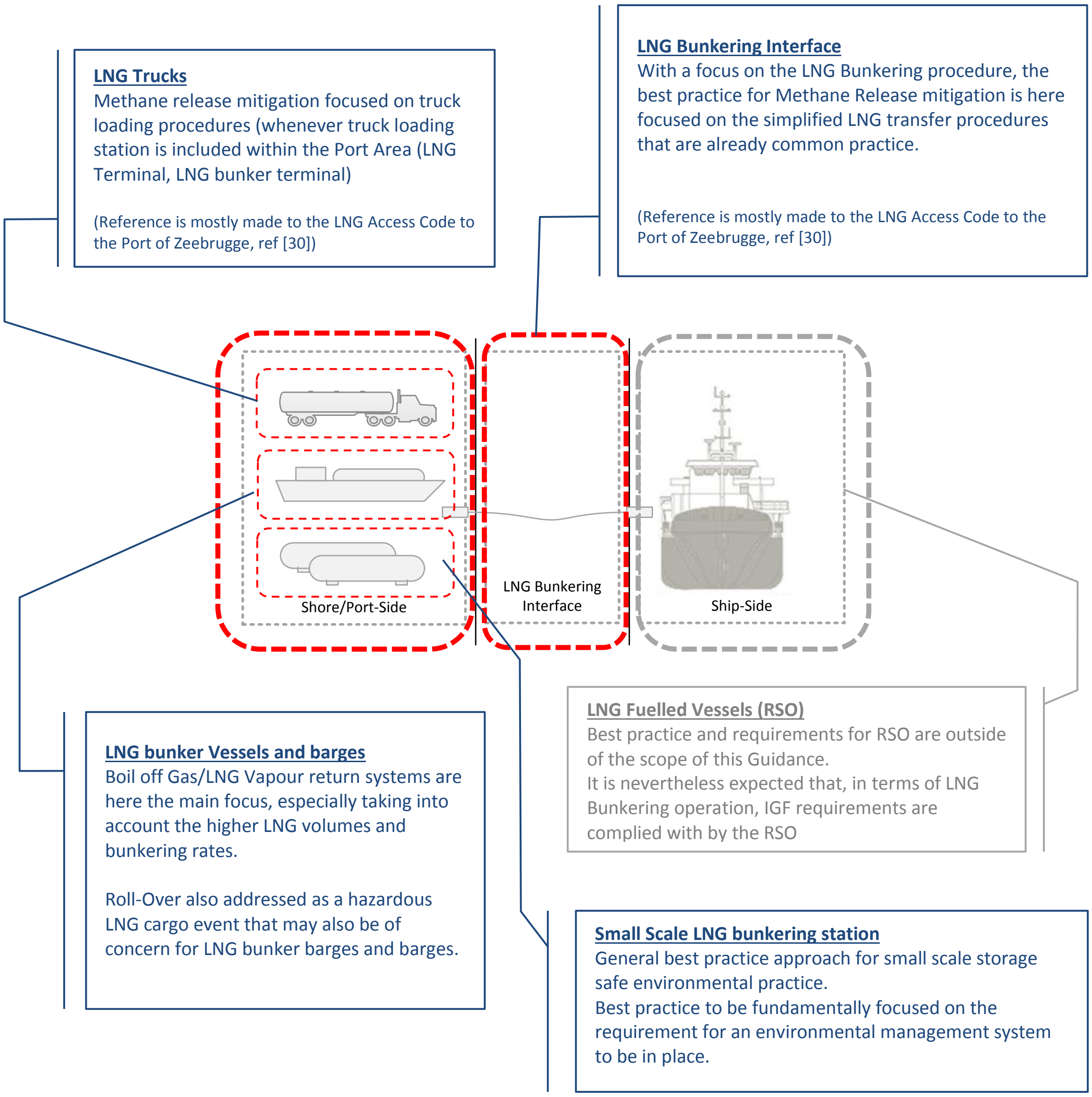


Figure 3.3 – LNG Bunkering – Different dimensions for the development of Methane Release mitigation best practice Guidance (inside the red dashed box).

Notwithstanding the fact that the LNG Fuelled Vessel (RSO) is not covered by the present Guidance it is important to underline that the receiving vessel will be expected to comply, as a minimum, with the IGF Code, in particular with paragraph 8.5.2, requiring the bunkering system to *be so arranged that no gas is discharged to the atmosphere during filling of storage tanks*. This is an important requirement for the receiving vessel that should, nevertheless, be extended to the whole bunkering scope, not only the filling of storage tanks. The same concern, and limitation, should be extended to the connection and disconnection procedures, including purging and inerting of bunker lines. The filling of the RSO storage tanks will require consideration for LNG vapours to be adequately managed, but other moments of the LNG bunkering transfer procedures should also be accounted for when establishing a full evaluation of the potential environmental risks from bunkering related methane emissions.

3.3.2 LNG Bunkering Interface

Methane release mitigation in the LNG bunkering interface is directly related to the implementation of sound operational procedures. In fact, whereas technical measures for LNG vapour management can be implemented on LNG bunker vessels or bunker stations, or even on the receiving vessel, the interface, hose handling, purging, draining and inerting, are operations which are very dependent on training and experience, clear procedures and streamlined bunkering operation.

Regardless the LNG fuel source, from trucks, bunker vessels, barges or fixed bunkering stations, LNG bunkering presents similar challenges and procedure aspects. Inerting of bunkering lines, purging, cool-down procedures and draining, are similar, both in functional and technical aspects for all bunkering modes. LNG bunkering from trucks has been however the LNG bunkering mode where the largest share of experience has been gained in the last years, corresponding to the uptake in the learning curve regarding LNG bunkering. Figures 3.4 and 3.5, below, illustrate two different operational situations where LNG trucks are used.

Figure 3.4 – LNG Bunkering interface

(LNG bunkering interface from 2 LNG ISO containers via 3'' hose, with no vapour return)

No vapour return is not meaning of an "incomplete" bunkering set. Whether vapour return is needed or not will depend on-:
1) The ability of the vessel to cope with BOG pressure
2) BOG management system on vessels side
3) LNG spraying on vessel side to cool-down BOG.

Figure 3.5 – LNG Bunkering interface – manifold connection

(LNG trucks in simultaneous multiple connection for LNG bunkering)

Increasing volumes and rates of LNG Bunkering will also represent additional LNG vapour to manage. It is important to have a clear agreed procedure on how will LNG vapour be dealt with during bunkering.

Whilst Sections 10 and 12 of the present Guidance address the LNG bunkering process and organization in more detail, the present section seeks to identify the moments in the LNG bunkering procedure where the risk of methane release is higher, suggesting measures to mitigate that risk.

The diagram/table in figure 3.6 illustrates how the different stages of a simplified LNG bunkering procedure/operation relate to different potential risks of methane emission. From the connection of the hoses to their disconnection, in the end of the operation, it is important to understand in which moments of the operation the risk of methane release is likely to be higher and to consequently develop measures that are able to mitigate this risk.

The following stages of a simplified LNG bunkering process are considered in figure 3.6:

1. Bunkering Hoses <u>connection</u>
2. Inerting (for oxygen depletion)
3. Purge and Cool-down with LNG Vapour
4. Start Bunkering transfer
5. Top-up
6. Stop Bunkering transfer
7. Drain Bunkering lines
8. Inerting (for natural gas purging)
9. Bunkering Hoses <u>disconnection</u>

		Bunkering Hoses Connection	**Inerting Ox**	Purge & Cool-down with LNG Vapour	START Bunkering Transfer	Top-Up	STOP Bunkering Transfer	Drain Bunkering lines	**Inerting NG**	Bunkering Hoses Disconnection
	Objective/Description	▪ Following preliminary checks (see section 12, bunkering hoses are connected. ▪ Main transfer hoses and vapour return hoses can be considered	▪ Inerting of bunkering lines to displace oxygen from inside of the bunkering line – to avoid formation of explosive atmosphere ▪ Inert Gas used	▪ Also known as Gassing-up, or gas filling. ▪ Can be done with vapour purge line or with small volumes of new LNG ▪ Allows thermal shock to be avoided	▪ With cold lines and tanks both bunkering/transfer sides at similar temperatures, the bunkering begins.	▪ As the receiving ship tank is filled and aproaching its full conditon the rate must be reduced and the pressure constantly monitored. ▪ Procedure to be agreed between BFO and RSO.	▪ Once ensure no LNG is in the bunkering lines transfer is stopped. ▪ ESD shall not be used to stop bunkering transfer	▪ Drainage of bunkering lines to allow all liquid LNG to be displaced out of the bunkering line into RSO tank. ▪ LNG to vaporize in the lines while the valves leading to the ship's fuel tank are left open	▪ Inert the LNG bunker lines to prevent a flammable gas mixture from accumulating in the pipes or hose. ▪ Nitrogen typically used ▪ Also known as "Purging"	▪ Bunkering hoses disconnected after confirmation of <2% methane in volume inside the bunkering lines.
When Procedure complete	Contents in the hose	Air	Inert Gas (nitrogen)	Warm LNG/ LNG Vapour	LNG liquid	LNG liquid	LNG vapour	LNG vapour	Inert Gas (nitrogen)	Air (nitrogen remain inerting the RSO bunker line)
When Procedure complete	Temperature	Ambient	Ambient	Warm LNG (just above -160ºC)	LNG	LNG	LNG vapour	Warm LNG (just above -160ºC)	Ambient	Ambient
Environmental Risk Assessment	Potential for Methane release	▪ No potential methane release	▪ No potential methane release	▪ Potential for methane release if connections are not tight.	▪ Potential for methane release if connections are not tight. ▪ Potential pressure increase if RSO tank not cold enough (leading to PRV release)	▪ Methane release can occur if filling rate is not adjusted/ reduced when the tank filling is above 90% ▪ Tank overfilling leading to PRV release	▪ Potential for methane release due to overpressure in the bunkering transfer line (trapped volume) ▪ Potential for release is higher if ESD is used to stop bunkering.	▪ Liquid LNG in the bunkering line to vaporize onto RSO tank. ▪ If pressure in RSO tank exceeded (by excess of LNG vapour) PRV may be released.	▪ Operation with the highest potential for methane release. ▪ When displacing LNG vapour from the bunkering lines with nitrogen there is the risk of sending mixture to the atmosphere.	▪ Methane release to the atmosphere is possible if gas reading confirmation <2% methane has not been properly done.
Environmental Risk Assessment	Methane Release Mitigating Measure	▪ **Bunkering hoses to be properly connected.** ▪ **Standard QC/DC to be used** ▪ **Flanges inspected before connection for dirt, moisture or condensations**	▪ **Check connections for leakages.** ▪ **Where any leak is suspected, stop Inerting for tightening/repair.** ▪ **Pressure test bunkering line**	▪ **Check connections for leakages.** ▪ **Where any leak is suspected, stop coo-down for tightening/repair.** ▪ **Pressure test bunkering line and inert.**	▪ **Start bunkering transfer only when temperatures are checked and agreed for stable transfer.** ▪ **Check carefully pressure at the receiving**	▪ **BFO and RSO to agree on a top-up rate.** ▪ **Carefull monitoring of pressure and tank level throughout bunkering transfer.** ▪ **Do not use ESD for automatic sut-down by high tank level**	▪ **Valve from the RSO to remain open for draining - purging.** ▪ **Control required from BFO to ensure that supply tank remains at adequate temperature and pressure.**	▪ **Drain procedure to be properly controlled.** ▪ **Ensure maximum LNG is drained in liquid form, minimizing the need to vapourize.** ▪ **Straighten "U" shapes in the hose to avoid LNG accumulations**	▪ **BFO and RSO should agree how to properly manage and dispose of the remaining NG and N2 so that no methane release occurs.** ▪ **NG/N2 mixture to be either compressed back to proper BFO tank, or consumed in GCU.**	▪ **Careful measurement of methane concentration before disconnecting hoses.** ▪ **Repeat Inerting procedure if concentration is >2%.**

VAPOUR MANAGEMENT

- Vapour management **should be agreed between BFO and RSO, in strict observation of PAA requirements on this matter.**

- **Options**: 1) accumulated in the RSO tank as NG compressed on top of the tank; 2) Top-spray filling to reduce pressure; 3) Vapour return lines for BOG collection by BFO; 4) GCU (BFO or RSO) or 5) re-liquefaction on either side

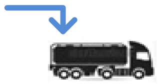
Figure 3.6 –Simplified LNG Bunkering Procedure – Potential for Methane release and Methane Release mitigating measures.

(For a more complete perspective of the LNG bunkering responsibilities and procedure refer to Sections 10 and 12)

3.3.3 LNG Trucks

Table 3.3, below, includes some of the LNG truck potential causes for operational related methane release. Both loading and off-loading are included. Technical and operational measures are presented for corresponding risk reduction.

Table 3.3 – LNG Truck – Methane release mitigating measures

LNG Bunkering/ LNG small Scale supply chain	Potential release scenario	Methane Release - Risk mitigating measures	
		Technical	Operational
LNG Trucks  (Loading)	During filling, onsite, at small scale LNG storage installation. **Release of LNG vapour may occur if no adequate BOG management scheme/system is implemented.**	▪ LNG spraying possibility to cool LNG vapour on top of the tank. ▪ LNG trucks to be fitted with economizer	▪ **Monitor Pressure and Temperature** ▪ **Top and Bottom filling**
	Holding time in the LNG truck trailer tank is limited. As the LNG ages inside, BOG generates and increases pressure . **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Adequate insulation to increase holding time. ▪ Limit the use of single-walled LNG trailer trucks ▪ LNG spraying possibility to cool LNG vapour on top of the tank.	▪ **Plan to avoid waiting times while loaded**
	If the tank is not in Cold condition (BOG temperature <120ºC) filling with new LNG will generate excessive BOG. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Provide technical means to cool-down with own LNG or Inert Gas/ Nitrogen	▪ **Plan for LNG loading in cold condition (either LNG or Nitrogen)** ▪ **Avoid waiting times in warmer tank temperatures.**
	Filling-rate should be adequate above 90% filling, for top-up of the LNG tank in the trailer truck **Inadequate filling rate for the top-up may result in LNG truck overfilling**	▪ LNG tank levels monitot ▪ LNG pressure monitor ▪ Adequate filling rate control mechanism at LNG truck filling station	▪ **Agree on adequate plan for top-up filling to avoid over-pressure in vapour side and MARVS exceedance.**
LNG Trucks  (Off-loading - Bunkering)	For bunkering transfer LNG trucks can use pressure-buil-up units to transfer LNG to RSO by increase in Vapour pressure on top of the tank. **If MARVS pressure is exceeded during pressure build-up PRV valve will open to relief pressure.**	▪ LNG pressure monitor ▪ **LNG regulator before pressure build-up unit.**	▪ **Adequate operating procedure for LNG transfer by pressure build-up**
	Malfunction and alarm conditions will lead to ESD actuation in RSO **If ESD not fully compatibe with LNG truck system there is the risk that following the RSO bunkering valve is shut pressure will build-up in the bunkering line (and in the truck LNG tank).** **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ **Fully compatible ESD to be used between LNG tank truck and** ▪ **Adequate pressure monitoring to ensure no excess BOG is generated in the LNG truck tank after bunkering has been ESD-stopped.** ▪ **Include back-pressure regulator into the circuit (regulated above operating pressure and below MARVS)**	▪ **Adequate procedures to be in place to avoid excessive BOG generation and methane release, following bunkering stop.**
	During LNG bunkering, if receiving tank is warmer there will be excessive BOG generation. If Truck receives return LNG vapour this will result in pressure increase in the truck tank. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Proper tank equalization needs to be ensured prior to LNG fuel transfer. ▪ Cool-down of receiving tank and bunkering lines needs to be ensured with the minimum LNG vapour possible.	▪ **Ensure adequate pre-bunkering procedures to be followed by BFO and RSO.** ▪ **Condition prior to bunkering to be carefully checked.**
	If draining/purging/inerting procedure is not adequately performed there is the possibility that some LNG/NG will remain in the bunkering line. **Release of LNG vapour may occur if bunkering hoses are disconnected with LNG/NG still in some point of the line.**	▪ Gas measurement to be performed before hose is disconnected. ▪ Avoid formation of "U" shapes where LNG can lay arrested.	▪ **Ensure draining is effective.** ▪ **Check for the existence of exterior ice cap (as an indicator for the presence of LNG inside the line) – heat up with water.**

All the measures presented in table 3.3, above, are of operational relevance and can also be referred to Section 12 of the present Guidance - Bunkering Operation. Notwithstanding the fact that the listed events and measures presented are also important for Safety purposes, it is here important to make note that an adequate environmental best practice approach should be the right frame for the methane release mitigating measures presented.

It is assumed that maintenance (both planned and condition-based) is appropriate for the truck LNG bunkering equipment (including tank, piping, PRVs, LNG pump and monitoring equipment/sensors).

For more operational related aspects related to LNG vapour management (BOG management) reference is made to Section 12.2.

3.3.4 LNG Bunker vessels and barges

The main difference between bunker barges and vessels, when compared to LNG bunker trucks, are the higher capacities and bunkering transfer rates possible. With higher volumes of LNG stored onboard, and higher transfer rates, also the amount of LNG vapour to be accounted for is higher (see Section 12.2 – LNG Vapour Management. Figure 3.7 and 3.8, below, present two examples of LNG bunker vessels, of very different capacities, one with capacity for LNG vapour return (on the right) and the other (on the left) with no capacity to manage LNG vapour return.

Figure 3.7 – Small LNG bunker vessel – AGA Seagas

LNG bunkering vessel, with a capacity of 187m3 and no vapour return. In a case of pressure tank to pressure tank bunkering this particular situation will inevitably require a careful bunkering procedure, and the ability of the receiving vessel to manage the LNG vapour generated in the operation.

Figure 3.8 – LNG Bunkering vessel – SKANGASS Coralius

With a significantly higher capacity (of 5,800m3) of LNG, higher bunkering transfer rates, and longer periods of LNG storage onboard, vapour management options are fundamental design features for such vessels.

Unless the LNG bunker vessel/barge tanks are designed to withstand the full gauge vapour pressure of the gas under conditions of the upper ambient design temperatures, means are to be provided to maintain the tank pressure below the MARVS by consuming or managing the natural LNG boil-off at all times, including while in port, manoeuvring or standing by.

Systems and arrangements that may be used for this purpose include one or a combination of the following methods:

1. **Pressure accumulation**, whereby the LNG is allowed to warm up and increase the tank pressure. The tank insulation, design pressure or both are to be adequate to provide for a suitable margin for the operating time and agreed cargo loading temperatures involved.
2. **LNG vapour re-liquefaction system,** through an onboard installation that allows the vessels to re-liquefy its own generated LNG vapour. It is here also possible to re-liquefy the return vapour from the receiving vessel, for re-liquefaction.
3. **Burning of natural or forced BOG in an approved consumer** such as a Gas Combustion Unit, dual fuel diesel engine or other approved combustion unit.
4. **LNG fuel cargo cooling**, with system to keep the LNG in the storage tanks down in cryogenic temperature, avoiding the excess in BOG.

It is assumed that maintenance (both planned and condition-based) is appropriate for the truck LNG bunkering equipment (including tank, piping, PRVs, LNG pump and monitoring equipment/sensors).

For more operational related aspects related to LNG vapour management (BOG management) reference is made to Section 12.2.

Table 3.4, in the next page, includes some of the LNG bunker vessels/barges potential causes for operational related methane release. Technical and operational measures are presented for corresponding risk reduction.

Table 3.4 – LNG Bunker vessel/barge – Methane release mitigating measures

LNG Bunkering/ LNG small Scale supply chain	Potential release scenario	Methane Release - Risk mitigating measures	
		Technical	Operational
LNG bunker vessels/barges  (LNG vessel/barge filling operation in small-scale LNG storage facility)	If the tank is not in Cold condition (BOG temperature <120ºC) filling with new LNG will generate excessive BOG. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Provide technical means to cool-down with own LNG or Inert Gas/ Nitrogen ▪ Cool-down with nitrogen plant or own LNG vapour.	▪ **Plan for LNG loading in cold condition (either LNG or Nitrogen)** ▪ **Avoid waiting times in warmer tank temperatures.**
	During LNG loading, at higher rates, if vapour pressure is not properly controlled there is the probability to exceed MARVS. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Adequate monitor for LNG tank vapour pressure. ▪ Communications and ESD high-pressure actuation for last resource.	▪ **Top-bottom filling of LNG fuel cargo tank to allow cool-down of top vapour side of the tank.**
	If the bunker barge/vessel LNG fuel cargo tank already contains older (aged) LNG there is the possibility for stratification. **Probability for "rollover" with peak excessive BOG generation.**	▪ Follow preventive technical measures for detection and prevention in SIGTTO Guidance [31]: *Guidance for the Prevention of Rollover in LNG Ships*	▪ **Definition of clear onboard procedures for corrective measures once stratification is detected.** ▪ Follow preventive operational measures for detection and prevention in SIGTTO Guidance [31]: ▪ *Guidance for the Prevention of Rollover in LNG Ships*
	If the bunker barge/vessel LNG fuel cargo tank is loaded with LNG/nitrogen mixture there will be the possibility for auto-stratification to occur. **Probability for "rollover" with peak excessive BOG generation.**		
LNG bunker vessels/barges  (LNG bunkering transfer operation) (bunkering with vapour return)	During LNG bunkering transfer to receiving ship, especially for large bunkering volumes, at higher transfer rates, it is possible that large amount of BOG is generated. **Possibility of methane release if LNG vapour return is such that vapour pressure in bunker vessel LNG tank exceeds MARVS.**	▪ One, or a combination, of the following technical measures shall be considered to manage large columes of LNG vapour [31]: ▪ **Pressure accumulation**, ▪ **LNG vapour re-liquefaction system**, ▪ **Burning** of natural or forced BOG in an approved consumer such as a Gas Combustion Unit, dual fuel diesel engine or other approved combustion unit. ▪ LNG **fuel cargo cooling**	▪ **Ensure adequate pre-bunkering procedures to be followed by BFO and RSO.** ▪ **Condition prior to bunkering to be carefully checked.**
	If the receiving ship tank is not in Cold condition (BOG temperature <120ºC) filling with new LNG will represent high rate of vapour return. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**		
	If the LNG bunkering line is excessively long (for instance, when the delivery and receiving flanges are far apart) excessive LNG vapour pressure may build-up inside the bunkering line. **Vapour pressure generated in the bunkering line will return through LNG vapour return line. Excess of LNG vapour may take MARVS to be exceeded. PRV will open to relief pressure.**	▪ Minimize length of LNG bunkering lines ▪ Use properly insulated hose whenever possible. ▪ For rigid arms use vacuum insulated feeding and bunkering pipes where possible	▪ **Bunker vessel/barge delivery manifold station to be as close as possible side-by-side to LNG receiving vessel bunkering station** ▪ **Minimization of trapped volume**
	If draining/purging/inerting procedure is not adequately performed there is the possibility that some LNG/NG will remain in the bunkering line. **Release of LNG vapour may occur if bunkering hoses are disconnected with LNG/NG still in some point of the line.**	▪ Gas measurement to be performed before hose is disconnected. ▪ Avoid formation of "U" shapes where LNG can lay arrested.	▪ **Ensure draining is effective.** ▪ **Check for the existence of exterior ice cap (as an indicator for the presence of LNG inside the line) – heat up with water.**

3.3.5 Small Scale Fixed LNG bunkering Stations

Fixed LNG bunkering stations are infrastructures, as presented in section 2.6, (figures 2.36 to 2.38) which can have very different levels of complexity, with some specific features that are outlined below [32]:

1. Very often, these installations are unmanned. In the few cases where they are manned, the personnel are reduced to the minimum and they are only on site for maintenance or unloading operations.
2. Most of the small scale storage and re-liquefaction plants are built with prefabricated equipment (like in the industrial gases industry) and pre-assembled modules brought directly to site, providing a faster project schedule especially regarding the tank (which is usually the long lead item on a conventional terminal).

3. In some cases, pressure build up is used in tanks prior to bunkering transfer instead of a pump.
4. LNG inventory is lower, allowing in most cases scaled safety measures and simpler safety devices, without compromising on the overall plant safety level.
5. Maintenance is reduced as there are very few rotating parts and instrumentation.
6. Very often the LNG transfer is through a flexible hose, using a dry break coupling as the emergency disconnection system. Boil off gas generated naturally or due to LNG processing is handled in the pressurized tank, until it is condensed with the next subcooled delivered LNG or by utilization of backup liquid nitrogen.
7. Small re-liquefaction units are part of the preferred equipment for their simplicity and the absence of operating expenditures.

For the purpose of methane release mitigation, more than aspects related to the operation, it is important to focus on BOG management as a key driver to mitigate the risk of methane emissions to the atmosphere.

For a detailed overview of the possible BOG management/mitigation strategies available for LNG fixed bunkering station, refer to Section 12.2.

Again, as indicated in the previous sections, for trucks and barges/vessels, it is assumed that maintenance (both planned and condition-based) is appropriate for the fixed bunkering station LNG bunkering equipment (including tank, piping, PRVs, LNG pump and monitoring equipment/sensors).

Figure 3.9 – Small scale LNG establishment

Small scale LNG site, comprising of LNG pressure tanks and a visible set of vaporizers. Small LNG storage with the ability to regasify LNG to the grid for multi-customer service.

From these particular sites it is also possible to have direct pipelines to take LNG directly to the bunkering location for transfer to the receiving ship.

(Source: CRYONORM)

Figure 3.10 – LNG bunkering station

With a different combination of pressure tanks than the one presented above, it is here also possible to appreciate how small scale LNG infrastructure can be modularized and limited in terms of area footprint.

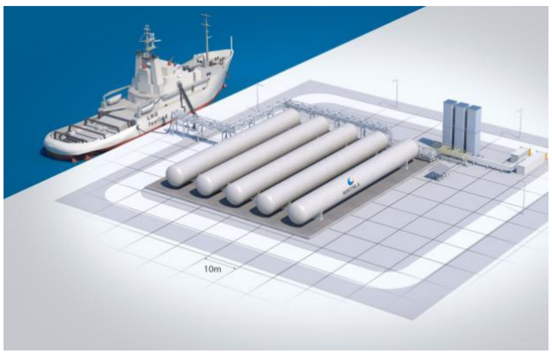


Figure 3.11 – LNG bunkering station

Artist impression of a modular small scale fixed LNG bunkering installation
(Source: WARTSILA)

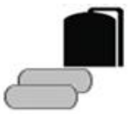
LNG bunkering from small-scale LNG facilities or storage, such as the ones presented in figures 3.9 to 3.11, is typically done by loading on trucks or small LNG bunker vessels/barges, for off-site LNG bunkering location and, by pipeline via fixed manifold connection, for close bunkering transfer point. Sometimes a small jetty will be required if loading onto dedicated small LNG vessels is part of the business case.

LNG bunkering stations, as presented in summary in Section 2.6, are installations with a fair potential for modularization. Notwithstanding this the transfer systems require typically quite some space due to safety distances, which in some environments also requires significant civil work (jetty length, truck plot space). Other equipment items found in the transfer area are safety systems (i.e. gas and fire detectors, ESD panels and firefighting equipment), interface for the crew or truck driver (panels, control rooms), custody transfers (Coriolis or flow meters with gas chromatographs) and LNG spill containment. For truck units, small loading arms or hoses are quite common. Typically, 3'' is the largest hose diameter found for truck loading. For LNG bunker vessels/barges typically hoses are only used if the diameter is below 8''. For 4inch and larger also often loading arms are available.

The transfer flow can be typically created by pressure build up when using pressurized storage, submerged pumps or external sealless cryogenic pumps. For cooling down the transfer lines and custody equipment before the transfer, a recycle line is required for recycling the initial BOG creation during cool down. In most LNG systems, a purging option (typically N2) to purge out the remaining amount of LNG after the transfer is also present. Alternatively, the lines can be continuously kept cold by LNG recycle flows. Transfer of LNG generates typically some BOG which needs to be handled. When there are BOG compressors, they need to be adequately sized to cope with the fluctuating BOG by LNG transfer.

As previously indicated for LNG bunkering mobile units (trucks, vessels/barges) the key focus for methane release mitigation from small scale fixed installation is still very much related to the handling of LNG vapour, not only as a result from ageing of LNG inside the storage tanks but also how purging, draining and inerting procedures are set up.

Table 3.5 – LNG Bunker Station – Fixed LNG bunkering onsite storage – Methane release mitigating measures

LNG Bunkering/ LNG small Scale supply chain	Potential release scenario	Methane Release - Risk mitigating measures	
		Technical	Operational
LNG small scale onsite storage 	If theLNG storage tank already contains older (aged) LNG there is the possibility for stratification. **Probability for "rollover" with peak excessive BOG generation.**	▪ Follow preventive technical measures for detection and prevention of statification in the relevant design codes.	▪ **Definition of clear procedures for corrective measures once stratification is detected.** ▪ Follow preventive operational measures for detection and prevention in the relevant operational codes for avoidance of LNG statification in storage tanks.
	If the LNG storage tank is loaded with LNG/ nitrogen mixture there will be the possibility for auto-stratification to occur. **Probability for "rollover" with peak excessive BOG generation.**		
	For Atmospheric Tanks, if LNG Vapour management does not respond to the necessary re-liquefaction rate (or condensing/refrigeration) excessive BOG will be generated. At atmospheric pressure there is no ability in the tank to sustain na increase in pressure. **Release of LNG vapour will occur if pressure relief valve is actuated.**	▪ Storage tank to be designed for adequate holding time (time between loading and off-loading) ▪ Insulation, Re-liquefaction and refrigeration for adequate LNG vapour management.	▪ Adequate planning for distribution or vaporization/consumption before holding time limit.
	For Pressure Tanks, if excess boil-off accumulates, leading to pressure increase in the storage tank (BOG can be here originated both from loading, off-loading or during holding period) There will be a certain (limited) ability of pressure tanks to sustain higher vapour pressures. **Release of LNG vapour will occur if pressure relief valve is actuated.**	▪ Possible technical measures to mitigate BOG generation in pressurized LNG tanks: ▪ Insulation (vacuum insulation) ▪ Top-spraying to coolddown/ condense LNG vapour ▪ Refrigeration with internal coils.	▪ Adequate control of LNG properties inside the storage tank. ▪ Procedure in place to avoid BOG release through PRV ▪ Plan for adequate LNG consumption, to avoid long holding times.

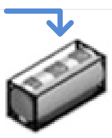
3.3.6 LNG ISO containers

LNG ISO containers have the potential to play an important role in the near future as they can provide flexibility to ships or ports adopting LNG as fuel through the implementation of modification and conversion projects allowing for modularity and the convenience of ISO standardized LNG fuel containers. These advantages and already some characteristics of this specific LNG fuel storage unit have already been presented in 2.6.

LNG ISO containers are typically LNG pressurized storage tanks contained within and ISO frame that allows the LNG to be transported through the wider logistical chain. Applications can be diverse but for the present case the analysis is strictly on the use of ISO LNG containers for LNG transfer from shore to the receiving ship (i.e. ISO containers that are embarked for plug-in, onboard LNG fuelled ships, are not covered as they are covered by the IGF Code).

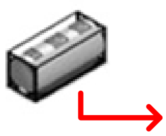
Below, in table 3.6, some methane release mitigating measures are listed, which should be taken into account when using LNG ISO containerized pressure tanks for LNG bunkering.

Table 3.6 – LNG ISO container units –Methane release mitigating measures

LNG Bunkering/ LNG small Scale supply chain	**Potential release scenario**	**Methane Release - Risk mitigating measures**	
		Technical	**Operational**
LNG ISO container 	If the tank is not in Cold condition (BOG temperature <120ºC) filling with new LNG will generate excessive BOG. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Provide technical means to cool-down with own LNG or Inert Gas/ Nitrogen ▪ Cool-down with nitrogen vapour before filling.	▪ **Plan for LNG loading in cold condition (either LNG or Nitrogen)** ▪ **Avoid waiting times in warmer tank temperatures.**
	During LNG loading, at higher rates, if vapour pressure is not properly controlled there is the probability to exceed MARVS. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Adequate monitor for LNG tank vapour pressure.	▪ **Top-bottom filling of LNG fuel ISO tank to allow cool-down of top vapour side of the tank.**

LNG ISO container

(Holding Mode)
	If the ISO LNG tanks are kept full, waiting, for longer than the specified holding time, excess LNG vapour will be generated.
	Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.
		▪ Possible technical measures to mitigate BOG generation in pressurized LNG tanks:
		  ▪ Insulation (vacuum insulation)
		  ▪ Top-spraying to coolddown/ condense LNG vapour
		  ▪ Refrigeration with internal coils.
			▪ **Adequate control of LNG properties inside the storage tank.**
			▪ **Procedure in place to avoid BOG release through PRV**
			▪ **Plan to avoid waiting times longer than the holding time reference for the LNG ISO container.**

LNG ISO container 	During LNG bunkering, if receiving tank is warmer there will be excessive BOG generation. **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ Proper tank equalization needs to be ensured prior to LNG fuel transfer. ▪ Cool-down of receiving tank and bunkering lines needs to be ensured with the minimum LNG vapour possible.	▪ **Ensure adequate pre-bunkering procedures to be followed by BFO and RSO.** ▪ **Condition prior to bunkering to be carefully checked.**
	For bunkering transfer LNG trucks can use pressure-buil-up units to transfer LNG to RSO by increase in Vapour pressure on top of the tank. **If MARVS pressure is exceeded during pressure build-up PRV valve will open to relief pressure.**	▪ LNG pressure monitor ▪ **LNG regulator before pressure build-up unit.**	▪ **Adequate operating procedure for LNG transfer by pressure build-up**
	Malfunction and alarm conditions will lead to ESD actuation in RSO **If ESD not fully compatibe with LNG ISO tank system there is the risk that following the RSO bunkering valve is shut pressure will build-up in the bunkering line (and in the truck LNG tank).** **Release of LNG vapour may occur if MARVS is exceeded. PRV will open to relief pressure.**	▪ **Fully compatible ESD to be used between LNG ISO tank** ▪ **Adequate pressure monitoring to ensure no excess BOG is generated in the LNG truck tank after bunkering has been ESD-stopped.** ▪ **Include back-pressure regulator into the circuit (regulated above operating pressure and below MARVS)**	▪ **Adequate procedures to be in place to avoid excessive BOG generation and methane release, following bunkering stop.**

3.3.7 Intermittent flow applications

There are cases where LNG is provided directly from an LNG truck trailer or ISO LNG containerized pressure tank directly into the LNG fuelled ship. This operation, considered as bunkering within the scope of the present Guidance, is a very particular application where different factors need to be taken into account.

One particular factor that is relevant for LNG vapour management control, and methane release mitigation, is the possible intermittency in supply flow rate.

In the cases where LNG is delivered for intermittent flow applications, or where brief interruptions in the vaporization process, an accumulator tank should be considered in the vaporization system with a safe but higher than operating pressure relief valve.

In the particular case of figure 3.12, an LNG fuelling operation is shown where an LNG ISO container (wheeled) is used to provide LNG fuel to harbour DF generator onboard an LNG fuelled ship (AIDA Prima). Constant flow into vaporizer (onboard) may be achieved if generator works at near-constant load, with negligible load variation.

Figure 3.12 – LNG feeding operation directly into LNG dual fuel engine inside the ship

AIDA Prima being fuelled from shore LNG ISO tank (on truck).

(Source: AIDA)

3.3.8 LNG Pipelines

LNG pipelines are typically not very long. Some references indicate 250m as a reference maximum distance [21] and, even if we consider longer distances, this is taken for the purpose of the present Guidance as an indicative figure. The length of LNG pipeline systems is mostly limited by insulation limitations and the need to limit the inevitable heat exchange along the length of the pipeline. This is the case even if highly advance insulating material or vacuum jacketing insulation are used.

For the purpose of identifying potential for methane release scenarios LNG pipelines are elements where fugitive losses are not to be expected. On one hand they would be highly insulated (in principle double-walled) and no bolted flanges should be expected as the different sections of the pipeline will be welded together.

LNG pipelines will typically be installed in fixed LNG bunkering stations, possibly connecting LNG pressure storage tanks to LNG bunkering rigid arms.

A Pipeline Integrity Management System (PIMS) adequate for the LNG pipeline installation/ infrastructure should be in place, providing not only the identification of all the technical elements in the pipeline but also identifying all objectives in place to ensure adequate pipeline safety and integrity. Environmental objectives, in particular, shall give expression to zero-methane release to the atmosphere.

3.4 Good Environmental Practice for LNG Bunkering

3.4.1 General

R3.1. **Environmental benefits of LNG as fuel should be potentiated and highlighted in the context of adequate policy measures designed for local air quality improvement. Here PAAs can play an important role in facilitating the adoption of measures that highlight the environmental potential of LNG as an Alternative Fuel for shipping, whilst establishing clear limitations on potential operational NG emissions.**

R3.2. **The impact of including LNG as fuel development into a given port service portfolio should be highlighted in the context of its wider contribute to Sustainability and to the development of an increasingly cleaner energy source for maritime, inland and road transport. As multi-modal hubs, ports can in fact play an important role in highlighting the potential of LNG in a Port-centric small scale LNG development.**

R3.3. **LNG as fuel, however, only represents an environmental sustainable option, as an alternative fuel, if methane's GHG potential is adequately addressed. PAAs should have provisions in place prohibiting any type of methane release to the atmosphere, with the only exception of emergency situations.**

R3.4. **No methane release to the atmosphere shall result from LNG bunkering operations, considering all infrastructure elements, mobile units involved or operational procedures implemented. PAAs should ensure that adequate environmental practice is promoted in all aspects related to LNG storage, distribution, on-site transfer and bunkering.**

3.4.2 Methane Release Mitigation

R3.5. **PAAs should require Operators to demonstrate that an adequate set of measures to mitigate the release of natural gas to the atmosphere are in place, adequately identified in LNG Bunkering Plan.**

The avoidance of methane release to the atmosphere should be expressed by the BFO as an objective in a relevant Quality Management System. Management systems that can be used are ISO 9001, ISO 14001, ISM, ISO/TS 29001 and API Spec Q1 (as specified in EN ISO 20519).

Methane release mitigation measures should be:

.a) <u>Relevant</u> (the measures listed by the BFO should relate to the actual LNG bunkering process in place. They should be directly related and adapted to the different stages in the LNG bunkering process);

.b) <u>Enforceable</u> (PAAs should be able to confirm actual practice of the measures presented for methane release mitigation. Not only it should be possible to confirm the actual implementation of the technical but also the operational measures in place)

.c) <u>Safe</u> (from the implementation of the presented methane release mitigation measures no potential unsafe operation or condition should derive).

.d) <u>Quantifiable</u> (it should be possible to quantify, through the adoption of the listed methane mitigation measures, the amount of methane that is not sent to the atmosphere.[25])

R3.6. **Different LNG bunkering and small scale LNG projects will have very different characteristics, with different bunkering modes, arrival of LNG to the port and, potentially, even storage on-site. Different technical characteristics, LNG capacities and**

[25] This would allow a cost-benefit analysis that would allow an economic perspective in support of the Operators.

bunkering rates will represent also different methane release mitigating measures, adequate and applicable to different LNG bunkering solutions.

PAAs should ensure that the BFO presents a combination of the methane release mitigation measures summarized into 4 (four) distinct groups (including in all cases both technical and operational measures):

.a) <u>Boil Off Gas (BOG) management</u>

- **i. Minimization of trapped volume inventory;**
- **ii. Loading, off-loading and bunker transfer operations with similar tank temperatures, at BFO and RSO sides;**
- **iii. LNG transfer rates to be adjusted to the ability from both BFO and RSO to handle BOG;**
- **iv. Holding times in pressurized LNG storage tanks not to be exceeded, unless adequate BOG management in place.**
- **v. Vapour return:**
  - **(1). For bunkering of ships with <u>atmospheric LNG tanks</u> (IMO type A, B or Membrane) a vapour return line should always be provided.**
  - **(2). For bunkering of ships with <u>pressurized LNG tanks</u> (IMO type C) a vapour return line may be provided. It is a possibility that the receiving ship is able to cope with some pressure increase due to LNG vapour generation.**
- **vi. Vapour management - On either side (RSO or BFO) the following options can be considered for LNG vapour management purposes:**
  - **(1). Pressure accumulation (if pressure tanks are considered)**
  - **(2). Re-liquefaction**
  - **(3). Refrigeration**
  - **(4). Gas consumption (GCU or onboard gas consumers)**

.b) <u>Maintenance</u>

- **i. Maintenance of all equipment involved in LNG bunkering should follow programmed maintenance program as per manufacturer indication.**
- **ii. Operators must hold, for each piece of separate LNG bunkering equipment:**
  - **(1). Valid Certificate**
  - **(2). Maintenance record**

.c) <u>Planning</u>

- **i. Plan transport, storage and bunkering according to expected demand, accounting for the specific holding times of storage elements and infrastructure in place.**
- **ii. Avoid waiting times in holding mode**
- **iii. Develop a plan, involving an agreement between BFO and RSO for implementation of an adequate LNG bunkering sequence, where the whole streamlined process is well understood and shared.**

.d) <u>Compatibility</u>

- **i. 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.**
- **ii. As a minimum, compatibility assessment should be undertaken for the systems and equipment listed in IACS Recommendation 142, LNG Bunkering Guidelines, Section 1.4.2, and included as reference also in Section 12.3.1 of the present Guidance.**

.e) Purging and Inerting

i. Purging and Inerting procedures should be part of the LNG Bunkering Management Plan, to be presented by the BFO, allowing PAAs to understand the full technical and operational details supporting the procedures (bunkering transfer hose(s) and vapour return).

ii. Any mixture of inert gas (e.g. nitrogen) and natural gas should be recovered, either by the BFO or RSO, and not vented.

R3.7. **Venting to the atmosphere, either resulting from automated or manual action, through PRV actuation, or through any other possible outlet from the LNG storage or bunkering system, should be only possible in case of emergency, for safety reasons.**

An emergency venting of LNG vapours should be reported, quantified and the reasons, leading to the emergency venting to occur, understood and subject to analysis.

Notwithstanding the possibility of venting in case of emergency it should not suffice to justify this with a vapour pressure increase. Bunkering and containment systems for LNG fuel on either side of the bunkering interface should be designed for the intended operations and there should be limitations in physical/operation parameters (flow rates and temperatures).

R3.8. **PAAs should develop a reporting mechanism for emergency venting that promotes a diligent and voluntary action from operators.**

R3.9. **In addition to R3.8, for a higher level of enforcement, PAAs can consider the possibility of requiring the installation of methane detectors (also known as natural gas detectors) equipped with tamper-proof recording, in a suitable location of the venting mast**[26]

3.4.3 Environmental Management Systems

R3.10. **As a best practice provision PAAs should require Operators to have Environmental Management Systems in place, certified according to a recognized EMS such as ISO 14001:2015, certified by an independent certification body.**

An EMS would allow:

i. An holistic approach to environmental impacts, where methane release throughout the entire LNG bunkering could be addressed (and not only venting events)

ii. Focusing on only critical aspects and processes

iii. Making use of time-tested, mature approaches recognized worldwide

iv. Establishment of a positive relationship between PAAs and Operators.

R3.11. **The purpose of the EMS should be to implement general requirements and guidelines that, when followed, should provide reasonable assurance that the outputs from the LNG bunkering operation will have minimal negative environmental impact and improved environmental performance. It should, in this regard, be noted that the ISO 14001 standard is nonprescriptive; that is, it details what should be done, not necessarily how to do it. It**

R3.12. **The EMS in place should be based on a “plan-do-check-act” (PDCA) model of improvement, an iterative process that must be applied regularly to ensure benefits are being realized and the standard is being upheld. The primary operational components of an EMS can be grouped as follows:**

a. <u>Create/update environmental company policy</u>

[26] Even though no international legislation exists that regulates methane emissions from ships (or even for the whole transport sector) it would be possible, within the context of port regulations to include the possibility of methane release monitoring as an environmental best practice approach.

Operators' environmental company policies should allow PAAs to ascertain the level of the commitment with the particular aspect of methane emissions.

b. <u>Plan</u>:
- **i. Environmental aspects**
- **ii. Legal and other requirements**
- **iii. Objectives, targets, and programs**

c. <u>Do</u>:
- **i. Resources, responsibilities, and authority**
- **ii. Competence, training, and awareness**
- **iii. Communication**
- **iv. Documentation**
- **v. Control of documents**
- **vi. Operational control**

d. <u>Check</u>:
- **i. Monitor and measure**
- **ii. Evaluate compliance**
- **iii. Nonconformity, corrective and preventive action**
- **iv. Control of records**
- **v. Internal audits**

e. <u>Act</u>:
- **i. Management review**
- **ii. Audit**

R3.13. **Should the PAA also have any type of EMS certification, LNG bunkering as a service has the potential to contribute directly to any possible local air quality objectives. This is directly the consequence of LNG being a much cleaner fossil fuel when compared to oil fuels. It is nevertheless important to express objectives into the EMS regarding GHG emissions mitigation.**

Any potential GHG emissions objectives and measures should be clearly expressed into PAAs EMS system.

4. Regulatory Framework

The Regulatory Framework for LNG Bunkering, on the shore-ship or ship-to-ship interface, is composed of high level regulatory instruments, standards & guidelines and industry good practice references. Not only the hierarchy of the references is different but they exist in two separate regulatory frames that often result in gaps or overlaps in the bunkering interface. The receiving ship, the bunker barge, or bunker vessel, the LNG truck, the LNG terminal and possible small scale storage

In Section 4 of this Guidance, different instruments relevant to LNG Bunkering are listed. The diagram in figure 4.1, below, is used for each instrument presented, indicating to which part of the LNG Bunkering it is relevant to.

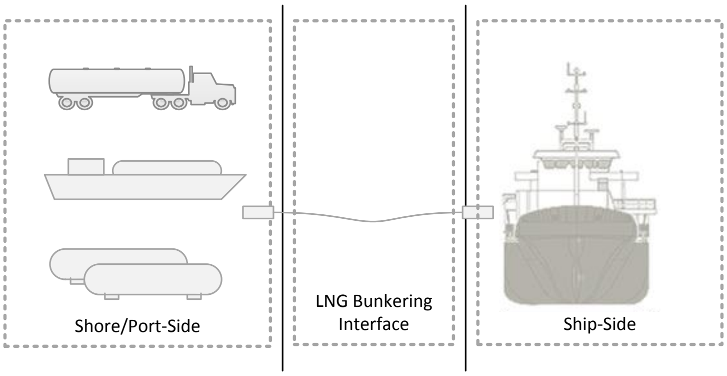


Figure 4.1 – LNG Bunkering – Ship-Shore interface

4.1 Regulatory Structure

The international (global or regional) regulatory frame is composed of 4 essential levels to which a fifth level can be added, accounting for Port regulations that are able to, locally, shape the specific regulatory environment for LNG Bunkering.

High Level	•**IGF** Code/ SOLAS/ STCW •MARPOL - MARPOL Annex VI •EU Sulphur Directive •Alternative Fuel Infrastructure Directive	High level instruments are relevant in the definition of the **main drivers for adoption of LNG as an alternative fuel**. Mostly environmental related, globally/regionally binding.
Standards	•**ISO** Technical Specifications and International Standards •EN Standards •Equipment Standardization	Technical Standards are relevant for LNG bunkering operations and equipment, including small scale LNG storage. They are binding through reference to higher level regulatory instruments.
Class Rules	•**IACS** URs/Recs •**Class Rules** for Construction •Guidance Notes •Guidelines	Class Rules are relevant instruments for Classification Societies to ensure safety, quality and compliance in the application of international regulations, following a common technical interpretation of different provisions.
Industry Guidance	•**SGMF Guidelines** •Industry Guidance •Guidance Notes •LNG Bunkering Check Lists	Industry references are fundamental in definition of the best practices in LNG bunkering, both on equipment, safety, operations and outline of responsibilities. Non-binding set of best practices.
Port Local Regulations/ Byelaws	**Port specific regulations** Ports can set rules by themselves, addressing specific operational aspects and their specific context. Port Byelaws often reflect the nature of each port authority management principle. They are of local and limited application, reflecting	

4.2 High Level Instruments

The present section lists the relevant **High Level instruments** with relevance to the shore-side, ship-side and LNG bunkering interface. In particular f

4.2.1 Europe

In EU law it is first important to make the distinction between 1) Regulations and 2) Directives. Whereas **Regulations** have binding legal force throughout every Member State and enter into force on a set date in all the Member States, **Directives** lay down certain results that must be achieved but each Member State is free to decide how to transpose **directives** into national laws. This is an important note regarding EU Framework since the present Guidance, whenever addressing Directives, does not make distinction between different implementation exercises in each EU Member States[27]

Other instruments are also of significance and these are, altogether, summarised in Table 4.1. For example, the Seveso Directive, in the context of major accident prevention, is one of the most important references for the permitting procedures of small scale LNG projects, with requirements on safety aspects, impact assessment and public consultation. Similarly, the ADR and ADN conventions, and Directive 2016/1629, are important instruments within the LNG supply chain.

Table 4.1 – EU high-level instruments

Title	Responsible	Type	Scope
EU Sulphur Directive Directive 2016/802/EU relating to a reduction in the sulphur content of certain liquid fuels (*codifying Council Directive 1999/32/EC as regards the sulphur content of marine fuels, as amended by Directive 2012/33/EU*)	EC	European Directive	Limitation of sulphur content in certain fuels, with obligations on EU Member States, affecting EU flag ships and foreign flag ships visiting EU ports.
EU Ports Regulation Regulation (EU) 2017/352 Of The European Parliament And Of The Council of 15 February 2017 establishing a framework for the provision of port services and common rules on the financial transparency of ports	EC	European Regulation	EU Regulation establishing a framework for the provision of port service, and common rules for transparency and on port services. LNG bunkering is within the scope and applicability of this regulation, either inside the port area or on the waterway access to the port.
EU Alternative Fuel Infrastructure Directive Directive 2014/94/EU on the deployment of alternative fuels infrastructure	EC	European Directive	Development of an alternative fuel infrastructure throughout the TEN-T Core Network, including LNG for waterborne applications.
Seveso III – Directive Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC	EC	European Directive	Control of major-accident hazards for establishments involving dangerous substances
EIA Directive Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment	EC	European Directive	Environmental Impact Assessment Directive The initial Directive of 1985 and its three amendments have been codified by DIRECTIVE 2011/92/EU of 13 December 2011. Directive 2011/92/EU has been amended in 2014 by DIRECTIVE 2014/52/EU

[27] In this way there will be particular aspects from the different national instruments that will not be captured by the present Guidance. It is important to be mindful that, for each EU Member State there should be a national instrument correspondent to the implementation of a directive. In this Guidance, whenever Directives are addressed, for a complete evaluation of each EU MS context, the corresponding national law should be consulted.

Title	Responsible	Type	Scope
ADR – European agreement concerning the International Carriage of Dangerous Goods by Road	UNECE	Convention	Transport of hazardous goods by road
ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland waterways	UNECE	Convention	Transport of dangerous goods via inland waterways - technical requirements for different type of inland navigation vessels carrying dangerous goods - certificates for vessels - requirements for crew/experts (trainings, certificates) - applicable in all UNECE MS
Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods.	EC	European Directive	Directive 2008/68 refers to ADN, ADR and RID incorporated them into EU legal framework – ADN is obligatory in all EU
Rhine Vessel Inspection Regulations (RVIR)	CCNR	Regulation	Reference to technical requirements for Inland Navigation vessels Certificates for the Inland Navigation vessels Inspection of the Inland Navigation vessels Reference will be made to Technical Requirements within CESNI Standard ES-TRIN 2017/1.
Regulation for Rhine navigation personnel (RPN)	CCNR	Regulation	Training and manning requirements for crews of inland vessels
Rhine police regulations (RPR)	CCNR	Regulation	Operational requirements for Inland Navigation vessels, including signage, mooring and bunkering procedure. The use of the standard for LNG bunker checklist (CCNR 1.0) is mandatory for all LNG bunker operations involving a ship if this bunkering takes place along the Rhine waterway or in a port.
Directive /EU) 2006/87 of 12 December 2006 laying down technical requirements for inland waterway vessels **(applicable until 6 October 2018)**	EC	European Directive	- technical requirements for Inland Navigation vessels - certificates for the Inland Navigation vessels - inspection of the Inland Navigation vessels Directive recognizes both types of the certificates for Inland Navigation vessels on EU waterways – issued in accordance with Directive 2006/87 and with the Rhine Regulations (still the technical requirements are separately included in both legal regimes – EU and CCNR)
Directive 2014/68/EU **(Pressure Equipment Directive)**	EC	European Directive	The Pressure Equipment Directive (PED) applies to the design, manufacture and conformity assessment of stationary pressure equipment with a maximum allowable pressure greater than 0,5 bar. The directive entered into force on 20 July 2016.

Title	Responsible	Type	Scope
Directive (EU) 2016/1629 laying down technical requirements for inland waterway vessels, amending Directive 2009/100/EC and repealing Directive 2006/87/EC **(applicable from 6 October 2018)**	EC	European Directive	Reference to technical requirements for Inland Navigation vessels Certificates for the Inland Navigation vessels Inspection of the Inland Navigation vessels Reference is made to Technical Requirements within CESNI Standard ES-TRIN 2015/1 (and will be updated to ES-TRIN 2017/1).
Directive 99/92/EC on the minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres	EC	European Directive	Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres
Directive 2014/34/EU on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast)	EC	European Directive	The ATEX Directive 2014/34/EU covers equipment and protective systems intended for use in potentially explosive atmospheres.

EU Sulphur Directive
Directive 2016/802/EU relating to a reduction in the sulphur content of certain liquid fuels
(codifying Council Directive 1999/32/EC as regards the sulphur content of marine fuels, as amended by Directive 2012/33/EU)

Organization

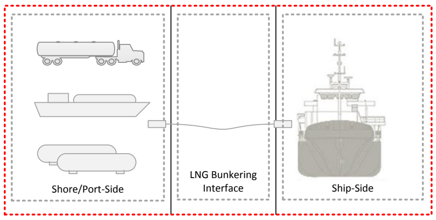
European Union

For more info

http://eur-lex.europa.eu/homepage.html

Applicable to

EU Member States



In the EU, SOx emissions from ships are regulated by Directive 2016/802/EC, known as the 'Sulphur Directive'. The recent codification includes not only the limitation on the sulphur content of marine fuels but also of land-based oil fuels, establishing limits on the maximum sulphur content of gas oils and heavy fuel oil. The Directive also contains some additional fuel-specific requirements for ships calling at EU ports, obligations related to the use of fuels covered by the Directive and the placing on the market of certain fuels (e.g. marine gas oils).

The Directive had been previously amended by Directive 2012/33/EU, now repealed, in order to further adapt the European Union's legislation to developments at international level under MARPOL Annex VI. Since 1 January 2015, stricter sulphur limits for marine fuel in SECAs apply (0.10 %) as well as in sea areas outside SECAs (3.50 %). In addition, a 0.1% maximum sulphur requirement for fuels used by ships at berth in EU ports was introduced from 1 January 2010. Furthermore, passenger ships operating on regular services to or from any EU port shall not use marine fuels if their sulphur content exceeds 1.50 % in sea areas outside the SECAs.

Relevance

The relevance of the Sulphur Directive in the context of LNG as fuel comes in the terms of Article 8, according to which *Member States shall allow the use of emission abatement methods (EAMs) by ships of all flags in their ports, territorial seas, exclusive economic zones and pollution control zones, as an alternative to using marine fuels.* Being an alternative fuel, LNG is eligible to be considered an Emission Abatement Method, and its use should be allowed in ships of all flags in ports, territorial seas and economic exclusive zones of the EU. Ships using EAMs in these areas shall continuously achieve reductions of sulphur dioxide emissions that are at least equivalent to the reductions that would be achieved by using marine fuels (Annex I).

According to the Directive (Article 8) the following EAM can be considered:

- Mixture of marine fuel and boil-off gas (BOG) for LNG carriers – criteria established in ref. [13]
- Exhaust Gas Cleaning Systems (EGCS), commonly known as 'scrubbers'
- Biofuels (and mixtures of biofuels and marine fuels)

And, where applicable:

- On-shore power supply
- Alternative Fuels e.g. LNG, Methanol.

At the international level, the use of EAMs is regulated by the MARPOL Annex VI (Regulation 4). According to this regulation, the Administrations of Party shall allow a fitting, material, appliance, apparatus or other procedures, alternative fuels, or compliance methods used as an alternative to that required by MARPOL Annex VI.

Figure 4.2, below, shows the relevant limits to consider regarding sulphur oxide emissions.

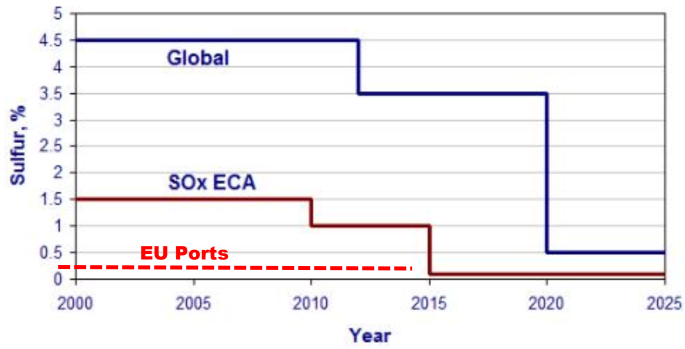


Figure 4.2 – Sulphur oxide emission limits - from 2015, in ECAs the limit of 0.10% applied and from 2020 the decision to reduce the global cap to 0.50% has been taken at IMO MEPC70

EU Ports Regulation

Regulation (EU) 2017/352 Of The European Parliament And Of The Council of 15 February 2017 establishing a framework for the provision of port services and common rules on the financial transparency of ports

Organization

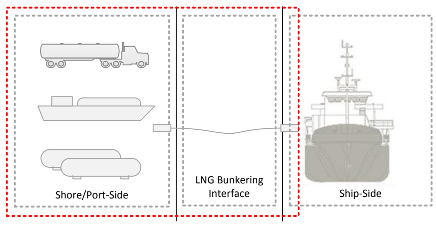
European Union

For more info

http://eur-lex.europa.eu/homepage.html

Applicable to

EU Member States



This Regulation establishes a framework for the provision of port services, and common rules on financial transparency and on port service and port infrastructure charges, being applicable to all maritime ports of the trans-European transport network, as listed in Annex II to Regulation (EU) No 1315/2013 (EU TEN-T core ports).

Regulation (EU) 2017/352 is divided into 4 main Chapters: 1) Scope, Application and Definitions; 2) Provision of Port Services; 3) Financial Transparency and Autonomy and 4) General and Final provisions.

Relevance

Regulation (EU) 2017/352 includes a large number of concepts which are relevant in the context of this Guidance. The concept of "bunkering", "competent authority" and "managing body of the port" are all related directly to the present Guidance, and their definitions are adopted in this document (see section 1.4) with the intention to use this regulation as an immediate legal reference to good practice guidance included in this document.

LNG bunkering is directly within the scope and applicability of this Regulation (Chapter II, Article 1).

The aim of Regulation (EU) 2017/352 is to 'level the playing field' in the sector, and create a climate more conducive to efficient public and private investments. The Regulation defines the conditions under which the freedom to provide port services apply, for instance the type of minimum requirements that can be imposed for safety or environmental purposes, the circumstances in which the number of operators can be limited and the procedure to select the operators in such cases.

It introduces common rules on the transparency of public funding and of charging for the use of port infrastructure and port services, allowing the differentiation of port infrastructure charges in order to promote among others high environmental performance and energy or carbon efficiency of transport operations. It places particular emphasis on the consultation of port users and other stakeholders. It requires each Member State to have in place a clear mechanism to handle complaints and disputes between port stakeholders. Finally it requires all port service providers to ensure adequate training to employees.

Even though the Regulation does not deal with technical aspects in itself, it contains several articles which are likely to have a significant impact on how the service providers will have to demonstrate the ability to provide a service (LNG bunkering being our case of interest):

- Art 4 (Minimum requirements for the provision of port services)
- Art 6 (Limitations on the number of providers of port services)
- Art 7 (public service obligations)
- Art 14 (training of staff)
- Art 15 (Consultation of Port Users and other stakeholders).

In Section 4.6.3 these articles are further expanded with the good practice suggested for the case of LNG bunkering.

Regulation (EU) 2017/352 was published on the 15 February 2017, having entered into force in all EU MS twenty days after that and being applicable from 24 March 2019.

Figure 4.3 – EU Ports Regulation –Regulation 2017/352, also relevant for LNG bunkering as a port service, is an important reference for transparency.

EU Alternative Fuel Infrastructure Directive
Directive 2014/94/EU on the deployment of alternative fuels infrastructure

Organization

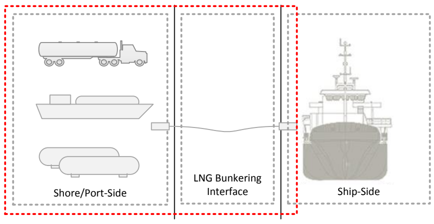
European Union

For more info

http://eur-lex.europa.eu/homepage.html

Applicable to

EU Member States (with EEA relevance)



The Directive on the deployment of alternative fuels infrastructure is an integral part of the Clean Power for Transport package. This package aims to facilitate the development of a single market for alternative fuels for transport in Europe, whilst harmonizing the efforts in the development of the relevant infrastructure for the deployment and availability of alternative fuels.

As per Directive 2014/94, "Alternative Fuels" means *fuels or power sources which serve, at least partly, as a substitute for fossil oil sources in the energy supply to transport and which have the potential to contribute to its decarbonisation and enhance the environmental performance of the transport sector*. The following fuels are considered in the context of this Directive:

- electricity
- hydrogen
- biofuels as defined in point (i) of Article 2 of Directive 2009/28/EC
- synthetic and paraffinic fuels,
- natural gas, including biomethane, in gaseous form (compressed natural gas (CNG)) and liquefied form (liquefied natural gas (LNG))
- liquefied petroleum gas (LPG)

The final Directive, as adopted by the European Parliament and the Council on 22 October 2014:

- Requires Member States to develop national policy frameworks for the market development of alternative fuels and their infrastructure;
- Foresees the use or common technical specifications for recharging and refuelling points;
- Paves the way for setting up appropriate consumer information on alternative fuels, including a clear and sound price comparison methodology.

The required coverage and the timings by which this coverage must be put in place is as presented in follows, in table 4.2.

Table 4.2 – Directive 2014/94 – applicable deadlines.

	Coverage	Timings
Electricity in urban/suburban and other densely populated areas	Appropriate number of publically accessible points	by end 2020
CNG in urban/suburban and other densely populated areas	Appropriate number of points	by end 2020
CNG along the TEN-T core network	Appropriate number of points	by end 2025
Electricity at shore-side	Ports of the TEN-T core network and other ports	by end 2025
Hydrogen in the Member States who choose to develop it	Appropriate number of points	by end 2025
LNG at maritime ports	Ports of the TEN-T core network	by end 2025
LNG at inland ports	Ports of the TEN-T core network	by end 2030
LNG for heavy-duty vehicles	Appropriate number of points along the TEN-T core network	by end 2025

Specifically for LNG as fuel, as stated in this Directive the TEN-T Core Network should be the basis for the deployment of LNG infrastructure as it covers the main traffic flows and allows for network benefits. TEN-T Core Ports are, in this sense, the main focus for the development of LNG at maritime ports, as indicated above. The deployment of the refuelling points, and LNG bunkering facilities should for LNG (and CNG) be adequately coordinated with the implementation of the TEN-T Core Network (see TEN-T network in figure 4.4 – 9 corridors with all EU TEN-T core ports indicated).

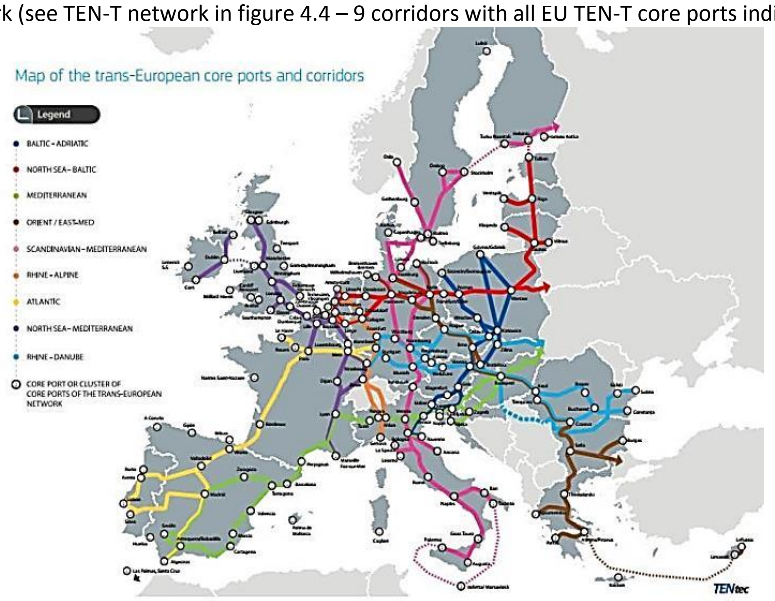
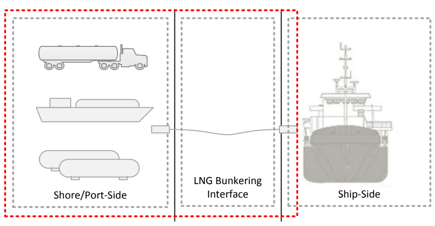


Figure 4.4 – EU-TEN-T Core ports and corridors

Concerning technical specifications for interoperability of recharging and refuelling points, this Directive establishes that these should be specified in European or international standards. In particular for LNG Bunkering standard, the Directive mentions, in point 57 of its recital, the 'Guidelines for systems and installations for supply of LNG as fuel to ships' (ISO/DTS 18683). With the recent publication of the ISO Standard on LNG Bunkering (ISO 20519:2017 Specification for bunkering of liquefied natural gas fuelled vessels) this becomes the relevant Standard for LNG Bunkering, providing the necessary reference for LNG bunkering equipment, procedures, training, safety/risk assessment and quality management.

Seveso III Directive

Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC

Organization	
European Union	
For more info	
http://eur-lex.europa.eu/homepage.html	
Applicable to	
EU Member States	

The Seveso III Directive includes obligations on the operator, in particular measures to prevent major accidents and the requirement to communicate information on potential major-accidents with dangerous substances on its establishments. Transport outside establishments and directly related intermediate temporary storage of dangerous substances (including loading and unloading) are specifically excluded from this directive by Article 2(2) (c). LNG is listed as a named dangerous substance in entry 18 of Annex I Part 2 to the Directive. This Directive is applicable to all[28] LNG installations, except offshore exploration, underground offshore gas storage.

All establishments which hold at least 50 tonnes[29] of LNG (less if other dangerous substances are also present) fall under the scope of the Directive and, amongst others, need to establish a major accident prevention policy. In addition, operators of upper tier establishments holding more than 200 tonnes of LNG (equivalent to approximately 440 m^3) need to establish, amongst others, a safety report. This safety report must include identification and assessment of major hazards and necessary measures to prevent major accidents. Other requirements include a safety management system and emergency plan.

Loading and unloading of dangerous goods and the related safety aspects are in principle governed by legislation on transport.

Table 4.3 – Seveso III Directive– applicability to LNG bunkering

Specific aspect on the applicability of the Seveso III Directive requirements	Good practice approach
<u>A. Temporary Storage</u> Despite being clear regarding the non-applicability of Seveso III Directive to LNG transport, there are cases where temporary situations will require additional judgement. Some examples are presented below <u>Examples</u>: **1. LNG truck trailer left temporarily in LNG Bunkering location**  **Figure 4.5 – LNG Truck trailers**. **2. Bunker barge, non-propelled, left alongside a ship, or moored alongside a pier**.  **Figure 4.6 – LNG barge**.	A disconnected transport container or a container-trailer disconnected from its means of transport may occur as part of the transport chain. These examples could meet the conditions for 'intermediate temporary storage'. Although, there is no common definition of 'intermediate temporary storage' the Seveso Expert Group has concluded that this refers to necessary intermediate storage in the transport chain. Whilst the unloading of trucks/containers does not define the location as a Seveso establishment there may be implications for the location where the loading takes place[30]. If it takes place within a site which is already classified as a Seveso establishment, the amount of dangerous substances involved would have to be considered by the operator of the establishment, e.g. whether or not the storage is temporary. The exclusion in Article 2(2) (c) only applies to temporary storage 'outside the establishment'. In this case the relevant Seveso establishment would have to consider the activities within or nearby its establishment as a potential risk factor and where necessary adapt its risk management measures accordingly. On the other hand, if the loading takes place within a site which is not (yet) classified as a Seveso site (but where certain amounts of dangerous substances are present, though below the thresholds), then it will be important to assess the temporary character of the loading. In the light hereof, it would play a role how often and how long the fuelling activity l takes place at the location. If there is a frequent presence of at least 50 tonnes of LNG over a longer period of time it could be argued that there was a de-facto (semi-) permanent presence of a certain amount of a dangerous substance (i.e. LNG) at a certain location, even if the actual truck or mobile container changes. In which case the operator responsible for the location may have to check with the competent authorities whether the location might have to be considered a Seveso establishment or the de-facto (semi-)permanent presence of the LNG may have to be added to the inventory of dangerous substances at the location. However, LNG (or any other fuel) that is actually used to fuel vehicles (i.e. contained in the corresponding fuel tank of the vehicle) is not taken into account **Following the above, the applicability of Seveso III Directive requirements to intermediate storage situations, as the ones presented in 1, 2 and 3 should be subject to case-by-case assessment by the BFO and PAA, in consultation with the competent authorities, which should in the best interest of safety have the following elements into consideration:**

[28] The Seveso III Directive does not differentiate between onshore and offshore. To this end, as an example, a ship or another floating unit could be subject to this Directive provided that is falls out of the temporary storage situation. In addition, where a barge is used as a permanent storage unit (table 3.4 case E). This can actually be a risk reduction measure to keep greater distance from the onshore part of the establishment. Such situations fall under the Seveso III Directive. Only the offshore exploration of gas and oil as such is excluded.

[29] Also establishments with less than 50 tonnes can be covered if other dangerous substances are present. This could be very relevant in harbours where other fuels are present. Under the Seveso III Directive different dangerous substances are summed up. This is an important point to take into account when assessing on the applicability of the Seveso Directive requirements to a given small scale/bunkering project.

[30] A similar understanding can be found in USCG CG-OES Policy Letter 02-14, where it is considered in enclosure (1), point 1) a) that *LNG tank trucks and railcars are not considered waterfront facilities handling LNG. However, when trucks or railcars are used as a means for transferring LNG to a marine vessel, the location where the transfer occurs may so be considered.*

3. ISO framed LNG container

Figure 4.7 – LNG ISO containers.

- Quantities of LNG actually or anticipated to be present in intermediate storage
- Whether or not the intermediate storage is directly related to transport outside Seveso establishments
- Duration and frequency of the intermediate storage
- Other risk factors at the location or in its proximity such as intermediate storage of other hazardous substances.

The particular case of the ISO containers may be further divided in 3 (three) different situations: 1) LNG ISO container at the end of the transport chain; 2) LNG ISO unit cargo in-between the transport chain ; 3) LNG fuel units for ISO bunkering of LNG fuelled ship.

Whenever considered as part of an "LNG Virtual Pipeline" concept, these LNG ISO containers can be potentially waiting in the port area for embarkation on-board a container vessel to a different destination.

For any of the cases presented above it is important to identify the end of the actual transport chain and, again, to address intermediate storage considering the elements listed above.

B. LNG fuelling

Figure 4.8 – LNG fuelling.

The situation presented in figure 4.8 illustrates an LNG truck parked alongside a passenger ship, undertaking an operation that, in the context of this Guidance, will be addressed as "LNG fuelling", a process-operation that cannot be considered as loading/unloading or even bunkering in exact terms. In this particular case the LNG truck parked alongside the receiving ship, feeds LNG fuel to direct use (e.g. dual fuel port generator).

Article 2(2) (c) excludes from the scope of the Seveso III Directive the transport of dangerous substances and directly related intermediate temporary storage outside establishments covered by the scope of the Directive. Loading and unloading of dangerous goods and the related safety aspects are in principle governed by legislation on transport. The scenario described is not however a typical unloading situation (e.g. unloading into a storage tank) and is more suitably classified as a process-operation that is, otherwise not covered in transport instrument requirements. As outlined under "A", the truck may affect the assessment of the location in which the truck is parked, and it may also be relevant whether or not the tractor is uncoupled from the container during the fuelling.

Typically the competent authorities also apply time limits (e.g. 24h) above which 'intermediate temporary storage' can no longer be claimed. This may be subject to a case by case assessment.

C. LNG powered shore-side electricity

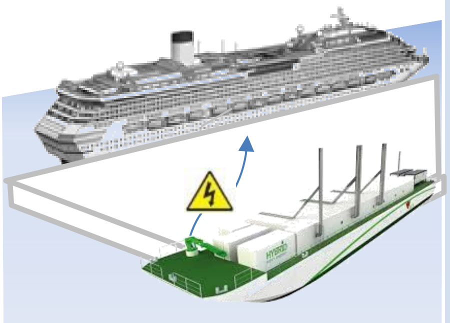


Figure 4.9 – LNG power barge (electricity supply).

Figure 4.10 – LNG fuelled floating power plant

LNG "power barges" are already used to provide electrical shore-side energy to ships that so wish to connect to an external electrical power source.

The several advantages of having shore-side electricity to ships are obvious. The electricity is, in the case represented in the figure to the left, sourced from an LNG powered "power barge". In essence a floating power plant that is able to produce electricity from gas or dual-fuel generators.

To date only small LNG power barges have been commissioned but there is no technical limit to the size and capacity of this concept.

Notwithstanding the rationale behind this particular arrangement, similarly to case "B", above, it represents a situation where LNG is not "bunkered" to the receiving ship. In fact LNG is not being transferred at all. The use of LNG is taking place on the barge. The major concern for the location where the barge is moored to derives from the on-board LNG storage.

Another consideration that may be possible is that the LNG "power barge", either self-propelled or not, is not engaged in transport of LNG but rather on the deployment of a service (electricity production and supply). The barge is however not undertaking transport of LNG and, in comparison to "B" the transport chain has clearly ceased. This would, in principle, mean that this situation would not be covered by the exclusions in Article 2(2) (c).

Applicability of Seveso III Directive requirements should be very clearly considered by PAAs, giving special consideration to the situations where such barges are alongside a fixed location within the port area. Even though these are floating units they should be assessed in light of Seveso safety requirements.

As with other cases it may well be that similar measures to those prescribed by Seveso III Directive are already taken (Safety Report, Safety Management System and an Emergency Plan) as part of the project.

D. Bunkering by Multiple trucks to one manifold

Figure 4.11 – LNG bunkering with multiple trucks, via common manifold

LNG bunkering via a common manifold, as shown in the figure to the left, may represent an operational advantage in LNG bunkering via trucks. Optimization of LNG bunkering times, volumes and transfer rates, including reduction of operational times for truck arrival, preparation, connection/disconnection, are amongst some of the relevant drivers for the manifold multi-truck solution.

The quantities of LNG in one place, and the procedures followed to connect/disconnect to the manifold, altogether, are distinctive characteristics of this type of LNG bunkering interface solution.

Overall, this scenario is in principle no different from example 1 above and determination of applicable regulations may depend upon the maximum amount of LNG that may be expected in the location over a relevant amount of time, at any time. However, given the larger amount of LNG present[31] and the fact that a fixed installation (i.e. the manifold) could be seen as an indication of more regular activities, this scenario is more likely than example 1 to conclude that the location is to be considered as a Seveso establishment.

A case-by-case approach should be exercised, in direct consultation with PAA and Competent Authorities, with Seveso requirements applied on the basis of the maximum quantities of LNG expected for that location at any time (e.g. maximum capacity of the manifold). The presence in the area of other hazardous substances (Annex I of Seveso III Directive) should also be duly considered and added.

E. LNG Bunkering FSU (Floating Storage Unit)

Figure 4.12 – Small LNG FSU

An LNG bunkering small FSU, in intermediate position, between shore and the receiving ship, as shown in figure 4.12, may represent an additional advantage, with the receiving ship able to moor-and-bunker faster. The LNG small FSU could, in this case, fall under the Seveso III requirements.

For the assessment of a particular location it does not matter whether the storage or use is land-based or water-based. If a given location happens to include an expanse of water, then this area needs to be considered as well. A vessel (e.g. a barge) that mostly remains within a certain location under the control of a single operator (e.g. a harbour) could not benefit from the exclusion described in Article 2(2)(c) of the Seveso III Directive because this refers to temporary storage during transport outside the establishment and not to transport or storage within an establishment.

F. LNG small scale storage

Figure 4.13 – Small scale LNG storage – pressurized tanks and evaporators for re-gasification.

Small scale LNG storage installations, such as the one illustrated in the figure to the left, are typically within the scope and applicability of the Seveso III Directive, with LNG capacities up to 10,000m^3.

Fixed LNG installations, for higher capacity bunkering operations would include LNG storage tanks such as the pressure tanks illustrated. The storage installation, together with the rest of the terminal installations would be unquestionably scoped under Seveso III Directive. The LNG storage may however be done in different ways, with LNG tanks of different construction and different containment systems, amongst other aspects.

Noting further that the quantities contributing to the thresholds indicated in the Seveso directive are the summation of all stored/handled hazardous substances in a given location, amongst others the following requirements apply:

- **Major-accident prevention policy (MAPP) –** Article 8 (for all tiers)
- **Safety Report –** Article 10
- **Safety Management System**
- **Emergency Plan**

All the above situations, explored in terms of Seveso III Directive requirements applicability, may be subject to case-by-case assessments. Notwithstanding this, the following conclusions may be taken in assistance to the definition of a good practice approach in the permitting of LNG bunkering facilities:

- Seveso III does not apply to mobile units undertaking transport of LNG outside Seveso establishments. The

[31] Particular reference is made to the definition of "presence of dangerous substances" in Article 3 of Seveso III Directive. This includes the concept of anticipated presence. So in case of a manifold as depicted in the figure for situation "D" the maximum possible would be assumed to be present, i.e. 4 tanks.

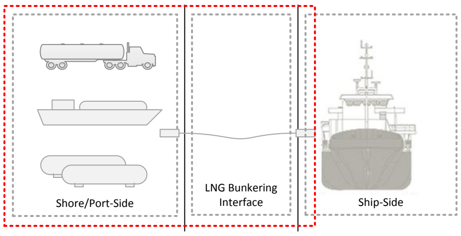
bunkering operation in itself, being part of the logistic chain, is also part of the LNG distribution. Article 2(2)(c), therefore, typically applies to LNG trucks and LNG bunkering vessels or barges provided that it is directly linked to the transport in which case it would be unloading.

- The location where bunkering takes place, however, can be considered as a specific location where hazardous substances are handled, in this case LNG, and therefore be subject to consideration for application of Seveso. This is better addressed in Chapter 7, on Permitting.
- Competent Authorities for Seveso III Directive requirements, at national level, should engage periodically with PAAs to assess specific situations that may result from continuously developing LNG bunkering technology.
- LNG bunkering, in otherwise-Seveso installations (i.e. installations already classified as Seveso) should be carefully considered, e.g. in light of possible domino effects. Safety Distances should take pre-existing hazardous substances into account.

Seveso III includes also the following Annexes, relevant as references to
- Annex I — Dangerous substances (LNG include in entry 18, Part 2)
- Annex II — Minimum data and information to be considered in the **safety report** referred to in Article 10
- Annex III — Information referred to in Article 8(5) and Article 10 on the **safety management system** and the organisation of the establishment with a view to the prevention of major accidents
- Annex IV — Data and information to be included in the **emergency plans** referred to in Article 12
- Annex V — Items of **information to the public** as provided for in Article 14(1) and in point (a) of Article 14(2)
- Annex VI — Criteria for the **notification of a major accident** to the Commission as provided for in Article 18(1)

EU Environmental Impact Directive
Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment.

Organization	
European Union	
For more info	
http://eur-lex.europa.eu/homepage.html	
Applicable to	
EU Member States	



IA Directive (2011/92/EU as amended by Directive 2014/52/9EU)[32] defines the Environmental Impact Assessment (EIA) process which ensures that projects likely to have significant effects on the environment are made subject to an assessment, prior to their authorization. Consultation with the public is a key feature of EIA procedure. The EIA Directive applies to a wide range of public and private projects, which are defined in Annexes I and II. Annex II lists so called "Energy Industry" projects and more specifically storage of gas. For projects listed in Annex II, the national authorities have to decide whether an EIA is needed (by a so-called "screening procedure"). Although the EIA Directive specifies no specific thresholds or criteria for 'storage of gas' (LNG) installations, during the screening procedure the national authorities must take into account the criteria laid down in Annex III. The EIA Directive also specifies the requirements on participation of environmental authorities, local and regional authorities, affected Member States as well as the public in the process.

Together with Seveso III, the EIA Directive can be a relevant instrument for LNG bunkering projects, especially with regards to Permitting processes. As LNG bunkering projects fall under Annex II of the EIA Directive and Member States may have introduced different thresholds or criteria for this type of projects, it is important to verify the applicable national legislation. The Directive, as such, aims to set the framework for EIA and, national legislation to provide for the technical measures.

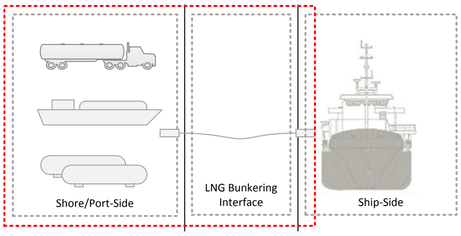
As indicated above, it is the responsibility of each Member State to identify the thresholds and/or criteria for LNG storage capacity above which the provisions of the Directive apply, or they can apply case-by-case examination to determine of Annex II projects shall be subject to EIA.

Whether an LNG project, with local small-scale storage, would be subject to an EIA should be a result of a determination in accordance with national legislation transposing Art. 4(2)-(6) of the EIA Directive.

In section 4.6.5 a good practice procedure is included to address the screening and assessment of LNG bunkering projects, in the wider context of permitting process. A flow diagram is included to identify the main parts that constitute the EIA process (see figure 4.25).

[32] The initial Directive of 1985 and its three amendments have been codified by DIRECTIVE 2011/92/EU of 13 December 2011. Directive 2011/92/EU has been amended in 2014 by DIRECTIVE 2014/52/EU

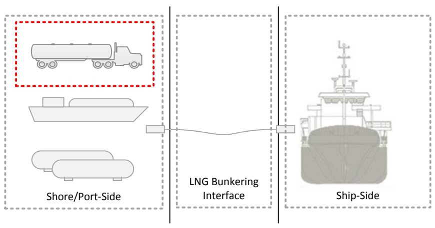
EU Environmental Impact Directive
Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment.

Organization	
European Union	
For more info	
http://eur-lex.europa.eu/homepage.html	
Applicable to	
EU Member States	

EIA Directive (85/337/EEEC)[33] (and its updates) defines the Environmental Impact Assessment (EIA) and minimum requirements for the public consultation procedure. The EIA Directive (85/337/EEC) is in force since 1985 and applies to a wide range of public and private projects, which are defined in Annexes I and II. Annex II specifies requirements for so called "Energy Industry" and more specifically storage of gas. For projects listed in Annex II, the national authorities have to decide whether an EIA is needed. The EIA-directive specifies no threshold for 'storage of gas' (LNG) installations. In general this Directive, and its implementation in national law by Member States, applies to larger LNG installations (some exceptions exist) rather than to small scale terminals. The EIA also specifies the requirements on public participation in the process.
Together with Seveso III, the EIA Directive can be a relevant instrument for LNG bunkering projects, especially with regards to Permitting processes. It will however depend very much on the transposition exercise of this EU Directive the very extent of its applicability to LNG bunkering projects, making it remarkably important to observe the relevant provisions for EIA in each Member State national law. The Directive, as such, aims to set the framework for EIA and, national legislation to provide for the technical measures allowing for the adequate scoping of EIAs to the relevant projects.
As indicated above, it is the responsibility of each Member State to identify the thresholds for LNG storage capacity above which the provisions of the Directive apply.
In principle, from conclusions of the EU LNG Study [2], there are very few Member States that would consider small scale LNG developments, such as small-scale storage associated to LNG bunkering, as subject to EIA requirements. Whether an LNG project, with local small-scale storage, would be considered for EIA requirement is subject to local/national thresholds fixed for that purpose.

In section 4.6.5 a good practice procedure is included to address the screening and evaluation of LNG bunkering projects, in the wider context of permitting process. A flow diagram is included to identify the main parts that constitute the EIA process (see figure 4.25).

ADR – European agreement concerning the International Carriage of Dangerous Goods by Road
(Update version ADR January 2017)

Organization	
UNECE	
For more info	
https://www.unece.org/trans/danger/	
Applicable to	
LNG Trucks Transport of LNG by road/trailer trucks. Handling operations in loading/offloading of LNG	

The transport of hazardous goods by road is covered in the European Agreement concerning the International Carriage of Dangerous Goods by Road, commonly known as ADR ('*Accord européen relatif au transport international des marchandises dangereuses*') from the Economic Commission for Europe (UNECE or ECE). The ADR is translated and included in the national legislation of the applicable countries. The Agreement itself is short and simple. The key article is the second, which describes that, excluding some excessively dangerous goods, other dangerous goods may be transferred internationally in road vehicles subject to compliance with the conditions laid down in Annexes A (packaging and labelling) and B (construction, equipment and operation of the vehicle carrying the goods in question) [14].

[33] The initial Directive of 1985 and its three amendments have been codified by DIRECTIVE 2011/92/EU of 13 December 2011. Directive 2011/92/EU has been amended in 2014 by DIRECTIVE 2014/52/EU

Trucks that transport LNG are subjected to Annex A with respect to labelling of hazardous materials and to Annex B when it comes to construction of the cargo tank. Trucks that are using LNG as fuel are subjected to Annex B for the construction of the fuel tank.

A new version of the ADR has entered into force the 1st of January 2017. No modifications impacting LNG transport via trucks have been made.

ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland waterways (Update version ADN January 2017)

Organization

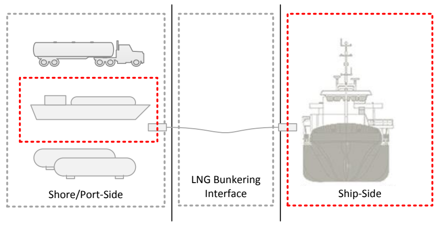
UNECE

For more info

https://www.unece.org/trans/danger/

Applicable to

LNG bunker vessels and barges operating in rivers and port areas (see contracting countries in Figure 4.14)
Construction, Operation, training of crew



The ADN is published together with the Central Commission for the Navigation of the Rhine (CCNR). The provisions annexed to the ADN concern dangerous substances and articles, provisions concerning their carriage in packages and in bulk on board inland navigation vessels or tanks vessels, as well as provisions concerning the construction and operation of such vessels [15]

Figure 4.14 shows the ADN contracting countries.

Figure 4.14 - ADN Contracting Countries (source: UNECE).

In "Table A" of the addendum, a list of substances is mentioned specifying the conditions of transportation via inland waterways for each of these substances. With an amendment coming into force of 1.1.2015, the LNG was included in the authorised cargo. ADN also prohibited the installation and utilization of engines that use a fuel with a flashpoint below 55 °C. However, in 2017, an amendment was approved to allow derogations subject to compliance with the requirements laid down by CESNI standard ES-TRIN. It will come into force of 1.1.2019 (See ECE/TRANS/WP.15/AC.2/62, items 68 and 69).

Technical requirements for the loading and unloading procedure for liquefied natural gas (LNG) are not in scope of the update of ADN.

Figure 4.15 - Ship-to-ship LNG bunkering – riverine LNG bunker vessel to receiving ship

Of particular relevance, Part 8 of the ADN contais **training requirements applicable for crew s of LNG bunker vessels**, barges or riverine LNG carriers, (This paragraph states that an expert shall be on board the vessel, not less than 18 years of age, who has special knowledge of the ADN, taken part in a basic or specialization course as referred to in 8.2 ADN).

Proof of this knowledge shall be furnished by means of a certificate from a competent authority or from an agency recognized by the competent authority).

The ADN does not require specific training for crew of inland LNG tankers, indeed LNG falls under the provisions of gas specialisation courses.

Rhine Vessel Inspection Regulations (RVIR)

Organization

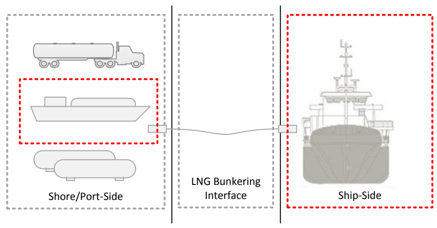
CCNR

For more info

https://www.ccr-zkr.org/

Applicable to

Inland navigation vessels (Beyond the river Rhine, the Rhine vessel certificates are recognised on all EU waterways)



The CCNR technical rules and requirements for inland waterway vessels are captured in the RVIR [17]. The Rhine inspection regulations, which are only legally applicable on the Rhine itself, have become Europe's technical reference base for the construction of new vessels, irrespective of whether they are intended for use on the Rhine or somewhere else. Indeed, beyond the river Rhine, the Rhine vessel certificates are recognised on all EU waterways.

Until very recently, the RVIR prohibited the use of fuel with a flashpoint below 55°C, as stated in Article 8.01 (3) of RVIR. Hence, the use of LNG as a fuel for inland waterway vessels was not allowed. From 2012, CCNR allows derogations to the RVIR in order to give ship owners and builders the opportunity to develop alternative arrangements (for example LNG supply system) if comparable safety guarantees could be provided. Several vessels were built and operated, especially in the Netherlands. After an analysis of what has been learned from operating of these vessels, the CCNR adopted supplements to its regulations for Rhine navigation in order to create a legal framework which would allow the regular use of LNG as a fuel for inland navigation in Europe. In particular, from December 2015, a new chapter 8a and annex T have been included in the RVIR.

Following the update of the RVIR, the relevant technical requirements for LNG have also been included in the standard ES-TRIN published by CESNI. ES-TRIN is not binding per se. The CCNR and EU intend to enact ES-TRIN in a coordinated way, with effect from 07 October 2018, by means of a reference in their respective legislative frameworks (RVIR and Directive 2016/1629).

An evaluation of items relevant to LNG bunkering in the RVIR draft chapter 8b and Annex T is presented in Table 4.4, below. (Similar observations are valid for ES-TRIN, Chapter 30 and Annex 8).

Table 4.4 - Items relevant for LNG bunkering in draft RVIR chapter 8b and Annex T

RVIR chapter 8b and Annex T	
Reference	*Description*
Article 8b.03 Safety aspects	Vessels equipped with propulsion or auxiliary systems operating on fuels with a flashpoint equal to or lower than 55 °C shall keep safety instructions on board. It shall include information on the measures to be taken in the event of accidental release of liquid or gaseous fuel, for instance during bunkering.
Annex T Part 1 LNG, Chapter 2 Vessel arrangements and system design, 2.1 General	A risk assessment shall be conducted on any new or altered concept or configuration or other significant changes. Hazardous areas shall be restricted and equipment installed in hazardous areas shall be minimized. Sources of ignition in hazardous areas shall be limited. Components of LNG system shall be protected against external damage. Bunkering arrangements shall be capable of taking on board and containing the fuel in the required state without leakage or environmental emissions (venting). Control, alarm, monitoring and shutdown systems along with fired detection, protection and extinction measures shall be provided.

Annex T Part 1 LNG, Chapter 2 Vessel arrangements and system design, 2.2 LNG containment	Requirements for LNG storage tanks are presented in this section. Under specific conditions, LNG storage tanks can be single or double walled, located below or on open deck. Design shall be according to EN 13530, EN 13458-2:2002, IGC-code (type C tank), the ADN or another appropriate standard to the satisfaction of the competent authority.
Annex T Part 1 LNG, Chapter 2 Vessel arrangements and system design, 2.3 Engine rooms	Engine rooms shall be gas safe or designed as ESD protected and specific requirements are given in this section.
Annex T Part 1 LNG, Chapter 2 Vessel arrangements and system design, 2.4 LNG piping systems	Requirements for LNG piping are given in this section. It covers items such as location, isolation; design pressure and pressure relieve valves.
Annex T Part 1 LNG, Chapter 2 Vessel arrangements and system design, 2.8 LNG bunkering system	- The LNG bunkering system shall be so arranged that no gas is discharged to the atmosphere during filling of LNG storage tanks. - The LNG bunkering station shall be located on open deck. - The bunkering manifold shall be so positioned and arranged that any damage to the gas piping does not cause damage to the vessel's LNG containment system. The bunkering manifold shall be designed to withstand external mechanical loads during bunkering. The connections shall be of dry-disconnect type equipped with additional safety dry break-away coupling/ self-sealing quick release. - Suitable means shall be provided to relieve the pressure and remove liquid contents from pump suctions and bunker piping. - Hoses used for LNG transfer shall be suitable for LNG. Hoses shall be designed for a bursting pressure not less than five times the maximum bunkering pressure. - It shall be possible to operate the master gas fuel valve for bunkering operations from a safe control station on the vessel. - Bunkering piping shall be arranged for inerting and gas freeing. During operation of the vessel the bunkering piping shall be free of gas.
Annex T Part 1 LNG, Chapter 2 Vessel arrangements and system design, 2.9 filling limits for LNG storage tanks	The level of LNG in the storage tank shall not exceed the filling limit of 95 % full at the reference temperature (temperature corresponding to the vapour pressure of the fuel at the opening pressure of the PRV's). A filling limit curve dependent of the actual LNG filling temperatures shall be prepared.
Annex T Part 1 LNG, Chapter 3 Fire safety	This section gives all the requirements related to fire safety, covering alarm system, insulation, prevention, cooling and extinguishing. Specific for bunkering are: - Bunker station shall be separated by class A-60 insulation from engine rooms, accommodation and high fire risk spaces. - Two additional dry powder fire extinguishers of at least 12 kg capacity shall be located near the bunkering station.
Annex T Part 1 LNG, Chapter 5 Control monitoring and safety systems, 5.2 LNG bunkering system and LNG containment system monitoring	This section gives all the requirements related to control, monitoring and safety systems for the LNG bunkering and containment system. It covers items such as pressure and level indicators and alarms.

Regulation for Rhine navigation personnel (RPN)

Organization

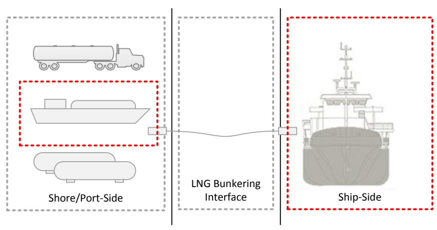
CCNR

For more info

https://www.ccr-zkr.org/

Applicable to

Training and manning requirements for crews of inland vessels.



After an analysis of what has been learned from operating inland navigation vessels already testing the use of LNG, the CCNR adopted supplements to its regulations for Rhine navigation in order to create a legal framework which would allow the regular use of LNG as a fuel for inland navigation in Europe.

In June 2015, the CCNR adopted an amendment of the Regulation for Rhine Navigation Personnel (RNP) (Resolution 2015-I-7) to come into force on 1 July 2016. The RNP includes a new Chapter 4bis on "Additional provisions concerning the expertise of crew members of inland navigation vessels fuelled by liquefied natural gas (LNG)". This Chapter includes requirements on stipulating that skippers and crew members involved in the bunkering procedure shall be subject to an obligation of expertise, and on laying down the content of training courses and examinations.

In the future, similar provisions will be included in CESNI Standards.

Rhine police Requirements (RPR)

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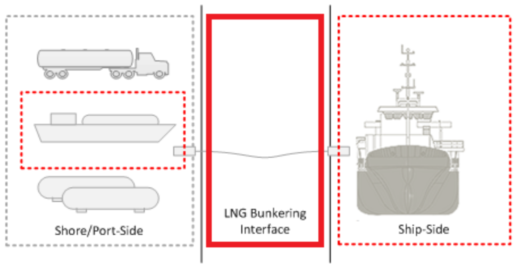
<tr><td><u>Organization</u></td><td rowspan="6">
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<tr><td align="center">CCNR</td></tr>
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<tr><td align="center">https://www.ccr-zkr.org/</td></tr>
<tr><td><u>Applicable to</u></td></tr>
<tr><td>Inland Navigation vessels, along the Rhine waterway or in a port.</td></tr>
</table>

After an analysis of what has been learned from operating inland navigation vessels already testing the use of LNG, the CCNR adopted supplements to its regulations for Rhine navigation in order to create a legal framework which would allow the regular use of LNG as a fuel for inland navigation in Europe.

In June 2015, the CCNR adopted an amendment to the Rhine Police Regulations (RPR). These regulations determine the operational requirements, including during the bunkering, applicable to ships using Liquefied Natural Gas (LNG) as a fuel which came into force on 1st December 2015.

To give effect to these requirements, the CCNR has published in October 2015 edition 1.0 of the standard for a liquefied natural gas (LNG) bunker checklist truck to ship. This standard, available in French, German, Dutch and English, is based on that published by the International Association of Ports and Harbours (IAPH) and already used by a number of river/sea ports. It comprises the checklist required by the Rhine Police Regulations (RPR) on the one hand and guidelines on the other hand, aiming to expand on the content of this list and to assist the boatmaster in completing it.

The use of this standard is mandatory for all LNG bunker operations involving a vessel if this bunkering takes place along the Rhine waterway or in a port.

Directive (EU) 2016/1629 laying down technical requirements for inland waterway vessels, amending Directive 2009/100/EC and repealing Directive 2006/87/EC

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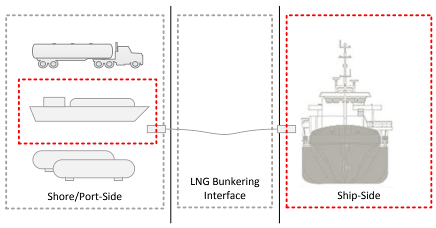
<tr><td><u>Organization</u></td><td rowspan="6">
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<tr><td>http://eur-lex.europa.eu/homepage.html</td></tr>
<tr><td><u>Applicable to</u></td></tr>
<tr><td>Inland navigation vessels (Union vessel certificates are also recognised on the river Rhine)</td></tr>
</table>

The Directive (EU) 2016/1629 lays down the provisions for inspection of Inland Navigation vessels, the issuance of Union certificates and the reference to the technical requirements included in CESNI standard ES-TRIN.

In order to ensure consistency of two existing legal regimes for technical requirements for inland navigation vessels (Rhine and UE) it is necessary to provide the same standards. Both EU law and CCNR Regulation will be referring to standards delivered by CESNI – to ES-TRIN 2017/01 from 7 October 2018 (deadline of transposition of Directive EU 2016/1629 and date of applicability of ES-TRIN 2017/01).

Meanwhile the use of fuel with a flashpoint below 55°C was prohibited with the previous directive 2006/87/EC, the reference to ES-TRIN (especially to Chapter 30 and Annex 8) offered the opportunity to apply the special provisions for craft using LNG as fuel.

4.2.2 International Framework

The international framework for LNG as fuel, similarly to the European context, starts with the main environmental instrument MARPOL, imposing restrictions on air emissions from ships, through it Annex VI regulations 13 and 14, for NOx and SOx emissions, respectively. Effectively the use of LNG is an option to allow ships meeting air pollution requirements, in particular for SOx emissions (with dramatic reductions in emissions above 95% in even in dual fuel engine systems). Being a gaseous fuel, of flashpoint lower than 60ºC (actually -175ºC) LNG could not be considered as fuel, within SOLAS frame[34]. Due to that reason, addressing the particular aspects concerning safe use of LNG as fuel, building from the experience of the IGC Code and from the application of Interim Guidelines[35] the IGF Code was developed. Containing what is today the best collection of provisions for the design, construction and operation of LNG fuelled ships the IGF Code entered into force on 1st January 2017 and is the central focus of this section. Its functional requirements are further outlined in this section and a parallel is established with the whole LNG bunkering interface, making the relation that similar functional requirements should be applicable throughout the entire LNG bunkering scenario.

On its own the IGF Code represents a highly relevant instrument, defining the safety requirements for the construction and operation of LNG fuelled ships and, at the same time, defining the level of ambition in terms of safety, relevant safeguards, control and associated procedures. The LNG bunkering related provisions are significant and selected, transcribed and commented below. It is, in the context of this guidance, important to follow the IGF Code requirements and establish good practice that can be expanded to the LNG Bunkering Interface and Shore-Side. Communications, Check-lists, Pre-Bunkering verification procedures, Emergency Shutdown (ESD) link compatibility, bunkering control, Persons in Charge (PICs), are amongst some of the aspects where harmonization of technical aspects and procedures must be ensured between all parties involved, including PAAs.

Table 4.5 – International high-level instruments

Title	Responsible	Type	Scope
IGF Code **International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels** (IMO Res.MSC.391(95))	IMO	International Code	Ships constructed or converted to the use of gases or low flashpoint fuels, after the 1st January 2017 Requirements for design, construction and operation.
International convention for the Safety of Life at Sea (SOLAS)1974, as modified by the protocol of 1988 relating thereto	IMO	Convention	Ships engaged in international voyages. IGF Code is made mandatory through amendment in SOLAS, in new Regulation 57, introduced through Resolution MSC.392(95)
IGC Code International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk	IMO	International Code	Construction, equipment and operation of ships carrying liquefied gases in bulk.
MARPOL International Convention for the Prevention of Pollution from Ships	IMO	Convention	Relevant in particular for Annex VI, with limits on SOx and NOx Emissions, Energy Efficiency and EAMs.
STCW **(Convention)** International convention on standards of training, certification and watch keeping for seafarers	IMO	Convention	Training, certification and qualification of seafarers serving on board sea-going ships Minimum standards of competence for seafarers
STCW **(Code)** International convention on standards of training, certification and watch keeping for seafarers	IMO	International Code	Training, certification and qualification of seafarers serving on board sea-going ships Minimum standards of competence for seafarers

[34] The use of fuels with flashpoint lower than 60ºC is not permitted as per SOLAS 1989/1990 Amend / Chapter II-2 / Reg. 15.

[35] MSC.285 (86) - Interim guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships

IGF Code
International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels
(IMO Res.MSC.391(95))

Organization

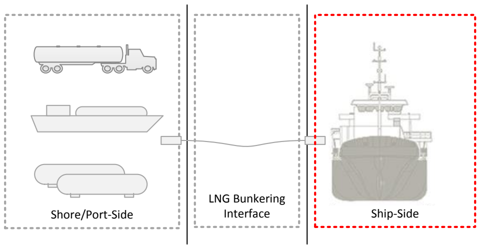
IMO

For more info

http://www.imo.org/en/Publications

Applicable to

LNG fuelled ships built or converted after 1st January 2017.



This Code provides an international standard for ships using low-flashpoint fuel, other than ships covered by the IGC Code. The basic philosophy of this Code is to provide mandatory provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using low-flashpoint fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

The International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) was adopted by the Maritime Safety Committee (MSC) at its ninety-fifth session in June 2015, by resolution MSC.391(95), in order to provide an international standard for the safety of ships using low-flashpoint fuel, other than ships covered by the IGC Code. The IGF Code is made mandatory under amendments to chapters II -1, II -2 and the appendix to the annex of the International Convention for the Safety of Life at Seas (SOLAS), 1974, that were adopted by the MSC at the same session, by resolution MSC392(95) (entry into force: 1 January 2017).

Relevance

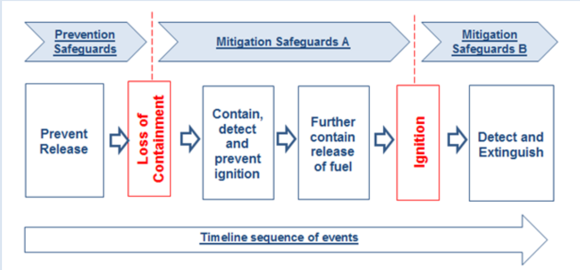
From the IGF Code the following Chapters are of particular relevance in the context of LNG Bunkering:

- **Section 3.2 - Functional Requirements**
- **Chapter 8 – Bunkering**
  (Outline of functional requirements for bunkering equipment (ship-side) with requirements to the Bunkering Station and manifold onboard the LNG fuelled ship),
- **Section 18.4 – Regulations for Bunkering Operations**
  (description of operational procedures to be followed for LNG bunkering, with the description of the particular responsibilities for the PICs and operational aspects related to communications, control and safety systems and verification of conditions for bunkering),
- **Section 15.4 – Regulations for bunkering and liquefied gas fuel tank monitoring**
  (Set of requirements specific for LNG tank filling monitoring, especially relevant during bunkering, both for overfills mitigation and for LNG vapour management.
- **Section 15.5 – Regulations for bunkering control**
  (LNG bunkering control aspects, including requirements for LNG bunkering control location.)

Section 3.2 of the IGF Code lists the Functional Requirements that are the basis of the requirements developed throughout the entire Code. The Functional requirements are also fundamental also in the context of the LNG bunkering interface, and should be followed and used as fundamental principles.

Table 4.6 – IGF Functional Requirements – Applicability to Bunkering Interface

IGF Code Functional Requirement (Section 3.2)	Applicability in LNG Bunkering
3.2.1 The safety, reliability and dependability of the systems shall be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery	The concept of "an equivalent safety level" is important to extend also to the LNG bunkering interface. The safeguards in place should also there meet the equivalent safety level principle. LNG fuelled ships should be treated a normal ships, under the observation of the specific safety requirements

IGF Code Functional Requirement (Section 3.2)	Applicability in LNG Bunkering
3.2.2 The probability and consequences of fuel-related hazards shall be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions shall be initiated.	A 2 layered safeguard approach is here outlined as a safety functional requirement. Also for the LNG bunkering interface this should be followed (1st layer – avoid the hazard by design – 2nd layer – mitigate the hazard once it occurs). In this context the Safety concept as prescribed in this IGF Functional Requirement can be schematized in the diagram below. The 1st layer prevention safeguards and the 2nd layer is mitigation safeguards (further sub-divided into "A" and "B").  **Figure 4.16 – Prevention and Mitigation measure layered arrangement**
3.2.3 The design philosophy shall ensure that risk reducing measures and safety actions for the gas fuel installation do not lead to an unacceptable loss of power	(functional requirement specific for the ship side)
3.2.4 Hazardous areas shall be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment.	In the context of the LNG Bunkering Interface this Functional Requirement should dictate best practice such that the Hazardous Area defined for the LNG Bunkering Operation is restricted so as to minimise impact on surrounding spaces.
3.2.5 Equipment installed in hazardous areas shall be minimized to that required for operational purposes and shall be suitably and appropriately certified.	*Functional requirement also applicable to the whole LNG bunkering interface. It is very important that this alignment is ensured between the RSO, BFO and all parties involved in the LNG bunkering operation.*
3.2.6 Unintended accumulation of explosive, flammable or toxic gas concentrations shall be prevented.	Applicable in the context of LNG bunkering interface. The LNG bunkering space and all physical elements of the LNG bunkering interface to be protected against external damages.
3.2.7 System components shall be protected against external damages	Applicable in the context of LNG bunkering interface. LNG bunkering Hazardous Area to be protected. All physical elements of the LNG bunkering interface to be protected against external damages.
3.2.8 Sources of ignition in hazardous areas shall be minimized to reduce the probability of explosions.	Applicable in the context of the whole LNG bunkering interface. Reference standards applicable to the definition and characterization of hazardous zone: IEC60079-10-1, API 501 or NFPA 497 (See Chapter 9 – Control Zones – for the best practice advised by this Guidance on Hazardous Zone definition).
3.2.9 It shall be arranged for safe and suitable fuel supply, storage and bunkering arrangements capable of receiving and containing the fuel in the required state without leakage. Other than when necessary for safety reasons, the system shall be designed to prevent venting under all normal operating conditions including idle periods.	Functional Requirement 3.2.9 introduces a significant requirement applicable to the whole LNG bunkering operation. Venting should only be a possibility for safety reasons. This should otherwise not be possible. All equipment, systems and procedures, as described in the LNG Bunkering Plan should be designed in such a way that Venting is not considered an acceptable operational procedure.

IGF Code Functional Requirement (Section 3.2)	Applicability in LNG Bunkering
3.2.10 Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application shall be provided.	Functional requirements applicable to the whole bunkering interface and to equipment used also by BSOs. LNG Bunkering system should share similar safety levels, in particular in terms of overpressure relief, compatibility and quality standards.
3.2.11 Machinery, systems and components shall be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.	Applicable to all equipment and machinery used in the LNG bunkering operation.
3.2.12 Fuel containment system and machinery spaces containing source that might release gas into the space shall be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.	(functional requirement specific to the ship side)
3.2.13 Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.	Applicable to all equipment and machinery used in the LNG bunkering operation. Control, alarm, monitoring and shutdown systems should be shared by all parties in the LNG bunkering operation, in particular relevant to the BSO-RSO bunkering line where immediate action is vital in case of loss of containment or any other LNG hazard in the bunkering interface. Compatibility of equipment and procedures is fundamental.
3.2.14 Fixed gas detection suitable for all spaces and areas concerned shall be arranged.	Fixed gas detection is, indeed, a fundamental requirement to detect potential loss of containment. This functional requirement should be shared by the whole bunkering interface. Visual detection and temperature detection may however be the most effective control measures for detection of potential LNG leakage/release. Depending upon gas detector locations, under certain open-air dispersion characteristics[36] visual and temperature detection may be more appropriate (i.e. faster) to detect leakage rather than gas detectors.
3.2.15 Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.	Applicable to the whole LNG bunkering interface and parties involved. Suitable fire detection, protection and extinction should be considered. Similar safety level to be shared by all parties
3.2.16 Commissioning, trials and maintenance of fuel systems and gas utilization machinery shall satisfy the goal in terms of safety, availability and reliability.	Should also, as best practice, be applicable to LNG bunkering equipment. Applicable to all parties.
3.2.17 The technical documentation shall permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.	The relevant technical documentation, also for the case of LNG Bunkering, should be included in an LNG Bunkering Plan, where the procedure, certificates, diagrams and maintenance records, should all be kept. As a best practice this would allow the easier verification of compliance and assessment of the RSO or BSO readiness, compatibility and preparation for a given LNG Bunkering operation.
3.2.18 A single failure in a technical system or component shall not lead to an unsafe or unreliable situation.	Should be applied to the whole LNG bunkering context. A single failure event should not lead to an unsafe or unreliable situation.

[36] Dispersion characteristics, following a loss of containment event, are influenced by temperature, wind and other environmental factors. Whether gas detectors will find

Throughout this Guidance the Functional Requirements addressed above will also be present in the definition of the best practice considered also for PAAs in the context of LNG Bunkering.

Having visited the Functional Requirements of the IGF Code, and derived their applicability to LNG Bunkering, the transcription of both Chapter 8 and Section 18.4, below, is intended to highlight the relevance of these IGF Code provisions in the context of LNG Bunkering operations. Being applicable to the Receiving Ship, the requirements transcribed below define the level of protection intended for the receiving ship, both on equipment requirements (Chapters 8, Sections 15.4 and 15.5) or on operational procedures (Section 18.4).

Chapter 8 is fully dedicated to Bunkering, in particular to constructive aspects related to the location and details of the bunkering station. Functional requirements are outlined, followed by elements related to the bunkering station location, hoses, manifold and bunkering system.

8 BUNKERING

8.1 Goal

8.1.1 The goal of this chapter is to provide for suitable systems on board the ship to ensure that bunkering can be conducted without causing danger to persons, the environment or the ship.

8.2 Functional requirements

8.2.1 This chapter relates to functional requirements in 3.2.1 to 3.2.11 and 3.2.13 to 3.2.17. In particular the following apply:
8.2.1.1 The piping system for transfer of fuel to the storage tank shall be designed such that any leakage from the piping system cannot cause danger to personnel, the environment or the ship.

8.3 Regulations for bunkering station

8.3.1 General
8.3.1.1 The bunkering station shall be located on open deck so that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations shall be subject to special consideration within the risk assessment.
8.3.1.2 Connections and piping shall be so positioned and arranged that any damage to the fuel piping does not cause damage to the ship's fuel containment system resulting in an uncontrolled gas discharge.
8.3.1.3 Arrangements shall be made for safe management of any spilled fuel.
8.3.1.4 Suitable means shall be provided to relieve the pressure and remove liquid contents from pump suctions and bunker lines. Liquid is to be discharged to the liquefied gas fuel tanks or other suitable location.
8.3.1.5 The surrounding hull or deck structures shall not be exposed to unacceptable cooling, in case of leakage of fuel.
8.3.1.6 For CNG bunkering stations, low temperature steel shielding shall be considered to determine if the escape of cold jets impinging on surrounding hull structure is possible.
8.3.2 Ships' fuel hoses
8.3.2.1 Liquid and vapour hoses used for fuel transfer shall be compatible with the fuel and suitable for the fuel temperature.
8.3.2.2 Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, shall be designed for a bursting pressure not less than five times the maximum pressure the hose can be subjected to during bunkering.

8.4 Regulations for manifold

8.4.1 The bunkering manifold shall be designed to withstand the external loads during bunkering. The connections at the bunkering station shall be of dry-disconnect type equipped with additional safety dry break-away coupling/ self-sealing quick release. The couplings shall be of a standard type.

8.5 Regulations for bunkering system

8.5.1 An arrangement for purging fuel bunkering lines with inert gas shall be provided.
8.5.2 The bunkering system shall be so arranged that no gas is discharged to the atmosphere during filling of storage tanks.
8.5.3 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the connecting point. It shall be possible to operate the remote valve in the control location for bunkering operations and/or from another safe location.
8.5.4 Means shall be provided for draining any fuel from the bunkering pipes upon completion of operation.
8.5.5 Bunkering lines shall be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering pipes shall be free of gas, unless the consequences of not gas freeing is evaluated and approved.
8.5.6 In case bunkering lines are arranged with a cross-over it shall be ensured by suitable isolation arrangements that no fuel is transferred inadvertently to the ship side not in use for bunkering.
8.5.7 A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source shall be fitted.
8.5.8 If not demonstrated to be required at a higher value due to pressure surge considerations a default time as calculated in accordance with 16.7.3.7 from the trigger of the alarm to full closure of the remote operated valve required by 8.5.3 shall be adjusted.

Section 18.4 is directly related to LNG Bunkering operations (i.e. procedures, planning and responsibilities. Significant concepts are brought into the regulatory frame through the IGF code and should be respected. The terminology used in Section 18.4 should be respected in the definition of the terminology used for the entire LNG Bunkering interface. The definition of responsibilities, through the IGF code, indicates the relevance of procedural aspects as safeguards in LNG

Bunkering operations.

18.4 Regulations for bunkering operations

18.4.1 Responsibilities

18.4.1.1 Before any bunkering operation commences, the master of the receiving ship or his representative and the representative of the bunkering source (Persons In Charge, PIC) shall:
.1 agree 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;
.2 agree in writing action to be taken in an emergency; and
.3 complete and sign the bunker safety check-list.
18.4.1.2 Upon completion of bunkering operations the ship PIC shall receive and sign a Bunker Delivery Note for the fuel delivered, containing at least the information specified in the annex to part C-1, completed and signed by the bunkering source PIC.

18.4.2 Overview of control, automation and safety systems

18.4.2.1 The fuel handling manual required by 18.2.3 shall include but is not limited to:
.1 overall operation of the ship from dry-dock to dry-dock, including procedures for system cool down and warm up, bunker loading and, where appropriate, discharging, sampling, inerting and gas freeing;
.2 bunker temperature and pressure control, alarm and safety systems;
.3 system limitations, cool down rates and maximum fuel storage tank temperatures prior to bunkering, including minimum fuel temperatures, maximum tank pressures, transfer rates, filling limits and sloshing limitations;
.4 operation of inert gas systems;
.5 firefighting and emergency procedures: operation and maintenance of firefighting systems and use of extinguishing agents;
.6 specific fuel properties and special equipment needed for the safe handling of the particular fuel;
.7 fixed and portable gas detection operation and maintenance of equipment;
.8 emergency shutdown and emergency release systems, where fitted; and
.9 a description of the procedural actions to take in an emergency situation, such as leakage, fire or potential fuel stratification resulting in rollover.
18.4.2.2 A fuel system schematic/piping and instrumentation diagram (P&ID) shall be reproduced and permanently mounted in the ship's bunker control station and at the bunker station.

18.4.3 Pre-bunkering verification

18.4.3.1 Prior to conducting bunkering operations, pre-bunkering verification including, but not limited to the following, shall be carried out and documented in the bunker safety checklist:
.1 all communications methods, including ship shore link (SSL), if fitted;
.2 operation of fixed gas and fire detection equipment;
.3 operation of portable gas detection equipment;
.4 operation of remote controlled valves; and
.5 inspections of hoses and couplings.
18.4.3.2 Documentation of successful verification shall be indicated by the mutually agreed and executed bunkering safety checklist signed by both PICs.

18.4.4 Ship bunkering source communications

18.4.4.1 Communications shall be maintained between the ship PIC and the bunkering source PIC at all times during the bunkering operation. In the event that communications cannot be maintained, bunkering shall stop and not resume until communications are restored.
18.4.4.2 Communication devices used in bunkering shall comply with recognized standards for such devices acceptable to the Administration.
18.4.4.3 PICs shall have direct and immediate communication with all personnel involved in the bunkering operation.
18.4.4.4 The ship shore link (SSL) or equivalent means to a bunkering source provided for automatic ESD communications, shall be compatible with the receiving ship and the delivering facility ESD system.
(Note: Refer to ISO 28460, ship-shore interface and port operations).

18.4.5 Electrical bonding

Hoses, transfer arms, piping and fittings provided by the delivering facility used for bunkering shall be electrically continuous, suitably insulated and shall provide a level of safety compliant with recognized standards.35
5 Refer to API RP 2003, ISGOTT: International Safety Guide for Oil Tankers and Terminals.

18.4.6 Conditions for transfer

18.4.6.1 Warning signs shall be posted at the access points to the bunkering area listing fire safety precautions during fuel transfer.
18.4.6.2 During the transfer operation, personnel in the bunkering manifold area shall be limited to essential staff only. All staff engaged in duties or working in the vicinity of the operations shall wear appropriate personal protective equipment (PPE). A failure to maintain the required conditions for transfer shall be cause to stop operations and transfer shall not be resumed until all required conditions are met.
18.4.6.3 Where bunkering is to take place via the installation of portable tanks, the procedure shall provide an equivalent level of safety as integrated fuel tanks and systems. Portable tanks shall be filled prior to loading on board the ship and shall be properly secured prior to connection to the fuel system.

18.4.6.4 For tanks not permanently installed in the ship, the connection of all necessary tank systems (piping, controls, safety system, relief system, etc.) to the fuel system of the ship is part of the "bunkering" process and shall be finished prior to ship departure from the bunkering source. Connecting and disconnecting of portable tanks during the sea voyage or manoeuvring is not permitted.

Section 15.4 is also related to LNG Bunkering Operations. It establishes the required controls for LNG tank monitoring, being of special relevance in the avoidance of LNG tank overfilling. In essence, as stated in 15.4.2, as transcribed below, the following overfill controls are required: 1) liquid level gauging device (of direct or indirect type); and 2) liquid level alarm (independent of level gauge, for each tank). In addition to other requirements, control of overfill is fundamental to avoid accidental release of LNG/NG vapour through the pressure relief/safety valve on each receiving tank.

15.4 Regulations for bunkering and liquefied gas fuel tank monitoring

15.4.1 Level indicators for liquefied gas fuel tanks
.1 Each liquefied gas fuel tank shall be fitted with liquid level gauging device(s), arranged to ensure a level reading is always obtainable whenever the liquefied gas fuel tank is operational. The device(s) shall be designed to operate throughout the design pressure range of the liquefied gas fuel tank and at temperatures within the fuel operating temperature range
.2 Where only one liquid level gauge is fitted it shall be arranged so that it can be maintained in an operational condition without the need to empty or gas-free the tank.
.3 Liquefied gas fuel tank liquid level gauges may be of the following types:
.1 indirect devices, which determine the amount of fuel by means such as weighing or in-line flow metering; or
.2 closed devices, which do not penetrate the liquefied gas fuel tank, such as devices using radio-isotopes or ultrasonic devices;
15.4.2 Overflow control
.1 Each liquefied gas fuel tank shall be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated.
.2 An additional sensor operating independently of the high liquid level alarm shall automatically actuate a shutoff valve in a manner that will both avoid excessive liquid pressure in the bunkering line and prevent the liquefied gas fuel tank from becoming liquid full.
.3 The position of the sensors in the liquefied gas fuel tank shall be capable of being verified before commissioning. At the first occasion of full loading after delivery and after each dry-docking, testing of high level alarms shall be conducted by raising the fuel liquid level in the liquefied gas fuel tank to the alarm point.
.4 All elements of the level alarms, including the electrical circuit and the sensor(s), of the high, and overfill alarms, shall be capable of being functionally tested. Systems shall be tested prior to fuel operation in accordance with 18.4.3.
.5 Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented. When this override is operated continuous visual indication is to be provided at the navigation bridge, continuously manned central control station or onboard safety centre.
15.4.3 The vapour space of each liquefied gas fuel tank shall be provided with a direct reading gauge. Additionally, an indirect indication is to be provided on the navigation bridge, continuously manned central control station or onboard safety centre.
15.4.4 The pressure indicators shall be clearly marked with the highest and lowest pressure permitted in the liquefied gas fuel tank.
15.4.5 A high-pressure alarm and, if vacuum protection is required, a low-pressure alarm shall be provided on the navigation bridge and at a continuously manned central control station or onboard safety centre. Alarms shall be activated before the set pressures of the safety valves are reached.
15.4.6 Each fuel pump discharge line and each liquid and vapour fuel manifold shall be provided with at least one local pressure indicator.
15.4.7 Local-reading manifold pressure indicator shall be provided to indicate the pressure between ship's manifold valves and hose connections to the shore.
15.4.8 Fuel storage hold spaces and interbarrier spaces without open connection to the atmosphere shall be provided with pressure indicator.
15.4.9 At least one of the pressure indicators provided shall be capable of indicating throughout the operating pressure range.
15.4.10 For submerged fuel-pump motors and their supply cables, arrangements shall be made to alarm in low-liquid level and automatically shut down the motors in the event of low-liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low-liquid level. This shutdown shall give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.
15.4.11 Except for independent tanks of type C supplied with vacuum insulation system and pressure build-up fuel discharge unit, each fuel tank shall be provided with devices to measure and indicate the temperature of the fuel in at least three locations; at the bottom and middle of the tank as well as the top of the tank below the highest allowable liquid level.

Section 15.5 establishes the requirements for LNG bunkering control from the ship side.

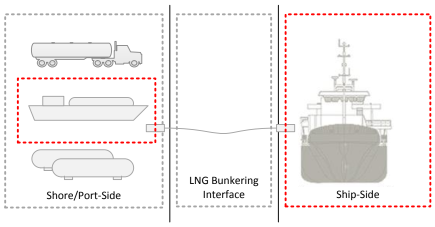
15.5 Regulations for bunkering control

15.5.1 Control of the bunkering shall be possible from a safe location remote from the bunkering station. At this location the tank pressure, tank temperature if required by 15.4.11 and tank level shall be monitored. Remotely controlled valves required by 8.5.3 and 11.5.7 shall be capable of being operated from this location. Overfill alarm

and automatic shutdown shall also be indicated at this location.
15.5.2 If the ventilation in the ducting enclosing the bunkering lines stops, an audible and visual alarm shall be provided at the bunkering control location, see also 15.8.
15.5.3 If gas is detected in the ducting around the bunkering lines an audible and visual alarm and emergency shutdown shall be provided at the bunkering control location.

The above transcriptions define the expected safeguards for the LNG bunkering interface of the receiving ship (i.e. ship-side). Similar safeguards should be expected for the LNG bunkering supply (e.g. from LNG trucks/trailers, rigid arms and LNG bunker vessels). Although the bunkering supply may be subjected to different regulatory frameworks it is a vital safety aspect because the IGF Code only addresses the receiving ship).

SOLAS
International Convention for the Safety of Life at Sea (SOLAS)
(as amended by Resolution MSC.392(95)))

Organization	
IMO	
For more info	
http://www.imo.org/en/Publications	
Applicable to	
Applies to seagoing ships, engaged in international voyages.	

The SOLAS convention is an international maritime safety treaty. It is generally regarded as the most important of all international treaties concerning safety of (merchant) ships. SOLAS requires Flag States to ensure that their ships comply with minimum safety standards in construction, equipment and operation.
The IGF Code is mandatory through amendment to SOLAS, in new Regulation 57, introduced through Resolution MSC.392 (95).
A new Part G is introduced in SOLAS Chapter II-2:

Regulation 56 – Application

1 Except as provided for in paragraphs 4 and 5, this part shall apply to ships using low-flashpoint fuels:

.1 for which the building contract is placed on or after 1 January 2017;

.2 in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 July 2017; or

.3 the delivery of which is on or after 1 January 2021.

Such ships using low-flashpoint fuels shall comply with the requirements of this part in addition to any other applicable requirements of the present regulations.

2 Except as provided for in paragraphs 4 and 5, a ship, irrespective of the date of construction, including one constructed before 1 January 2009, which converts to using low-flashpoint fuels on or after 1 January 2017 shall be treated as a ship using low-flashpoint fuels on the date on which such conversion commenced.

3 Except as provided for in paragraphs 4 and 5, a ship using low-flashpoint fuels, irrespective of the date of construction, including one constructed before 1 January 2009, which, on or after 1 January 2017, undertakes to use low-flashpoint fuels different from those which it was originally approved to use before 1 January 2017 shall be treated as a ship using low-flashpoint fuels on the date on which such undertaking commenced.

4 This part shall not apply to gas carriers, as defined in regulation VII/11.2:

.1 using their cargoes as fuel and complying with the requirements of the IGC Code, as defined in regulation VII/11.1; or

.2 using other low-flashpoint gaseous fuels provided that the fuel storage and distribution systems design and arrangements for such gaseous fuels comply with the requirements of the IGC Code for gas as a cargo.

5 This part shall not apply to ships owned or operated by a Contracting Government and used, for the time being, only in Government non-commercial service. However, ships owned or operated by a Contracting Government and used, for the time being, only in Government non-commercial service are encouraged to act in a manner consistent, so far as reasonable and practicable, with this part.

Regulation 57 – Requirements for ships using low-flashpoint fuels

Except as provided in regulations 56.4 and 56.5, ships using low-flashpoint fuels shall comply with the requirements of the IGF Code."

GENERAL GOVERNANCE RISK & SAFETY ORGANIZATION BUNKERING EMERGENCY CERTIFICATION

MARPOL
International Convention for the Prevention of Pollution from Ships
(focus on MARPOL Annex VI)

Organization

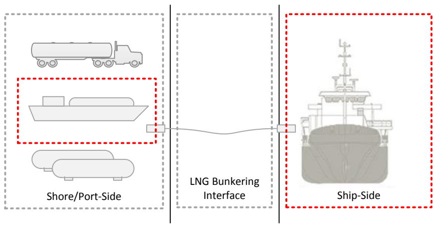
IMO

For more info

http://www.imo.org/en/Publications

Applicable to

All ships.



The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL Annex VI is the main international treaty addressing air pollution prevention requirements from ships.
As previously mentioned, MARPOL Annex VI is here presented as a relevant reference in the context of LNG as fuel. With the provisions of Regulation 13 and 14, with limitations to the emissions of NOx and SOx from ships, LNG represents an alternative fuel that allows ships to operate with significantly lower pollutant emissions (95 to 100% reduction in SOx emissions and up to 90% reduction in NOx, depending on engine technology). With the decision, at MEPC70, to reduce global sulphur cap to 0.50%, by 2020 (see figure 3.5, to the right, following the outcome of a Fuel Availability Study commissioned by IMO) the urgency for compliance is further underlined.
Finally, another relevant regulation from MARPOL Annex VI: Regulation 4 – Equivalents. Through Regulation 4.1 an *Administration of a Party may allow any fitting, material, appliance or apparatus to be fitted in a ship or other procedures, alternative fuel oils, or compliance methods used as an alternative to that required* by Annex VI *if such fitting, material, appliance or apparatus or other procedures, alternative fuel oils, or compliance methods are at least as effective in terms of emissions reductions as that required by this Annex, including any of the standards set forth in regulations 13 and 14.* LNG as fuel comes, in the context of Regulation 4, as an Equivalent.

In allowing LNG as fuel as an equivalent, following Regulatio 4.2, the *Administration of a Party which allows a fitting, material, appliance or apparatus or other procedures, alternative fuel oils, or compliance methods used as an alternative to that required by this Annex shall communicate to the Organization for circulation to the Parties particulars thereof, for their information and appropriate action, if any*.
Regulation 4 further determines that *any relevant guidelines developed by the Organization pertaining to the equivalents provided for in this regulation* should be taken into account by different Administrations who, further by Regulation 4.4, whilst allowing the use of an Equivalent, *shall endeavour not to impair or damage its environment, human health, property, or resources or those of other States*.

STCW Convention and Code
International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
Seafarers' Training, Certification And Watchkeeping (STCW) Code
(following amendments introduced by Resolution MSC.396(95) and MSC.397(95) (adopted on 11 June 2015)

Organization

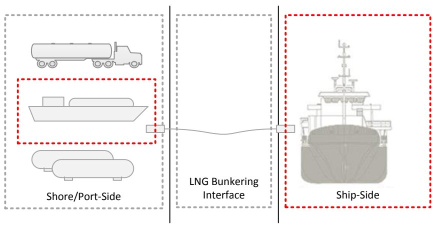
IMO

For more info

http://www.imo.org/en/Publications

Applicable to

Training, certification and Watchkeeping for seafarers on an international level



Following adoption of the IGF Code, the STCW Convention and Code were consequently amended, with the revised version having entered into force also on 1JAN2017.

The STCW Convention was amended through Resolution MSC.396(95) - (adopted on 11 June 2015), which introduced a new regulation into the existing Chapter V:

Regulation V/3

Mandatory minimum requirements for the training and qualifications of masters, officers, ratings and other personnel on ships subject to the IGF Code

1 This regulation applies to masters, officers and ratings and other personnel serving on board ships subject to the IGF Code.

2 Prior to being assigned shipboard duties on board ships subject to the IGF Code, seafarers shall have completed the training required by paragraphs 4 to 9 below in accordance with their capacity, duties and responsibilities.

3 All seafarers serving on board ships subject to the IGF Code shall, prior to being assigned shipboard duties, receive appropriate ship and equipment specific familiarization as specified in regulation I/14, paragraph 1.5.

4 Seafarers responsible for designated safety duties associated with the care, use or in emergency response to the fuel on board ships subject to the IGF Code shall hold a certificate in basic training for service on ships subject to the IGF Code.

5 Every candidate for a certificate in basic training for service on ships subject to the IGF Code shall have completed basic training in accordance with provisions of section A-V/3, paragraph 1 of the STCW Code.

6 Seafarers responsible for designated safety duties associated with the care, use or in emergency response to the fuel on board ships subject to the IGF Code who have been qualified and certified according to regulation V/1-2, paragraphs 2 and 5, or regulation V/1-2, paragraphs 4 and 5 on liquefied gas tankers, are to be considered as having met the requirements specified in section A-V/3, paragraph 1 for basic training for service on ships subject to the IGF Code.

7 Masters, engineer officers and all personnel with immediate responsibility for the care and use of fuels and fuel systems on ships subject to the IGF Code shall hold a certificate in advanced training for service on ships subject to the IGF Code.

8 Every candidate for a certificate in advanced training for service on ships subject to the IGF Code shall, while holding the Certificate of Proficiency described in paragraph 4, have:

> ***.1 completed approved advanced training for service on ships subject to the IGF Code and meet the standard of competence as specified in section A-V/3, paragraph 2 of the STCW Code; and***
>
> ***.2 completed at least one month of approved seagoing service that includes a minimum of three bunkering operations on board ships subject to the IGF Code. Two of the three bunkering operations may be replaced by approved simulator training on bunkering operations as part of the training in paragraph 8.1 above.***

9 Masters, engineer officers and any person with immediate responsibility for the care and use of fuels on ships subject to the IGF Code who have been qualified and certified according to the standards of competence specified in section A–V/1-2, paragraph 2 for service on liquefied gas tankers are to be considered as having met the requirements specified in section A-V/3, paragraph 2 for advanced training for ships subject to the IGF Code, provided they have also:

> ***.1 met the requirements of paragraph 6; and***
>
> ***.2 met the bunkering requirements of paragraph 8.2 or have participated in conducting three cargo operations on board the liquefied gas tanker; and***
>
> ***.3 have completed sea going service of three months in the previous five years on board:***
>
> > ***.1 ships subject to the IGF Code;***
> >
> > ***.2 tankers carrying as cargo, fuels covered by the IGF Code; or***
> >
> > ***.3 ships using gases or low flashpoint fuel as fuel.***

10 Every Party shall compare the standards of competence which it required of persons serving on gas-fuelled ships before 1 January 2017 with the standards of competence in Section A-V/3 of the STCW Code, and shall determine the need, if any, for requiring these personnel to update their qualifications.

11 Administrations shall ensure that a Certificate of Proficiency is issued to seafarers, who are qualified in accordance with paragraphs 4 or 7, as appropriate.

12 Seafarers holding Certificates of Proficiency in accordance with paragraph 4 or 7 above shall, at intervals not exceeding five years, undertake appropriate refresher training or be required to provide evidence of having achieved the required standard of competence within the previous five years."

The STCW Code was amended through Resolution MSC.397 (95) - (adopted on 11 June 2015), essentially to assist in the technical details for Regulation V/3 of the Convention. The Basic and Advanced Courses are outlined and a reference to possible exemptions is indicated. Table 4.7, in the next page, lists the basics requirements from the amendments brought into force by the STCW Code:

Table 4.7 – STCW requirements for IGF Code crew

STCW Code, Section A-V/3, As amended by MSC.397 (95) (adopted on 11 June 2015)	**Applicability in LNG Bunkering**
Basic training for ships subject to the IGF Code	*1 Every candidate for a certificate in basic training for service on ships subject to the IGF Code shall:* *.1.1 have successfully completed the approved basic training required by regulation V/3, paragraph 5, in accordance with their capacity, duties and responsibilities as set out in table A-V/3-1; and* *.1.2 be required to provide evidence that the required standard of competence has been achieved in accordance with the methods and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/3-1; or* *.2 have received appropriate training and certification according to the requirements for service on liquefied gas tankers as set out in regulation V/3, paragraph 6.*
Advanced training for ships subject to the IGF Code	*2 Every candidate for a certificate in advanced training for service on ships subject to the IGF Code shall:* *.1.1 have successfully completed the approved advanced training required by regulation V/3, paragraph 8 in accordance with their capacity, duties and responsibilities as set out in table A-V/3-2; and* *.1.2 provide evidence that the required standard of competence has been achieved in accordance with the methods and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/3-2; or* *.2 have received appropriate training and certification according to the requirements for service on liquefied gas tankers as set out in regulation V/3, paragraph 9.*
Exemptions	*3 The Administration may, in respect of ships of less than 500 gross tonnage, except for passenger ships, if it considers that a ship's size and the length or character of its voyage are such as to render the application of the full requirements of this section unreasonable or impracticable, exempt the seafarers on such a ship or class of ships from some of the requirements, bearing in mind the safety of people on board, the ship and property and the protection of the marine environment.*

The STCW contains requirements in Section A/V3 tables A-V/3-1 and A-V/3-2 for a minimum standard of competence in basic and advanced training, respectively, for ships subject to the IGF Code. These tables can be considered highly relevant in setting the wider structure of competencies that should also be considered for the LNG bunkering interface. Even though this will be subject for Section 16, figure 4.17, in the next page highlights the relevance of addressing the necessary harmonization of competencies in the context of LNG bunkering.

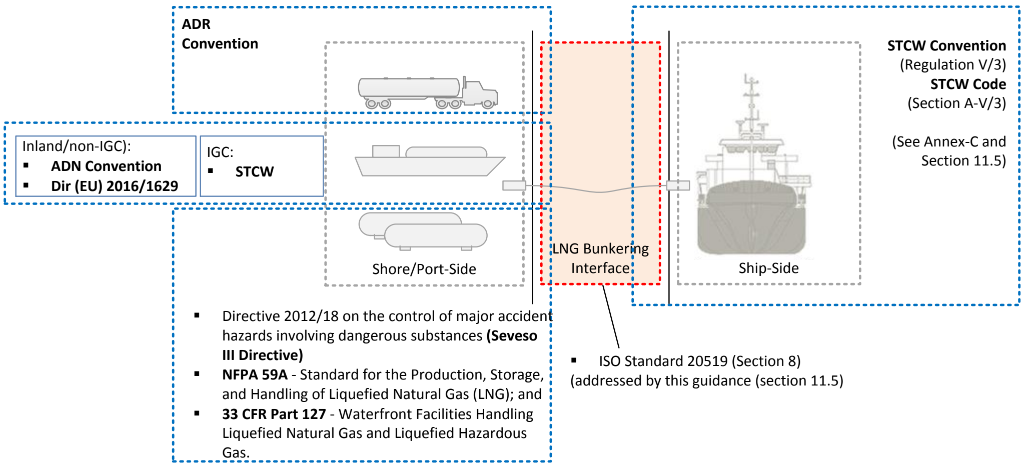


Figure 4.17 - Applicable references in Competencies and Training requirements – complexity of the LNG Bunkering interface

EN ISO 20519 highlights, in Section 8, that all crew members should be trained in the particular aspects of the Standard, as far as LNG bunkering procedures are concerned.

4.3 Standards

Standards are fundamental to make the bridge between high level instruments, such as the ones presented in the previous section, and the operational, or technical, implementation of their provisions. The present section makes only reference to international standards developed and published by international standardization bodies (ISO, CEN and IEC). Other relevant references, supporting standardization in best practices, in particular the ones developed and commonly accepted by industry associations are included in Section 4.5.

The importance of international standards in LNG bunkering, working together with global reaching regulations, is directly related to the promotion of safety and confidence in the development of LNG as fuel for shipping. By setting out requirements for specific items, material, components, systems or equipment, or describing in detail a particular method or procedure, international standards facilitate international trade by ensuring compatibility and interoperability of components, products and services. They bring benefits to operators and authorities in terms of reducing costs, enhancing performance and improving safety.

Standards are developed and defined through a process of sharing knowledge and building consensus among technical experts nominated by interested parties and other stakeholders - including businesses, consumers and environmental groups, among others.

The formal definition of a standard is a “document, established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context”.

There are several different types of standards. Basically, standards include requirements and/or recommendations in relation to products, systems, processes or services. Standards can also be a way to describe a measurement or test method or to establish a common terminology within a specific sector.

European Norms (ENs) are documents that have been ratified by one of the three European Standardization Organizations (ESOs), CEN, CENELEC or ETSI; recognized as competent in the area of voluntary technical standardization in line with EU Regulation 1025/2012.

An EN (European Standard) “carries with it the obligation to be implemented at national level by being given the status of a national standard and by withdrawal of any conflicting national standard". Therefore, a European Standard (EN) automatically becomes a national standard in each of the 34 CEN-CENELEC member countries.

Standards are voluntary which means that there is no automatic legal obligation to apply them. However, laws and regulations may refer to standards and even make compliance with them compulsory.

The International Standardization Organization (ISO), through its TC67 and TC8 sub-committees, on materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries and Ships and Marine Technology, respectively, have been responsible for a large part of the LNG related standards that have been published, with relevance to LNG as fuel, small scale developments and bunkering. CEN, the European equivalent to ISO, has developed and published in parallel important standards for LNG equipment and safety. These are referred as EN/ISO standards.

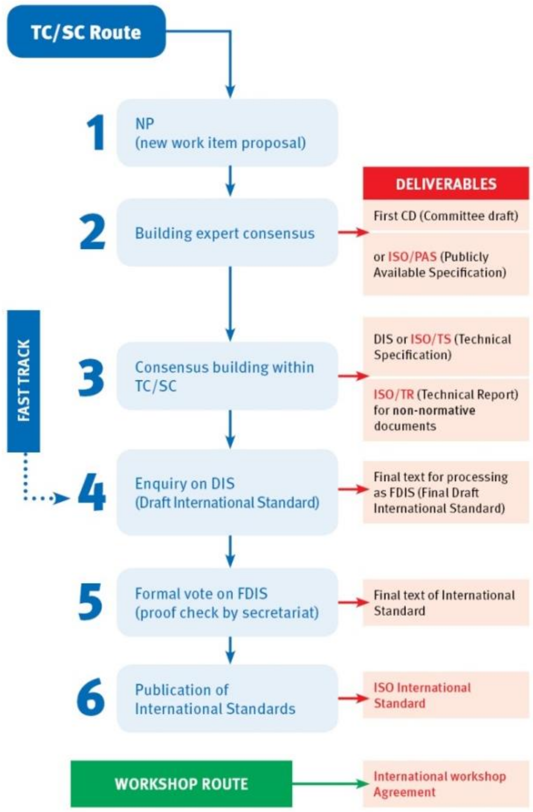


Figure 4.7 – Development of ISO instruments – Technical Standards and International Standards – The diagram allows to see that the International Standard, following the TC/SC Route, comes as a natural continuation, following the TC/SC route

TC67 has developed ISO/TS 18683, Guidelines for systems and installations for supply of LNG as fuel to ships, whilst TC8 has recently finalized EN ISO 20519.

Table 4.8, below, lists the standards applicable to LNG as fuel, bunkering, and small scale LNG installations, considered relevant to equipment, safety and procedures in the context of LNG bunkering.

Table 4.8 – International Standards on LNG as fuel (ISO, IEC, CEN)

Title	Responsible	Type	Scope
EN STANDARDS			
EN 1160 General characteristics of liquefied natural gas	CEN	European Norm	(replaced by EN ISO 16904)
EN 1473:2017 – Installation and equipment for liquefied natural gas – Design of onshore installations	CEN	European Norm	Design onshore LNG installations with LNG storage >200t For large storage facilities, EN 1473 is the prevailing standard. This standard is based on a risk assessment approach. According to the scope this standard covers all kinds of LNG storage but is limited to atmospheric storage tanks. The standard is valid for LNG storage above 200t. Pressurized intermediate storage tanks are excluded from this standard, as well as satellite plants with a storage capacity of less than 200t, which are covered by EN 13645. Standard valid for plants with LNG storage at pressure lower than 0.5 bar and capacity above 200t <u>and for the following plant types</u>: • LNG liquefaction installations (plant); • LNG regasification installations (plant); • Peak-shaving plants; • <u>**The fixed part of an LNG bunker station**</u>.
EN 1474-1 - Design and testing of marine transfer systems. Design and testing of transfer arms	CEN	European Norm	(replaced by EN ISO 16904)
EN 1474-2 - Design and testing of marine transfer systems. Design and testing of transfer hoses	CEN	European Norm	Installation and equipment for liquefied natural gas. Design and testing of marine transfer systems. Design, minimum safety requirements and inspection and

Title	Responsible	Type	Scope
EN 1474-3 - Design and testing of marine transfer systems. Offshore transfer systems			testing procedures. Loading and unloading devices, Liquefied natural gas, Natural gas, Petroleum products, Loading (materials handling), Tankers, Ships, Design, Safety measures, Risk assessment, Equipment safety, Safety devices, Alarm systems, Control systems, Inspection, Performance testing
EN 12065 - Testing of foam concentrates of extinguishing powders used on LNG fires	CEN	European Norm	Installations and equipment for liquefied natural gas. Testing of foam concentrates designed for generation of medium and high expansion foam and of extinguishing powders used on liquefied natural gas fires. Flame retardants, Foams, Particulate materials, Concentrates, Fire retardants, Test equipment, Expansion (deformation), Testing conditions, Efficiency, Reports, Fire tests, Compatibility, Performance testing, Fire extinguishers
EN 12066 - Testing of insulating linings for liquefied natural gas impounding areas	CEN	European Norm	Thermal insulation, Linings (containers), Test specimens, Test equipment, Dimensions, Thickness, Evaporation, Water-absorption tests, Mathematical calculations
EN 12308 - Suitability testing of gaskets designed for flanged joints used on LNG piping	CEN	European Norm	Installations and equipment for LNG. Suitability testing of gaskets designed for flanged joints used on LNG piping Gas storage, Thermal insulation, Linings (containers), Test specimens, Test equipment, Dimensions, Thickness, Evaporation, Water-absorption tests, Mathematical calculations
EN 12838 - Suitability testing of LNG sampling systems	CEN	European Norm	Installations and equipment for liquefied natural gas. Suitability testing of LNG sampling systems. Sampling equipment, Sampling methods, Gas analysis, Gas chromatography, Pressure testing, Flow measurement, Thermal testing, Test equipment, Performance testing, Capability approval, Physical properties of materials, Accuracy, Classification systems, Measuring instruments, Measurement characteristics, Mathematical calculations, Control samples, Statistical methods of analysis
EN13463-1 - Non electric equipment for use in potentially explosive atmospheres	CEN	European Norm	Standard with requirements for non-electrical equipment for use or located in potentially explosive atmospheres.
EN 13645 – Installation and equipment for liquefied natural gas – Design of onshore installations 5 t and 200 t	CEN	European Norm	Design onshore LNG installations with LNG storage capacity 5t-200t It complements EN 1473, covering smaller scale storage LNG installations. This standard only deals with pressurized vessels (above 0.5 barg)
EN 13766:2010 – Thermoplastic multi-layer (non-vulcanized) hoses and hose assemblies for the transfer of liquid petroleum gas and liquefied natural gas – Specification	CEN	European Norm	Requirements for two types of thermoplastic multi-layer (non-vulcanized) transfer hoses and hose assemblies for carrying liquefied petroleum gas and liquefied natural gas.

Title	Responsible	Type	Scope
EN14620:2006 – Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and -165°C	CEN	European Norm	This European Standard is a specification for vertical, cylindrical tanks, built on site, above ground and of which the primary liquid container is made of steel. The secondary container, if applicable, may be of steel or of concrete or a combination of both. The maximum design pressure of the tanks covered by this European Standard is limited to 500 mbar.
ISO STANDARDS			
ISO/DTS 16901 - Guidance on performing risk assessment in the design of onshore LNG installations including the Ship/Shore interface	ISO	ISO Technical Specification	Risk assessment for LNG facilities onshore and at shoreline (export & import terminals)
EN ISO 16903 - Characteristics of LNG, influencing the design, and material selection	ISO	International Standard	Guidance on the characteristics of liquefied natural gas (LNG) and the cryogenic materials used in the LNG industry. It also gives guidance on health and safety matters. It is intended to act as a reference document for the implementation of other standards in the liquefied natural gas field. It is intended as a reference for use by persons who design or operate LNG facilities
EN ISO 16904 - Design and testing of LNG marine transfer arms for conventional onshore terminals	ISO	International Standard	Specifies the design, minimum safety requirements and inspection and testing procedures for liquefied natural gas (LNG) marine transfer arms intended for use on conventional onshore LNG terminals, handling LNG carriers engaged in international trade. It can provide guidance for offshore and coastal operations. It also covers the minimum requirements for safe LNG transfer between ship and shore. Although the requirements for power/control systems are covered, this International Standard does not include all the details for the design and fabrication of standard parts and fittings associated with transfer arms. ISO 16904:2016 is supplementary to local or national standards and regulations and is additional to the requirements of ISO 28460.
ISO/AWI TR 18624 – Guidance for conception, design and testing of LNG storage tanks	ISO	International Standard	This guideline is under development by the ISO/ TC67, but is still in preparatory stage. More specific information about the content is not yet available at the time of writing.

Title	Responsible	Type	Scope
ISO/TS 18683 - Guidelines for systems and installations for supply of LNG as fuel to ships	ISO	ISO Technical Specification	ISO/TS 18683:2015 gives guidance on the minimum requirements for the design and operation of the LNG bunkering facility, including the interface between the LNG supply facilities and receiving ship as shown in Figure 1. ISO/TS 18683:2015 provides requirements and recommendations for operator and crew competency training, for the roles and responsibilities of the ship crew and bunkering personnel during LNG bunkering operations, and the functional requirements for equipment necessary to ensure safe LNG bunkering operations of LNG fuelled ships. It covers LNG bunkering from shore or ship LNG supply facilities, as shown in Figure 1 and described in Clause 4, and addresses all operations required such as inerting, gassing up, cooling down, and loading. <u>Aspects covered by ISO/TS 18683 that are not in EN ISO 20519</u>: - Risk assessment for SIMOPS - Risk Criteria
EN ISO 20088-1 - Determination of the resistance to cryogenic spillage of insulation materials — Part 1: Liquid phase	ISO	International Standard	Describes a method for determining the resistance to liquid cryogenic spillage on cryogenic spillage protection (CSP) systems. It is applicable where CSP systems are installed on carbon steel and will be in contact with cryogenic fluids. Liquid nitrogen is used as the cryogenic medium since it has a lower boiling point than liquid natural gas or liquid oxygen and it is not flammable. Additionally, it can be safely used for experiment. Future parts of the standard will cover vapour phase and jet exposure conditions. The test laboratory is responsible to conduct an appropriate risk assessment according to local regulation in order to consider the impact of liquid and gaseous nitrogen exposure to equipment and personnel.
EN ISO 20519 - Specification for bunkering of liquefied natural gas fuelled vessels	ISO	International Standard	Requirements for LNG bunkering transfer systems and equipment used to bunker LNG fuelled vessels, including equipment, operational procedures, training and qualifications of personnel involved. ISO 20519:2017 sets requirements for LNG bunkering transfer systems and equipment used to bunker LNG fuelled vessels, which are not covered by the IGC Code. This document includes the following five elements: a) hardware: liquid and vapour transfer systems; b) operational procedures; c) requirement for the LNG provider to provide an LNG bunker delivery note; d) training and qualifications of personnel involved; e) requirements for LNG facilities to meet applicable ISO standards and local codes.

Title	Responsible	Type	Scope
ISO/TS 17177 - Guidelines for the marine interfaces of hybrid LNG terminals	ISO	International Standard	ISO/TR 17177:2015 provides guidance for installations, equipment and operation at the ship to terminal and ship to ship interface for hybrid floating and fixed LNG terminals that might not comply with the description of "Conventional LNG Terminal" included in ISO 28460. It is intended to be read in conjunction with ISO 28460 to ensure the safe and efficient LNG transfer operation at these marine facilities. This standard also addresses high pressure natural gas (HPNG) at the transfer interface at facilities where liquefaction or regasification is undertaken, but does not describe requirements for the process plant generally forming part of the terminal facility. These guidelines are based around facilities that are currently in operation or under development.
ISO 28460 – Standard for installation and equipment for LNG – Ship to shore interface and port operations	ISO	International Standard	Onshore LNG terminals and LNG carriers. ISO 28460:2010 specifies the requirements for ship, terminal and port service providers to ensure the safe transit of an LNG carrier through the port area and the safe and efficient transfer of its cargo
ISO 10976:2015 - Refrigerated light hydrocarbon fluids -- Measurement of cargoes on board LNG carriers	ISO	International Standard	Describes the steps needed to properly measure and account for the quantities of cargoes on liquefied natural gas (LNG) carriers. This includes, but is not limited to, the measurement of liquid volume, vapour volume, temperature and pressure, and accounting for the total quantity of the cargo on board. This International Standard describes the use of common measurement systems used on board LNG carriers, the aim of which is to improve the general knowledge and processes in the measurement of LNG for all parties concerned. This International Standard provides general requirements for those involved in the LNG trade on ships and onshore.
ISO 15970:2008 - Natural gas -- Measurement of properties -- Volumetric properties: density, pressure, temperature and compression factor	ISO	International Standard	ISO 15970:2008 gives requirements and procedures for the measurement of the properties of natural gas that are used mainly for volume calculation and volume conversion: density at reference and at operating conditions, pressure, temperature and compression factor. Only those methods and instruments are considered that are suitable for field operation under the conditions of natural gas transmission and distribution, installed either in-line or on-line, and that do not involve the determination of the gas composition. ISO 15970:2008 gives examples for currently used instruments that are available commercially and of interest to the natural gas industry.
ISO 18132-1:2011 - Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels -- General requirements for automatic tank gauges -- Part 1: Automatic tank gauges for liquefied natural gas on board marine carriers and floating storage	ISO	International Standard	ISO 18132-1:2011 establishes general principles for the accuracy, installation, calibration and verification of automatic tank gauges (ATGs) used for custody transfer measurement of liquefied natural gas (LNG) on board an LNG carrier or floating storage. The LNG described in ISO 18132-1:2011 is either fully refrigerated (i.e. at the cryogenic condition), or partially refrigerated, and therefore the fluid is at or near atmospheric pressure.

Title	Responsible	Type	Scope
ISO 23251:2006 - Petroleum, petrochemical and natural gas industries -- Pressure-relieving and depressuring systems	ISO	International Standard	ISO 23251:2006 is applicable to pressure-relieving and vapour-depressuring systems. Although intended for use primarily in oil refineries, it is also applicable to petrochemical facilities, gas plants, liquefied natural gas (LNG) facilities and oil and gas production facilities. The information provided is designed to aid in the selection of the system that is most appropriate for the risks and circumstances involved in various installations.
ISO 31000:2009, Risk management – Principles and guidelines	ISO	International Standard	ISO 31000:2009, *Risk management – Principles and guidelines*, provides principles, framework and a process for managing risk. It can be used by any organization regardless of its size, activity or sector. ISO 31000 cannot be used for certification purposes, but does provide guidance for internal or external audit programmes.
ISO 17776:2016 - Petroleum and natural gas industries -- Offshore production installations -- Major accident hazard management during the design of new installations	ISO	International Standard	ISO 17776:2016 describes processes for managing major accident (MA) hazards during the design of offshore oil and gas production installations. It provides requirements and guidance on the development of strategies both to prevent the occurrence of MAs and to limit the possible consequences. It also contains some requirements and guidance on managing MA hazards in operation.
ISO/IEC Guide 73 Risk Management – Vocabulary	ISO/IEC	International Standard	ISO Guide 73:2009 provides the definitions of generic terms related to risk management. It aims to encourage a mutual and consistent understanding of, and a coherent approach to, the description of activities relating to the management of risk, and the use of uniform risk management terminology in processes and frameworks dealing with the management of risk.
IEC 31010:2009, Risk management -- Risk assessment techniques	IEC/ISO	International Standard	IEC 31010:2009 is a dual logo IEC/ISO, single prefix IEC, and supporting standard for ISO 31000 and provides guidance on selection and application of systematic techniques for risk assessment. This standard is not intended for certification, regulatory or contractual use.
IEC STANDARDS			
IEC 60092-502 Electrical installations in ships –Tankers – Special features	IEC	International Standard	This part of IEC 60092 summarizes the present IMO electrical requirements giving in a single publication details of suitable measures regarding the explosion protection of electrical equipment, in particular for tankers.
IEC 60079-10-1:2015 - Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres	IEC	International Standard	Standard concerned with the classification of areas where flammable gas or vapour hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas. It is intended to be applied where there may be an ignition hazard due to the presence of flammable gas or vapour, mixed with air

Title	Responsible	Type	Scope
IEC 61508:2010 Functional safety of electrical/ electronic/programmable electronic safety-related systems – Parts 1 to 7	IEC	International Standard	IEC 61508 is the international standard for electrical, electronic and programmable electronic safety related systems. It sets out the requirements for ensuring that systems are designed, implemented, operated and maintained to provide the required safety integrity level (SIL).
CESNI STANDARDS			
CESNI Standard ES-TRIN 2015/1 - European standard laying down technical requirements for inland navigation vessels	CESNI	European Inland Navigation Standard	Contains provisions on inland navigation vessel construction, arrangement and equipment, special provisions for certain categories of vessel such as passenger vessels, pushed convoys and container vessels, as well as instructions on how to apply the technical standard. ES-TRIN also incorporates the new requirements governing the use of liquefied natural gas as a fuel (LNG). In order to ensure consistency of two existing legal regimes for technical requirements for inland navigation vessels (Rhine and EU) it is necessary to provide the same standards. Both EU law (Directive (EU) 2016/1629) and CCNR Regulation will be referring to ES-TRIN standards delivered by CESNI from 7 October 2018. In July 2017, the new edition 2017/1 of ES-TRIN was published. The CCNR and EU intend to enact ES-TRIN 2017/1 in a coordinated way, with effect from 07 October 2018, by means of a reference in their respective legislative frameworks.

Other relevant standards are under preparation[37]:

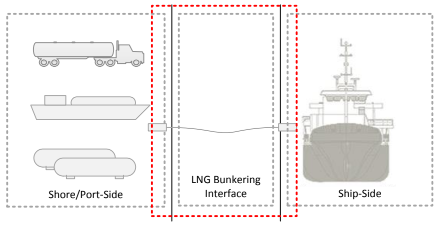
- LNG Bunker connectors – QC/DC (Marine LNG fuel bunkering quick connect/disconnect coupling), following the functional requirements outlined by ISO 20519, but taking the work up to the level of International Standard. NWIP ISO 21903.
- LNG metering - Guidance for the calibration, installation and use of flow meters for LNG and other refrigerated hydrocarbon fluids, under development as a new item proposal NWIP ISO 21903 accepted 28/09/2016
- LNG quality

From all the standards listed in the table 4.8, two particular documents are summarized below, accounting for their relevance in the context of LNG bunkering operations. They are ISO/TS 18683 and EN ISO 20519. Both standards are similar in scope and some parts of ISO/TS 18683 can even be found in the most recent standard EN ISO 20519. They both focus on the LNG bunkering interface, excluding the LNG supplier system/infrastructure, and the receiving ship, establishing the division line at the flanges from both sides (see figure 4.18, below)

It is relevant to mention, in the context of this Guidance, that given the normal course of ISO publications life-cycle, ISO/TS 18683 is likely to be repealed in the near future, leaving the necessary space for the International Standard (EN ISO 20519) as the reference specification for LNG bunkering.

[37] At the date of first release for the present Guidance Document: FEB2018

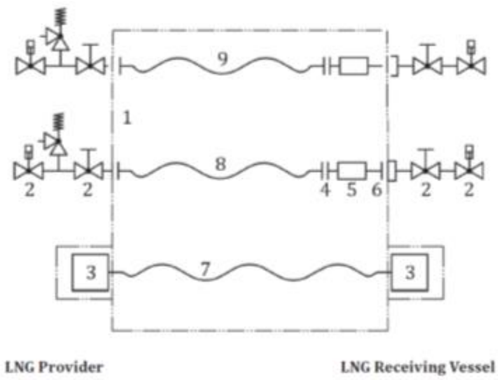
EN ISO 20519 - Specification for bunkering of liquefied natural gas fuelled vessels
(published 10-2-2017)

Organization	
ISO	
For more info	
http://www.iso.org/en/	
Applicable to	
LNG Bunkering interface, functional requirements, equipment, operation, training and qualification	

ISO 20519:2017 is the most recent standard of relevance to LNG bunkering, setting requirements for transfer systems and equipment used to bunker LNG fuelled vessels, which are not covered by the IGC Code. This document includes the following five elements:

a) hardware: liquid and vapour transfer systems;
b) operational procedures;
c) requirement for the LNG provider to provide an LNG bunker delivery note;
d) training and qualifications of personnel involved;
e) requirements for LNG facilities to meet applicable ISO standards and local codes

The scope of ISO 20519 is presented in figure 4.18, below.



1 Scope boundary
2 Automatic and manual ESD valve.
3 ESD junction box
4 Insulation flange
5 Emergency release coupling
6 QC/DC – Quick Connect/ Disconnect Coupling
7 Ship/shore or ship/ship ESD link
8 Loading system (systems include-: vessel to vessel transfer arms, articulated rigid piping)
9 Vapour return system

Figure 4.18 - Scope of EN ISO 20519

An important point to note in figure 4.18, above, is the inclusion of the vapour return as an important point covered by the functional requirements in EN ISO 20519. It is an important point to consider that during bunkering of LNG vapour management is fundamental. A part of the LNG delivered will evaporate due to the heat transfer in the bunkering line and fuel piping onboard, down to the receiving tank. To manage pressure build-up inside the tank, it is important to address the need to return vapour from that same tank during the bunkering process. Venting is not an operational option, and should only be considered in emergency.

The scope of both EN ISO 20519 and ISO/TS 18683 is important to understand how the regulatory frame should be composed to shape a consistent and coherent legal frame for LNG bunkering. Being strictly scoped to the LNG bunkering interface and operations, both standards exclude coverage of any mobile LNG bunkering units/transport or even of any elements related to the ship side. The challenge is to provide the best compatibility instrument between all involved parties and relevant elements.

A particular element where the scope may be extended, covering aspects related to other elements is the Risk Assessment. In fact, in regards to Safety evaluation the scope cannot be defined so rigidly and all the elements (truck, bunker barges, receiving ship, onsite storage, etc., need to be assessed as a whole, integrated in the same risk assessment, both from an hazard identification perspective and from risk evaluation.

The following parts are covered by EN ISO 20519:

Transfer system design requirements (Section 5)	LNG bunkering processes and procedures (Section 6)	Management System/ Quality Assurance (Section 7)

- **Bunker vessel requirements**
- **Receiving Vessel requirements**
- **Facility requirements**
- **Transfer equipment requirements** (list of standards applicable to the transfer system components)
- **ESD/ERS systems** (Emergency Release System, including requirement for Emergency Release Coupling, **ERC**). Outline of functional requirements for system components.
- **Specific Requirements for**
  - **System Support**
  - **Hoses, corrugated metallic or composite**
  - **Transfer Arms**
  - **Bunkering Connections**
  - **Insulation Flange**
  - **Fall arrest**
- **Transfer system design analysis**
- **Maintenance/Maintenance manual**
	- **Mooring**
	- **Communication in preparation for a transfer**
	  - **Information that the BSO shall provide to the RSO**, for each transfer and, specifically, for the first transfer.
	  - **Information that the RSO shall provide to the BSO**, for each transfer and, specifically, for the first transfer.
	- **Risk Assessment**
	  - **Conditions Considered** for the Risk Assessment
	  - **Methodology**
	  - **Acceptable bunkering parameters**
	- **Vessel Safety Assessment**
	- **Transfer Procedures,** including aspects related to the PICs, manifold and hose watch during transfer, references to CCTV, check-lists, PPE
		- **Management Systems** Conformance with EN ISO 20519, through management objective in one of the following accredited management systems:
		  - ISO 9001
		  - ISO 14001
		  - ISM
		  - ISO/TS 29001
		  - API Spec Q1
		- **Management systems for transfer equipment manufacturers**

Personnel training (Section 8)	Records and Documentation (Section 9)	Check-Lists (Annex A)

- **Vessel personnel training requirements**
  - Minimum requirements: STCW, IGC and IGF provisions as applicable.
- **Additional training requirements for personnel involved in bunkering operations on vessels** (additional to requirements in STCW, ADR, ADN)
  - For personnel with assigned duties to LNG bunkering:
    - **Onboard a vessel**
    - **Port**
- **Documentation of training**
	- **List of relevant records and documents that should be maintained for compliance with EN ISO 20519:**
	  - Transfer System analysis
	  - RSO vessel certification
	  - BSO vessel certification
	  - ISO 20519 compliance document for port facilites, vehicles, portable tanks.
	  - Listing of maintenance and inspection of selected equipment (all the equipment listed in the transfer system)
	  - Copies of all completed check-lists
	  - Training Records
	  - Copies of the Risk Assessment
	  - **LNG Bunker Procedures Manual**
	  - Bunkering parameters for the transfer system described, BFO and (to be kept by all parties adhering to EN ISO 20519)
		- **Minimum Check-list template included for:**
		  - Planned Operations Checks (to be filled within 48h in advance)
		  - Pre-Operational Checks (Pre-Bunkering check-list) – vessel-to-vessel
		  - LNG Transfer (Checks immediately before transfer of LNG) – tank-to-tank.
		  - SIMOPS
		  - Post-bunkering (vessel-to-vessel)
		
		Risk Assessment & Controlled Zones (Annex B)
		  - **Criteria and methodology for Control Zones definition** (same approach as ISO/TS 18683)

EN ISO 20519 is referred throughout this Guidance as the standard that should serve as a basis for certification, accreditation and quality assurance of all stakeholders. The EN notation is here essential to ensure that, at least in the EU, the standard is incorporated by all EU Member States as a national standard.

This standard represents an instrument of direct support to the IGF Code, providing the frame for implementation of IGF Section 18.4 provisions on bunkering operations.

As mentioned above, this International Standard shares some significant parts that were already known from ISO/TS 18683 (e.g. the parts on determination of safety zones, transfer system functional requirements, and requirements for training and documentation). It is important to note that these two ISO documents currently co-exist in the frame of LNG Bunkering. It is typical of the ISO development process for a Technical Specification to be developed as a first step towards an International Standard. In this regard, it has been suggested that the ISO/TS may be withdrawn at a later stage. For the purposes of this Guidance, the two instruments are considered valid and complementary. In the next page, ISO 18683 is summarized.

ISO/TS 18683 - Guidelines for systems and installations for supply of LNG as fuel to ships
(Technical Specification published 15-1-2015)

Organization

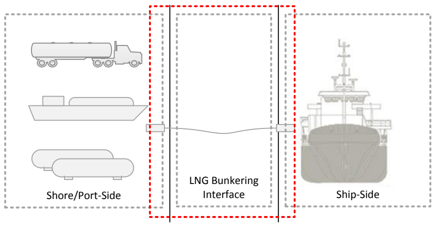
ISO

For more info

http://www.iso.org/en/

Applicable to

LNG Bunkering interface, functional requirements, risk assessment, equipment, operation, training and qualification.



ISO/TS 18683:2015 gives guidance on the minimum requirements for the design and operation of the LNG bunkering facility, including the interface between the LNG supply facilities and receiving ship. It provides requirements and recommendations for operator and crew competency training, for the roles and responsibilities of the ship crew and bunkering personnel during LNG bunkering operations, and the functional requirements for equipment necessary to ensure safe LNG bunkering operations of LNG fuelled ships. It covers LNG bunkering from shore or ship LNG supply facilities, and addresses all operations required such as inerting, gassing up, cooling down, and loading.

The objective of this Technical Specification is to provide guidance for the planning and design of the following and thereby ensuring that an LNG fuelled ship can refuel with a high level of safety, integrity, and reliability:

- bunkering facility;
- ship/bunkering facility interface;
- procedures for connection and disconnection;
- monitoring procedures during bunkering;
- emergency shutdown interface;
- LNG bunkering process control.

The LNG bunkering interface is for the first time scoped and defined in ISO/TS 18683, being defined as the area of LNG transfer and includes manifold, valves, safety and security systems and other equipment, and the personnel involved in the LNG bunkering operations.
The ISO/TS 18683:2015 thus defines the overall philosophies of designs and operations relevant to LNG bunkering and suggests a list of 24 functional requirements, whilst addressing safety by outlining 3 (three) layers of defence to ensure safe operations. The 3 layers of defence are defined as follows:

- PREVENT - The **1st LOD** is concerned with establishing requirements for operations, systems and components aiming at prevention of accidental releases that could develop into hazardous situations;
- CONTAIN - The **2nd LOD** is concerned with establishing requirements to contain and control hazardous situations in the case that a release occurs and thereby prevent/minimize the harmful effects;
- REACT - The **3rd LOD** is concerned with establishing emergency preparedness procedures and plans to minimize consequences and harmful effects in situations that are not contained by the 2nd LOD.

The structure of functional requirements, summarized in Annex C of ISO/TS 18683, and transcribed in table 3.9 below, defines the basic functions that need to be accomplished by any designed solution for LNG bunkering, both in terms of equipment and procedures.

Table 4.9: ISO/TS 18683:2015 Functional Requirements

Functional Requirement ISO/TS 18683	**Short description**	**Relevant Section in** ISO/TS 18683	**Relevant Section in** EN ISO 20519
F1	Compatibility check between supplier and ship	8.3	5.3, 5.4
F2	Can the system be commissioned and operated (purged and inerted) without release of LNG or natural gas to the atmosphere?	8.4, 9.2 (Table 1, Table 2)	5.5.4, 6.5.9
F3	Is the system closed and leak tested prior to bunkering?	8.4, 9.2 (Table 1, Table 2)	6.5.5
F4	Design should reflect operating temperature and pressure and be in accordance with recognized standards.	8.5.2, 9.2 (Table 1, Table 2), Annex G	5.3.2, 5.3.3,
F5	The design shall reflect the required operational envelope (motions, weather, visibility)	8.5.2, 9.2 (Table 1, Table 2)	5.6)k), 5.4, 5.7.1

Functional Requirement ISO/TS 18683	**Short description**	**Relevant Section in** ISO/TS 18683	**Relevant Section in** EN ISO 20519
F6	The transfer system shall be capable of being drained, de-pressurized and inerted before connections and disconnections are made.	8.5.2, 9.2 (Table 1, Table 2), Annex G	5.5.4, 5.6, 6.5.9,
F7	The bunkering transfer system shall be designed to avoid trapped liquid	8.5.2, 9.2 (Table 1, Table 2)	No reference
F8	Operating procedures shall be established and documented to define the bunkering process and to ensure that components and systems are operated in a safe way within their design parameters during all operational phases. For truck loading, the procedures will normally be defined for the truck operation but need to be aligned to specific ship requirements.	8.5.2, 9.2 (Table 1, Table 2)	Section 6 No specific reference to truck-to-ship operation 6.5.1
F9	All systems and components shall be maintained and tested according to, as a minimum, vendor recommendation to maintain their integrity	8.5.2, 9.2 (Table 1, Table 2)	5.8
F10	An organizational plan shall be prepared and implemented in operational plans and reflected in qualification requirements.	8.5.2, 9.2 (Table 1, Table 2)	6.5 Section 9 (LNG Bunkering Procedures Manual)
F11	Operating procedures shall include a checklist to be completed and signed by both parties prior to the commencement of bunkering (this may serve as a bunkering permit as required by authorities).	8.5.2, 9.2 (Table 1, Table 2)	6.5.3 6.5.7 6.5.8 6.5.11
F12	Emergency equipment and personnel shall be mobilized in accordance with the emergency response plan.	8.5.2, 9.2 (Table 1, Table 2)	6.5.1, Section 9 (LNG Bunkering Procedures Manual)
F13	Operating procedures shall not be applied as an alternative to a particular fitting, material, or item of equipment.	8.5.2, 9.2 (Table 1, Table 2)	No reference
F14	Minimize the likelihood of igniting potential LNG releases. This is accomplished by elimination of ignition sources in classified areas and by controlling activities in the proximity of the bunkering operation. No smoking signs.	8.5.3	Annex B – Controlled Zones
F15	Elimination of the potential spark or high currents from static or galvanic cells when the bunkering system is connected or disconnected.	8.5.3	5.5.6
F16	Effective detection of release of LNG and natural gas. Selection of sensors and sensors location should consider possible presence of mist and fog that might mask the leak. Manual detection may be accepted for continuously monitored short duration operations Manual detection in areas where water mist can occur shall not be accepted	8.5.3	6.5.2.2 6.5.2.3 Relevance is given to hose and manifold watch, including CCTV.
F17	The transfer operation shall be capable of being stopped safely and effectively without release of liquid or vapour, either manually or by an ESD signal	8.5.3, 9.2 (Table 1, Table 2)	5.4.1.1 5.4.1.2 5.4.2
F18	The transfer system shall be provided with an ERS (emergency release system) or breakaway coupling, to minimise damage to the transfer system in case of ships drift or vehicle movement. This should be designed for minimum release of LNG if activated. The ERS may be linked to the ESD system (where this may be referred to as ESD 2)	8.5.3, 9.2 (Table 1, Table 2)	5.4.1 5.4.1.1

Functional Requirement ISO/TS 18683	Short description	Relevant Section in ISO/TS 18683	Relevant Section in EN ISO 20519
F19	The release of LNG or cold vapour should not lead to an escalation due to brittle fractures of steel structure.	8.5.3	Reference in Part A Check-List – Annex A
F20	Personnel shall use PPE (personnel protective equipment) as appropriate for the operations	8.5.3	6.5.10
F21	A safety zone shall be implemented around the bunkering operation into which only essential personnel shall have access	8.5.3	Annex-B
F22	Activities in the area adjacent to the bunkering operation shall be controlled to reduce possible ignition sources.	8.5.3	6.3.5 Part B Check-list – Annex A
F23	Contingency plan shall be in place.	8.5.4	No exact reference. Section 9 (LNG Bunkering Procedures Manual)
F24	Copies of the plan shall be communicated to all parties involved in the bunkering operation including the planned emergency response team and be part of the training program. This should be practiced at regular intervals both as “table top” and practical exercises.	8.5.4	The plan can be scoped within the LNG Bunker Procedures Manual (part of Section 9)

As it can be seen in the table above, both ISO/TS 18683 and EN ISO 20519 share provisions that relate to the same functional requirements outlined in the first Technical Specification. There is however a difference that should be noted. ISO/TS 18683 is more a standard to assist in the design of the LNG Bunkering solution, whilst EN ISO 20519 is more focused on the operational aspects of LNG Bunkering. Functional requirements for equipment are addressed in both. The most significant difference between the two documents is the contents related to the safety philosophy and provisions on Risk Assessment that are in ISO/TS 18683, but not in EN ISO 20519. Whilst the first document, as a technical specification, list requirements for Risk Assessment, of a more prescriptive nature, the second outlines very briefly the objective for the Risk Assessment, listing the minimum conditions that should be observed and documented for that exercise. In actual terms EN ISO 20519 does not prescribe any methodology, nor does it explain which approach should be followed for the Risk Assessment. It leaves room, in this way, for Risk Assessments to be developed in strict response to requirements from specific national/local competent authorities[38]. On the other hand, ISO/TS 18683 requires risk assessments to be *agreement with recognized standards, such as ISO 31010, ISO 17776, and ISO 16901*[39], describing further both “qualitative” and “quantitative” risk assessment approaches, listing for each one the activities they should be comprised of, the study basis and the elements that should be present the different approaches.

The Risk Assessment approaches, as described in ISO/TS 18683, together with the concepts outlined for risk matrix and for possible risk criteria to adopt, provide examples that, together with ISO 31010, ISO 17776 and ISO 16901, can be considered as relevant references in the context of risk assessment of bunkering LNG as fuel for ships. Notwithstanding this, the matrix given in Annex A, Figure A-1 should deserve careful reflection before its use in the context of bunkering LNG as fuel for ships. Due to (1) little/insufficient experience of bunkering LNG as fuel for ships (let alone by a single operator); and (2) a poor categorisation suitable to the estimation of high-consequence, low-probability events (especially as there is little experience) it would be better to simply state that examples of risk criteria are given and their applicability needs to be agreed with stakeholders

Other industry best practice references, national safety legislation or others may also be relevant, especially with regards to the definition of the applicable risk criteria (Annex-A of ISO/TS 18683 provides only an example which is non-binding or compulsory, even if the standard is made mandatory through any legal reference). As regards LNG bunkering, this technical specification remain the reference for the main risk assessment concepts, not outlined as a standard but more as a technical frame that should be taken into account when preparing, conducting, reporting and evaluating risk studies that are required as support tools to the development of LNG bunkering solutions.

The above considerations, in the context of ISO/TS 18683, are relevant to underline that EN ISO 20519 should not be regarded as a replacement for this technical specification, or as its evolution. ISO/TS 18683 is still valid, especially with regards to the aspects related to Risk Assessment, with a very significant list of possible hazardous scenarios that need to be considered, with an outline of minimum requirements and methodologies explained. EN ISO 20519, on the same subject of risk assessment, takes the route of suggesting that the risk assessment methodology should be the one

[38] EN ISO 20519 paragraph 6.3.4 a) If the risk assessment is being performed to meet a requirement set by national or local authorities that have jurisdiction over the safety and security where the bunkering operation will take place, the assessment methodology used should conform to requirements set by the authorities

[39] ISO/TS 18683 section 7.1.

prescribed by the competent/local authority where the permitting is being sought from. This is also found to be highly relevant but leading to considerations on how prepared are competent authorities to prescribe actual methodologies or, even, in some cases, to have clearly defined risk criteria.

The following parts are covered by ISO/TS 18683:

Properties and behaviour of LNG (Section 5)

- Properties and behaviour of LNG
- Description and hazards of LNG
- Potential hazardous situations associated with LNG transfer
- Composition of LNG as a bunker fuel

Safety (Section 6)

- Objectives
- General Safety Principles
- Approach

Risk Assessment (Section 7)

- **Qualitative Risk Assessment**
  - Main steps
  - Study basis
  - HAZID
  - Determination of Safety Zones
  - Determination of Security Zones
  - Reporting
- **Quantitative Risk Assessment**
  - Main steps
  - Study basis
  - HAZID
  - QRA calculation
  - Frequency Analysis
  - QRA Report

Functional requirements for LNG bunkering system (Section 8)

- Design and operation basis
- Compatibility between supplier and ship
- Prevention of releases of LNG or natural gas to the atmosphere
- Safety
- Functional requirements to reduce risk of accidental release of LNG and natural gas
- Requirements to contain hazardous situations
- Emergency preparedness.

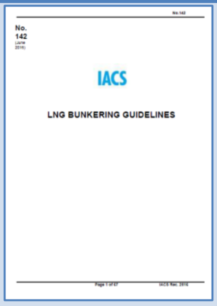
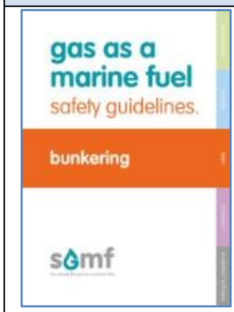
4.4 Guidelines

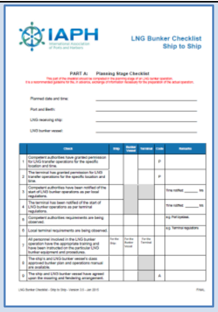
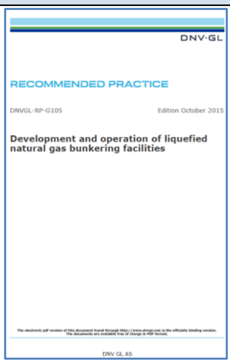
The present section provides an overview of available guidelines on LNG bunkering that have been the main support references in the development of LNG bunkering solutions. ISO/TS 18683 and EN ISO 20519 are included.

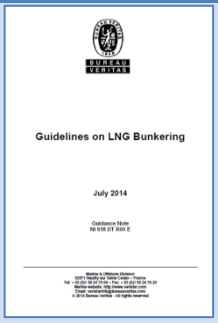
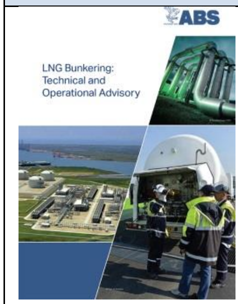
A summary of existing guidelines and best practice references is included in table 4.10 below, representing what are today the best industry-recognized references to assist LNG bunkering operations.

Table 4.10 - Guidelines on LNG Bunkering

Document		By	Available at	Short description
	**ISO/TS 18683:2015** Guidelines for systems and installations for supply of LNG as fuel to ships	ISO	http://www.iso.org/iso/ (available for purchase)	ISO Technical Specification including> • Functional Requirements specified for LNG bunkering equipment and operations. • Risk Assessment methods, requirements and risk acceptance criteria example • Functional design requirements. • Safety Distances calculation. (See section 3.3 for description on this ISO Technical Specification)
	**EN ISO 20519 -** Specification for bunkering of liquefied natural gas fuelled vessels	ISO	http://www.iso.org/iso/ (available for purchase)	EN ISO 20519 represents the most recent ISO development regarding LNG Bunkering, not intended to replace ISO/TS 18683. It actually shares some important parts with that previous instrument, remarkably the part on Controlled Zones. EN ISO 20519 includes • Transfer System Design – functional design requirements. • LNG Bunkering responsibilities and operational aspects, including LNG bunkering process definition. • Management system/Incorporation of EN ISO 20519 into other quality standard. • Minimum requirements for Risk Assessment. (See section 4.3 for description on this ISO International Standard)

Document		By	Available at	Short description
	**IACS Rec 142** LNG Bunkering Guidelines	IACS	http://www.iacs.org.uk/publications/recommendations/ (available for free)	This guideline provides recommendations for the responsibilities procedures and equipment required for LNG bunkering operations and sets harmonized minimum baseline recommendations for bunkering risk assessment, equipment and operations. IACS Rec.142 is, in practice, the result of a dedicated Working Group with experts from different Classification Societies, bringing together several references to existing guidelines/material into one document. This instrument is designed to complement the requirements from the existing applicable guidelines and regulations, such as port and terminal checklists, operator's procedures, industry guidelines and local regulations. This guide provides guidance to clarify the gaps that have been identified in the existing guidance and regulations. In particular, the following items are covered: • The responsibility of different parties involved in the LNG transfer, • The LNG bunkering process, • SIMOPs • Safety distances, • QRA and HAZID It has been today reflected integrally into the 2nd Version of the SGMF Bunkering Guidelines.
	**SGMF** **LNG Bunkering Guidelines** Safety Guidelines **Version 1** February 2015 **Version 2** April 2017	SGMF	www.sgmf.org (available for purchase)	The Society for Gas as a Marine Fuel (SGMF) launched the first version of the SGMF Guidelines in February 2015, representing an important milestone in the efforts by different industry stakeholders to lay down best practice guidance that could support the safe development of LNG Bunkering operations. SGMF Safety Guidelines for LNG bunkering include the following parts: • **LNG Hazards**, with an extensive description of potential hazards that have to be considered when addressing safety in LNG bunkering operations. • **Safety Systems**, with – Description of Organization for LNG bunkering and the roles and responsibilities of those involved in the preparation and execution of operations. – Communications – Hazardous Areas – Safety and Security Zones – Cryogenic Protection – Prevention of Ignition – Emergency Systems – Fire-fighting • **Bunkering Procedure,** addressing the different processes in LNG Bunkering, from Compatibility Assessment to Post-Bunkering disconnection. • **Situation specific guidance,** with considerations on the different types of LNG bunkering modes that are possible. Apart from the LNG bunkering specific aspects, the SGMF Guidelines are also important in compiling a good number of LNG equipment, procedural and technical aspects which are directly imported from good contribution and experience from the LNG

Document		By	Available at	Short description
				industry. A recent revision of the SGMF Safety Guidelines for LNG Bunkering took place in 2017, having incorporated the IACS Rec. 142 *LNG Bunkering Guidelines*. Other SGMF publications cover areas such as LNG Metering and Custody Transfer, with a separate set of Guidelines to assist in the more commercial side of LNG bunkering.
 IAPH LNG Bunker Checklist Ship to Ship PART A: Planning Stage Checklist	IAPH LNG Bunkering **Check-Lists** Check-lists for: Truck-to-Ship Ship-to-ship Port-to-Ship	IAPH	http://www.lngbunkering.org/lng/bunker-checklists (available for free)	IAPH's WPCI LNG working group has developed harmonized LNG bunker checklists for known LNG bunkering scenarios: **ship-to-ship, shore-to-ship and truck-to-ship**. These checklists reflect the extra requirements of ports with regard to LNG bunkering operations in or near their port environment. By using bunkering checklists, a high level of quality and responsibility of the LNG bunker operators can be ensured. Implemented harmonized bunker checklists will be of great benefit to the vessels bunkering LNG in different ports, as this will reduce the potential for confusion caused by having to comply with different rules and regulations in different ports. The IAPH check-lists are not guidelines themselves; nevertheless they are highly relevant references in establishing a quality structure, defining a procedural framework that can be used, with or without adaptations by all stakeholders involved in the LNG Bunkering process. In Annex-B of this Guidance the IAPH check-lists are included, adapted to include the relevant actions by the Port Authority when authorizing, overviewing or evaluating LNG bunkering operations.
 DNV·GL RECOMMENDED PRACTICE DNVGL-RP-G105 Edition October 2015 Development and operation of liquefied natural gas bunkering facilities DNV GL AS	DNV-GL **Recommended Practice G105** **DNVGL-RP-G105** Development and operation of liquefied natural gas bunkering facilities	DNV-GL	http://rules.dnvgl.com/docs/pdf/DNVGL/RP (available for free)	DNVGL-RP-G105 provides guidance to the industry on development, organizational, technical, functional and operational issues in order to ensure global compatibility and secure a high level of safety, integrity and reliability for LNG bunkering facilities, throughout all its life-cycle. The functional requirements provided in this RP are in line with, but elaborate on, ISO/TS 18683 *Guideline for systems and installations for supply of LNG as fuel to ships.* "LNG Bunkering Facilities" in the context of this document is the ship/facility interface where LNG bunkering is intended to take place or is taking place. The term may be used for any of the bunker scenarios terminal-to-ship, truck-to-ship or ship-to-ship. The **main topics covered by this RP** are as follows: • Development of LNG bunkering facilities • Risk assessments for LNG bunkering facilities • Safety management system (SMS) requirements • Operation of LNG bunkering facilities • Determination of the quantity and properties of the supplied LNG

Document		By	Available at	Short description
	Bureau Veritas' **guidelines on LNG bunkering** July 2014 Guidance Note NI 618 DT R00 E	Bureau Veritas	http://www.veristar.com/portal (available for free)	BV's Guidance on LNG Bunkering NI 618 provides recommendations on LNG bunkering, focusing on the framework to be established with port authorities and bunkering organizations before any commercial operation, conditions to be observed before, during and after each bunkering operation, management of emergency situations and the training of staff involved in bunkering operations. These guidelines aim to give ports, terminals, LNG suppliers and ship owners' confidence to proceed. The document is not about specifying the equipment (which is assumed to be done by the ISO), it is talking about managing the risks and getting the procedures and people part of this right. The BV guidelines do not cover design arrangements, specific operational limitations and safety distances; this is assumed to be addressed elsewhere. The BV guidelines are therefore more serving as an overview and guidance document rather than practical operational guidelines. Annex 2 of the document however provides guidelines for developing LNG bunkering procedures.
	ABS **LNG Bunkering Technical and Operational Advisory**	ABS	https://ww2.eagle.org/content/dam/eagle/publications (available for free)	This Advisory has been developed in order to respond to the need for better understanding by members of the maritime industry of the issues involved with bunkering vessels with natural gas. It is intended to provide guidance on the technical and operational challenges of LNG bunkering operations both from the bunker vessel's perspective (or land-side source) and from the receiving vessel's perspective. Some of the key areas that are addressed in this Advisory are critical design issues, methods of analysis, and current thinking on possible solutions to the requirements of regulations and safe practice, as well as important areas of operational process, training and safeguards. The following sections are included in the Advisory: General Information on LNG General Considerations for LNG Bunkering Key Characteristics of LNG and Tank Capacity for Bunkering Vessel Compatibility Operational Issues Aboard the Receiving Ship Special Equipment Requirements Aboard the Receiving Ship LNG Storage Tanks and Systems for Monitoring and Control of Stored LNG • Operational and Equipment Issues from the Supplier Side • Bunker Operations • Commercial Issues and Custody Transfer • Regulatory Framework • Safety and Risk Assessments • List of Guidance Documents and Suggested References

The table above includes a list of standards, guidelines and references containing requirements and best practices regarding equipment, safety, procedures and other aspects related to LNG bunkering. They are the best references today where industry experience has resulted in a comprehensive collection of provisions to support the safe development of LNG bunkering facilities and operations, providing the framework for efficient and safe bunkering. They put forward requirements with regard to safety management, operational procedures and minimum safeguards to prevent accidents and/or mitigate the consequences. A structured way to discuss the quality and the completeness of the LNG bunkering guidelines listed above has been used in the EU LNG Study, by DNV-GL, where the different categories of items are structured in a systematic approach[40].

The LNG bunkering guidelines presented in Table 4.10 are now compared to assist PAAs whenever referring to existing guidance/best practice documents. Where and how complete the information can be found is the objective of the analysis and comparative exercise.
Table 4.11, below, lists and details the categories and criteria used to compare the different instruments.

Table 4.11 – Categories for comparison of LNG Bunkering Guidelines

Comparison Category	Summary descriptor
Material Problems (MP)	This category is concerned with the potential hazards and the conditions that need to be maintained in order to safely store, handle and process the materials: LNG, nitrogen. This includes: • Flammability, Flash points • Potential for material instability • Static electrical charge build up and discharge (grounding/bonding) • Safe storage & transfer temperature & pressure • Exposure Limits - personal protective equipment requirements • Contamination from outside sources • Contamination through process connections • Mixing or settling hazards
External Effects or Influences (EE/I)	This category is intended to help identify the effect of outside forces or demand scenarios which might result in the development of some of the hazards identified during discussions of material problems (MP). Included might be natural phenomena, weather influences. Also to be considered are man-made random events such as arson, civil disturbances, or a nearby explosion which might in some way impact the operation
Operating Errors and Other Human Factors (OE&HF)	This category is related to every conceivable way to mis-execute the process as intended. It is important to remember that many operating errors are the result of inadequate training or poorly written or incomplete instructions
Analytical or Sampling Errors (A/SE)	This category is related to all potential analytical or sampling requirements or operations • Sampling procedure is unsafe • Significance of analysis results not well understood by operator • Test results are delayed • Test results are incorrect • In-line analytical device out of calibration • Sample point left open or leaking
Equipment/Instrumentation Malfunction (E/IM)	This category is related to all potential significant mechanical and instrumentation failures. It is crucial to note of protective devices and systems which must remain operative if the various mechanical and human demands are to be prevented from causing a hazard. Protective system proof testing schedules should also be reviewed.
Process Upsets of Unspecified Origin (PUUO)	This category is intended to be a "catch all" for additional demands. This category also should serve as a reminder that the materials and process conditions within a system or subsystem may be directly influenced by the conditions at the point of interface with other systems or subsystems
Utility Failures (UF)	This category is straightforward but care should be taken to note that external effects or influences (EE/I), analytical or sampling errors (A/SE), operating errors and other human factors (OE&HF) and electrical/instrumentation malfunction (E/IM) may directly cause a utility failure (UF) type hazard • Power fails • Instrument air fails • Inert fails • Communications system fails • Fire system fails
Integrity Failure or Loss of Containment (IF/LOC)	This category should draw heavily upon all the preceding categories. Additional care concerning the accuracy and detail of the logical interaction of previous errors and/or failures with each other should be considered. Integrity failure or loss of containment (IF/LOC)

[40] The approach used is the Structured What-If Checklist (SWIFT) technique (DNV-GL trademark)

The SWIFT study technique has been developed as an efficient technique for providing effective hazards identification. SWIFT is a systems-oriented technique which examines systems, subsystems or activities.

	hazards certainly can introduce some additional considerations such as normal and emergency venting. However, some combination of the demands and hazards previously identified will probably represent the major basis for those scenarios which could result. It should also be noted that tanks, lines, pumps and various other components need to be considered in this discussion, and the size of such failures should be specified (small leak, catastrophic failure, etc.).
Emergency Operations (EO)	If the analysis of the ultimate effects of the various consequences relating to all the previous categories, new issues will rarely be discovered at this stage. It is, however, very important to consider emergency operations independently because errors or failures related directly to the emergency condition or emergency procedures may not have been readily apparent when the emergency was discussed in the context of the precipitating events. Possible escalation of minor situations during emergencies should also be evaluated.
Environmental Release (ER)	The most obvious release will be that caused by integrity failure or loss of containment (IF/LOC). However, correctly functioning emergency vents, various mechanical failures and operating errors must also be considered

Table 4.11, using the categories presented below, makes a comparison of topics addressed in the different procedures & guidelines (the IAPH checklist is not included in the table).

The level of detail of how these topics are addressed can differ significantly between the different documents. It is advisable therefore to use the published guidelines as a first informative resource to gain background on technology, equipment requirements and procedures. How the Guidelines, altogether, can be used will depend mainly on the following factors:

- Agreement between all parties involved (BSO, RSO, Terminal, Competent Authority(ies)
- Prescription of specific Guidelines by local regulations
- Technology development

Guidelines are also very different in nature. Whilst ISO/TS 18683 establishes functional requirements for equipment and procedural aspects, the SGMF Safety Guidelines for LNG bunkering are more of an operations guide, in support of operations control/management in the LNG bunkering interface. It is important to use the relevant guidelines for the relevant aspects of LNG bunkering. None of the instruments listed can be considered complete and, following the very nature of guidance documents, they aim to provide orientation in particular aspects of LNG bunkering equipment design, operations, competencies and training.

Table 4.12 - Guidelines on LNG Bunkering – Documents comparison

	ISO TS 18683	EN ISO 20519	DNV GL RP	BV guidelines	ABS guidelines	SGMF guidelines
General issues						
general introduction& scope	x	x	x	x	x	x
bunkering scenarios/options/ configurations	x	(1)	x	x	x	x
Material Problems (MP)						
general safety	x	x	x	-	x	x
use of checklists	x	x	x	-	-	x
general risk management	x	-	x	-	-	x
safety and security zones, general	x	x	x	-	x	x
fire protection systems	-	(2)	x	x	x	x
ignition prevention	x	(2)	x	x	x	x
fire and gas detection	x	(2)	x	-	x	
safety zones requirements	x	x	x	x	x	x
personal protective equipment (PPE)	x	x	x	-	x	x
External Effects Or Influences (EE/I)						

	ISO TS 18683	EN ISO 20519	DNV GL RP	BV guidelines	ABS guidelines	SGMF guidelines
lighting / visibility conditions	-	(3)	x	x	-	x
weather conditions, operating envelope	x	x	-	x	-	x
Operating Errors And Other Human Factors (OE&HF)						
roles & responsibilities general	x	-	x	-	x	x
person in charge definition		-	-	x	x	x
training requirements	x	x	x		x	x
port & authorities involvement/approval	(4)	(4)	x	x	-	x
specific supplier responsibilities	x	-	x	-	-	-
outline of LNG transfer procedure	x	x	x	x	x	x
specific instructions for LNG bunkering operations	x	x	x	x	-	x
ship & supplier compatibility	x	-	x	x	x	x
communication / language	x	x	x	x	x	x
documentation requirements	x	x	-	-	-	-
Analytical Or Sampling Errors (A/SE)						
LNG bunker quantity & quality	x	-	x	-	x	(8)
Equipment/Instrumentation Malfunction (E/IM)						
loading arms	-	-	x	-	-	-
bunkering hoses	-	-	x	x	-	-
bunker piping	-	-	-	x	-	x
Process Upsets Of Unspecified Origin (PUUO)						
alarms	x	(5)	-	x	x	x
management of change	-	-	X		x	-
specific design requirements	(6)	(6)	-	x	x	-
simultaneous operations (SIMOPS)	x	-	X	-	x	x
control of operations	x	x	X	-	-	x
Utility Failures (UF)						
electrical insulation	x	-	x	-	x	x
specific purging instructions	-	-	x	-	x	x
Integrity Failure Or Loss Of Containment (IF/LOC)						
guidance for development & design of bunkering facilities	x	x	x	-	-	-
risk assessment requirements	x	-	x	x	x	x
cryogenic protection	x	-	x	-	x	x
specific connection instructions	-	-	-	-	x	x
specific transfer instructions	x	x	x	x	x	x
Emergency Operations (EO)						
emergency shut down and emergency release	x	x	x	x	x	x

	ISO TS 18683	EN ISO 20519	DNV GL RP	BV guidelines	ABS guidelines	SGMF guidelines
testing of ERS and ESD	x	X	-	-	-	-
emergency response	x	-	x	x	x	x
Environmental Release (ER)						
vapour management	-	(7)	x	x	-	x

Notes to Table 3.12

(1). EN ISO 20519 does not address specific bunkering scenarios/options/ configurations. The provisions are considered to be applicable to all bunkering modes. The check-lists included in this standard are however only for ship-to-ship bunkering.
(2). Even though no specific provisions are included for fire safety, EN ISO 20519 includes requirements for emergency systems such as ESD or ERS. These can be considered relevant for protection against spill/accidental LNG release and, therefore, also relevant in fire and ignition prevention.
(3). Small reference to lighting and visibility in 6.2.3
(4). Alignment with competent authority requirements mentioned.
(5). Only related to ESD.
(6). Only functional requirements
(7). Vapour return is included
(8). SGMF has specific guidance on Quality, Quantity and Custody

4.5 Other References

Having listed high-level instruments in section 4.2, International Standards in section 4.3 and Guidelines in section 4.4, the present section includes further references considered relevant in the context of LNG bunkering. Table 4.13, below, includes a list of references which are considered important to either address the whole, or part, of the LNG bunkering process. Study reports, including relevant analysis and findings, national/local/port regulations, industry guidance on specific equipment or operational aspects, are some of the documents presented in the table.

Table 4.13 - Guidelines on LNG Bunkering – Documents comparison

Title	Responsible	Type	Scope
USCG Regulations and Policy letters			
Title 33 Code of Federal Regulations (33 CFR 127) Parts 127 Waterfront facilities handling Liquefied Natural Gas and Liquefied Hazardous Gas	US Federal Regulation	Regulation	This high level document includes regulation for LNG bunkering in all bunkering modes. It includes requirements on: • Equipment • Operations • Maintenance • Training • Firefighting • Security Available from: https://www.gpo.gov/fdsys/
49 CFR 19 - Liquefied Natural Gas Facilities: Federal Safety Standards (DOT)	US Federal Regulation	Regulation	This high level document includes regulation for LNG equipment and facilities.
CG-OES Policy Letter 01-17 – 14AUG17 Guidance for Evaluating Simultaneous (SIMOPS) During Liquefied Natural Gas (LNG) Fuel Transfer Operations	USCG	Policy Letter	USCG Operational & Environmental Standard (OES) Policy letter providing a structured approach for port authorities to address and authorize SIMOPS. Policy Letter to Port Authorities. Available from: https://www.uscg.mil/hq/cg5/lgcncoe/fuelreferences.asp

Title	Responsible	Type	Scope
CG-OES Policy Letter 02-15 (2015) Guidance related to Vessels and Waterfront Facilities Conducting Liquefied Natural Gas (LNG) Marine Fuel transfer (Bunkering) Operations	USCG	Policy Letter	Guidance to owners and operators of vessels and waterfront facilities intending to conduct LNG bunkering operations, and to Coast Guard Captains of the Ports (COTPs) who assess fuel transfer operations. Minimum safety and security requirements for LNG fuel operations, providing guidance that may be used by Port Authorities assessing the different situations in LNG Bunkering. Available from: https://www.uscg.mil/hq/cg5/lgcncoe/fuelreferences.asp
CG-OES Policy Letter 01-15 (2015) Guidelines for Liquefied Natural Gas Fuel Transfer Operations and Training of Personnel of Vessels Using Natural Gas as Fuel	USCG	Policy Letter	Policy letter providing guidance regarding vessels that use natural gas as fuel and conduct LNG fuel transfer operations. It addresses fuel transfer operations and training of personnel working on US flagged or foreign vessels that use LNG as fuel and conduct LNG fuel transfer operations in waters subject to US jurisdiction. Available from: https://www.uscg.mil/hq/cg5/lgcncoe/fuelreferences.asp
USCG CG-521 Policy Letter 01-12 Equivalency Determination: Design Criteria for Natural Gas Fuel Systems	USCG	Policy Letter	Policy letter providing guidance regarding vessels that use natural gas as fuel and conduct. Updated 12JUL17, incorporating aspects from the IGF Code, following its entry into force on 1JAN17
LGC NCOE Field Notice 01-2015, CH-1	LGC NCOE	Field Notice – Technical recommendation	Field notice (memorandum) to augment to the references: • CG-OES Policy Letter 01-15 – Guidance for Liquefied Natural Gas Fuel Transfer Operations and Training of Personnel on Vessels using Natural Gas as Fuel • CG-OES Policy Letter 02-15: Guidance Related to Vessels and Waterfront Facilities Conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations. Includes specific recommendations following field experience in LNG bunkering operations. Focus on procedures, understanding of actual hazardous properties of LNG, training requirements
LGC NCOE Field Notice 01-2017, on SIMOPS	LGC NCOE	Field Notice – Technical recommendation	Recommended Process For Analysing Risk Of Simultaneous Operations (SIMOPS) During Liquefied Natural Gas (LNG) Bunkering
USCG NVIC No. 01-2011 – Guidance related to waterfront LNG facilities	US/USCG	Guidance	This circular from the Unites States Coast Guard provides guidance to an applicant seeking a permit to build and operate a shore side LNG terminal. It also includes information on assessing the suitability of waterways for LNG marine traffic. Even though it is applicable to LNG terminals it offers a broad general example on how permitting process can be structured. It provides a good reference on best practice
Industry Best Practice – Industry Guidance			
Alleviation of Excessive Surge Pressures on ESD (recommended practice)	SIGTTO	Industry Recommended Practice	This paper provides practical guidance to operators, designers and engineers, of both liquefied gas ship and terminal loading and unloading systems, by enabling them to recognise the potential hazard of surge pressure.

Title	Responsible	Type	Scope
Manifold recommendations for Liquefied Gas Carriers	SIGTTO	Industry Guidance	Developed by SIGTTO and OCIMF, these recommendations summarise the manifold arrangements and strainer guidelines for LPG and LNG carriers. The document's aim is to promote improved safety and efficiency in operations and to assist in planning the position of loading and discharging facilities in new jetties.
Liquefied Gas Fire Hazard Management	SIGTTO	Industry Guidance	The Fire Hazard Management guidelines covers many aspects of the liquefied gas industry, including large refrigerated and smaller pressurised storage terminals, ships, cylinder filling plant and road and rail tanker loading racks. The development of these guidelines focuses on operational staff, such as plant supervisors and ships' officers, who are involved in the handling of flammable liquefied gases. It will also be beneficial to fire officers and emergency planners who have liquefied gas instillations within their jurisdiction, or experience regular road or rail car traffic involving these products in their area. This publication has been compiled to provide readers with an insight into the design and operation of liquefied gas installations and the equipment essential to the safe and efficient functioning of such installations.
ESD Arrangements and linked ship to shore systems for Liquefied Gas Carriers	SIGTTO	Technical Note	A note produced (2009) solely due to clarify the functional requirements for ESD systems, primarily differences between the needs of the LNG industry and those of the LPG industry. Proposals are presented for a standardised links to connect ship and terminal emergency shutdown (ESD) systems that are designed to communicate and initiate ESD of cargo transfer as safely and as quickly as possible.
LNG Transfer Arms and Manifold Draining, Purging and Disconnection Procedures	SIGTTO	Industry Guidance (also adopted as Policy Letter USCG)	Due to confusion and misunderstanding among some ship and jetty operators regarding safe conduct of this operations these guidelines have been prepared. This advice specifically pertains to terminals employing rigid transfer arms. (The basic principles are applicable for hose systems that may be used for LNG ship to ship transfer, but there will be differences in the detail.)
The safe transfer of Liquefied Gas in an offshore environment	OCIMF	Best practice document/ Guidance	This publication primarily addresses the inter-relation between a Floating-Production-Storage-Offloading (FPSO) unit and conventional gas tankers operating in a side by side mooring configuration. It includes recommendations for mooring equipment, considers mooring loads and operations, motions of the FPSO and gas tanker, station keeping, cargo transfer equipment and cargo transfer operations. The Guidelines are primarily intended to familiarise Masters, ship operators, FPSO operators and project development teams with the general principles and equipment involved in LPG offloading activities between FPSOs and gas tankers.
Ship Inspection Report Programme	OCIMF	Inspection Format Guidance	OCIMF ship inspection report programme (SIRE) is developed for tanker and barge risk assessment. It is a tool launched in 1993, used by charterers, terminal operators and government bodies to assist in the assurance of vessel safety and to provide a standardized inspection format, with objective reports capable of being shared.

Title	Responsible	Type	Scope
Mooring Equipment Guidelines	OCIMF	Guidelines	First published in 1992 and now on a third edition reflecting on changes in ship and terminal design as the shipping industry has always been concerned with safe mooring practices. A fundamental aspect of this concern entails the development of mooring systems which are adequate for the intended service, with maximum integration of standards across the range of ship types and sizes. Although numerous standards, guidelines and recommendations concerning mooring practices, mooring fittings and mooring equipment exist they are often incomplete. These guidelines are intended to provide an extensive overview of the requirements for safe mooring from both a ship and terminal perspective embrace the full spectrum of issues from the calculation of a ship's restraint requirements, the selection of rope and fitting types to the retirement criteria for mooring lines.
Accident prevention – The use of hoses and hard-arms at marine terminals handling Liquefied Gas (2nd edition)	SIGTTO	Industry Guidance	This paper covers accidents relating to hoses, hard-arms and pipeline incidents close to ship or shore manifolds. The report only covers the liquefied gas industry. Where possible, and resulting from incidents, the design and operation of various equipment types is discussed
The selection and testing of valves for LNG applications	SIGTTO	Industry Guidance	This document provides guidance to designers and operators on the general requirements for valves for services, generally designed with an operating temperature range of +80°C to –196°C. This guidance is primarily intended for the shipping and storage of these products but may be applied throughout the LNG and LPG industries as appropriate.
The selection and testing of valves for LNG applications	SIGTTO	Industry Guidance	This document provides guidance to designers and operators on the general requirements for valves for services, generally designed with an operating temperature range of +80°C to –196°C. This guidance is primarily intended for the shipping and storage of these products but may be applied throughout the LNG and LPG industries as appropriate.
Guidance for the prevention of rollover in LNG ships	SIGTTO	Information Paper	For receiving terminals, the issues are generally well understood and suitable mitigation methods are in place. For LNG ships, while the circumstances leading to rollover are quite unusual, rollover has occurred, leading to the release of this information paper.
SIGTTO - LNG ship to ship transfer guideline	SIGTTO	Industry Guidance	The LNG Ship to Ship Transfer Guidelines, published in 2001, covers the transfer of LNG from LNG carriers at anchor, alongside a shore jetty or while underway. They are also useful for reference when establishing rules and procedures for transfer operations between seagoing ships and LNG regasification vessels (LNGRV) or LNG floating storage and offloading vessels (FSOs) in inshore waters.
SIGTTO – Ship/shore interface – Safe working practice for LPG & Liquefied Chemical Gas Cargoes	SIGTTO	Industry Standard	The main objective of this document is to improve safety at the ship/shore interface. The document considers cargo transfer operations and the processes involved within the ship/shore interface to ensure cargo transfer of LPG and liquefied chemical gases is carried out safely and reliable.

Title	Responsible	Type	Scope
SIGTTO Crew Safety Standards and Training for large LNG carriers	SIGTTO	Industry Standard	This document has been prepared primarily for the guidance of ship owners and operators who may be entering LNG ship operation for the first time. It is also of use to existing LNG operators who are training new crews due to expansion. The document highlights the salient statutory requirements for the training of LNG tanker crews and the provisions of the International Standards of Training and Watch Keeping Convention, as it applies to gas tankers. It outlines the publications which are recommended for carriage on board all LNG tankers. It also provides advice on the application of the International Safety Management Code to the training and management of tanker crews. In all these matters, it draws heavily on the experience of SIGTTO member companies that have extensive operating experience with this class of vessel. Hence, it may be considered, as a guide to current best industry practice

Industry Standards			
Static Electricity (NFPA 77)	NFPA	Best Practices	In addition to being a danger to individuals and an operating problem in industry, static electricity is often the ignition source for an ignitable mixture. The latest, best practices are outlined in this document to help guard against fires and explosions given clear guidelines for the assessment of ignition potential and protocols for fire prevention.
NFPA 52 Vehicular Gaseous Fuel Systems Code	NFPA	Standard	Standard with requirements for gaseous fuel systems • CNG and LNG systems on all vehicle types • Fuel compression, processing, storage, and dispensing systems • CNG residential fuelling facilities (RFF-CNGs) • LNG fuelling facilities • LNG fire protection • Installation of ASME tanks for LNG • LNG and CNG on Commercial Marine Vessels and Pleasure Craft
Classification of Class I/II Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas (NFPA 497A/B)	NFPA	Standard	This practice applies to those locations where flammable gases or vapours, flammable liquids, or combustible liquids are processed or handled; and where their release into the atmosphere may result in their ignition by electrical systems or equipment.
Standard for the production, handling and storage of LNG (NFPA 59A)	NFPA	Standard	Standard that applies to the location, design, construction, maintenance and operation of all facilities that liquefy, store, vaporise and handle natural gas. It also deals with the training of personnel involved with LNG.
Protection against ignitions arising out of statics, lightning and stray currents **API RP 2003:Ed 7**	API	Information paper	Presents the current state of knowledge and technology in the fields of static electricity, lightning, and stray currents applicable to the prevention of hydrocarbon ignition in the petroleum industry and is based on both scientific research and practical experience. The principles discussed are applicable to other operations where ignitable liquids and gases are handled.

Title	Responsible	Type	Scope
API Standard 620 (2002) – Design and construction of Large, Welded, Low-Pressure Storage Tanks	API	Standard	Appendix Q of this standard covers specific requirements for the material, design and fabrication of tanks to be used for the storage of liquefied ethane, ethylene and methane.
EEMUA Publication 147 – Recommendations for the design and construction of refrigerated liquefied gas storage tanks	EEMUA	Standard	This publication contains basic recommendations for the design and construction of single, double and full containment tanks for the bulk storage of refrigerated liquefied gases down to -165 C, for both metal and concrete material /28/. Liquids covered by the scope of this publication, which is intended for international application, include LPG, ethylene, LNG and similar hydrocarbons.
ISGOTT – International safety guide for oil tankers & terminals	ICS OCIMF IAPH	Safety Guide	The International Safety Guide for Oil Tankers & Terminals (ISGOTT) is devolved for the safe carriage and handling of crude oil and petroleum products on tankers and at terminals. To ensure that the ISGOTT reflects the current best practice and legislation the guideline is reviewed by the ICS and OCIMF, together with the International Association of Ports and Harbours (IAPH). It is recommended by the industry that a copy of the International Safety Guide for Oil Tankers & Terminals (ISGOTT) is kept and used on board every tanker and in every terminal so that there is a consistent approach to operational procedures and shared responsibilities for operations at the ship/shore interface.
ISGINTT – International safety guide for Inland Navigation Tank-barges and Terminals	CCNR OCIMF	Safety Guide	The Oil Companies International Marine Forum (OCIMF) together with other stakeholders for inland waterways, like the CCNR developed the International Safety Guide for Inland Tank-barges and Terminals (ISGINTT). The International Safety Guide for Inland Tank-barges and Terminals is not intended to replace or to amend current legislation as ADN and RVIR, but to provide additional recommendations. The CCNR supports the Guide as the principal industry reference manual on the safe operation of tankers and terminals that serve them. The ISGINTT does not give restrictions on fuel properties that can or cannot be used for the propulsion of inland ships. The link with LNG can be found in the hazards that arise for liquids with a flashpoint below 60°C. The ISGINTT does distinguish between volatile and non-volatile liquids based on their flashpoints. However, this link is purely based on hazard identification and not on shipping fuel related activities.
Other			
LNG Operating Regulations **1/7/2016**	Port of Gothenburg	Port Regulation	Regulation valid for LNG Bunkering Operations in the Port of Gothenburg.
LNG access code for truck loading for the Zeebrugge LNG terminal	Port of Zeebrugge	Port Regulation	This LNG access code for truck loading consists of a standard set of rules and procedures governing regulated access to the LNG services offered at the LNG terminal in Zeebrugge. It contains operating rules for LNG truck loading, an LNG truck approval procedure, LNG specifications and detailed procedures for determining the LNG mass loaded.

Title	Responsible	Type	Scope
Study on the completion of an EU framework on LNG-fuelled ships and its relevant fuel provision infrastructure	European Commission	Study Report	Lot 1, out of the 4 Lots comprising the EU Study on the completion of an EU framework on LNG-fuelled ships and its relevant fuel provision infrastructure The study provides for an analysis of the EU context in LNG bunkering, in particular addressing the Gaps found in the regulatory frame and developing To analyse, further evaluate and propose solutions to the identified gaps and barriers on the basis of the findings of the EMSA study, while taking into account the on-going work and preliminary results at the ISO and the IMO; work and initiatives that have been already undertaken at local and national level; findings from relevant TEN-T projects To identify and address the remaining issues related to the regulatory framework, standardisation of the LNG bunkering process, the permitting process, QRA and incident reporting, proposing solutions for an EU-wide harmonisation
PGS 33-2 – Dutch national guideline for LNG bunkering of ships	The Netherlands	National Guidelines	The Dutch national guideline for LNG bunkering of ships is one of the PGS guidelines, which are formulated to provide design requirements for a safe installation. Although PGS 33-2 in itself is no regulation, these guidelines are used by the authorities and industry to prove conformity to the regulation by complying with the requirements of PGS. Authorities can chose to make reference to the guideline and thereby enforce it. PGS 33-2:2014 provides a consistent and transparent framework for shore-to-ship LNG bunker station design. The guideline includes harmonised risk analysis procedures for the siting of LNG bunker stations. For a detailed evaluation of technical guidelines and standards including PGS33-2 reference is made to “Sub-activity report 2.3 II LNG bunkering procedures”.
Bunkering of Liquefied Natural Gas-Fuelled Marine Vessels in North America	ABS	Study Report	ABS’ report on Bunkering of Liquefied Natural Gas-Fuelled Marine Vessels in North America aims to provide guidance to potential owners and operators of gas-fuelled vessels, as well as LNG bunkering vessels and facilities, to help them obtain regulatory approval for projects. This report lays out an integrated approach to addressing the federal, state, provincial and local requirements that may impact LNG bunkering infrastructure.
BS 4089:1999 – Specification for Metallic Hose Assemblies for Liquefied Petroleum Gases and Liquefied Natural Gases	UK National Standards Body (NSB)	British Standard	This British Standard specifies requirements and test methods for metallic hose assemblies used for the loading and unloading of LPG and LNG under pressure. These hoses are primarily used for road and rail tankers or for ship to shore duties
ISO/DTS 16901 **Guidance on performing risk assessment in the design of onshore LNG installations including the Ship/Shore interface**			This technical specification, published in March 2015, provides a common approach and guidance to those undertaking assessments of the major safety hazards as part of the planning, designing and operation of LNG facilities onshore and at shoreline using risk based methods and standards, to enable a safe design and operation of LNG facilities. The technical specification is aimed to be applied both to export and import terminals but can be applicable to other facilities such as satellite and peak shaving plants.

4.6 Regulatory Frame Best Practice – Applicability in the Bunkering Interface

Sections 4.1 to 4.5 have listed instruments and references relevant to LNG Bunkering. The present section contains the recommended best practice approach to PAAs with regards to the regulatory frame, how should the existing references be regarded by competent authorities, how should their use be advise and, in particular, how may the different instruments reflect in the evaluation and control of LNG bunkering within ports.

4.6.1 Port Regulations

Port Regulations are the best vehicle to integrate all the hierarchy for regulatory instruments presented in the introduction to Chapter 4. On one hand including the higher level instruments and, on the other, bringing the reference to Technical and International Standards, Port Regulations are important in the adequate definition of the complete legal and administrative framework for LNG bunkering.

R4.1. **Ports should set rules to control LNG Bunkering, and small scale LNG installations, by themselves, in the context and frame of their jurisdiction and meeting closely the relevant national and international applicable legislation. Ports should, in this respect, note that the alignment of port regulations/byelaws with the full hierarchy of legal/reference instruments is fundamental to the harmonized and safe development of LNG Bunkering.**

R4.2. **When developing Port Regulations specifically for LNG bunkering PAAs should align these with all the relevant regulatory references affecting the use of LNG as an alternative fuel in shipping, handling of hazardous substances within the port area, transport of hazardous substances by road and waterways.**

R4.3. **The applicable regulatory frame, for each individual Port, will be the sum of the different instrument types listed in Sections 4.2 to 4.5. Ports should develop their regulations in strict observation of the available instruments, allowing in addition for additional justifiable provisions in order to improve safety in LNG bunkering operations (e.g. in the case of lessons learnt from casualties, incidents or near misses).**

R4.4. **Whenever Port Regulations include requirements of higher stringency than those within national regulations, or technical measures understood to be different of those prescribed in International Standards, a substantiated justification should be included, preferably with the inclusion of possible alternative means of compliance. Whenever these alternative means are not expressed, a case-by-case analysis may be a possibility to be considered, allowing for the demonstration of equivalency.**

R4.5. **The following points may be considered as core elements for the structure in Port Regulations for LNG bunkering**

- **Regulatory Framework**
- **Port Organization structure**
- **Management System requirements (Safety, Quality, Environmental)**
- **Risk & Safety (Risk Assessment methodology, Risk Criteria)**
- **Technical Requirements**
    - i. **BOG management**
    - ii. **Interface**
    - iii. **Emergency equipment**
    - iv. **Communications**
- **Operational Envelopes (Weather, Traffic, Visibility, Night/day operations)**
- **Safety Distances**
- **Simultaneous Operations (SIMOPS)**
- **Authorization process**
- **Check-Lists**

R4.6. **Port Regulations should define clearly the Scope in terms of the different LNG bunkering modes. Different modes for LNG transfer will inherently represent different operational considerations and instrumental/technical/legal references. Existing industry guidelines, or best practice documents, usually privilege one, or some, of the possible LNG bunkering modes.**

R4.7. **It is, in this context advisable that a specific Port Regulations for LNG Bunkering are adopted by each PAA. With the objective of informing and adequately preparing prospective LNG Bunker Operators. Port Regulations should, as far as practicable, make reference to the standards mentioned in Section 4.3, giving special consideration for those adopted as European Standards**[41]

R4.8. **Port Local Regulations/ Byelaws, as instruments of local and limited application, should, to the extent possible make reference to existing international standards. Whilst addressing specific aspects related to the safety of navigation, handling and transport of dangerous substances, amongst others, port local rules should, to the extent possible, be aligned with existing published best practice on LNG Bunkering.**

R4.9. **Liaison with the relevant competent authorities for different aspects in LNG bunkering is an important point that PAAs should take into account. Notwithstanding the obligations on the Operators/BFOs, to notify and submit the relevant permit request elements, PAAs can, in the best interest of an efficient an optimized process, act as facilitators for the administrative aspects. Port Regulations can include aspects relative to the process flow and steps to be taken into consideration for permitting.**

R4.10. **PAAs should promote regular updates of Port Regulations, maintaining an adequate tracking of revisions. They should be free and available for free access through any type of web portal that allows easy download for later reference.**

4.6.2 National Policy Frameworks

R4.11. **Port Regulations should be aligned with the National Policy Framework defined at National Level**[42] **in all aspects related to LNG as Fuel. As part of the wider value chain for this Alternative Fuel, Ports represent important elements in the transfer of both LNG as fuel and LNG as cargo. They should therefore be aligned with the main national policy vectors.**

R4.12. **Notwithstanding the importance of aligning LNG bunkering developments and infrastructure with the National Policy Frameworks, PAAs should also consider that LNG as fuel is a cross-border development. Apart from aligning with national wide policy it is also recommended that PAAs adopt dialogue and cooperation channels to allow shared development of LNG bunkering regulations aiming towards a harmonized approach to control measures.**

R4.13. **Whenever evaluating or facilitating in favour of prospective LNG bunkering projects, PAAs are advised to consult closely with the national competent authority for the implementation of Directive 2014/94 on the deployment of an alternative fuel infrastructure. National Policy Frameworks should be able to provide the necessary environment for the consideration of LNG bunkering facilities, in the context of availability of LNG as fuel in maritime core-ports.**

R4.14. **In the case of a National Policy Framework containing specific measures of any nature that may determine or influence the permitting process for a give prospective LNG bunkering facility project, PAAs should exercise a facilitating role and assist, wherever possible and relevant, with information to operators.**

[41] Standard code “EN” or “EN ISO”

[42] National Policy Frameworks defined as per Article 3 of Directive 2014/94 [18]

4.6.3 EU Ports Regulation

R4.15. **In the interest of efficient, safe and environmentally sound port management, PAAs[43] should be able to require that providers of LNG bunkering are able to demonstrate that they meet minimum requirements for the performance of the service in an appropriate way. Those minimum requirements should be limited to a clearly defined set of conditions in so far as those requirements are transparent, objective, non-discriminatory, proportionate and relevant for the provision of the port service. In accordance with the general objectives of Regulation 2017/352, incorporating references to the relevant standards and, where applicable to this Guidance, the minimum requirements should contribute to a high quality of port services and should not introduce market barriers.**

R4.16. **PAAs should refer to Regulation (EU) 2017/352 for the establishment of minimum requirements for the provision of LNG bunkering as a port service. Notwithstanding the non-technical nature of this Regulation, it allows the legal vehicle for the relevant technical standards, for equipment and procedures, training requirements and best practice provisions contained in this Guidance.**

R4.17. **Port Regulations should comply with Regulation (EU) 2017/352 and, where possible and deemed adequate, to incorporate the relevant references to LNG bunkering technical standards (Section 4.3), guidelines and other references, as applicable (Sections 4.4 and 4.5 respectively). In addition, best practice elements of this Guidance may be considered when developing the LNG bunkering requirements for Port Services. The diagram in figure 4.19, on the next page, indicates the relevant minimum requirements to LNG bunkering as a port service, suggesting also the relevant section within this Guidance.**

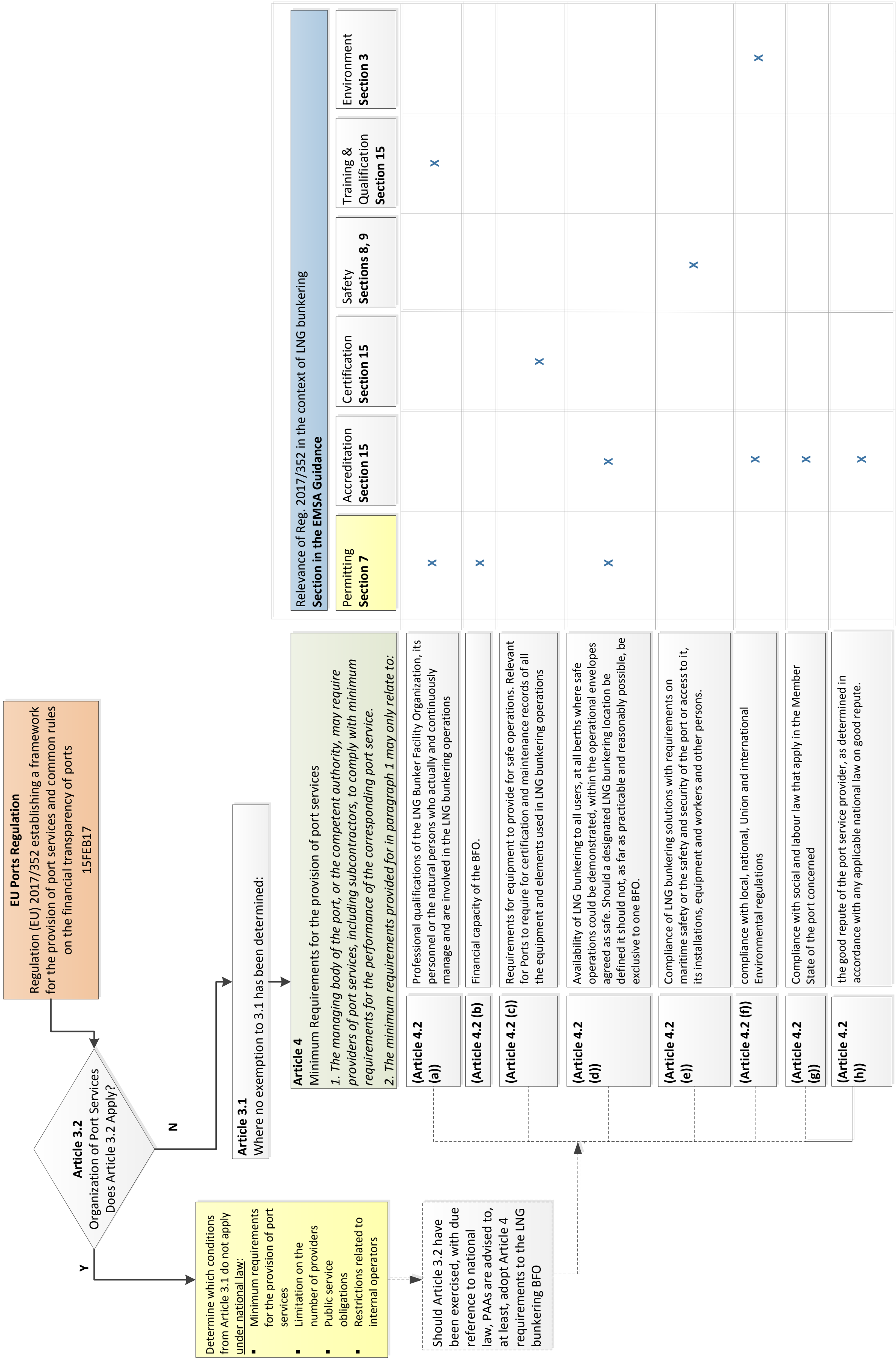
R4.18. **In the context of LNG bunkering permitting, PAAs should develop information and adequate communication channels to allow for prospective service providers to be sufficiently prepared to meet the specific requirements for safety, security, staff qualification, equipment certification and any other that are found to be relevant to the adequate completion and submission of a permitting process. In addition, in accordance with art 15 of the Regulation (EU) 2017/352 shall, consult port users on its charging policy, including environmental matters, matters having impact on spatial planning and measures to ensure safety in the port area.**

R4.19. **When PAAs are themselves the providers of the LNG bunkering service, careful observation should be given to Articles 6(6) and 8 of Regulation (EU) 2017/352. Minimum requirements for the provision of LNG bunkering service should apply in a context of transparency in the best interest of Safety.**

In particular for Risk Assessment, whenever setting up an LNG bunkering facility, the same requirements for demonstration of safety levels, meeting the relevant risk criteria, should be imposed on either Internal Operators[44] or External LNG bunkering providers.

[43] Port Authority or Administrations (PAAs) are mentioned in Regulation 2017/352 as Competent Authority or Managing Body of a Port

[44] Internal Operators as defined in Reg. 2017/352, Article 8



		Permitting Section 7	Accreditation Section 15	Certification Section 15	Safety Sections 8, 9	Training & Qualification Section 15	Environment Section 3
(Article 4.2 (a))	Professional qualifications of the LNG Bunker Facility Organization, its personnel or the natural persons who actually and continuously manage and are involved in the LNG bunkering operations	x				x	
(Article 4.2 (b))	Financial capacity of the BFO.	x					
(Article 4.2 (c))	Requirements for equipment to provide for safe operations. Relevant for Ports to require for certification and maintenance records of all the equipment and elements used in LNG bunkering operations			x			
(Article 4.2 (d))	Availability of LNG bunkering to all users, at all berths where safe operations could be demonstrated, within the operational envelopes agreed as safe. Should a designated LNG bunkering location be defined it should not, as far as practicable and reasonably possible, be exclusive to one BFO.	x	x				
(Article 4.2 (e))	Compliance of LNG bunkering solutions with requirements on maritime safety or the safety and security of the port or access to it, its installations, equipment and workers and other persons.				x		
(Article 4.2 (f))	compliance with local, national, Union and international Environmental regulations		x				x
(Article 4.2 (g))	Compliance with social and labour law that apply in the Member State of the port concerned		x				
(Article 4.2 (h))	the good repute of the port service provider, as determined in accordance with any applicable national law on good repute.		x				

Figure 4.19 – EU Ports Regulation – Minimum requirements to the provision of port services, with reference to the applicable EMSA Guidance section for each element of Article 4.2 of the Regulation.

4.6.4 Seveso III Directive – Major Accident Prevention Directive

R4.20. **The decision on the applicability of Seveso III Directive framework[45] provisions, to any particular LNG bunkering project plan or solution, should be made at the earliest stage, during the permitting phase, immediately after receipt of a Concept Project and Letter of Intent. In addition to the obligation of notification[46] by Operators/BFO, also PAAs should liaise directly with national competent authorities for Seveso III Directive implementation (CA(S)), with a view to determine the applicability of the Seveso-III directive and the implications.**

R4.21. **PAAs can, from a very early stage in the process, as indicated in the best practice flow-chart in figure 4.24, assume the role of facilitator in the context of the permitting process. Applicability of Seveso III Directive provisions in the classification of a given LNG bunkering location should also represent the indication of important action points to PAAs**

R4.22. **In the context of Seveso III Directive applicability it is important to note and distinguish the concept behind the relevant framework safety provisions. Table 4.14 below indicates for different establishments which requirement applies. In the context of LNG bunkering also non-Seveso locations/projects are included. In this category would fall a large number of LNG bunkering facilities based on spot LNG bunkering via trucks or LNG bunkering vessels or barges to which a different regulatory framework applies.**

Table 4.14 – Seveso III framework requirements

<table>
<tr><th></th><th>Seveso Upper-Tier</th><th>Seveso Lower-Tier</th><th>Non-Seveso</th></tr>
<tr><td><u>Major Accident Prevention Policy</u>
(MAPP)</td><td><u>Yes</u>
For upper tier establishments: SMS - in accordance with Annex III – is one of the means by which the operator has to demonstrate that a MAPP has been properly implemented.</td><td><u>Yes</u>
For lower-tier establishments, the obligation to implement the MAPP may be fulfilled by other appropriate <u>means, structures and management systems</u>, proportionate to major-accident hazards, taking into account the principles set out in Annex III of Seveso III Directive.</td><td rowspan="2"><u>Other</u>
For Non-Seveso LNG bunkering facilities the application of EN ISO 20519 (Section 7) would set the reference to Safety Management System.
Compliance with EN ISO 20519 shall list conformance with this that as a management objective in the Operator/BFO management system.
Management systems that can be used are <u>ISO 9001, ISO 14001, ISM, ISO/TS 29001 and API Spec Q1.</u></td></tr>
<tr><td><u>Safety Management System</u>
(SMS)</td><td><u>Yes</u>
The MAPP shall be implemented by appropriate means and a safety management system.
SMS is not part of the Safety Report.</td><td><u>Yes</u>
The MAPP shall be implemented by appropriate means and a safety management system</td></tr>
<tr><td><u>Safety Report</u>
(SR)</td><td><u>Yes</u>
Required to demonstrate actual implementation of the MAPP.
SMS is not part of the Safety Report.
Safety Report outlines the measures taken and demonstrates that all relevant aspects have been taken into account
Can include, for LNG bunkering establishments, the technical requirement for a Risk Assessment in the terms of EN ISO 20519 and ISO/TS 18683.</td><td colspan="2"><u>Other</u>
For <u>Lower-Tier</u> and <u>Non-Seveso</u> LNG bunkering facilities, the applicability of EN ISO 20519 and ISO/TS 18683 may be considered as best practice.
For this requirement to be implemented is important to ensure that compliance with these standards is inscribed in objectives of the BFO</td></tr>
</table>

[45] Seveso only provides a framework. It will be the risk assessment under the Major Accident Prevention Policy and/or the Safety Report that will determine what technical and organisational risk management measures will actually be necessary.

[46] The obligation is with the Operator/BFO to notify the CA(S). It is not the competent authority that determines. The BFO may however seek confirmation of its assessment. Actual process may be subject to national variations, accounting for each Member State implementation of Seveso Directive.

	Seveso Upper-Tier	Seveso Lower-Tier	Non-Seveso
Emergency Plan	<u>Emergency Plan</u> (Article 12 Seveso III) Internal Emergency Plan to be developed applied and tested. Elements to be included in the Emergency plan as in Annex IV	<u>Emergency Response Plan</u> **(Reference to IACS Rec. 142 and SGMF LNG Bunkering Guidelines)** Emergency Response Plan as part of the LNG Bunkering Management Plan (IACS Rec.142) Emergency Response Plan focused on the equipment and procedural aspects related to the LNG bunkering operation.	

R4.23. **Referring to Table 4.14, above, for Upper Tier establishments both MAPP and Safety Report apply, whilst for lower tier only MAPP is required. An important note is however to be made, to clarify that these are, in essence, framework provisions, and not detailed technical requirements. It is quite likely and possible that the current safety practice, or national/local/port regulations, for LNG bunkering projects, facilities and locations, already include similar provisions in place, further detailed at national level, either on the technical or administrative levels. PAAs should make sure that the framework requirements in Table 4.14 are structured in detail at the technical level**

R4.24. **PAAs should in all cases require BFOs have a management system; lower and upper tier Seveso establishments a SMS, or non-Seveso establishments, at least some type of management system where, as a minimum the requirements from EN ISO 20519 and ISO/TS 18683 can be included as objectives. Each system has to be in accordance with Annex III. Each system has to be proportionate to the major-accident hazards.**

R4.25. **Management Systems that should be considered:**

- **Safety Management Systems**
  - i. **SCC (Safety Certificate for contractors)**
  - ii. **BS 8800 OHSAS 18001, 18002 (Occupational Health and Safety Assessment System**
- **Quality Management Systems**
  - i. **ISO 9000 – 9004**
  - ii. **ISO/TS 29001**
  - iii. **ISM**
  - iv. **API Spec Q1[47].**
- **Environmental Management System**
  - i. **EMAS**
  - ii. **ISO 14001**

R4.26. **It should be possible to ascertain the implementation of the MAPP by appropriate means and a SMS applied for permitting. Whilst the content and issues to be addressed in the SMS are laid down in Annex III of the Directive, it is again important to note that this instrument in itself is only specifying the framework minimum requirements for the safety management system. It should in essence allow the verification of a management loop (plan – do – check – act).**

As per Annex III the SMS should include the part of the general management system which includes the organizational structure, responsibilities, practices, procedures, processes and resources for determining and implementing the MAPP;
The following issues shall be addressed by the SMS:

- **<u>Organization and personnel</u> — the roles and responsibilities of personnel, identification of training needs, involvement of employees and subcontractors;**

47 API Spec Q1 Definition - API Spec Q1 is a company level certification based on the standard developed and published by the American Petroleum Institute (API) titled "Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry".

- **Identification and evaluation of major hazards — procedures for systematically identifying major hazards, likelihood and severity;**
- **Operational control — adoption and implementation of procedures and instructions for safe operation;**
- **Management of change — adoption and implementation of procedures for planning modifications;**
- **Planning for emergencies — adoption and implementation of procedures to identify foreseeable emergencies by systematic analysis, to prepare, test and review emergency plans to respond to such emergencies;**
- **Monitoring performance — adoption and implementation of procedures for the ongoing assessment of compliance with the objectives set by the operator's major- accident prevention policy and safety management system;**
- **Audit and review — adoption and implementation of procedures for periodic systematic assessment of the MAPP and the effectiveness and suitability of the SMS**

R4.27. **In all requirements related to the framework provisions in Seveso Directive, PAAs should integrate correctly the hierarchy of the different elements, as depicted in figure 4.20, below. The Safety Report, being a central element of the requirements applicable to the Operators, following the interpretation leading to Seveso framework applicability.**

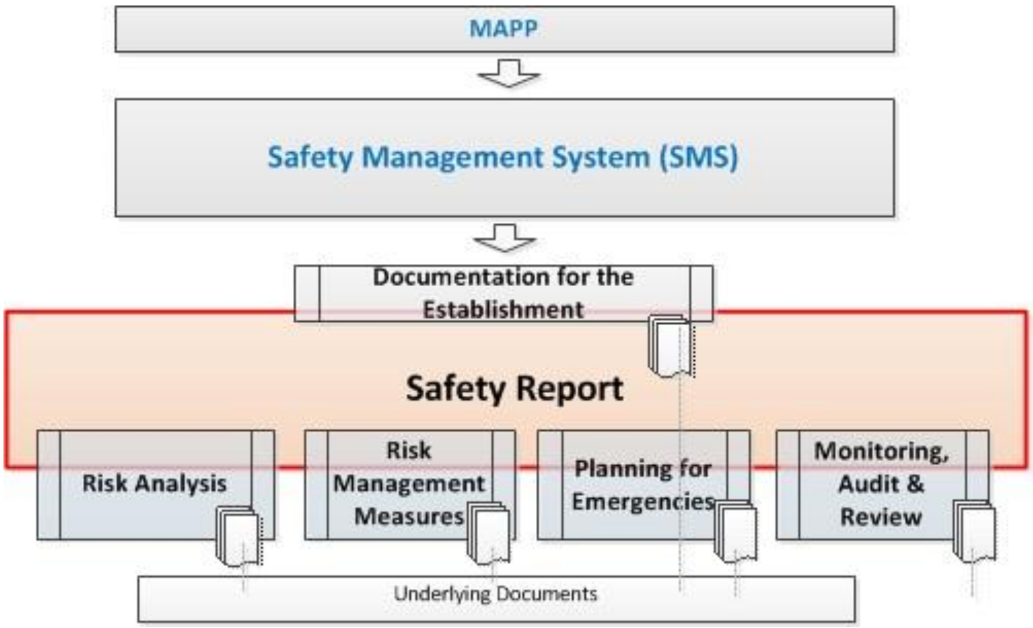


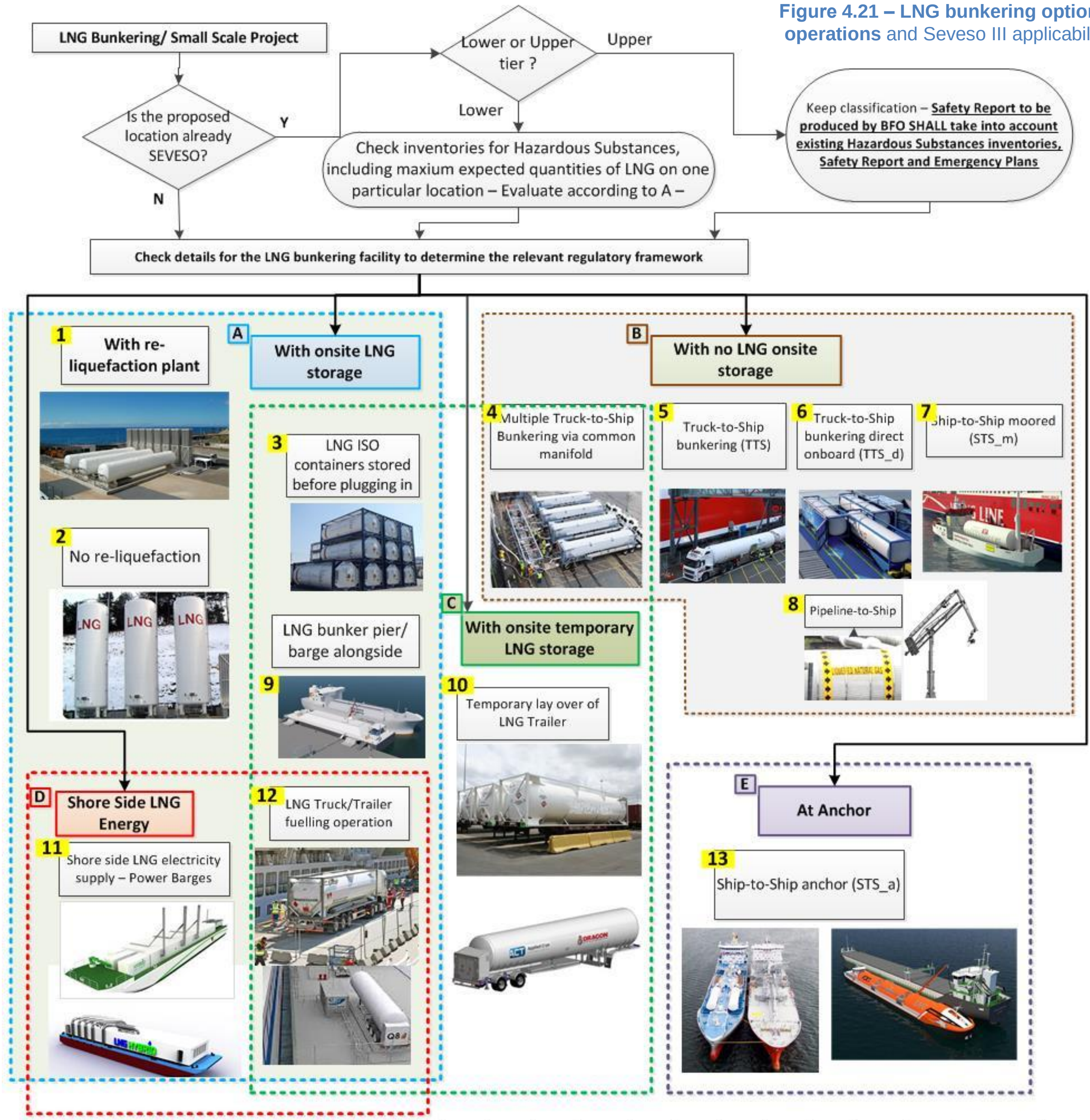
Figure 4.20 – Document structure – Seveso III Directive.

R4.28. **Following the previous point, and again with the focus on figure 4.21 in the next page, a suggestion is made for grouping LNG bunkering solutions into 4 (four) different groups, depending on the possibility of onsite LNG storage. The following groups are defined:**

A. **Fixed LNG bunkering solution with onsite storage,**
B. **Mobile Units in LNG bunkering, without onsite intermediate storage,**
C. **Mobile Units in LNG bunkering, with onsite intermediate storage,**
D. **Shore-side LNG energy, either as direct fuelling[34] or LNG-electricity supply,**
E. **Ship-to-ship LNG bunkering, out of area[48].**

[48] Ship-to-ship LNG bunkering can take place in the port area (at berth or at anchor) or out of area, at sea.

Figure 4.21 – LNG bunkering options, operations and Seveso III applicability**.**



	Case	1	2	3	4	5	6	7	8	9	10	11	12	13
Applicable Safety Standard provisions to LNG bunkering facility	**Risk Assessment** EN ISO20519 – ISO/TS18683	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Emergency Response Plan (Consistent with Risk Assessment)	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑ (note 4)	☑	☑
	ADR (Carriage of Dangerous Substances road)				☑	☑					☑		☑	
	UNECE S**afety Guidelines & Good Practices for Pipelines**	☑	☑						☑					
Applicable SEVESO requirements to the LNG bunkering location	Article 7 (**Notification**)	>50t	>50t	>50t	>50t/ manifold	N/A	N/A	N/A	N/A	>50t	>50t	>50t	>50t	N/A
	Article 8 (**Major Accident Prevention Policy – MAPP**) (note 1)	>50t	>50t	>50t	>50t/ manifold	N/A	N/A	N/A	N/A	>50t	>50t	>50t	>50t	N/A
	Article 10 (**Safety Report**)	>200t	>200t	>200t	>200t/ manifold	N/A	N/A	N/A	N/A	>200t	>200t	>200t	>200t	N/A
	Article 12 (**Emergency Plan**)	>200t	>200t	>200t	>200t/ manifold	N/A (note 2)	N/A (note 3)	N/A (note 2)	N/A (note 4)	>200t	>200t	>200t (note 5)	>200t	N/A (note 6)

NOTES:
1. For lower-tier establishments, the obligation to implement the MAPP may be fulfilled by other appropriate means, structures and management systems, proportionate to major-accident hazards.
2. Not applicable where Article 2(2)(c) applies –
   - Possible major accident prevention provisions (similar to Seveso) to be judged by Seveso Competent Authorities, in light of the following relevant elements:
     - Possible existing Seveso classification for the intended bunkering location
     - Inventory of other possible hazardous substance, already in the area (possibly even below LOWER TIER threshold)
     - Technical solution proposed for LNG bunkering
     - Quantity of LNG on-site
     - Frequency of LNG bunkering operations
3. Evaluation based on the permanence of ISO LNG containers ashore, waiting to be loaded onto LNG fuelled ship (case 3)
4. Not applicable where Article 2(2)(c) applies / pipelines outside establishments are exempt from Seveso application / Good practice to follow UNECE Safety Guidelines.
5. The case of LNG power floating units is outside the scope of application of ISO 20519 or ISO/TS 18683. Similar measures, in particular for Risk Assessment, are mentioned here as important best practice.
6. It is important to be certain that a transport or temporary storage situation can still be verified. If not, even for a ship, used for LNG storage, Seveso provisions can apply.

R4.29. **The division in the mentioned group in the previous point reflects and is aimed to capture the level of prevalence of a given LNG quantity close to the receiving ship or at any point with the port area. It reflects the need to address safety of LNG bunkering projects on the basis of how much LNG is onsite, and for how long. To this end PAAs should liaise with national Seveso competent authorities at the earliest possibility, as suggested in R4.18, accounting for the need to determine the necessary provisions, either from direct application of Seveso III Directive or, alternatively, for those cases falling within its Article 2.2.(c), by adopting the best practice suggested in this Guidance.**

Sub-division presented in figure 4.21 is only indicative and should be taken as an example. It only suggests the need to differentiate between LNG bunkering solutions.

R4.30. **Fixed LNG bunkering installations, with small scale storage of LNG (with or without refrigeration/re-liquefaction), constituting Group A in figure 4.21, should be directly considered as eligible for Seveso III Directive application. Falling outside the derogation in Article 2.2.(c), fixed installations are subject to all provisions in Seveso III and, even if the intended location for LNG bunkering is already a Seveso classified area, it will require an update of all information, with the new hazardous substance (LNG) quantities reflected in the Emergency Plan procedures and Safety Report.**

R4.31. **To use the definition in the Seveso III Directive, Article 3.1, the whole location under the control of an operator" needs to be considered. This encompasses the storage site and the area adjacent to it, including all infrastructure and equipment elements connected to the storage tank downstream to the to the bunkering location/connection point (figure 4.22 and 4.23).**

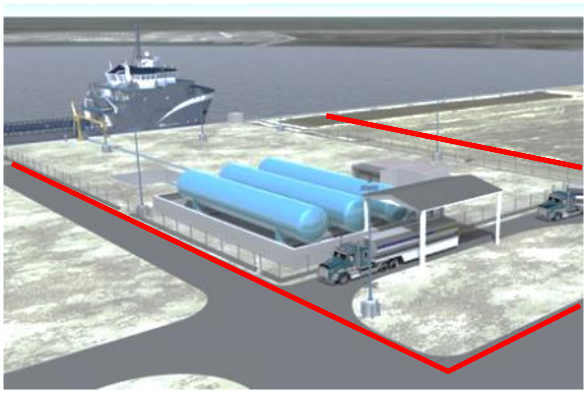


Figure 4.22 – LNG Bunkering – small-scale LNG bunkering with onsite storage.
(source: Harvey Gulf)

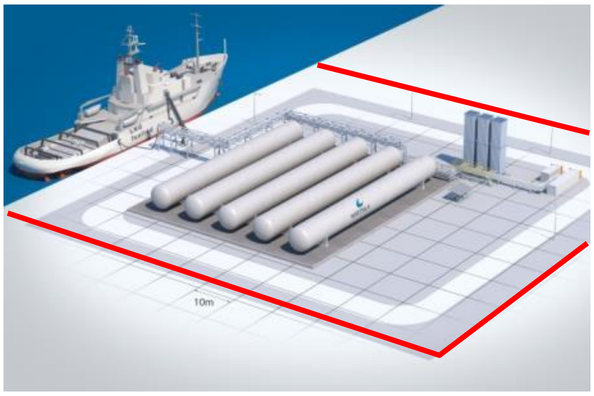


Figure 4.23 – LNG Bunkering – small scale LNG bunkering with onsite storage
(source: Wartsila)

R4.32. **Seveso III Directive provisions are not applicable to the transport of dangerous substances and directly related intermediate temporary storage by road, rail, internal waterways, sea or air, outside the establishments covered by this Directive, including loading and unloading and transport to and from another means of transport at docks, wharves or marshalling yards;**[49]

R4.33. **For this reason, LNG tank trucks, railcars, and other mobile units, are not considered under the scope of Seveso III Directive, as Seveso establishments as long as they fulfil the conditions of Article (2)(2)(c). However, when these mobile units are used as a means for transferring LNG to a marine vessel, the location where the transfer occurs (i.e., any area on shore immediately adjacent to such waters, used or capable of being used to transfer liquefied natural gas, in bulk, to or from a vessel) can become subject, to Seveso III Directive provisions, depending on the circumstances.**

[49] Seveso III – Directive 2012/18/EU – Article 2.2.c)

R4.34. **PAAs should nevertheless be aware that LNG tank trucks, railcars, and other mobile units are subject to additional, existing international or local requirements.**

R4.35. **Following R3.9, and considerations in Section 4.2.1, table 4.3, the applicability of Seveso III Directive requirements to possible intermediate storage situations, as the ones presented in Table 3.4 (situation 1, 2 and 3) is subject to a case-by-case assessment from PAAs and Seveso III competent authorities, which should, in the best interest of safety, have the following elements into consideration:**

a. **Actual or anticipated quantities of LNG in bunkering location/intermediate storage, taking into consideration also other dangerous substances present in the location**
b. **Part of the distribution/transport chain where the bunkering /intermediate storage element is integrated**
c. **Duration and frequency of the bunkering or intermediate storage at the location**
d. **Other risk factors at the location or in its proximity such as the intermediate storage of other hazardous substances.**

R4.36. **In the case that the location where LNG bunkering is being proposed is already a Seveso establishment the classification of that location should be subject to a revision, including careful consideration for the full aggregation of hazardous substances, in addition to the LNG storage/intermediate storage. For a Lower-Tier establishment, even if outside the scope for a Safety Report (Article 10) or an Emergency Response Plan (Article 12), it is advised as a good practice to also require the application of the technical provisions already in ISO/TS 18683 and EN ISO 20519[50].**

R4.37. **Apart from the total volume of hazardous substance, in this case LNG, other elements should be taken into account which will be relevant for the Safety Report. ANNEX II in Seveso III Directive (*Minimum data and information to be considered in the safety report referred to in Article 10*) lists the minimum elements to be considered. It is important however to underline that requirements for Risk Assessment will very likely already be in place, whether it is a fixed installation or a mobile unit. Even if Seveso III Directive may, on a first analysis, exempt mobile units, requirements from other instruments may be in place and Risk Assessment and Emergency Plan may be already part of the requisite for the LNG bunkering project to be developed in the first place. Port Regulations play here a fundamental role in bringing the non-binding provisions from International Standards such as ISO/TS 18683 and EN ISO 20519, into an enforceable status.**

R4.38. **The process to determine the applicability of Seveso III Directive to a given LNG bunkering location, independently of the LNG bunkering solution designed, will be very much dependent on a case-by-case assessment by the operator, ideally in cooperation with the competent authorities regarding the proposal as described in the LNG bunkering Concept Project and Letter of Intent, to be submitted by the prospective BFO, and possibly endorsed by the TO. The diagram in figure 4.24, below, proposes a procedure for confirmation of possible Seveso classification for the intended LNG bunkering location. A short description of the process is presented in Table 4.16, with explanations to the diagram in figure**

R4.39. **As an alternative good practice approach it is possible to define a more simplified way of segmenting Major Accident Prevention application accounting for a staged application of different instrument provisions, following the outline of table 4.15, in the next page.**

[50] Requirements for Risk Assessment and reference to an Emergency Plan are already part of both ISO/TS 18683 and EN ISO 20519. There is however an important difference between what is prescribed as a Safety Report in Seveso III Article 10, and an actual Risk Assessment. The Safety Report is more representative of a Risk Study, where Risk is not a specific figure to be calculated. Assessment against relevant criteria is, in this sense, not possible. Whereas the Safety Report provisions from the Seveso directive provide the framework for the overall Safety Study, the Risk Assessment provisions, from ISO technical standards, provide for the Technical provisions relevant to evaluate Risk.

Table 4.15 – Risk, Emergency Plan, Management System and Major Accident Prevention requirements (simplified scheme)

<table>
<tr><th></th><th></th><th>RISK ASSESSMENT</th><th>EMERGENCY RESPONSE PLAN (ERP)</th><th>MANAGEMENT SYSTEM</th><th>MAJOR ACCIDENT PREVENTION
Seveso</th></tr>
<tr><td rowspan="2">With No Onsite Storage</td><td>LNG Bunkering by mobile units
Groups B, D and E in figure 4.21</td><td rowspan="2">ISO/TS 18683
EN ISO 20519
Important to note the scope of these standards is focused on the LNG bunkering interface and, applicable to all LNG bunkering solutions.</td><td>ERP
To reflect key aspects of Risk Assessment
Following indicative scope as per IACS Rec.142/SGMF Guidelines.</td><td>Quality Management System
EN ISO 20519 Section 7.1
Objectives for LNG Bunkering compliance with EN ISO 20519 to be inscribed in QMS.</td><td>In principle not applicable
Article 2.2.(c) Seveso Directive)
May have implications for location, (evaluation by Competent Authority).</td></tr>
<tr><td>Pipeline</td><td>ERP
To reflect key aspects of Risk Assessment</td><td>Pipeline Integrated Management System (PIMS)
UNECE</td><td>In principle not applicable
Article 2.2.(d) Seveso</td></tr>
<tr><td>With Onsite Intermediate temporary Storage</td><td>LNG Bunkering by mobile units
With onsite intermediate storage elements
Groups C, D and E in figure 4.21</td><td>ISO/TS 18683
EN ISO 20519
Scope of these standards is focused on the LNG bunkering interface and, applicable to all LNG bunkering solutions.</td><td>ERP
To reflect key aspects of Risk Assessment
Following indicative scope as per IACS Rec.142/SGMF Guidelines.</td><td>Quality Management System
EN ISO 20519 Section 7.1
Objectives for LNG Bunkering compliance with EN ISO 20519 to be inscribed in QMS.</td><td rowspan="2">Subject to evaluation by Competent Authority as to which extent relevant Major Accident Prevention Provisions may apply to location.
- As a minimum Good Practice a Risk Assessment should be conducted to demonstrate risk mitigation to ALARP levels</td></tr>
<tr><td rowspan="3">With Onsite Storage</td><td>LNG Bunkering
With onsite storage elements
<50ton</td><td rowspan="3">ISO/TS 18683
EN ISO 20519
Scope of these standards is focused on the LNG bunkering interface and, applicable to all LNG bunkering solutions.

(it is important to note the Risk Assessment and scope of both ISO standards is for the "bunkering interface" (see figure 4.18)</td><td>ERP
To reflect key aspects of Risk Assessment
Following indicative scope as per IACS Rec.142/SGMF Guidelines.</td><td>Quality Management System
EN ISO 20519 Section 7.1
Objectives for LNG Bunkering compliance with EN ISO 20519 to be inscribed in QMS.</td></tr>
<tr><td>LNG Bunkering
With onsite storage elements
>50ton</td><td>Emergency Response Plan as part of MAPP+SMS</td><td>Safety Management System
Need to demonstrate that all MAPP Hazard Scenarios have been addressed</td><td>Seveso LOW-TIER
- Notification (Article 7)
- MAPP+SMS (Article 8)
- Public Consultation (Article 15)
- Information to Public (Article 14)</td></tr>
<tr><td>LNG Bunkering
With onsite storage elements
>200ton</td><td>Emergency Response Plan (Article 12)</td><td>Safety Management System
Need to demonstrate that all MAPP Hazard Scenarios have been addressed</td><td>Seveso UPPER-TIER
- Notification (Article 7)
- MAPP+SMS (Article 8)
- Safety Report (Article 10)
- Emergency Response Plan (Article 12)
- Public Consultation (Article 15)
- Information to Public (Article 14)</td></tr>
<tr><td rowspan="2">LNG Shore-side energy</td><td>Shore Side Electricity
LNG power supply</td><td>No fuel transfer interface.
Risk Assessment for the</td><td rowspan="2">ERP
To reflect key aspects of Risk Assessment

ERP applicable as a minimum Good Practice for both cases.</td><td rowspan="2">Quality Management System
Reflecting the specific service objectives and details.
Safety objectives to be defined and inscribed in QMS.</td><td rowspan="2">Subject to evaluation by Competent Authority as to which extent relevant Major Accident Prevention Provisions may apply to location.</td></tr>
<tr><td>LNG Fuel direct to onboard generator
LNG fuel supply</td><td>ISO/TS 18683
EN ISO 20519
Fuelling interface to be considered within scope.</td></tr>
</table>

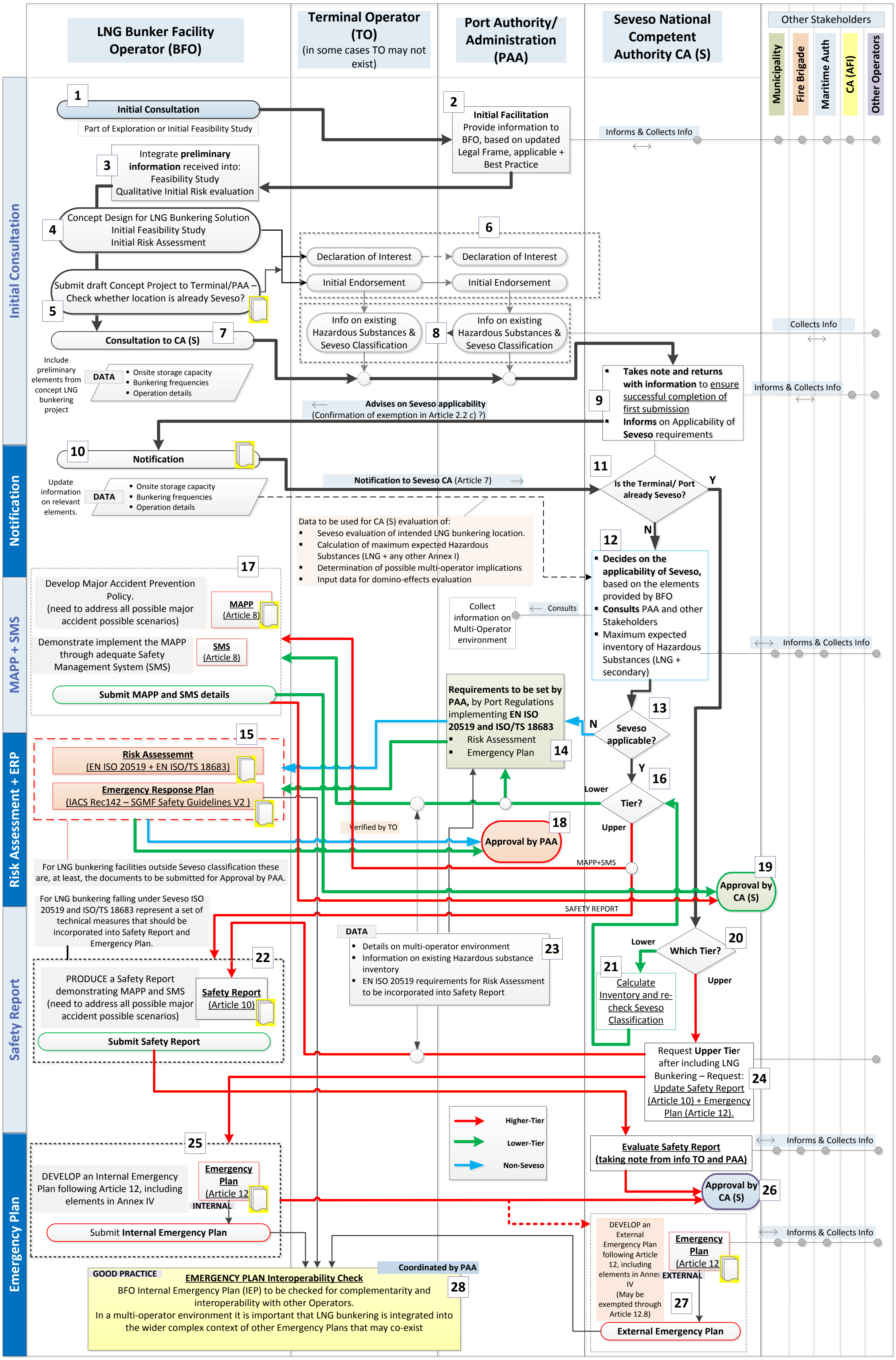


Figure 4.24 – LNG bunkering - Seveso applicability (see table for legend)

Table 4.16 – Table legend for diagram in Figure 4.24

Item in diagram figure 4.24		**Who?**	**Observation/ Note/ Guidance**
1	Initial Consultation	BFO	BFO consults PAA on the relevant aspects that need to be accounted for before initiating the process. Important to detail the main lines of the concept, share ideas on preferred bunkering location and outline the permitting process adequately.
2	Initial Facilitation	PAA	PAA, as a Good Practice approach, can be constituted as an initial facilitator the process. This would support all parties involved in having a single focal provider for initial information.
3	Collection of preliminary information	BFO	Resulting from initial consultations the BFO is here able to gather all the necessary information to develop the adequate permitting process, including in particular Risk Assessment and Major Accident Prevention aspects.
4	Development of Concept Design	BFO	Development of initial Concept Design to include elements of Qualitative Risk Assessment, Feasibility Analysis and, in particular, incorporating relevant elements from TO and PAA consultation. A dialogue with the PAA should be established at this point on the technical level. Non-disclosure agreements may be considered for adequate level of information sharing at this point.
5	Draft Concept Project for Peer Consultation	BFO	Submission, of the Concept Design for intended LNG bunkering facilities and operations, to the Terminal Operator (TO) and PAA.
6	Declarations of Interest and Initial Endorsements	TO/PAA	Should the TO and PAA be also interested parties in the setting of the LNG Bunkering project/service this information should be here subject to declaration. This is considered to be an important initial step for transparency purposes.
7	Consultation with Seveso Competent Authority	BFO	Include preliminary elements from concept LNG bunkering project, including 1) Onsite storage capacity, 2) Bunkering frequencies, 3) Operation details, 4) Possible temporary storage elements, 5) information on existing Seveso III Directive classification, including in particular aspects related to the proximity of populations as required by art 7 of the Seveso III Directive.
8	Information on existing Hazardous Substances onsite and potential existing Seveso classification	TO/PAA	Relevant information on possible Seveso classification for the intended LNG bunkering facilities location. Information on existing Hazardous Substances storage elements or handling location.
9	Preliminary information package	CA	In the best interest of a complete submission, relevant for the LNG bunkering project being proposed, it is important to have a consolidated information package from the CA. It is advised that CA informs on applicability of Seveso requirements.
10	Notification	BFO	Formal Notification, including all elements prescribed in Article 7 of Seveso Directive (Directive 2012/18/EU). Include, as a good practice element, also information on: • Onsite storage capacity • Bunkering frequencies • Operation detail
11	Evaluation of previous Seveso classification for intended LNG Bunkering facilities location	CA	CA assesses whether site is already Seveso establishment or, in the context of additional information, whether it should merit becoming a Seveso establishment in view of the following information provided under Article 7: Data to be used for CA (S) evaluation of: • Operator information and assessment confirming intended LNG bunkering location. • Calculation of the anticipated presence of Hazardous Substances (LNG + any other Annex I substances) • Determination of possible multi-operator implications • Input data for domino-effects evaluation
12	**(Case where location is not a Seveso Establishment)** Need to build the case to evaluate adequately Seveso provisions applicability.	CA	Decision of Seveso applicability to be based on the elements provided by the BFO, following consultation with PAA and Terminal Operator. Pursues aggregation of maximum expected inventory of Hazardous Substances at any time. Information on multi-operator environment to be obtained from PAA CA to determine accident prevention based on national legislation/standards.
13	Decision on Seveso applicability, for new LNG Bunkering projects	CA	Following evaluation of elements obtained in (12) CA decides on Seveso applicability to the detailed LNG bunkering project. Exact requirements following on the BFO will follow from this early evaluation of project details.

Item in diagram figure 4.24		**Who?**	**Observation/ Note/ Guidance**
14	For Non-Seveso outcome from (13), and also for Lower-Tier establishments, PAA to set requirements for **Risk Assessment** and **Emergency Response Plan.**	PAA	Following determination of Seveso non-applicability in (13) the PAA receives indication from the CA to detail the requirements for Risk Assessment and Emergency Response Plan. The role of the PAA is here fundamental as it holds the overview of the multi-operator scenario in the port area and holds the external ERP. The involvement of the PAA in the setup of the essential framework for Risk Assessment and ERP is here an important good practice note. As applicable, the PAA should define the applicable Risk Criteria and minimum Hazard Scenarios to evaluate in the context of a Risk Assessment (with reference to ISO/TS 18683 and EN ISO 201519). It is important also to note here that the requirements should apply to both Non-Seveso and Seveso Lower-Tier establishment as the Risk Assessment and Emergency Response Plan are not required by the Seveso III Directive for lower tier establishment.
15	Production and submission of **Risk Assessment** and **Emergency Response Plan**	BFO	Development of Risk Assessment and Emergency Response Plan following requirements from PAA (as good practice the minimum is to be established by ISO/TS 18683 and EN ISO 201519). There should however be a reference to these Standards in Port Regulations. For HAZID assessment the PAA should be involved in the workshop team. For SIMOPs Risk Assessment evaluation the multi-operator environment should be adequately defined, with representative information of all relevant activities and stakeholders involved.
16	On the situation that the intended location is not a Seveso establishment already (11) and having confirmed the applicability of Seveso, CA defines Tier for location.	BFO (possibly in cooperation with CA)	CA to determine Tier for Seveso classification of location-establishment. It is here important to integrate all possible Hazardous Substances in addition to LNG bunkering storage elements. The distinction between Lower and Upper Tier is to be made here on the exact basis of the threshold values present in Annex I to the Seveso III Directive.
17	Development of **Major Accident Prevention Policy (MAPP)** and decide on suitable **Safety Management System (SMS)**	BFO	Requirement for both Lower and Upper tier establishments. Development of Major Accident Prevention Policy and adequate setting up of a Safety Management System that is able to demonstrate that all possible major accident scenarios are addressed. In particular for Lower tier establishments it is important that **MAPP** and **SMS** are adequately aligned with the **Risk Assessment** and **Emergency Response Plan** drafted as a consequence of ISO 201519 where the same accident scenarios must be evaluated and the risk mitigation measures adequately outlined.
18	Approval of **Risk Assessment** and **Emergency Response Plan** by PAA	PAA	As a good practice measure the approval of Risk Assessment and Emergency Response Plan is to be made at PAA level, drafted as a consequence of ISO/TS 18683 and EN ISO 201519. PAAs should have the best overview perspective of the entire operational scenario and land planning, including multi-operator relevant aspects that are important to the adequate integration of all emergency response.
19	Approval of MAPP by CA	CA	MAPP and SMS for approval by CA – applicable to Lower and Upper tiers.
20	For Seveso outcome from (11), i.e. following positive confirmation from (11) it is here made the decision on **which tier would result from LNG bunkering facilities implementation**.	BFO (possibly in cooperation with CA)	For the situations where the intended location is already a Seveso establishment, the main objective at this stage is to evaluate, based on existing tier classification, what would the result be after the addition of the new LNG bunkering facility, considering not only the relevant LNG storage elements but also the details of the intended LNG bunkering operations. Should the location be Lower-tier, the objective for the evaluation should be to decide whether the location would need to be updated for Higher-tier or if, otherwise the classification of the location could remain unchanged.
21	For the cases **where a Lower Tier** has been determined following evaluation in (20), **calculate inventory and re-check Seveso classification.**	CA	In the case the location is already a Lower-tier establishment a re-calculation of the aggregated quantities of hazardous substance(s) including the LNG would have to be made, as this may bring the establishment into the upper-tier range, following the terms outlined in Seveso III Directive. The process diagram, following (21) indicates then the need to re-assess the tier for the location by connecting with (16) in the diagram.
22	Development and submission of a **Safety Report**	BFO	One of the distinct requirements for Higher Tier establishments is the production of a Safety Report, following the terms of Article 10 of Directive 2012/18/EU and covering all elements listed in its Annex II (*Minimum data and information to be considered in the safety report referred to in Article 10).* For LNG bunkering projects for facilities falling under Seveso, ISO 20519 and ISO/TS 18683 represent a set of technical measures that should be incorporated in addition to the requirements established in the Seveso III Directive for the Safety Report and Emergency Plan, as applicable. In fact it is here important to note that the requirements for the Safety Report, as contained in Annex II of Directive 2012/18/EU are only providing a framework for the actual study to be developed and produced.

Item in diagram figure 4.24		Who?	Observation/ Note/ Guidance
			The Safety Report should reflect directly the elements contained in the MAPP, SMS and, amongst other aspects, it should be able to address all the identified possible Hazardous Scenarios whilst, at the same time, listing the relevant mitigation measures.
23	**Data** provision for the following: • Details on multi-operator environment • Information on existing Hazardous substance inventory • EN ISO 20519 requirements for Risk Assessment to incorporated into Safety Report	BFO/PAA	Ports are typically multi-operator environments and that should be well taken into account in the definition of Emergency Plans, Risk Assessment, Safety Report, amongst other relevant instruments contributing to Permitting and Major Accident prevention. Relevant information regarding existing Hazardous substances already on site is also fundamental for the adequate classification of the location in the context of the Seveso Directive. Potential for Domino Effects to be evaluated according to Article 9 of Directive 2012/18/EU.
24	**Update** on "**Upper-Tier**" classification - following evaluation in (20)	BPO (possibly in cooperation with CA)	Request Upper Tier after including LNG Bunkering – Request: Update relevant documentation and procedures. The update of an already Upper tier establishment should focus in particular on the update of the Safety Report to reflect adequately the addition of the LNG bunkering facility/project. Potential for Domino Effects to be evaluated according to Article 9 of Directive 2012/18/EU.
25	**Internal Emergency Plan**	BFO	Develop an Internal Emergency Plan following Article 12, including elements in Annex IV
26	**Approval Safety Report** by CA	CA	Approval of the Safety Report including the following good practice procedure: • Check for completeness, according to Annex II of Directive 2012/18/EU. • Cross check with elements in the MAPP • Evaluate if all Hazardous scenarios are covered, incorporating elements which are relevant for the situational scenario in the intended LNG bunkering location. • Check if other onsite Hazardous Substance storage elements are considered. • Consult with the PAA
27	**External Emergency Plan**	CA/PAA	Having information as submitted by the BFO, under Article 12(1)(b), it is up to the *authorities designated for that purpose by the Member State* to *draw up an external emergency plan for the measures to be taken outside the establishment* (Article 12. 1 c)) The concept of the External Emergency Plan is of great importance in the actual design of the Safety concept for the whole LNG Bunkering facility. In fact, a potential LNG release scenario could very likely require the involvement of actions from other operators on site, emergency services, either from the Port or external, amongst several other entities. It is important that the External Emergency Plan is prepared in close observation of the Internal Emergency Plan and that they both work together to ensure the preparedness and response capability in the best time frame possible, as well as ensuring good communication and cooperation between the operator and external emergency services. It is suggested as a good practice that the PAA should be responsible for the preparation of the External Emergency Plan, consulting all possible entities involved to optimize the amount of hazardous scenarios covered and response measures designed. Emergency plans shall contain, at least, the information set out in Annex IV.
28	**Testing Emergency Plans and** Interoperability Check	PAA	Emergency Plans are to be tested at least every three years. It would constitute good practice to also check the interoperability between internal and external emergency plans and where relevant with neighbouring operators. BFO Internal Emergency Plan (IEP) to be checked for complementarity and interoperability with other Operators. In a multi-operator environment it is important that LNG bunkering is integrated into the wider complex context of other Emergency Plans that may co-exist. In exact terms there should be the sufficient flexibility to PAAs to bring the wider operators community to the process. It should here be possible to design wider scale Exercises to test and evaluate how well adapted Emergency Plans are, in terms of continuity of response[51]

[51] Continuity of Response is a term further explored in Section 14 of this Guidance, accounting for the need to have both external and internal ERPs sized and developed for a continuous response both in terms of Firefighting, Evacuation, Command and Control and External Emergency services.

4.6.5 EIA Directive

R4.40. **The EIA Directive is, together with the Seveso Directive, an instrument with a strong potential to influence and shape the permitting process for LNG bunkering projects. Having this in mind, and following the previous section where the applicability of Seveso was addressed, it is now important to highlight that LNG bunkering projects fall under the scope of the EIA Directive (Annex II) and have to undergo a screening by the national authorities to determine whether they need to be subject to an EIA procedure. PAAs should here exercise an important role in conveying updated and accurate information to prospective BFOs.**

R4.41. **EIA Directive (2011/92/EU as amended)[52] applies to a wide range of public and private projects, which are defined in Annexes I and II. For projects listed in Annex II, the EIA competent authorities have to decide whether an EIA is needed.**

The EIA also specifies the requirements on public participation in the process. This, together with the Public Consultation and information from Seveso Directive provisions, underlines the importance of the public involvement in the process. PAAs should be well informed and, consequently, inform adequately prospective BFOs, which applicable criteria is in place for EIA application. The indicative process is presented below, in figure 4.25.

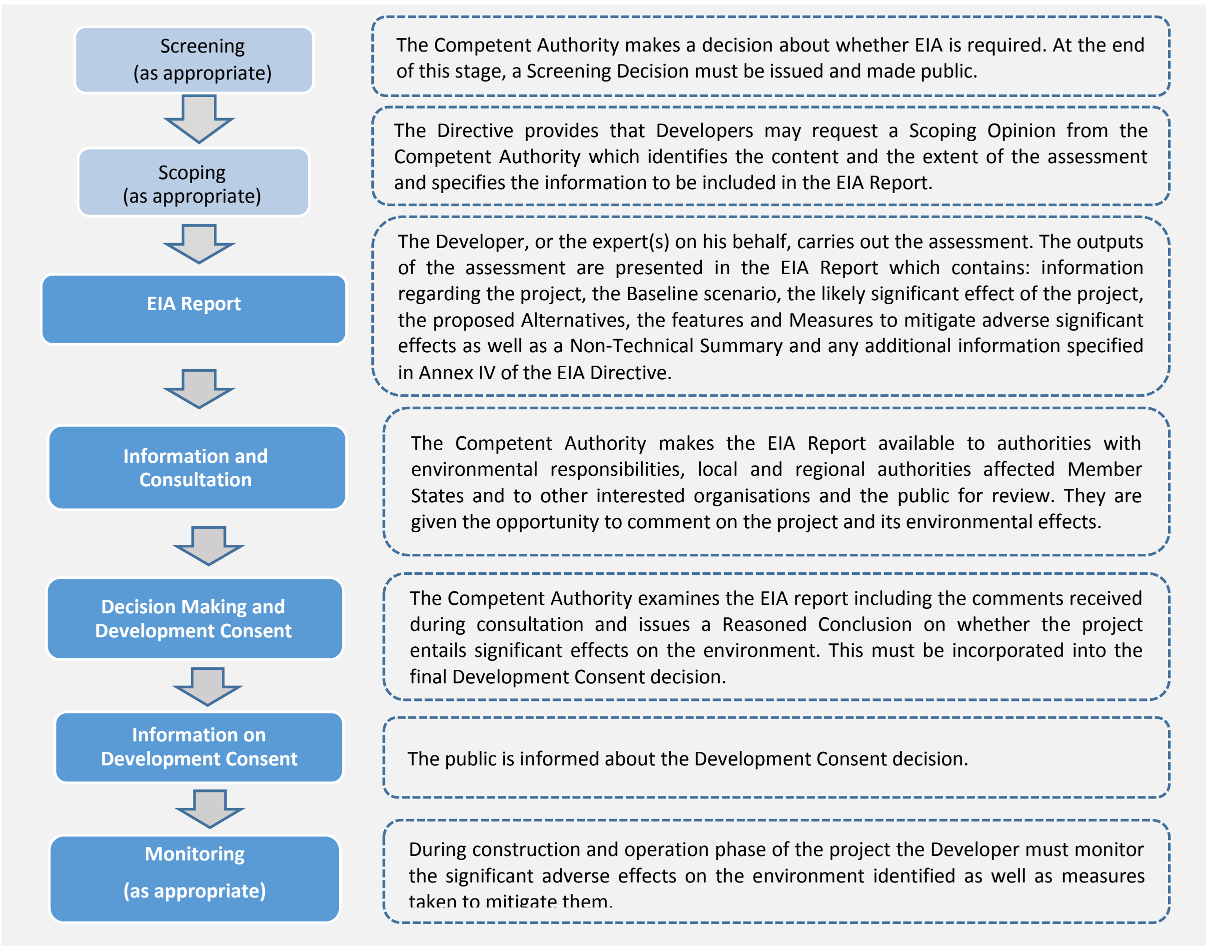


Figure 4.25 – Environmental Impact Assessment – General reference process

[52] The initial Directive of 1985 and its three amendments have been codified by DIRECTIVE 2011/92/EU of 13 December 2011. Directive 2011/92/EU has been amended in 2014 by DIRECTIVE 2014/52/EU

4.6.6 IGF Code

R4.42. **For ships certified according to the IGF Code (IGF Code ships) the application of a specific LNG Bunkering Plan[53] should meet all the requirements outlined in Chapter 8, Sections 18.4, 15.4 and 15.5 of the Code. Being all provisions specifically included in the code to ensure safe bunkering equipment, control and operations, it is important that, to the extent possible, all other parties involved in the LNG bunkering operation share the safety concept, terminology and procedures. National or local regulations for LNG Bunkering Operations should be adapted to IGF Code Goals, Functional Requirements and requirements outlined for the control and safety on LNG bunkering operations.**

R4.43. **Where different terminology is found, coexisting in the LNG bunkering interface, all parties involved should, as a best practice approach, align the operation and safety concept with the requirements of the IGF Code. Functional requirements are extracted from the IGF Code and included in table 4.6. IGF functional requirements should also be respected, wherever applicable, in the whole bunkering interface.**

R4.44. **For non-IGF Code ships, i.e. for ships built or converted to LNG as fuel before the entry into force of the Code (1st January 2017), the safety principles followed in bunkering should follow the same IGF regulations outlined in 18.4, especially in terms of responsibilities, pre-bunkering verification procedures, control systems, and all other requirements related to LNG bunkering operation.**

4.6.7 LNG Bunkering Guidelines and Standards

R4.45. **PAAs should have the LNG Bunkering Guidelines listed in Section 4.4 as the relevant documents where industry best practice is reflected, resulting from a significant number of stakeholders in the Industry with experience in LNG. Functional requirements for LNG bunkering equipment, where listed, are also the reflection of current experience and good practice, not only in terms of the LNG Transfer System equipment but also regarding operational aspects. PAAs should nevertheless be aware that these documents are not mandatory in nature and should, in the context of a legal framework, be incorporated as references into national or port regulations.**

R4.46. **For the particular case of ISO/TS 18683 or EN ISO 20519 a possible incorporation by reference into national or port regulations, would have to take into account the different nature of these two documents. Whilst some parts are repeated in both documents, there are very relevant aspects which can only be found in one or the other. This is the case with "Risk Assessment" (where ISO/TS 18683 includes a more thorough list of considerations) or with "Management system/quality assurance" where only EN ISO 20519 includes provisions that can be considered relevant[54].**

R4.47. **PAAs should note that EN ISO 20519 does not constitute a full substitute to ISO/TS 18683. Notwithstanding the repetition of some elements (as highlighted in section 3.3 and 3.4) both documents should be read together. As a Technical Specification ISO/TS 18683 contains elements which are relevant to design and procedures**

R4.48. **Existing LNG Bunkering Guidelines contribute collectively to the safe development of LNG bunkering, helping to promote safety though harmonization and shared responsibility. Provisions established by port regulations should, as far as reasonable and practicable, conform to the relevant technical aspects with the Guidelines, making reference, first, to international standards and, secondly, wherever more convenient or applicable, to industry guidance documents.**

EN ISO 20519 is referred to throughout this Guidance as the standard that should serve as a basis for certification, accreditation and quality assurance for all stakeholders. The

[53] "LNG Bunkering Plan" should here be understood in the exact terms defined in Section 1.4 of this Guidance. The concept extends from the IACS LNG Bunkering Guidelines (Rec.142) [3], where it is defined as "LNG Bunkering Management Plan".

[54] Reference to Section 7 in EN ISO 20519

EN notation is here essential to ensure that, at least in the EU the standard is incorporated in to all EU Member States as a national standard.

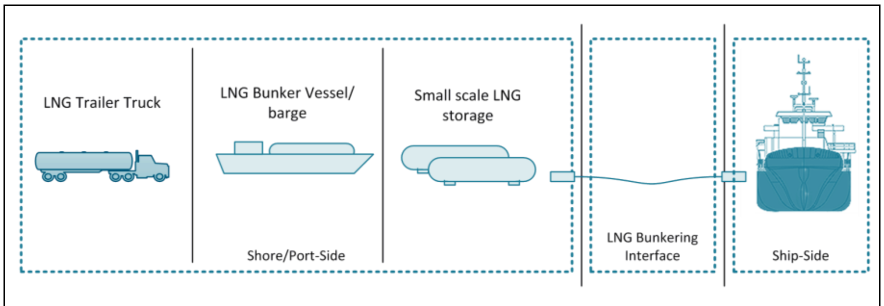
This standard represents an instrument of direct support to the IGF Code, providing the frame for implementation of IGF Section 18.4 provisions on bunkering operations.

4.7 Summary of Applicable Instruments

R4.49. **Table 4.17, below, provides an informative summary of applicable regulatory instruments, standards and guidelines in the context of LNG bunkering. Port Authorities should have the summary below as reference when having to quickly decide on the scope of application of each reference.**

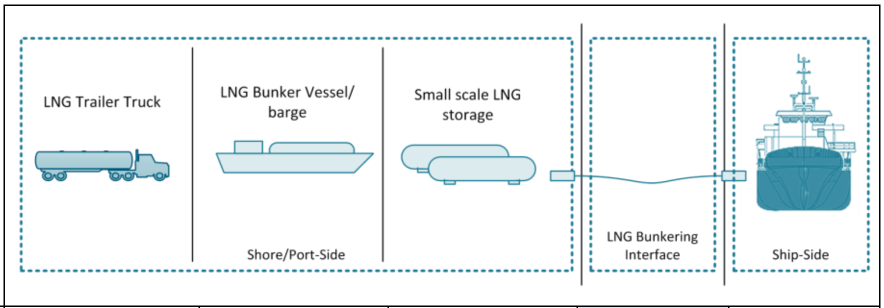
R4.50. **For the particular case of ISO/TS 18683 or EN ISO 20519 a possible incorporation by reference into national or port regulations, would have to take into account the different nature of these two documents. Whilst some parts are repeated in both documents, there are very relevant aspects which can only be found in one or the**

Table 4.17 – Applicable instruments in LNG Bunkering



	LNG Trailer Truck	LNG Bunker Vessel/ barge	Small scale LNG storage	LNG Bunkering Interface	Ship-Side
IGF Code					
IGC Code					
STCW Code					
Directive 2014/94/EC					
EU Ports Regulation 2017/352					
Seveso III	(subject to evaluation – applicable to location)				
ADN					
ADR					
EN 1473:2014			>200t[55]		
EN 1474-2					
EN 1474-3					
EN 12065	(testing of firefighting foam)				
EN 12066	(testing of insulating linings)				
EN 12308	(testing of gaskets)				
EN 13645			<200t		
EN 13766:2010					
EN14620:2006			LNG vertical tanks		
ISO/DTS 16901					
EN ISO 16903	(characteristics of LNG influencing design)				
EN ISO 16904					
ISO/TS 18683					
EN ISO 20088-1	(cryogenic protection)				
EN ISO 20519					

[55] Reference is here made for 2017 update of EN 1473, noting in particular that this standard is only for atmospheric storage tanks above 200 t (in the current version). An updated version should be issued in 2018 for pressure vessels > 200t.



ISO/TS 17177					
ISO 17776:2016					
ISO 18132-1:2011					
ISO 23251:2006	(Pressure-relieving and depressuring systems)				
IEC 60079-10-1:2015	(Classification of areas - Explosive gas atmospheres)				
IACS Rec.142					
SGMF Bunkering Guidelines					
IAPH Check-lists					
DNVGL-RP-G105					

5. Ports

The present Section highlights the role of Port Authorities and Administrations in the context of LNG bunkering, throughout the entire life-cycle of these projects, from concept to development and actual implementation, as differentiated Port Services.

How to incorporate LNG as fuel, and in particular LNG bunkering, into the different management policies for PAAs, is a fundamental aspect for the incentive and development of LNG bunkering. On a different formulation it is furthermore important to adapt management principles, policies and strategies to support the development of LNG bunkering projects.

The following aspects are covered in the present Section:

1. Different LNG bunkering scenarios (in the context of existing Port activities)
2. Good Governance and the role of port authorities in the development of LNG as a ship fuel, with a reference to the different implications of LNG bunkering for Ports managerial practice
3. Directive 2014/94 *on the deployment of an alternative fuel infrastructure* implementation;
4. Suggested Best Practice for PAAs in the context of LNG bunkering development as a differentiated Port Service.

The present section does not prescribe any elements for port management, nor is it intended to qualify governance models and ownership structures. Diversity is an important feature of the European port system, with no two ports operating in exactly the same way. The present Guidance, in line with European Port Policy[56] respects that diversity and does not seek even to suggest a uniform model for ports.

5.1 LNG bunkering for Ports

The diagram in Figure 5.1, below presents the interaction areas between PAAs, LNG bunkering supply organizations and costumer LNG fuelled ships.

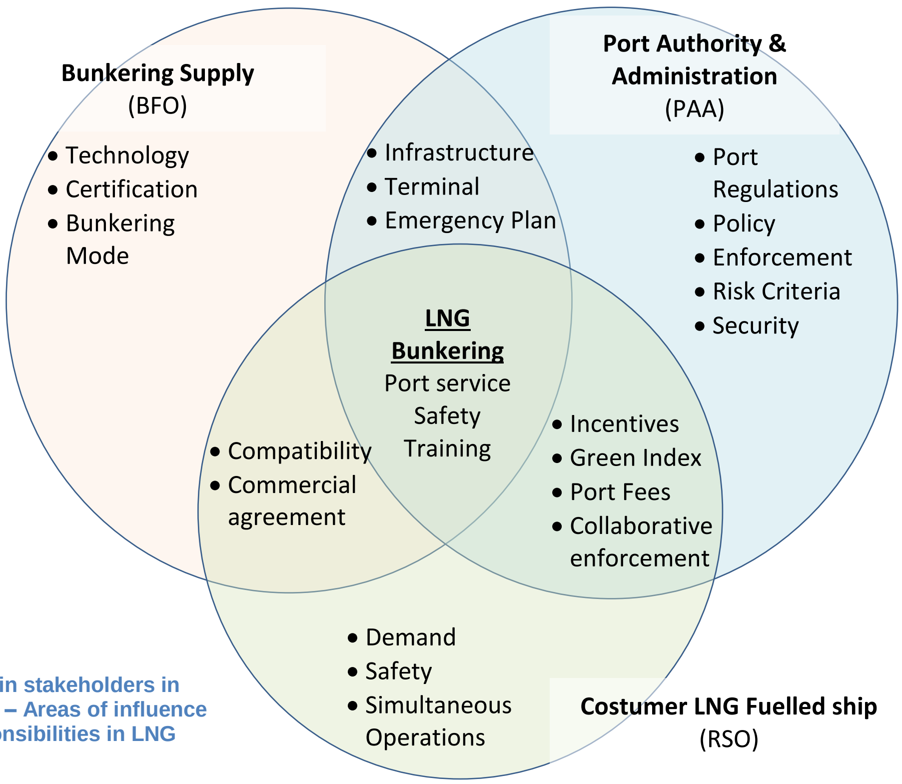


Figure 5.1 – Main stakeholders in LNG bunkering – Areas of influence and main responsibilities in LNG bunkering

[56] COM(2013) 295 – Ports: An Engine for Growth

Ports are today characterized by fast-developing multi-operator environments, evolving increasingly to corporatized and highly specialized service portfolio, where LNG bunkering is now becoming a relevant addition.

Figure 5.1, in the previous page, identifies the general areas of interaction between the 3 (three) main stakeholders in the LNG bunkering service development and implementation. The areas of interaction are not mutually exclusive but, instead, they complement each other in the implementation of LNG bunkering projects and sustainable services. The following three-partite generic arrangement can be identified (some variations may occur in the context of different port management and organization models):

- **<u>LNG bunkering supply organization</u>** (other organizations can be involved or directly related, such as the gas supplier, liquefaction or storage services, transport and distribution. Cooling, inerting, or even gas recycling can be also provided by other parties).
- **<u>Port Authority & Administration</u>** (Port Authority and Port Administration can be the same or different entities – see Section 5.3 for definition, or 1.4, together with other relevant terms and definitions).
- **<u>Costumer LNG Fuelled Ship</u>** (representing ultimately the demand side for LNG bunkering)

The 3 parties have, different interests and their inter-relations are characterized by different levels of communications and potential partnerships. Safety is expressed as an objective by all parties, but how much commitment to safety must be defined in clear regulations. Also on the subject of Safety it is furthermore important to establish measures of <u>acceptability</u> but also of <u>credibility</u> and <u>independency</u>. If Risk Criteria is used to define an "acceptable level" of risk, other criteria could be used to ascertain credibility and independency of risk evaluation results. This example for Safety is relevant also for other aspects of the LNG bunkering, such as compatibility assessment and other. To help identifying the relevance of "independency", figure 5.2 below, based in the diagram of 5.1, highlights the important separation vectors that must be observes to directly ascertain the adequate level of independency in LNG bunkering.

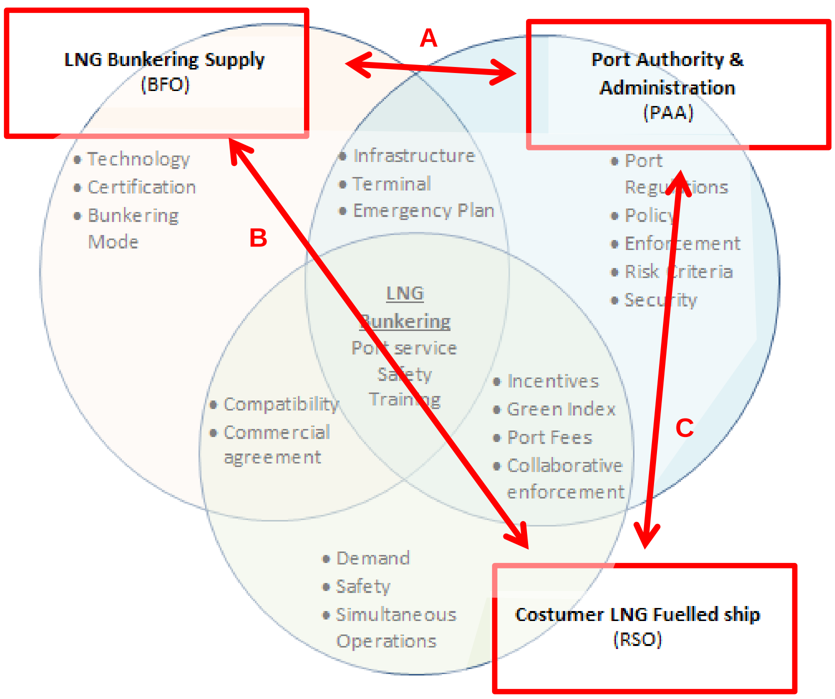


Figure 5.2 – Inter-relation links in LNG bunkering – for transparency purposes it should be possible to measure the distance between the 3 main stakeholders involved. How safe and credible the processes are is also very important.

On the basis of the above, a fundamental principle that should govern the inter-relationship vectors in LNG bunkering is the one of "Transparency". The distances "A", "B" and "C" should always be observed, in the best interest of "Transparency". In this sense, and following the same approach, whenever one of the distances could not be observed a potential conflict of interests could be claimed.

Figure 5.3, below presents a particular case where the LNG Bunkering Supply is totally or part-owned by the PAA. The absence of distance "A" leads to the potential conflict of interest situation when the Port Regulator function may be affected resulting in a less than ideal scenario that can affect transparency in the LNG bunkering process.

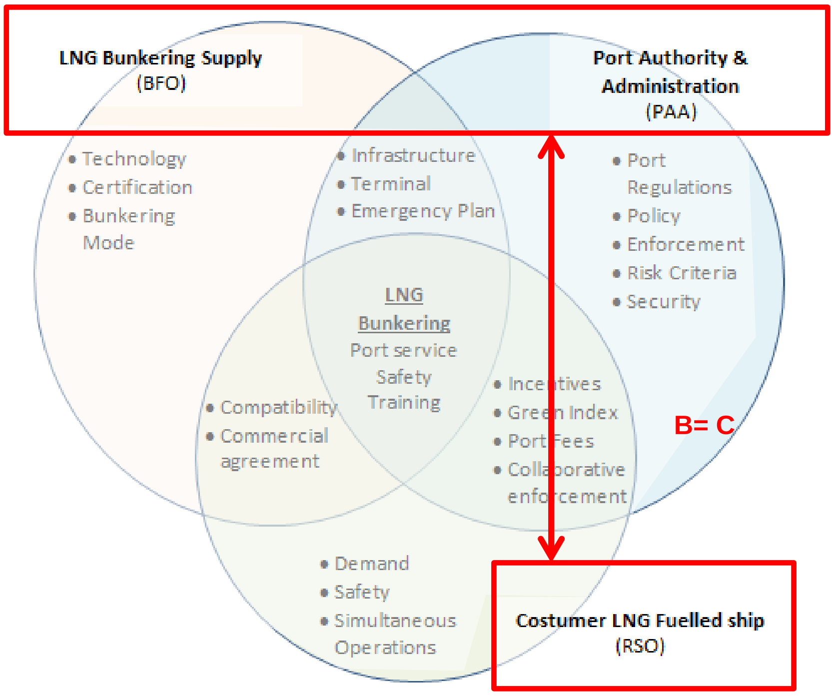


Figure 5.3 – Inter-relation links in LNG bunkering – When the LNG Bunkering Company is part-owned by the Port Authority/Administration

The situation below represents a case where BFO and RSO are the same company.

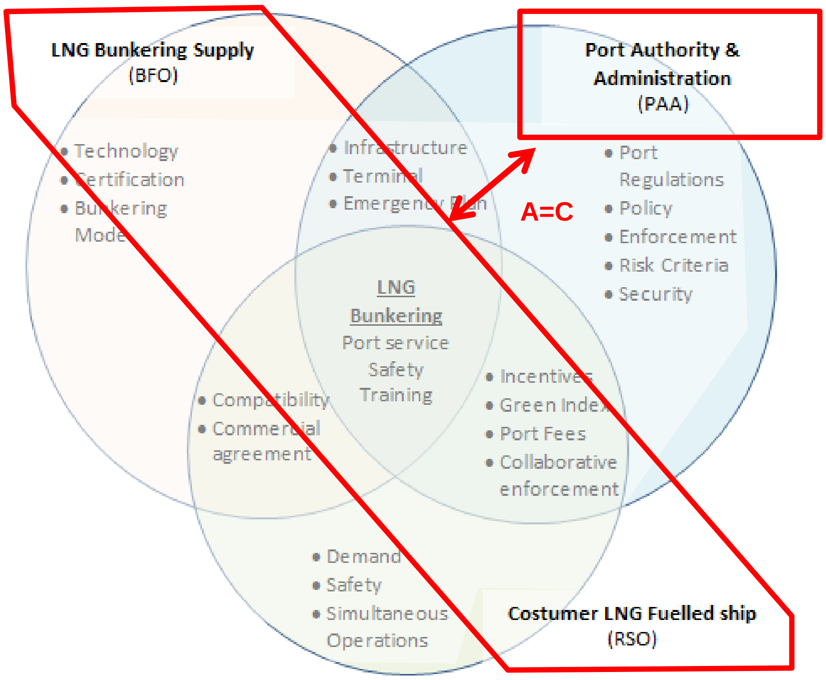


Figure 5.4 – Inter-relation links in LNG bunkering – When the LNG Bunkering Supply Company owns the LNG fuelled ship.

Situations like those presented in 5.3 and 5.4 are very specific in nature and, of course they do not immediately translate a situation where a conflict of interests could inherently result in a compromise, for instance, in safety. They represent however an illustration of the importance to keep the triangular formulation in LNG bunkering as an indicator (or measure) of transparency on the process.

Growing towards complex hubs in a multi-operator context, with management and organizational systems which differ significantly from port to port, PAAs should give a particular relevance to the need to ensure transparency in processes, with the involvement of the wider stakeholders' community inside and in interaction with the port.

Examples of processes where transparency is a fundamental pillar in LNG bunkering:

- Vessel compatibility Assessment
- Risk Assessment (whenever performed to ascertain ALARP[57] Risk levels).
- Permitting
- Simultaneous Operations
- Safety Distances.

When deciding or intervening on any of the above aspects BFO, RSO and PAA will interact within a specific regulatory frame (see Section 4) which can only be enforced to an adequate level if the processes are conducted with the necessary independency.

Compliance with EN ISO 20519, as introduced in Section 4, declared and inscribed as an objective within an appropriate Safety/Quality Management System should be the basis for the minimum requirement advisable as best practice. Enforcement is made easier through the provision of adequate "external audits" by a competent authority, whilst allowing planning and continuous development of processes by the Operators.

5.2 LNG small scale and bunkering scenarios

The above is even more relevant if we take into account the wide variety of Port activities that can involve LNG bunkering or, on a more widely scoped approach, small scale LNG applications and developments within the wider port area. Figure 5.5, below, and table 5.1 feature some of the possible LNG bunkering activities that may take part in a port, highlighting the need for good governance.

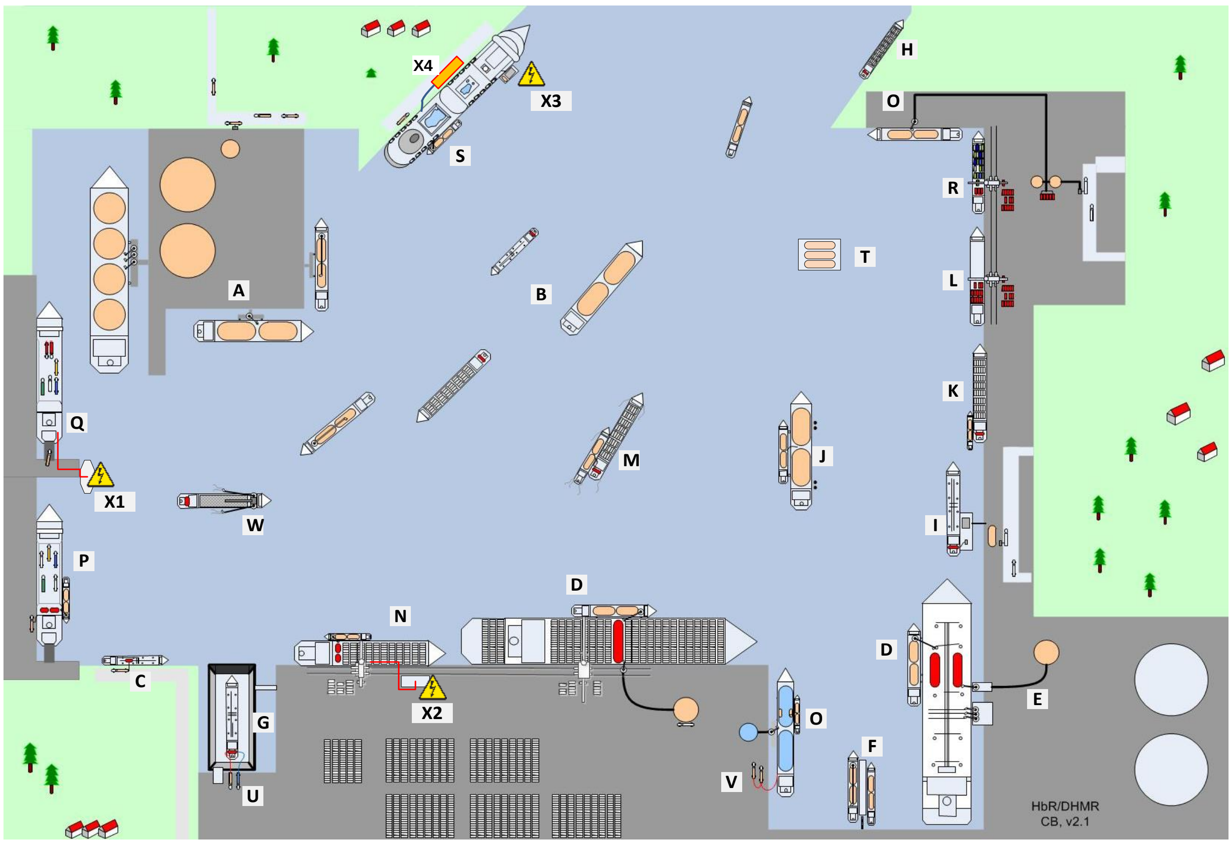


Figure 5.5 – Possible LNG bunkering activities and small-scale LNG activity within a generic layout of a Port

[57] ALARP – As Low As Reasonably Possible

Table 5.1 – LNG bunkering Activities in the wider port area (legend to Figure 5.5) - LNG bunkering situations are indicated with (LNG bunkering). Other situations are also described that do not fall within the context of LNG Bunkering but contribute to complete the small scale LNG frame within the port area. Even though the present Guidance is focused on LNG Bunkering, other small scale LNG elements within the port also need to be considered as, to some extent, they will be part of the LNG bunkering chain in the port area**.**

ID	Generic Port configuration (Figure 5.2)		LNG bunkering mode/ observations/ business model
A	Large LNG terminal, break bulk terminal	Import, export, gas to the grid, loading of LNG tank trucks, LNG tankers and LNG bunker vessels	LNG Terminals are fundamental in the feasibility evaluation of LNG bunkering projects. The proximity of an LNG terminal may represent a good indicator to the LNG bunkering potential for a given port. Should the Terminal be located within the port area it is important to take into account the wide variety of LNG break-bulk services that are also possible (e.g. LNG truck loading, bunker barge/vessel loading, re-gasification, etc.)
B	Maritime traffic	Including inland- and seagoing LNG tankers, LNG bunker vessels, LNG fuelled inland vessels and LNG fuelled seagoing vessels	Considerations on maritime traffic within the port basins, canals and navigable waters, should take into account the possible traffic of LNG fuelled vessels and LNG bunkering barges/vessels. Control, or potential restrictions, over maritime traffic, during bunkering operations, should be responsibility of the PAA. Adequate measures to control maritime traffic should be put in place.
C	Inland vessel **bunkering from a tank truck** (LNG bunkering)	LNG tank truck, bunkering of a LNG fuelled inland vessel or port service vessel	LNG bunkering by truck is typically associated to low flow-rates and low volume capacities. Smaller LNG fuelled vessels, such as inland vessels, with reduced LNG fuel storage capacities, will still be typical demand for LNG bunkering by TTS mode.
D	Seagoing vessel **bunkering with a large bunker vessel** (LNG bunkering)	**Ship to ship LNG bunkering** of large container ships or large crude oil carriers with a large LNG bunker vessel	In “D” the particular situation of a large containership being bunkered by an LNG bunker vessel is represented. This offers an interesting view on how large LNG fuelled containerships, in particular, will most likely receive LNG fuel. On one hand LNG bunker vessels will be able to deliver higher transfer rates and capacities. On the other hand, bunkering from the side opposite to the quay will favour potential SIMOPS, with the LNG being bunkered from the opposite side to the cranes operating, loading on/off.
E	Large seagoing vessel **bunkering from the shore** (LNG bunkering)	Shore bunkering of large container ships or large crude oil carriers from a local LNG buffer storage	Bunkering from shore, or the so designated PTS mode, will inherently involve fixed storage of larger LNG quantities, a distribution system with some way of fixed LNG pipeline and a fixed bunkering location with manifold or mechanical bunkering arm. Fixed bunkering locations represent high throughput solution at the cost of losing some flexibility.
F	Lay by berth for inland LNG (bunker) tankers	One cone berth for waiting inland LNG tankers	Location for LNG bunker vessels to berth whilst waiting for bunker delivery service. This can either be a designated lay-by position or coincident with the loading berth, where the LNG bunker vessel loads LNG.
G	Port service/ maintenance/repair for LNG fuelled ships	LNG-cryogenic maintenance, repairs on LNG tankers or LNG fuelled ships, cooling and de-gassing of LNG installations etc.	A large variety of maintenance/repair works are typically needed on board ships, both for corrective or planned maintenance purposes. LNG fuelled ships are not different in this regard. Maintenance needs may be directly related or not with LNG fuel systems onboard. It is important that any permits for work within the port are subject to a specific procedure and that all relevant details for the works are given to the PAA.

ID	Generic Port configuration (Figure 5.2)		LNG bunkering mode/ observations/ business model
			It is important here to distinguish between 1) Maintenance/repair conducted in designated shipyards or 2) in normal berthing location. Both cases should be regarded separately, with different considerations to be made.
H	Lay by berth for LNG fuelled ships	Lay by location	Lay by berth for LNG fuelled vessels should, in principle, deserve attention with regards to possible exposure to passing maritime traffic.
I	**Bunkering from a bunker pontoon** (LNG bunkering)	LNG bunkering from a bunker pontoon of inland LNG fuelled vessels, small seagoing LNG fuelled vessels, LNG fuelled port service vessels	LNG bunkering from a bunkering pontoon may seem, at first, a PTS bunkering mode. Careful attention should however be given to the fact that the pontoon may be considered a mobile unit, with implications to the applicable regulatory frame. The good practice approach advised in the current Guidance is to consider the LNG bunkering pontoon as semi-fixed infrastructure, to be considered within the adequate regulatory scope regarding major accident prevention.[58]
J	Ship to Ship (STS) LNG transfer	LNG transfer between seagoing LNG tanker, floating storage, Inland LNG tankers and LNG bunker vessels	The example in "J" represents a ship undertaking LNG bunkering whilst moored inside the port basin area. This STS arrangement can be achieved within the port area, in protected waters, as long as the maritime traffic is not impaired and due consideration has been given to navigational/collision risk. This should typically be a restricted possibility to authorized anchorages.
K	**STS LNG bunkering** of an inland LNG fuelled vessel (LNG bunkering)	LNG bunkering of an inland LNG fuelled vessel with a small LNG (inland) bunker vessel	STS bunkering of an inland LNG fuelled vessel, with a small LNG inland bunker vessel represents the situation where none of the vessels has to be a SOLAS vessel and, therefore, to which the IGF Code does not apply as a mandatory requirement. It is nevertheless important to assess the certification of such vessels according to their respective regulatory frame, with due consideration for the need to have these vessels certified, at least for bunkering of LNG fuel, with requirements that are at least equivalent to those of the IGF. Adequate compatibility to be assessed.
L	Distribution of LNG tank containers	Container vessel loading of LNG tank containers for distribution	Loading on/off of LNG containers is, in all aspects, a cargo handling operation. The important aspect to consider is the potential implication for the classification of the location in the port with regards to major accident prevention. LNG containers holding time is limited, therefore special consideration needs to be made with regards to the waiting times for such containers in the port area.
M	Sailing **STS LNG bunkering** (LNG bunkering)	LNG bunkering of an inland LNG fuelled vessel with a small LNG (inland) bunker vessel during sailing	Again, as in situation "K" this represents a case where none of the vessels has to be SOLAS. Similar concerns with regards to IGF equivalent requirements are to be made. Regarding the LNG bunkering operation itself, STS during sailing, within the port basin, it is at least possible to mention that very careful consideration needs to be made especially with regards to the need for careful collision risk analysis, accounting in particular for the local traffic conditions.

[58] As anticipated in Section 4.2.1 and 4.6.4, it is advised to evaluate the location where the LNG bunkering pontoon is moored as a potential Seveso establishment, taking the storage capacity of the LNG bunkering pontoon as the main indicative criteria for the classification of the location. Major accident prevention with regards to floating structures, such as pontoons, should lead to considerations that are likely to affect the adjacent port are surrounding the mooring location.

ID	Generic Port configuration (Figure 5.2)		LNG bunkering mode/ observations/ business model
N	**STS LNG bunkering** of a Short Sea / Feeder vessel (LNG bunkering)	LNG bunkering of a LNG fuelled short sea / feeder vessel with a small LNG (inland) bunker vessel	Similarly to "D" the situation here represented highlights the favourable aspect of STS as an LNG bunkering mode with the potential to allow for SIMOPs, with a feeder container vessels loading/offloading containers whilst bunkering from the outside. It is, of course, purely representative, and SIMOPs should follow a specific procedure, potentially based on a dedicated risk assessment. The operational advantage of SIMOPs is however, especially for containerships with very limited turn-around times at port, a very important aspect that PAAs should be sensible to.
O	Loading of a local LNG (buffer) storage	LNG transfer from a LNG tanker to a local LNG storage or bunker pontoon	Not an LNG bunkering operation. The represented situation, in the context presented, is more related to LNG break-bulk cargo operation. The relevance of the presented case is however directly related to the LNG small scale infrastructure within the port area. LNG storage onsite (local LNG (buffer) storage) is an important element of the fixed LNG bunkering solution (PTS LNG bunkering mode).
P	Ferry or Ro/Ro bunkering (LNG bunkering)	LNG bunkering from the shore, with an LNG tank truck or STS from a small bunker barge	RO-PAX is another typical example of ships with very limited turn-around times in port. For this reason SIMOPs are very important, with the potential need for LNG bunkering whilst passenger embarkation/disembarkation or vehicle roll-on/off is taking place. Typically location for RO-PAX operation is fixed in the port and, therefore, it is possible to implement dedicated mitigation measures to allow for SIMOPs to be potentially considered (e.g. enclosed passenger gangway). Management of vehicle flow is very important to avoid congestion traffic in the way of potential LNG trucks on site.
Q	Ro-Ro ship re-fuelling by tank container (LNG bunkering)	Unloading (empty) and loading trailers with LNG tank container for the ship propulsion	The case presented in "Q" is the particular case were LNG fuel is bunkering in a special containerized unit mode, with the LNG containers embarking via vehicle ramp to be plugged-in onboard. Specific requirements for the use of containerized LNG ISO units are present on the IGF Code. Aspects related to the control of access to LNG trucks are however to be dealt with by PAAs. As an opposite observation to the case represented in "P", in this particular situation the important point to make is that roll on-off of vehicle cargo movement should be restricted during onboard containerized bunkering, unless very specific mitigation safeguards are in place.
R	Container ship re-fuelling by tank container (LNG bunkering)	Unloading (empty) and loading LNG containers for the ship propulsion	The situation represented in this case is different from the one presented in "L". The case now presented is a special LNG bunkering operation, using LNG ISO containerized units. In this case containers are loaded-on from the shore using a crane and plugged-in onboard. Similar concerns for the waiting of LNG containers ashore can be mentioned. Holding time for LNG in the container is limited and due consideration to that fact should be given by PAAs whenever authorizing this type of LNG bunkering to take place within the port area.
S	**LNG bunkering of a cruise vessel**	**LNG bunkering** of a Cruise Ship **with a tank truck or LNG bunker vessel**	LNG bunkering for a large cruise ship will have to take, again, as in previous cases presented in "D" and "P" to take into consideration the short turn-around times for such ships.

ID	Generic Port configuration (Figure 5.2)		LNG bunkering mode/ observations/ business model
	(LNG bunkering)		In addition to this the very likely large number of passengers onboard will add another important factor to take into consideration. The risk assessment for any potential LNG bunkering with embarkation/ disembarkation of passengers will have to take these factors into consideration. Replenishment of goods, short port maintenance services amongst others, are typical services that concur during the short stay of cruise ships in a given port. It is very important that PAAs have in consideration the need to coordinate any LNG bunkering operation in the context of multi-operator scenario.
T	**Floating Storage Unit**	**Floating Storage Unit (FSU)** for the storage of LNG away from shore berthing position. For buffer storage and/or LNG bunkering.	The use of FSU solutions for LNG bunkering is a possible option within the port area. Aspects related to the following aspects need to be carefully observed: <u>1) Regulatory frame</u> It is important to determine which regulatory frame best applies to this specific case. MODU or IGC code would not be mandatory in case of inland FSU. Requirements can however be used to assess certification as good practice. <u>2) Major accident prevention</u> Applicability of major accident prevention measures will depend on elements such as LNG storage capacity of the FSU and its location. Even if this is, in practice, a floating unit, it should be assessed with regards to possible impact on port area location. <u>3) Risk Assessment</u> Aspects related to LNG FSU unit, its location and intended bunkering operation profiles should be subject to risk assessment under agreed conditions by all parties. Aspects related to the Risk Assessment need to take into consideration assumptions It is very important to define the anchoring location for the FSU taking into account collision risk analysis and the particular maritime traffic profile in the area.
U	Bunkering (commissioning) at a dock yard (LNG bunkering)	Following planned repair period, at a dock yard, the first filling of the LNG storage tanks onboard requires special attention.	Commissioning of LNG storage tanks will require inerting and cooling services to be provided. The first filling of the tanks involves a complex procedure where it needs to be guaranteed that no air is present in the LNG tanks for the loading of LNG fuel (inerting) and that the tanks are sufficiently cool to avoid excessive boil-off (cooling).
V	Multi-truck bunkering (LNG bunkering)	TTS bunkering mode where several LNG trucks bunker an LNG fuelled vessel through a common manifold.	The situation represented in “V” offers a view of a possible variation from the TTS LNG bunkering mode where several LNG trucks are used to bunker an LNG fuelled vessel. The number of LNG trucks is only limited by the number of plug-in connection in the manifold structure and, in practice the LNG bunkering capacity and possible flow rate will depend on the exact manifold arrangement. The multi-truck bunkering solution should deserve careful consideration from PAAs, especially in terms of bunkering procedures, including inerting of the manifold connections, piping and hoses and considerations for connection/disconnection of

ID	Generic Port configuration (Figure 5.2)		LNG bunkering mode/ observations/ business model
			successive trucks onto the manifold.
W	LNG fuelled dredger	LNG fuelled service vessel.	Operation on LNG with significant improvements for local air quality, especially for energy intensive ships like dredgers. Tugs are likely to adopt the same principle, favouring the use of cleaner fuels in the port area. Having service ships fuelled with LNG is part of a strategy to improve the quality of the port as an LNG hub, diversifying and increasing demand.
X1	**Electrical Energy supply** to a feeder containership	Electric power supply by floating LNG driven generator set (at a distance from the supplied ship)	Electrical energy supply from an LNG "power barge". Electrical energy is supplied to the receiving ship as "shore side electricity". No LNG transfer occurs between power barge and receiving vessel. This may represent a new advantage from the use of LNG to produce energy in ports, reducing the footprint from ships at berth (any type of ship), allowing for electrical energy supply for all hotel load and services whilst at berth. Considerations with regards to the LNG capacity stored onboard the "power barge" can be made, especially if the amounts of LNG stored onboard are in excess of 50t (lower tier threshold for Seveso
X2	**Electrical Energy supply** to a feeder containership	Electric power supply by shore-side mobile LNG driven generator.	Electrical energy supplied from an LNG fuelled shore-side generator. In all things similar to shore-side electricity supply, with the particular case that LNG storage onsite may have to be considered, even if attached to modular containerized unit. Risk assessment to be performed in order to identify possible risks from solution presented.
X3	**Electrical Energy supply** to a cruise ship	Electric power supply by floating LNG driven generator set (alongside the supplied ship)	Electrical energy supplied by LNG "power barge" from location alongside the receiving ship. The substantial differences in comparison with "X2" are in essence that in this case we have a cruise ship and the proximity of the LNG "power barge" is very close to the receiving vessel. On one hand the risk from potential LNG hazardous event would be higher and, on the other hand, the proximity of the "power barge" would also represent that any potential LNG hazard in the barge could potentially escalate to the receiving ship. This is merely indicative and a specific risk assessment would have to be made taking these factors into account.
X4	**LNG fuel supply** directly to Generator onboard the ship	LNG fuelling operation, with LNG directly feeding dual fuel engine onboard a cruise ship.	For a ship with no onboard LNG storage, but with engine(s) that are prepared to run on natural gas/dual fuel, it is possible, at berth, to feed in this fuel from an external LNG storage unit. Even though it may look like normal LNG bunkering, involving the transfer of LNG to a receiving ship, there are a few distinctive features that should be taken into account: • <u>Transfer of very low LNG fuel volumetric rates</u>, mainly dictated by the onboard engine fuel consumption rate. Unless a buffer tank exists onboard the rate of transfer will correspond to the engine consumption. When compared to the volumes transferred in bunkering this should be much less. • <u>Delivery unit (LNG truck, barge or ISO container) stay close to the ship for longer periods.</u> In fact the presence

ID	Generic Port configuration (Figure 5.2)	LNG bunkering mode/ observations/ business model
		of the LNG supply/storage will last for the whole visit of the ship, with the energy at berth coming from the LNG fuelled onboard generator. • Regasification can occur either at the delivery or inside the ship, through a dedicated evaporator. Different configurations are possible depending on how technically prepared the ship is to undertake such type of operation. PAAs should take into consideration particular elements for this type of operation, such as: i. Regulatory frame. Even though not a typical LNG bunkering operation it is important to frame LNG fuelling into the existing instruments for LNG bunkering (EN ISO 20519, ISO/TS18683, IACS Rec.142) ii. Risk Assessment to be conducted, as indicated in the diagram in figure 4.21, where agreed possible hazardous scenarios must be reflected. iii. Safeguards to implements, derived from RA above, or others, such as 1) physical barriers, 2) Detection and Alarm, 3) access restriction, 4) Emergency response measures, 5) Dispersion mitigation measures, amongst others. iv. Manned attendance of the LNG delivery point. Taking into account that this is a type of operation that may extend for several hours, it is important to have consideration for the possible need to ensure manned attendance of the LNG delivery point/storage. This should be an important point focused at the RA. v. Credible release scenarios. In the context of the RA it is important to determine what would be a credible release scenario from such an LNG fuelling operation.

5.3 Ports Good Governance for LNG Bunkering

Good governance in LNG Bunkering development in Ports, like in other activities, has 9 major characteristics. It is participatory, consensus oriented, accountable, clear, transparent, responsive, effective and efficient, equitable and inclusive, and follows the rule of law. Good governance is responsive to the present and future needs of the organization, exercises prudence in policy-setting and decision-making, and that the best interests of all stakeholders are taken into account.

In the specific context of LNG as fuel PAAs will have the overall responsibility for the good governance and the safety framework for LNG bunker operations in the port. Decisions and requirements for LNG bunkering should be based on a risk analysis carried out in advance, and in the early-involvement of all parties. In this way the port can conduct public affairs and manage public resources. Again, as introduced in the previous section, transparency plays a major role as one of the Good Governance Principles listed.

Table 5.2, lists the relevant principles of Good Governance in LNG bunkering that should serve a safe, sustainable and harmonized development of this activity as an important multi-operator and relevant activity in the port area and service portfolio.

Table 5.2 – Principles for Good Governance in LNG Bunkering

Good Governance principle	Description of Good Governance Principle	Good Governance for LNG bunkering development in Ports
1. Rule of Law	Good governance requires fair legal frameworks that are enforced by an impartial regulatory body, for the full protection of stakeholders	• Imperative to follow: - International Regulatory frame (IGF Code, IGC Code, EU Regulations and Directives) - Both ship-side and shore-side regulatory context. • Particular attention to be given to EU Directives as transposition into national law leads to different implementation exercise between EU Member States. • Develop adequate Port Regulations/ bye-laws, inclusive of LNG bunkering. • Refer Standards in regulations to allow legally binding reference for Operators to follow. Standards are not mandatory instruments unless they are included/ indicated in mandatory instruments. • Ensure adequate level of information to all stakeholders on the applicable regulatory frame to LNG Bunkering. • Ensure that all Competent Authorities implied in LNG bunkering are involved and that no conflicting requirements exist.
2. Clarity	The framework, its rules and their justification, the governing principles and schemes, should be clear to all stakeholders.	• In addition to the points above, the framework for the application of law should be clear and understandable to all stakeholders, in particular to Operators. • Scope and applicability of regulations should be clear, with particular consideration for the different characteristic modes of LNG bunkering. Notwithstanding the fact that more general provisions can be applicable to all modes, it is important to realize and be clear in the rules as to which particular measures/requirements apply to each particular LNG bunkering mode.
3. Transparency	Transparency means that information should be provided in easily understandable forms and media; that it should be freely available and directly accessible to those who will be affected by governance policies and practices, as well as the outcomes resulting therefrom; and that any decisions taken and their enforcement are in compliance with established rules and regulations.	• Easy access to rules and requirements for LNG bunkering operation in a specific port is fundamental. . • Web-based information access should be privileged, without prejudice to other potential communication media where access to other stakeholder is found to be more adequate.
4. Responsiveness	Good governance requires that organizations and their processes are designed to serve the best interests of stakeholders within a reasonable	• The ability to respond to the needs from operators, within an adequate timeframe is fundamental for the confidence in the processes and competencies of the port. • LNG bunkering, as in other oil fuel bunkering

Good Governance principle	Description of Good Governance Principle	Good Governance for LNG bunkering development in Ports
	timeframe.	operations is a highly time-sensitive business. LNG is to be delivered on-time, as scheduled, to ships which are often under the pressure of time. This should not only be taken into account by PAAs, it should motivate PAA to develop mechanisms to swiftly respond to concrete technical, operational or administrative needs from Operators, in the frame of their competencies. • Permitting is another aspect of LNG bunkering which is highly time-critical, notwithstanding on a different time scale. Responsiveness in the particular context of LNG bunkering permitting is one of the factors that may contribute most to the reduction of inefficiencies in permitting processes.
5. Consensus Oriented	Good governance requires consultation to understand the different interests of stakeholders in order to reach a broad consensus of what is in the best interest of the entire stakeholder group and how this can be achieved in a sustainable and prudent manner.	• Within the applicable legal frame reaching consensus and common understanding in LNG bunkering is essential for the success of projects, implementation and operations. • The width and ambition of consensus should be adequate to the complexity of the LNG bunkering solution and to the impact of that project to other operators within the Terminal or Port area. • Consensus with the wider public community is also fundamental, as applicable and necessary, and should not be limited to public consultations required by legal instruments. • A permanent platform for dialogue should be established.
6. Equity and Inclusiveness	The organization that provides the opportunity for its stakeholders to maintain, enhance, or generally improve their well-being provides the most compelling message regarding its reason for existence and value to society.	• Equal opportunities to operators wishing to initiate LNG bunkering projects should be given, in the particular context of the Port, with due consideration to operational and spatial limitations. • Equity and Inclusiveness should be exercised, as a priority, in the access to information and support to permitting initiation. • All operators should receive the same level of information, same level of opportunity to demonstrate the concept projects and feasibility for a given intended LNG bunkering development. .
7. Effectiveness and Efficiency	Good governance means that the processes implemented by the organization to produce favorable results meet the needs of its stakeholders, while making the best use of resources – human, technological, financial, natural and environmental – at its disposal.	• Processes should be mapped. Criteria and Key Performance Indicators should be defined for an adequate measurement of Effectiveness and Efficiency. • All the life-cycle of an LNG bunkering project should here be subject to adequate measurements of effectiveness and efficiency (regarding the action of the PAA): i. Concept Project ii. Permitting iii. Implementation iv. In –service v. Surveys vi. Modifications vii. Surveys viii. Temporary Cessation ix. Decommissioning

Good Governance principle	Description of Good Governance Principle	Good Governance for LNG bunkering development in Ports
8. Accountability	Accountability is a key of good governance. Who is accountable for what should be documented in policy statements. In general, an organization is accountable to those who will be affected by its decisions or actions as well as the applicable regulations.	• PAAs are accountable to Operators in the exact measure of the applicable legislation. • In addition to Mission Statement and other Quality related instruments, PAAs should identify clearly who, and in which areas, is responsible and accountable, in all areas of the Port Administration, including LNG Bunkering, Safety, Emergency, and other related responsibility areas. • For the sake of Good Governance the adequate channels for complaints, appeals and suggestions should be clear, accessible and included as part of a Quality Management System. • Independent investigation of incidents should be ensured.
9. Participation	Participation is a key cornerstone of good governance. Participation needs to be informed and organized.	• In the interest of a sound port operating environment, all interested stakeholders should be given the opportunity to participate, comment and interact • Participation of the wider public community is also fundamental, as applicable and necessary, and should not be limited to public consultations required by legal instruments. • A permanent platform for dialogue and participation should be established.

Good governance is an ideal which is difficult to achieve in its totality. Governance typically involves well-intentioned people who bring their ideas, experiences, preferences and other human strengths and shortcomings to the policy-making table. Good governance is achieved through an on-going exercise that attempts to capture all of the considerations involved in assuring that stakeholder interests are addressed and reflected in policy initiatives. It should be all-inclusive and drawn in respect to an existing regulatory frame which is well understood by all parties.

In the same way that different Ports will have different management models, also Good Governance is different for every port so the list of items above is just guidance. It depends on your customers' needs and LNG availability. Some ports only will be in need of the distribution of LNG to Small River crafts, other ports only will have LNG fueled seagoing vessels to be bunkered at anchorage. Most ports will have a mix of customers, all with their own LNG bunker needs.

5.4 Port Authorities and Port Administrations

5.4.1 Definitions

Ports usually have a governing body referred to as the port authority, port management, or port administration. Port authority is used widely to indicate any of these three terms.

It is, in the particular context of this Guidance, important to underline the definition used for Port Authority & Administration (PAA). The concept contains, in practice, a "two-in-one" definition: The "Port Authority" and the "Port Administration". Even though merged together in the present Guidance, the two concepts have distinct definitions, with one responsible for the enforcement of the applicable legal provisions, and the other for the management of the port. Today's management models followed by some ports have however merged these two, in fact, allowing for the corporatization of port authorities, serving the interest of an increasingly dynamic port activities' environment.

In Regulation (EU) 2017/352 Port Authority and Port Administration are defined, respectively, through the concepts of "competent authority" and "managing body of the port". Definitions given as per table below

Table 5.3 – Port Authority and Port Administration definitions

Regulation (EU) 2017/352	EMSA Guidance	Description (from Regulation (EU) 2017/352)
Competent authority	**Port Authority**	Any public or private body which, on behalf of a local, regional or national level, is entitled to carry out, under national law or instruments, activities related to the organisation and administration of port activities, in conjunction with or instead of the managing body of the port;
Managing body of the port	**Port Administration**	Any public or private body which, under national law or instruments, has the objective of carrying out, or is empowered to carry out, at a local level, whether in conjunction with other activities or not, the administration and management of the port infrastructure and one or more of the following tasks in the port concerned: the coordination of port traffic, the management of port traffic, the coordination of the activities of the operators present in the port concerned, and the control of the activities of the operators present in the port concerned;

Adequate implementation of LNG bunkering will depend on the good coordination of both Port Authority and Administration core activities, especially bearing in mind that other authorities play an important part also in facilitation, permitting, emergency response, amongst other aspects. From the adequate and well-structured regulatory frame, taking into account international, regional and local/port aspects, to the execution of different approval and control activities it is the responsibility of PAAs to coordinate the necessary efforts to allow the best development of LNG bunkering activity within the port area.

Good practice Guidance in this document is applicable to the different parts of the LNG bunkering activity, throughout the different stages of its life cycle.

5.4.2 Port Roles and Responsibilities in LNG Bunkering

Table 5.4, below, outlines the main Port Roles and responsibilities, in the context of LNG bunkering, integrating both "competent authority" and "administration" aspects and highlighting the challenges that should be met by PAAs.

Table 5.4 – Port Authority and Port Administration roles and responsibilities in LNG bunkering

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
Develop a regulatory framework for LNG bunkering in the ports	As indicated in Section 4 the development of an adequate Port Regulation that is inclusive of LNG bunkering, is the fundamental instrument for the development of this activity. Ensure adequate integration of different LNG bunkering standards. (Refer to Section 4 in this Guidance)	X	X
Allow for adequate information on LNG bunker activities within the port	Implementation of well-documented permitting procedures, including relevant provisions for		X

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
by reporting procedures	management of modifications. Definition of adequate channels for communications, with the identification of the responsible Port representative(s), electronic address, or other that should be taken into account by RSO, BFO or other interested parties. Adequate information channel for reporting of incident and near-misses in LNG bunkering. (Refer to Sections 7, 12, 13 and 15 in this Guidance)		
Develop restrictions on bunkering operations if necessary	Restrictions on bunkering operations can be of several types and dependent on different factors: • Risk Assessment based Restrictions and limitations may be the practical result from risk assessment results. These may be restrictions on bunkering parameters (pressure, flow rate, hose diameter) or restriction in other operational aspects. • Weather based Weather elements, such as wind, rain, temperature can determine possible operational envelopes. • Local harbour/maritime traffic Special local maritime traffic conditions can dictate restrictions to bunkering. PAAs should be able to aim for a balance of normal operating profiles within the port, whilst ensuring the sufficient safeguards for the LNG bunkering location. • Security restrictions Restrictions on LNG bunkering may arise from possible security related elements. Ports should avoid, to the extent possible, to favour restrictions in looking for safe LNG bunkering operations. It should be important to develop a favourable environment for this type of operations, based on a minimum restriction approach (Refer to Section 12 in this Guidance)		X
Approval of Safety Zone in way of the bunkering area	The safety zone is an important parameter that should be calculated by the BFO and approved by the PAA. It is important, as good practice, to allow sufficient freedom to the BFO to elaborate on LNG bunkering parameters, local safeguards and to submit the proposal to the PAA for evaluation and approval. It should be avoided, also in the terms of a good practice approach, a fixed safety distance applicable to all situations. This approach is not consistent with the mechanism that justifies the fixation of the safety distance, based on considerations on gas dispersion. Since this is fundamentally affected by environmental and local conditions, it is important to evaluate a proposed	X	X

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
	safety distance also in the light of these parameters. (Refer to Section 9 in this Guidance)		
Definition of Security Zone around bunkering location	The definition of the Security zone should be a responsibility of the PAA (eventually defined by the Administration and approved by the Port Authority. The fundamental objective of the Security Zone is to allow control of any possible element that may cause interference with the LNG bunkering operation. Maintenance of the Security Zone should be a responsibility of the PAA, allowing for an alternative security maintenance scheme if so agreed between all parties, subject to approval of the Port Authority. (Refer to Section 9 in this Guidance)	X	X
Confirmation of Hazardous Zone	Surrounding the LNG bunkering manifold connections a hazardous area shall be defined at the responsibility of the BFO and RSO. Port Authorities should confirm by inspection that all personnel working and equipment used inside Hazardous Zones is adequately certified for the area in consideration. PPE and EX-proof material should be used. Even though a responsibility of the parties involved, the maintenance of the permitting should be based on periodic confirmation by PAAs that all safety procedures and measures are well kept in place and ensured by parties involved. (Refer to Section 9 in this Guidance)	X	
Approve and enforce additional control zones (in addition to Hazardous, Safety and Security Zone)	In addition to Safety Zone and Security Zone, other Control Zones may be defined to ensure the safe execution of LNG bunkering operations, These may involve navigation restricted areas or other control zones. It is important that the definition of relevant control zones is effective and adequately enforced. The definition of the relevant zones should take into account the local conditions and infrastructure that may influence the access control to these areas. (Refer to Section 9 in this Guidance)	X	
Establish passing distances for other ships during LNG bunkering	Either in context with Safety or Security zones, or even separately, the control of passing navigational traffic should be a concern of PAAs. The necessary measures should be developed, implemented and adequately enforced in order to restrict navigational traffic in the way of the LNG bunkering location. The need for control of passing navigational traffic will also vary according to the LNG bunkering type into consideration (STS at berth, STS at anchor,	X	

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
	PTS, TTS) with all STS modes deserving the closest attention. Similarly to all control zones, also in the definition of passing distances for other ships the main objective is to avoid any external interference on the LNG bunkering operation. (Refer to Section 9 in this Guidance)		
Mooring requirements	Safe mooring during LNG bunkering operations is a fundamental element to allow a stable and secure LNG bunkering interface. It should be the role of the PAA to define the standard requirements for mooring, including under which conditions reinforced or special mooring should be considered. Mooring of the receiving ship and bunker facility, industry standards may be referenced (e.g. OCIMF Effective Mooring 3rd Edition 2010) (Refer to Section 12 in this Guidance)		X
Develop environmental protection requirements	As mentioned in Section 3, LNG bunkering operations should deserve careful attention with regards to potential negative environmental impact. The adequate prevention of any methane release in connection/disconnection, inerting/purging, or even in pressure relief, depends mostly on the definition of good procedures for pre-bunkering, bunkering and post-bunkering phases, including consideration for equipment compatibility. It is important that PAAs establish as a minimum requirement that no venting is allowed. Adequate measures for control should also be developed. (Refer to Sections 3, 12 in this Guidance)		X
LNG bunkering checklists	The implementation of LNG bunkering checklists is an important measure to ensure adequate documentation of important aspects of LNG bunkering operations. IAPH check-lists, ISO 20519 or their adaptation as include in the present Guidance, can be used for this purpose. It is the role of the Port Administration to ensure that adequate verification and treatment of validated check-lists is adequately done. This may be either part of the port regulations or a requirement derived from the permitting process. (Refer to Section 10 in this Guidance)		X
Develop proposals for spatial planning and bunker locations	Concurrently with other competent authorities with responsibilities for land planning, use, classification and administration, PAAs should consider the need to integrate possible LNG bunkering locations into the spatial planning of the port.		X

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
	A possible approach is to determine pre-destined locations for LNG bunkering, allowing for easier prospective permitting processes. Important elements to take into account for spatial planning: • Waterways accessibility • Proximity of locations handling/storing hazardous substances • Emergency response facilities • Proximity of Populated areas and commercial services Commercial. • Areas of restricted security (Refer to Section 7 in this Guidance)		
Approve Spatial planning elements and LNG bunkering location	Based on elements developed in the proposal for spatial planning, above, it should be the role of the Port Authority, following the administrative proposal, to assess the compliance of the proposal with respect to major accident prevention requirements and other national port authority regulations. (Refer to Section 7 in this Guidance)	X	
Develop measures to allow possible simultaneous activities and operations (SIMOPs) during LNG bunkering	Simultaneous Operations (SIMOPs) are an important aspect to consider especially in LNG bunkering of larger ships with short turn-around times (such as passenger vessels and container ships). PAAs should be involved and dialogue with interested parties, from the beginning, in the development of the necessary measures to allow SIMOPs to be conducted in the safest operational environment possible. Port Administrations, as a good practice approach, can be involved with the role of finding and developing the necessary solutions, in support to BFO and RSO, that can support SIMOPs to take place (Refer to Section 11 in this Guidance)		X
Approve SIMOPs	Port Authorities should be responsible for the approval of SIMOPs. This approval can however be distinguished in two levels: 1) Permitting and 2) Approval. In the first the BFO and RSO may be certified, within a given permit for operation, to undertake SIMOPs. On the second, Approval, the Port Authority should confirm that all necessary and agreed elements in the permit are well in place. (Refer to Section 11 in this Guidance)	X	
Develop general procedures for traffic control and restrictions in case of an LNG bunkering	Both to ensure the integrity of the Safety and Security zones (and any other control zones defined by the PAA) it is important to define relevant traffic control and restrictions. Amongst the measures for traffic control the following can be considered:		X

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
	• Visual signals and traffic indications • Speed limit (with possibility to vary speed limit indication depending on operational context). • Barriers to restrict traffic • Traffic lights for temporary restriction • Active manned traffic control • Traffic diversion The adequate degree of authority should be ensured to implement and enforce the defined Traffic restrictions. (Refer to Section 12 in this Guidance)		
Establish clarity on the roles and responsibilities between the involved parties	The adequate definition of responsibilities between all parties involved should be a central aspect of Port Regulations. In the absence of definition in relevant port instruments the responsibilities to be defined should take EN ISO 20519, the present guidance and Industry relevant guidelines. PAAs should also define clear internal division of responsibilities (permitting, inspections, emergency, amongst others) (Refer to Section 12 in this Guidance)		X
Emergency Response Plan (internal) Approve internal LNG bunkering facility emergency response plan.	PAAs should, in cooperation with other relevant competent authorities, approve the Emergency Response Plan developed by the BFO. In approving the internal ERP PAAs should develop good practice to collect elements and check for compatibility of possible existing port emergency or contingency plans. This is particularly relevant and important for major accident scenarios, where good coordination between all parties is necessary. (Refer to Section 14 in this Guidance)	X	X
Emergency Response Plan (external) Develop external emergency plan, based on internal LNG bunkering facility emergency response plan.	Based on the approved internal emergency plan developed and submitted for approval by the BFO, PAAs should develop/update their emergency plans. All ERPs should be aligned and adequate management of possible modifications should be ensured. The adequate reflection of the multi-operator environment should be a challenge addressed by PAAs when developing the external emergency plan. (Refer to Section 14 in this Guidance)		X
Emergency Response Plan (external) Approve external emergency plan	In cooperation with other relevant competent authorities, Port Authority should approve the external ERP, taking into account all relevant ERPs existing in the multi-operator context of the port. The Port Authority should, in particular for this approval, and whenever major accident prevention	X	

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
	aspects are relevant, liaise directly with the competent authorities responsible for that particular area. (Refer to Section 14 in this Guidance)		
Emergency Response Plan (training) Develop and implement an LNG fuel training program adequate for port personnel directly or indirectly with LNG bunkering.	In order to ensure adequate implementation of the Emergency Response Plan, PAAs should develop and put in practice an adequate training program to be undertaken by all relevant members of the emergency response organization. It is the responsibility of the PAA to ensure that all staff members directly or indirectly involved are aware of their roles in emergency. Training in LNG bunkering emergency & response should consider the involvement of all relevant operators involved in LNG bunkering. (Refer to Section 14 in this Guidance)		**X**
Build adequate Enforcement capacity **Initiate an enforcement system by LNG trained enforcements officers**	Enforcement is an important factor to ensure that the relevant requirements are well implemented and complied with by the relevant parties involved in LNG bunkering. Requirements and relevant legal/technical provisions should therefore be enforceable, clear and well understood by all parties. It is also very important that the enforcement exercise takes into account the practical aspects, both in terms of equipment and cost-benefit of possible safeguard solutions. (Refer to Sections 7, 9, 15 in this Guidance)	**X**	**X**
Approve risk acceptance criteria	In the absence of relevant directly applicable risk acceptance criteria, the BFO, RSO or Port Administration may propose relevant risk criteria to be adopted. As a good practice approach, where better procedure is not available, the risk criteria should be subject to approval by the Port Authority. In approving the risk criteria, Port Authority should liaise in close cooperation with other relevant competent authorities involved in prevention of major accidents, or with responsibilities on civil and port protection. (Refer to Section 8 in this Guidance)	**X**	
Accreditation of the BFO Authorize /accredit bunkering facilities, once they have demonstrated that they are compliant and prepared	In pursuit of a transparent and equitable regulatory and administrative framework for the development of LNG bunkering in ports, PAAs should develop an LNG bunkering accreditation scheme. The scheme should be clear and allow for equal opportunities to all those that present intention or projects for LNG bunkering within the port. The following factors should be taken into account for the accreditation scheme: • Certification of LNG bunkering		**X**

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
	Equipment • Qualification of BFO personnel • Safety Management System implemented by the BFO • Number of available hours per year • Results of periodic in-service inspections (Refer to Section 15 in this Guidance)		
Qualification of the Person-in-Charge (PIC)	Define the main elements to consider for the qualification of the Person-in-Charge (PIC). What competencies should be derived from the already IGF-defined responsibilities for the PICs should be a responsibility of PAAs. As a minimum it should be here considered that the RSO and BFO PICs should have equivalent qualification for LNG bunkering operation. (Refer to Section 15 in this Guidance)		
Restrictions for repairs and maintenance on LNG installations on board of ships	(Not directly related to LNG bunkering) Repairs and maintenance of LNG fuelled ships, either planned or non-planned, in designated areas or other locations within the port should be subject to consideration of the PAA. Subject is not related to LNG bunkering but it is of great relevance and importance in the context of operations with LNG fuelled ships. It is included in the present Guidance under Section 15, on Certification/Permit to Work.	X	X
Safety requirements for LNG propelled ships on (dock)yards	(Not directly related to LNG bunkering) Even if the repairs of LNG fuelled ships take part in dedicated shipyards, PAAs should be reassured that relevant precautions and procedures are followed in both unloading-inerting and commissioning-cooling-loading operations. Shipyards should be required to have relevant procedures in place to allow for safe repair works in LNG fuelled ships. Subject is not related to LNG bunkering but, for the same reason as the previous point, it is included in the present Guidance under Section 15, on Certification/Permit to Work.		
Safety requirements for LNG propelled ship on a lay bye berth to avoid a BOG problem	In the context of the development and implementation of relevant provisions for methane release mitigation, PAAs consider the development of all necessary measures to reduce the amount of NG release to the atmosphere. Should an LNG fuelled ship be on a lay bye berth it should be possible to ensure that adequate measures are put in place to avoid difficult BOG management situations, in particular when LNG vapour pressures are such that PRVs are actuated allowing the pressure relief at cost of environmental impact of methane release to the		X

Port Role/Responsibility	Main Aspects to Consider (reference to section in the Guidance)	Port Authority Role	Port Administration Role
	atmosphere.		

As indicated in table 5.4, above, PAAs, either in the Port Authority or in Port Administration context, take stake of a considerable amount of roles and responsibilities. The listed elements in the table include the main aspects that need to be to be considered by PAAs. Different aspects can be taken either by the Port Authority or Administration, depending on the specific port management model and on specific national contexts. Table 5.4 provides only for an indicative structure of different port roles and responsibilities in LNG bunkering.

It should not be the role of the Port Authority to interfere with the normal operations during LNG bunkering. Once the adequate Authorization procedure (see section 12.3.6) is concluded, for a given LNG bunkering operation, PAAs should implement a suitable inspection and verification model (see section 7.3.9) to ensure that the conditions established during the permitting procedure are kept in-service, throughout the life-cycle of the LNG bunkering facility.

5.5 Spatial Planning

From table 5.4, in the previous section, one of the most relevant responsibilities of PAAs is the proposal and approval of spatial planning within the port area, accounting for the development of a new LNG bunkering facility or operation.

To approve a bunker location for an LNG bunkering among other things PAAs can consider different elements that collectively may contribute to the definition of the most suitable location for the LNG bunkering operation;

- the different types of ships to bunker with LNG;
- the expedience of the terminal with LNG bunker operations;
- the planned simultaneous operations during the LNG bunkering;
- the water depth;
- availability of proper anchoring, mooring and fendering appliances;
- double banking possibilities (dolphins, buoys or bollard loads);
- nautical accessibility;
- nautical safety, including maneuvering basin area's;
- frequency and type of passing vessels (collision risk);
- the space for the passing of vessels taking into account safety zone and ship exclusion zone;
- Water movements due to tidal amplitudes, swell, passing ships etc.
- the quay maximum admissible load in case of a truck to ship bunkering
- enough safety distance to populated areas (in line with national legislation)
- Impact on other activities, both waterborne or on the shore side.
- security, accessibility by public

In order to minimize the risk of a collision during bunkering, the bunker location should ideally not be located in waterways with high vessel traffic intensity levels or complicated nautical situations, including basins dedicated to maneuvering;

In addition to the elements above it is also important to note that Spatial Planning is done to incorporate the possibility of LNG bunkering in the existing spatial layout of a given port. Different concurring factors may contribute for this, some safety related and others of a more operational and economical nature. This would be the case of Safety Distances and proximity of LNG, respectively. Notwithstanding this fact, planning for a new LNG bunkering location will be an exercise that will be done concurrently with already existing factors, within sometime restricted boundaries and in a context which may present several challenges.

Figure 5.6, below, presents a graphical image of the spatial planning in the Port of Rotterdam, an extreme example of a very large port, dealing with a large variety of ship types and cargoes. Assuming that LNG bunkering can be a potential operation for any ship type it can be easily concluded that it will be very likely to have LNG bunkering areas superimposed with other areas with necessary judgement to be taken into account, not only in the context of potential SIMOPs but, most certainly, in those cases where hazardous substances other than LNG are present.

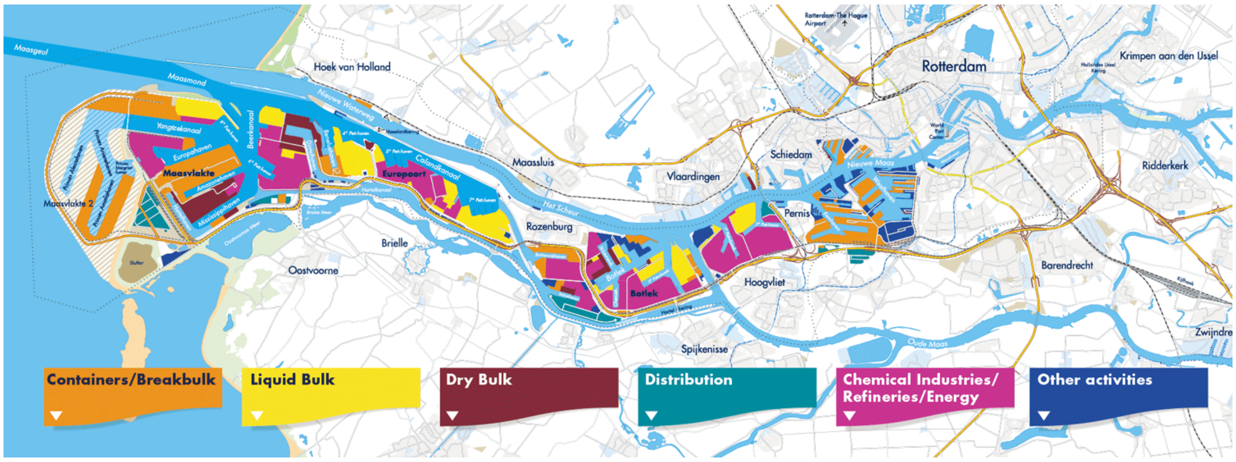


Figure 5.6 – Example of Spatial Planning port area plant – Area identification Port of Rotterdam (Source: Port of Rotterdam)

5.6 The Role of Ports in the development of LNG bunkering facilities

Whilst the previous section outlined the more operational roles for PAAs, in the context of LNG bunkering, the present Section aims to provide the same entities with options to promote and support the use of LNG as a marine fuel and develop bunkering facilities in full length. The elements contained in this particular section are based on a study [33] published by the World Maritime University in 2015, where 8 (eight) relevant Ports, recognized as first-movers for LNG bunkering, were analysed with regards to the aspects related to direct or indirect support to this activity. The study, based on questionnaires and evaluation of the different Ports (all inside ECA) allows a summary of the different initiatives to support the development of LNG bunkering.

Regardless the management structure of a port and the corporatization level of both port authority and administration bodies, the development of LNG bunkering can be characterized across the four main functions of a Port [33]: 1) Landlord function; 2) Regulator function; 3) Operator Function and, finally, 4) Community Manager Function. These are outlined below to provide PAAs a generic Menu-Portfolio of the policy-vectors and strategies that are available to support development of LNG bunkering potential.

5.6.1 Landlord function

The typical landlord function of port authority in the development of LNG bunkering facilities refers to the provision of land for an LNG bunkering terminal, the construction of quay walls, jetties, or other possible basic infrastructure for maritime access, and the associated development policies. Most port authorities go beyond the traditional landlord function by adopting ‘‘proactive’’ and ‘‘cooperative’’ policies to speed up the development progress of this new application [33]. These policies relate to (1) a proactive coordinating role in conducting feasibility studies on LNG bunkering in cooperation with various stakeholders (i.e., local government, competent authorities, private actors, etc.), (2) the development of a comprehensive location selection policy, (3) the forging of strategic partnerships with private industrial players and even with other ports for developing LNG bunkering and, finally, (4) the adoption of an adequate infrastructure investment policy.

The above policy-vectors are structured in the diagram of figure 5.6, showing the main trends on how PAAs enact the landlord function in order to play a proactive coordinating role in performing feasibility studies on LNG bunkering (e.g., technical, regulatory, and market dimensions) together with various stakeholders in order to obtain confidence among market players to kick-start the business. The selection of a location for LNG infrastructure currently is a key problem faced by the ports. The LNG bunkering facilities would be better built close to the customers (e.g., shipping lines), while considering the safety issue of handling LNG as a dangerous cargo, some ports prohibit LNG operations in populated port area. Other ports are however developing dialogue platforms [33] with the general public on the construction of LNG facilities near residential areas.

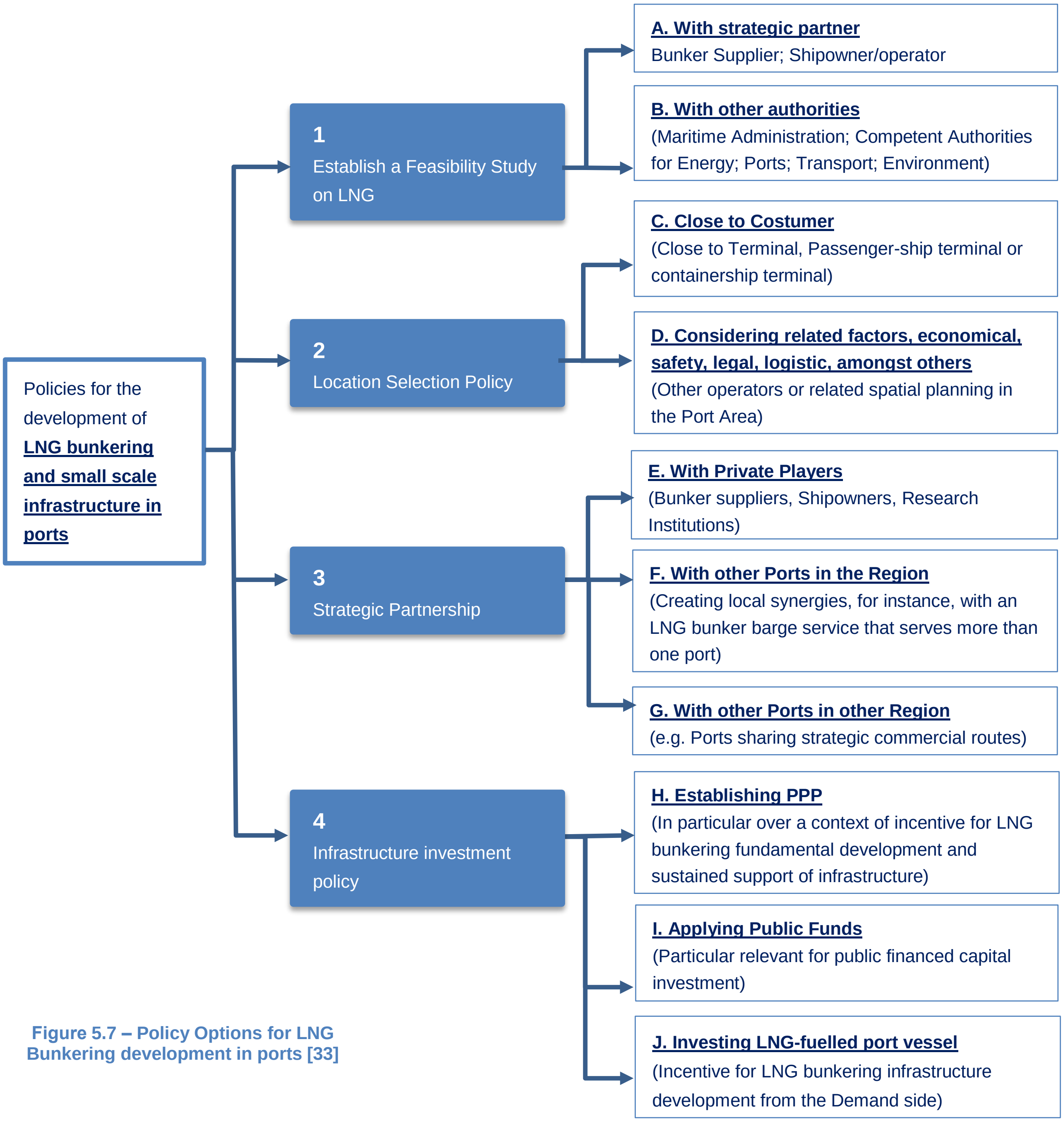


Figure 5.7 – Policy Options for LNG Bunkering development in ports [33]

5.6.2 Regulator function

The traditional regulator function of port authorities is to apply and enforce rules and regulations set by regulatory bodies. The current scenario for LNG bunkering in ports is however characterized by the lack of a set of unified harmonized rules and standards for a number of different aspects in this activity (Safety Distances, SIMOPs, Permitting, Risk Acceptance criteria, amongst others). In this particular context, the development of relevant rules and standards for such new application is a key for the wide diffusion of the LNG technology. Below is presented a summary of the regulatory role of that may be followed by ports in the development of LNG bunkering [33]. Port authorities mainly adopt a stronger regulatory role in the following ways:

1) By actively assisting regulatory authorities to enforce air emission standards, underlining the relevance of an adequate control that mitigates the risk of non-compliances, also promoting in that way the option for EAMs such as LNG as fuel.

2) By proactively coordinating and facilitating the development of regulations on the maritime use of LNG and by setting corresponding port bylaws.

Relevant regulations and rules on LNG bunkering have already been developed by a significant number of ports, remarkably by those located in ECA areas. The challenges, whilst developing such instruments, are diverse and PAAs should be prepared to develop the relevant port regulations in a collaborative manner with other ports and competent authorities.

3) By developing LNG bunkering checklists and establishing appropriate Risk Criteria.

   Initiatives like the World Ports Climate Initiative (WPCI) – www.lngbunkering.org, have allowed the participation of Ports in a dedicated working group to jointly develop an LNG bunkering checklists[59] for different significant bunkering solutions (e.g., ship to ship, truck to ship, etc.).

   The definition of adequate risk criteria is further relevant in the context of LNG bunkering allowing risk evaluation studies to be properly assessed, promoting transparency and defining clearly the acceptance frame.

4) By setting a differential port tariff on ships fuelled by LNG or other clean fuels.

5.6.3 Operator function

Looking at the three traditional functions of port authorities, i.e., the landlord, regulator, and operator functions, it can be concluded [33] that, as operators, port authorities gradually moved away from providing services of cargo handling, stevedoring and bunkering, etc. These have in most cases been privatized [34]. A common best-rated strategic option for port authorities is today to enact an active control and supervision of concessions to stimulate intra-port competition and market contestability as well as sustainable and efficient operations of private operators. Thus, LNG bunkering services are supposed to be mainly operated by private actors, although at the beginning of market development, the port authorities might adopt incentive policies promoting investments in the maritime application of LNG.

The Operator function by PAAs, in the context of LNG Bunkering, similarly to the example of other relevant port services, is not expected to be privileged. Exception to this may however be considered in the cases where the business case for LNG bunkering is not yet fully developed or secured, leading in the extreme situation where PAAs may take the lead in the development of an LNG bunkering service infrastructure.

5.6.4 Community manager function

The function of community manager assumes a coordinating role of the port authority to solve collective problems in and outside the port perimeters, for instance, marketing and promoting innovations, etc. It is a common function of port authorities today acting as community managers in promoting LNG as a ship fuel.

1) Marketing and promotion on the maritime use of LNG.

   PAAs may use different ways to promote and market the maritime use of LNG by organizing conferences, seminars, and workshops or by sending handbooks or arranging meetings with the interested parties.

2) Learning and sharing knowledge and skills with port stakeholders and even other ports.

   Possibility to enhance interactive learning and knowledge sharing with port stakeholders by establishing various workshops or stakeholder platforms or developing strategic alliances with other ports in/or across the regions.

3) Establishing a close dialogue with government and raising public awareness.

[59] Check-lists included in Annex-A, adapted to include relevant aspects to Port Authorities and Administrations. The baseline check-lists used are IAPH and ISO

5.7 Ports Good Practice approach for LNG bunkering

Sections 5.1 to 5.5 addressed several and different aspects related to Ports in the context of LNG Bunkering. In 5.1 the main principles that should assist PAAs in the development of control mechanisms for LNG bunkering are derived and discussed, with a triangle established with the following vertices:

- **LNG Bunkering Facility Organization (BSO),**
- **Port Authority & Administration** (Port Authority and Port Administration can be the same or different entities – see Section 5.3 for definition, or 1.4, together with other relevant terms and definitions),
- **Receiving LNG Fuelled Ship (Receiving Ship Organization – RSO)**

In addition, contained in the same section and making use of a generic port layout, different LNG bunkering scenarios are presented. For each scenario different considerations are outlined, highlighting some of the main particulars for each situation. Table 5.1 provides this list of possible LNG bunkering scenarios, including some particular small scale LNG cases possible within ports. No such thing as “Good Practice” can be indicated for the presented scenarios. They are typically developed in the operational context and, notwithstanding the list in Table 5.1 being considered extensive, it will still be possible to have new concepts for LNG Bunkering, or even small-scale LNG bunkering solutions being developed. For this reason it is important to note that good practice should not be derived from the list of possible LNG Bunkering Scenarios. Instead, a sound Good Practice approach for Ports to deal with LNG bunkering operations should be supported by adequate Good Governance principles (Section 5.3), clear definition of the responsibilities falling on PAAs (on both Port Authorities and Administrations) (Section 5.4) and, finally, by adequately defining the position of PAAs regarding the development of LNG bunkering (Section 5.6). Spatial Planning, one of PAAs responsibilities also included in Section 5.4 is also mentioned separately accounting for the details and complex port-specific considerations that can be derived in this particular point.

5.7.1 LNG bunkering for Ports – Good Practice for Transparency

R5.1. **Transparency is, in the context of LNG Bunkering as in others related to relevant port services, a primary principle that should be privileged by PAAs.**

Accounting for the three main vertices of a triangle, mentioned above and in 5.1 (BFO, RSO and PAA) it is, in the best interest of transparency, important to ensure that adequate separation and absence of conflict of interests is ensured between all parties.

Different interests can be derived for all parties and their inter-relations may be characterized by different levels of communications and potential partnerships. Safety can be expressed as an objective by all parties, but how much commitment to safety must be defined in clear regulations.

R5.2. **Growing towards complex hubs in a multi-operator context, with management and organizational systems which differ significantly from port to port, PAAs should give a particular relevance to the need to ensure transparency in processes, with the involvement of the wider stakeholders’ community inside and in interaction with the port.**

Examples of processes where transparency is a fundamental pillar in LNG bunkering:

- **Vessel compatibility Assessment**
- **Risk Assessment (whenever performed to ascertain ALARP Risk levels).**
- **Permitting**
- **Simultaneous Operations**
- **Safety Distances.**

R5.3. **In Section 5.1 a specific approach is presented to determine adequate independency of all parties involved in LNG Bunkering. Independency between all the parties identified has there been identified as a marker for transparency. It is however important to note that other stakeholders may also be involved in ancillary tasks (such as inerting, cooling, amongst others) from service providers other than the BFO.**

PAAs should have a clear overview of all the parties involved in the LNG bunkering operations, looking for the identification any less transparent situations and questioning, in particular, how, and by whom, are provided the elements for safety of operations (risk assessment, supervision, compatibility assessment, definition of safety distances, etc, as listed in R5.2, above).

R5.4. **PAAs may, as and when appropriate, require the involvement of a third-party independent experienced professional to ensure transparency. This may be particularly useful in the cases where a Risk Assessment is being proposed by any of the parties who have any type of perceived economic interest or financial return from the LNG bunkering operation (as it is typically the case with the BFO or RSO).**

Notwithstanding it can be reasonably assumed that Safety is of primary importance for all parties involved in LNG bunkering, it is important to define transparency and independency as pillars of all risk & safety related elements. This is to be considered at the level of first principles governing LNG bunkering for PAAs.

R5.5. **When deciding or intervening on any of the above aspects BFO, RSO and PAA will interact within a specific regulatory frame (see Section 4) which can only be enforced to an adequate level if the processes are conducted with the necessary independency.**

R5.6. **Compliance with EN ISO 20519, as introduced in Section 4, declared and inscribed as an objective within an appropriate Safety/Quality Management System should be the basis for the minimum requirement advisable as best practice. Enforcement is made easier through the provision of adequate "external audits" by a competent authority, whilst allowing planning and continuous development of processes by the Operators.**

5.7.2 Good Practice in the evaluation of LNG small scale and bunkering scenarios

R5.7. **Table 5.1 list (from "A" to "X4") different possibilities in the context of LNG bunkering or LNG small scale realizations that can potentially take place within the port area. Not all situations represent LNG bunkering strictu senso, including a few which are related to small scale LNG elements. These are included in Table 5.1 as relevant elements that are either likely to be part of the LNG bunkering chain, distribution or local storage.**

PAAs are encouraged, in a good practice approach, to include the whole context of LNG small scale elements within the port area. This, in practice, means that, apart from LNG Terminals, all elements of storage and distribution, directly or indirectly related to bunkering of LNG fuelled ships, should be considered. In addition, also small break bulk LNG cargo facilities, should be taken into account in the context of the overall LNG bunkering scenarios. This is particularly relevant if and when considered to define LNG bunkering locations, or in the context of spatial planning.

R5.8. **From a good practice perspective PAAs should consider to work closely with all the possible stakeholders involved in prospective LNG bunkering in order to determine at the earliest stage all the possible technical and operational implications from a given specific LNG bunkering solution. How these would affect port activities or spatial planning are some of the aspects that should be considered at the earliest stage.**

R5.9. **Table 5.1 list notes and particular recommendations for different LNG bunkering and small-scale scenarios within the port area. They are not extensive, looking in particular to distinguish some of the relevant elements that may guide PAAs in the assessment of different situations. It is in particular important to distinguish the elementary differences between bunkering, fuelling, use, storage and distribution of LNG within the port area.**

Table 5.5, in the next page, presents these different main groups to be considered, with a main focus on LNG bunkering.

Table 5.5 – LNG Small Scale operations that are possible within the Port Area – Elements for the consideration of PAAs in the support for LNG bunkering and small scale developments within ports

LNG Operation	Description	Stakeholders	Risk & Safety elements Notes for Spatial Planning
Bunkering	Delivery of LNG to a receiving LNG fuelled ship. High flow-rates of LNG through flexible hose(s) or equivalent flexible connection arrangement. Increasingly higher volumes transferred (up to 1000-5000m^3 LNG per delivery). Different modes for delivery of LNG fuel are possible (See section 2.5).	1. Bunker Facility Operator (BFO) 2. Receiving Ship Operator (RSO) 3. (Optional) Cooling services for RSO provided by specialized company 4. (Optional) Inerting services for RSO and/or BFO provided by specialized company	**Risk & Safety** • Main aspects to consider for Risk & safety evaluation are related to the nature of the operation and to the specific location where it occurs. • Higher LNG transfer volumetric rates • Safety Zones to be determined/ agreed on the basis of LNG bunkering parameters, surrounding port/nearby infrastructure and environmental conditions. • Risk Study to be provided as a function of bunkering parameters, location, receiving ship. • Risk Assessment to be made on the basis of existing accepted risk criteria. **Spatial Planning** • Bunkering should take place at a designated bunkering location. • SEVESO area classification with respect to potential existing hazardous substances in the area to be considered. • Bunkering by STS is less likely to have an decisive impact in spatial planning.
Fuelling	Supply of LNG fuel directly to a gas/DF engine onboard a ship whilst alongside. Characterized by: • Transfer of very low LNG fuel volumetric rates, mainly dictated by the onboard engine fuel consumption rate. Unless a buffer tank exists onboard the rate of transfer will correspond to the engine consumption. When compared to the volumes transferred in bunkering this should be much less. • Delivery unit (LNG truck, barge or ISO container) stay close to the ship for longer periods. In fact the presence of the LNG supply/storage will last for the whole visit of	1. Fuelling/Bunkering Facility Operator (BFO) – provider of the LNG external storage unit. 2. Receiving Ship Operator (RSO) 3. (Optional) Cooling services for RSO provided by specialized company	**Risk & Safety** • Fuelling is conceptually different from Bunkering in the following main aspects: – Significantly lower volumetric transfer rates when compared to bunkering. – Longer periods for the stay of the LNG delivery unit (truck, barge, container) close to the receiving ship. • Even though a consequence from a hose rupture event could be considered to be very limited, the fact that the fuel transfer is taking place over a prolonged period of time should assume the main risk-based concern. • Measures to mitigate any possible risks arising from a long stay nearby the receiving vessel should be carefully considered by PAAs, including, but not limited to: – Permanent attendance of the fuelling unit. – Physical barriers for the fuelling

LNG Operation	Description	Stakeholders	Risk & Safety elements Notes for Spatial Planning
Fuelling (cont.)	the ship. • Regasification can occur either at the delivery or inside the ship, through a dedicated evaporator.		**location.** – **Physical protection/ enclosure for the fuelling hose.** – **Visual signs to indicate** **Spatial Planning** • **LNG Fuelling is likely to impose a significant driving factor for area classification.** On one aspect the LNG transfer flow rate is less when compared to bunkering but, on another, the LNG storage unit will be connected to the ship from the shore side for much longer periods. • **SEVESO area classification with respect to potential existing hazardous substances in the area to be considered.** • **Case of temporary storage of LNG can be reasonably argued due to the permanence of the truck/barge/container close to the receiving ship for a much longer period (when compared to bunkering)** **PAAs should note the particular aspects regarding LNG fuelling and give careful consideration to the quasi-permanent installation of an LNG storage unit next to the receiving ship. How this is likely to impact operations or spatial planning is very much dependent on the location and arrangement of the port or quay.** **SIMOPS will be inevitably a subject to be dealt with. Fuelling, being a permanent operation throughout the whole stay of the ship, will concur with other operations such as vehicle roll-on/roll-off, passenger embarkation/disembarkation or cargo handling.** **The location for the LNG storage unit will have to be decided on the basis of minimum impact with the ship's different operations at berth.** **Main elements to consider when evaluating proposed LNG fuelling facilities and operations:** **1. LNG fuel delivery service (truck, container or barge)** **2. How long will fuelling take place** **3. Exact location proposed for the fuel storage and delivery unit** **4. Degree of exposure to traffic, cargo or passenger movements.**

LNG Operation	Description	Stakeholders	Risk & Safety elements Notes for Spatial Planning
Fuelling (cont.)			5. **ESD arrangement** 6. **Manning/supervision/attendance of the storage/fuelling unit from the shore/quay side.** 7. **Firefighting equipment proposed arrangements** 8. **Communications between receiving ship and LNG fuel storage and fuelling facility.** 9. **Hazardous Zone – Ex-Proof equipment.**
Use	Use of LNG by: • **LNG fuelled vessels whilst alongside or at anchor** • **LNG power barges, for the supply of electricity**. This will typically be the case in those ships where the power generation is provided by DF engines or other electric power source using LNG as fuel (Fuel Cells, combined cycle turbines or others).	1. Ship using LNG as fuel, at berth. 2. Barge or other LNG consuming unit producing electricity within the port area.	**Risk & Safety** • **Use of LNG onboard LNG fuelled ships or other LNG consuming units within the port area should pose a very limited concern to PAAs. With certified LNG systems, only the following points may be of interest for PAAs, for the implementation of any relevant control measures:** – **Venting,** with PAAs to exercise the option of actively controlling any possible accidental and/or operational/intentional emission of LNG vapours to the atmosphere**.** – **LNG storage tanks on deck,** where SIMOPS are taking place. Due consideration should be paid to possible exposure of LNG service/ fuel tanks. **Spatial Planning** • **No impact on Spatial Planning should be expected from the use of LNG onboard an LNG fuelled ship.** • **Different consideration may have to be given to LNG fuelled power barges or other semi-fixed LNG fuelled installation.** Being almost fixed installations, moored, anchored or ashore, these units will typically produce electrical energy from dual-fuel generators. **How much LNG is stored in this facilities should be part of the elements PAAs will collect in the assessment of such facilities.**
Storage	Storage of LNG within the port area will typically be the case of small scale fixed LNG installations. These may be **directly** or **indirectly** related to Bunkering:	1. Terminal Operator (TO), when small-scale storage is part of a terminal complex. 2. Bunkering Facility Operator (BFO), when	**Risk & Safety** • **LNG small-scale storage within the port area will be subject to SEVESO Major Accident prevention provisions (see Section 4)** • **Relevant aspects to consider regarding small-scale LNG storage**

LNG Operation	Description	Stakeholders	Risk & Safety elements Notes for Spatial Planning
Storage (cont.)	• **Directly:** LNG fuel storage which is either located at the quay or close to it, using cryogenic fixed piping installation between storage and bunkering location. • **Indirectly:** LNG fuel storage within the port area. Used together with a loading point for trucks, barges or bunker vessels. Typical small scale LNG storage will make use of Type-C tanks up to 5000m3 each (ranging from 500 to 5000)	the LNG small-scale storage unit is part of the BFO facility storage/supply LNG chain within the port area.	**installations within the port area:** – **Aggregated Capacity of the LNG storage site (m3)** – **Existing area/terminal/port SEVESO classification** – **What changes in area classification following the proposed installation of the new LNG storage facility.** – **Is a re-gasification unit included with gas supply to the grid?** – **How will LNG loading and offloading/distribution going to be?** – **Who will the LNG clients be?** – **Which safeguards are proposed (3 layers of defence – ISO 18683)** – **Risk Study/ Risk Assessment (preferably by independent 3rd party/ professional consultant)** **Spatial Planning** • **LNG storage plants, within terminal facilities or within the wider port area are very likely to impact significantly in Spatial Planning.** • **If the area is already classified with regards to Major Accident prevention policies only a minor revision of the classification may be required.** • **Should the area be unclassified within SEVESO frame it will be important to determine whether the prospective LNG storage facility will warrant a Lower-Tier (above 50ton LNG) or Higher-Tier (above 200m3).** • **Even for LNG storage facilities proposed of <50ton (approx. 110m3) it will be important to determine what will be the impact on the site Major Accident prevention classification attainable.** **(See Section 4 for more information on the applicability of Major Accident prevention provisions).**
Distribution	Distribution of LNG fuel within the port area can be done by: • LNG Truck/trailer-truck • LNG barge • LNG bunker vessel • Pipeline (cryogenic)	1. Terminal Operator (TO), when small-scale storage is part of a terminal complex. 2. Bunkering Facility Operator (BFO), when the LNG small-scale storage unit is part of the BFO	**Risk & Safety** • **Risk and Safety considerations will depend on the LNG distribution mode within the port area:** – **LNG Truck/trailer-truck** – Should be ADR certified (truck and driver/operator), with the adequate means for first intervention in the case

<table>
<tr><th>LNG Operation</th><th>Description</th><th>Stakeholders</th><th>Risk & Safety elements
Notes for Spatial Planning</th></tr>
<tr><td><u>Distribution (cont.)</u></td><td></td><td>facility storage/supply LNG chain within the port area.</td><td>of an accident.
– LNG temperature is of particular relevance. Adequate adjustment to the receiving ship LNG temperature must be ensured.
– Truck operator should be familiar with the authorization procedures and port-specific conditions for bunkering location.
– <u>LNG Barge</u>
– Barges represent a very limited LNG distribution facility. No self-propulsion typically dictates that these have to be either tugged or pushed/pulled to be in place for bunkering operations.
– At anchor, or being towed, LNG barges, with associated tug, will have reduced manoeuvrability, thus, a reduced ability to avoid accident in higher traffic intensity areas.
– <u>LNG bunker vessel</u>
– Represents the mobile solution which will be able to distribute larger quantities of LNG for bunkering.
– Certification of the LNG bunker vessels should be consistent with the provisions of the IGC Code (and IGF Code, where applicable).
– Crews should be specialized and able to demonstrate relevant qualifications.
– Regular routes for the bunker vessel, within the port area should avoid higher traffic intensity areas.
– <u>Pipeline (cryogenic)</u>
– From fixed LNG storage to a designated bunkering location, LNG pipelines allow for short range distribution.
– Routing of pipelines is critical. Either above ground/ aerial or routed through channels aground, LNG pipelines should be visible and easy to inspect.
– Pipelines should be double walled and insulated.</td></tr>
</table>

LNG Operation	Description	Stakeholders	Risk & Safety elements Notes for Spatial Planning
Distribution (cont.)			**Spatial Planning** • **All modes of LNG distribution are likely to have some impact on Spatial Planning, in particular LNG trucks or pipeline distribution.** • **PAAs should promote the development of LNG distribution routes through areas/zones of less traffic and operational activity.**
Cooling	**Cooling**, in the context of LNG Bunkering, refers to the operation of bringing the temperature inside the ships to "cold LNG" level, equalizing the delivered and receiving ships LNG temperature.	1. Bunker Facility Operator (BFO) 2. Receiving Ship Operator (RSO) 3. Cooling services for RSO provided by specialized company 4. (Optional) Inerting services for RSO and/or BFO provided by specialized company	**Risk & Safety** • **Cooling typically involves nitrogen to bring the LNG fuel system and receiving tank before actual bunkering of LNG.** In this particular situation the risks to be assessed are mostly related to cryogenic hazards and to the possibility of oxygen displacement in confined spaces (following a possible release and dispersion of nitrogen cloud). Safety Distances should also apply for the control and mitigation of these risks in a reasonable area. • **Cooling may also be done with LNG, especially in the cases where the receiving tank is partially filled.** Cooling with LNG will require particular attention to BOG management. **Spatial Planning** • **Cooling is an ancillary operation to LNG bunkering.** • **No specific concerns for Spatial Planning should arise from cooling operation.**
Inerting	**Inerting**, in the context of LNG Bunkering, refers to the operation of displacing all oxygen in the LNG bunkering line before and after bunkering.	1. Bunker Facility Operator (BFO) 2. Receiving Ship Operator (RSO) 3. Inerting services for RSO (or as sub-contractors to BFO) provided by specialized company	**Risk & Safety** • **Inerting typically involves nitrogen to displace oxygen from the LNG bunkering line and, additionally, to cool it down prior to bunkering.** It is of particular relevance to determine how the inerting operation is performed. If provided by a 3rd party it is important to ensure coordination between all parties involved. • **Inerting will take place in two different stages of the bunkering process.** **First**, before bunkering, the objective is the displacement of oxygen and cooling of the bunkering line. **Second**, after bunkering, the objective is the removal of Natural Gas/LNG vapours from the bunkering lines (ship

LNG Operation	Description	Stakeholders	Risk & Safety elements Notes for Spatial Planning
			and shore sides). Main Risk & Safety concerns with nitrogen operations are: – **Cryogenic** Liquefied nitrogen will present same cryogenic hazardous nature as LNG. – **Oxygen depletion** Lighter than air (at a gas to air ratio of 0.97), nitrogen vapours will rise and potentially lead to oxygen depletion at any point where gas trapping is possible, or any confined space nearby. The problem can also have expression in open-air accidental releases as the nitrogen dispersion cloud, visible but inodorous, will be asphyxiating at any point of its expansion-dispersion border and interior.
Unloading	Prior to docking or in any other operational condition ships may have to unload their LNG fuel tanks. This might be the case when preparing to undertake planned or corrective maintenance in the LNG fuel system.	1. LNG fuel unloading receiver (can be the BFO) 2. Receiving Ship Operator (RSO) 3. Inerting services for RSO (or as sub-contractors to BFO) provided by specialized company	**Risk & Safety** • **Unloading of an LNG fuelled tank from an LNG fuelled ship may involve several challenges:** – **Transfer temperature gradient:** It is necessary to ensure that receiving tank (truck, barge or bunker vessel) is at adequate temperature to avoid excessive BOG and associated pressure increase. – **Transfer method:** In the event that the ship has no transfer pump able to transfer out the LNG this will be very likely ensured by applying vapour pressure (evaporator) in the upper side of the tank. – **Inerting:** Following the unloading of LNG inerting will have to be necessarily conducted. Either with onboard inert gas supply or external source. **Spatial Planning** • **Unloading of LNG fuel may be regarded as a non-typical operation and may be subject to the definition of a pre-determined LNG unloading location that may be used specifically for that purpose.**

R5.10. **LNG Fuelling represents today an increasingly offered port service. Despite not being exactly an LNG bunkering operation PAAs should regard this service in the same regulatory framework as LNG bunkering. To this end all provisions in the relevant ISO Standards and existing Guidance should be referred to, as applicable.**

The main differences, as mentioned above, in Table 5.5, will be essentially on the <u>much lower LNG flow rates</u> passed onto the RSO (mainly dictated by the DF/gas engine consumption

For a ship with no onboard LNG storage, but with engine(s) that are prepared to run on natural gas/dual fuel, it is possible, at berth, to feed in this fuel from an external LNG storage unit.

Even though it may look like normal LNG bunkering, involving the transfer of LNG to a receiving ship, there are a few distinctive features that should be taken into account:

1. **<u>Transfer of very low LNG fuel volumetric rates</u>, mainly dictated by the onboard engine fuel consumption rate. Unless a buffer tank exists onboard the rate of transfer will correspond to the engine consumption. When compared to the volumes transferred in bunkering this should be much less.**
2. **<u>Delivery unit (LNG truck, barge or ISO container) stay close to the ship for longer periods.</u> In fact the presence of the LNG supply/storage will last for the whole visit of the ship, with the energy at berth coming from the LNG fuelled onboard generator.**

   Regasification can occur either at the delivery or inside the ship, through a dedicated evaporator. Different configurations are possible depending on how technically prepared the ship is to undertake such type of operation.

R5.11. **<u>PAAs should take into consideration particular elements for this type of operation, such as:</u>**

1. **Regulatory frame. Even though not a typical LNG bunkering operation it is important to frame LNG fuelling into the existing instruments for LNG bunkering (EN ISO 20519, ISO/TS18683, IACS Rec.142)**
2. **Risk Assessment to be conducted, as indicated in the diagram in figure 4.21, where agreed possible hazardous scenarios must be reflected.**
3. **Safeguards to implement, derived from RA above, or others, such as 1) physical barriers, 2) Detection and Alarm, 3) access restriction, 4) Emergency response measures, 5) Dispersion mitigation measures, amongst others.**
4. **Manned attendance of the LNG delivery point. Taking into account that this is a type of operation that may extend for several hours, it is important to have consideration for the possible need to ensure manned attendance of the LNG delivery point/storage. This should be an important point focused at the RA.**
5. **Credible release scenarios. In the context of the RA it is important to determine what would be a credible release scenario from such an LNG fuelling operation.**

5.7.3 Ports Good Governance for LNG Bunkering

R5.12. **In the specific context of LNG as fuel PAAs will have the overall responsibility for the good governance and the safety framework for LNG bunker operations in the port. Decisions and requirements for LNG bunkering should be based on a risk analysis**

carried out in advance, and in the early-involvement of all parties. In this way the PAAs can conduct public affairs and manage public resources.

Table 5.5, below, summarizes the Good Governance principles, with a focus on the principles that should guide PAAs in the context of LNG bunkering.

Table 5.5 – LNG Small Scale operations that are possible within the Port Area – Elements for the consideration of PAAs in the support for LNG bunkering and small scale developments within ports

1. Rule of Law	2. Clarity
• Imperative to follow: - International Regulatory frame (IGF Code, IGC Code, EU Regulations and Directives) - Both ship-side and shore-side regulatory context. • Particular attention to be given to EU Directives as transposition into national law leads to different implementation exercise between EU Member States. • Develop adequate Port Regulations/ bye-laws, inclusive of LNG bunkering. • Refer Standards in regulations to allow legally binding reference for Operators to follow. Standards are not mandatory instruments unless they are included/ indicated in mandatory instruments. • Ensure adequate level of information to all stakeholders on the applicable regulatory frame to LNG Bunkering. • Ensure that all Competent Authorities implied in LNG bunkering are involved and that no conflicting requirements exist.	• The framework for the application of law should be clear and understandable to all stakeholders, in particular to Operators. • Scope and applicability of regulations should be clear, with particular consideration for the different characteristic modes of LNG bunkering. Notwithstanding the fact that more general provisions can be applicable to all modes, it is important to realize and be clear in the rules as to which particular measures/requirements apply to each particular LNG bunkering mode.
3. Transparency	**4. Responsiveness**
• The ability to respond to the needs from operators, within an adequate timeframe is fundamental for the confidence in the processes and competencies of the port. • LNG bunkering, as in other oil fuel bunkering operations is a highly time-sensitive business. LNG is to be delivered on-time, as scheduled, to ships which are often under the pressure of time. This should not only be taken into account by PAAs, it should motivate PAA to develop mechanisms to swiftly respond to concrete technical, operational or administrative needs from Operators, in the frame of their competencies. • Permitting is another aspect of LNG bunkering which is highly time-critical, notwithstanding on a different time scale. Responsiveness in the particular context of LNG bunkering permitting is one of the factors that may contribute most to the reduction of inefficiencies in permitting processes.	• The ability to respond to the needs from operators, within an adequate timeframe is fundamental for the confidence in the processes and competencies of the port. • LNG bunkering, as in other oil fuel bunkering operations is a highly time-sensitive business. LNG is to be delivered on-time, as scheduled, to ships which are often under the pressure of time. This should not only be taken into account by PAAs, it should motivate PAA to develop mechanisms to swiftly respond to concrete technical, operational or administrative needs from Operators, in the frame of their competencies. • Permitting is another aspect of LNG bunkering which is highly time-critical, notwithstanding on a different time scale. Responsiveness in the particular context of LNG bunkering permitting is one of the factors that may contribute most to the reduction of inefficiencies in permitting processes.

5. Consensus Oriented	6. Equity and Inclusiveness
• Within the applicable legal frame reaching consensus and common understanding in LNG bunkering is essential for the success of projects, implementation and operations. • The width and ambition of consensus should be adequate to the complexity of the LNG bunkering solution and to the impact of that project to other operators within the Terminal or Port area. • Consensus with the wider public community is also fundamental, as applicable and necessary, and should not be limited to public consultations required by legal instruments. • A permanent platform for dialogue should be established.	• Equal opportunities to operators wishing to initiate LNG bunkering projects should be given, in the particular context of the Port, with due consideration to operational and spatial limitations. • Equity and Inclusiveness should be exercised, as a priority, in the access to information and support to permitting initiation. • All operators should receive the same level of information, same level of opportunity to demonstrate the concept projects and feasibility for a given intended LNG bunkering development.
7. Effectiveness and Efficiency	**8. Accountability**
• Processes should be mapped. Criteria and Key Performance Indicators should be defined for an adequate measurement of Effectiveness and Efficiency. • All the life-cycle of an LNG bunkering project should here be subject to adequate measurements of effectiveness and efficiency (regarding the action of the PAA): i. Concept Project ii. Permitting iii. Implementation iv. In –service v. Surveys vi. Modifications vii. Surveys viii. Temporary Cessation ix. Decommissioning	• PAAs are accountable to Operators in the exact measure of the applicable legislation. • In addition to Mission Statement and other Quality related instruments, PAAs should identify clearly who, and in which areas, is responsible and accountable, in all areas of the Port Administration, including LNG Bunkering, Safety, Emergency, and other related responsibility areas. • For the sake of Good Governance the adequate channels for complaints, appeals and suggestions should be clear, accessible and included as part of a Quality Management System. • Independent investigation of incidents should be ensured.

9. Participation
• In the interest of a sound port operating environment, all interested stakeholders should be given the opportunity to participate, comment and interact • Participation of the wider public community is also fundamental, as applicable and necessary, and should not be limited to public consultations required by legal instruments. • A permanent platform for dialogue and participation should be established.

5.7.4 Port Roles and Responsibilities in LNG Bunkering

R5.13. **Definitions of Port Authority and Port Administration, in the present Guidance coalesced in the term "PAA" should be referred to Regulation (EU) 2017/352. Port Authority and Port Administration are defined, respectively, through the concepts of "competent authority" and "managing body of the port". Definitions given in section 5.4.1 and 1.4 of the present Guidance.**

R5.14. **Where PAAs are, in practice, two separate bodies it is important that Port Authority and Administration sides clarify their individual roles and responsibilities in the specific frame of LNG Bunkering. The definition of responsibilities amongst the competent authority and the management body of the port will be decisive in the adequate coverage**

of the LNG bunkering frame. Coordination between all parties contributing to risk & safety evaluation, permitting and authorizations will be essential for the development of LNG bunkering services within a specific port.

R5.15. **Table 5.6 lists the relevant responsibilities for Port Authorities and Administrations in the context of LNG Bunkering, outlined from section 5.4.2, including a brief description of the main elements to consider in each role.**

Should there be more than one entity sharing the different roles/responsibilities it is important to distinguish clearly who is responsible for what, giving privilege to the principle "one role, one responsible entity", allowing for a complementary arrangement of responsibilities and for clarity in the decision-making structure.

Table 5.5 – LNG Small Scale operations that are possible within the Port Area – Elements for the consideration of PAAs in the support for LNG bunkering and small scale developments within ports

Port Role/Responsibility	Summary description
Develop a regulatory framework for LNG bunkering in the ports	The development of an adequate Port Regulation that is inclusive of LNG bunkering is the fundamental instrument for the development of this activity within a port. Ensure adequate integration of different LNG bunkering regulations, standards and guidelines. PAAs should, in this particular aspect, seek to ensure harmonization with other ports, at national, regional or global level, in the best interest of all parties involved.
Allow for adequate information on LNG bunker activities within the port by reporting procedures	Implementation of well-documented permitting procedures, including relevant provisions for management of modifications. Definition of adequate channels for communications, with the identification of the responsible Port representative(s), electronic address, or other that should be taken into account by RSO, BFO or other interested parties. Adequate information channel for reporting of incident and near-misses in LNG bunkering. Support to involved parties and other national competent authorities in the context of any LNG bunkering incident.
Develop restrictions on bunkering operations if necessary	Restrictions on bunkering operations can be of several types and dependent on different factors: • Risk Assessment based Restrictions and limitations may be the practical result from risk assessment results. These may be restrictions on bunkering parameters (pressure, flow rate, hose diameter) or restriction in other operational aspects. • Weather based Weather elements, such as wind, rain, temperature can determine possible operational envelopes. • Local harbour/maritime traffic Special local maritime traffic conditions can dictate

Port Role/Responsibility	Summary description
	restrictions to bunkering. PAAs should be able to aim for a balance of normal operating profiles within the port, whilst ensuring the sufficient safeguards for the LNG bunkering location. • Security restrictions Restrictions on LNG bunkering may arise from possible security related elements. Ports should avoid, to the extent possible, to favour restrictions in looking for safe LNG bunkering operations. It should be important to develop a favourable environment for this type of operations, based on a minimum restriction approach
Approval of Safety zone in way of the bunkering area	The safety zone is an important parameter that should be calculated by the BFO and approved by the PAA. It is important, as good practice, to allow sufficient freedom to the BFO to elaborate on LNG bunkering parameters, local safeguards and to submit the proposal to the PAA for evaluation and approval. It should be avoided, also in the terms of a good practice approach, a fixed safety distance applicable to all situations. This approach is not consistent with the mechanism that justifies the fixation of the safety distance, based on considerations on gas dispersion. Since this is fundamentally affected by environmental and local conditions, it is important to evaluate a proposed safety distance also in the light of these parameters.
Definition of Security Zone around bunkering location	The definition of the Security zone should be a responsibility of the PAA (eventually defined by the Administration and approved by the Port Authority. The fundamental objective of the Security Zone is to allow control of any possible element that may cause interference with the LNG bunkering operation. Maintenance of the Security Zone should be a responsibility of the PAA, allowing for an alternative security maintenance scheme if so agreed between all parties, subject to approval of the Port Authority.
Confirmation of Hazardous Zone	Surrounding the LNG bunkering manifold connections a hazardous area shall be defined at the responsibility of the BFO and RSO. Port Authorities should confirm by inspection that all personnel working and equipment used inside Hazardous Zones is adequately certified for the area in consideration. PPE and EX-proof material should be used. Even though a responsibility of the parties involved, the maintenance of the permitting should be based on periodic confirmation by PAAs that all safety procedures and measures are well kept in place and ensured by parties involved.
Approve and enforce additional control zones (in addition to Hazardous, Safety and Security Zone)	In addition to Safety Zone and Security Zone, other Control Zones may be defined to ensure the safe execution of LNG bunkering operations, These may involve navigation restricted areas or other control zones. It is important that the definition of relevant control zones

Port Role/Responsibility	Summary description
	is effective and adequately enforced. The definition of the relevant zones should take into account the local conditions and infrastructure that may influence the access control to these areas.
Establish passing distances for other ships during LNG bunkering	Either in context with Safety or Security zones, or even separately, the control of passing navigational traffic should be a concern of PAAs. The necessary measures should be developed, implemented and adequately enforced in order to restrict navigational traffic in the way of the LNG bunkering location. The need for control of passing navigational traffic will also vary according to the LNG bunkering type into consideration (STS at berth, STS at anchor, PTS, TTS) with all STS modes deserving the closest attention. Similarly to all control zones, also in the definition of passing distances for other ships the main objective is to avoid any external interference on the LNG bunkering operation.
Mooring requirements	Safe mooring during LNG bunkering operations is a fundamental element to allow a stable and secure LNG bunkering interface. It should be the role of the PAA to define the standard requirements for mooring, including under which conditions reinforced or special mooring should be considered. Mooring of the receiving ship and bunker facility, industry standards may be referenced (e.g. OCIMF Effective Mooring 3rd Edition 2010)
Develop environmental protection requirements	As mentioned in Section 3, LNG bunkering operations should deserve careful attention with regards to potential negative environmental impact. The adequate prevention of any methane release in connection/disconnection, inerting/purging, or even in pressure relief, depends mostly on the definition of good procedures for pre-bunkering, bunkering and post-bunkering phases, including consideration for equipment compatibility. It is important that PAAs establish as a minimum requirement that no venting is allowed. Adequate measures for control should also be developed.
LNG bunkering checklists	The implementation of LNG bunkering checklists is an important measure to ensure adequate documentation of important aspects of LNG bunkering operations. IAPH check-lists, ISO 20519 or their adaptation as include in the present Guidance, can be used for this purpose. It is the role of the Port Administration to ensure that adequate verification and treatment of validated check-lists is adequately done. This may be either part of the port regulations or a requirement derived from the permitting process.
Develop proposals for spatial planning and bunker	Concurrently with other competent authorities with

Port Role/Responsibility	Summary description
<u>locations</u>	responsibilities for land planning, use, classification and administration, PAAs should consider the need to integrate possible LNG bunkering locations into the spatial planning of the port. A possible approach is to determine pre-destined locations for LNG bunkering, allowing for easier prospective permitting processes. Important elements to take into account for spatial planning: • Waterways accessibility • Proximity of locations handling/storing hazardous substances • Emergency response facilities • Proximity of Populated areas and commercial services Commercial. • Areas of restricted security
<u>Approve Spatial planning elements and LNG bunkering location</u>	Based on elements developed in the proposal for spatial planning, above, it should be the role of the Port Authority, following the administrative proposal, to assess the compliance of the proposal with respect to major accident prevention requirements and other national port authority regulations.
<u>Develop measures to allow possible simultaneous activities and operations (SIMOPs) during LNG bunkering</u>	Simultaneous Operations (SIMOPs) are an important aspect to consider especially in LNG bunkering of larger ships with short turn-around times (such as passenger vessels and container ships). PAAs should be involved and dialogue with interested parties, from the beginning, in the development of the necessary measures to allow SIMOPs to be conducted in the safest operational environment possible. Port Administrations, as a good practice approach, can be involved with the role of finding and developing the necessary solutions, in support to BFO and RSO, that can support SIMOPs to take place
<u>Approve SIMOPs</u>	Port Authorities should be responsible for the approval of SIMOPs. This approval can however be distinguished in two levels: 1) Permitting and 2) Approval. In the first the BFO and RSO may be certified, within a given permit for operation, to undertake SIMOPs. On the second, Approval, the Port Authority should confirm that all necessary and agreed elements in the permit are well in place.
<u>Develop general procedures for traffic control and restrictions in case of an LNG bunkering</u>	Both to ensure the integrity of the Safety and Security zones (and any other control zones defined by the PAA) it is important to define relevant traffic control and restrictions. Amongst the measures for traffic control the following can be considered: • Visual signals and traffic indications • Speed limit (with possibility to vary speed limit

Port Role/Responsibility	Summary description
	indication depending on operational context). • Barriers to restrict traffic • Traffic lights for temporary restriction • Active manned traffic control • Traffic diversion The adequate degree of authority should be ensured to implement and enforce the defined Traffic restrictions.
Establish clarity on the roles and responsibilities between the involved parties	The adequate definition of responsibilities between all parties involved should be a central aspect of Port Regulations. In the absence of definition in relevant port instruments the responsibilities to be defined should take EN ISO 20519, the present guidance and Industry relevant guidelines. PAAs should also define clear internal division of responsibilities (permitting, inspections, emergency, amongst others)
Emergency Response Plan (internal) Approve internal LNG bunkering facility emergency response plan.	PAAs should, in cooperation with other relevant competent authorities, approve the Emergency Response Plan developed by the BFO. In approving the internal ERP PAAs should develop good practice to collect elements and check for compatibility of possible existing port emergency or contingency plans. This is particularly relevant and important for major accident scenarios, where good coordination between all parties is necessary.
Emergency Response Plan (external) Develop external emergency plan, based on internal LNG bunkering facility emergency response plan.	Based on the approved internal emergency plan developed and submitted for approval by the BFO, PAAs should develop/update their emergency plans. All ERPs should be aligned and adequate management of possible modifications should be ensured. The adequate reflection of the multi-operator environment should be a challenge addressed by PAAs when developing the external emergency plan.
Emergency Response Plan (external) Approve external emergency plan	In cooperation with other relevant competent authorities, Port Authority should approve the external ERP, taking into account all relevant ERPs existing in the multi-operator context of the port. The Port Authority should, in particular for this approval, and whenever major accident prevention aspects are relevant, liaise directly with the competent authorities responsible for that particular area.
Emergency Response Plan (training) Initiate an LNG trained and LNG prepared emergency response organization	In order to ensure adequate implementation of the Emergency Response Plan, PAAs should develop and put in practice an adequate training program to be undertaken by all relevant members of the emergency response organization. It is the responsibility of the PAA to ensure that all staff members directly or indirectly involved are aware of their

Port Role/Responsibility	Summary description
	roles in emergency. Training in LNG bunkering emergency & response should consider the involvement of all relevant operators involved in LNG bunkering.
Build adequate Enforcement capacity **Initiate an enforcement system by LNG trained enforcements officers**	Enforcement is an important factor to ensure that the relevant requirements are well implemented and complied with by the relevant parties involved in LNG bunkering. Requirements and relevant legal/technical provisions should therefore be enforceable, clear and well understood by all parties. It is also very important that the enforcement exercise takes into account the practical aspects, both in terms of equipment and cost-benefit of possible safeguard solutions.
Approve risk acceptance criteria	In the absence of relevant directly applicable risk acceptance criteria, the BFO, RSO or Port Administration may propose relevant risk criteria to be adopted. As a good practice approach, where better procedure is not available, the risk criteria should be subject to approval by the Port Authority. In approving the risk criteria, Port Authority should liaise in close cooperation with other relevant competent authorities involved in prevention of major accidents, or with responsibilities on civil and port protection.
Accreditation of the BFO Authorize /accredit bunkering facilities, once they have demonstrated that they are compliant and prepared	In pursuit of a transparent and equitable regulatory and administrative framework for the development of LNG bunkering in ports, PAAs should develop an LNG bunkering accreditation scheme. The scheme should be clear and allow for equal opportunities to all those that present intention or projects for LNG bunkering within the port. The following factors should be taken into account for the accreditation scheme: • Certification of LNG bunkering Equipment • Qualification of BFO personnel • Safety Management System implemented by the BFO • Number of available hours per year • Results of periodic in-service inspections
Qualification of the Person(s)-in-Charge (PICs)	Define the main elements to consider for the qualification of the Person-in-Charge (PIC). What competencies should be derived from the already IGF-defined responsibilities for the PICs should be a responsibility of PAAs. As a minimum it should be here considered that the RSO and BFO PICs should have equivalent qualification for LNG bunkering operation.

Port Role/Responsibility	Summary description
Restrictions for repairs and maintenance on LNG installations on board of ships	(Not directly related to LNG bunkering) Repairs and maintenance of LNG fuelled ships, either planned or non-planned, in designated areas or other locations within the port should be subject to consideration of the PAA. Subject is not related to LNG bunkering but it is of great relevance and importance in the context of operations with LNG fuelled ships. It is included in the present Guidance under Section 15, on Certification/Permit to Work.
Safety requirements for LNG propelled ships on (dock)yards	Even if the repairs of LNG fuelled ships take part in dedicated shipyards, PAAs should be reassured that relevant precautions and procedures are followed in both unloading-inerting and commissioning-cooling-loading operations. Shipyards should be required to have relevant procedures in place to allow for safe repair works in LNG fuelled ships. Subject is not related to LNG bunkering but, for the same reason as the previous point, it is included in the present Guidance under Section 15, on Certification/Permit to Work.
Safety requirements for LNG propelled ship on a lay bye berth to avoid a BOG problem	In the context of the development and implementation of relevant provisions for methane release mitigation, PAAs consider the development of all necessary measures to reduce the amount of NG release to the atmosphere. Should an LNG fuelled ship be on a lay bye berth it should be possible to ensure that adequate measures are put in place to avoid difficult BOG management situations, in particular when LNG vapour pressures are such that PRVs are actuated allowing the pressure relief at cost of environmental impact of methane release to the atmosphere.

5.7.5 The Role of Ports in the development of LNG bunkering facilities

R5.16. **From current references it is possible to determine/summarize a set of good practices in promoting the maritime use of LNG, making it possible to further develop a set of port implementation policies. Cooperative Development, Financial Incentive or Coordinating communication are the selected policies available to Ports for the support to development of LNG bunkering facilities.**

1. **<u>Cooperative development policy:</u>**

   Port authorities should establish various forms of cooperation with stakeholders in or outside of the port perimeter (such as industrial players, governmental authorities, research centres, and other ports in the region and even cross-region). The cooperation can focus on the development of LNG port infrastructure (e.g., location selection), the assessment of the safety risks of the use of LNG in the port environment, and the development of a set of bunkering standards or guidelines. In addition, close partnerships with industrial actors in conducting commercial feasibility studies (e.g., market demand, logistics, price, etc.) is also a key to

success. It is believed that cooperation can enhance interactive learning and knowledge sharing which can reduce the market uncertainty and improve the confidence among market players.

2. **Financial incentive policy:**

   The infrastructure investment is the crucial issue in the process of developing LNG as a ship fuel. Port authorities should use various types of financial instruments to promote the market development of LNG facilities, for instance, (a) by building joint ventures or PPPs with private actors to invest in bunkering facilities; (b) by providing funding or applying for subsidies from the EU or local government to support investment; (c) by developing a differential port tariff favouring ships powered by clean fuels, like LNG (e.g., ESI and Green Award), or by providing funding for ship conversion (e.g., in port of Stockholm); and (d) if applicable, by establishing pilot projects, for example, owning LNG-powered port vessels, to kick-start LNG market development and solve the chicken-and-egg problem.

3. **Coordinating communication policy:**

   Port authorities should take a proactive coordinating role in view of maintaining a good communication within the port community regarding the development of LNG facilities, for instance, (a) by launching a promotion campaign or by organizing conferences, seminars, or workshops; (b) by building a "stakeholder platform" to share knowledge and skills among various stakeholders; and (c) by lobbying the government and raising public awareness to facilitate the permit process.

6. Feasibility

Following the previous section, where the Ports Role could be explored in support of LNG bunkering development, the present section is focused of the Feasibility Analysis of LNG Bunkering projects from the perspective of PAAs. The multi-dimensional structure of Feasibility Analysis is here addressed without, however, focusing in depth the economic aspects, considered outside the scope of the present Guidance.

Aspects related to Economic Feasibility of LNG nevertheless highly relevant in the establishment of LNG bunkering business models and should be a great attention by Operators.

In generic terms the aspects covered in this Section relate to the Technical and Operational Feasibility of prospective LNG Bunkering projects, with the outline of elements considered relevant to PAAs in the evaluation of these projects within the frame of their jurisdiction and competencies.

Having PAAs involved in the Feasibility Evaluation of LNG bunkering projects, from a very preliminary stage, either at concept or front end engineering development (FEED) it will be possible to early mitigate any risks of incompatible or unrealistic solutions, failing to meet PAAs requirements or to address any possible technical or operational constraints imposed by the administrative, physical or safety environment within the port.

The present section includes: 1) Elements to be considered by PAAs for Feasibility Analysis; 2) Main elements with a potential impact on Feasibility for a given LNG bunkering project; 3) SWOT and Multi-Criteria Analysis as tools for Feasibility Analysis and, finally, a set of recommended good practice elements that PAAs may use to support prospective LNG bunkering projects, towards the improvement of the feasibility prospects for a given project.

6.1 LNG Bunkering Project dimensions

There are several distinct dimensions for an LNG bunkering project that need to be included into a Feasibility Study, as presented in the diagram in figure 6.1, below.

A. Technical

- Concept design and engineering solution.
- Engineering development, approval, manufacturing, technical standards
- Optimization

B. Legal

- Regulatory framework for the proposed LNG bunkering solution.
- Regional/Local/Port rules
- Permitting

C. Operational

- Operational Model.
- Simultaneous Operations
- Operational Resources
- Competencies and operational planning.

D. Market/Financial

- Demand evaluation
- Customized/Tailored contract
- LNG pricing and opportunities
- Competitors
- Market
- Financial Cost-Benefit

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E. Economical

- Evaluation of economic cost-benefit.
- Impact assessment of LNG Bunkering in port/local economic profile.

F. Social

- Social Acceptance for LNG bunkering solution.
- Social impact
- Public consultation

G. Risk

- Risk Assessment for the proposed LNG bunkering solution.
- Feasibility of Safe solution

H. Sustainability

- Environmental impact.
- Sustainability of the project.
- Socio-Economical-Environmental balance
- Impact on the sustainability profile for the Port.

Figure 6.1 – LNG Bunkering project dimensions – Feasibility Analysis
In blue all the dimensions that are considered within the scope of this guidance.

A complete Feasibility Analysis of LNG bunkering projects will be the analytical, qualitative and, where possible, quantitative, evaluation of proposed projects covering at least the dimensions presented in the diagram of figure 6.1., all collectively contributing to the development and implementation of LNG bunkering projects and should be taken into consideration by PAAs at the earliest possible moment from the presentation of the project.

Addressing adequately all dimensions will be, primarily, of interest to the Bunker Facility Operator and associated direct/indirect economic operators. Whether an LNG bunkering project initiative is more or less successful will, in fact, impact first on those who commit to capital investment and initiate the venture towards implementation. Notwithstanding this may be the first relevant perception from the feasibility prospects of LNG bunkering projects it is not the only side. PAAs should also be not only implied but also, perhaps moreover, involved in the early evaluation of these specific projects. LNG bunkering constitutes an important add-on service to any Port's service portfolio. It has the potential to differentiate any Port in a positive way, to attract further investment, defining new ship routes and increasing the potential options for local air quality improvement, in support of shipping and local, near-port populations. LNG bunkering as an economic differentiator for ports should here be regarded as a fundamental driver that may lead Ports to support such projects from an early Feasibility Analysis approach.

For a Port, the Feasibility Analysis, divided into each one of its dimensions (as presented in figure 6.1), will provide an early evaluation study on the prospects of any LNG bunkering project. It is also possible to demonstrate through this structured exercise whether the proposed project will aggregate value to the Port service portfolio, along with an indication on risk, economical cost-benefit, and operational process optimization, amongst other important indicators.

Being involved from early stages in the Feasibility Analysis for an LNG bunkering project will allow PAAs to provide input, indicate potential restrictions, provide relevant statistical data, and even promoting the alignement between private, or public-private, initiatives with the port strategic vectors. These may vary significantly from one port to another, remarkably so if we acknowledge that ports have very different sizes, management models, operational and market contexts. Ports may be located in the overlapping between ocean-borne navigation, inland and other relevant multi-modal transportation hubs. LNG is a relevant fuel for transport on a wider perspective. PAAs may find therefore relevant and advantageous to integrate the wider scope in the early stage of LNG bunkering feasibility studies.

It is nevertheless important to underline that Feasibility Analysis will, in principle, represent an instrument to support business decision from the BFO side, including or not agreement with specific RSOs. When, how and to which extent PAAs are consulted in the context of Feasibility Studies will depend largely if a first contact/initiative have been established by the economic operators. The platform for this initiative should be created by PAAs. Promoting the early collaborative environment will allow the opportunity for PAAs to work closely with the BFO for the onset of an optimized permitting process. Cumulative involvement of other competent authorities would further allow minimizing any elements in the concept design that could potentially impose delays in the permitting process, other than those already related to the administrative process flows.

How, and how much, PAAs should support LNG bunkering operators is, in summary, a function of the level of involvement allowed during the concept definition and early project development stages. Information on location or operational restrictions, *big-data*[60]*,* risk acceptance criteria or other relevant elements that can be provided to operator are likely to have a significant impact in the early stages of concept exploration and project development.

Figure 6.2, in the next page, includes a suggested generic LNG bunkering project development flow diagram which is included to highlight the different stages where PAAs are likely to play a very relevant role. Feasibility of an LNG bunkering project can, as expressed in the diagram, develop from concept study down to operational and process analysis through staged typical project development logic, with the support from PAAs being possible in different stages, depending how successful has been the establishment of a collaborative environment between operators and competent authorities. In LNG bunkering projects, as with other projects of relevance to the port's service portfolio, the outcome of collaboration between operators and PAAs will derive in positive outcomes for all parties involved.

[60] **Big data** is a term that describes a **large** volume of **data** – both structured and unstructured – that results from any monitored system, process or operation.

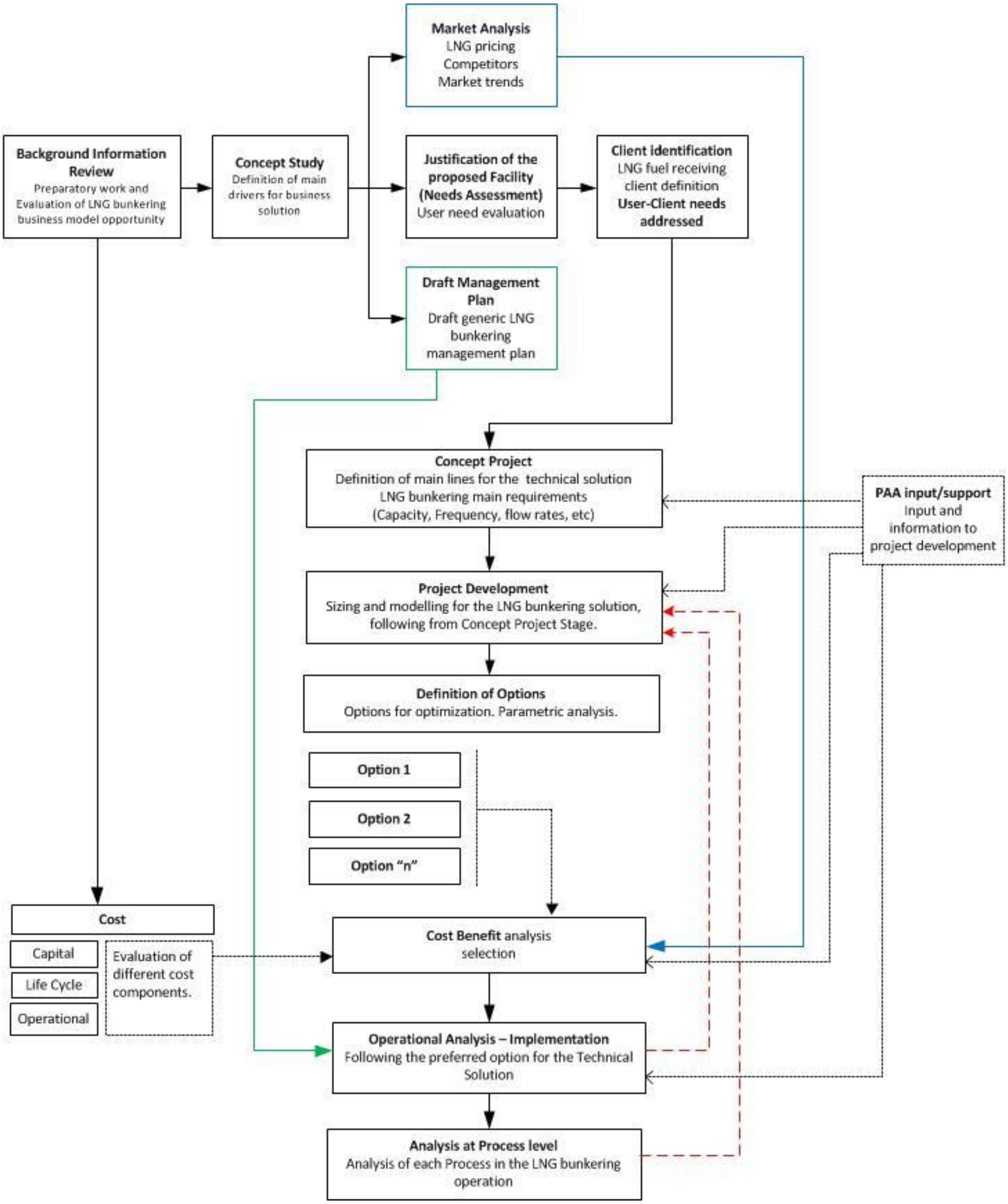


Figure 6.2 – LNG Bunkering project Flow Diagram.
Generic diagram representing the project development for LNG bunkering facilities, indicating the different points where PAAs can support operators - involvement in different parts of the project will depend on the degree of involvement allowed by operators in advance to initiation of the permitting process.

Collaboration and integration are very likely to pay dividends to all parties even if it may be considered that commercial/industry sensitive information is sometimes not shared in advance. Information and transparency, together with non-disclosure agreements should be able to allow for the necessary early trust and engagement to be developed.

6.2 Elements for Feasibility Analysis

Following the different dimensions presented in figure 6.1, defining LNG bunkering project dimensions, table 6.1, below, lists some suggested elements that PAAs may use not only in the support of Feasibility Analysis studies but also as a direct contribution to the feasibility prospects for any LNG bunkering project.

For each selected project dimension the suggested elements indicate which aspects PAAs may provide support with.

Table 6.1 – LNG bunkering projects – elements for Feasibility Analysis

Project Dimension (figure 6.1)	**Elements for Feasibility Analysis** (elements that should be observed for Feasibility Analysis of LNG bunkering projects)	**Support from PAAs** (elements where PAAs support may have a direct impact in Feasibility)
A. Technical	**LNG source/availability** – distance to LNG import/LNG storage from break-bulk distribution.	• Mapping of existing LNG facilities, storage and distribution infrastructure. • Facilitation in the development of the logistic chain.
	LNG bunkering option (STS, PTS, TTS, ISO-LNG containerized unit)	• Share with operators the main restrictions imposed either by port area layout or activities.
	Onsite storage for LNG fuel – requirement for consideration of local LNG storage facility for PTS bunkering (or PTS filling of LNG bunkering mobile units – barges, vessels or trucks)	• Provide operators with proposed location options for LNG fixed storage elements. • Support with land use elements relevant for possible building permits or land-use classification.
	Bunkering parameters required by specific LNG fuelled ships – LNG flow rate, pressures, temperatures may be some of the more important parameters to be fixed for a given LNG bunkering solution. (typically related to required turn-around times and operational constraints)	• Should there be any restrictions on possible bunkering parameters, make them available and clear to operators from the early concept development stages • Together with the relevant restriction elements, give indication of any possible risk-based review of those restrictions. (bunkering parameters are a fundamental aspect of the LNG bunkering service, in particular accounting for ships that will require increasingly shorter turn-around times, such as RO-PAX ferries)
	Cooling services – requirement for cooling services may be derived from the need to fill otherwise warm LNG fuel tanks.	• PAAs should define restrictions for "hot LNG" bunkering and enforce adequate temperature control for LNG trucks or other mobile LNG bunkering units.
	Inerting – Both before and after LNG transfer, inerting is a requirement for safety of operation, preparing the bunkering lines prior to LNG filling and clearing them of LNG vapours immediately after drainage. Technical option for inerting should designate whose responsibility is it for inerting operations. Which resources are to be used, together with the operational and Process level evaluation, should be	• PAAs should make clearly available any specific requirements regarding inerting of: – Bunkering lines – LNG bunkering rigid arm fixed installations – LNG distribution lines – Vapour return lines – NG lines • Inerting is a fundamental safety aspect in LNG bunkering facilities and operations. PAAs should consider, in particular for fixed installations there may be large extensions of LNG lines that require inerting prior and after operation. • Displaced LNG vapours, in the end of operation must have a declared fate. What will be drainage sump? It is important to avoid all operational venting considerations. • PAAs should make clear requirements for inerting and, with this, support the early feasibility for LNG bunkering projects, defining clearly the baseline that should be considered for the technical concept project.

Project Dimension (figure 6.1)	**Elements for Feasibility Analysis** (elements that should be observed for Feasibility Analysis of LNG bunkering projects)	**Support from PAAs** (elements where PAAs support may have a direct impact in Feasibility)
	Communications – A variety of different options may be considered for communications during LNG bunkering.	• Communications are an important element for technical feasibility analysis, in particular with regards to the necessary communication channels for operational aspects such as authorization procedures. • Radio frequencies, encrypted data, digital, web-based communications, SATCOM, emergency communication, and any other technical aspects relevant for the technical/operational feasibility of the project. • PAAs should make available all possible options for communications' planning within the context of any prospective LNG bunkering facility project. • An important aspect to take into account is the interoperability of systems and, in the particular case of emergency, the possibility to have communication channels shared by the wider multi-operator community in the port area.
	Standardization – Are the different LNG bunkering solution elements to be certified according to relevant international standards?	• A key rule in the context of certification for a prospective LNG bunkering facility will be standardization. • PAAs should consider the identification of standardization elements as positive aspects towards feasibility of a given LNG bunkering project. • The relevant standards for LNG bunkering facilities and operations are listed and summarized in Section 4.3 with 4.6.7 underlining suggest good practice in the reference to these standards. • PAAs should make clear reference to the relevant standards for LNG bunkering in their requirements for certification of LNG bunkering facilities. Legally binding requirements for standardization must be inscribed either in national legislation of port-specific regulations.
	Certification – will the LNG bunkering facility proposed meet all the requirements for certification?	• PAAs should adopt structured certification schemes for LNG bunkering projects and operations. With guidance for certification, making reference to specific standards it will be, in principle, easier to assess the feasibility for a prospective project.
	Technical Maturity of the proposed project – Has the solution presented for implementation been tested in operation before? For how long? For solutions that have already been implemented, prospective LNG bunkering projects should provide as many elements as necessary to support in the evaluation of their technical feasibility.	• For solutions that have already been implemented it is important to check for evidence and elements of reference projects. • For new technology elements, in order to support technical maturity for a prospective LNG bunkering project PAAs can, as appropriate, establish connection points with other ports and initiatives, seeking for any possibility of technology transfer. • In the particular case of public funded projects, it should be possible for prospective LNG bunkering initiatives to get information and demonstrated results which belong partially[61] to the public domain. PAAs may play an important role in the dissemination and availability of these results, establishing the link with the public funding competent authorities.
	Automation – What is the degree of automation in the proposed LNG bunkering	• Automation elements may be present in some LNG bunkering projects. The degree of automation, however, will inevitably be different from project to project, with LNG fuelling or LNG

[61] LNG bunkering and small scale LNG projects, when supported by some type of public funding, will typically be under the obligation to provide some type of results report for public information. Technology elements and non-commercially sensitive information may very likely be sourced from these elements in support for prospective and ongoing LNG bunkering projects.

Project Dimension (figure 6.1)	**Elements for Feasibility Analysis** (elements that should be observed for Feasibility Analysis of LNG bunkering projects)	**Support from PAAs** (elements where PAAs support may have a direct impact in Feasibility)
	solution? Is supervision considered?	bunkering via rigid/automated arms being likely to incorporate elements of automation for reduced human intervention. • It is important, in this context, that PAAs may define what the minimum requirements are for manning of LNG bunkering installations, even in the case where full automation is considered. • Any automated elements in LNG bunkering solutions must be provided for with manual over-ride options that allow for manned operation. • In the particular case of LNG fuelling, where the LNG delivery is provided for by LNG mobile units alongside the receiving vessel throughout its whole stay at port.
B. Legal	**National legislation** – What are the applicable legislative references to the proposed LNG bunkering solution? (Taking the whole supply chain into consideration[62]). **Port Regulations** – Are any specific requirements for LNG bunkering inscribed in the Port Regulations?	• PAAs should, as appropriate and reasonably possible, provide an information package to prospective LNG bunkering operators including all legal references that may be relevant for the definition of the concept project, supporting from an early stage in the definition of a feasible solution. • In the case of early consultation by prospective BFO/Operators, PAAs should assess any specific details of the proposed LNG bunkering project and provide the relevant legal references applicable to that case. • From the early evaluation of the proposed project, along with the relevant legal references, PAAs may issue a first indication regarding the feasibility for the presented solution.
	Permitting – Are all steps for permitting being observed? Permitting can represent a significantly burdensome process if all aspects are not accounted for in a preliminary phase. Feasibility of any LNG bunkering projects should address, in advance, all different parts of the permitting process to ensure that no major obstacles are posed to the good realization of the project.	• Provide operators with all the relevant elements for permitting, making them available in a transparent and informative manner. • Assuming the position of a "facilitator" in the permitting process, PAAs should provide operators with the relevant mapping and points of contact for the different parts of the permitting process. • The establishment of a "single-desk" approach, where all relevant permits could be initiated and monitored, would be a highly relevant initiative. One of the main factors of success for such measure would be the level of collaboration between different competent authorities.
C. Operational	**Operational Restrictions**. The adequate design of operations should take into account any restrictions possible/likely to be imposed by any given PAA.	• Operational restrictions should be clearly expressed in Port Regulations. • In addition, as a way to support the feasibility of prospective LNG bunkering projects, PAAs should also consider alternative options, possibly risk-based, where excursions beyond the operational restrictions would be possible.
	Operational Envelopes. Similarly to the Operational Restrictions, the Feasibility Analysis of LNG bunkering projects should take into account the Operational Envelopes imposed by possible local weather	• Provide information to operators on local conditions that may result in operational envelopes to be accounted for in LNG bunkering operations. • Inform on the local characteristic weather patterns, with local

[62] By taking the whole supply chain into consideration, for the appreciation of the applicable legislative frame, it will be possible to evaluate the feasibility of the different possible options for LNG delivery, transport and handling representing the complete chain for a given LNG bunkering solution.

Project Dimension (figure 6.1)	**Elements for Feasibility Analysis** (elements that should be observed for Feasibility Analysis of LNG bunkering projects)	**Support from PAAs** (elements where PAAs support may have a direct impact in Feasibility)
	restrictions (wind/ temperature/ other)	weather office data for a typical year-round chart (wind, temperature) • Make available to operators all operational information found relevant to the feasibility analysis of new LNG bunkering projects. • PAAs should also consider alternative options, possibly risk-based, where excursions beyond the operational envelope restrictions/limitations would be possible. Justification to be presented on the basis of specific risk assessment.
	Simultaneous Operations (SIMOPS) – Any consideration regarding possible Simultaneous Operations should be considered well in advance as these may impact significantly on the Feasibility prospects of any LNG bunkering project. Some Ports may have more or less strict requirements regarding SIMOPS. Whether these are inscribed in specific Port Regulations or derived from a later Risk Assessment, they will highly relevant to the feasibility analysis of LNG bunkering projects. Can SIMOPS be considered? Under which conditions? Are there technical implications for the proposed solution? These are some of the questions that need to be answered in the context of a feasibility study for any proposed LNG bunkering project. With RSOs being, ultimately, the main interested party in having short turnaround times they should also, in principle, take part in the proposed solution.	• PAAs should define under which conditions Simultaneous Operations (SIMOPS) are allowed. • SIMOPS will represent a fundamental aspect in the feasibility prospects for any prospective LNG bunkering project/facility. In some cases it may be that the LNG bunkering will only represent a viable option if some degree of SIMOPs is allowed. • Establish and inform operators, relevant stakeholders and involved parties, of a specific procedure to plan and approve SIMOPS. This should be inscribed in the Port Regulations or, alternatively, be issued as guidance or stand-alone documents as Circulars or Memos. • Define clearly the staged approach in the authorization for SIMOPS. • Evaluate the prospective project in the light of its preparation for SIMOPS, providing input under the form of recommendations.
D. Market/ Financial	Aspects such as LNG price, competition, demand, opportunities and other important market related variables are taken into consideration as primary factors for feasibility. They will also impact necessarily on the technical solution through life-cycle cost analysis. NOTE: Market/Financial aspects may well be the main aspects typically evaluated in a Feasibility Study. These however aspects that are not considered within the scope of the present Guidance document.	Not applicable
E. Economical	**Multi-Operator Environment**. Other Port Service operators will have to be considered in advance as important factors affecting the feasibility of proposed LNG bunkering projects/facilities. Interaction between operators and potentially incompatible activities within the port area are some of the aspects that should be considered at the earliest opportunity.	• PAAs may provide useful data on other activities within the port area which are likely to have some impact in the prospective LNG bunkering project.
	Local Port Economy factors. In a variety of different aspects, LNG bunkering will impact and be impacted from the local port	• Depending on the level of exchange with LNG bunkering project proponents and operators, PAAs may provide elements related to local port economy development.

Project Dimension (figure 6.1)	**Elements for Feasibility Analysis** (elements that should be observed for Feasibility Analysis of LNG bunkering projects)	**Support from PAAs** (elements where PAAs support may have a direct impact in Feasibility)
	economy. Some of the main relevant aspects regarding the economic factors will be: • Potential for LNG multi-client hub development. • Potential for growth (increasing number of LNG fuelled ships and bunkering operations) • Local "green economy" trends • Existing LNG bunkering operators • Schemes for Port Fees and incentives for alternative fuels and clean power solutions.	• Future prospects for LNG/Energy developments in the port area, potential for growth, fees and incentive schemes are some of the support information that can be provided. • How the different information will impact on feasibility of different LNG bunkering projects will depend on a case-by-case evaluation.
	Economic Cost-Benefit. An Economic cost-benefit may, in a way, be regarded as more relevant to the port and local economy than to the LNG bunkering operator.	• The economic cost-benefit of an LNG bunkering development in the port area may be evaluated in the early stages of the project. • How PAAs may support operators in this regard is very dependent on the exact nature of the business and solution proposed. • The essential note should be, in this context, that PAAs have the opportunity to evaluate the feasibility of LNG bunkering projects also from the perspective of port economy development, associating opportunities generated by the LNG bunkering development into the evaluation of the project feasibility itself.
F. Social	**Public Consultation**. Only in some specific cases Public Consultation will be required (remarkably where imposed as a SEVESO requirement for higher tier establishments (see Section 4.6.4). There is however a significant role that can be played by PAAs in the facilitation of local public/communities- consultation. This can be a relevant factor to take into account to support the feasibility of a given LNG projects, remarkably where LNG bunkering operation is envisaged for a location situated close to densely populated areas.	• On the cases where Public Consultation needs to be accounted for (see Section 4.6.4), PAAs may liaise with local authorities to support with additional information, facilitating the public consultation, especially on those element which may be more related to risk & safety. • PAAs may use the privileged knowledge of local communities to facilitate the consultation process, clarifying any elements where transparency and clarity may be of support for a better informed consultation process.
	Information campaigns. In itself information to public and general information campaigns are not a fundamental factor for the feasibility of LNG bunkering projects. They have however the ability to enhance and facilitate the acceptance of LNG as fuel and associated projects.	• PAAs may support social feasibility of LNG bunkering projects through information on different channels targeting the following communities: – Local authorities – Port operators – Service providers within the port area. – Ship Agents • Information is particularly important in defining the risk & safety perception of LNG as fuel for ships. PAAs choosing to enforce LNG perception with information campaigns will improve directly the social feasibility prospects of LNG bunkering projects. • Examples of such initiatives may be found in the shape of informative websites such as the EC www.lngforshipping.com or the WPCI www.lngbunkering.org.
	Opportunities. Social perception of LNG as an alternative fuel for ships will greatly depend on the ability of the proposed	• It is important to build the case for LNG bunkering projects, including as important factors the potential direct benefits for

Project Dimension (figure 6.1)	**Elements for Feasibility Analysis** (elements that should be observed for Feasibility Analysis of LNG bunkering projects)	**Support from PAAs** (elements where PAAs support may have a direct impact in Feasibility)
	projects to highlight the new opportunities created by LNG as an alternative cleaner fuel, including benefits for the environment, new and more specialized jobs, together with a strong possibility for improvement of the local economy in a wider scale.	environment and economy. • PAAs may support feasibility of new LNG bunkering projects through the exploration of new opportunities, immediate or with through-life relevance.
G. Risk	**Risk Assessment**. The evaluation of risk for an LNG bunkering project is likely to be the most relevant document to be used not only for permitting but also, especially in the initial stages of concept or project development, an important tools to reassess the concept or project in itself. Risk Assessment is more likely to introduce modification into the proposed solution than to deem it to a negative feasibility prospect. It will be able to introduce elements which can then be used to detail the engineering solution, inclusive of any identified necessary safeguards to improve the evaluated safety risk level for the proposed project. Assessment of risk will be made either following a quantitative or qualitative approach. In both cases there are elements that can be considered fundamental drivers for an adequate feasibility evaluation derived from a risk assessment: • Adequate representation of the LNG bunkering facility and operation in the risk assessment. • HAZID team composition (experience, proven competency, number of participants) • Number of different risk case scenarios considered (including the complete scope of operations).	• Risk Criteria (will be the most relevant element for QRA Risk Analysis). PAAs must clearly define Risk Criteria wherever Quantitative Risk Assessment is required. There must be a clear understanding, promoted by PAAs, that the usefulness of QRAs is only best explored where LNG bunkering risk criteria. In the absence of national framework for such risk criteria, ISO/TS 18683:2015 suggested risk criteria example (Annex-A) should be taken as the biding reference. • Participate in HAZID workshops. Participation in HAZID workshops for prospective LNG bunkering projects will give PAAs the possibility to support operators in the definition of risk scenarios, underlining the most critical situations and supporting, through the drafting of relevant safeguards, the project feasibility. • Data on Incidents and near-misses related to bunkering, eventually held by PAAs, should be used to draft recommendations or specific requirements for PAAs, improving in this way the feasibility prospects for the project. • Should the HAZID represent the first step before the development of more thorough Risk Assessment (QualRA or QRA), PAAs should take the opportunity of participation to provide elements considered relevant for feasibility. • Involvement of third-party risk evaluation professionals should be regarded positively by PAAs, as an indication of transparency in the risk study/assessment process. For prospective LNG bunkering projects PAAs should underline the need for independent risk study (at least as much as reasonably possible). In this regard "independency" is to be understood as a good guarantee for feasibility of the prospective LNG bunkering project.
	Safety Distances/ Control Zones. One of the direct results of Risk Assessment will be the definition of the Safety Zone and additional control zones (such as the security zone or navigation exclusion zone (see section 9). Focusing primarily on the Safety Zone it is important to evaluate if the intended location, adjacent infrastructure and proposed Safety Distance are compatible. If not entirely possible to eliminate potential ignition sources, gas trapping spots and conflicting activities, within the proposed Safety Zone, the feasibility of the project will be inevitably affected. This should be subject to continuous review. Since the Safety Zone, by definition, should encompass the elimination of potential ignition sources and other activities/ operations inside the defined zone, it will be important to ensure that no conflicts arise.	• As a first-principle in the interpretation of proposed safety distances PAAs should consider that no Safety Distance is the "right" Safety Distance (see section 9). • PAAs should provide support with the indication of any baseline minimum required safety distances for LNG bunkering, underlining the concept of Meaningful Protection (Section 9). • Feasibility analysis, based on suggested safety distances, should be based on the evaluation of meaningful protection for persons and infrastructure. • Dispersion studies should be regarded as a good indication on positive risk feasibility, resulting, in principle, in the definition of more realistic safety distances, based in numeric gas dispersion calculations. • Assumptions used in all numeric/computational gas dispersion calculations should be assessed by PAAs as indicators on how accurate is modelling of local conditions.

Project Dimension (figure 6.1)	**Elements for Feasibility Analysis** (elements that should be observed for Feasibility Analysis of LNG bunkering projects)	**Support from PAAs** (elements where PAAs support may have a direct impact in Feasibility)
H. Sustainability	**Air Emissions**. The use of LNG as fuel is one of the main options available to ship operators to improve/reduce air pollution, reducing sulphur oxides, particulate matter and nitrogen oxides emissions to the atmosphere. The use of LNG as fuel is therefore a direct measure to improve the environmental performance of ships using this fuel, but not only. It may also represent a direct factor contributing to the improvement of any port's environmental performance. A direct and sustainable reduction in emissions (SOx, NOX and PM) should be assessed together with a relevant set of measures to mitigate the risk of any methane emissions to the atmosphere (see Section 3). Purging, Inerting, cooling and filling procedures should all be detailed with explicit reference to the measures considered relevant to PAAs evaluation.	• Air Emissions from LNG bunkering operations are the main fundamental aspect in the field of Sustainability for the use of LNG as marine fuel. On one hand using LNG as an alternative fuel will immediately reflect in lower emissions of SOx (by more than 95%), NOx (to an extent directly related to the engine technology, that can go up to 70% in lean gas burning engines) and Particulate Matter (also by more than 95%). On another hand CO_2 emissions may outbalance the very positive figures from above, with methane (CH_4) representing a GHG emission which is 25 times worse than CO_2 on a 100 years scale. With the above in consideration PAAs should look for all elements related to prevention and mitigation of LNG vapour emissions through venting, pressure release or incorrect BOG management. • Purging and inerting procedures should be revised and the fate of post-bunkering LNG in the bunkering lines questioned. Emission to the atmosphere, as a result of quick temperature increase and pressure build-up in the bunkering line should not be acceptable in the context of feasibility analysis.
	Environment. The feasibility of the LNG bunkering solution as a sustainable environmental project should be assessed from the early stages of the concept project. The following stages of the Environmental Impact Assessment are relevant for the Feasibility Analysis: 1) Screening; 2) Scoping and 3) Prediction and Mitigation (see diagram in figure 4.25).	• PAAs should ensure that EIA related feasibility is successfully addressed, in preparation for the permitting process.
	Logistics and Supply. How far is LNG sourced from for the proposed LNG bunkering facility? Which logistic routes are followed for LNG distribution? The footprint of LNG distribution chain in the port area, and its supply routes (road/sea) should be evaluated, in particular with regards to possible conflicting and congestion points.	• PAAs should assess the impact on access to the port and within the port area. • To support feasibility of the LNG bunkering project PAAs may provide alternative options and design logistic solution in close cooperation with operators.

All elements from the table above should be addressed in the context of the desired earliest involvement of PAAs in the feasibility discussion of prospective LNG bunkering projects. This may not always be possible, and LNG bunkering proposed solutions may be presented in a stage of development such that less flexibility to accommodate proposed recommendations may become a problem in the permitting and/or implementation stages. PAAs have here an opportunity to engage early, participate and through collaborative support be able to potentiate the LNG bunkering project as a port service adding value to a specific port economy profile.

6.3 Factors affecting LNG Bunkering feasibility in the Port Area

Following from the previous section, where the main elements for Feasibility Analysis where listed and detailed, for each LNG bunkering project dimension, it is now possible to identify the essential aspects which can be either relevant aspects or "showstoppers" in the development of prospective LNG bunkering facilities. PAAs may take this for reference when evaluating LNG bunkering projects and should, in principle, be able to provide support in the clarification of any possible restrictions and, at the same time, support with the possible drafting of alternative options/possibilities.

The diagram in figure 6.3, below, presents the main factors and how they can, potentially, pose a negative impact in the Feasibility of LNG bunkering projects.

1. LNG Availability

- Availability of LNG close to the vicinity of the LNG bunkering location will be fundamental to the business feasibility.
- No availability will lead to complex logistical chain to source LNG.
- Longer logistic/distribution chains will impact on LNG bunker prices, environmental profile and sustainability of any specific project.
- Longer distances from source will likely lead to the need for intermediate buffer LNG storage.

2. LNG Bunkering parameters

- Requirements for LNG bunkering will come typically with very specific LNG bunkering parameters.
- Flow rate will be the primary driving factor, dictating the total time length for LNG bunkering operation
- Other LNG bunkering parameters (such as pressure) will also be fundamental for bunkering control.
- LNG bunkering parameters are highly relevant in the particular case of accidental releases, followed by dispersion LNG cloud. Higher flow rates and pressures will lead to higher accidentally released volumes.

3. LNG Bunkering mode

- The LNG bunkering mode will be dictated by different operational aspects (including the bunkering volumes, transfer rates, requirement for SIMOPS.
- Restrictions on mobility, spatial planning and other port specific elements may represent challenges for the feasibility of LNG bunkering projects.
- The LNG bunkering mode selected must meet RSOs needs, whilst being able to address any possible local restrictions.

4. Demand profile

- More than the business/market relevance of LNG bunkering demand, it is important to establish the demand profile.
- What LNG ships (which specific requirements) more than "How Many"
- Fixed LNG bunkering contract with dedicated costumer will have a positive impact on feasibility.
- Spot LNG bunkering will present more risks but will have to be a supported option.

LNG Bunkering Project
(Factors affecting Feasibility)

Feasibility of LNG bunkering projects may be affected directly by different factors.
Interpretation of these factors by PAAs will allow the best support to be provided in a timely manner.
The support effect from PAAs and anticipated in the previous section should be taken into consideration.
All factors should be taken into consideration in equal terms and recommendations on each aspect be issued by PAAs where and when appropriate

5. Risk Assessment/ Risk Criteria

- The Risk Assessment is a fundamental part of the proposed LNG bunkering project.
- Recommendations following Risk Assessment are important elements to ensure safety of a given LNG bunkering project.
- Critical risk ranking (above ALARP) for any risk scenario will result in the negative feasibility of the project.
- Not incorporating recommendations or failing to meet ALARP risk levels will represent failing feasibility.

6. Environmental

- The technical solution proposed should detail the environmental protection solutions for methane emission mitigation.
- Failing to describe, with sufficient detail, the methane emission mitigation measures should lead PAAs to question the feasibility of the project.
- An LNG bunkering project should only be considered feasible if able to demonstrate adequate environmental management throughout the project life-cycle.

7. Onsite Storage

- Onsite Storage will represent an important element of the LNG bunkering project. Specific major accident prevention requirements will be in place (see Section 4.6.4).
- The relevant standards for construction and operation of LNG small scale fixed installations must be explicitly followed.
- Risk assessment for fixed installations should preferably be a Quantitative Risk Assessment, accounting for the fixed presence onsite of larger LNG quantities (see Section 8)

8. Logistics

- The LNG bunkering impact on waterborne and land based logistic routes must be evaluated.
- Congestion points or any other points of critical logistic challenge must be identified and feasibility routes defined.

9. Location

- LNG Bunkering location will be defined as a result of risk assessment, spatial planning and other operational considerations.
- Availability of locations for LNG bunkering will be a port-specific consideration.

Figure 6.3 – Factors affecting feasibility of LNG bunkering projects
Potential challenges for prospective LNG bunkering projects, eventually leading to non-feasibility.

Whilst the diagram in figure 6.3 identifies some of the most relevant challenges to feasibility of LNG bunkering projects, it is important to note that today there are many technical options available to operators. As the market moves from smaller capacities (typically TTS mode) to higher LNG volumes (STS or PTS modes) there is a change in paradigm which will inevitably reflect in future LNG bunkering projects. Feasibility of different LNG bunkering projects will therefore be a characteristic to evaluate in increasingly relevant solution, remarkably in terms of the LNG quantities involved.

How PAAs should support operators, and when, is difficult to define. The only possible guidance advice is that it should happen at the earliest possibility in the project development, with operators having to disclose early concept lines of the projects, in exchange for support from PAAs with aspects related to the feasibility prospects of each project.

6.4 Analytical Tools

Whilst the previous sections listed the different dimensions in LNG Bunkering Projects, together with the different factors affecting Feasibility Analysis, the present section features three different analytical tools that may be helpful in the evaluation, decision-making and support to prospective LNG bunkering projects: 1) **SWOT** Analysis (Strengths, Weaknesses, Opportunities and Threats); 2) Life-Cycle Analysis (**LCA**) and 3) Multi Criteria Analysis (**MCA**):

1. The **SWOT** analysis has the potential to identify different critical aspects of the LNG bunkering, considering the external and internal factors which may impact on the feasibility of any specific project. Intrinsic strengths and weaknesses of the project are also identified and a SWOT matrix is built to support the analysis.
2. The **LCA** analysis focuses on the structured life-cycle evaluation of the LNG bunkering project as any other engineering development, incorporating a) Concept, b) Development, c) Implementation; d) Operation and e) Decommissioning.
3. The **MCA** analysis used in decision-making, which may be regarded as particularly useful for PAAs faced with different options for LNG bunkering projects (such as deciding which bunkering mode to allow, bunkering parameters, and others).

To which extent PAAs may get involved in the feasibility evaluation of LNG bunkering projects will depend on the level of understanding and collaboration between competent authorities and operators. SWOT, LCA and MCA tools will be some of the possible instruments for a transparent and structured evaluation of LNG bunkering projects feasibility, in all project's dimensions.

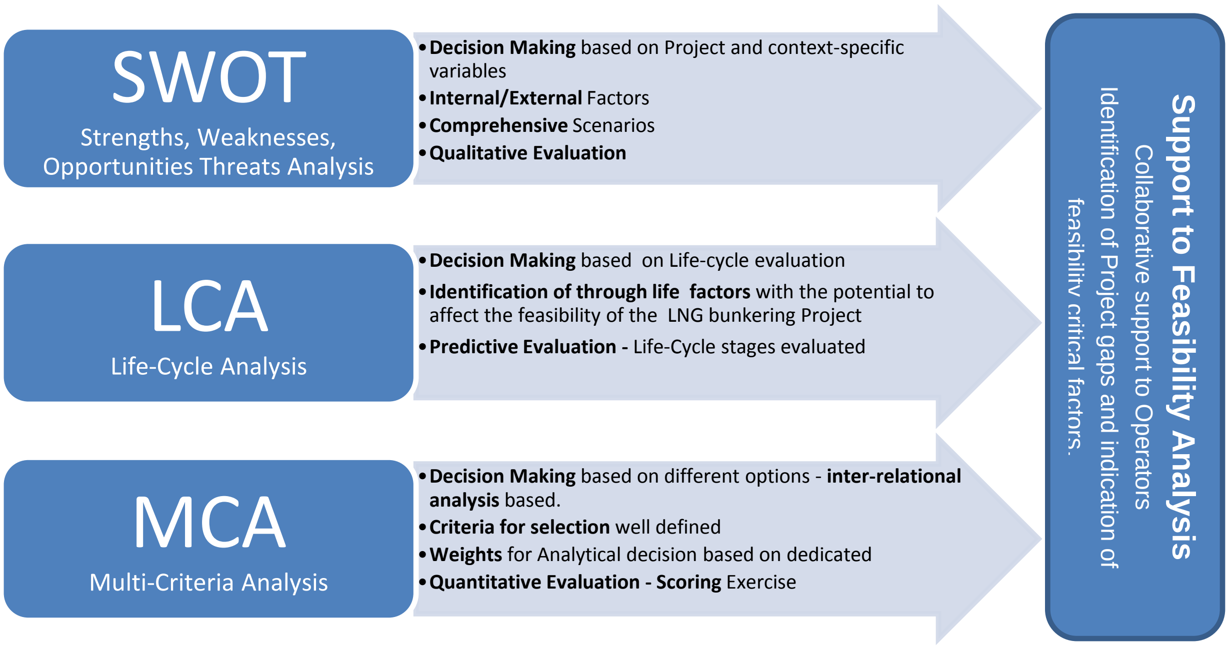


Figure 6.4 – SWOT and MCA – Tools for Feasibility Analysis
Tools to assist in the multi-dimensional feasibility analysis of LNG bunkering projects

6.4.1 SWOT Analysis

SWOT is a typical strategic planning tool used to evaluate the strengths, weaknesses, opportunities, and threats to a project. It involves specifying the objective of the project and identifying the internal and external factors that are favourable and unfavourable to achieving that objective. The strengths and weaknesses usually arise from within the project details and organisation, and the opportunities and threats from external context. SWOT analysis is adopted from strategic planning to project feasibility analysis but, in practice, it can be used widely in many other practical applications.

The SWOT analysis is, in this sense, an important part of the project planning and feasibility analysis process:

- **Strengths:** attributes of the project and operator(s) that are understood to have a direct impact in the feasibility of the project.
- **Weaknesses:** attributes of the project and operator(s) that have to potential to stop, or significantly diminish, the achievement of the project objective/implementation.
- **Opportunities:** external conditions, including port-specific conditions, which help achieve the LNG bunkering project objective.
- **Threats:** external conditions, including port-specific conditions, which have the potential to endanger the full achievement of the LNG bunkering project objectives/ implementation.

Table 6.2, below, represents a SWOT matrix, with a few examples of what can be considered in the context of LNG bunkering projects. The qualitative approach of a SWOT allows for the analysis to be used in a multi-variable context.

Table 6.2 – LNG bunkering projects – elements for Feasibility Analysis

	Positive	Negative
	Strengths	**Weaknesses**
Internal	1. Maturity (similar successes and evidence of technological maturity for LNG bunkering solution) 2. Resource availability (LNG Terminal close) 3. LNG chain owned by BFO (Terminal and distribution) 4. Skill levels (demonstrated competence of personnel) 5. Processes and systems (properly mapped LNG bunkering process) 6. Reputation (built references from operation in other ports or other sides of the LNG activity) 7. Complete and Independent Risk Assessment (including variety of risk scenarios and quantitative calculations, including gas dispersion modelling).	1. Gaps in knowledge and expertise, with evident lack of previous experience in the field 2. Insufficiently detailed technical solution. (Lack of details for any part of the LNG storage, distribution or bunkering segments 3. Timescale and deadlines, for project implementation which may be regarded as non-realistic. 4. Financial capability, in particular regarding the lack of demonstration for capital investment. 5. Certification challenges, in particular if standardization is not well clarified. 6. One-Client solutions, when LNG bunkering solution is customized taylor-made to one ship – poor flexibility.
	Opportunities	**Threats**
External	1. Technology and infrastructure development (development of a new terminal, standards for LNG bunkering) 2. LNG fueled ships uptake – more ships and increase in LNG fuel capacities – increasing number of ships suitable for the technology offered. 3. Multimodal LNG hub – How adequate is the project proposed to respond to multi-modal LNG hub opportunities. 4. New innovations (R&D) 5. Market demand 6. Financing Opportunities	1. Environmental factors, with methane emissions becoming a major focus of attention, particularly sensitive if no adequate methane emission mitigation is included in the project. 2. Competition/ Competitor projects 3. Risk Assessment in ALARP borderline. Variation of external factors potentially leading to unacceptable risk levels. 4. LNG bunkering demand not compatible with the proposed solution (either in capacity or technical specification)

PAAs, in the course of a SWOT-assisted feasibility analysis for any given LNG bunkering project, should, as far as possible and appropriate, support operators in the adequate definition of the external environment factors (a large majority of them likely to be port-specific).

6.4.2 LCA Analysis

Every engineering project, or product development, will have in principle to be evaluated on the basis of its anticipated Life-Cycle. Not only are the costs a relevant aspect to evaluate through the life of the project but also the performance, environmental impact and other operational aspects. For LNG bunkering projects the same will apply and a Life-Cycle Analysis (LCA) may be one of the instruments to support the evaluation of feasibility for any prospective LNG bunkering project. The table 6.3, below, proposes an indicative structure for LCA of LNG bunkering projects, suggesting a few relevant questions to be asked by PAAs for each different phase.

Table 6.3 – LNG bunkering projects – elements for Life Cycle Analysis

LNG Bunkering Project Life-Cycle Stage		Description	**LCA Analysis** from PAA perspective – support to Operators
Pre-Project	1. Scope 2. Requirements 3. Business Plan 4. Project execution Plan	Adequate definition of the project scope, including business plan, pre-requisites for the project, pre-contractual agreement. Demand characterization, including technological elements for compatibility.	- Data on possible LNG market potential. - Support in scope definition - Potential estimated demand - Economic data that may be of support in the business plan. - Info on possible funding/financing - Check for compatibility of Project execution plan
Design	5. Concept design 6. Pre-Feasibility 7. Feasibility 8. Engineering Concept 9. Options	Concept design description of the LNG bunkering project, including the proposed LNG bunkering mode, anticipated LNG bunkering volumes. Anticipation of Feasibility prospects for the project. Engineering solution, considering different options for possible MCA Analysis	- Concept design evaluation. - Support in Feasibility Analysis - Identification of technical critical elements. - Verification of earlier success elements - Is the solution adequate to required bunkering demand? - Are all elements for feasibility analysis ready at this stage? (reference may be made to Table
Risk	10. HAZID 11. Risk Assessment 12. Safeguards 13. Major accident Prevention	HAZID workshop with widest possible stakeholders' representatives, resulting in first risk ranking on different risk scenarios. First recommendations from HAZID. Risk Assessment against specified risk criteria. MAP whenever required. All elements to be prepared at this stage, anticipating permitting.	- Participate in HAZID - Evaluate HAZID team composition and realized risk scenarios. - Check for critical risk scenarios and evaluate defined safeguards - Ensure critical scenarios, from PAA perspective, are included from HAZID scoping. - Provide Risk Criteria whenever QRA is required - Provide risk contour charts of port are whenever hazardous activities or MAP classification risk assessments exist for the port area. - Assist operators, facilitating through MAP or EIA processes, in advance to the permitting process. Review initial documentation.
Implementation	14. Permitting 15. Procurement 16. Certification 17. Construction 18. Trials	Preparation of all documentation for Permitting. Procurement for construction and equipment. Construction phase, followed by reception and trials.	- Support operators throughout the permitting process, either establishing a single-desk/ single-permit approach, or through the establishment of the relevant channels with different competent permitting authorities (Point of Contact approach). - Have clear structured BFO certification scheme, including all necessary references for certification (standards, rules, port regulations, etc.) - Evaluate impact of construction phase. - Support with Trials execution and Assess results.
Operation	19. Commissioning 20. Procedures 21. Maintenance 22. Modifications	Preparation of all documentation for Permitting. Procurement for construction and equipment. Construction phase, followed by reception and trials.	- Evaluate commissioning program. - Check for all elements in the LNG Bunkering Management Plan. - Verify Competences and Training Certificates for all personnel involved. - Check for streamlined procedures and implementation of the relevant check-lists for the LNG bunkering activities.
End-of-Life	23. Decommissioning preparation 24. Close-out actions 25. Decommissioning	Elements relevant for phase-out or decommissioning.	- Evaluate end-of-life impact of the project.

6.4.3 MCA Analysis

Whilst SWOT is a typical tool, adapted from strategic planning, used to evaluate the strengths, weaknesses, opportunities, and threats, the Multi Criteria Analysis (MCA) stands for a project-focused analysis establishing a comparative framework for different parametric options for the same project. In the case of LNG bunkering this may be useful in particular for PAAs to support operators in the location selection for a prospective LNG bunkering facility.

Multi-Criteria Analysis (MCA), or Multi-Criteria Decision Analysis (MCDA), is a discipline aimed at supporting decision makers who are faced with making numerous and conflicting evaluations. MCA aims at highlighting these conflicts and deriving a way to come to a compromise in a transparent process. MCA methods have been developed to improve the quality of decisions involving multiple criteria by making choices more explicit, rational and efficient. The goal is to create a structured process to identify objectives, create alternatives and compare them from different perspectives.

MCA may be of particular interest, for instance, in the **selection of alternatives for a designated LNG bunkering location**. In this context MCA can be used to establish a clear and structured decision-support to the selection, with the impact of the analysis depending on a wider involvement of stakeholders and on the consensus reached for the selection of evaluation criteria. The MCA for site selection will, in the case of LNG bunkering, be inevitably related to Risk Assessment, Logistics and Operations.

General steps in an MCA process adapted to risk assessment, selection of alternatives and site selection are an adaptation of the standard MCA frame, fully adapted. The steps in a general MCDA and spatial MCDA are similar. First, the objective of the analysis is defined (step1). Next, the key stakeholders that should be involved in the analysis process are identified (step 2). The following steps involve defining all possible alternatives under consideration (step 3) and all of the relevant criteria for evaluating these alternatives (step 4). These steps are interchangeable and may lead to an iterative process of refining which stakeholders to involve. Next, the alternatives are assessed based on the identified criteria (step 5). Performance indicators or decision variables are created for each intersecting pair of alternative and criteria.

For spatial MCA, evaluation criterion maps are generated to evaluate the performance of alternatives. Constraint maps can also be generated to display the limitations of the values that decision variables may assume. Following this, all criteria are weighted by participating stakeholders in order to reflect the preference values of those involved (step 6). It should be noted that not all MCDA approaches make use of weighting; other ordering techniques such as pair-wise comparison can be used. Next, a mathematical combination of the criteria is performed using a decision rule and effectively combines the results of the preceding four steps (step 7). The combined criteria produce an ordering of alternatives. Finally, a sensitivity analysis is performed to examine the robustness of the ranking outcome (step 8). The end result of the MCA process is a recommendation consisting either of the best-ranked alternative or group of alternatives.

The diagram below, in figure 6.5 identifies the different steps in MCA Analysis, whilst Table 6.4, in the next page, structures the adaptation of the MCA tool to LNG bunkering site selection.

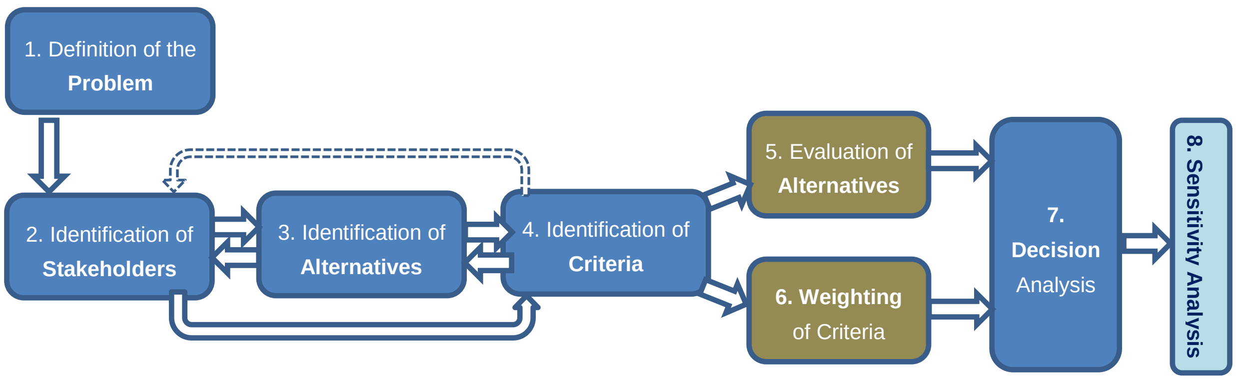


Figure 6.5 – LNG bunkering projects – Multi Criteria Analysis flowchart

Table 6.4 – LNG bunkering projects – Multi Criteria Analysis flow procedure

Adapting The MCA methodology for LNG bunkering location selection				
General MCA steps	**Risk Assessment**	**Selection of Alternatives**	**Location Selection**	**Strengths**
1. Definition of the **Problem**	Define the Scope for the Risk Assessment Identify risk determinant factors.(LNG bunkering parameters, traffic, nautical, local weather patterns)	Define the Objective for the MCA exercise	**Which Location for LNG bunkering facility/ operation?**	Implemented by decision-makers, actual questions reflecting the needs of PAAs
2. Identification of **Stakeholders**	This step can be run as a single-stakeholder process or as a group process. Stakeholders can include: Operators; Terminals, PAAs, other competent authorities, research community; scientific and engineering experts; representatives of local administration bodies.			Able to include views from multiple stakeholders (operators, PAAs, other competent authorities, NGOs, private organizations)
3. Identification of **Alternatives**	What is the Risk ranking for the different options? What is the spatial individual and societal risk distribution for the different locations?	What are the spatial effects (consequence modelling) of the different alternatives? **Identify potential choices & alternatives**	**Identify potential locations for LNG bunkering (all viable locations to select from)**	Allows comparison between a large range of alternatives.
4. Identification of **Criteria**	Examples of Criteria for evaluation: Impact on local port traffic and logistics; LNG bunkering turn-around (per m^3 LNG); public perception; risk ranking; public and private costs, human resource needs, impact on construction, impact on through-life operation)			Able to integrate multiple considerations or criteria (economical, environmental, social, amongst other)
5. Evaluation of **Alternatives**	**Calculation of the effect s of each alternative on all criteria using current data from literature, consultation with experts or surveys.**			Synthesis of current knowledge, using both quantitative and qualitative data.
6. Weighting of Criteria	Stakeholder determination of the relative importance of all criteria by survey. How much each individual criterion will contribute for the final result in the determination of the LNG bunkering location will be dictated by the relative weighting of each criteria. Different routes can be followed to determine the weighting for the criteria, through stakeholders' direct contributions			Enables exploration of disciplinary, organisational, cultural preferences and values
7. Decision Analysis	**Application of MCA decision rule and analysis of results**. Decision Analysis will be quantitative (in the sense that it will be supported by a mathematical formulation) and qualitative (since it includes judgement and prioritization selected by participating stakeholders). The decision rule will be a mathematical calculation which will have only inputs the evaluated alternatives, weighted according to stakeholders' preferences. When evaluating alone, PAAs should allow for the involvement of operators, other competent authorities, RSO representatives or other service providers existing in the port area.			Captures complexity. Exploration and comparison
8. Sensitivity Analysis	Simulations of extreme effects on ranking and assessment of the robustness of results. Variations on the Risk Assessment, for the different parametric variations should be documented. A cost-benefit analysis may be possible before implementation of recommended safeguards.			Allows exploration of the relative importance of criteria and effect on the efficiency ranking of an alternative.

The use of MCA methodology, adapted to any decision in LNG bunkering projects (location for LNG bunkering, in the case presented above, used as an example) is possible to scale and adapt to other decision-making aspects (such as deciding on the LNG bunkering mode). The adoption of such tool by PAAs will be limited to the type of cooperation established with operators. It will enable not only a more transparent decision-process but also allow for a structured approach in a complex multi-variable context.

The tool, as presented in the present Guidance, can in itself be also significantly helpful for operators in a variety of other decision making contexts. The approach is multi-disciplinary

In the way of illustrating how the MCA can be used as an instrument by PAAs, an example is demonstrated in the next page, including only a limited set range of parameter and criteria, with 4 (four)

LNG bunkering locations subject to analysis, all defined options by applicant operator for the establishment of a wide LNG bunkering service in the port area.

Table 6.5 – LNG bunkering location – Example for the application Multi Criteria Analysis flow procedure

Example for the application of Multi-Criteria Analysis to the selection of LNG bunkering location within the port area

PAA application of MCA for approval of LNG bunkering location.

Situation: 4 (four) proposed LNG bunkering locations to be selected, submitted for PAA evaluation/ assessment.

Figure 6.6 – LNG bunkering locations – Example for MCA methodology application

Description

Four proposed bunkering locations are indicated in the figure above.

1) Containership terminal
2) Cruise ship terminal
3) and 4) Ro-Pax terminals

The exercise proposed underlines the fact that many different ship types, with different operational profiles will turn out to be potential clients to LNG fuel. It will therefore be very difficult to imagine a scenario where a dedicated location would be used for bunkering, especially for ships with limited/reduced turn-around times.

The exercise is therefore focused on the **selection between locations 3 and 4**, for TTS bunkering mode, supplying LNG fuel to RO-PAX ferries. With locations 1 and 2 fixed by force of the operational profile of the ships involved (containerships and cruise ships respectively) the exercise is now where to consider the location for RO-PAX TTS LNG bunkering.

The procedure to be followed will be that of table 6.4, with all 8 steps followed until decision-making is reached. The problem is defined, focused on the decision-making process to select between locations 3 and 4, for RO-PAX LNG bunkering service, via shore-side LNG truck. Selection of stakeholders follows, to participate in the definition of the alternative solutions. The alternatives are then subject to risk assessment, definition of individual and societal risk contours to support risk-based decision. Criteria are then identified, with a scoring range for each. According to an agreed prioritization the different criteria is weighted accordingly. A mathematical agreed formulation will then assist decision through analytical approach. A final sensitivity analysis is possible but not provide for in the featured example.

1. Definition of the Problem

Decide on which LNG bunkering location for TTS bunkering of RO-PAX ferries – (locations presented in figure 6.6).

Locations 1 and 2 are restricted to STS bunkering mode, accounting for the operational nature of the ships illustrated (containership and RO-PAX).

Location 3 and 4 are the locations to decide from, both with TTS bunkering mode arrangement.

2. Identification of Stakeholders

Stakeholders to share the MCA process with would involve, for instance:

- **PAAs**
- **Operators (BFO, RSO, other)**
- **Competent Authorities (other than PAAs)**
- **Local traffic authority**
- **Commercial areas (representatives)**
- **Local police**
- **Fire Department/ Brigade**

3. Identification of Alternatives

Alternatives indicated in figure 6.6, location 3 and 4.

Location 3: Close to the port basin entry, in the riverfront, facing a commercial and estate development.

Location 4: Inside the port basin.

For each alternative the risk contours are presented, to allow for a risk assessment against the criteria suggested by ISO 18683 (as presented in the table below, Table A-1 taken from the technical standard). Criteria to be used is identified in red boxes below:

	Acceptance criteria	Comment
Individual risk first party personnel	$IR < 10^{-5}$	Applies to crew and bunkering personnel directly involved in the activity.
Individual risk second party personnel	$IR < 5 \cdot 10^{-6}$	Port personnel and terminal personnel.
Individual risk third-party personnel with intermittent risk exposure	Risk contour for $IR < 5 \cdot 10^{-6}$	Third-party personnel should not have access for prolonged period.
Individual risk third-party personnel with prolonged risk exposure	Risk contour for $IR < 10^{-6}$	General public without involvement in the activity. No residential areas, schools, hospitals, etc. inside this risk contour.

The alternatives are characterized according to their individual aspects, with the pros and cons of each location, from a risk & safety, operational and logistic perspectives.

4. Identification of Criteria

Example of criteria for classification of the alternatives may be:

C1. Houses and commercial spaces inside individual risk contour $IR10^{-5}$ (**total area, m^2**)

C2. Other activities inside IR 10^{-5} contour – road traffic, crane operation, other ships

a. Road length (**<u>in Km</u>**)

b. Number of operating cranes and equipment (**unit quantity**)

c. Number of berthing positions (**unit quantity**)

C3. Distance to LNG terminal (**<u>in Km</u>**)

C4. Nautical Risk (**NR**) (**qualitative**) – **scale of 1 to 5 - "1" to minimum risk up to "5" to maximum risk.**

5. Evaluation of Alternatives

For the evaluation of alternatives the criteria, all the identified stakeholders participate in the application of the agreed criteria to the two options:

<u>Criteria</u>	<u>Location 3</u>	<u>Location 4</u>
C1	Over 5,000m2 of commercial areas and estate development in riverfront. All within $IR10^{-5}$.	No houses or commercial areas within $IR10^{-5}$
C2a	No roads crossing $IR10^{-5}$.	5km of road length within $IR10^{-5}$.
C2b	No cranes or relevant working equipment within $IR10^{-5}$.	**1** overhead crane other side of the basin

Criteria	Location 3	Location 4
C2c	No additional berthing positions inside $IR10^{-5}$	**3** additional berthing positions inside $IR10^{-5}$
C3	35 (distance from Terminal to proposed LNG bunkering location)	30 (distance from Terminal to proposed LNG bunkering location)
C4	NR = 4 TTS bunkering mode less exposed to nautical risks. Bunkering location is however more exposed to incoming/ outgoing traffic, into and out from the basin.	NR = 2 TTS bunkering mode less exposed to nautical risks. Nevertheless bunkering location inside protected harbor basin, with only risk related to maneuvering inside the basin. Very-low speed transit inside basin.

6. Weighting of Criteria

Stakeholders provide for weighting of criteria, with agreed factors, as indicated in the table below. Stakeholders, in this sense, decide on which criteria are to be prioritized.

It is, in this particular case, important to note the relevance of the individual risk contours (assuming these were calculated for both proposed LNG bunkering locations 3 and 4, supporting now in the decision making process. This may not always be the case, being here taken only as an example.

Criteria	Weighting (0 to 1)	
C1	w1	1
C2a	w2a	0.8
C2b	w2b	0.6
C2c	w2c	0.6
C3	w3	0.5
C4	w4	0.8

7. Decision Analysis

To reach a full analytical indicator for decision making, the final step of the MCA approach.

The highest value is the MCA decision.

$$Decision = 1/((C1.w1 + C2a.w2a + C2b.w2b + C3.w3) \times 10^{-3} + C2c.w2c + C4.w4)$$

With the calculation results presented below:

	w	Loc3	Loc4
C1	1	5000	0
C2a	0.8	0	5
C2b	0.6	0	1
C2c	0.6	0	3
C3	0.5	35	30
C4	0.8	4	2
		0.121692	**0.292432**

The result from the MCA indicates **Location 4** as the preferred location for LNG bunkering of RO-PAX ferries, with a result that clearly expresses the evaluation of the two alternatives, using the agreed criteria, weighed in accordance to the relative importance of each criterion, as agreed by the participating stakeholders.

The example in table 6.5 illustrates some practical aspects behind MCA methodology. Notwithstanding its simplicity, the example illustrates the flexibility of MCA, its structured workflow, and the ability to integrate several alternative solutions, to be assessed by different criteria, weighted according to stakeholders review and assessment of the situation.

Important final additional notes regarding the example demonstrated:

- The example is the result of several simplifications, only valid for the demonstration of the MCA methodology for decision-making support.
- Locations 1 and 2 are the example of LNG bunkering locations which are dictated by the operational profiles of the ships at berth (containerships and cruise ships). SIMOPs are, for these ships inevitable operational aspects to address. In the case for locations 1 and 2, the choice/selection of a preferred bunkering location is not the central problem – it is rather more on how to make the
- Locations 3 and 4 are indicated already with individual risk contours, following from risk quantification/ risk assessment in support of decision-making. This will not always be the case, even if the baseline for an adequate comparison of the proposed locations should preferably be risk-based.

6.5 Good Practice in the evaluation and support to prospective projects

R6.1. **Feasibility Evaluation of prospective LNG bunkering projects is a relevant step of every project development, with the objective of verifying whether a given LNG bunkering facility/service will, in one hand, be supported by sound, feasible and demonstrated technical/engineering aspects and, on the other hand, representing a safe and sustainable activity as a relevant port service.**

R6.2. **A complete Feasibility Analysis of LNG bunkering projects will be the analytical, qualitative and, where possible, quantitative, evaluation of proposed projects covering at least the dimensions presented in the diagram of figure 6.1., all collectively contributing to the development and implementation of LNG bunkering projects and should be taken into consideration by PAAs at the earliest possible moment from the presentation of the project.**

R6.3. **PAAs should get involved in the Feasibility Evaluation of LNG bunkering project at the earliest possibility. This will greatly increase the possibilities for early mitigation of any risks of incompatible or unrealistic solutions, failing to meet PAAs requirements or to address any possible technical or operational constraints imposed by the administrative, physical or safety environment within the port.**

This involvement will, despite all good practice indications, be subject to multi stakeholder initiative, disclosure and to the establishment of an early collaborative environment, favourable to sharing of information related to concept project stage. The initial stages of an LNG bunkering project (as shown in figure 6.2) are fundamental for the adequate shaping of a feasible solution. PAAs should, to the extent adequate and possible, participate and support operators with information, data sharing, facilitation with the wider community of stakeholders, competent authorities and other service providers within the port area.

R6.4. **Direct support from PAAs to prospective LNG bunkering feasibility can be materialized through the provision of different elements, relevant to the different project dimensions. These are listed in table 6.1, and can be summarized in the following categories:**

a. **<u>Rules and Regulations</u> – through clear Port Regulations, where LNG bunkering related provisions are included, PAAs support prospective projects through transparency. In addition to design codes, standards, it is possible that port-specific requirements may have to be considered at the earliest stage by**

operators in order to avoid negative impact further down towards development stages.

b. **<u>Restrictions</u> – Any restrictions that may apply to LNG bunkering (or fuelling) scenarios should be made very clear, along with possible alternatives that may ensure the safe and necessary development of alternative fuels infrastructure within the port area.**

c. **<u>Data</u> – In the initial stages of concept and project development, data availability is one of the key success factors for LNG bunkering developments. Risk Studies require data for probabilistic calculations. Data on bunkering related incidents and near-misses is, in this regard, important to be available. Demand forecast and compatibility will require data on the profile of the different ships visiting the port and, finally, spatial planning, existing risk contours and area classification will further assist operators in the design of a feasible LNG bunkering location.**

d. **<u>Information</u> – Informative elements should be made available actively or on request, regarding:**

   i. **possible incentives, funding, special conditions for the establishment of potential environmental sound technologies,**

   ii. **administrative aspects related to permitting procedure,**

   iii. **general port service portfolio, with specific information on any specific service which might be of interest in the context of LNG bunkering,**

e. **<u>Facilitation</u> – PAAs may develop support vectors to prospective LNG bunkering projects through facilitation between all relevant stakeholders, in particular throughout the permitting process.**

f. **<u>Analysis</u> – In support to operators, in the early stages of LNG bunkering project development, PAAs may**

R6.5. PAAs, whenever engaged in the evaluation of prospective LNG bunkering project LNG bunkering projects may be supported through one or more of the following methodologies: 1) SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats); 2) Life-Cycle Analysis (LCA) and 3) Multi Criteria Analysis (MCA):

a. **The <u>SWOT</u> analysis to identify different critical aspects of the LNG bunkering, considering the external and internal factors which may impact on the feasibility of any specific project. Intrinsic strengths and weaknesses of the project are also identified and a SWOT matrix is built to support the analysis.**

b. **The <u>LCA</u> analysis focused on the structured life-cycle evaluation of the LNG bunkering project as any other engineering development, incorporating a) Concept, b) Development, c) Implementation; d) Operation and e) Decommissioning.**

c. **The <u>MCA</u> analysis, to be used in direct support to decision-making, which may be regarded as particularly useful for PAAs faced with different options for LNG bunkering projects (such as deciding on proposed bunkering location, which bunkering mode to allow, bunkering parameters, and others).**

7. Permitting

The present Section covers one of the aspects of LNG bunkering that has deserved most attention from many of the involved stakeholders: Permitting. Even though the outline details and flow of permitting processes are different for each country, it is also true that, in essence, they share similar elements and common parts.

It is the objective of the present section to define a general permitting process, based on the Life-Cycle of LNG bunkering projects. The permitting process here suggested as indicative cannot be taken directly as representing any actual procedure in practice, or directly representing the permitting process in any Member State.

For the present Section the permitting process will be typically that of an LNG bunkering fixed installation, with small scale LNG storage infrastructure. Other types of LNG bunkering typologies also require permitting and should be considered (remarkably those involving mobile LNG elements, such as Trucks, Barges or ISO-LNG containerized modules. Thus, for the purpose of making the concept as generic as possible "**LNG bunkering project**" means all LNG **fuel handling facilities designed for the purpose of transferring LNG fuel to ships**. This should encompass projects from fixed installations, to mobile LNG bunkering solutions which will, whenever in place, undertaking LNG bunkering operations, be subject to same levels of evaluation of fixed projects (environmental, safety and, where applicable, construction).

For aspects related to certification of LNG bunkering projects involving mobile units Section 15 – Certification – should be consulted. Trucks and bunker vessels/barges follow very specific certification/approval references (ADR and IGC, respectively).

All aspects addressed in the present section should be read in conjunction with Section 4, where the relevant legal instruments are listed and summarized.

7.1 Permitting Process

Permitting is a key aspect in the development of LNG infrastructure. The current average duration of permitting procedures for energy infrastructure projects, from submission of application document to issuing of the permit can go up to 4 years [1]. Public opposition to the project (via the mandatory stakeholder dialogue) is often the main reasons for delay/failure of the process, but this may often be due to insufficient information being made available to all stakeholders with an adequate advance

The permitting processes in the different European countries for small-scale LNG infrastructure (i.e. LNG bunker station, LNG satellite plants, ...) differ regarding the number of permits/processes in the permitting procedure, number of authorities responsible to deliver the permitting procedures, documents to be produced and delivered, timing, etc.

Two EU instruments strongly influence the permitting process for LNG bunkering facilities at national level: the **EIA Directive** and the **Seveso Directive**. For both directives it is important to underline that their transposition exercise in each Member State may have introduced aspects which are here not fully covered. It is important, when addressing this Guidance for reference at national level, to make clear which elements in national legislation may have introduced differences specific requirements.

The permitting process/requirements differ between countries, but there is strong similarity in the type of permits required at a national level. Often required permits are:

1. Environmental permit
2. Permit to store dangerous goods
3. Handling of dangerous goods permit
4. Building permit

The average number of processes required in countries analysed to obtain all the required permits for the construction and operation of a project is 3 or more. A typical permit procedure consists of the steps presented in the diagram below, in figure 7.1[63]:

63 Permitting procedures for energy infrastructure projects in the EU: evaluation and legal recommendations, Roland Berger Strategy Consultants, Final report, EC DG Energy, July 31, 2011

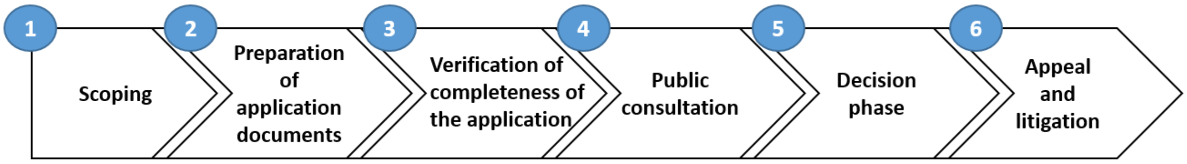


Figure 7.1 – LNG bunkering locations

The following general phases of the Permitting Process are present in most LNG bunkering permitting processes.

(1). **Scoping**: process of determining the content of the matters to be covered in the environmental information to be submitted to the competent authority

(2). **Preparation of application documents**: the developer prepares the application documents based on the list of requirements

(3). **Verification of completeness of the application**: ensure that application documents cover the scoping and enable a proper assessment of all potential impacts of the project

(4). **Public consultation**: formal dialogue is established between responsible authorities, stakeholders and project developers

(5). **Decision phase**: goal of this phase if to issue a permit

(6). **Appeal and litigation**: after a permit has been issued, stakeholders may appeal

The differences of the permitting processes of EU member states was one of the aspects covered by DNV-GL analysis and evaluation of identified gaps and of the remaining aspects for *completing an EU-*wide framework for marine LNG distribution, bunkering and use, mandated by the European Commission's Directorate-General for Transport und Mobility (DG MOVE).

A typical common aspect of all permitting processes, regardless the country, is the involvement of several competent authorities, responsible for different parts of the project, either directly, or indirectly through consultation or special information/evaluation requests. There is potential for special complexity to be introduced only due to this fact, with the involvement of different authorities representing a potential complex document management control and sometimes unforeseen delays in the process which accumulate along the permitting chain.

To address special complexity of some permitting processes, and the involvement of different competent authorities, some Member States have created “single-permits” or “single-desks” with a view to allow for simplification of processes, minimization of process length and complexity. At the same time a more customer-oriented service is the tone followed by most administrations [1].

The Permitting Process complexity is highly influenced by the number of intervening authorities, consultations, periods for analysis and, remarkably, by the number of different entities providing elements for granting the permit. The complex environment of a permitting process can today be made simpler through eh adoption of simple measures for procedural simplification or better management o information. Some of these measures are further discussed in Section 7.4.

In specific for LNG bunkering projects it will be useful if PAAs adopt the facilitation approach, interacting with all stakeholders and, as far as reasonably possible, promote a consolidated overview of the process, intervening whenever a difficulty might be perceived.

7.2 General Permitting Process Map

The General Permitting process map, suggested for LNG bunkering projects is presented in figure 7.2, in the next page, with table 7.1 identifying the main elements that can be taken into account, contributing collectively for permitting.

As indicated previously the General Permitting Process gives an indicative reference for the LNG bunkering permitting process. It is not intended to be used as a standard process. Different countries will have specific processes implemented which may, or may not, resemble the process in figure 7.2.

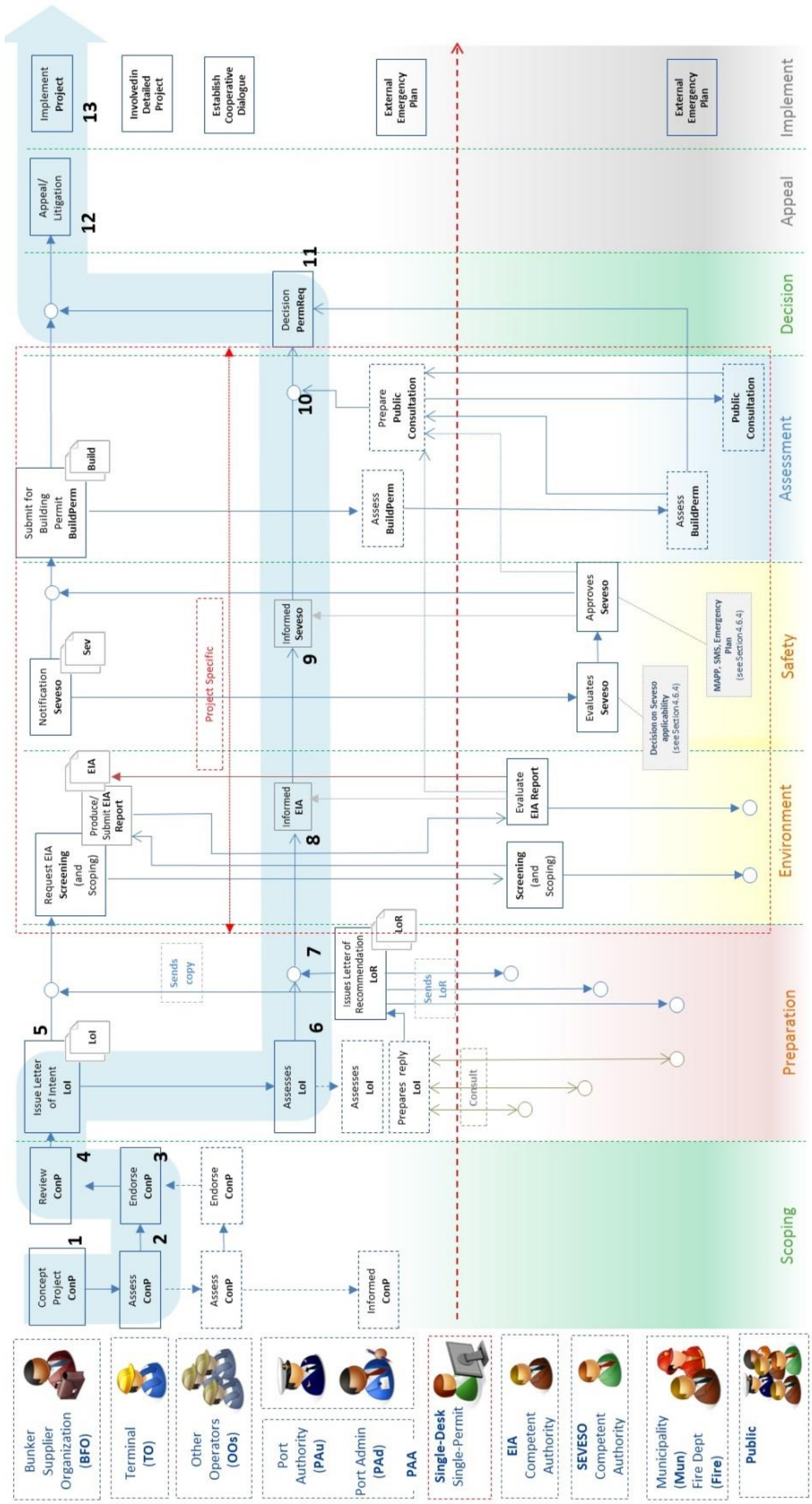


Figure 7.2 – LNG Bunkering – General Permitting Process

Table 7.1 – LNG bunkering General Permitting process (legend for figure 7.2)

Nr (diagram in Figure 7.2)		Stage	Responsible	Description
1	SCOPING	Concept Project	BFO	• The Concept Project is developed by the Operator(s) and submitted in advance to the beginning of the Permitting Process. • Submission to PAA, TO and Other Operators, for preliminary evaluation of technical/operational feasibility of the project. • This possibility will allow different stakeholders to be engaged at the earliest opportunity, being able to provide relevant information for the project. • Feasibility issues can be addressed at the earliest stage. • BFO has here the opportunity to send as much information as possible for a good preliminary appreciation of the Project. • At this stage, Concept Project sent to PAA for information.
2		Assessment of Concept Project	TO Other Operators	• In those cases where a Terminal is involved it is important to have a first review of the Concept Project by the Terminal Operator. • At this stage it is relevant to check for any possible incompatible activities.
3		Endorsement of Concept Project	TO Other Operators	• Following the preliminary assessment of the Concept Project the TO endorses the reviewed material reverting to the BFO. • Endorsement from other operators also possible to reinforce the operational feasibility of the project. • Any relevant indications on possible incompatibilities, envisaged SIMOPS, safety concerns, major accident prevention policies, should here be shared with the BFO
4		Review Concept Project	BFO	• Revision of the Concept Project, with due consideration to the feedback provided by TO and other operators. • Implementation of any possible modifications to the Concept Project.
5	PREPARATION	Issue Letter of Intent	BFO	Ref: Section 7.3.3 • Letter of Intent, covering revised Concept Project, to be sent to PAA. • The Letter of Intent gives initiation to the Permitting Process.
6		Assess Letter of Intent	PAA	• PAA assesses the Letter of Intent (LoI), looking for elements that might have already indicated and rose in the preliminary evaluation, during SCOPING phase. • Complete evaluation of Concept/detailed project.
7		Letter of Recommendation	PAA	• Letter of Recommendation issued on the basis of Project evaluation, with the objective to facilitate the evaluation of other competent authorities. • Include formal assessment of Concept Project • In issuing the Letter of Recommendation, PAAs may take preliminary information from respective competent authorities, municipality and other stakeholders.

Nr (diagram in Figure 7.2)		Stage	Responsible	Description
8	**ENVIRONMENT** (see also section 4.6.5)	EIA Environmental Permit Request for Screening (possible request for Scoping if necessary)	**BFO**	BFO submits request for screening NOTE: The applicability of the EIA is defined through the screening process and. There is no other
		Screening (and Scoping if requested)	**EIA Competent Authority** (On BFO request)	• SCREENING: The Competent Authority makes a decision about whether EIA is required. At the end of this stage, a Screening Decision must be issued and made public. • SCOPING: The Directive provides that Developers may request a Scoping Opinion from the Competent Authority which identifies the content and the extent of the assessment and specifies the information to be included in the EIA Report.
		EIA Report	**BFO**	• The BFO carries out the assessment. • EIA Report contains: information regarding the project, the Baseline scenario, the likely significant effect of the project, the proposed Alternatives, the features and Measures to mitigate adverse significant effects as well as a Non-Technical Summary and any additional information specified in Annex IV of the EIA Directive.
		Information and Consultation	**EIA Competent Authority**	• The Competent Authority makes the EIA Report available to authorities with environmental responsibilities, local and regional authorities affected Member States and to other interested organisations and the public for review. They are given the opportunity to comment on the project and its environmental effects.
		Decision Making and Development Consent	**EIA Competent Authority**	• The Competent Authority examines the EIA report including the comments received during consultation and issues a Reasoned Conclusion on whether the project entails significant effects on the environment. This must be incorporated into the final Development Consent decision.
		Information on Development Consent	**EIA Competent Authority**	• The public is informed about the Development Consent decision
		Monitoring (as appropriate)	**BFO**	• During construction and operation phase of the project the Developer must monitor the significant adverse effects on the environment identified as well as measures taken to mitigate them.
9	**SAFETY** (see also section 4.6.4)	SEVESO Notification (Safety/ Risk Assessment) Safety Permit	**BFO**	Submit Notification Formal Notification, including all elements prescribed in Article 7 of Seveso Directive (Directive 2012/18/EU). Include, as a good practice element, also information on: • Onsite storage capacity • Bunkering frequencies • **Operation detail**

Nr (diagram in Figure 7.2)		Stage	Responsible	Description
9 (cont.)	**SAFETY** (see also section 4.6.4)	Assessment of SEVESO applicability	**SEVESO Competent Authority**	CA assesses whether site is already Seveso establishment or, in the context of additional information, whether it should merit becoming a Seveso establishment in view of the following information provided under Article 7: Data to be used for CA evaluation of: • Operator information and assessment confirming intended LNG bunkering location. • Calculation of the anticipated presence of Hazardous Substances (LNG + any other Annex I substances) • Determination of possible multi-operator implications • Input data for domino-effects evaluation
		SEVESO applicable **(Lower-Tier and Higher-Tier)** Development of **Major Accident Prevention Policy (MAPP)** and decide on suitable **Safety Management System (SMS)**	**BFO**	• Development of Major Accident Prevention Policy and adequate setting up of a Safety Management System that is able to demonstrate that all possible major accident scenarios are addressed. • In particular for Lower tier establishments it is important that MAPP and SMS are adequately aligned with the Risk Assessment and Emergency Response Plan drafted as a consequence of ISO 201519 where the same accident scenarios must be evaluated and the risk mitigation measures adequately outlined.
		SEVESO applicable **(only Upper-Tier)** Development and submission of a **Safety Report**	**BFO**	• One of the distinct requirements for Higher Tier establishments is the production of a Safety Report, following the terms of Article 10 of Directive 2012/18/EU and covering all elements listed in its Annex II (Minimum data and information to be considered in the safety report referred to in Article 10). • For LNG bunkering projects for facilities falling under Seveso, ISO 20519 and ISO/TS 18683 represent a set of technical measures that should be incorporated in addition to the requirements established in the Seveso III Directive for the Safety Report and Emergency Plan, as applicable. • In fact it is here important to note that the requirements for the Safety Report, as contained in Annex II of Directive 2012/18/EU are only providing a framework for the actual study to be developed and produced
		SEVESO not-applicable For Non-Seveso, and also for Lower-Tier establishments, PAA to set requirements for Risk Assessment and Emergency Response Plan.	**BFO** (on PAA request)	• PAA receives indication from the CA to detail the requirements for Risk Assessment and Emergency Response Plan. • The role of the PAA holds the overview of the multi-operator scenario in the port area and holds the external ERP. The involvement of the PAA in the setup of the essential framework for Risk Assessment and ERP is here an important good practice note. • PAA should define the applicable Risk Criteria and minimum Hazard Scenarios to evaluate in the context of a Risk Assessment (with reference to ISO/TS 18683 and EN ISO 201519). • Requirements should apply to both Non-Seveso and Seveso Lower-Tier establishment as the Risk Assessment and Emergency Response Plan are not required by the Seveso III Directive for lower tier establishment.

Nr (diagram in Figure 7.2)		Stage	Responsible	Description
	ASSESSMENT	Building Permit	**BFO**	• Following positive conclusion of Environmental and Safety Permits, the Building Permit is the next step in the permitting process. • Not all LNG bunkering projects will have construction/ infrastructure elements or actual physical installations in the port area. This would be the case of LNG projects which involve mobile LNG units such as LNG trucks and barges. • Submission of the relevant elements for the Building Permit can be made well in advance, even before the Safety or Environmental permits. This should allow land-use issues to be cleared as soon as possible, allowing the detail of any constructive elements to be discussed and further detailed to include any results from a risk assessment.
10	ASSESSMENT	Public Consultation	**PAA**	• For SEVESO establishments Public consultation for all Lower-Tier and Upper-Tier, according to Article 15 of Seveso Directive, subject to national legislation on the matter. • For LNG bunkering projects, in particular for any small-scale LNG storage incorporating the need for specific land-use arrangement affecting the Public, PAAs may provide support to operators, making available all elements to support public consultations, including the support media for its launching. • The integration of the Port with the local community and any existing channels of good synergies with local population should be here explored for public consultation.
11	DECISION	LNG Bunkering Permit Decision/ Licensing		• PAA to issue the permit for LNG bunkering within the port area based on the outcomes from: – EIA – SEVESO/Risk Assessment – Building Permit – Certification of any mobile units – Public Consultation (if required) • Permitting Decision from PAA will be based on the elements provided throughout the process. • It is particularly important to ensure all elements derived from the Risk Assessment have been implemented in the detailed project. • All project elements should be in preparation for the issuing of the permit
12	APPEAL	Appeal/Litigation	BFO	In the context of existing national legislation, operators should be given the opportunity to appeal. All information on procedures and channels to appeal should be made available.
13	IMPLEMENT	Implement Project	BFO	Implementation of the LNG bunkering project is the final stage of the General Permitting Process. Following this stage all project elements should be subject to final inspection by competent authorities, under coordination by the PAA.
	IMPLEMENT	Detailed Project	BFO	
	IMPLEMENT	External Emergency Plan	PAA and competent authorities	External Emergency Plan to be updated

7.3 Elements for LNG Bunkering General Permit

Having the General Permitting Process (Section 7.2) as reference, the present section outlines with more detail some of the elements featured in figure 7.2 and Table 7.1. The complete life-cycle of LNG bunkering projects is presented in 7.3.1.

7.3.1 Life Cycle of LNG Bunkering Projects

Concept Project

- Concept Project to be submitted, inclusive of all technical elements necessary for the preliminary evaluation of the project.
- Elements that should be in the Concept Project: LNG bunkering type, LNG storage elements, intended location, existing arrangements with RSO, preliminary safety considerations, bunkering frquencies and logistical chain for LNG distribution envisaged.

Scoping

- Concept project submitted with letter of Intent (LoI) to PAA.
- Scoping initiated with information from PAA on the ncessary permit elements (environment/safety/builing/other).
- Leeter of Recommendation returned to BFO with the result of the assessment and indications for contionuation of the Permitting Process,

Preparation

- Based on the revie w of the Concept Project, including all comments and indications from PAA, the BFO prepares relevant permit requests.
- PAA Letter of Recommendation should always follow as an element to cover all Permit requests.

EIA

- Environmental Permit, following the EIA Directive procedures.
- Applicability decided by Competent Authority through Screening
- **Follow procedures outlined in section 4.6.5.**

Safety/ Risk Assessment

- Safety Permit will require preliminary evaluation with regards to Major Accident Prevention - need to check SEVESO applicability.
- HAZID and Risk Assessment to be programmed for this stage.
- **Follow procedures outlines in section 4.6.4.**

Operation

- Following Permit and Licensing for LNG bunkering the Operational Phase is initiated.
- A final inspection (7.3.9) prior to the begining of Operations will e required.
- LNG Bunkering Management Plan (LNGBMP) to be completed prior to Operations
- All safeguards derived from the Risk Assessment to be implemented and tested prior to Operations

Maintenance/ Modifications

- A Maintenance Plan must be followd by the BFO, covering all infrastructure and mobile units involved in the LNG bunkering operation. Suitable Maintenance records should be kept by the BFO.
- Whenever Modifications are planned it is necessary to revise the conditions for the LNG bunkering permit. It may be required to reproduce the Risk Assessment, in particular if additional LNG storage capacities are intended.

Cessation/ De-commissioning

- Cessation of activity for a given defined period should be subject to conditions agreed with the PAA - it is of particular relevance for those installations with LNG storage, fixed distribution or manifolds which should be inerted if subject to temporary cessation of activity.
- De-commissioning should be evaluated with regards to any impacts on environment and safety. Should be part of project evaluation from the beginning.

Figure 7.3 – Life Cycle of LNG bunkering projects

7.3.2 Concept Project

The Concept Project should define all technical elements of the LNG bunkering project, including:

1. LNG Storage elements, mobile units involved, fixed installation elements.
2. Identification of stakeholders involved
3. LNG bunkering mode
4. Intended location for LNG bunkering
5. Logistical aspects: Loading of LNHG prior to bunkering, distribution, temporary storage
6. Frequency estimated for bunkering operations (including any possible agreement/contracts with RSOs)
7. Intended range of operating parameters for LNG bunkering
8. LNG Vapour Management (BOG management)
9. Onsite pipeline routing (if applicable)
10. Required Staff Competencies / Envisaged Training
11. Preliminary Risk Assessment elements.
12. Preliminary Nautical Risk/Suitability evaluation (pre-NRE)
13. Indication in Port Map/Nautical Chart of the location, intended manoeuvring points, approach by sea, traffic routing, parking, bunkering are, hazardous zones, preliminary proposed safety zone.

The Concept Project will not yet include elements related to the Risk Assessment, unless this has been preliminarily conducted. It should however be sufficiently complete to provide the basis for the HAZID workshop.

7.3.3 Letter of Intent

Operators intending to develop a new LNG bunkering project, or operators planning to expand or modify existing LNG bunkering facilities and/or activities, where the construction, expansion, or modification would result in an increase in the size and/or frequency of LNG bunkering operations, should submit a Letter of Intent (LoI) to the PAA of the port in which the facility is or will be located. The LoI must meet the requirements in this section.

The BFO must submit the LoI to the PAA prior to the initiation of the Permitting process. It is suggested to consider sending the LoI to PAA at least 1 (one) year prior to the intended beginning of construction and. This should then encompass the whole General Permitting Process as described in the previous section.

An owner or operator intending to reactivate an inactive existing facility must submit an LoI that meets the requirements listed in this section, remarkably in terms of contents. In this case the BFO should submit the LoI at least 6 (six) months prior to reactivation of existing LNG bunkering facility.

The LoI should contain all elements listed in the Concept Project, as outlined in 7.3.2.

As indicated in 7.3.2 the LoI should include a preliminary Nautical Risk/Suitability Evaluation. This is especially relevant for the cases where waterborne LNG bunkering units are used (LNG bunker vessels/barges, platforms. Charts showing waterway channels and identifying commercial, industrial, environmentally sensitive, and residential areas in and adjacent to the waterway used by the LNG waterborne units, heading to/from the LNG bunkering location, within at least 10 km of the facility.

The pre-NRE, where an assessment of the port waterways suitability is made, should

1. Be submitted to the PAA as part of the Concept Project and LoI; and
2. Provide an initial (as detailed as possible) explanation of the following—
    a. Port characterization;
    b. Characterization of the LNG bunkering facility, indicating in particular the routes intended for any waterborne LNG mobile units;
    c. Risk assessment for maritime safety and security;
    d. Risk management strategies; and
    e. Resource needs for maritime safety, security, and response.

The LoI should also include, as an appendix, a draft emergency response plan which should allow PAA to plan in advance the necessary integration of internal-external emergency plans (see Section 14).

7.3.4 Letter of Recommendation

Based on the evaluation of the Letter of Intent, should the LNG bunkering project merit due consideration, PAAs should issue a Letter of Recommendation (LoR) commenting on the suitability of the location, both waterways and port infrastructure, to the competent authorities having jurisdiction for siting, construction, and operation, sending, at the same time, copy to the BFO, based on the

1. Information submitted in the LoI;
2. Technical references provided in the Concept Project
3. Density and character of marine traffic in the waterway;
4. Locks, bridges, or other waterway infrastructure elements;
5. Factors adjacent to the facility such as
    - .a Depths of the water;
    - .b Tidal range;
    - .c Protection from high seas;
    - .d Natural hazards, including reefs, rocks, and sandbars;
    - .e Underwater pipelines and cables;
    - .f Distance of berthed vessel from the channel and the width of the channel;
6. Operational aspects related to Terminals operating within the port area
7. Preliminary risk assessment aspects already included in the Concept Project/LoI.
8. Other safety and security issues identified.

7.3.5 EIA Screening

See Section 4.6.5 and 7.2 for EIA application. Screening should determine whether a given LNG bunkering project is subject to EIA provisions.

Screening should be requested by BFOs to EIA Competent Authority well in advance to intended construction or initiation of LNG bunkering activities.

7.3.6 Seveso Notification

See Section 4.6.4 and 7.2 for SEVESO applicability.

Following Notification should determine whether a given LNG bunkering project is subject to EIA provisions.

Screening should be requested by BFOs to EIA Competent Authority well in advance to intended construction or initiation of LNG bunkering activities.

7.3.7 Other Permits

PAAs should inform on any other relevant Permits that should be considered by Operators/BFO. It is important, in particular, to indicate the relevant Points of Contact for those Competent Authorities which are responsible for issuing the different permits.

7.3.8 LNG Bunkering General Permit

The LNG Bunkering General Permit should be issued in the end of the Permitting process, following the issuing of the Environmental, Safety and Building Permit (as applicable).

The Permit, to be issued by PAA, should contain all relevant restrictions imposed at Port level and any other indications of technical, safety or operational nature, of the responsibility of the PAA.

The LNG Bunkering General Permit should be issued, in addition, upon the completeness of the following elements:

– LNG Bunkering Management Plan

– Implementation of safeguards derived from Risk Assessment.

– Insurance and Liability guarantees (as applicable)[64]

[64] Not covered in the present Guidance, subject to national requirements.

7.3.9 Inspections

A suitable inspection regime should be implemented by PAAs, preferably in conjunction with the relevant competent authorities at national level, to ensure that the conditions evaluated and verified during the permitting process are maintained and that the evaluated safety levels are kept throughout the life of the LNG bunkering project.

The Inspection regime should be designed at national level, reflecting the national and port requirements for LNG bunkering installations and activities.

Inspections should be carried out by competent professionals, using check-lists developed for the specific inspections procedures implemented.

PAAs should ensure that, for any LNG bunkering project type, a suitable inspection regime is implemented where the characteristics verified and approved during the permitting process can now be verified in and after implementation.

The present Guidance does not specify a detailed inspection regime as this should, in principle, be subject to the definition by different competent authorities. PAAs are, ultimately, the one interested in the guarantee that the LNG bunkering project is not implemented or activities initiated without having the necessary programmed inspections carried out.

Not all LNG bunkering projects will include constructive elements. LNG trucks and LNG barges/vessels are an example of LNG bunkering mobile units which will not directly imply infrastructure at the bunkering location. In this case, inspections should focus on operational aspects and equipment certification.

7.3.9.1 General information about inspections

Before starting to use a new bunkering installation and following alterations and repairs, an inspection (**final inspection**) should always be carried out to ensure that the installation is fit for purpose and safe.

Installations should be inspected periodically during the operational phase to ensure that the technical conditions remain satisfactory (a **systematic condition inspection**).

The person carrying out the inspection should have the required competence according to Section 16 of the present Guidance. As a rule, someone should not carry out an inspection of their own work, nor should this be carried out by any company related in any way to the BFO activity. Conflict of Interest declarations may be considered in this regard.

An inspection report should be prepared, documenting what was inspected, how it was inspected and the result of the inspection. The report should be clear and provide an assessment of the results/deviations, so that the owner/user is able to assess which measures must/ought to be initiated.

An inspection before starting to use the installation (final inspection) and a systematic condition inspection of installations should be done by an independent inspector. An independent inspector means, in this context, a technical inspection body, user inspectorate or an accredited inspection body. Accredited inspection bodies that are used must be accredited for inspection of such installations.

7.3.9.2 Inspection Prior to Installation

A **construction inspection** should ensure that drawings, specifications, etc. that form the basis of the construction of the installations are in accordance with the body of rules, standards and the relevant specifications and descriptions.

A **receiving inspection** of storage tanks, components, pipes and other equipment should be done. Prior to putting down the pipeline system and equipment that should be covered, they should be inspected to ensure that they are not damaged and that the corrosion protection is intact. The inspection should be documented with photos with sufficient resolution so that all relevant details can be verified.

An inspection of the work and associated documentation must be carried out. This will, among other things, apply to risk assessments, drawings, the location of main components, distance requirements, descriptions, procedures and qualification requirements for the specialist personnel, as well as fitting guidelines.

7.3.9.3 Inspection during installation

Inspections during installation shall ensure that the work is done in accordance with the work and associated documentation.

Deviations uncovered during installation in relation to existing provisions and the planned construction of the installations should be rectified before starting to use the installations. Anyone involved in the installation is responsible for this and is subject to the regulations on the handling of hazardous substances.

A non-destructive essay (NDE) program should be implemented to verify, amongst other things, the quality of welding in pressure equipment and pipe welded joints.

7.3.9.4 Inspection following installation (final inspection)

Before LNG is brought into the installations, a final inspection should be done to ensure that the equipment and installations have been fitted and assembled in relation to permits, the body of rules and norms and specifications. A final inspection should ensure that the fitting and assembly documentation is updated in relation to any alterations that occur during construction.

A final inspection should also be done after repairs and alterations to the installations.

Pressure testing and leakage testing of the entire installations should also be done. Pipeline systems that will be concealed should be pressure tested and leak tested before they are covered or encased. The entire length of pipeline that will be pressure and leak tested should be accessible for the inspection.

Pressure testing and leakage testing should be done according to recognised standards, written procedures and set acceptance criteria for testing. Regarding the selection of a test pressure medium, please see the pressure equipment regulations. For leakage testing, all connections should also be visually inspected for leaks.

In cases where pressure testing of storage tanks, devices, pipeline systems and standard equipment has already been done in accordance with the requirements of the pressure equipment regulations, these should be accepted.

A functional inspection should ensure that the equipment and installations work as specified in the design documentation.

Safety valves should be tested within three months of starting to use the installations.

A functional check of inspection, control and securing devices, valves, regulators, etc. should be done. Where such a functional check has already been done in accordance with the requirements of the pressure equipment regulations, for example as part of a conformity assessment again in accordance with the requirements of the pressure equipment regulations, this should be accepted.

A final inspection of individual bunkering installations should be done by an independent inspector.

For serious safety deviations, the inspector shall send a copy of the inspection report to the relevant supervisory authority.

The same above shall apply to LNG bunkering projects involving bunker vessels/barges or LNG trucks. A rehearsed LNG bunkering operation should be performed for the purpose of a Final Inspection. During this inspection all the procedures in the LNGBMP should be checked. Leakage tests of the bunkering lines should be performed with real operating conditions.

7.3.9.5 Systematic Condition Inspections

To ensure that the technical conditions of installations and equipment remain satisfactory, in addition to ordinary maintenance, owners and users must ensure that a systematic condition inspection is done according to the set plan. A systematic condition inspection is thus an in-depth safety inspection of the installations that is done in addition to any service or regular maintenance.

The scope and frequency of the systematic condition inspection must be adapted to the operating conditions and risk potential for installations and equipment and any experience of similar equipment to ensure that satisfactory operating safety and protection against undesirable incidents are maintained.

Systematic condition inspection should preferably be done by an independent inspector.

There should be a written plan for all inspections activities (frequency and scope) as well as written procedures for how the inspections should be done. Where several contractors are involved, individual areas of responsibility should be clearly defined.

A systematic condition inspection of bunkering installations should be done at least every five years. The scope and recommended inspection interval can be adjusted in relation to the operating conditions, surroundings and operating experience, etc. of the installations and equipment.

Inspection and safety functions that have major safety implications should be inspected and tested in accordance with established procedures in accordance with the test programme that the enterprise has prepared. Standard EN IEC 61508 can be used to establish an inspection interval; see also Part 2, Chapter 7.6 of the standard. However, such inspections should be done at least every two years.

Valves that have important safety functions should be tested in accordance with established procedures and the prepared testing programme.

If safety valves are removed for testing during operation, the remaining valves should be able to withstand depressurisation. An alternative to inspection and testing will be replacement.

For serious or repeated safety deviations, the inspector should send a copy of the inspection report to the relevant supervisory authority.

7.3.10 Operation

Safety deviations uncovered during operation must be rectified immediately. If necessary, use of the installations and equipment must cease until the deviations have been satisfactorily rectified.

There should be operating and maintenance instructions that are adapted to operating conditions for the installations and equipment. The instructions must also include abnormal operating situations. All these operating and maintenance instructions should be included in the LNGBMP, subject to approval by the PAA.

Safety and operating instructions should be in a convenient language suitable to the understanding of all BFO and third-party staff.

An emergency preparedness and response plan with associated procedures should also be prepared.

All instructions and plans should be regularly updated including for any alterations.

Operating personnel (including bunkering operators) should have had training in regard to the installations and the specific operations with LNG and Inert Gas bunkering installations. They should be familiar with existing instructions, relevant user manuals and recognised norms that form the basis of operation and maintenance of the installations.

For installations where LNG is stored between bunkering but is not serviced between bunkering, an agreement with competent personnel who can quickly handle abnormal operating situations should be established.

7.3.11 Maintenance

The owner or user must ensure that maintenance of the installations, mobile units and equipment is carried out to ensure a continued high safety level.

Maintenance must be carried out by personnel who have the required technical competence and experience and are familiar with relevant methods of systematic maintenance. If the owner or user themselves do not have the required competence for carrying out maintenance, such competence must be obtained. Maintenance should be carried out according to the manufacturer’s instructions. Using checklists that specify checkpoints and intervals will make the work easier and clearer. Maintenance should be documented.

7.3.12 Modifications/ Retrofitting

All intended modifications/retrofitting of the LNG bunkering facilities or operations should be subject to a renewal of the permitting.

A new Letter of Intent (LoI) should be sent by the BFO to the PAA, containing all relevant modification/ retrofit concept project elements.

For all purposes, a concept project for modification/retrofitting should follow all the steps as indicated in the General Permitting Process in 7.2. Modification may have a significant impact in risk and therefore, safety and environmental impact should be assessed by the relevant competent authorities.

7.3.13 Temporary Cessation

The BFO should ensure that installations that are no longer in use are removed or properly secured to avoid unintentional use, or possibly maintained as if they were in normal operation. Before starting to use the installations again, a new systematic condition inspection must be done.

On those cases where fixed installation elements are present it should be guaranteed that a specific procedure for inerting of all installations is followed.

7.3.14 De-Commissioning

De-commissioning should be evaluated with regards to any impacts on environment and safety. Should be part of project evaluation from the beginning of the permitting process, in the early stages of project evaluation.

As part of a life-cycle approach for LNG bunkering project developments it is important to take de-commissioning into account, especially with regards to end-of-life aspects for equipment, systems and installations.

7.4 Measures for Time-Effective Permitting

A “Good practice” Permitting process is something that is very difficult to suggest. The present Guidance proposes instead a General Permitting Process (in section 7.2) without calling it a “good practice” especially due to the fact that different countries will have different distribution of competencies amongst different national authorities.

Instead of “good practice” the present section lists relevant elements which are likely to improve the time-efficiency of permitting processes. The elements listed are, in principle, applicable to projects other than LNG bunkering. In the context of the present Guidance focus is however given to LNG bunkering.

The length of LNG bunkering permitting processes has, in fact, been one of the main points indicated by Operators as being demotivating for new developments. Even if it can be taken into account that LNG bunkering is still taking early developing steps, with an ongoing learning curve to all stakeholders involve, it is still possible to suggest measures for process efficiency which may even be derived from permitting experience with

Table 7.2 includes 6 (six) measures that will very likely have a direct potential reflection in efficiency of the permitting process. The different measures have already, to some extent, been experimented in different countries [1] with significant advantages for the permitting process efficiencies.

Bringing different stakeholders together, in particular different competent authorities may be one of the most challenging tasks. PAAs have here a remarkable opportunity to act as facilitators and provide the common ground for LNG bunkering projects to develop in a collaborative environment.

The measures proposed, as part of this Section, can be implemented partially or in a combination. To measure how efficiency has been improved by their implementation it is important to develop and adopt specific performance indicators (such as overall waiting time between reception of the permit request and conclusion of the process).

Table 7.2 – Seven Measures for Time-Efficient Permitting

Measure	Description
1 **Build Mutual Understanding**	PAAs may find ways to break down communication barriers and build understanding between local permitting departments, applicants, consultants, related local and state agencies, elected leaders, and the general public. Building mutual understanding of land development permitting and the construction and inspection processes levels the playing field. Mutual understanding tends to create more open communication which allows participants to discover or explore opportunities for improving the process together. The result, overall, is a more predictable and efficient permit review process. 3 (three) approaches are possible: 1. **Technical Forum/Seminars** for industry and permitting departments to get to know each other and better understand each other's requirements and objectives. 2. **Training for Permitting Staff**, including all competent authorities, preferably coordinated by PAAs 3. **Common Platform for technical information**, where all stakeholders may access relevant elements and information relevant for a levelling of understanding between all stakeholders involved.
2 **Develop Single-Desk/ Single-Permit**	In trying to introduce measures for the efficiency of LNG bunkering permitting processes it is a possible option to develop a Single-Desk/Single-Permit approach consisting of a set of different Administrative procedures to encapsulate the different permits applicable to one project. On either definition, for **"single-desk" or "single-permit" the objective is to ensure that Operators/BFO would only need to approach PAAs and the relevant competent authorities through a simplified procedure**. The routing of the permitting application would follow the path towards the different competent authorities through designated mapped flow of information, designed for best efficiency. PAAs could provide the physical point of entry for all applications, in a single-desk approach, providing, in addition, mediation throughout the whole process and allowing the best understanding between all parties involved.
3 **Engage All Reviewers and Stakeholders Early**	Early engagement provides reviewers an opportunity to see what the applicant proposes, discuss requirements that would influence project design, and discuss options for avoiding and minimizing adverse impacts. For LNG bunkering projects a **pre-application meeting is recommended**. Some jurisdictions require pre-application meetings. Promote early engagement of all parties for preliminary meeting. To be effective pre-application conferences must clarify all application information requirements and detail the process (including timelines) through which the application, once submitted will be reviewed and acted upon. Contact persons must be identified and their contact information provided. Project proponents must be warned of potential red flags and the persons/agencies to contact for working out problems. It may be noted here that in order for a pre-application meeting to provide the information described above, an applicant must submit detailed information about the proposed site, initial project objectives, and at least a start on project design.

Measure	Description
4 **Ensure Complete Applications**	PAAs, working as facilitators for a prospective LNG bunkering project, should define what constitutes a complete application for LNG bunkering projects and verify that all elements have been included with each application at the time of submittal. A useful format for conveying these requirements is through a reception check-list. The check-list should indicate what must be presented at submittal for different types of LNG bunkering projects (from TTS proposal to PTS, involving onsite LNG storage and distribution). A good reception check-list identifies the information that staff need for conclusive review. The specific items vary based on the type of permit and the characteristics of the local jurisdiction. Only complete applications should be accepted. Incomplete applications should not be accepted, with all outstanding elements or deficiencies explained at the reception meeting.
5 **Analyse Process, Performance, and Costs**	Another measure to promote time-effective permitting processes would be to **analyse permitting procedures, performance, and costs of service**. Analysis of the process and performance trends reveals and allows prioritization of opportunities for improved predictability, efficiency, speed, and collaboration. When the whole process is visible, inefficiencies become better revealed. Permitting, for a variety of projects other than LNG bunkering, uses a variety of methods and models for **process mapping**. The most successful models reach to a very detailed level of analysis and provide information about who carries out each task, how much actual work time is required for the task, and how much total time or work-time is associated with the task. When one task cannot be completed until another task is started or completed, these dependencies are indicated and may also be mapped. The analysis should include an assessment of what options exist for changing or removing constraints as well as eliminating, consolidating, or rearranging tasks in the process. 1. **Build detailed flowchart "process models"** of your existing process. 2. Include **measurements of work time**, wait time, and overall performance. 3. **Analyse the results**, looking carefully at low value and/or high wait time tasks; also **identifying constraints** such as staff availability or required notice and appeal periods. 4. **Develop change recommendations** that respond to opportunities identified in the process maps and account for local circumstances and priorities. 5. **Implement changes** and measure results. Process mapping should be done by a team with direct experience in all aspects of the review process directly related to LNG bunkering projects. All participants in the review process should have an opportunity to contribute to development of the map. This investment in time improves the accuracy of the flowcharts, reveals variations in the ways particular reviewers approach the same review, and eases implementation and changes because the reasons for change become apparent to participants in the review process. Initially, it is important to map how the actual process flows, not how you want or think it ought to work. PAAs should mediate/facilitate the production of process maps, including the participation of all different competent authorities involved in the permitting decision. For **Performance Analysis**, once process mapping is concluded, it is suggested to develop performance indicators to measure the efficiency of the mapped permitting process. Amongst these indicators it is possible to outline a few: 1. Total calendar days to reach a decision on LNG bunkering projects. 2. Number or percent of days when the application is on hold awaiting new

Measure	Description
	information from the applicant, and conversely, number of days of the total when the jurisdiction is on the "clock." 3. The number of comment or correction cycles necessary to correct deficient applications. 4. Response times or cycle times for first reviews, second reviews, and so-on. 5. Backlog of pending applications and inspections by type of permit or decision. In developing options or recommendations for change, the process maps and measurements link to a local jurisdiction's overall goals. These goals may be specifically focused on improving permit turnaround time or may seek to improve customer experiences by clarifying application requirements or improving response times to telephone or email inquiries.
6 **Use Information Technology**	**Use technology such as electronic permit tracking systems, geographic information systems (GIS), and the interconnection of these systems online to improve communication, reduce paperwork and build easily accessible project record**. Make the best use of computers and information technology (IT). These tools are helping many jurisdictions and applicants operate more efficiently and provide better service. The uses of information technology range from in-house electronic permit tracking systems to online access for the general public to a range of permit records and reports, to social networking sites or blogs to keep stakeholders updated on project status. Online access to departmental forms, codes and standards is also a possibility, as well as online maps and aerial photos. An increasing number of competent authorities use workflow or project management software, as well as wireless or remote access to department records and systems for field inspectors and other staff. A few other authorities accept and review certain types of applications on-line. These have largely been limited to simpler engineering permits, along with very simple or standard building permit plans, but interest is growing in online submittal and review based on applicant and agency time savings and other customer service benefits. Electronic permit tracking systems could be a relevant approach to develop adequate information to applicants on the status of the permitting process. They provide a real-time tool for reviewers and inspectors to enter their findings, archive supporting documents, and indicate when they are waiting for additional information. Current web design tools make it easy to put these references into an applicant's hands miles away from the permit counter. Some jurisdictions substitute on-demand printing for traditional inventories of lobby forms. Online files can allow applicants to complete forms with their computers, producing a cleaner result that is easier for everyone to understand. In some cases, they also have an electronic record of their completed application form. Many authorities (municipalities, port authorities and others) also provide online access to their in-house geographic information system (GIS). GIS provides applicants a preliminary indication of the environmental, land use, and other considerations a development project needs to consider. This reduces surprise during permit review and increases efficiency when the project designs incorporate these considerations at the beginning. This approach can be particularly beneficial for countries where LNG bunkering would fall into multiple departments involved in the permitting process. Managing and financing IT systems at an enterprise level does not happen overnight and requires a significant leadership commitment from all institutional stakeholders.

8. Risk & Safety

LNG bunkering safety risk aspects have been debated extensively and it is very common to read or listen to the expression "risk assessment" almost every time LNG bunkering is addressed or discussed in a more or less technical manner. The expression is often used as a "safe passage" through subjects or areas where deterministic knowledge, standards, rules or experience hasn't yet fully developed or, as in the case of LNG bunkering, where the interaction of different elements, following a potential incident, may represent in unacceptable risk to life or property. ´

The design of safe LNG systems and operations requires the adequate understanding of LNG safety aspects, modelling of accident scenarios, development of safeguards to prevent LNG release, ignition or fire escalation. Risk Assessment tools will support PAAs in the understanding and

The current section includes the elements listed below, in Table 8.1, considered relevant to assist Port Authorities and Administrations in the context of LNG Risk & Safety aspects, not only from a Risk Assessment perspective but also from on the understanding of LNG safety aspects.

Table 8.1 – Section 8 Summary table description

Section	Title	Summary Description
8.1	LNG Risk & Safety Principles	• Section including generic risk principles, from an informative perspective. • LNG Safety Concepts, Hazards and main factors affecting LNG safety. • Mechanisms behind LNG hazardous events.
8.2	Risk Assessment in Land Use Planning	• Section mostly relevant to those LNG bunkering projects which have been determined within the scope of applicability of SEVESO. • Land Use Planning as a tool for major accident prevention • Typically relevant for small scale fixed LNG bunkering installations.
8.3	Risk Assessment in LNG Bunkering	• Risk Assessment requirements from ISO/TS 18683[65] summarized. • Minimum risk assessment requirements for different LNG bunkering modes. • Qualitative Risk Assessment/ Quantitative Risk Assessment • Minimum Hazard Scenarios
8.3	Risk Criteria – framework and thresholds	• Different types of Risk Criteria for Risk Assessment. • ISO/TS 18683 suggested Risk Criteria
8.4	Risk-based evaluation of Ports Feasibility for LNG bunkering	• Section providing guidance elements for Ports willing to define a Technical Specification for the evaluation of LNG bunkering feasibility in the port area.
8.5	Good practice for Ports on Risk Assessment	• Good practice for Ports on LNG bunkering Risk Assessment. • Which methodologies to consider for different situations. • Elements to question and look for when reading/reviewing a risk assessment report. • Flow diagram with proposed/recommended process map for LNG bunkering risk assessment. • Independency in Risk Assessment

[65] By the time this guidance has been published (version "0"), January 2018, the future of ISO/TS 18683 is yet uncertain. Following the publication of ISO20519 both ISO instruments co-exist with several overlapping points (see Section 4.4). Since ISO 20519 does not contain the full depth and scoping for LNG bunkering Risk Assessment as in ISO/TS18683, it would be very important to ensure that the provisions from the Technical Standard endure for the future. The EMSA Guidance is, however, published in a context of some concern over a possible withdrawal of ISO/TS18683.

Following the situation described above, the EMSA Guidance has taken the route of including part transcriptions and summaries of the provisions in the ISO Technical Standard 18683, instead of drafting a simple reference to an instrument that is very likely to be withdrawn or replaced in the very near future.

8.1 LNG Risk & Safety Principles

8.1.1 Hazard and risk

Hazard is a function of the inherent properties of the agent/event in question whereas risk is a function of both the hazard and of the potential likelihood and extent of being exposed to the hazard. In other words, while hazard represents an abstract danger, risk expresses the combination of the level of hazard and the likelihood of its occurrence.

It is the most important relation to retain in all Risk & Safety discussions

Risk = Hazard **Consequence** (expressed in terms of its negative impact) **x Likelihood** of its occurrence.

While the two variables are not independent of each other and while the impacts of the hazard depend on preparedness or preventive behaviour (as is the case of natural hazards), the risk must be expressed as a functional relationship rather than a simple multiplication of both variables

Risk is defined as the product of the probability of occurrence of an accident and its consequence which is usually expressed in terms of lives lost and injuries caused or financial losses suffered.

8.1.2 LNG Safety Concepts

LNG safety is the structured composition of a considerable number of different aspects. All need to be addressed in order to achieve the lowest risk levels. From the technical to the human element, the chain that allows safe and successful operation of LNG as fuel for shipping encompasses the following 4 (four) main contributing areas:

REGULATIONS

Need to address properly user needs and industry expectations through regulations that promote LNG as fuel for shipping.

All operational environment needs to meet adequate regulatory measures promoting safety and competitiveness, allowing a fair playingfield.

Alignment and harmonization is a key success factor in LNG related regulatory initiatives. Not only shipping is a global business but also the ship-shore interface (bunkering) involves regulatory environments that need to work together and be aligned.

RISK & SAFETY

LNG Safety depends directly on the understanding Risk & Safety aspects. Key subject to be dealt by:

- **High energy content of the LNG tank**
- **Explosion hazard in case of gas leakage**
- **Extremely low temperatures of the LNG fuel**
- **Location/arrangements of LNG ship systems**
- **Hazardous vs. non-hazardous spaces**
- **Inexperienced crew (new fuel source)**
- **Ship-shore interface in bunkering**

Risk Assessment is the composition of Risk Calculations meeting predetermined Risk Criteria.

INCIDENT REPORTING

Incident Reporting is an important aspect to be taken into account. Through the reporting of LNG related incidents or near-misses it is possible to:

- **Take lessons learnt and improve procedures**
- **Improve the accuracy of risk calculations**
- **Further develop safety oriented behaviours**
- **Improve design of equipment and systems**

TRAINING

The Human Element is a key success factor for LNG safe operations, especially when dealing with a new application as an alternative fuel. From bunkering to emergency procedures, onboard maintenance to machinery operation, it is very important that onboard crew, and port personnel, have the necessary competencies for LNG safe operation.

Gas carriers have been using LNG as fuel for decades and have established an extremely good safety record. Even though most principles remain the same, using LNG as fuel for conventional ships requires specific adaptations. There is one essential key aspect that makes the real difference. By introducing LNG as fuel to different types of ships, especially those carrying passengers like RO-PAX or cruise ships, the risk calculations, and associated risk mitigation measures need to be adequately addressed.

The development of international regulations, such as the IGF Code, adopted in June 2015, expected to enter in force in January 2017, is fundamental in the establishment of risk based requirements. Nonetheless, and because LNG as fuel for shipping is a growing reality, it is always important to be aware of LNG safety first principles and to have always in mind the relevance of all stakeholders.

In order to continue the good safety record, the risks related to both property, and life, have to be minimized. The subject has been identified therefore by all the stakeholders involved in LNG as an alternative fuel for shipping, with safety being addressed at both international and regional/national levels with a continuous developing regulatory frame and published industry guidance and best practices in LNG handling.

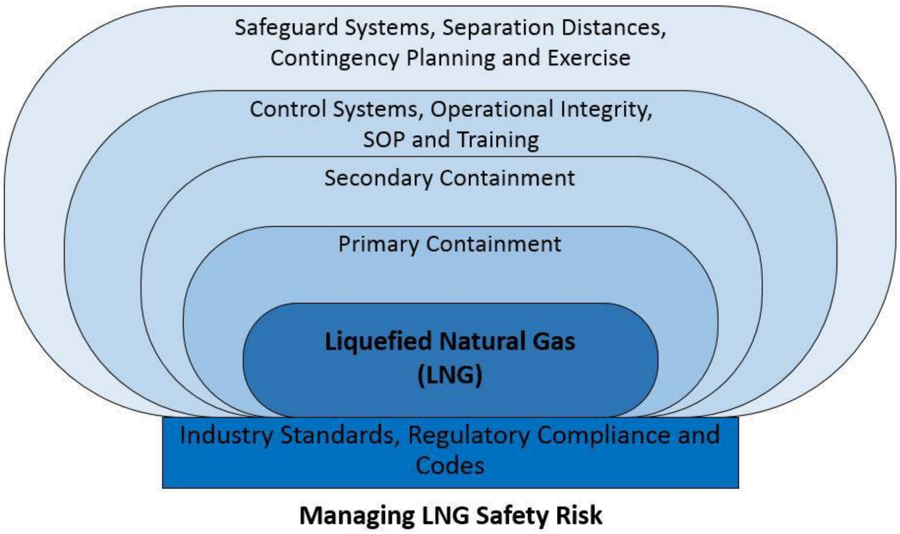


Figure 8.1 – Baseline and layers of defence in LNG Safety

Table 8.2, below, identifies the main **Factors** and most relevant possible **LNG Hazards**, which contribute directly to LNG Safety.

Table 8.2 – Main Factors in LNG Safety and LNG hazards

IMPORTANT FACTORS IN LNG SAFETY	LNG HAZARDS
- Fire Hazard Properties of LNG - LNG Physical State reaction - Concentration in air - Low temperatures of the LNG fuel - High energy content of the LNG tank - Crew Experience and ground staff handling LNG	- **Fire, deflagration or explosion if in confined space** from ignited natural gas vaporising from spilled LNG - **Vapour dispersion** and remote **flash fire** - LNG **Leaks** - **Brittle fracture of the steel** structure exposed to LNG spills - **Frost burns** from liquid or cold vapour spills - **Asphyxiation** from vapour release - **Over-pressure of transfer systems** caused by thermal expansion or vaporization of trapped LNG - Rapid Phase Transformation (**RPT**) caused by LNG spilled into water - Boiling Liquid Expanding Vapour Explosion (**BLEVE**) of a pressurized tanks subjected to a fire - Tank over-pressurization due to **rollover** effects

8.1.3 Fire Hazard Properties of LNG

One key aspect that has to be taken into consideration when talking about the fire hazard properties of LNG is that flammability or explosion only occur in very limited physical circumstances. Flammability only occurs when gas volume concentrations are between 5% and 15% by volume in a mixture with air, but auto-ignition only occurs at high temperatures. Gas clouds may ignite at the edge if they meet an ignition source as they disperse Explosion, on the other hand, requires gas concentrations within a confined space and, on top, an ignition source. It is not possible to refer to LNG as not being explosive or flammable without giving the exact physical and ambient conditions involved.

Table 8.3, below, indicates the fire hazard properties of LNG in comparison with other fuels.

Table 8.3 – Fire hazard properties of LNG in comparison with other fuels

Properties		Petrol (100 Octane)	Diesel	Methane (LNG)	Propane (LPG)
Flash Point (ºC)		<-40	>62		
Flammability in air	Lowest concentration in air (%)	1.4	0.6	**4.5**	2.1
	Highest concentration in air (%)	7.6	7.5	**16.5**	9.5
Auto-Ignition temperature (ºC)		246-280	250-300	**537**	480

8.1.4 Factors of LNG Safety

8.1.4.1 LNG Physical State reactions

Understanding of LNG physical state is fundamental to predict possible reactions at any stage of the production, transport, delivery and usage stages. LNG is Natural Gas (NG) at cryogenic temperature, brought to -163ºC, just below evaporation temperature of NG (predominantly Methane, CH_4). Liquefaction of Natural Gas is a key advantage of LNG as it allows transportation and storage at 1/600th the volume it would otherwise take to carry the same amount of NG in the gaseous form.

Production, transportation, distribution and bunkering are only some of the possible operations involved in the life cycle of LNG as fuel for shipping. It is therefore important to understand the behaviour of LNG when pumped, moved and, especially, when different parts of LNG are added in refuelling operation.

Leak and spill prevention is a serious objective in LNG prevention with all technical and operational details of the LNG handling operations to be designed towards zero-leakage/zero-release objective.

In the accidental event of a spill, LNG will immediately vaporize, giving shape to a white cloud of cold LNG vapour that will disperse with the prevailing wind. Should the spill take place into an enclosed space, the evaporated gas will potentially give origin to an explosive atmosphere (if the closed volume reaches the 5-15% concentration of gas in air).

In case of an LNG release into water, a rapid phase transformation (RPT) will occur. This is a very rapid physical phase transformation of LNG liquid to methane vapour mainly due to submersion in water. RPT does not involve any combustion and cannot be characterised as a detonation. The pressure pulse created by small pockets of LNG that evaporates instantaneously when superheated by mixing in water will travel by the speed of sound and decay as any other pressure pulse. The hazard potential of rapid phase transitions can be severe, but is highly localized within or in the immediate vicinity of the spill area. It will not cause ignition but can be potentially damaging for the ship or equipment. However, RPT is unlikely to damage large structural elements of a ship. The probability of explosion could be limited by a good design of the LNG bunker Vessel. This means that the vessel should have an open design where confinement is limited, so no significant overpressures can be built up after ignition.

8.1.4.2 Concentration in Air

As mentioned above, LNG has a flammability range between 5-15% in volume in air, below this range there is no sufficient fuel (natural gas) for combustion and, above, there is no sufficient oxygen in the mixture for a potential ignition to produce any effect.

From any loss of containment event (spill, release) evaporation will result immediately. Evaporated cold natural gas is then a problem that should be regarded differently depending on whether it takes place outside or inside an enclosed space. If the event takes place outside the generation of a white cloud of cold natural gas will lead to a the dispersion of a plume according to the prevailing wind. Flammability range can be reached in the boundaries of the cloud.

If the release leads to the enclosure of gas pockets, either within the structure of the ship or in the port infrastructure, there is the potential creation of an explosive atmosphere. Ship design and port facilities, wherever LNG is handled should take into consideration.

LNG is neither carcinogenic nor toxic. It is an asphyxiant, which dilutes or displaces the oxygen contained in the atmosphere, leading to death by asphyxiation if exposed long enough. Since natural gas in its pure form is colourless and odourless, confined spaces are subject to special attention. With large uncontrolled release quantities, personnel in direct surroundings may be suffering from low oxygen concentrations (<6-15 V %), which should be counteracted by technical and procedural solutions.

8.1.4.3 Low temperatures of the LNG fuel

LNG is typically stored at a pressure between 1 and 10 bar, whereby the equilibrium temperatures are approximately –160°C to –120°C. In order to minimise the risks related to both property and life, it is vital that the material used for the LNG system has been certified for cryogenic temperatures and that the system has built-in pressure relief functionality.

At atmospheric pressure, depending on composition, LNG will boil at approximately -160 degrees Celsius and represent a cryogenic hazard. The cryogenic nature of LNG bunker vessels poses the risk of potentially injurious low temperature exposure of personnel, structural steel, equipment, instrumentation, control and power cabling. Cryogenic exposure of personnel causes frost burns; cryogenic exposure of carbon steel causes embrittlement, possibly resulting in structural failure. Through potential fractures of the hull, following from LNG spills into unprotected structural steel, it is important to note that LNG may penetrate through into enclosed adjacent spaces, leading to potential formation of explosive atmosphere pockets.

8.1.4.4 High-energy content of the LNG tank

It is vital that the material used for the LNG system has been certified for cryogenic temperatures and that the system has built-in pressure relief functionality. When designing the vessel, deciding where to place the LNG fuel tank and processing equipment, as well as how to arrange the ventilation ducts and pressure relief masts and LNG/gas piping in general, must be well thought through. Access to hazardous areas must be arranged in a safe manner and great effort must be put into developing a complete and consistent safety philosophy from the beginning of any vessel design.

A special type of hazard is a fireball, which is a very rapid combustion process most often associated with a Boiling Liquid Expanding Vapour Explosion (BLEVE). These are only associated with pressurized liquids. The normal mechanism for BLEVE is a pressure vessel containing pressurized liquefied gas (e.g. a pressurized LNG tank) subjected to external fire impingement or catastrophically failing due to other causes. Insulation of a pressurised tank generally contributes to reducing the risk of escalation from impacting fire. Physical barriers prevent direct fire impingement and mechanical impact and reduce the likelihood of a BLEVE. For example, in case an LNG fuel tank is placed below deck, the ship’s hull will act as physical barrier.

8.1.4.5 Crew Experience and ground staff handling LNG

Inexperience of crew and ground staff can cause wrong handling of LNG and therefore increase the likeliness of hazardous accidents to occur. To avoid hazardous accidents, the planning, design and operation should focus on preventing the release and vapour of LNG. Thereby, factors such as transfer rates, inventories in hoses and piping, protective systems such as detection systems, ESD and spill protection are essential. The safety philosophy must involve the entire system – from gas bunkering to consumers – and include everything from shutdown functionality to crew awareness.

8.1.5 LNG Hazards

An important part of understanding the table below includes a summary description of the relevant LNG Hazards. They depend not only on the factors described above but also on the design options followed for a given vessel LNG solution.

Figure 8.2 and 8.3 present different schematic representations the possible LNG Hazards, depending on the type of release, ignition and confinement. Table 8.4 details the LNG Hazards.

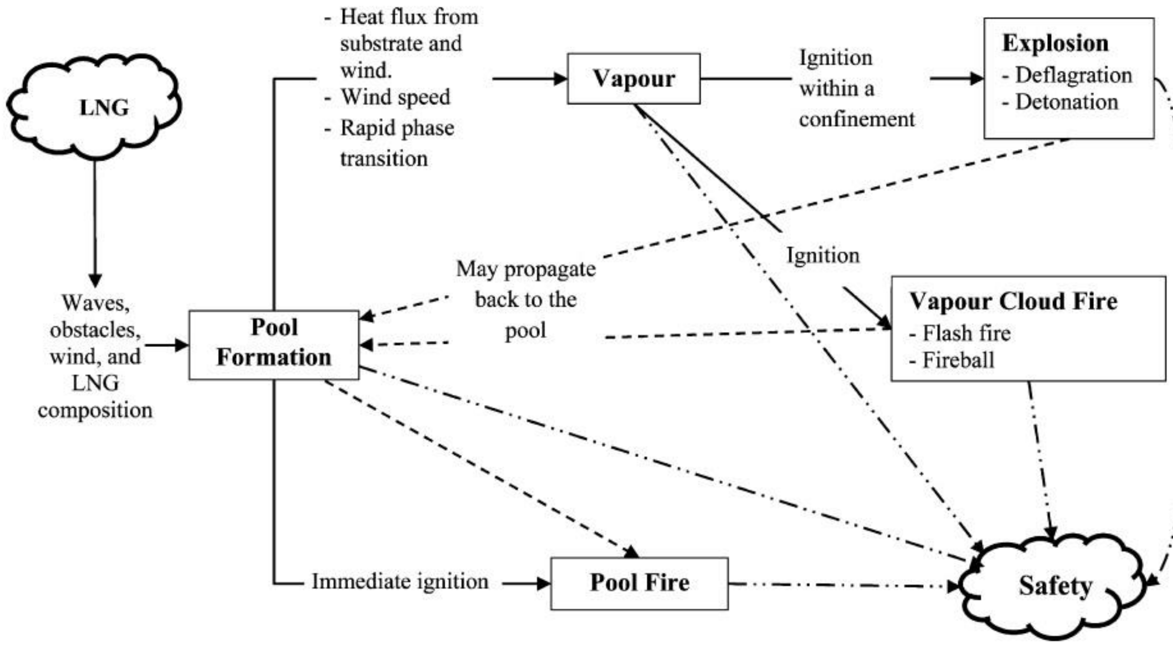


Figure 8.2 – LNG Hazards

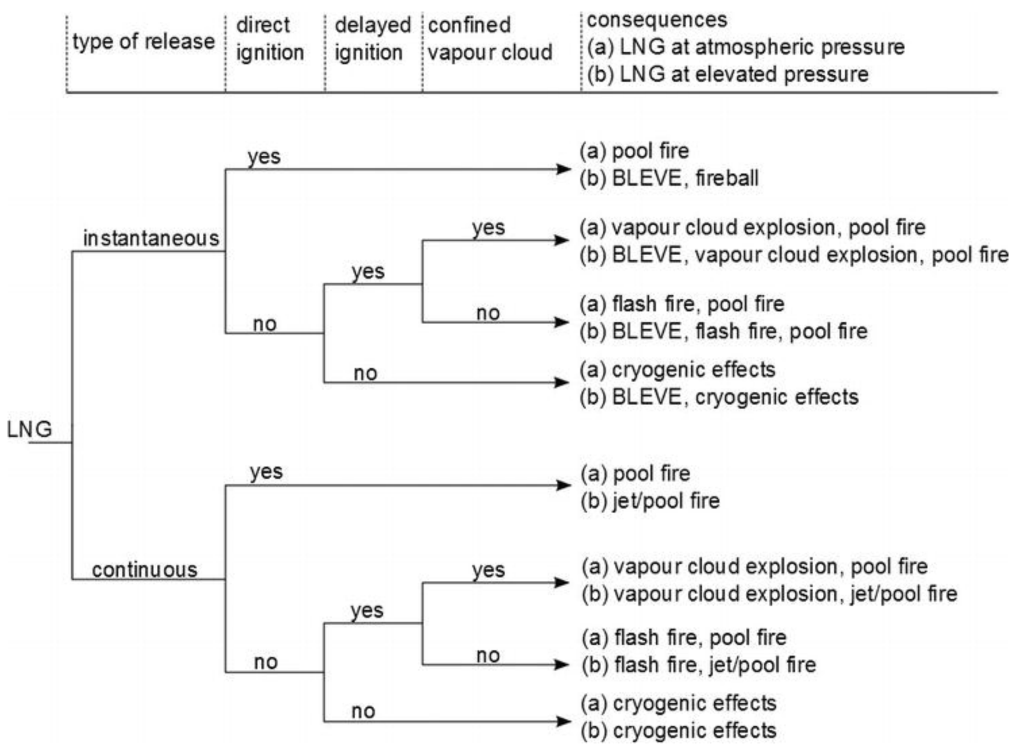


Figure 8.3 – LNG Hazards

Table 8.4 – LNG Hazards

LNG Hazard	Summary Description
Flash Fire	A flash fire can occur when a cloud of gas burns without generating any significant overpressure. The LNG cloud can only be ignited where the concentration is above the Lower Flammable Limit (LFL) and below Upper Flammable Limit (ULF). For methane the flammable range is 5% to 15% in mixture with air. Below 5% mix (methane/air) it will be too lean to ignite, and above 15% it will too saturated to ignite. The gas clouds can only be ignited at the edge as they disperse and meet an ignition source (e.g. open flame, internal combustion engine, sparks). An ignited cloud will “flash back” across all its flammable mass (i.e. that part within the flammable range – between the UFL and LFL). It will then burn at the UFL boundary until the entire gas is consumed. The duration of the flash fire is relatively short, but it may stabilise continuing as a jet fire or pool fire from the leak origin.
Pool Fire	For large spills, air cannot transfer enough heat to vaporize much LNG so a part of the spill is likely to end up in a liquid pool. A pool fire may result after a flash fire. A LNG pool fire generates significant thermal radiation with the surface emission power above $200 kW/m^2$ (a person in protective clothing will typically withstand 12 kW/m for a short time). Once combustion adds to evaporation, the pool will shrink significantly in size to a sustainable pool fire diameter.
Jet fire	Jet fires are burning jets of gas or atomised liquid whose shape is dominated by the momentum of the release. Jet fires typically result from gas or condensate releases from high-pressure equipment, e.g. HP pump, high pressure piping etc. Jet fires may also result from releases of high-pressure liquid containing dissolved gas, due to the gas flashing off and turning the liquid into a spray of small droplets. Typical conditions for this are pressure over 2 bar_g.
BLEVE (fire ball)	Fireballs are very rapid combustion processes most often associated with Boiling Liquid Expanding Vapour Explosions (BLEVE) and these are only associated with pressurized liquids. When these are released quickly, the gases flash and this creates extreme speeds and turbulence. This in turn allows a flame front to travel rapidly across the whole flammable envelope. As these releases often do not have much air entrained, the fireball burns across the entire external envelope and causes the flammable mass to rise and radiate large amounts of heat in typically 20 to 40 seconds.
Explosion	A vapour cloud explosion can occur when a large flammable mass of hydrocarbon vapour is ignited in a confined space (e.g. an enclosed box). In an open space, outdoors situation, there is no confinement and the experimental evidence is that methane gas will burn relatively slowly with all the expansion resulting in a vertical rise of gas. Within methane clouds, flame propagation is slow. Sufficient flame acceleration to create explosion overpressure will not occur if there not enough congestion or confinement.
Asphyxia	Methane, or natural gas, is not toxic. However, in the case of a release of natural gas in an enclosed or semi-enclosed area it can result in asphyxiation due to the lack of oxygen caused by decrease of the partial pressure of oxygen in the inhaled air, which is established when mixing methane and air. Concentrations of 50% by volume (methane in air) will cause obvious suffocation symptoms like difficulties in breathing and rapid breathing at the same time as the ability to respond deteriorates and muscle coordination weakens.
Brittle fracture and cryogenic burns	The cryogenic properties are particular for LNG and it thus require special attention. In order to get the methane into liquid phase it needs to be cooled down below its boiling temperature of - 161 degrees Celsius thus representing thermal hazards to personnel (e.g. in contact with the liquid). However, the extremely low temperatures are not only hazardous to people. While stainless steel will remain ductile, carbon steel and low alloy steel will become brittle and fractures are likely if exposed to such low temperatures. This embrittlement combined with the high thermal induced strains causes a collapse of normal steel structures when get in contact to LNG. Standard ship carbon steel (of all grades) shall therefore be protected and insulated from any possible exposure to an LNG spillage.
Rapid Phase Transformation (RPT)	This is a very rapid physical phase transformation of LNG to vapour mainly due to submersion in water. It can cause a small but serious local physical explosion effect, which at greater distances can cause low overpressures. The risk of RPT is limited to the LNG/water mixing zones. The intensity of explosion will be much less than a detonation (supersonic velocities) and more equivalent to a pressure wave limited to

LNG Hazard	Summary Description
	sonic velocity or less. This is unlikely to damage large structural elements of a ship or jetty. No specific modelling is undertaken for RPT as it is unlikely to increase the hazard range of a major spill that has already occurred. Rapid phase changes have not resulted in any known major incidents involving LNG.
Overpressure due to Rollover	Rollover is the process of spontaneous mixing up of a similar or two different gaseous cargos due to changes in the density of upper and lower layers level in the tank. This happens because of the boiling off of lighter fractions from the gaseous cargo, resulting in the liquid layer adjacent to the liquid surface to become denser than the layer beneath it. When this situation occurs, stratification develops and the unstable condition relieves itself with spontaneous mixing known as rollover. Tank over pressurization and excessive boil-off leading to emergency venting is the likely consequence of such occurrence. The rollover phenomenon is more likely to occur in large tanks where LNG with different densities is stored. This can result, for instance, from bunkering LNG into a tank which is partially filled with aged liquefied gas.
Trapped LNG	If LNG is trapped in the piping or somewhere along the transfer line, a phase transition will cause a local pressure build up. The expansion can potentially cause a pipe burst leading to a significant release of natural gas or LNG depending on the size of the burst and operating conditions. All pipe sections and tanks shall therefore be secured with thermal relief valves. Always take necessary precautions when encompassing system modification or maintenance, as the case of trapped liquid between two valves can lead to fatal consequences (tube cracking).

8.1.6 Ignition Sources

Table 8.4, below, includes a comprehensive list of possible ignition sources, with a large scope and variety of typical ignition energies. The different ignition sources should be taken in consideration when assessing LNG fire risk in Hazardous and Safety Zones for LNG bunkering.

Table 8.5 – Ignition sources

Overview of effective sources of ignition	
Source of ignition	Examples of causes
Sparks	Mechanically created sparks (e.g., caused by friction, impact or abrasion processes), electric sparks
Arcs	Short circuit, switching operations
Hot surfaces	Heater, metal-cutting, heating up during operation
Flames and hot gases	Combustion reactions, flying sparks during welding
Electrical systems	Opening/closing of contacts, loose contact A PELV (U < 50 V) is not an explosion protection measure. Low voltages can still generate sufficient energy to ignite a potentially explosive atmosphere.
Static electricity	Discharge of charged, separately arranged conductive parts, as with many plastics, for example
Electrical compensating currents, cathodic anti-corrosion protection	Reverse currents from generators, short circuit to exposed conductive part/ground fault, induction
Electromagnetic waves in the range of $3 \times 10^{11} \ldots 3 \times 10^{15}$ Hz	Laser beam for distance measurement, especially for focusing
High frequency $10^4 \ldots 3 \times 10^{12}$ Hz	Wireless signals, industrial high-frequency generators for heating, drying or cutting
Lightning strike	Atmospheric weather disturbances
Ionizing radiation	X-ray apparatus, radioactive material, absorption of energy leads to heating up
Ultrasound	Absorption of energy in solid/liquid materials leads to heating up
Adiabatic compression and shock waves	Sudden opening of valves
Exothermal reactions	Chemical reaction leads to heating up

8.2 Risk Assessment in Land-Use Planning

NOTE: The text as included in the present Section is adapted from the *Study on the completion of an EU framework on LNG-fuelled ships and its relevant fuel provision infrastructure*, LOT 1 Final Report, DNV-GL, 2016

The present section includes Risk Assessment provisions relevant for Land Use Planning, applicable to small scale LNG installations, including in particular those where SEVESO applicability has been determined. Figures 8.4 to 8.7, below, are typical installations to which Land-Use Planning (LUP) would be applicable.

Figure 8.4 – Fixed LNG small scale installation, for LNG bunkering and grid supply – equipped with re-liquefaction plant.

Figure 8.5 – Type-C tanks in small scale LNG installation (with visible evaporators) – for NG supply to the grid and LNG trucks (source: Grupo Sousa Gáslink)

Figure 8.6 – Type-C tanks in fixed LNG bunkering installation.

(source: Harvey Gulf)

Figure 8.7 – LNG floating storage unit – subject to SEVESO applicability evaluation (see Section 4) – likely to be considered under the SEVESO framework**.** (source: Wartsila)

8.2.1 Land-Use Planning - Introduction

Different risk assessment approaches (e.g. quantitative risk assessment: QRA) and regulatory risk acceptance criteria for small scale LNG infrastructure (i.e. primarily those installations that fall under the Seveso directive) are adopted in the different EU countries. Various techniques, methodologies, guidelines and tools used for the general analysis of the risks of activities with hazardous substances were identified. These are commonly used to determine external safety distances between major hazard industrial facilities (or activities) and surrounding land-uses (e.g. vulnerable objects such as residential areas). This process is also commonly known as Land-Use Planning (LUP).

Specific focus is on the different risk assessment approaches and criteria used in EU countries for LUP as per the national legislative implementation of the Seveso directive and to illustrate which (parts of) approaches and criteria have specific or general applicability.

Background information is provided on the various existing methodological approaches. In particular, the QRA approach is elaborated by describing its generic methodology, required tools and available guidelines for the risk analysis. With respect to guidelines, attention is given to industry best practices that supersede national or local regulations, e.g. global QRA best practices and methodologies used by major oil & gas companies or advisory companies.

Furthermore, many countries have established risk criteria for regulatory purposes. These are essential to assess the risk in a QRA (i.e. to determine whether the risks are acceptable or can be considered tolerable). For this reason, the generic framework for risk criteria and the principles of (risk) threshold criteria are explained in more detail.

Next to the use of a QRA approach in LUP, various other potential applications of a QRA are discussed for the safe and secure operation of Small Scale LNG infrastructure or activities:

- Assessment of specific risks and mitigating measures for Simultaneous Operations
- Determination of safety zones
- Determination of internal safety distances (i.e. to prevent cascading effects).

Finally, based on the identified issues, concrete suggestions for harmonization of and improvements for risk assessment approaches (including methodologies, guidelines, tools and risk criteria) used for LNG small scale infrastructure and activities across Europeans port are provided.

The structure of this section is as follows:

- **An overview of existing (categories of) methodological approaches used for LUP** is provided in section 8.2.2. The main principles and differences are explained. The QRA approach is only one of the approaches used for LUP;
- Section 8.2.3 describes the **generic methodology of a QRA approach**, followed by an overview of leading consequence and QRA software tools required for a QRA (8.2.4) and QRA guidelines and best practices (8.2.4);
- A **framework for risk criteria and principles of (risk) threshold criteria** are detailed in paragraph 8.48.4;

In addition to the above the **application of LUP approaches in the different EU countries** can be found in the *Study on the completion of an EU framework on LNG-fuelled ships and its relevant fuel provision infrastructure*, LOT 1 Final Report, DNV-GL, 2016[66], giving indication of the risk criteria practice for LUP in different selected EU countries and listed as reference [2] to this Guidance.

8.2.2 Methodological approaches

Existing methodological approaches for land-use planning in European countries have been summarized and described in literature. In general, the existing methodologies can be divided into the following four categories:

8.2.2.1 Consequence-based approaches

The consequence-based approach is based on the assessment of consequences of credible (or conceivable) accidents, without explicitly quantifying the likelihood of these accidents. The consequences of the accidents are mostly taken into consideration by calculating the distance in which the physical and/or human health impacts (e.g. heat radiation) reach, for a given exposure period and a threshold value (e.g. irreversible health effect/harm or fatality). The external safety zone is thus defined according to which LUP restriction is applied. The method has been generally used in Luxembourg and Austria.

[66] Can be downloaded from https://ec.europa.eu/transport/sites/transport/files

8.2.2.2 Deterministic approach with implicit judgment of risk

A simplified form of the consequence-based approach is the use of “generic” separation distances. These distances are usually derived from selected scenarios and developed on a conservative basis. In their most simple form, they are derived from expert judgement, including consideration of historical data or experience from operation similar plants. The approach of generic separation distances has been established and used in Germany.

8.2.2.3 Risk-based (or “probabilistic”) approaches (i.e. QRA)

The risk-based approaches define the risk as a combination of the consequences derived from a range of possible accidents, and the likelihood of the accidents. The results are represented as individual risk and/or societal risk. LUP criteria are based on specific acceptability criteria with respect to the calculated risk. In general, the approach is similar to the QRA methodology described in the next paragraph. This approach is followed in e.g. the United Kingdom, Belgium (Flanders) and the Netherlands.

8.2.2.4 Hybrid approaches

Hybrid approaches (or semi-quantitative) combining risk and consequence-based approached have been developed and extensively used in France and Italy. Under these methods, one of the elements (usually frequency) is assessed more qualitatively, i.e. using classes rather than continuous figures. The use of a risk matrix is a typical example. For instance, France adopted a hybrid approach that combines a consequence-based approach for the determination of the zones that correspond to damage thresholds and a risk-based approach for the determination of the considered accident scenarios. Respectively, Italy has adopted a hybrid criterion that takes into account the frequencies, as mitigation factor for the damaged zones, identified using a consequence-oriented approach.

The above described approaches often require the use of risk tools as described in paragraph 8.2.4. Next to these tools, (risk) threshold criteria are needed to determine the extent of the external safety zone in LUP (see 8.4).

8.2.3 QRA methodology

A quantitative risk assessment is a well-known and widely accepted methodology to quantify safety risks. It is an approach to determine risk levels associated with accidental Loss of Containment events (e.g. spills, gas releases).

A QRA can give insight into the risks to human life or property of a certain activity by calculating the potential hazardous effects of a variety of scenarios as well as considering the probability of occurrence of these scenarios. The QRA methodology is visualized in **Error! Reference source not found.**.

<u>Typical objectives of a QRA study are:</u>

- Quantify the level of safety risks (to people or property) associated with the operation of a plant or activity with hazardous materials
- Demonstrate that the levels of risks are in compliance with risk acceptance criteria as agreed with authorities.
- Evaluate and select safeguards and risk reducing measures, if needed

In general, a QRA tries to answer five simple questions. Beside each question, the technical term is listed for that activity in the risk assessment process:

1. What can go wrong?	**Hazard Identification**
2. How bad?	**Consequence Modelling**
3. How often?	**Frequency Estimation**
4. So What?	**Risk Assessment**
5. What do I do?	**Risk Management**

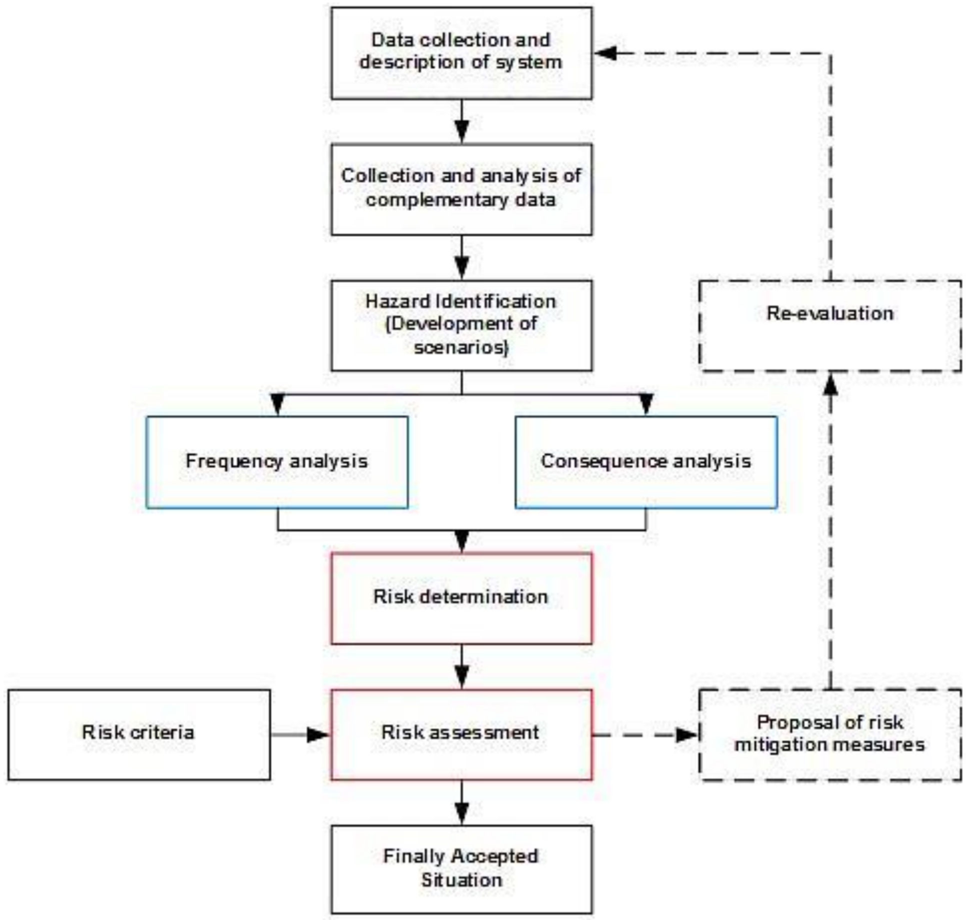


Figure 8.8 – QRA Methodology

The QRA activities are explained in more detail underneath.

Hazard identification (What can go wrong?)

The first part of the quantitative risk assessment is similar to the qualitative risk assessment, i.e. to establish the study basis and perform a Hazard Identification Session (HAZID) to identify and screen potential hazardous situations. Potential hazards to people or property can arise if a loss of containment occurs. A comprehensive identification of potential hazardous scenarios is critical. Typical accident and loss of containment scenarios based on historical incident data can be assessed on relevance and should be complemented with the outcomes of a site specific HAZID.

The current industry practice is to perform a HAZID for LNG activities, especially in case of special circumstances where the risks are not fully known, such as SIMOPS (see also section 11) or in case of e.g. non-standard LNG bunkering scenarios. Some authorities also request a HAZID to be carried out as part of the permitting process, despite the fact that this is normally not specifically mandated in legislation.

Risk assessment guidelines may also prescribe accident scenarios for failure of various equipment types and piping based on historical incident data. These are, however, not LNG-specific. The ISO/DTS 16901 specifies types of accident scenarios to be considered for LNG import/export terminals. The specifics of the given accident scenarios (e.g. release size and associated base frequencies) are however not provided. There is a need for a complete and detailed definition of credible accident scenarios that can occur during the operation of Small Scale LNG installations and activities. It must be noted that there are currently developments[67] in the Netherlands with the purpose to fill this knowledge gap (reference is made to paragraph 8.2.5 for more information).

Consequence Modelling - (How bad?)

In parallel with the frequency analysis, consequence modelling evaluates the resulting effects if the accidents occur, and their impact on people and property. Ignited flammable releases can result in various consequences such as jet,-, pool, - or flash fire, fireball or vapour cloud explosions depending on the type of scenario and time and place of ignition. The consequence assessment shall be carried out using recognized consequence modelling tools that are capable of determining the resulting effects and their impact on personnel, equipment and structures. These tools are normally validated by experimental test data appropriate for the size and conditions of the hazard to be evaluated.

Reference is made to paragraph 8.2.4 for more information regarding leading consequence and risk assessment tools and their suitability to quantify consequences or risks of potential accidents occurring in LNG installations or during activities.

Failure frequencies - (How often?)

After the hazards of a system or activity have been identified, the next step in performing the QRA is to estimate the frequency at which the hazardous events (or scenarios) may occur. The following are common techniques and tools available for frequency assessment:

- Analysis of historical incident data;
- Fault tree analysis;
- Event tree analysis;
- Simulations.

The selected technique will depend on the availability of historic data and statistics.

There are a few sources of data for failure frequency data for process equipment loss of containment: Netherlands and Belgium have issued two different onshore frequency datasets for use in Seveso Directive risk assessments, and some companies and consultants have their own data. It must also be stressed that nominated frequencies are tightly integrated with national risk criteria. Unfortunately, there are currently no LNG specific failure frequencies due to the lack of available incident data. Risk analysts are forced to use release frequency data from generic sources. DNV GL recommends using data from the hydrocarbon from the Hydrocarbon Release Database (HCRD) from the UK HSE, which are based on historical data from oil platforms in the North Sea and are representative for equipment used in those installations. This is considered the most extensive dataset of its type and superior to current published datasets, which often have much smaller and older data which do not reflect current integrity management programs. The data forms the basis for onshore and offshore QRA's which, in the absence of LNG specific data, is also used in QRAs for LNG installations. There is currently no statistically sound basis for modifying the source failure data from the HCRD (or any other dataset for that matter) to account for onshore and cryogenic or LNG specific applications.

There is, however, a strong believe among owners and designers of LNG equipment that release frequencies from LNG-specific equipment and piping should have lower values than those from their equivalent in offshore platforms. Therefore, QRA results based on HCRD release frequencies are believed to be conservative for LNG applications. It is unknown to what extent this conservatism could potentially drive the calculated risk of LNG installations to high, thus requiring the implementation of (expensive) risk reduction measures or require large external safety distances.

Risk Assessment - (So What?)

The next stage is to introduce criteria which are yardsticks to indicate whether the risks are “acceptable”, “tolerable” or “negligible” or to make some other value-judgment about their significance. The most common criteria used in the industry for risk assessments when relating risk to people are

[67] Projects and developments such as: Dutch Safety Program, LNG-specific risk calculation guidelines, research into failure frequencies for LNG equipment.

individual and societal risk criteria (reference is made to section 8.4.2 for more details). This step begins to introduce non-technical issues of risk acceptability and decision making, and the process is then known as risk assessment.

Risk Management - (What to do?)

In order to make the risks acceptable, risk reduction measures may be necessary. The benefits from these measures can be evaluated by recalculating the risk. Investigation of risk mitigation measures and their impact on the calculated risk can also be performed to demonstrate that the residual risk is As Low as Reasonably Practical (**ALARP**). For a risk to be ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained (see also 8.4.1).

8.2.4 Consequence and risk analysis software tools

A comprehensive overview of leading software tools for undertaking consequence and risk (e.g. QRA) analysis is published in a paper by the American Society of Safety Engineers [41]**Error! Reference source not found.**. The key findings of this paper where that there is no single "best" consequence tool. What is important is the selection of the appropriate tool for the specific situation being modelled, i.e. the tool should be proportionate to the magnitude of the hazard.

In addition, it is important that the software models are periodically maintained, verified and validated in order to establish that accurate results are generated. Model validation for LNG releases is of particular importance. For instance, an LNG release often results in heavy gas dispersion behaviour despite the fact that methane is lighter than air. This mechanism is difficult to model and therefore the dispersion model should be properly validated to ensure that accurate results are predicted.

8.2.5 Risk assessment guidelines and best practices

Various guidelines and best practices to perform risk assessments (i.e. QRA) exist. The purpose of this paragraph is to outline and describe the main publications and to discuss LNG applicability in particular. It is not the intention to provide an exhaustive list.

Various guidelines and best practices are published by e.g. the following entities and are more detailed below:

- National authorities (e.g. UK HSE, National Institute for Public Health and the Environment, (RIVM, the Netherlands))
- Major oil and gas companies
- Advisory companies (e.g. DNV GL, Bureau Veritas)
- International guidelines (e.g. ISO)

National authorities

In countries that set requirement for a QRA, rather detailed information is needed for the design of the LNG small scale supply chain installations, the possible failure scenario's, the frequency of occurrence, the release consequences and how to model all these items. Not all countries are in that respect prescriptive (i.e. no specific guidelines are mandated). For instance, the Netherlands prescribe complete guidelines (and software tools) to be used to execute QRA's. Belgium (Flanders) mandates only the use of specific failure frequencies, but not the use of specific software tools and accompanying model parameters. The UK HSE, on the other hand, provides only guidance on the evaluation of risk and risk tolerability (e.g. ALARP demonstrations), rather than the definition of failure cases, failure frequencies and how to model the latter. No specific onshore risk assessment guidelines are currently mandated (or published for that matter) by the UK HSE.

The most well-known and world-wide accepted guideline for the execution of quantitative risk assessment is the 'purple book'. Together with the other 'coloured books' (yellow, green and red) the guideline forms valuable reference material for safety studies[68]. The books are written by Dutch

[68] The coloured books are freely available in electronic form and can be downloaded here: https://www.tno.nl/en/focus-area/urbanisation/environment-sustainability/public-safety/the-coloured-books-yellow-green-purple-red/, accessed on 05-01-2015

Government (RIVM) with support from the research institute TNO. The coloured books have become obsolete and are not kept up-to-date anymore since 2005. The successor is the Dutch Reference Manual Risk Assessments Bevi **Error! Reference source not found.**, which is mandated in the Netherlands for the execution of QRA's (see also Appendix-A). Although these guidelines are not specifically written for LNG, they have generic applicability. However, the main limitation is that they do not specify LNG-specific failure frequencies. Therefore, the RIVM has recently initiated a project (start-up phase) into LNG-specific failure frequencies for LNG transfer systems and stationary (double walled) pressure vessels. This project is part of a larger two-yearly (national) LNG safety research program with the purpose to enhance and accelerate full development of LNG safety issues including the determination of external safety distances used in LUP[69].

Furthermore, separate guidelines have been developed by the RIVM for risk assessments of specific (LNG) installations. The most recent guideline (or risk calculation methodology) is the draft version: 'Risk methodology LNG delivery installations for road vehicles'[70]. A similar guideline for LNG bunker stations is currently under development (final stage). These guidelines also contain case studies.

International guidelines

An LNG-specific risk assessment guideline is recently published by the International Organization for Standardization. This is the ISO/DTS 16901 (OGP 116901) – Guidance on performing risk assessment in the design of onshore LNG installations including the Ship/Shore interface.

8.3 Risk Assessment in LNG Bunkering

8.3.1 References

The following references were considered in particular for the present Section:

- ISO/TS 18683:2015. (15-Jan. 2015). Guidelines for systems and installations for supply of LNG as fuel to ships. Technical Specification.
- ISO/DIS 20519:2016. Ships and marine technology – Specification for bunkering of gas fuelled ships. (Draft International Standard).
- LNG Bunkering Guidelines IACS Recommendation n. 142, on LNG Bunkering, IACS, 2016.
- Society for Gas as a Marine Fuel (SGMF) (2017) - Gas as a marine fuel, safety guidelines, Bunkering Version 2.0, February 2015
- DNVGL-RP-G105 Edition October 2015 - *Development and operation of liquefied natural gas bunkering facilities, Recommended Practice*, DNV GL, 2015

8.3.2 Introduction

The present Section includes references and elements strictly relevant to LNG Bunkering Risk Assessment, highlighting the provisions from ISO/TS 18683 and ISO 20519,

A bunkering operations risk assessment should be undertaken in accordance with ISO/TS 18683. 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 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

[69] The LNG Safety Program has started in the beginning of 2014 and is carried out as a joint cooperation between public and private stakeholders. The two-year (2014-2015) program has been initiated by the National (Dutch) LNG Platform after numerous requests from market parties and Dutch emergency response organisations to enhance and accelerate full development of LNG safety issues.

[70] Draft version can be downloaded here: http://www.rivm.nl/dsresource?objectid=rivmp:262836&type=org&disposition=inline&ns_nc=1 , accessed on 23-12-2014

- Preparation, testing and connection of equipment
- LNG transfer and boil-off gas (BOG) management
- Completion of bunker transfer and disconnection of equipment
- Simultaneous operations (SIMOPS)

Following the above Following the indication of ISO/TS 18683 the risk assessment shall be carried out in agreement with recognized standards, such as ISO 31010, ISO 17776 and ISO 16901.

ISO/TS 18683 indicates already an important point which anticipates one of the most important good practice notes in terms of Risk Assessment: ***The risk analysis shall be carried out with a team ensuring an objective and independent assessment.*** This is an important aspect of Risk Assessment requirements as outlined in ISO/TS 18683, bringing the concept of "independency" of risk assessment process.

ISO/TS 18683 indicates, as a minimum, a qualitative risk assessment to be carried out for bunkering installations complying with the defined standard bunkering scenarios as defined in ISO/TS 18683 (TTS, PTS or STS). A note is however made in section 8.6.1 where standard LNG bunkering modes would still very likely require a QRA to be conducted, leading the requirement above the minimum framework defined by ISO/TS 18683.

For bunkering installations deviating from the standard bunkering scenarios[71] defined in ISO/TS 18683 or not meeting all requirements, the qualitative risk assessment shall be supplemented by a detailed assessment of the deviations as agreed with the regulator. Normally, this includes a comprehensive quantitative risk assessment to demonstrate that the overall acceptance criteria are met and that implemented safeguards compensate for not meeting all requirements.

The schematic approach is illustrated in Figure 8.9, extracted from ISO/TS 18683

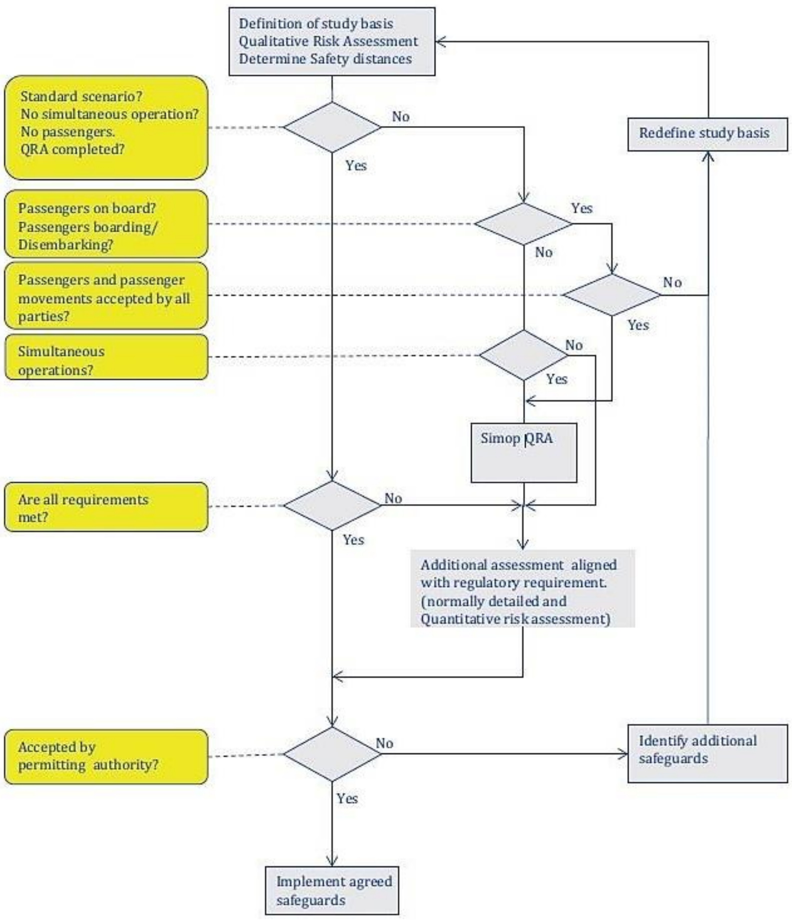


Figure 8.9 – Schematic approach of risk assessment (source: ISO/TS 18683**)**

[71] Standard bunkering is characterised by three bunkering scenarios, as noted in ISO/TS 18683:
1. PTS (Port/Shore-to-ship); 2. TTS (Truck-to-Ship); 3. STS (Ship-to-Ship)

8.3.3 Qualitative risk assessment (QualRA)

8.3.3.1 Contents

A qualitative risk assessment for a LNG bunkering project/operation shall, as a minimum, comprise of the following elements, as described in ISO/TS 18683

a) **SCOPE**: Definition of study basis and familiarization with the design and planned operation of the bunkering facility

b) **HAZID**: HAZID review with the purpose of identifying hazards and assess the risks using a risk matrix. The HAZID shall also identify risk reducing measures for all hazards representing medium or high risks. The HAZID should consider accidental spills and consider/identify technical and operational safeguards. The HAZID shall also determine maximum credible release scenarios as a basis for the determination of the safety zones;

c) **SAFETY ZONE**: Determination of safety zones and security zones (these may later be revised with reference to QRA);

d) **REPORT**: Reporting.

The qualitative risk assessment shall consider all possible bunkering configurations reflecting the variety of ships to be bunkered.

8.3.3.2 Scope

As adapted from ISO/TS 18683 below the scoping basis is defined where a minimum sample the relevant elements are listed, for consideration

a) Description and layout of the bunkering installation, including all Concept Project drawings and intended receiving ship's characteristics;
b) All technological elements envisaged for safety control (such as alarms or other relevant features)
c) Description of other simultaneous activities and stakeholders and third parties in the area;
d) Description of all systems, components with regard to function, design, and operational procedures and relevant operational experience;
e) Description of operations and operational limitations;
f) Organization of the bunkering activities with clear definitions of roles and responsibilities for the ship crew and bunkering personnel;
g) Identification of authority stakeholders;
h) Acceptance criteria for the project aligned with authority requirements, in which the risk matrix shown in Annex A represents example of minimum requirements with respect to risk to personnel.

8.3.3.3 Methodology

The QualRA methodology is strongly based on the HAZID (its core part), following an initial scoping basis, and finalizing with the adequate screening of the LNG bunkering hazardous situations. The HAZID Methodology is outlined in the following section, using ISO/TS 18683 as reference.

8.3.3.4 HAZID

Table 8.6, below, outlines the structure and contents of the HAZID as the core part of the Qualitative Risk Assessment.

Table 8.6 – HAZID Methodology (ISO/TS 18683)

Part	Description/Details
General	• workshop meeting with a multi-discipline team using a structured brainstorming technique based on a checklist of potential HSE issues, • means of identifying, describing, and assessing HSE hazards and threats at the earliest practicable stage of a development, and • Rapid identification and description process only.
HAZID team	The HAZID team shall involve a facilitator supported by experienced representatives from different disciplines. The following disciplines shall be represented:

Part	Description/Details
	• LNG operational experience; • marine expertise; • bunkering experience; • local knowledge; • other specialist should be available "on call"; • familiarity with risk assessment techniques for LNG facilities including assessment of dispersion, fire, and explosion The HAZID team shall be selected to ensure objective and **independent assessment**. **As good practice PAAs should always be represented in HAZID workshops for prospective LNG bunkering projects within their ports**. Before participation in HAZID Workshops PAA participants should be able to contribute with Port specific information that may be of assistance to safety discussions. Examples of such information: • Tidal information • Local known weather effects • Operational restrictions • Multi-operator information • Berthing information
Workshop methodology	• Identify potentially hazardous events. • Assess these events with regard to consequence and likelihood and rank the risks. The process of risk ranking is normally performed using a risk matrix (see Annex A). • Identify and assess potential risk-reducing measures. • Identify hazards and safeguards that need to be followed up later in the project. • Identify maximum credible accidental release (i.e. release scenarios that shall be the basis for definition of the safety zones). • Identify need for PPE for the personnel involved in the operation.
Hazardous events	The HAZID shall, **as a minimum**, consider the following hazardous events: 1. LNG releases: a. failure of QC/DC or ERC equipment; b. hose or loading arm failure due to the following: i. design flaws; ii. wear, tear, and fatigue; iii. excessive loads due to dropped objects or collision and impacts from ships or trucks; iv. ships mooring failure; v. unplanned movement of the truck; c. pressure surge in transfer lines; d. releases from piping systems; e. incorrectly planned or performed maintenance; f. incorrect operational procedures including the following: i. cooling down; ii. connection; g. failure to detect releases masked by mist and fog due to cold surfaces; h. failure to detect releases at low level due to location of gas and leak detectors; i. over-filling and over-pressurization of ships bunker tanks (e.g. by flashing, incorrect bunker rate, or bunkering procedure); j. over-pressure of transfer systems caused by thermal expansion or vaporization of trapped LNG; k. possible rollover in bunker tanks caused by loading LNG of different densities; 2. ignition sources: a. electrical hazards; b. other ignition sources; c. activities inside the safety zone; d. gas dispersion beyond the safety zone; 3. release of nitrogen, asphyxiation; 4. Events caused by human error.
Hazardous effects	Hazardous effects following the initial events shall be considered. These shall include the following: 1. fire hazards: a. structural failure and escalation due to high temperatures; b. injuries to personnel;

Part	Description/Details
	c. damage to equipment; d. ignition of secondary fires; e. potential BLEVE of pressurized LNG containment subjected to a fire; 2. possible vapour cloud deflagration/flash fires: a. damage to equipment and escalation; b. injury to personnel; c. damage to fire-fighting equipment and safeguards; 3. cryogenic hazards: a. structural failures including brittle fracture of the steel structure exposed to LNG spills; b. frostbite from liquid or cold vapour spills; 4. other hazards: a. asphyxiation; b. Possible rapid phase transition caused by LNG spilled into water.
Hazardous effects	Action plan a) The HAZID shall produce a list of hazards, ranked with respect to consequence and likelihood b) Recommendations for risk reducing measures and an action plan for follow up. c) Safeguards to be considered in the HAZID should, as a minimum, include the following: a) training of involved personnel; b) maintenance planning; c) cryogenic spill protection; d) personal protective equipment for operators; e) evacuation plans; f) fire-fighting equipment; g) shore to ship and ship to ship communication plan; h) Elimination or minimization of ignition sources, including the use of isolation elements. d) The action plan addresses each recommendation developed along the HAZID meeting and shall be e) Followed up for its assessment and implementation.
Meeting records	A typical HAZID workshop is normally recorded with the following: a) activity ID; b) function; c) system failure effect; d) consequence category (environment, people, cost, reputation); e) consequence (ranked according to risk matrix being used); f) likelihood (ranked according to risk matrix being used); g) criticality (low, medium, or high); h) action items identified; i) Comments.
Risk Matrix	The risk matrix is an effective tool for qualitative risk assessment and screening. It is normally used in workshops in support of HAZIDs and FMEA. It can be used to identify hazards that shall be further investigated in the subsequent quantitative analysis. The Risk Matrix allows in particular The results from the detailed analysis in terms of frequency and consequences can be reported in the matrix. This enables to track and tune the efficiency of the risk reducing measures, qualify initial assumptions, and confirm the initial scenario ranking. ISO/TS 18683 contains a Risk Matrix, with risk ranking categories that can be used unless, at national level, other frame is applicable.

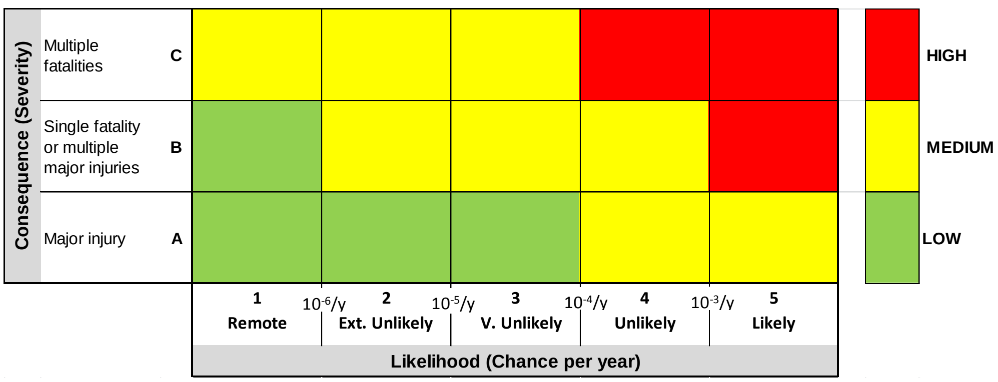


Figure 8.10 – Risk Matrix Example – With Risk Ranking Categories **(ISO/TS 18683)**

Part	Description/Details
	Consequence Category A. Major injury - long-term disability / health effect B. Single fatality or multiple major injuries - one death or multiple individuals suffering long-term disability / health effects C. Multiple fatalities - two or more deaths **Likelihood Category** 1. Remote - 1 in a million or less per year 2. Extremely Unlikely - between 1 in a million and 1 in 100,000 per year 3. Very Unlikely - between 1 in 100,000 and 1 in 10,000 per year 4. Unlikely - between 1 in 10,000 and 1 in 1,000 per year 5. Likely - between 1 in 1,000 and 1 in 100 per year The likelihood categories can be related to a ship life. For example, assuming a ship lifetime is 25 years, then for a scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the ship's lifetime is 1 in 40,000 (i.e. 1/(10-6 x 25)). **Risk Rating and Risk Criteria Guidance (referring to figure 8.13)** Low Risk – A1, A2, A3 & B1 The risk can be accepted as 'mitigated as necessary'. Where practical and cost-effective it is good practice to implement mitigation measures that would further reduce the risk. Medium Risk – A4, A5, B2, B3, B4, C1, C2 & C3 The risk is tolerable and considered 'mitigated as necessary'. This assumes implementation of all reasonably practicable mitigation measures. High Risk – B5, C4 & C5 The risk is unacceptable and is not 'mitigated as necessary'. Additional or alternative mitigation measures must be identified and implemented before operation, and these must reduce the risk to medium or low. Mitigated as necessary: This is the wording used within the IGF Code and is akin to the phrase 'As Low As Reasonably Practicable', commonly referred to as ALARP.
Safety Zone	The work towards the determination of the Safety distance can be part of the HAZID Workshop. The determination of the Safety Zone, however, should be initiated as an analytical process, based on a maximum release scenario. Should a "maximum release scenario" produce impracticable Safety Zones it would be possible to establish, in the context of the HAZID workshop, a risk based re-evaluation and, collectively, determine a credible release scenario that could be used for that purpose. The release scenario to be considered should be identified in the HAZID reflecting the project specific factors such as the following: • transfer rates and inventory in the bunkering facilities; • operational modes; • implemented safeguards; • Properties of the LNG in the bunkering system (temperature, pressure). (see also Section 9)
Security Zone	Findings from the HAZID should also contribute to provide input to the determination of the Security Zone. (see also Section 9)
Reporting	The HAZID Report will be an important part of the Risk Assessment Report and should be subject to Approval by the PAA. For projects to which Seveso applicability has been determined the Risk assessment shall be part of the Safety Report (Upper-Tier) and submitted to the competent authority and to the PAA. (see Section 4.6.4) The minimum information indicated in ISO/TS 18683 should be: a. study basis including description of design, operations, and assumptions being made; b. description of the working process including participants in the workshops; c. summary of the identified hazards and the risk assessment; d. release scenario to serve as a basis for determination of the safety zone; e. determined safety distances; f. definition of the security zones; g. summary of follow up actions; h. Detailed records from the workshop.

8.3.3.5 Report

The HAZID Report will be an important part of the Risk Assessment Report and should be subject to Approval by the PAA.

For projects to which Seveso applicability has been determined the Risk assessment shall be part of the Safety Report (Upper-Tier) and submitted to the competent authority and to the PAA.

(See Section 4.6.4)

The minimum information to be contained in the Report, as adapted[72] from ISO/TS 18683 should be:

a. Study basis including description of design, operations, and assumptions being made;
b. Description of the working process including participants in the workshops;
c. Summary of the identified hazards and the risk assessment;
d. Identification of the Risk Matrices with the full risk screening developed in the HAZID
e. Clarification on the risk ranking categories used
f. Release scenario to serve as a basis for determination of the safety zone (maximum or credible release scenario;
g. Determined safety distances;
h. Definition of the security zones;
i. Summary of follow up actions;
j. Detailed records from the workshop.

8.3.4 Quantitative risk assessment (QRA)

8.3.4.1 Contents

In addition to the QualRA, a Quantitative Risk Assessment (QRA) is recommended when:

1. Bunkering is not of a standard type (PTS, TTS or STS, in simple standard configuration, as defined in ISO/TS 18683);
2. Design, arrangements and operations differ from the guidance given in ISO/TS 18683 or IACS Rec.142;
3. Simultaneous Operations (SIMOPS) are planned to take place along with LNG bunkering.
4. Automation elements are introduced to significantly reduce human intervention in operations (linked to system analysis)
5. A reduction in a Safety Zone is intended, on the basis of consequence/ probabilistic data for the specific LNG bunkering location
6. Whenever a numerical calculation of Risk is required for verification of any given Risk Criteria.

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

A quantitative risk assessment for a LNG bunkering project/operation shall, as a minimum, comprise of the following elements (most of them coincident with the QualRA

e) **SCOPE**: Definition of study basis and familiarization with the design and planned operation of the bunkering facility

f) **HAZID**: HAZID review with the purpose of identifying hazards and assess the risks using a risk matrix. The HAZID shall also identify risk reducing measures for all hazards representing medium or high risks. The HAZID should consider accidental spills and consider/identify technical and operational safeguards. The HAZID shall also determine maximum credible release scenarios as a basis for the determination of the safety zones;

[72] Information from ISO/TS 18683 adapted and augmented in particular with information regarding Risk Matrices, risk ranking and ranking categories used for the screening.

g) **CRITICAL HAZARDS** for Modelling and Risk Analysis (Taken from Critical HAZID scenarios)

h) **SAFETY ZONE**: Determination of safety zones (as derived from curves for LNG vapour dispersion, individual risk, societal risk, thermal radiation, explosion pressure. Typical curves to set QRA safety distances would be IR – Individual Risk and FN – Societal Risk curves);

i) **REPORT**: Reporting.

The qualitative risk assessment shall consider all possible bunkering configurations reflecting the variety of ships to be bunkered.

8.3.4.2 Methodology

Described in 8.2.3

8.3.4.3 Report

QRA Report should contain all elements listed in 8.3.3.5 and, in addition:

a. Identification of the most critical scenarios;
b. Approach followed
c. Software used for consequence modelling
d. Identification and experience of the analyst, including evidence of company-specific validation procedures.
e. Assumptions used for modelling
f. Simplifications used in computational model
g. Probability data
h. Software used for any probability event failure scenarios calculation
i. Risk Calculations
j. Risk contours in adequate aerial images for the area of interest
k. Identification of any operation-specific elements taken into consideration for the modelling.
l. Safeguards considered and due justification for any risk attenuation which hasn't either derived from

8.3.5 HAZOP

The risk assessment activities will be broken into two main parts, a higher level HAZID, included in the context of a QualRA/QRA activity, followed by a more detailed HAZOP. It is recommended that both of are conducted with professional guidance to ensure an appropriately detailed risk assessment outcome is achieved.

A **hazard and operability study** (HAZOP) is a structured and systematic examination of a complex planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment.

The intention of performing a HAZOP, in the specific context of LNG Bunkering, is to review the design to pick up design and engineering issues that may otherwise not have been found. The technique is based on breaking the overall complex design of the process (LNG bunkering system or operation) into a number of simpler sections called 'nodes' which are then individually reviewed. It is carried out by a suitably experienced multi-disciplinary team (HAZOP) during a series of meetings.

The HAZOP technique is **qualitative**, and aims to stimulate the imagination of participants to identify potential hazards and operability problems. Structure and direction are given to the review process by applying standardized guide-word prompts to the review of each node.

Guidance for conducting a HAZOP for LNG bunkering operation is detailed in the Annex of IACS Rec.142.

8.4 Risk criteria – framework and thresholds

Generically it is important to note that there will only be a "Risk Assessment" if Risk Criteria is available and agreed that allows it use to evaluate calculated risk figures.

Both in Qualitative and Quantitative Risk Assessments risk criteria must be in place that allows the evaluation and approval of a given Risk Evaluation Study. It can then be called a Risk "Assessment", following the exercised of risk ranking through the

8.4.1 Generic framework for risk criteria

A framework for risk criteria can be either two or three bands. The simplest framework for risk criteria is a single risk level which divides tolerable risks from intolerable ones (i.e. acceptable activities from unacceptable ones. This framework is based on two bands (implies a single risk criterion).

Another approach is to use two criteria; dividing risks into three bands:

- The upper band is where the risk are usually considered intolerable whatever benefits the activity may bring, and risk reduction measures are essential whatever their cost.
- The middle band is where risk reduction measures are desirable, but may not be implemented if their cost is high relative to the benefit gained (i.e. the ALARP principle should be demonstrated).
- The lower band where risks are negligible, or so small that no risk reduction measures are needed.

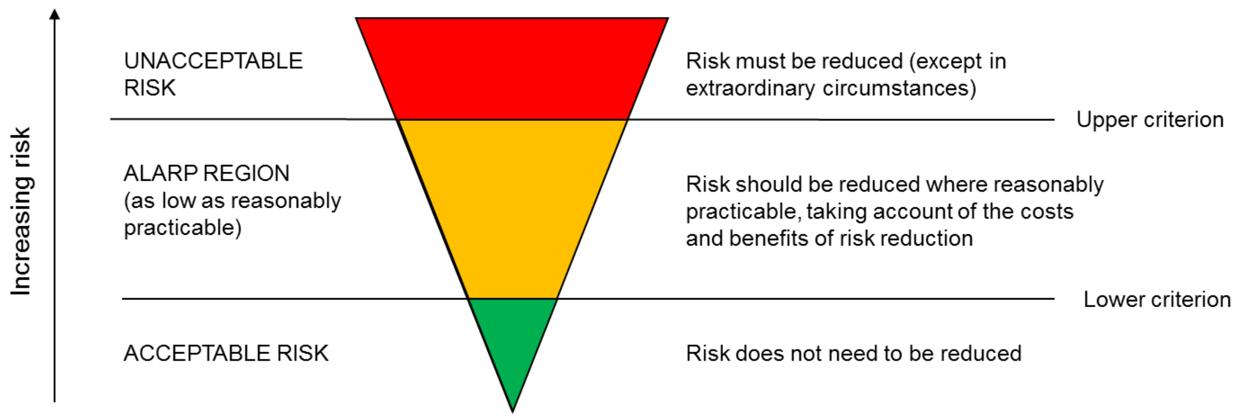


Figure 8.11 – 3-band Generic framework for risk criteria

For example, risk criteria in the Netherlands and Belgium (Flanders) are based on a two band framework wheras France and the UK use a three band framework.

8.4.2 Threshold criteria

Threshold criteria are used to assess risks on acceptability and are needed to establish external safety distances in the land-use planning process. Threshold criteria can be used as either non-legal binding values (i.e. target values) or hard (statutory) limits. The type of criteria applied will depend on the type of methodological approach prescribed in an EU-member state. In general, the following type of criteria can be distinguished:

- **Consequence-based criteria** (effect distances)
- **Risk-based criteria** (often expressed in individual risk and/or societal risk)

Consequence-based

Effect distances to certain threshold values for damage are determined, in the event that the methodology requires the calculation of effect-based distances (i.e. for the consequence-based and hybrid approaches). Typically, the 'damage' effect in LUP is considered as lethality and major or moderate injuries. Threshold values are established for various hazardous effects, e.g.:

- Toxic vapours: LC1% (concentration for 1% lethality), IDLH values (Immediately Dangerous to Life or Health) or an equivalent dose for shorter exposure durations;
- Fires: heat radiation exposure for a given duration resulting in either major (3rd degree burns) or serious health effects (e.g. 1st degree burns);

- Overpressure: corresponding to collapsed ear drum as a result from an explosion.

Risk-based

Risk-based criteria as usually expressed in individual and/or societal risk. The difference between the two expressions of risk is that location specific individual risk is used to show the geographical distribution of risk, while societal risk assesses to what level areas with high population density are exposed to risk. For land-use planning purposes, the Location Specific Individual Risk (LSIR) is often used to determine the external safety distances to vulnerable objects and in some countries it should also be demonstrated that the societal risk meets the legal (guiding) criteria.

It must be stressed that it has become increasingly clear that risk-based criteria cannot be considered stand alone. They are tightly integrated with nominated frequencies (reference is made to paragraph 8.2.3).

Individual risk (IR)

LSIR is the risk of death for an individual who is present at a particular location, continuously all year (i.e., 24 hours a day, 7 days per week) without wearing personal protective equipment. Individual risk is the frequency at which an individual may be expected to sustain a given level of harm from the realization of specific hazards. Individual risk is often interpreted as an incident every X number of years and is often referred to as the risk of death.

Examples of how to interpret individual risk is as follows:
- $1x10^{-3}$ per year is equivalent to one incident every 1,000 years
- $1x10^{-4}$ per year is equivalent to one incident every 10,000 years
- $1x10^{-6}$ per year or one incident every 1,000,000 years

These numbers do not imply that no event will occur for the specified time period. These risk levels are statistical representations of risk. They predict that an incident might occur within this average timeframe. The incident could happen tomorrow or sometime during the next 1,000 years.

Individual Risk is presented as isopleths similar to elevation contours on a map. The inner contour is the highest risk (often 10^{-3} or 10^{-4} per annum), and normally contours are plotted in declining order of magnitude circles. **Error! Reference source not found.**2 provides an example of a visualization of IR contours.

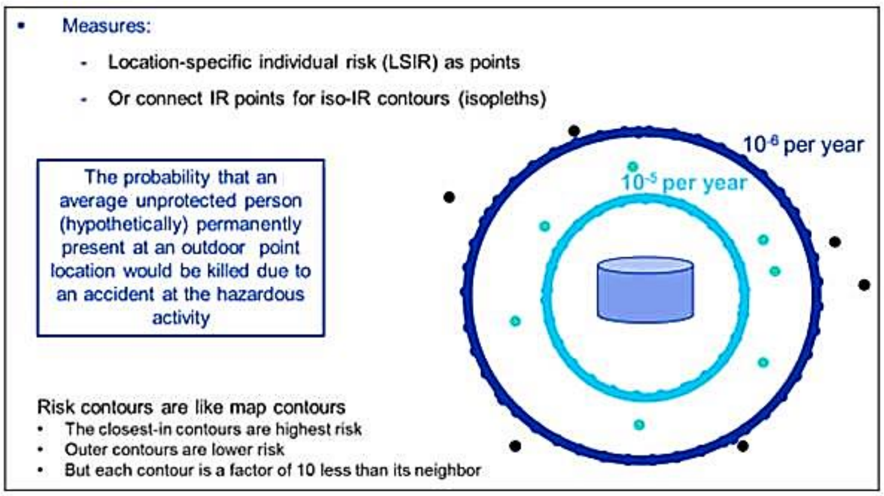


Figure 8.12 – Individual Risk

When several specific individual risk contours are composed together they give shape to a combination of ISO curves which are of particular use for land-use planning, as it has been detailed in section 8.2.

Figures 8.13, and 8.14, below, present 2 (two) cases relative to port/terminal areas where individual risk contours combines to produce a land-use map, divided into different risk areas.

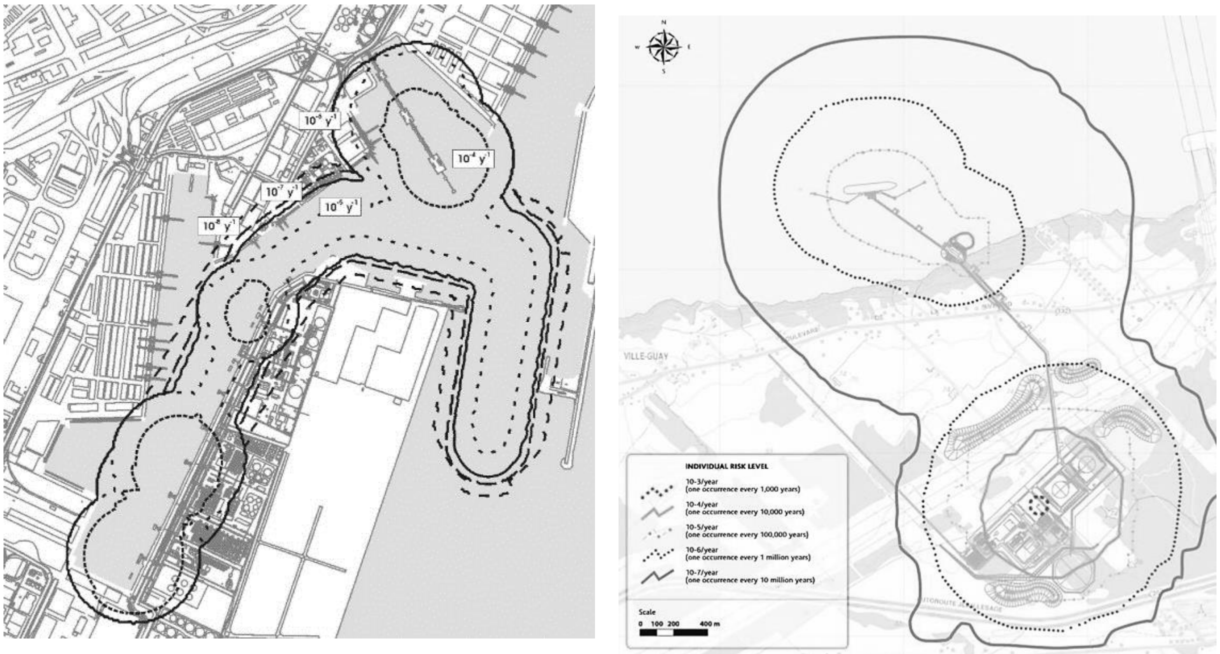


Figure 8.13 and 8.14 – Individual Risk contours combined in a port area. It can be seen how higher inner individual risk curves are "concentrical" to the berthing areas, revealing harm potential from activities taking place in these locations (LNG bunkering could be one of these activities, contribution to the composed IR combined shape).

Societal risk (SR)

Societal risk is defined as the (cumulative) frequency per year that a particular group of people dies concurrently as a result of accidents. Societal risk criteria have not been as widely used as individual risk criteria because the concepts and calculations involved are much more difficult. Societal risk is represented in an FN curve, which is a Log-log graph: the X-axis represents the number of deaths and the y-axis the cumulative frequency of the accidents, with the number of deaths equal to N or more.

An example of an FN curve including one criterion is given in **Error! Reference source not found.**.

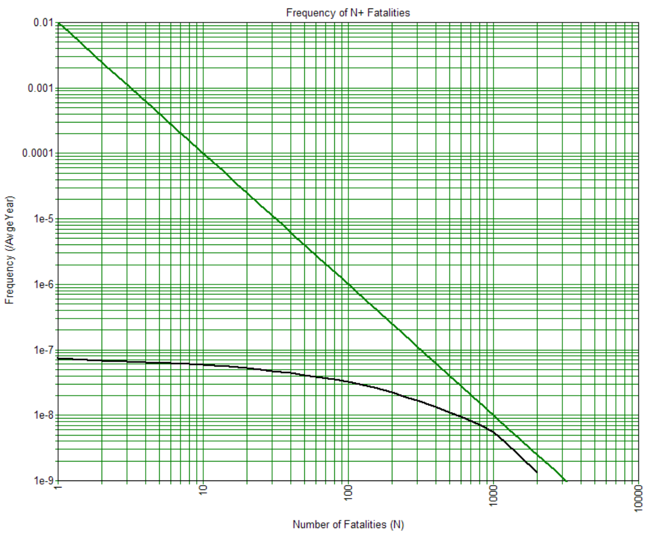


Figure 8.15: Example of an FN curve to express societal risk (black line is the societal risk, green line the intersection between the lower and upper band above which the risks could be considered intolerable.

8.4.3 Risk Criteria in ISO/TS 18683

ISO Technical Standard ISO/TS 18683 contains as Annex-A examples of recommended/possible risk criteria of applicable to both QualRA and QRA.

8.4.3.1 Risk Matrix

ISO 17776:2000, Table A.1, is reproduced in ISO/TS 18683, providing Qualitative Risk Criteria that allows risk ranking, derived from a HAZID report.

The risk analysis shall primarily be carried out with respect to consequences for people, but can require that risk to property and environment is also calculated.

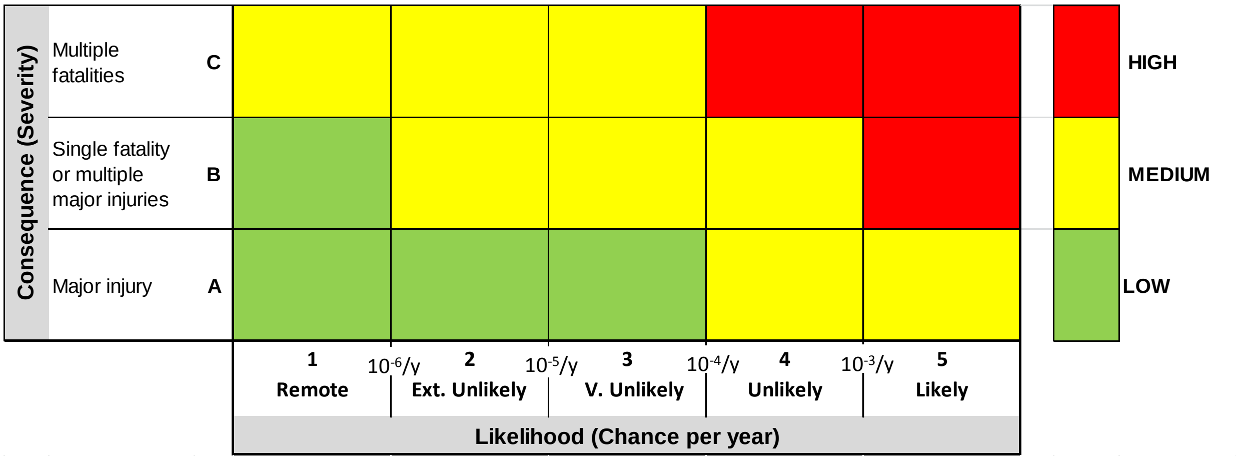


Figure 8.16 – Risk Matrix Example – With Risk Ranking Categories **(ISO/TS 18683)**

Consequence Category

A. Major injury - long-term disability / health effect
B. Single fatality or multiple major injuries - one death or multiple individuals suffering long-term disability / health effects
C. Multiple fatalities - two or more deaths

Likelihood Category

1. Remote - 1 in a million or less per year
2. Extremely Unlikely - between 1 in a million and 1 in 100,000 per year
3. Very Unlikely - between 1 in 100,000 and 1 in 10,000 per year
4. Unlikely - between 1 in 10,000 and 1 in 1,000 per year
5. Likely - between 1 in 1,000 and 1 in 100 per year

The likelihood categories can be related to a ship life or to other time period. For example, assuming a ship lifetime is 25 years, then for a scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the ship's lifetime is 1 in 40,000 (i.e. 1/(10-6 x 25)).

If instead of considering a ship lifetime we consider a typical interval consistent with the duration of a bunkering operation we would have, for a TTS operation, 2 hours, i.e. 0.00024 years, the scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the bunkering operation is 1 in 4,166,666,667 (i.e. 1/ (10-6 x 0.00024)). This is an extremely low probability which, in good truth, reveals that the adequacy of yearly averaged criteria may represent a limitation when trying to capture the probability of occurrence on a limited duration and infrequent operation. Establishing likelihood criteria "per operation" would probably be more representative avoiding the risk from being averaged over a full year's length.

8.4.3.2 Threshold Criteria

Another risk criteria in ISO/TS 18683 indicates a generic Individual Risk limit threshold criteria, as indicated in table 8.7. This is relevant when it is necessary to assess QRA results, presented with calculated risk figures for selected hazardous scenarios.

Risk criteria in quantitative risk assessments commonly refer to individual risk and societal risk (or group risk), and these are related to fatality or some other measure of harm. Where a significant number of people are exposed to the bunkering operations then both should be assessed. This is also explained in IACS Rec. 142: *"…the risk to any individual may be 'low' but the risk of harming many people in a single accident/incident might be sufficient to warrant risk reduction. Stakeholders should consider what constitutes a significant number of people to require assessment of societal risk. Dependent upon specifics this might be exposure of ten or more people"*.

Table 8.7 – Risk Criteria Example – With Individual Risk Thresholds suggested **(ISO/TS 18683)**

	Acceptance criteria	Comment
Individual risk first party personnel	$IR < 10^{-5}$	Applies to crew and bunkering personnel directly involved in the activity.
Individual risk second party personnel	$IR < 5 \cdot 10^{-6}$	Port personnel and terminal personnel.
Individual risk third-party personnel with intermittent risk exposure	Risk contour for $IR < 5 \cdot 10^{-6}$	Third-party personnel should not have access for prolonged period.
Individual risk third-party personnel with prolonged risk exposure	Risk contour for $IR < 10^{-6}$	General public without involvement in the activity. No residential areas, schools, hospitals, etc. inside this risk contour.

It is important to note that the criteria are typically expressed on a per annum basis (i.e. per year). For hazards that are present for a relatively short time (over a year) the per annum criteria may not be appropriate. This is because the risk is not spread uniformly across the year but peaks intermittently, and for long periods of time it does not exist. As such, if this is not recognised then proposed risk mitigation may not offer the protection envisaged. As a guide, per annum criteria may not be appropriate for a hazard which, like in the case of LNG bunkering, is infrequent and occurs during a very limited part of the year. This had already been recognized in section 8.4.3.1 and PAAs.

8.5 Risk-based evaluation of Ports Feasibility for LNG Bunkering

For PAAs willing to evaluate the feasibility of LNG bunkering within the ports under their jurisdiction this Guidance offers, in Appendix, a collection of tasks that can potentially shape a Technical Specification for a risk-based feasibility study aiming to study the development of LNG bunkering.

8.5.1 Objective

The main objective of the element tasks presented in Appendix is to provide PAAs with the necessary studies on LNG bunkering infrastructures and/or small storage siting facilities in order to support a safe development of the LNG facilities of the relevant ports or port areas, thus promoting the development LNG bunkering, on a risk-based evaluation.

8.5.2 Tasks

The aim of the task structure suggested in Appendix is twofold:

- Describe the existing standards/regulations/guidelines related to LNG bunkering and those currently under development. Provide a gap analysis identifying, documenting and comparing the differences between the existing requirements of current/on-going LNG bunkering related regulations. Provide recommendations how to overcome the identified gaps.
- Develop Individual Quantitative Risk Assessments for LNG as fuel bunkering operations, for prospective port(s), taking into consideration specific features of each port such as number and

type of ships calling at ports, type of operations, port location and surrounding infrastructures as well as other relevant variables for the establishment of each ports safety/risk profile.

The first point specified above is intended to address the policy and regulatory framework at international, regional and national levels, to define the policy and regulatory context of the relevant port(s).

The second focuses on the study and analysis of specific features of each port in order to assess the risks involved in LNG bunkering on a given port, against specific risk acceptance criteria, taking into consideration geo-morphological and meteorological characteristics affecting the ports, their operational profiles, e.g. types of trade, number of passengers, containers, total number of port calls.

The two points identified above are further subdivided in table 8.8, below, with specifications into different Tasks ranging from Task 1 to Task 8 as per table below.

Table 8.8 – Tasks for Risk-based evaluation of LNG bunkering feasibility in Ports

Task	Description
1	Gap Analysis Study of the Regulatory Frame and Evaluation of Applicable Standards to LNG as fuel for shipping
2	Feasibility Study
3	Definition of Risk Acceptance Criteria Study
4	Site Specific Data Description and Analysis Study
5	Nautical Analysis and Collision Risk Analysis Study
6	Hazard Identification – HAZID Study
7	Quantitative Risk Assessment (QRA) Study
8	Ship Collision Risk Study

Each Task, its technical description and expected deliverables, are described in the Appendix-A.

The Tasks consist of both generic and port-specific studies, targeting different needs regarding the state of development of the LNG bunkering infrastructures and operations in the relevant port(s). The Tasks are independent amongst them and are non-overlapping. In this way PAA may adopt here a modular construction of possible technical specifications for relevant studies on the feasibility of LNG bunkering development for their ports.

All the Tasks are related to Regulations, Standards, and Risk & Safety, consisting essentially of studies assisting the development and implementation of LNG bunkering facilities within the existing port areas. No engineering implementation studies or works are considered as part of these Tasks.

8.6 Good Practice for Ports on Risk Assessment

The elements included in the present section are intended to be taken as good practice recommendations, following from all aspects mentioned in Section 8. Good Practice approach in Risk Assessment for LNG bunkering projects, in the context of the present Guidance is essentially focused on the procedural aspects, interpretation of Risk Assessment reports and, of remarkable importance, on how to best ensure and evaluate the necessary independency in Risk Assessment activities.

8.6.1 Risk Assessment Methodologies

R8.1. Different Risk Assessment methodologies are available that may be used to evaluate the safety risks of LNG bunkering projects. The approaches followed, regardless he concrete methodology, should all respect common formal elements which should be enforced by PAAs:

- **a. Adequate description of the basis for the study,**
- **b. Description of the systems and definition of operational procedures**

c. **HAZID (identification of team, details of HAZID Workshop, risk ranking exercise with relevant risk matrices, justification for risk screening criteria and identification of the most critical scenarios)**

d. **All hazardous scenarios discussed should be screened in risk matrices, with clear indication of ALARP and most critical scenarios.**

e. **Identification of possible Risk Mitigating measures to address all most critical scenarios.**

f. **Safety Zone calculation**

g. **Identification of Software used for modelling & analysis (consequence modelling, probability or risk calculation), including validation and identification of analyst.**

h. **Report containing all the minimum elements listed in 8.3.3.5 and 8.3.4.3 of the present Guidance.**

R8.2. Risk Acceptance Criteria should be always agreed between operators and PAAs. In the case of existing national legislation and guidance on reference risk criteria thresholds these should be followed. Whenever this is not the case PAAs should agree with acceptable/adequate risk acceptance criteria for the intended risk assessment.

It is possible, and recommended, that PAAs get expert professional advice on the definition of risk acceptance criteria. It should be relevant for the risk assessment being performed.

Validation of risk acceptance criteria by PAAs should take place well in advance to HAZID workshop or any computational modelling takes place. It is important that all developed tasks within the risk assessment are collectively relevant to the demonstration against the agreed risk criteria.

R8.3. Whilst defining the minimum requirement of a Qualitative Risk Assessment (QualRA) for all LNG bunkering projects of standard type (PTS, STS and TTS modes), ISO/TS 18683 and IACS Rec.142 are clear in the indication that for those cases diverging from the listed modes, should be subject to a Quantitative Risk Assessment (QRA).

A QRA should be required when:

a. **Bunkering is not of a standard type (PTS, TTS or STS, in simple standard configuration, as defined in ISO/TS 18683);**

b. **Design, arrangements and operations differ from the guidance given in ISO/TS 18683 or IACS Rec.142;**

c. **Simultaneous Operations (SIMOPS) are planned to take place along with LNG bunkering.**

d. **Automation elements are introduced to significantly reduce human intervention in operations (linked to system analysis)**

e. **A reduction in a Safety Zone is intended, on the basis of consequence/ probabilistic data for the specific LNG bunkering location**

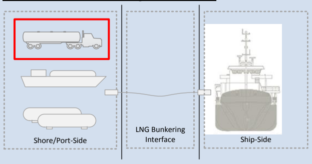
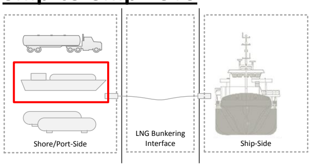
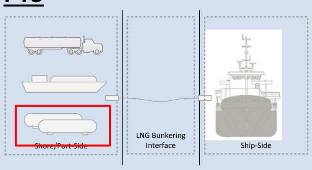
f. **Whenever a numerical calculation of Risk is required for verification of any given Risk Criteria.**

R8.4. The decision on whether to develop a QualRA or QRA to assess the particular safety risks of an LNG bunkering project should be not only subject to clear requirement from PAA and/or competent authorities responsible for permitting/licensing, it should also reflect the specific characteristics of the project. If no sufficient available data exists for a certain methodology to be applied, PAAs should promote discussion on the best approach to evaluate the risks for that specific project.

Data availability, relevant risk criteria, experienced team, computational resources, adequate modelling assumptions, amongst other factors, all contribute to the quality of the risk assessment results. Adequate consideration should be given to these factors and their potential impact after choosing one specific risk assessment methodology

R8.5. Table 8.9, on the next page, include a list of possible cases where the minimum QualRA prescribed in ISO/TS 18683 may not be enough for risk evaluation and design of the adequate risk mitigation measures.

Table 8.9 – Standard LNG bunkering scenarios – specific situations where more than the minimum QualRA requirement should be in place.

Method	Typical Volumes (V) and Bunker Rates (Q) [21]	**Possible situations where Standard LNG bunkering scenarios will require more than the minimum qualitative risk assessment framework** (as prescribed by ISO/TS 18683) (situations where standard bunkering modes will require further investigation in QRA, above minimum ISO requirement)
Truck-to-Ship – TTS 	V ≈ 50-100m3 Q ≈ 40-60m3/h	• Multi-LNG truck combination in TTS bunkering mode via common manifold. • Higher bunker rate than average (see reference value to the left). • Use of automated or semi-automated technologies for management of hose handling. • LNG Fuelling operations in TTS mode, whenever truck unattended (i.e. stand-alone truck supplying LNG during the whole stay of the ship at berth) • In cases where quantitative risk criteria thresholds are imposed by PAA. • In all cases where purging and inerting procedures are subject of special considerations, such as a request for exempting inerting on the basis of any special control technology.
Ship-to-Ship - STS 	V ≈ 100-6500m3 Q ≈ 500-1000m3/h	• Whenever nautical risk assessment identifies particular critical situations (manoeuvring, higher nautical traffic intensity). • Higher bunker rate than average (see reference value to the left). • Cases of bunker barges with no self-propulsion, using tugs for manoeuvring and propulsion. • In cases where quantitative risk criteria thresholds are imposed by PAA. • In all cases where purging and inerting procedures are subject of special considerations, such as a request for exempting inerting on the basis of any special control technology. • Whenever BOG management and vapour return are not in place.
Terminal (Port)-to-Ship - PTS 	V ≈ 500-20000m3 Q ≈ 1000-2000m3/h	• QRA recommended for all PTS situations, in order to address properly LNG storage elements and distribution pipeline routing within the port area. • Higher bunker rate than average (see reference value to the left). • In cases where quantitative risk criteria thresholds are imposed by PAA. • In all cases where purging and inerting procedures are subject of special considerations, such as a request for exempting inerting on the basis of any special control technology. • Whenever BOG management and vapour return are not in place.

8.6.2 Risk Assessment Review

R8.6. Risk Assessment studies can result in complex reports. PAAs should have in place approval processes well mapped and structured for approval of Risk Assessments which are delivered to satisfy PAA/competent authorities' requirements for LNG bunkering permitting, location, licensing and operation.

Approval processes should be adequate to the different types of Risk Assessment methodologies.

R8.7. PAAs should promote staff training on Risk Assessment methodologies, allowing not only for a more active participation of PAA experts in HAZID or HAZOP workshops, where the PAA is part interested, but also to ensure that the appropriate skills and judgement is in place for adequate Risk Assessment review and approval.

R8.8. Approval criteria and special recommendations from PAAs on risk assessment requirements (in particular those derived from R.8.3. and Table 8.9) should be made available to Operators well in advance to the beginning of risk assessment procedures/tasks.

R8.9. Quantitative Risk Assessments are model representations of real life physical/ engineering processes. PAAs are recommended to adopt a critical approach in the evaluation of QRAs processes and reports. Many assumptions and QRA-specific aspects are of critical importance to the conclusions derived from the assessment. PAAs should enquire operators and risk analyst on the main aspects behind the risk assessment study. Figure 8.17, below, includes a collection of some relevant points/clarifications that PAAs are recommended to request close to operators or analysts submitting risk assessment reports.

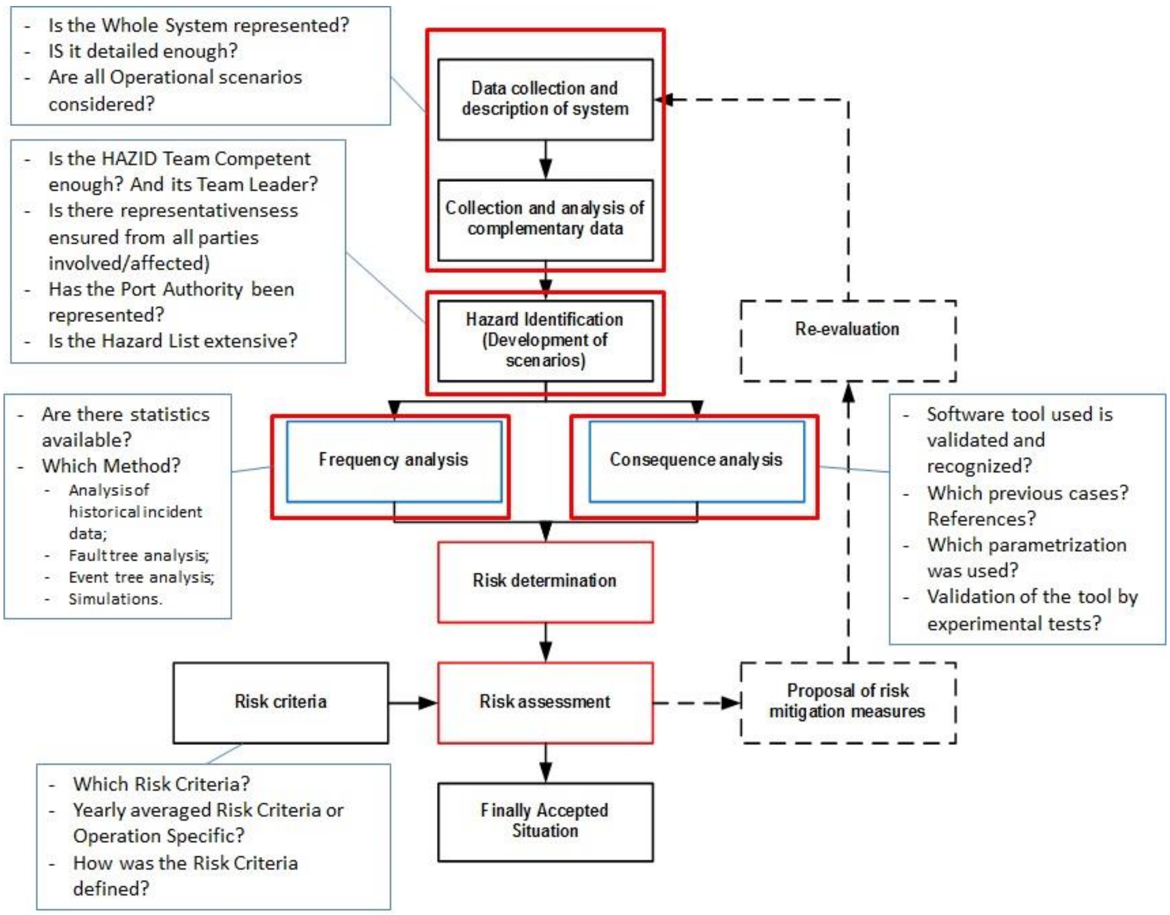


Figure 8.17 – Risk Matrix Example – With Individual Risk Thresholds suggested **(ISO/TS 18683)**

8.6.3 Independency in Risk Assessment

R8.10. Risk Assessment studies are typically provided by Operators, with possible involvement from consultants or experts in that particular field, produced with the objectives to:

a. Satisfy regulatory requirements and relevant risk criteria

b. Support design decisions

c. Develop and implement safe LNG bunkering operations

The involvement of Ports in those studies has been also an important element, not only through active participation in HAZID meetings but also in the definition of possible hazardous scenarios, input local knowledge, provision of relevant data, amongst other relevant elements.

All those involved in risk studies and risk assessment are interested in the best reassurance of Safety, identification of critical hazardous scenarios and in their adequate cost-effective mitigation.

It is also important to note, however, that all parts involved, in addition to the best interest of Safety, have also economical interest in the development of LNG bunkering operations, as a relevant port service.

With the above in consideration, it is recommended that PAAs develop and implement the necessary mechanisms and requirements to support transparency and avoid possible conflicts of interest in the development of risk assessments.

R8.11. Independency and Transparency in Risk Assessment studies should be ensured throughout the whole process. Some recommendations that may be of support to this objective are:

a. Requiring Risk Assessment studies to be developed by independent professional in the field of LNG Risk & Safety, with recognized and demonstrated experience.

b. Using Risk Criteria which has either been taken from existing legislative framework at national level or, alternatively, which has been imported from an existing published guidance, other country national risk criteria, industry guidance or standard (such as criteria in table 8.7, taken from ISO/TS 18683)

c. To ensure that all assumptions and limitations are well addressed in the risk assessment report.

8.6.4 Good Practice for Risk Assessment Process Flow

R8.12. The diagram in Figure 8.18 describes a good practice process flow for Risk Assessment in the particular case of LNG bunkering. It is not intended to represent a requirement nor does it reflect any specific process actually adopted. Its intention is to support PAAs and other involved stakeholders.

The process diagram is, in fact a gross simplification of the many processes that take part in the context of a Risk Assessment, from its scoping and basis definition, down to actual risk calculations and corresponding evaluation.

The diagram is intended to be relevant to both QualRA and QRA approached and it covers the different stages for the Risk Assessment development:

a. Scope

b. Preparation

c. **HAZID**

d. **Analysis**

e. **Assessment.**

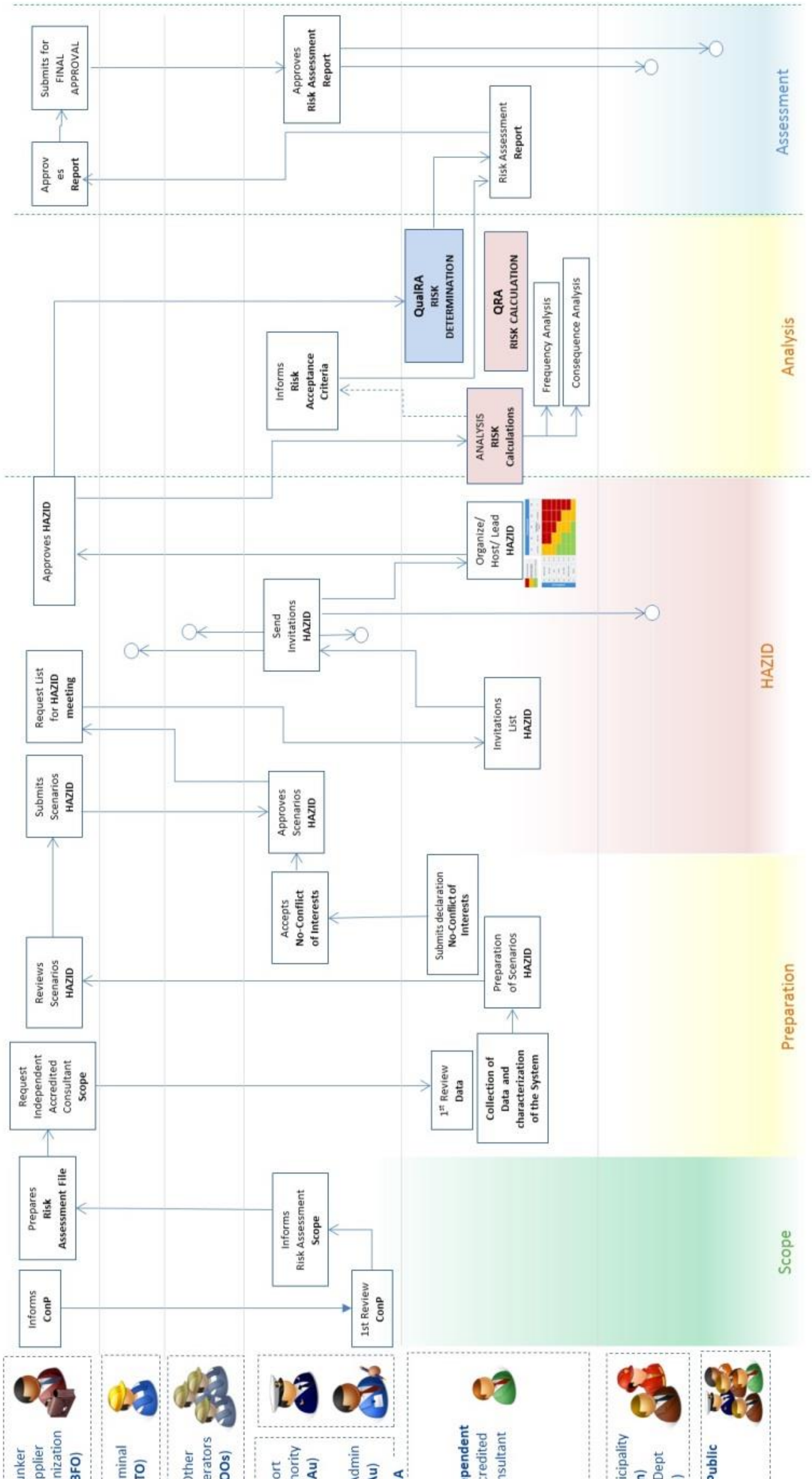


Figure 8.18 – LNG Bunkering –Good Practice for Risk Assessment Process Flow

9. Control Zones

Control Zones are an important topic in LNG Bunkering. For Safety, Security or Operation the need to establish control zones has been one of the important elements developed to mitigate the risks arising from potential hazardous releases of LNG or from the potential of external induce harm to LNG bunkering or small scale installations.

Chapter 9 addresses different control zones, seeking harmonization between existing international standards and industry guidance currently published. Both ISO/TS 18683 and ISO 20519 include a section on Safety Zones, in Annex, linked to Risk Assessment relevant provisions. The elements contained in both ISO documents are reviewed and taken as a departure point for the good practice suggested to PAAs in the present document.

Terminology used in the present Section will be directly consistent with ISO 20519, in particular to the number of control zones to be considered and their relative nomenclature.

In Section 9.1 a generic overview is given, with the indication of the main relevant elements to consider in this context. Section 9.2 is dedicated to Hazardous Zone, its definition, objectives, reference for the calculation of its extent, approval process and how to enforce it. The same approach is followed for both Safety Zone and Monitoring and Security area, respectively in Sections 9.3 and 9.4.

As a relevant initial note it is important to have in consideration, especially with regards to the Safety Zone definition, calculation, implementation and enforcement, the present Guidance does not prescribe distance values for any specific bunkering scenarios. Instead the path here followed is to advise on a good practice approach to PAAs evaluation and approval of Safety Distances. The core need for harmonization, in the interpretation given in this guidance document, is not for harmonized Safety Distance values but to a harmonized procedure for its evaluation and approval.

9.1 Controlled Zones in LNG Bunkering

Should an accidental loss of containment occur during LNG bunkering, LNG will be released and disperse under specific local conditions, subject to the intrinsic thermodynamic properties of LNG and to the dynamical behaviour of the LNG cloud. Once it achieves an air fuel mixture that will support combustion, it will burn when an ignition source is found. A safety zone designed to ensure that only essential personnel and activities are allowed in the area that could be exposed to a flammable gas in case of an accidental release of LNG or natural gas during bunkering shall be created. This annex provides guidance on the determination of that safety zone.

The safety zone will normally be inside the monitoring/security area and shall encompass hazardous zones defined by IEC 60079-10-1 or other relevant regulations. Figure 9.1 illustrates the relative location of the **Safety Zone**, the **Hazardous Zone** and **Monitoring and Security Area** related to the bunkering facility. The combined hazardous zones (including relief valve vent outlets) and safety zones for the LNG receiver and LNG provider shall be considered in the risk assessment, particularly if they are in the proximity of unsecured ventilation inlets.

The **Monitoring and Security Area** is a larger area that extends beyond the safety zone and is established to monitor vessel traffic and other activities that could be a threat during the bunkering operation, amongst other security relevant aspects. The monitoring and security area shall be established by the PAA, informed to the BFO and RSO. Other authorities, operators and intervening parts in the operational scenario should be well informed on the Security Area extent. Restricted areas within the port facility, required by the International Ship and Port Security (ISPS) Code, may constitute a portion of the monitoring and security area, however, are typically larger in extent.

The following Controlled Zones are defined in ISO/TS 18683 and EN ISO 20519 (figure 9.1, adapted from the ISO standards)

1. Hazardous Zones
2. Safety Zone
3. Monitoring and Securing Area

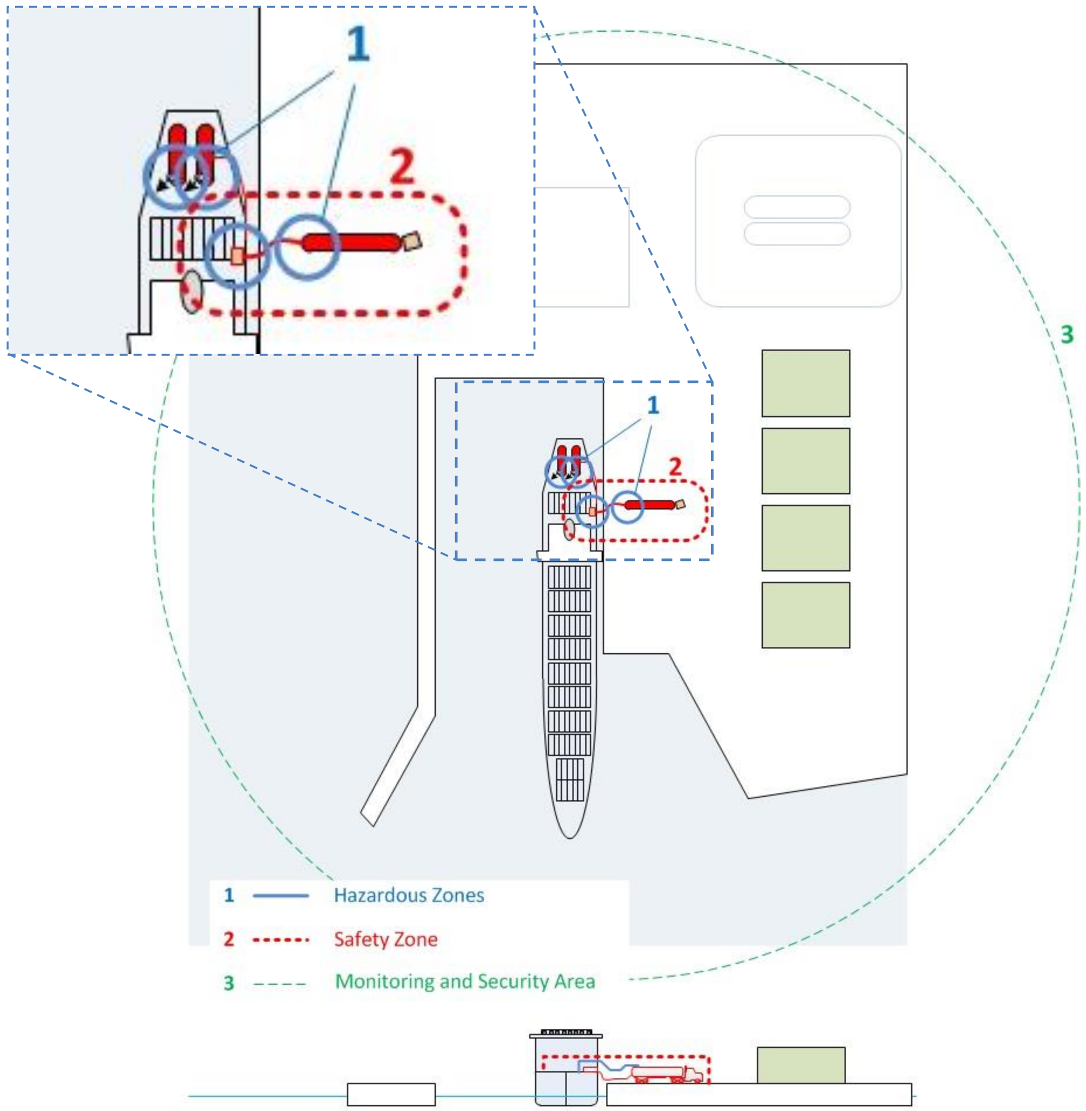


Figure 9.1 – Control Zones – Hazardous and Safety Zone, Monitoring and Security Area
(Adapted from ISO/TS 18683 and ISO 20519)

Sections 9.2 to 9.4 detail the relevant aspects relative to the Control Zones as presented. The graphical representation in figure 9.1 gives close reproduction to ISO diagram (figure B.1 in ISO 20519), with the three control zones defined represented in a generic way.

Recently SGMF [35] has augmented the set of control zones from three to five, providing for a Marine Zone and an External Zone. The Monitoring and Security area is still considered according to ISO definition, added now with 2 extra monitoring zones.

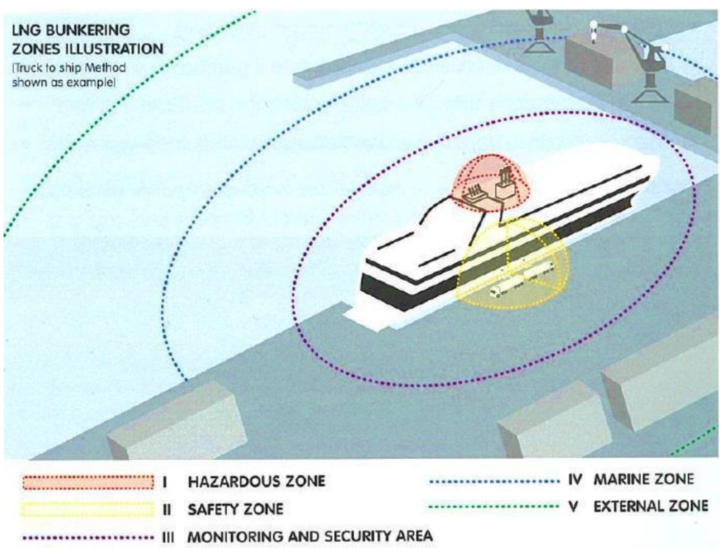


Figure 9.2 – LNG Bunkering Zones
(SGMF Guidelines, v2, 2017)

Definitions from SGMF are consistent with ISO for zones, with the three first, i) to iii), hazardous and safety zones and monitoring/security area, having the same definition. For the Marine Zone and External Zone, the new definitions for control zones brought by SGMF guidelines are illustrated in figure 9.2 and explained further in figure 9.3, below in this page.

i. ***Hazardous zone**: Three dimensional space where a flammable atmosphere may exist at any time*

ii. ***Safety Zone**: three-dimensional area around the LNG transfer system determined from the result of a leak or emergency discharge of LNG or vapour return occurring. Exists during bunkering operation only*

iii. ***Monitoring and Security Area**: an area around the LNG transfer equipment that needs to be monitored as a precautionary measure to prevent interference with the LNG transfer operation*

iv. ***Marine Zone**: a zone of sufficient size to prevent passing shipping from impacting the LNG transfer operation*

v. ***External Zone**: the distance to a defined risk level, frequently places where the public may be present as required by some regulatory regimes.*

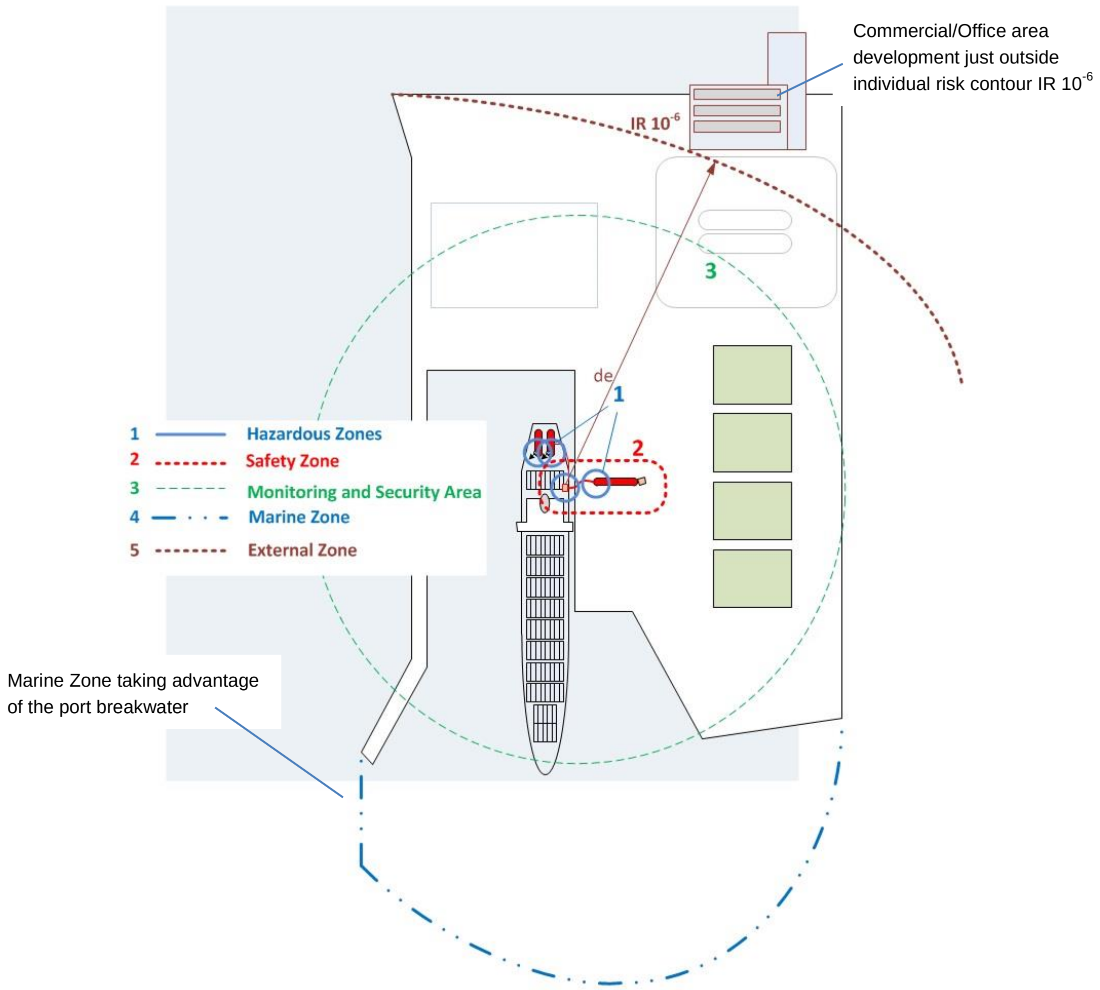


Figure 9.3 – Control Zones – Hazardous and Safety Zone, Monitoring and Security Area
Marine Zone and External Zone also represented
(Adaptation from SGMF Guidelines v2, 2016, [35], with interpretation for Marine (exclusion) zone and External zone)

The relevance of bringing SGMF definitions together with ISO standard references (for both ISO/TS 18683 and ISO20519) is related to the importance of understanding the control zones' concept as a whole. From 3 (three) ISO zones definition up to 5 (five) control zones in SGMF guidance, it should be important to establish the essential generic first principles that should be observed in all control zones determination:

- **Control Zones act as layers of defence** and should be regarded not as a numerical/geometric exercise but rather as a critical protection exercise, looking for potential risk scenarios, including security related concerns, and being able to plan and implement with a reasonable set of resources. An iterative exercise should assist the determination of the relevant Control Zones: 1) Define Control Zone; 2) Check level of protection; 3) Implement; 4) Evaluate and, if, necessary, 5) Re-define.
- **There is no hierarchy amongst Control Zones**. Hazardous Zones are not more important than the Monitoring and Security Area, and vice-versa. Safety Zone is not of primordial relevance when compared to other control zones. Only working together, making sense in one single implementation plan, all relevant control zones will contribute to a significant and meaningful protection.
- **The Safety Zone must be larger than the Hazardous Zone(s)** in all three dimensions.
- **The Monitoring and Security Area must be larger** than the Safety Zone.
- **Hazardous Zones are present at all times**. Hazardous zones are not operation dependent. They are equipment specific, dependent on the systems architecture, flange connections, manifolds, venting outlets, amongst other design features. Unless the system has been inerted the Hazardous Zones will be present.
- **Safety Zones and Monitoring and Security Areas will be present only during Operations**. Being operation related, the establishment and maintenance of Safety Zones and Security related area should be effective only during LNG transfer.
- **There are no Control Zones to fit all situations/conditions**. Determination of Control Zones may be port-specific, ship-specific, berth-specific, involving different conditioning factors, of technical or operational nature. Several factors are determinant to the size and shape of the different Control Zones. Examples of such factors will be the bunkering arrangement, weather factors, bunkering parameters or potential SIMOPs considered.
- **There is no single right Safety Distance**, regardless of the methodology followed to calculate it. The only measure of quality of a Safety Distance should be the effective protection provided by its adequate implementation and enforcement.
  There are many factors affecting the calculation of Safety Distances:
    1. Bunkering parameters (pressure, temperature)
    2. Potential for excessive BOG generation.
    3. Weather factors (in particular wind)
    4. Other activities nearby (remarkably those involving also safety distances)
    5. Local infrastructure
    6. Receiving ship characteristics
    7. Implemented safeguards, resulting from risk assessment
- **Control Zones should be proposed by Operators,** with the exception of Security Zone, submitted to PAAs for Approval, reflecting any existing requirements on Control Zones existing in local port regulations or in the specific national framework for LNG bunkering, handling of hazardous substances or other. In this way it will be possible for the proposed Control Zones
- **PAAs should have procedures for the evaluation, support in implementation, control and enforcement of Control Zones**. Through a structured procedure, PAAs should be able to evaluate, provide support in the implementation, control and enforce.
- **Controls Zones are only effective if effectively controlled and enforced**. Without the resources to effectively enforce the Controlled Zones these are of relatively small relevance. The safeguard derived from a Safety Zone is only effective if this control zone is adequately enforced.

The diagram presented in figure 9.4, below, outlines a staged approach for the definition and implementation of Control Zones. In addition to the description of each stage, the responsibilities for each of the steps are also suggested as good-practice.

Step	Description	Responsibilities
Calculate	• **Calculation of the distances and shape** of the Control Zones to establish • Clarification of the **factors affecting LNG bunkering** , in particular those with an impact on safety distance calculation.	• **Operator** (responsible for the calculation of all relevant Control Zones) • Responsible for the use of all available references for calculation
Plan	• **Define the necessary Control Zones plan** in accordance with the LNG bunkering plan. • **Draw control zones on port local map**, highlighting all infrastructure elements in the vicinity of the bunkering location	• **Operator** (responsible for the planning of all relevant Control Zones)
Share	• Communicate Control Zones' plan to other Operators in the Port Area, which are likely to be affected by their implementation and enforcement. • Receive input from other Operators - Check feasibility.	• **Operator** (responsible for sharing the pre-approved Control Zones plan with other operators)
Approve	• Submit proposed Control Zones, with supporting calculations and plan drawings • Approval of Hazardous and Safety Zones by PAAs	• **Operator** (responsible for the preparation of the Control Zones Plan and for its **submission to PAAs** • PAA (responsible for **Approval**)
Implement	• Physical implementation of the Control Zones (signs, barriers, traffic control, access control). • Determination of the necessary resources to put the Control Zones in practice.	• **Operators** are responsible for the implementation, with PAA support.
Control	• Effective enforcement of Control Zones should be possible at any point of the LNG bunkering operation • Control Zones plan should include a strategy for effective enforcement	• **Operators and PAAs should work together closely for the enforcement/ control of the different Control Zones**.

Figure 9.4 – General Procedure for Development and Implementation of Control Zones – 6 (six) steps approach to the definition and effective implementation of Control Zones.

In addition to the first principles presented in the previous page, and to the general procedure suggested above, in the diagram of figure 9.4, the present Guidance Control Zones "**minimum requirements**" and "**meaningful protection**" should necessarily be considered together

Minimum requirements will be derived directly from standards, direct/numerical calculations or modelling. References can be given for minimum required control zones and area definition.

Meaningful protection is based on the implementation of the minimum requirements, adding to it a critical iterative judgement of the situational scenario, infrastructure and local conditions at the time of LNG bunkering operation. This will be the concept further explored in section 9.5.

9.2 Hazardous Zone

9.2.1 References

The reference standard for the definition, calculation and implementation of Hazardous Zones is:

IEC 60079-10-1:2015 - Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres **adopted as European standard EN 60079-10-1**	IEC	International Standard	Standard concerned with the classification of areas where flammable gas or vapour hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas. It is intended to be applied where there may be an ignition hazard due to the presence of flammable gas or vapour, mixed with air

Other standards exist, remarkably the North-American:

- NFPA 497. 2012, Recommended practice for the classification of flammable liquids, gases or vapours and of hazardous (classified) locations for electrical installations
- NFPA 70 – National Electrical Code (Informational Note: Although the scope of this Code indicates that the Code does not cover installations in ships, portions of this Code are incorporated by reference into Title 46, Code of Federal Regulations, Parts 110–113).

There are some significant differences between the American and European standards, especially with regards to the calculation approaches for Hazardous Zone area calculations.

9.2.2 Definition

Hazardous Zone is any three-dimensional envelope in which a flammable and/or explosive atmosphere may occur in quantities such as to require special precautions to protect the safety of workers, third-party personnel and material. Special precautions and measures for construction, installation and use of electrical apparatus should be followed, as given in IEC EN 60079 -10-1.

Hazardous zones related to installed equipment, LNG storage or other will be present even outside bunkering operations. They are design-related and a classification framework exists for the definition of different Hazardous Zone classes, corresponding to specific probability-frequency based criteria.

9.2.3 Objective

The objectives for Hazardous Zone implementation are:

- To allow the definition of adequate measures to mitigate fire and/or explosion risk in areas where a probability frequency for flammability/explosion conditions is known in advance.
- To develop the necessary safeguards against fire and explosion originated in know flammable atmosphere sources.
- Elimination of ignition sources in the classified areas
- Minimization of the personnel involved in hazardous classified zones to the essential for safe operation.
- To restrict the use of electrical equipment to certified Ex-proof[73] equipment type. Different equipment will be subject to specific protection types[74] (corresponding to different parts of IEC EN 60079
- To allow for safe design even when the presence of flammable/explosive atmosphere cannot be completely eliminated

[73] Ex-proof refers to a characteristic of electric equipment which conforms to the relevant IEC EN 60079 standard. Different protection types may apply, depending on the type of equipment.

[74] Different protection types may be considered for different equipment classification.

9.2.4 Classification

Table 9.1, below, list the relevant Hazardous Areas, relevant in particular for LNG bunkering

Table 9.1 – Hazardous Areas Classification

Event	**IEC EN 60079 -10-1 IGC/IGF Definition** (NFPA 70 Definition)	**Frequency of Occurrence** (from available literature)	**Examples** (for LNG Bunkering Scenario)	**Reference distance**
Zone 0: **An area in which an explosive gas atmosphere is present continuously or for long periods**	**Zone 0** (Class 1 – Division 1)	Explosive atmosphere for more than 1000h/year	Inside the <u>LNG Storage tank</u>, of any type. Buffer storage tanks	No applicable reference distance. Zones "0" are self-contained within tank boundaries.
Zone 1: **An area in which an explosive gas atmosphere is likely to occur in normal operation**	Zone 1 (Class 1 – Division 1)	Explosive atmosphere for more than 10, but less than 1000 h/year	<u>Inside LNG bunkering transfer system</u> (hose, transfer lines, transfer arm). <u>Will only occur if inerting/purging haven't been achieved successfully</u>. This should happen both before and after bunkering.	No applicable reference distance. Zones "0" are self-contained within LNG transfer system boundaries.
Zone 2: **An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time.**	Zone 2 (Class 1 – Division 2)	Explosive atmosphere for less than 10h/year, but still sufficiently likely as to require controls over ignition sources	Flanged connections for bunkering LNG transfer and vapour return Bunkering manifold groups. Emergency Release Coupling (ERC) PRVs (Pressure Relief Valves)	Typically **3m** around any of the equipment/systems/design features listed as example.

9.2.5 Calculation

Calculation of Hazardous Zones is not a straightforward task. It is first important to underline the difference between Hazardous Zone and the Safety Zone: 1) The **<u>Hazardous Zone</u>** will be a project characteristic, derived from the engineering judgement that "**an explosive/flammable" atmosphere will be present, at a given location, with a certain frequency of occurrence**"; 2) The **<u>Safety Zone</u>**, a different concept, will be the **zone where dispersion of gas vapours are expected, following an incidental release of LNG**.

Both zones may be compared with regards to the type of safeguard they provide, based on the estimation of a certain gas dispersion, with the flammability limits travelling over time and space, following leakage, spillage or any type of containment loss, either at flanges, connectors, overfilling, venting, PRV malfunction or any incidental breaches along the LNG bunkering line. The essential difference will be on the fact that Hazardous Zones will be present at all times, around equipment and elements where explosive/flammable atmospheres are expected with a certain frequency of occurrence. Safety Distances are safeguards against an incidental unlikely event which, to achieve acceptable risk levels (qualitative or quantitatively perceived) must be in place. Elimination of ignition sources and mitigation of fire/explosion risks are the objective. Safety Distances are temporary in nature and are only present during LNG bunkering.

9.2.5.1 ISO/IEC Calculation

ISO/TS 18683 and ISO 20519 have no exact reference to the extent of hazardous zones, giving only indication that these are to be *in accordance to IEC 60079-10-1 or other relevant regulations* [4], [6]. In IEC 60079-10-1 a methodology is included for the calculation of Hazardous Zones, for both internal and external open-air locations. This methodology is firstly based in the determination of the Hypothetical Volume (V_Z.), a parameter representing the volume over which the mean concentration of flammable gas or vapour will be either 0,25 or 0,5 times the LEL, depending on the value of a safety factor, k. Methodology for hazardous zone estimation presented below.

The method developed allows the determination of the type of zone by

- estimating the minimum ventilation rate required to prevent significant build-up of an explosive gas atmosphere;
- calculating a hypothetical volume, V_Z which allows determination of the degree of ventilation;
- estimating the persistence time of the release;
- determining the type of zone from the degree and availability of ventilation and the grade of release using table B.1;
- checking that the zone and persistence time are consistent

An important note is made in the standard, to the methodology developed**: <u>It is not intended that these calculations are used to directly determine the extent of the hazardous areas.</u>** In fact the objective of the methodology developed is to ultimately define the ventilation required for a given explosion-classified space. The standard emphasizes in this way that the hypothetical volume is not directly related to the size of the hazardous area, and stresses that for detailed recommendations regarding the extent of the hazardous areas in specific industries or applications, reference may be made to national or industry codes relating to those applications.

Calculation of Hypothetical Volume (V_Z.) – (ref. IEC 60079-10-1)

1. Determine the theoretical minimum ventilation flow rate of fresh air to dilute a given release of flammable material to the required concentration below the lower explosive limit:

$$(\mathrm{d}V/\mathrm{d}t)_{\min} = \frac{(\mathrm{d}G/\mathrm{d}t)_{\max}}{k \times LEL_{\mathrm{m}}} \times \frac{T}{293} \qquad \text{(B.1)}$$

where

$(\mathrm{d}V/\mathrm{d}t)_{\min}$ is the minimum volumetric flow rate of fresh air (volume per time, m^3/s);

$(\mathrm{d}G/\mathrm{d}t)_{\max}$ is the maximum rate of release at source (mass per time, kg/s);

LEL_{m} is the lower explosive limit (mass per volume, kg/m^3);

k is a safety factor applied to the LEL_{m}; typically:

k = 0,25 (continuous and primary grades of release)

k = 0,5 (secondary grades of release);

T is the ambient temperature (in Kelvin, K).

NOTE For converting LEL_{v} (vol %) to LEL_{m} (kg/m^3), the following equation may be used for normal atmospheric conditions as given in 1.1;

$$LEL_{\mathrm{m}} = 0{,}416 \times 10^{-3} \times M \times LEL_{\mathrm{v}}$$

where M is the molecular mass (kg/kmol).

2. The relationship between the calculated value $(dV/dt)_{min}$ and the actual ventilation rate within the volume under consideration (Vo) in the vicinity of the release can then be expressed as a volume (Vk).

$$V_k = \frac{(\mathrm{d}V/\mathrm{d}t)_{\min}}{C} \qquad \text{(B.2)}$$

where

C is the number of fresh air changes per unit time (s^{-1}) and is derived from

$$C = \frac{dV_0/dt}{V_0} \qquad (B.3)$$

where

dV_0/dt is the total flow rate of fresh air through the volume under consideration, and

V_0 the entire volume (within the control of the plant) served by the actual ventilation in the vicinity of the release being considered.

3. Effective air exchange at the source of release will be lower than that given by C in equation (B.3), leading to an increased volume (Vz). By introducing an additional correction (quality) factor f to equation (B.2), the following is obtained

$$V_z = f \times V_k = \frac{f \times (dV/dt)_{min}}{C} \qquad (B.4)$$

where f is the efficiency of the ventilation in terms of its effectiveness in diluting the explosive gas atmosphere, with f ranging from $f = 1$ (ideal situation) to, typically $f = 5$ (impeded air flow).

4. Open-Air *Vz* estimation: In an open-air situation even very low wind speeds will create a high number of air changes. IEC 60079-10-1 uses the example of a hypothetical cube with side dimensions of 15 m in an open area. In the case presented a wind speed of approximately 0,5 m/s will provide an air exchange rate of more than 100/h (0,03/s) with volume Vo of 3 400 m3.

   In a conservative approximation using C = 0,03/s for an open-air situation, a hypothetical volume *Vz* of explosive gas atmosphere can be obtained by using the equation (B.5):

$$V_Z = \frac{f \times (dV/dt)_{min}}{0{,}03} \qquad (B.5)$$

where

f is a factor to allow for impeded air flow (see equation B.4);

$(dV/dt)_{min}$ is as previously defined (m^3/s);

0,03 is the number of air changes per second.

The methodology presented has several limitations which are important to note:

- The methodology presented by IEC 60079-10-1 is derived for indoor gas release evaluations, with the ultimate objective to define ventilation requirements for given explosion-classified spaces.
- The calculation of a hypothetical volume *Vz*, relevant for ventilation requirements, is of little value for Hazardous Zone determination. The shape of the zone, its extent, the influence of external factors and other shape-defining elements are fundamental to determine the extent of the hazardous zone.

  Ultimately the large interest in the design of LNG bunkering operation will be in the determination of realistic zones, not theoretical volumes.
- Recognizing the need also to define an approximation to exterior open-air spaces, factors are used to introduce the physical fact that even small displacement of air in exterior space will promote quick dissipation of small leakages. These are however factors which have little adherence with physical behaviour and have been proved to result, in a large number of cases, in conservative volumes.
- Because dispersion is normally more rapid in an open-air situation as a result of the different dispersion mechanism, calculation proposed by IEC 60079-10-1 will generally result in an overlarge volume.
- Factor *f*.is determinant in the magnitude of results for *Vz.* A factor of empirical nature should not have such a determinant weight in the end result.

9.2.5.2 IGF/IGC Code

Hazardous Areas are 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

In particular for the IGF Code, 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.

In the absence of a mandatory calculation methodology for the hazardous zones attained to LNG bunkering, and in view of the challenges for calculations following IEC 60079-10-1methodology for hypothetical volume, as presented in the previous section, a good practice approach may be established through the adoption of IGF/IGC Code Hazardous Areas reference, as listed above.

Figure 9.5, below, illustrates this application in a generic representation of a PTS LNG bunkering arrangement.

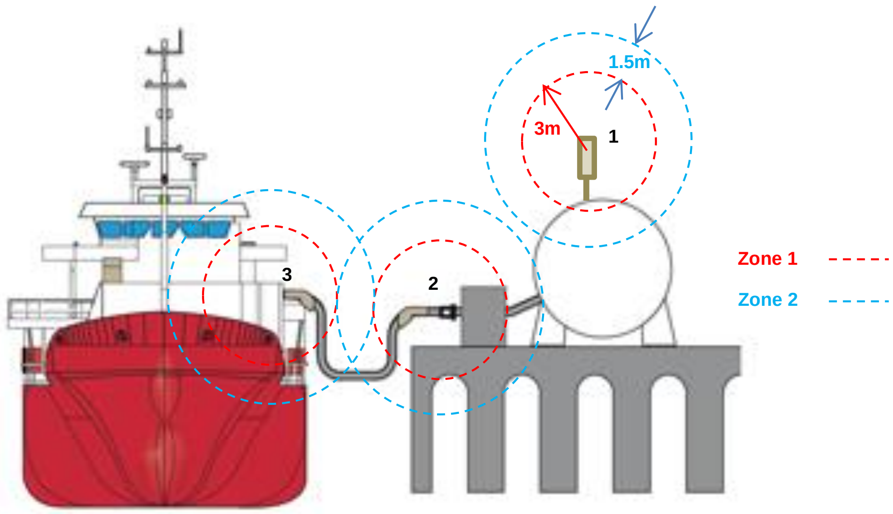


Figure 9.5 – Hazardous Zones (IGF Code) – Application of IGF Code hazardous zones to a PTS LNG bunkering arrangement. Locations for application of Hazardous Zones:

The bunkering-related hazardous area will include areas throughout the complete LNG bunkering system arrangement (truck, fixed installation ashore, bunkering manifold at the berth, etc.). Even though these areas are presented as fixed references, depending on the outcomes of the risk assessment and the specific details of the bunkering process (equipment and transfer flow rates and pressures) their size be increased.

The extent of the hazardous area classification zone, following the above approach, will be no more than about 4.5m, being always less than the Safety Zone.

The advantage of following the references used for the IGF Code, or IGC Code, is that a common ground for harmonization can be established, to be followed by all involved in the LNG bunkering operation. It may however fail to be representative of actual on-site conditions, especially in special cases where multiple connections on a common bunkering manifold are used. The likelihood of leakages associated to fast-connect/disconnect may increase significantly. If purging/inerting are not fully achieved this will be even more likely.

It is important to confirm the relevance of the hazardous zones, they will dictate the specification for electrical equipment and also define the areas where other hazards may be present (such as asphyxiation, through oxygen depletion or low-temperature/cryogenic).

Meaningful protection is to be checked for the Hazardous Zones proposed for any given LNG bunkering arrangement. The approval exercise should be based on the verification of the operational aspects, main assumptions, pressure and temperature parameters, amongst other aspects referred in sections 9.2.6 and 9.5.

9.2.5.3 Computational Calculation

Having in mind the limitations recognized to the methodology prescribed by IEC 60079-10-1 alternative calculation methods are possible and often looked for to define the actual extent of Hazardous Zones.

Whichever calculation methodology is followed, from whatever valid code, the calculation of a volumetric release, based on mas flow rate for any given leak, will only result in a non-realistic arbitrary zone. As an alternative to this, Computational Fluid Dynamics (CFD) has more recently been applied[75], in the majority to substantiate some criticism to the IEC standard applicability to open-air applicability of *Vz* calculations. The use of CFD here, as in other areas of engineering, allows the integration of non-linear effects, such as turbulence, modelling of the terrain and environmental conditions, amongst other aspects. Figure 9.5, below, presents a possible graphical comparison which may potentially affect the definition of the hazardous zone and, consequently, the protection classification for equipment being used within Hazardous zone 1 (blue).

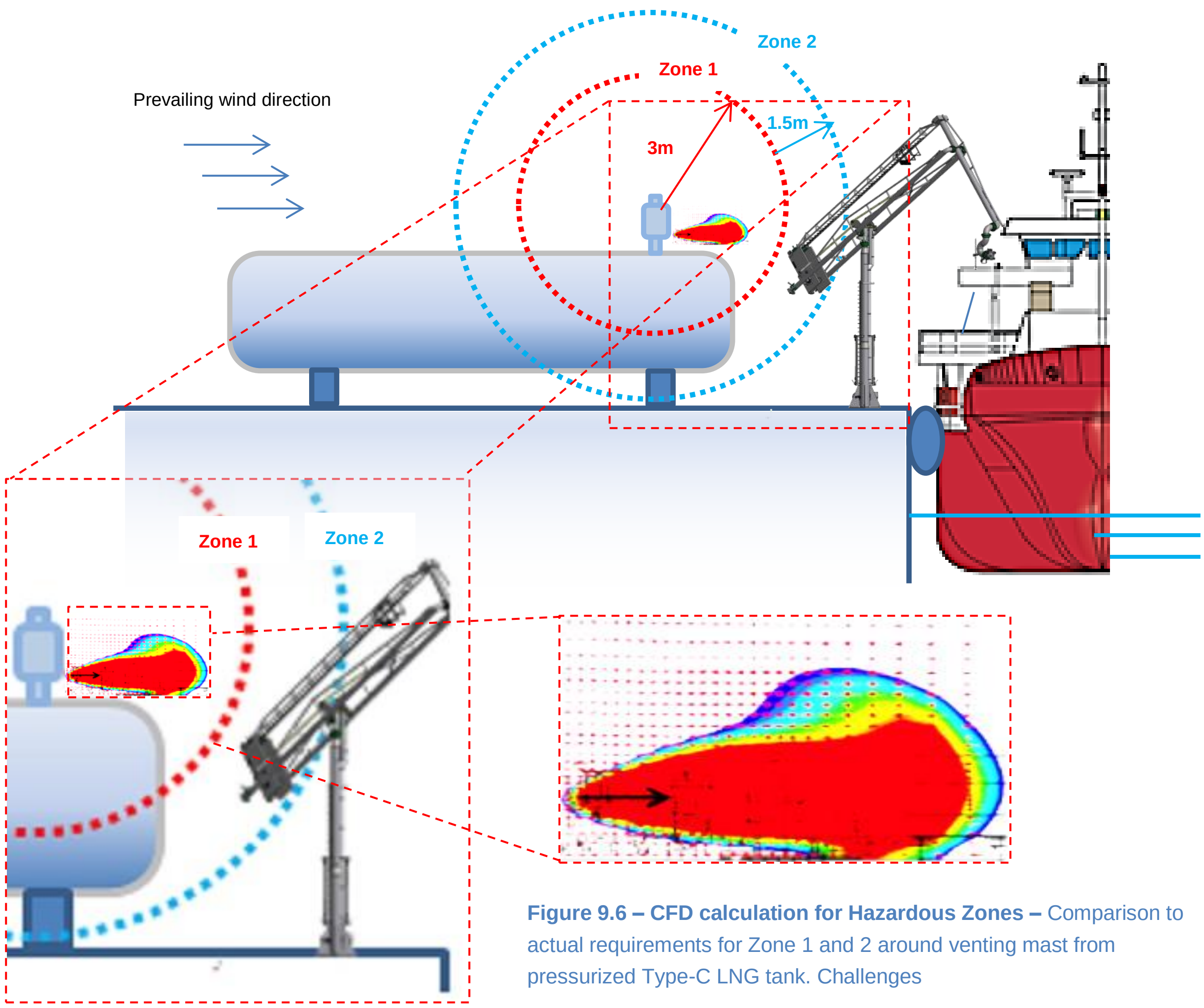


Figure 9.6 – CFD calculation for Hazardous Zones – Comparison to actual requirements for Zone 1 and 2 around venting mast from pressurized Type-C LNG tank. Challenges

[75] In the case of small LNG vapour leakages CFD will be the computational tool to use. Model can be refined enough to capture the dispersion of the small leakages that are typically associated to the definition of hazardous zones.

In figure 9.6 Zone 1 and 2 are indicated with a red and blue circle respectively. For the sake of simplicity only the hazardous zones around the type-C tank, from a generic fixed bunkering type installation.

CFD allows, in the presented figure, to verify that, not only the volume of released vapour is much smaller but that the extent of the hazardous zones is also going to be different. Should the assumptions for the CFD be accurate enough and the computational model sufficiently robust[76] a proposal for a smaller Hazardous Zone could be supported. This would reflect in the classification of nearby equipment, such as the crane represented in the generic example. The relation between the extent of the hazardous zone and the different equipment that can be allowed within those zones is the most important aspect regarding hazardous zones.

The quality of the CFD model, the assumptions made, the grid refinement, convergence study, amongst other aspects relevant for computational gas dispersion, should be the focus for PAAs evaluation, as detailed in section 9.7.

9.2.6 Equipment for Hazardous Zones

As indicated in the previous section, 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:

In Hazardous Zone, the principle of ignition sources mitigation dictates that only specialy protected, and certified, equipment should be used within those zones.

The equipment category indicates the level of protection offered by the equipment.

- **Category 1** equipment may be used in zone 0, zone 1 or zone 2 areas.
- **Category 2** equipment may be used in zone 1 or zone 2 areas.
- **Category 3** equipment may only be used in zone 2 areas.

All equipment certified for use in hazardous areas must be labelled to show the type and level of protection applied, conforming with the relevant parts of IEC 60079

In Europe the label must show the **CE mark** and the code number of the certifying body (**Notified Body**). The CE marking is complemented with the Ex mark, followed by the indication of the Group, Category and, if group II equipment, the indication relating to gases (G) or dust (D). For example: Ex II 1 G (Explosion protected, Group 2, Category 1, Gas) Specific type or types of protection being used will be marked.

– Ex ia IIC T4. (Type ia, Group 2C gases, Temperature class 4).

– Ex nA II T3 X (Type n, non-sparking, Group 2 gases, Temperature class 3, special conditions apply).

Figure 9.7 – Mark for ATEX certified electrical equipment for explosive atmospheres

Table 9.6, below, lists the minimum protection categories for Gas hazardous zones:

Table 9.6 – Minimum protection requirements for Gas Hazardous Zones [36]

Group	Ex-risk	Zone	EPL	Minimum type of protection
II **(gas)**	explosive atmosphere > 1000hrs/yr.	0	Ga	ia, ma
	Explosive atmosphere between 10 and 1000hrs/yr.	1	Gb	ib, mb, px, py, d, e, o, q, s
	Explosive atmosphere between 1 and 10hrs/yr.	2	Gc	n, ic, pz

[76] Only software which is either a commercial suite package (ANSYS CFX, FLUENT), or a demonstrated self-developed software should be considered acceptable. Verification & Validation procedures should apply to all models (as listed in section 9.7)

Table 9.7, below, presents the wider equipment classification chart, as adapted from ATEX [36]. Chart to be used for verification of equipment certification and confirmation of their use within LNG bunkering hazardous zones.

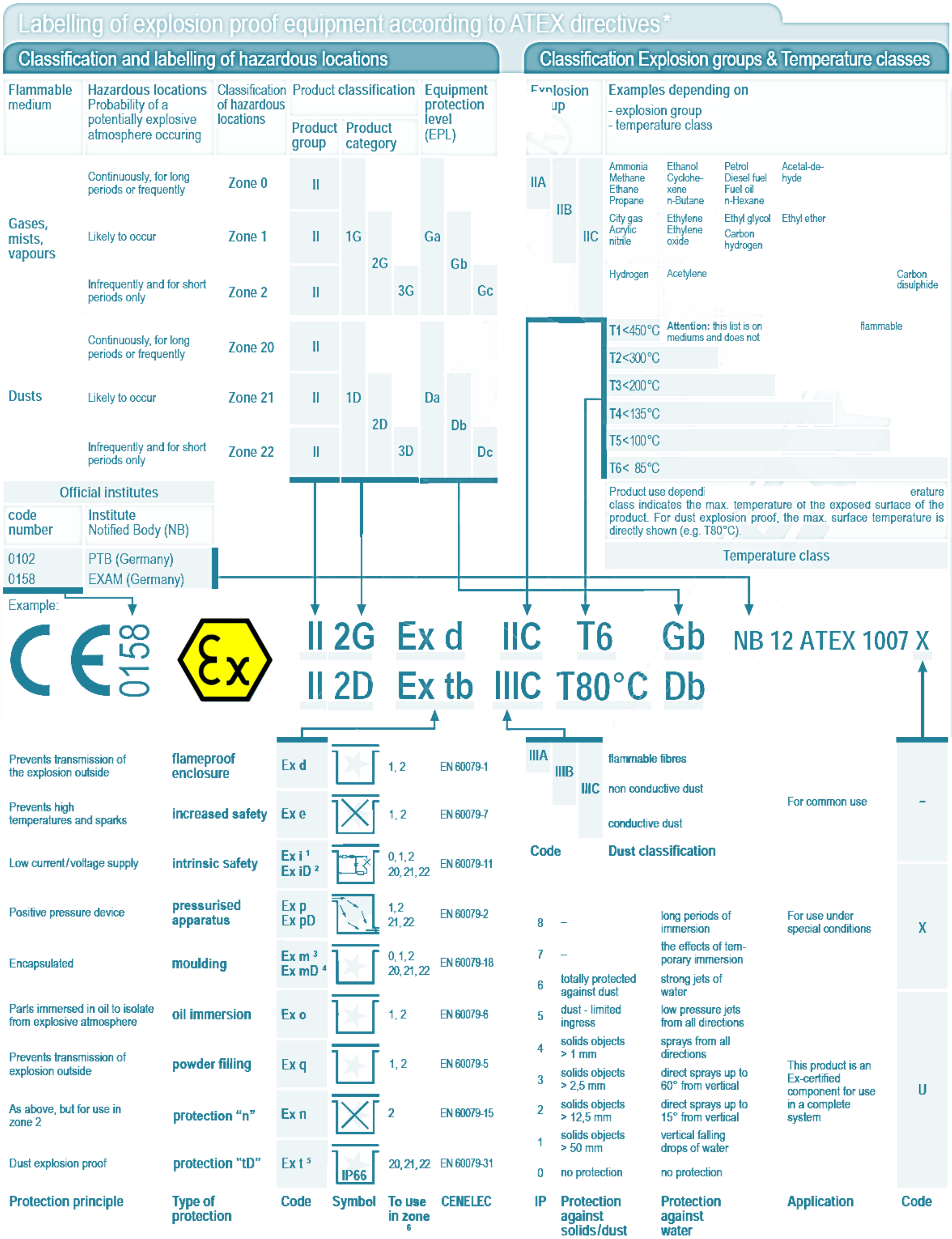


Table 9.7 – Labelling of explosion proof equipment according to ATEX Directive (ATEX 2014/34/EU)

9.2.7 Approval

Approval of Hazardous Zones is of the responsibility of the PAA during the evaluation of the project proposal, in the course of the permitting process.

The following elements should be checked for approval of Hazardous Zones by PAAs:

1. **Identification of all Hazardous Areas in suitable diagrams/plans where the whole LNG bunkering system is represented**. Zones 1 and 2 should be clearly identified and related to the following elements in the bunkering system
    - **a.** Bunkering manifolds, their flanged connections or containment coamings
    - **b.** Flanged connections along the bunkering line
    - **c.** Venting lines, GCUs
    - **d.** ERC
    - **e.** QC/DC bunkering connectors
    - **f.** Any flanged connection along the bunkering transfer system
    - **g.** Bunkering articulated arms, in particular where swivel LNG piping joints are present, mechanical elbows and other articulated connections.
2. **Identification of the references** for each Hazardous Zone presented. One or more of the references below should be presented:
    - **a.** IEC 60079-10-1, indicating which assumptions were followed for the definition of the Hazardous Zone extent.
    - **b.** IGF/IGC Code, making reference to the code, in particular indicating pressure and temperature windows defined for the bunkering. The reasoning behind this note is, in particular, relevant to check compatible physical p-t conditions between LNG delivered and LNG
    - **c.** Other Codes, in particular if national/regional standards have been followed, other than IEC/EN related.
    - **d.** CFD, identifying the responsible person for the calculations, the code used, assumptions followed, verification & validation procedures, including convergence of model, mesh refinement location, boundary conditions.
3. **LNG Bunkering management Plan,** to be checked for reference to Hazardous Zones, in particular provisions for its establishment and control.

    Only if a projected Hazardous Zone is proposed, along with effective measures for its control, it should be considered realistic. Sign, labelling and warning signs are some of the physical measures possible. Also confirmation keys, unlocked following Ex-proof verification can be considered.

9.2.8 Enforcement

Enforcement of Hazardous Zones should be done during in-service inspection of LNG bunkering facilities for Ex-proof confirmation of the whole inventory of electrical equipment used.

To support in this task, PAAs should request to operators a full updatable inventory for **Ex-proof equipment,** consisting of a list of electrical equipment that can subject to verification/check for Ex-proof conformity. Only electrical equipment contained in that list should be present in operation.

Other potential ignition sources, other than electrical equipment should be looked for.

Upon any finding which may raise concern regarding to insufficient ignition source mitigation, the LNG bunkering operation should be halted until the findings are resolved.

In-service inspections for Control Zone enforcement should be conducted with minimum impact in the planned course for the LNG bunkering operation, not leading to unnecessary undue delays to all operators involved.

9.3 Safety Zone

NOTE: The present Section defines and outlines a number of different approaches for Safety Distance Calculation. None of the approaches are advocated as the right approach. Safety Zones are a geometric definition surrounding the bunkering location. Whether these are providing meaningful protection should be the main question to ask. Section 9.5 should, to this end, be read in conjunction with this section to link the determination of a Safety Zone with the actual mitigation of different potential risk scenarios, and practical aspects in the implementation of these zones.

9.3.1 References

The reference standards for the definition, calculation and implementation of Safety Zones are:

ISO/TS 18683:2015 Guidelines for systems and installations for supply of LNG as fuel to ships	ISO	http://www.iso.org/iso/ (available for purchase)	Both ISO reference documents share the same contents regarding Safety Distances in LNG Bunkering. The same text is repeated in both standards. Calculation methodologies are mentioned (deterministic and probabilistic) with suggested curves for safety distance reference determination.
EN ISO 20519 - Specification for bunkering of liquefied natural gas fuelled vessels	ISO	http://www.iso.org/iso/ (available for purchase)	

References to Safety Distances can be widely found in literature, mostly on calculation of safety distances, comparative exercises on deterministic/probabilistic methodologies, risk assessments and others. This is, in fact, a particular subject where much has been written, where more or less conservatively, different Safety Distance calculation approaches have been developed.

Regardless how many different references might be possible, it is important to note that Safety Zones, unlike Hazardous Zones, are highly context-specific, depending on the

9.3.2 Definitions

Using the definition by SGMF [35]:

A safety zone is the 3-dimensional envelope where natural gas/LNG may be present as the result of a leak/incident during bunkering. There is a recognised potential to harm life or damage equipment/infrastructure as the result of a leak of gas/LNG, and its subsequent potential ignition. ***The zone is temporary in nature, only being present during bunkering. This zone may extend beyond the gas fuelled ship/LNG road tanker/bunker vessel, interconnecting pipework, ISO containers, etc. and will be larger than the hazardous zone.***

In the definition by SGMF further consideration is given, even if in very generic terms, to the extent of the zone, the objective for its establishment. It underlines the temporary nature of the zone which is the greatest distinction when compared to the hazardous zones, which are present at all times.

ISO/TS 18683 and ISO 20519 define Safety Zone as ***the area around the bunkering station where only dedicated and essential personnel and activities are allowed during bunkering.***

9.3.3 Objective

The objectives for Safety Zone implementation are:

- To **control ignition sources** in order to reduce the likelihood of igniting a flammable gas cloud that has dispersed following an accidental release of LNG or natural gas during bunkering
- To **limit the exposure** to non-essential personnel in the event of potential hazardous effects (e.g. fire) during an incident when bunkering.
- To **assess local infrastructure** for any potential gas trapping points, where explosive atmospheres may occur, as a result of accidental gas cloud dispersion.

The establishment of a Safety Zone will, in particular, allow for the structured application of safety and operational related restrictions that should, collectively, contribute to the achievement of the objectives above. These restrictions will inevitably be port-specific, reflecting the reality of each port, the local conditions, port own operational activity, potential major accident prevention policy, amongst others.

9.3.4 Restrictions

The restrictions policy to apply within the Safety Zone should be adequate and proportionate to the level of protection necessary for people, infrastructure and other operations within the port area. It is here important to mention that the restrictions to enforce within the Safety Zone will only be meaningful if the necessary strategy, plannification and resources are made available.

Collectively, the restrictions to enforce within the Safety Zone should contribute to the adequate achievement of the objectives expressed in 9.3.3.

The following restrictions will typically apply within the Safety Zone [3], [35]:

- Smoking is not permitted.
- Naked lights, mobile phones, cameras 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 eliminated.
- Access to the safety zone is restricted to the authorised staff, provided they are fitted with personal protective equipment (PPE) with anti-static properties and portable gas detector.
- Ventilation Intakes in the entire Safety zone should be restricted, with tag-out policy applied whenever LNG bunkering in course.

Vehicles, electrical equipment, cranes and other working gear, which are Ex-proof certified, can be considered for use within the Safety Zone. An inventory of this equipment should be part of the LNG Bunkering Management Plan.

All restrictions should be clearly indicated in the Port Regulations or informative notice sent well in advance to operators.

Consideration for the elimination of any of the restrictions above should always be based on a Risk Assessment approach.

9.3.5 Calculation

ISO/TS 18683, and subsequently ISO 20519, provides guidance for two different approaches that can be used to determine the safety zone:

1) **<u>Deterministic approach</u>** calculating the distance to LFL based on a maximum credible release;
2) **<u>Risk-based approach</u>**, also known as Probabilistic approach

The <u>deterministic approach</u> is based on a calculation of the distance to LFL for a maximum credible release conservatively defined as part of the HAZID. This calculation needs to consider both horizontal and vertical releases and subsequent dispersion.

The calculation can make use of analytical calculation tools, based on simple mass rate release, in a similar manner to the approach followed by IEC 60079-10-1, but that would render an extremely conservative approach which would not be realistic in terms of adequate modelling.

Both ISO references (TS 18683 and 20519) provide for curves to be used, both for: a) release of trapped volume, contained in the bunkering line, between ESDs, and b) continuous release from broken instrument connection (with the example of 25mm instrument connection hole). The origin of the curves is however not explained in the ISO standards, with some relatively large distances resulting from their use. Section 9.3.4.1 outlines a few more concerns that may rise from the use of these curves.

If the <u>risk-based or probabilistic approach</u> is used, this will normally result in a smaller safety zone compared with the distance to LFL for the maximum credible release.

The more complex risk based approach may be used if the simplistic approach results in too large (and conservative) distances from a practical point of view. A smaller safety zone may be accepted provided that it can be demonstrated by the QRA that risk acceptance criteria can be met for 1st, 2nd, and 3rd party personnel. If the risk is acceptable in accordance with the acceptance criteria (as agreed with authorities) the smaller safety zone is acceptable

Even though, in theory, a risk-based approach could, potentially, be able to define very small Safety Zones, based on a possible ambitious set of safeguards designed, it is important to note that minimum reference Safety Distance should be in place. The Safety Zone should never be smaller than

- the Hazardous Zone
- Port Specific requirements
- National Standards/Safety regulation potentially applicable

To both deterministic and probabilistic approaches, the use of computational tools will be determinant. Direct algebraic calculations are not simple for non-linear processes such as LNG spills, pool formation or gas cloud dispersion. Computational models will be a fundamental support to the structured development of consequence studies that are able to represent more or less accurately

9.3.5.1 Deterministic Approach

As expressed in ISO/TS 18683 and ISO 20519 the safety zone is defined as the area within the distance to LFL as determined by a recognized and validated dispersion model (see section 9.3.4.3) for the maximum credible release as defined as part of the HAZID. For LNG, the LFL is approximately 5% of natural gas in air.

The maximum credible release shall reflect the characteristics of the bunkering facility (dimensions, capacity, transfer rate, temperature/pressure, and if installed, vapour return) as well as the safeguards that are implemented.

The table below (table 9.8) outlines the existing possible deterministic calculation approaches

Table 9.8 – Safety Zone calculation – Deterministic approaches

<table>
<tr><th>Method</th><th>Description</th></tr>
<tr><td>Analytical

Analytical calculations based in first principle mathematical models</td><td>Standard / widely available mathematical equations for modelling light, neutrally buoyant and Dense Gas dispersion. Good for coarse first pass decision making.

Typical data to be used for analytical calculations will involve a variety of different parameters and some factors which should be able to approximate the mathematical models in a context of quasi-static linear algebraic solutions, including geometric representation of gas dispersion plumes.

Relevant references for analytical calculations

• TNO's Yellow Book (CPR 14E) [39] providing for many of these models and equations and also.

• Milton Beychok's book "Fundamentals of Stack Gas Dispersion" [40].

From TNO's Yellow Book, the following relevant areas can be found for calculations:
i. Outflow and Spray release
ii. Pool formation and evaporation
iii. Vapour cloud dispersion
iv. Vapour cloud explosion
v. Heat flux from fires
vi. Rupture of vessels
vii. Interfacing of models

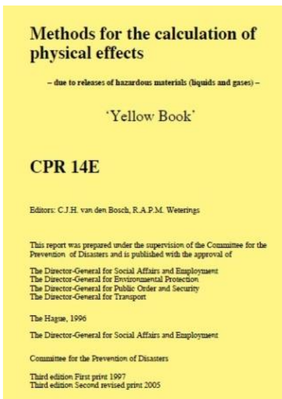


Figure 9.9 – •TNO's Yellow Book (CPR 14E) [39])</td></tr>
</table>

<table>
<tr>
<td>ISO (a)

Trapped Volume Release</td>
<td>

<u>**Release of the trapped inventory in the bunkering transfer line**</u>

ISO describes a worst case scenario for LNG bunkering transfer which can be defined as the rupture of the bunkering line due to a catastrophic accidental event (such as *drift off of the vessel due to a collision or a mooring failure*).

<u>Maximum credible release</u> calculation based on the following assumptions:

- Activation of the ESD prior to rupture. This would require a pre-warning of some kind, as it is admitted in ISO/TS 18683 and ISO 20519.
- Partial failure of the ERC/break away (i.e. only one of the ERC sides fail, resulting in partial release of hose LNG content.

Based on these assumptions, the release amount is determined as the inventory between the one end of the bunkering hose and the corresponding failing ERC (see figure 9.10)

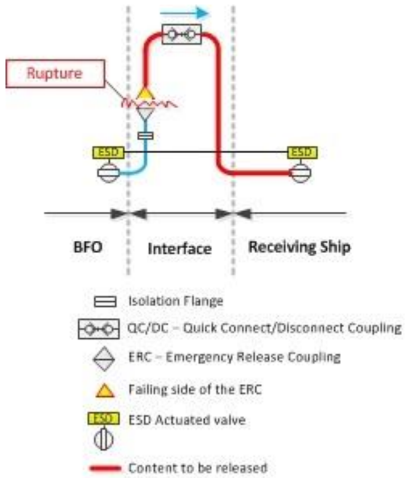


Figure 9.10 – Illustration of the trapped inventory release (between ESD and failing ERC side)

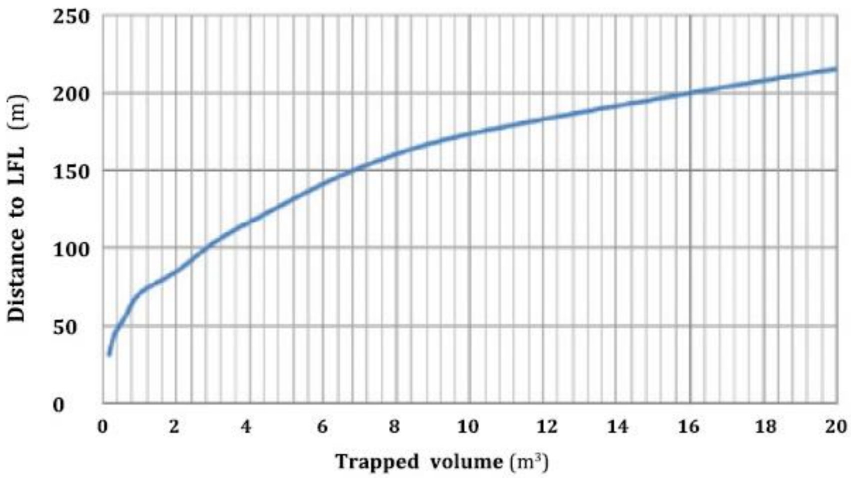


Figure 9.11 – Flammable extent with respects to volume of released LNG (reproduced from **ISO 20519 figure B.3)**

The ISO assumption of ESD activation prior to rupture, as indicated above, may not be fully realistic. The pre-warning for any catastrophic event will necessarily depend on the effectiveness of the alarms and the specification of the ESD actuation. Complete ESD shut-down may take several seconds, not only due to technical limitations but also to avoid pressure surge. For a realistic modelling of this maximum release scenario it is important to take the ESD shut-down time into account. The volume released will necessarily be more than the one presented in the ISO curve, above in figure 9.11.

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</table>

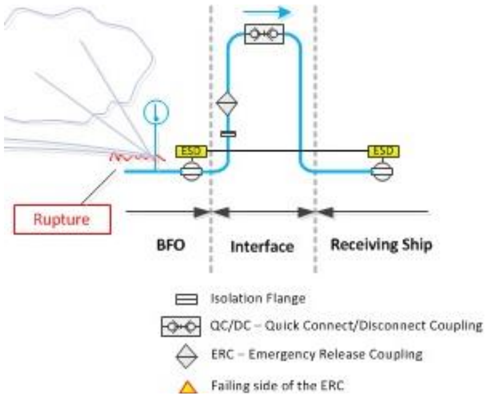
<table>
<tr>
<td>ISO (b)

Continuous release at constant pressure</td>
<td>

<u>**Constant pressure release of LNG through a broken instrument connection**</u>

The maximum credible release is defined as a broken instrument connection. Such scenarios may occur without automatic detection and is conservatively represented by a continuous release through a 25 mm hole. ESD is not activated and the pressure inside the transfer system is maintained by the cargo pumps. The distance to LFL as a function of the system pressure is shown in the table of figure 9.11.

Figure 9.11 – Illustration of the trapped inventory release (between ESD and failing ERC side



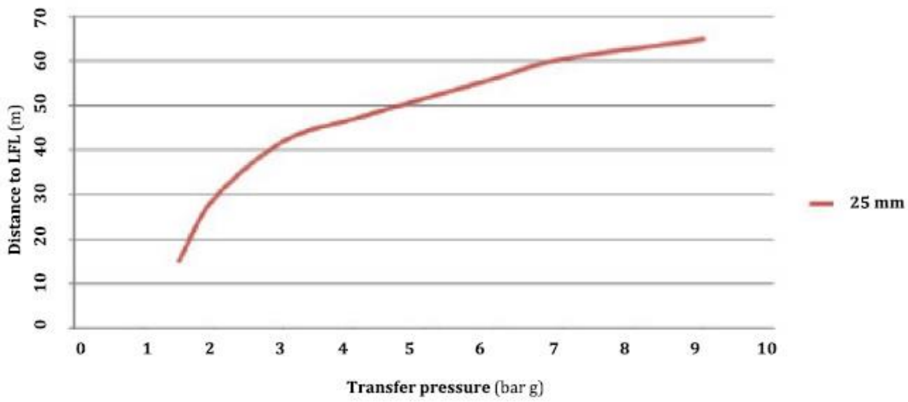


Figure 9.10 – Flammable extent with respects to pressure at LNG release point (reproduced from ISO 20519 figure B.4)

The extent of the Safety Zone would, in this case, be a function of how long the release had been running before either ESD was stopped or pump was stopped.

Computational modelling of 25mm constant pressure release has confirmed the impracticable distances from a 25mm hole [37]. The constant pressure release through an instrument broken connection of 25mm may be considered too conservative, leading to impracticable safety distances. This has been, for instance, the justification to explore different (smaller and more significant/representative) the case of 13mm hole hose rupture [37] referred to as "significant credible scenario", based on IOGP data [38], where 90% or more of all potential releases for the bunkering line equipment[77] are likely to be from 'holes' with a diameter of 13 mm or less.

The use of both ISO (b) and ISO (a) curves is however still the ISO reference for Safety Distance calculations.

</td>
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</table>

[77] flexible hose/line, instrument connections, valves and flanges

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<tr>
<td>Computational Supported Calculations</td>
<td>
Both approaches suggested by ISO/TS 18683, repeated by ISO 20519, are not sufficiently flexible to accommodate for the large variety of possible LNG bunkering scenarios and possible parameter variation. Not only the underlying construction assumptions for the curves are not declared in the ISO references, it is also very difficult to reproduce the values for the curves using numerical analysis and computer modelling [37].
Due to the large number of variables defining the physical processes involved in LNG pool formation and gas dispersion, the use of computational tools for modelling and analysis has become more and more the support for definition of Safety Distances for recent LNG bunkering projects. The recent tendency for higher LNG transfer rates, higher pressures and increased complexity of bunkering management, from STS to PTS bunkering modes, are some of the reasons to adopt more complex calculation and modelling techniques and tools.
For the <u>maximum release scenario</u>, the modelling of the LNG release and dispersion need to take into account the following elements:

Properties of the LNG, reflecting release conditions.
Size of the hole, reflecting the installed equipment and validated failure data. If validated failure data is not available, conservative assumptions shall be made;
Roughness of the surface over which the vapour/gas disperses, (i.e. land or water)
Release height and dispersion elevation;
Outflow conditions;
Release rate, release orientation, available inventory;
Evaporation/flashing of LNG reflecting LNG properties and heat transfer from ground/water;
Heavy gas dispersion;
Structures and physical features that that could significantly increase or decrease dispersion distances. Large objects, such as buildings and ships, and topography, such as cliffs and sloping ground, can constrain or direct dispersion
Weather conditions at the bunkering location; <u>wind speed, humidity, air temperature and the temperature of the surface upon which the fuel leaks</u>. The chosen conditions should reflect the worst-case conditions that result in the greatest distance to LFL;

There are currently a large range of options for computational modelling and analysis of LNG accidental release/spillage events. Section 9.3.5.1 outlines the main types of software tools, listing their most relevant advantages and disadvantages. Different types of modelling and analysis software will essentially differ in terms of computational effort, with Integral Models having the lowest computational requirements, up to CFD Navier-Stokes software, with the largest.
In cases where the local conditions are dominated by non-linear weather based effects, with complicated infrastructure or other obstacles close to the bunkering location, advanced modelling techniques, such as computational fluid dynamics (CFD) might be required to justify the zone’s shape and extent.
Verification & Validation procedures (see Section 9.6) should be considered for all computational calculations. Not only it should be possible to demonstrate that the model is actually c
Modelling and Analysis through computer tools should be performed by competent expert/professional with demonstrated experience record.
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9.3.5.2 Probabilistic Approach

Recognizing that the deterministic approach may result in impracticable large areas, both through ISO (a) or (b) methods or through any computational maximum credible scenario calculation, ISO/TS 18683, and subsequently ISO 20519, accept smaller zones, provided these can be demonstrated by a Quantitative Risk Assessment, with risk acceptance criteria met for first, second and third party personnel.

A HAZID should be held for initial identification and ranking of LNG bunkering hazardous scenarios where risk matrices are developed reflecting the different risks identified. Subsequent definition of safeguards to bring all risk scenarios to ALARP levels should allow a set of tangible measures to implement (physical barriers, alarms or other safety devices which are either able to reduce the consequence or the probability of a given hazard).

The risk assessment should address all hazard scenarios[78] as identified in the HAZID and reflect validated (or conservative) failure data. Safeguards identified in the HAZID and be considered in the Risk Assessment, provided these are reasonable, implementable and recognized as relevant for actual risk mitigation.

For consequence modelling all the selected hazard scenarios should be considered, with the modelling of the release and dispersion to be as described in 9.3.5.1.

Table 9.9, below, presents the main elements to be considered, including consideration on Risk Criteria

Table 9.9 – Risk Assessment - Specific requirements to set Risk-Based Safety Distances

Risk Assessment	Summary Description
Ignition probabilities	Ignition probabilities shall reflect installations and operations and be applied with reference to IEC 600079-10-1 for: i. the hazardous areas; ii. inside the safety zone; iii. outside the safety zone
Target Protection	i. **first party personnel** (crew and bunkering personnel) are continuously present in the safety zone during bunkering; ii. **second party personnel** (port and terminal operator, other vessel crew) are continuously present directly outside the safety zone during bunkering; iii. **third party personnel** (passengers and other persons visiting the site) can be present, but will not be continuously exposed to the risk; iv. **third party personnel continuously present** (residential areas, schools and hospitals) will be outside the risk contour for third party acceptance • The risk assessment should consider the risk exposure for first, second and third party personnel.
Escalating events	The impact on personnel shall **primarily assess the initial events**. Escalating events will be delayed and the impact should consider the efficiency of evacuation and emergency preparedness
Multiple Failure Scenarios	Multiple failure scenarios, in principle, should not be required. It should be possible to address each hazard for its own risk. As with the escalating events, initial scenarios should be the main investigation points. Should any cascade, domino or escalating events be considered these should be addressed in the context of the HAZID, properly documented before any modelling takes place.
Risk Criteria	Examples of risk acceptance criteria are adopted in ISO/TS 18683 annex A and are shown in Table 9.10

[78] ISO Standards define, as a minimum, flash fires, jet fires, and pool fires to be investigated.

Table 9.10 - Examples of risk acceptance criteria, adopted from ISO/TS 18683 - Annex A, Table A.1

	Acceptance criteria	Comment
Individual risk 1st party personnel	IR < 10^{-5}	Applies to crew and bunkering personnel directly involved in the activity.
Individual risk 2nd party personnel	IR < $5 \cdot 10^{-6}$	Port personnel and terminal personnel.
Individual risk 3rd party personnel with intermittent risk exposure	Risk contour for IR < $5 \cdot 10^{-6}$	3rd party personnel should not have access for prolonged period.
Individual risk 3rd party personnel with prolonged risk exposure	Risk contour for IR < 10^{-6}	General public without involvement in the activity. No residential areas, schools, hospitals etc. inside this risk contour.

NOTE:

The suitability of using annual (i.e. yearly) fatality criteria requires further consideration. This is because the bunkering operation may be infrequent and of a very short duration, and hence the risk is likely to be small when averaged over a year. Based on this, a safety zone of short extent might be set that would offer little protection in the event of a leak. In simple terms, the yearly 'averaged' criteria can mask peaks in risk related to periodic but infrequent short-duration operations.

An alternative to fatality risk is to set safety zone extent based upon the likelihood that flammable gas is present. That is, for a representative set of events, the distance at which the lower flammability limit is reached for an agreed likelihood. This likelihood could be per year or per bunkering operation. However, an annual likelihood would suffer from the same concerns noted above for 'averaging the fatality risk' over a year. As such, likelihood per operation might be preferable. For this approach to be used, further investigation and agreement is needed on likelihood criterion, for example, 1 in a million or 1 in 10 million per bunkering operation.

Figure 9.11, below, presents the generic diagram where all elements contributing Risk-Based Safety Distances are included.

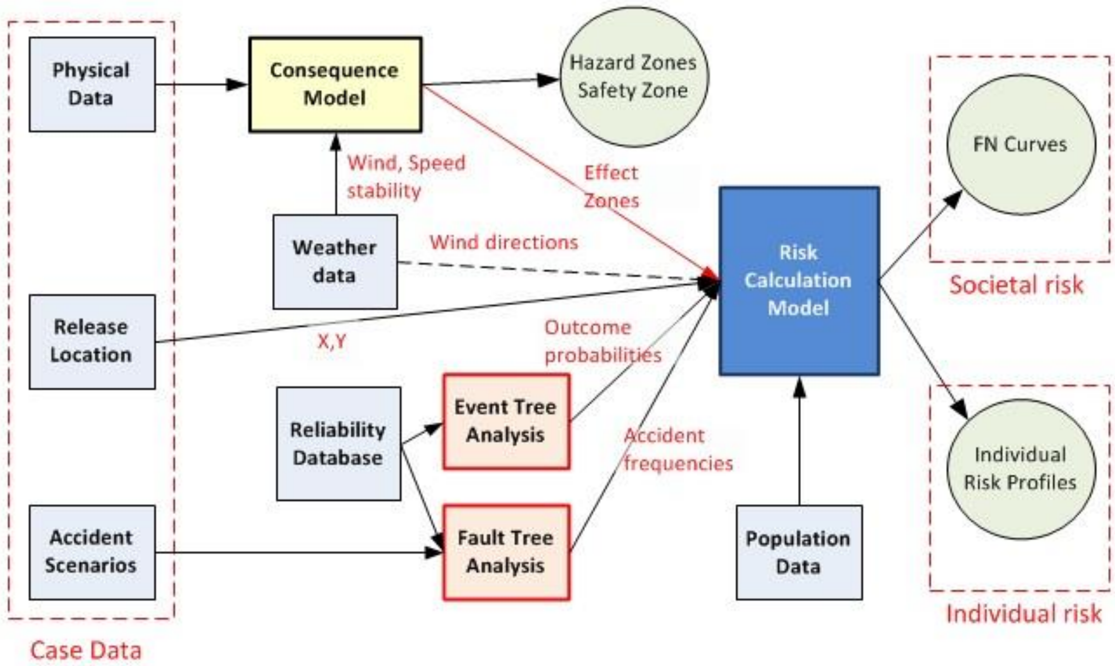


Figure 9.11 – Diagram for Risk-Based Safety Distances Calculation – Probabilistic Approach

9.3.5.3 Computational Calculation

In the recent years, the CFD modelling has become a very useful tool for many research areas. This is connected with the increasing power of desktop computers. Accordingly to that, the computations for which we needed supercomputers can be done on regular PCs. The ability of CFD to predict fluid flow and concentration of dangerous gases is essential to the people working on safety analysis. There are today many programs developed for the prediction of hazardous gas cloud spreading. Starting from very simple Gaussian models for the light gases (the density of gas is less or equal to that of air) continuing with box models for heavy gases (the density of gas is higher than that of air) and ending with complete solving 3D balance equations for mass, momentum and energy (CFD). The use of CFD models has high potential to be a tool which can after some adjusting and modification replace the experimental modelling or at least reduce the number of experimental trials.

For LNG bunkering computational calculations represent a mix between deterministic and probabilistic approach. On one hand the aim of the model is to determine a more realistic or representative pattern for LNG vapour cloud dispersion but, on the other hand, in doing so, there are a number of assumptions for the model construction, and subsequent analysis, which are based on more or less likely scenarios. Weather data would typically be available with a generic historic data record, potentially plotted on a rose-wind chart as the one presented in table 9.12. Such weather data brings a probabilistic element into the computational calculation and it is important to have this into account when supporting decision making on safety zones only on computational calculations like CFD.

Different options exist for computational modelling of LNG accidental releases during bunkering operations, differing essentially on how demanding they are in terms of computational effort and on how accurately they can model the LNG spillage physical phenomena under specific conditions. Table 9.11 presents the 3 main types of computer models used for LNG vapour/gas dispersion.

Table 9.11 - Examples of risk acceptance criteria, adopted from ISO/TS 18683 - Annex A, Table A.1

Computational model	Summary Description
Integral Models	Integral Models are the less computer-consuming tools that can be used to model LNG spillages, pool formation, evaporation, gas dispersion and fire. They use algebraic equations to obtain solutions and are usually limited to modelling of circular pools, flat substrates, and heat transfer only from the substrates. Modelling pool formation with Navier–Stokes models can be time-consuming because of their complexity. As a result, researchers prefer to model pool formation with integral models and then transfer the data over to Navier–Stokes models for further analysis. Typical entries for Integral Models account for: release characteristics (rate, height, orientation), spill volume, spill rate, vaporization rate, presence of obstacles, and atmospheric conditions are considered to be key parameters in determining the LFL extent and time-spatial distribution Examples of Integral Model software are: SOURCE5, GASP, SafeSite3G, PHAST, ALOHA, ABS Consulting model, LNGMAP, and FLACS. PHAST has, in particular, gained visibility from application in several recent LNG Bunkering consequence modelling. Some of the advantages presented by PHAST, when compared to other Integral Model codes are: 1) ability to model LNG spills onto water and land, 2) possibility to model non-circular pools.

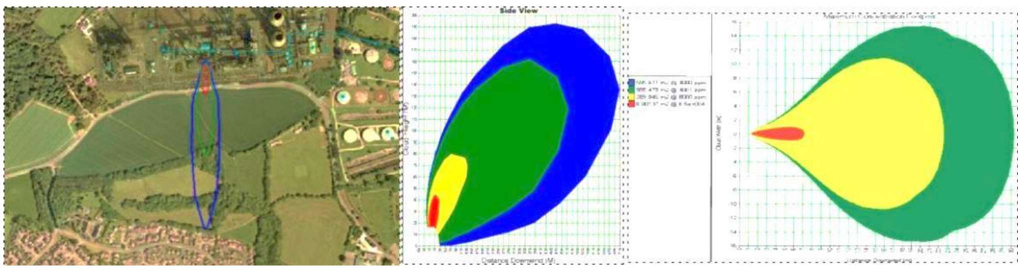
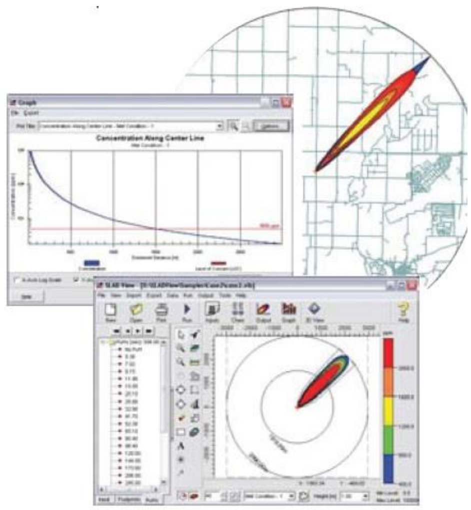
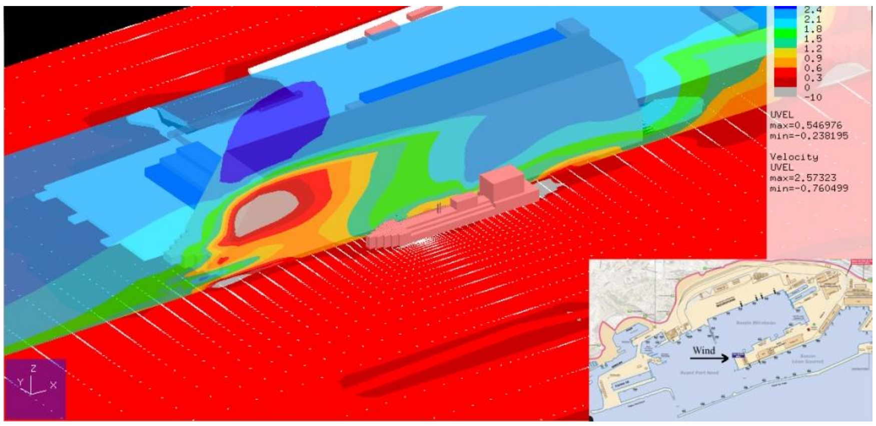


Figure 9.12 – PHAST interface representation. Example of dispersion top view over terrain top view, side view and top view for plume dispersion.

Box or Top-Hat Models	There are two types of box or top-hat models: modified Gaussian models and similarity-profile models, depending upon the complexity of conservation equations that must be solved. The modified Gaussian models are the simplest because the Gaussian equation is used for the mass conservation while neglecting or simplifying those for momentum and energy. The similarity-profile models use simplified conservation equations with a mathematical complexity of one dimension. Such simplicity is achieved via averaging the LNG cloud properties across the surface of the entire cloud or over the cross wind plane. To regain the structural loss because of averaging, similarity profiles are used, therefore leading to quasi-three-dimensional solutions (explored in 3D for SLAB3D) Examples of similarity-profile models include SCIPUFF, TWODEE, SLAB, HEGADAS, DEGADIS, ALOHA and GASTAR. Of these models, the most commonly used are SLAB, HEGADAS, DEGADIS, and ALOHA. SLAB and ALOHA seems to be the most widely used for safety engineering modelling applications in industry because of its fast computational time and reasonable accuracy.  **Figure 9.13 – SLAB interface representation.** 2D dispersion (SLAB 3D commercial suite already available with improved visualization options)
Navier-Stokes Models	Navier–Stokes Models. The Navier–Stokes models contain the most physically complete description of the LNG dispersion process and are constructed from three-dimensional and time-dependent conservation equations of momentum, mass, energy, and species. Examples of Navier–Stokes models that have been used for denser than air modelling include FEM3, FEMSET, FLACS, HEAVYGAS, and ZEPHYR. FLUENT and CFX numerical models have been the main Navier–Stokes models used for modelling. This is largely due to the key advantages of these models, including robustness, multiple solving methods, high levels of accuracy, and ability to add to the coding for specific simulations. Although giving a more complete description of the physical processes available and performing better than box or top-hat models, the Navier–Stokes models are the more demanding in terms of computational resources. Some examples of CFD visual outputs can be seen hereunder, in figures 9.14 to 9.16  **Figure 9.14 – CFD representation of an LNG cloud release, following a modelled STS bunkering.** Local wind and turbulence effects are modelled, providing a more accurate analysis of non-linear situations. To be noted the effect of the inter-ship space, where LNG cloud dispersion is bounded by the ship's shape, leading to a dispersion progression which is far from regular. (courtesy: LR/ Port of Marseille)

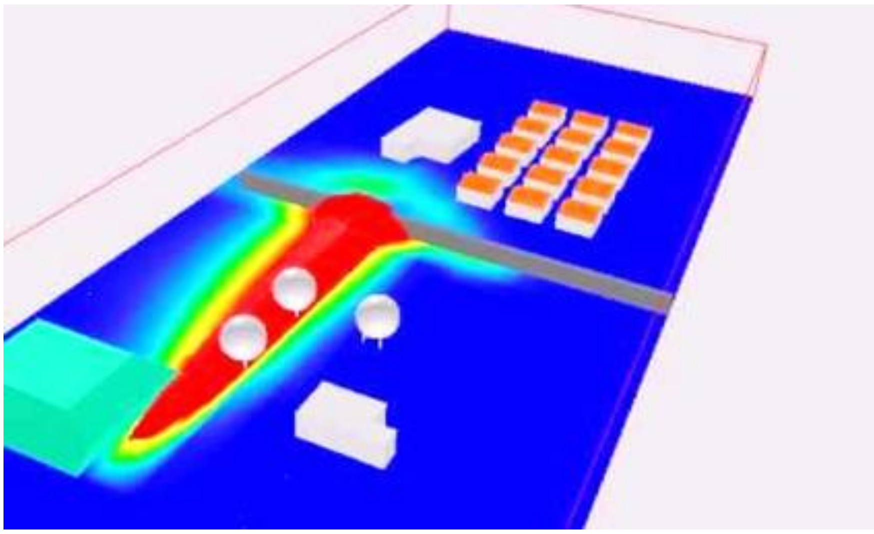


Figure 9.15 – CFD render representation. Plume dispersion meeting terrain obstacles. The figure, in particular shows the effect of a fence/wall as an obstacle to the progression of the LNG cloud, under certain local conditions and prevailing wind.

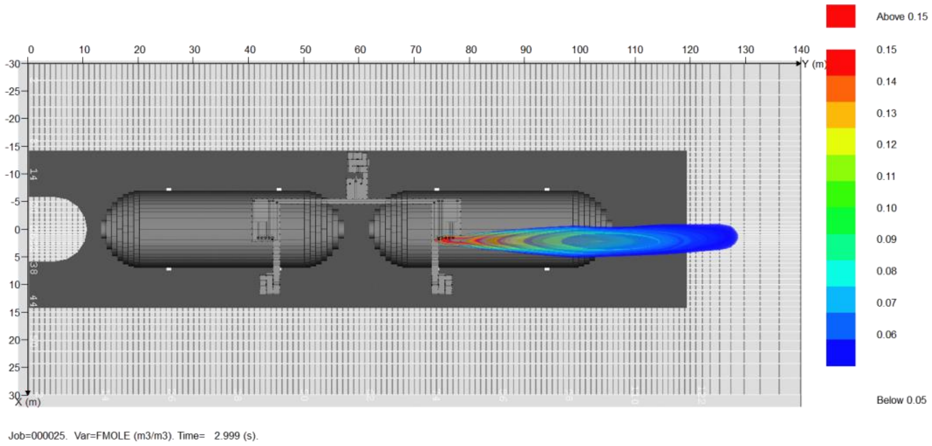


Figure 9.16 – CFD render representation. Plume dispersion following PRV actuation and venting up from a type –C LNG tank.

When assessing results based on computational calculations PAA should have consideration for the following important elements:

(1). Computational tool used:

a. Identification of the Code used for modelling & analysis, including year and version.
b. Evidence of proven experience with the reference software, including identification of general elements from other projects.
c. Commercial software or self-developed?
d. List of particular limitations of the model.
e. References

(2). Assumptions

a. Assumptions used for the modelling & analysis of the different LNG release situations.
b. Identification of approximations, averaging, rounding mechanisms used with the objective of computational simplification.
c. Wind directions studied.
d. LNG release parameters (flow rate/volume, height a location of release, release orientation)
e. Temperatures
f. Rate of evaporation assumed for possible pool modelling

(3). Model Construction

a. Site modelling, port local infrastructure, including boundary conditions assumed on different parts of the model.
b. Simplifications
c. Possible planes of symmetry used.
d. Mesh constructions and refinements, with the clear indication of refined meshing on specific areas of interest.

(4). Analysis

a. Calculation methodology
b. Convergence analysis, with adequate demonstration of convergence for all the solutions presented

(5). Verification

a. Procedure for code verification (particularly important for self-developed CFD software)
b. Verification procedures for quality assurance.
c. Error estimation or, in case of difficult assessment of error magnitudes, arguments on specific modelling features that may potentiate errors.

(6). Validation

a. Evidence of any validation experiments to support the tools used

When the determination of a Safety Zone is supported by computational calculations, PAAs must take special consideration to representativeness of the model, not only for the local conditions (boundary conditions, wind, temperature) but also to the LNG bunkering operation parameters (flow rate, transfer pressure, bunkering line location). This will be an important point to take into account for any of the models presented in the table above

Many factors contribute to the quality of the computational model & analysis. PAAs should, in principle, be able to revise reports with computational calculation results and, even if not in detail, be able to promote a dialogue and exchange on the parameters, basic modelling assumptions, parametric options and necessary quality control for any computational model.

Table 9.12, below, lists some of the important factors that directly affect the quality of computational models, with a particular focus on CFD. PAAs should be prepared to question the assumptions behind any computational calculation result, in particular if this is presented as a render image output.

Table 9.12 – Main factors affecting the quality of computational model calculations. Quality Criteria for computational modelling & analysis of LNG vapour dispersion.

Computational model	Summary Description
Calculation Codes	Integral, Box/Top-Hat or Navier-Stokes CFD are possible calculation codes with different complexities and corresponding computational calculation times, with CFD suites being the most demanding with a very high number of numerical iterative calculations. It should be important to note that, in particular for modelling of LNG vapour dispersion, following an accidental release, there should be some consideration for cost-benefit of which model to use. In addition and related to this, there should be a critical notion on the necessity to picture smaller scale turbulence effects (demanding for computational calculation) when the objective is to set higher level Safety Distances of a scale much larger than the smaller eddy/turbulence level. Clarification on the model used should allow PAAs to check for the maturity of the computational tool, which can be directly related to the quality of the
Technical Competence	The competence of the analyst responsible for the model, analysis and report presented to the PAA should be one of the main aspects to question. Evidence of experience should be available to PAAs on request. For those analysts with less experience PAAs should require for evidence of an internal verification/approval procedure shared responsibility with more experienced professionals. Identification of the responsible analyst, and possible chain of verification, should always be clearly stated in the final report.

Boundary conditions

Boundary conditions are important aspects to all models. They impose constant physical values or constraints with the main objective to approximate the LNG vapour dispersion to real conditions.

CFD models are only as good as the physical models produced. In the same way, the accuracy of the CFD solution is only as good as the boundary conditions provided to the numerical model. Many different constraints and boundary conditions specifications can be imposed in the model. These will affect directly the shape of the LNG dispersion. Figure 9.17, below, shows some of the possible boundary conditions that can be used to shape the approximation to reality.

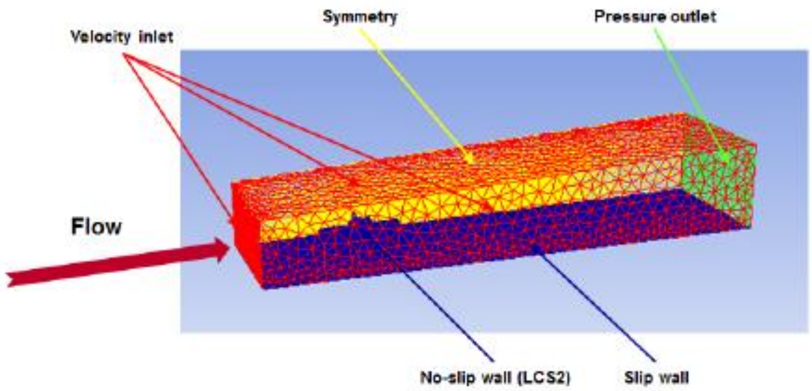


Figure 9.17 – Identification of boundary conditions in a simplified regular CFD control model volume.

All boundary conditions must be reported and justified.

Modelling of local conditions

Local conditions must be chosen in agreement with PAAs, using available data for wind and temperature, preferably for the location of interest (intended LNG bunkering location). If no local information exists, such as actual local wind information, the model should consider the possibility of creating a far field wind profile, with obstacles and infrastructure modelled so as to create a turbulent and more realistic air flow pattern at the location of studied LNG release.

Important weather/local parameters to consider:

- Wind
- Temperature (air and surface boundaries)
- Atmospheric stability (more relevant in terms of fire studies, with relevance for convection modelling of vertical fire columns).

Wind is probably the most important local condition that will dictate, together with temperature the progression of LNG cloud dispersion.

Which wind strength and direction to use will typically derive from available wind-rose distribution charts like the one presented to the right, in figure 9.18.

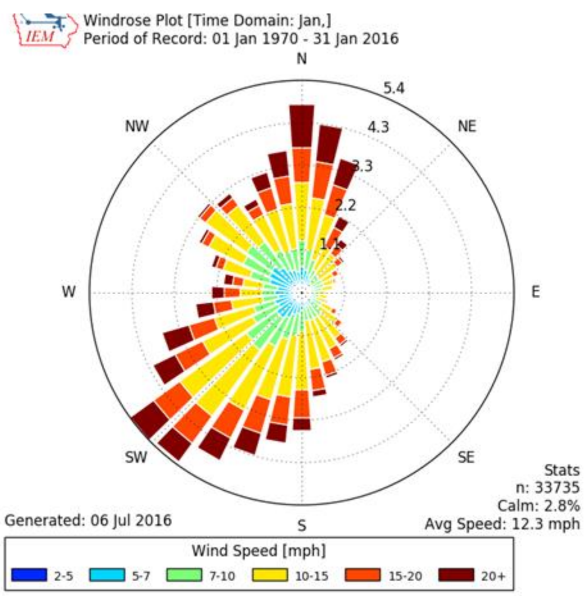


Figure 9.18 – Wind-rose distribution chart, including wind direction and speed radial histogram

The final report, with results from computational calculations, should include the rationale for the choice of important local parameters.

It is important that PAAs are involved in the modelling of local conditions, not only being able to provide available data sets but, furthermore, bringing the local experience into the model. Some local wind effects are very difficult to capture only by historic data, especially when that data is available for otherwise undisturbed locations.

In addition to the above, and because each calculation set will be based on specific conditions, it will be important to check from which direction to model the wind and, again, what wind field flow pattern is imposed in modelling.

Failure to be consistent with local conditions will derive in lack of representativeness of the computational model and results.

Modelling of bunkering conditions

Bunkering operation details should be well represented in the model, with the main parameters representative of actual operational conditions.

The following parameters are relevant:

- LNG transfer pressure
- LNG transfer rate
- Exact location of LNG bunkering point
- LNG temperature

Release Scenarios

Release scenarios should be agreed with the PAA, based on local conditions and expertise from analyst consultants responsible to undertake the modelling.

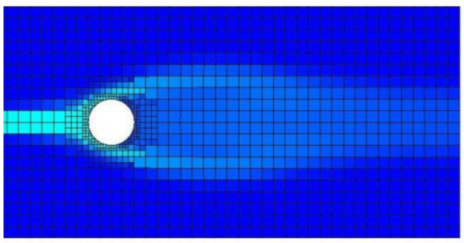
As a minimum good practice the following scenarios should be calculated:

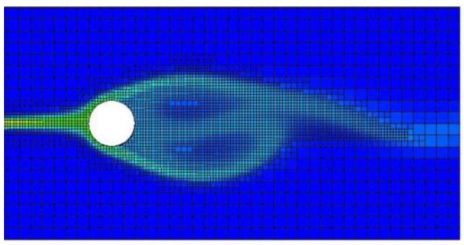
- ISO (a): Release of the trapped inventory in the bunkering transfer line
- ISO (b): Constant pressure release of LNG through a broken instrument connection (25mm instrument connection)
- Constant pressure release study for 13mm and 6mm holes in hose assuming:
  - .a) ESD shutdown time of 1min
  - .b) ESD shutdown time of 30sec.
  - .c) ESD inoperative: 2min to pump stop and manual isolation.

Possibility of other scenarios to be studied based on agreement between PAA and analyst. Possible national requirements to be evaluated.

Grid

Whichever results are derived from CFD calculations they will be as good and accurate as the grid used to describe them. Figures 9.19 and 9.20, below, present the effect over flow calculations of having a coarse or finer mesh.





Figures 9.19 and 9.20 – Flow around a cylinder – CFD representation with coarse mesh (9.19) and with finer mesh in the locations of interest (wake field).

It may be argued that finer mesh detail, introducing more calculations will inevitably burden over computational calculation times. There should be a cost-benefit balance between the mesh structure used and the purpose of the work.

To support decision-making in setting Safety Distances there should be, in principle, no special need to be excessively detailed in terms of detailed turbulent structures. The main objective/goal should be the overall definition of a zone where LFL may travel through potentially meeting ignition source. For that purpose the non-linear small scale effects are, in principle, not relevant.

Convergence

Convergence will likely be the main measure of quality of a Computational Calculation. Through a Convergence Test it is possible to compare the quality of results of a given model along iterative calculations, determining a minimum acceptable difference/error (%) between two consecutive iteration results.

LNG cloud dispersion problems following LNG accidental releases, as other fluid flow problems, are highly nonlinear in nature. Only through imposing restrictive conditions can the governing Navier-Stokes equations be solved analytically. As a result, CFD solutions must be calculated iteratively. This begs the question: How do I know when my solution has approximated enough to reality? If no real world results are known for validation, this will be done iteratively between two consecutive results. The question is then how do the analyst, and the PAA, conclude that the solution has converged (to acceptable result)?

Since the point at which the analysis is deemed converged is defined by the judgment of the analyst, he should have a solid understanding of when the analysis has reached its final solution. Typically, when assessing the convergence of a steady state CFD analysis, at a minimum monitor the following three criteria as the analysis progresses:

- Residual Values
- Solution imbalances
- Quantities of interest

Figure

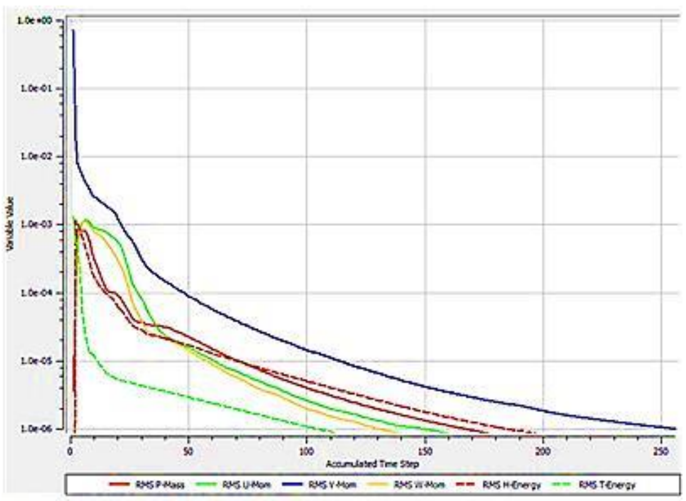


Figure 9.17 – RMS convergence diagram – Minimization of root mean squares of residuals between consecutive iterations.

For CFD, RMS[79] residual levels of 1E-4 are considered to be loosely converged, levels of 1E-5 are considered to be well converged, and levels of 1E-6 are considered to be tightly converged. For complicated problems, however, it's not always possible to achieve residual levels as low as 1E-6 or even 1E-5.

PAAs should, in particular for the CFD results provided, as for any convergence results or, at least, procedures, to be explained in the final report.

The factors included in table 9.12 all contribute collectively to the quality of computational calculations for LNG vapour cloud dispersion. They are mostly related and relevant to CFD calculations. Integral models programming and inputs also have different variables that are to be taken into account. Reports on computational calculation should all include the relevant parameters and assumptions to allow the quality assessment of any computational generated results.

[79] Root Mean Squared (RMS) of residuals, i.e., of error difference values between consecutive iterations.

9.3.5.4 Summary Table

Table 9.13, below, includes a summary of the methodologies, presented in the previous sections, for Safety Distances calculation.

Table 9.13 – Methodologies for Safety Distance Calculation – Summary Table

Method	Advantages	Disadvantages
Analytic	• Good for a first coarse estimation. • No need for complex software, taking into account fundamental first principles.	• May involve complex mathematical calculations. • Difficult geometric visualization of dispersion patterns. • Prone to error
ISO (a) Release of the trapped inventory in the bunkering transfer line **ISO (b)** Constant pressure release of LNG through a broken instrument connection	• Easy to use curves, available in ISO standards	• Lack of information on parameters and conditions behind the curves. • Scenarios for both cases (a) and (b) may not be fully realistic. • For (a) a 25mm hole is seen as a less credible scenario.
Computational – Integral	• Easy to use, with accessible software. • Lighter computational demand, when compared to more complex computer CFD tools. • Adequate for the purpose of setting Safety Distances when local conditions do not present complicated constraints. PHAST ability to model spills on both land and water.	• Usually limited to modelling of circular pools, flat substrates, and heat transfer only from the substrates. • May be insufficient to model situations where LNG vapour dispersion flow is predominantly non-linear.
Computational – Box/Top-Hat	• Fast computational time • Reasonable accuracy.	• Loss of LNG cloud complete structure due to averaging. • Cannot model complex terrain or flow around obstacles.
Computational – CFD/ Navier-Stokes	• Can model complex terrain and flow around obstacles • Typical customised and easy to use interface	• Excessive computational effort and long calculation times. • May introduce errors which are difficult to visualize.

9.3.5.5 Developing Practice

Developing practice is to set the safety zone based on the flammable extent from a maximum credible release of LNG where:

- Maximum credible release is determined by consideration of potential failure scenarios; and
- Flammable extent is the distance to the lower flammable limit (LFL) of the dispersing gas which is approximately 5% methane in air.

The concept of a maximum credible release acknowledges that it is not always possible to set a safety zone based on a worst-case release, but it is always appropriate to set a zone that provides protection of persons in the majority of release scenarios, so called, meaningful protection. It is therefore important that flammable extent is calculated accounting for representative weather and operational conditions, that is, atmospheric stability, wind speed, temperature, humidity, transfer pressure, hose diameter and time to isolate the release. Calculation will also need to consider: release orientation, although results suggest that generally downward releases provide the greatest flammable extent; and release height and surface, as both of these influence dispersion.

Established models using empirical relationships of dispersion phenomena can be used. However, this may need to be supplemented by expert judgement and/or modelling using computational fluid dynamics (CFD) where large obstacles such as ships, buildings and terrain can channel dispersion and significantly increase or decrease horizontal and vertical flammable extent.

Considering release sources and likelihood, and emergency shutdown arrangements, developing practice is tending towards a maximum credible release based on instrument failure. In such cases, and for dispersion modelling purposes, effective release diameters representing ½ inch or ¼ inch have been used (modelled as 5 mm, 6 mm, 10 mm or 13 mm diameter). Obviously, the effective diameter must be determined based on equipment specifics, therefore, ½ inch and ¼ should not be simply assumed as appropriate without justification.

Few modelling results have been published. Table 1 provides some indicative flammable distances (extents) using 'empirical relationship' type models [1]. These distances are for guidance only and are not intended to replace modelling and expert judgement/analysis with respect to bunkering specifics.

Table 9.14 – Indicative Flammable extent (meters) – Summary Table

	Transfer Pressure (barg)				
	3	**5**	**6**	**7**	**9**
F2 – stability F, wind speed 2 m/s					
Release at 1 m elevation onto					
Water	100	115	120	125	130
Land	95	100	NA	110	115
Release at 3 m elevation onto					
Water	100	115	120	125	130
Land	95	100	NA	110	115
A1 – stability A, wind speed 1 m/s					
Release at 1 m elevation onto					
Water	40	45	50	55	60
Land	40	45	NA	55	60
Release at 3 m elevation onto					
Water	50	55	60	60	65
Land	45	55	NA	60	65

Notes

1. All values above refer to horizontal extent from the release point. Vertical extent approximated 5 m in all cases.
2. Effective release diameter, ½ inch. 4 inch diameter hose.
3. Downward releases determine maximum extent in F2 (clear night, low wind speed, little or no cloud cover).
4. Horizontal impinged releases determine maximum extent in A1 (hot still day, no clouds cover).
5. Modelled using PHAST assuming: 100% methane, 420 kg/m^3; continuous release at transfer pressure; 74% relative humidity; surface roughness of 0.1 for releases onto land (concrete) and 5 mm for releases onto water; operating temperature of minus 160 degC; lower flammable limit (LFL) of 5% at 44,000 ppm (v/v); and a default 'averaging time' of 18.75 s.

9.3.6 Approval

Approval of Safety Zone is of the responsibility of the PAA during **Permitting**, subject to Confirmation prior to each Operation, at Pre-Bunkering phase:

1. **Permitting**: During presentation of the project/facility for Permitting, where the intended Safety Zones should be specifically indicated in the LNG Bunkering Management Plan. Operators will include the calculation
2. **Pre-Bunkering**: Prior to LNG bunkering operation, PAA should check consistency with permit approved Safety Zone.

The following elements should be checked for approval of Safety Zones by PAAs:

1. **Permitting (Approval** of Safety Zone**)**:
   - **A. Identification of Safety Zone in suitable diagrams/plans where the whole LNG bunkering system is represented, including surrounding infrastructure elements**. All relevant areas within the proposed Safety Zone should be clearly identified with the indication of points of contact for each area.

     Areas in the vicinity of the Safety Zone should also be clearly identified in particular indicating the existence of: 1) Hazardous Zones; 2) Populated areas; 3) Potential Ignition sources or 4) Gas trapping points.

     Should different Safety Zones have been approved during Permitting, all should be included in the diagram view, with the reference to the parameters followed
   - **B. Supporting Report with Calculations** for the definition of the Safety Zone. One or more of the references below should be presented:
     - i. Analytical Calculations, based on first principles calculation, following
     - ii. ISO Methodologies, following ISO/TS 18683, or ISO 20519, curves for ISO (a) or (b) methods, with the clear indication of the parameters assumed to read from the curve
     - iii. Computational calculations/CFD, identifying the responsible person for the calculations, the code used, assumptions followed and parameters used for modelling, verification & validation procedures, including convergence of model, with an RMS of less than 1E-5, mesh refinement location, boundary conditions.
   - **C. LNG Bunkering Management Plan,** to be checked for reference to Safety Zones, in particular provisions for its establishment and control.

2. **Pre-Bunkering (Confirmation** of Safety Zone**):**
   - **A. Confirmation of LNG bunkering parameters,** as indicated in the LNGBMP. Prior to initiation of LNG bunkering operation the Safety Zone must be Confirmed, taking into account the verification of the LNG bunkering parameters, local conditions, potential restrictions and other factors that may have to be accounted for by PAAs, in conjunction with Operators. (RSO and BFO).
   - **B. Safeguards,** with the verification that safeguards contributing to the definition of the Safety Zone, possibly defined in a risk assessment, are implemented.
   - **C. Context Evaluation,** considering any operational aspects which had not been foreseen during permitting, including any possible construction/maintenance works, temporary modifications,

As per the above it is important to note that a Safety Zone should only be implemented if: **Approved and Confirmed**. Elements relevant to the Approval should be documented as part of the Permitting/Certification documents. Those relevant to the Confirmation should be part of the Authorization documents, i.e. supported by check-list procedure.

9.3.7 Enforcement

Following its Approval and Confirmation, the Safety Zone is implemented by the Operators (BFO/RSO) and controlled/verified by the PAAs. Other arrangements are however possible, based on each port regulation or possible agreement with between operators and PAAs.

The following elements should be in place to enforce the Safety Zone:

- Physical barriers
- Visual support with warning, prohibitions and information on points of contact for BFO and PAA (figure 9.18).
- Contacts for Emergency
- Portable semaphores (wherever found relevant for traffic control, inside the port area or in any adjacent road).

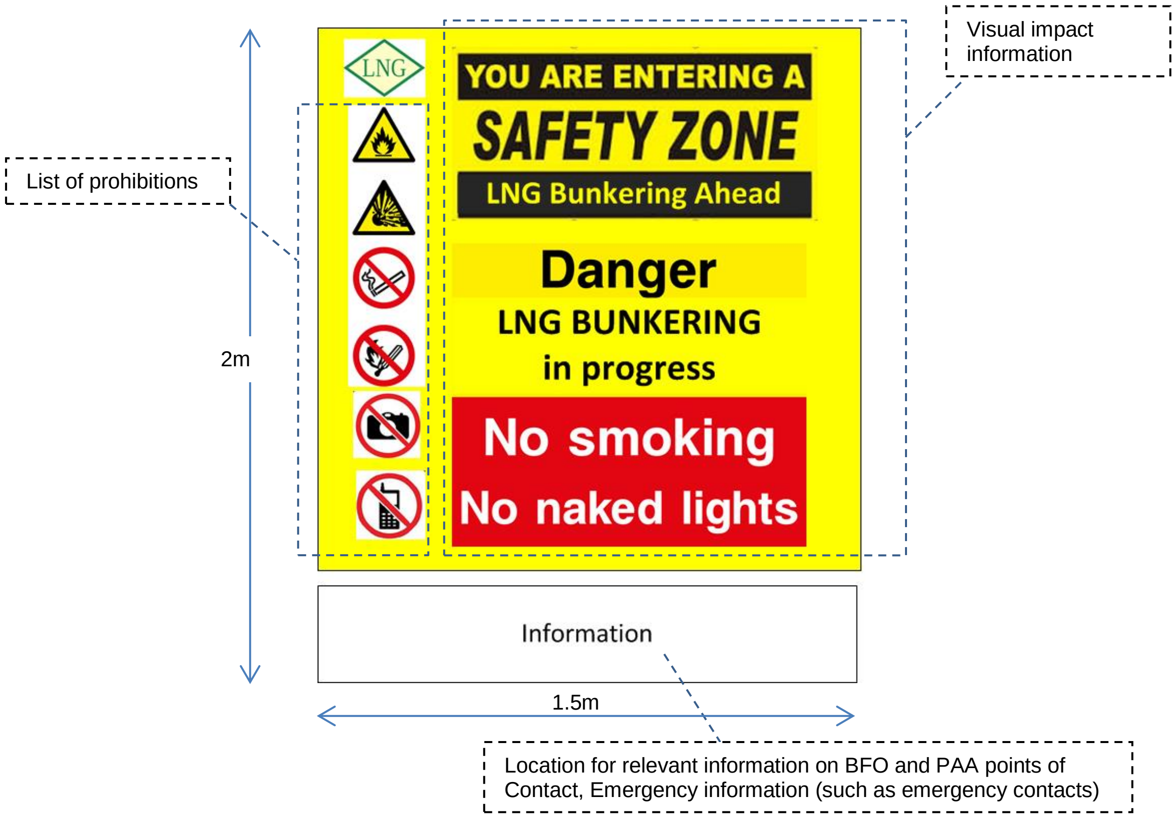


Figure 9.18 – LNG Bunkering Safety Zone notice – Suggested notice at main safety zone entrance points. Main objective is to support the actual control in the implementation of the Safety Zone, through an adequate level of warning/ information.

All the resources and means to establish monitor and control the Safety Zone should be provided by the Operators, subject to inspection/verification by PAAs.

The exact number of barriers and their location will be highly dependent on the local infrastructure and access points. Special attention should be given to areas where the proximity of densely populated areas requires the introduction of possible safeguards defined in a Risk Assessment. All the defined safeguards as described in the LNGBMP should be enforced as appropriate.

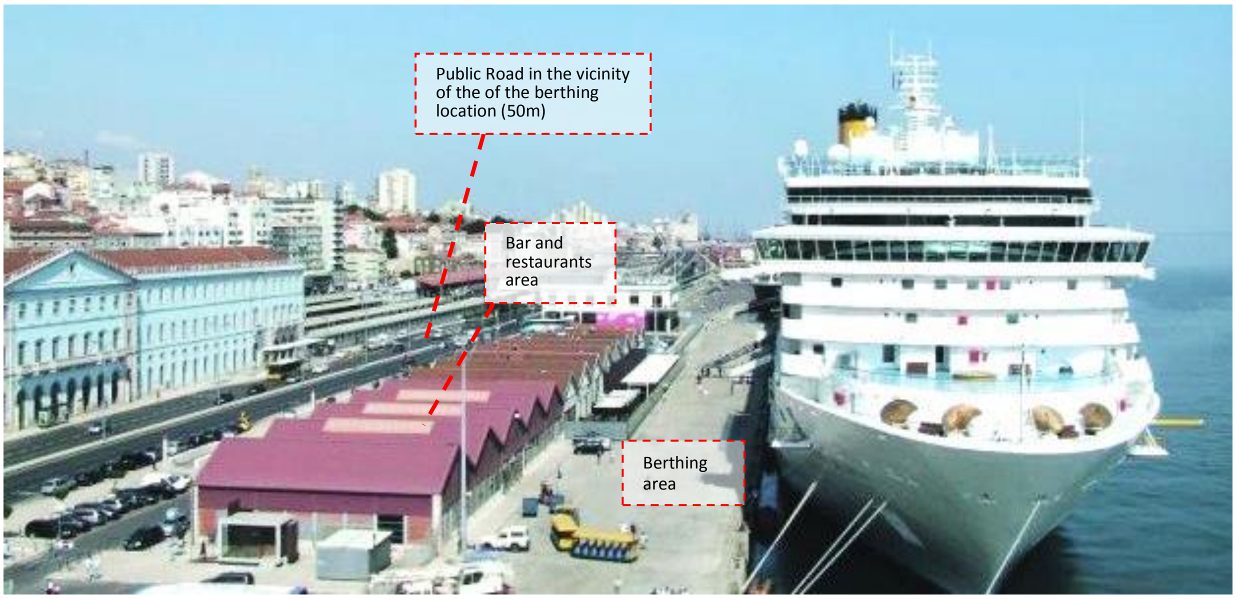
9.3.8 Implementation

The implementation of the Safety Zone may find some particular aspects that should be evaluated in a risk assessment. Each port will represent a particular challenge to implementation with different operational constraints and proximity to populated or commercial areas. In this section two special situations are addressed: 1) Proximity of a public road and 2) Other ships crossing the Safety Zone.

1) Proximity of a public road

Where the Safety zone is crossed by traffic routes which cannot be halted for long periods (typically in ports highly integrated with more populated locations) there should be control over traffic lanes that could, in the event of an LNG accidental release, be stopped. This can potentially be achieved with good coordination and alarm dissemination that allows, on one hand the normal traffic operation and, on the other hand, the LNG bunkering location in a densely populated area.

An example is shown in figures 9.19 and 9.20 on how a Safety Zone can be established in a berthing location of a port which is highly integrated with a public area within a city. The example shown is characteristic of many cruise ship terminals, reflecting an aspect which is familiar in many ports in Europe. LNG bunkering in such situations would necessarily have to address all the context elements in a risk assessment. In the case presented below the elements are only shown as an exercise under the topic of “safety zone enforcement”. It is here assumed that all define safeguards were derived from a risk assessment approved by PAAs.



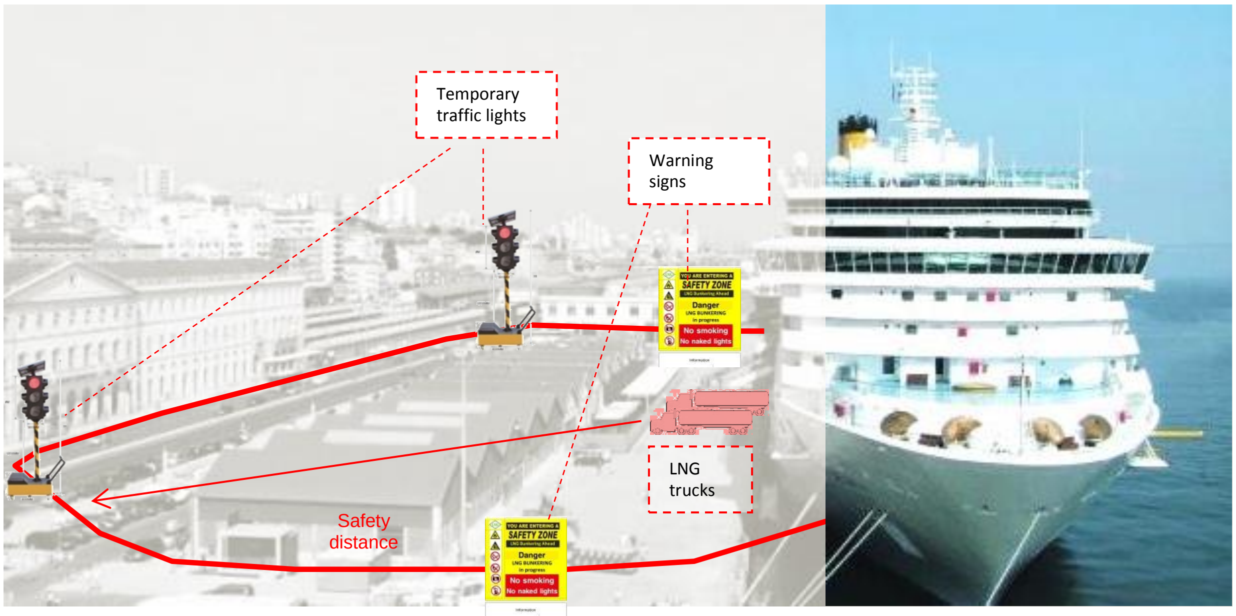


Figure 9.19 (above) and 9.20 (below) – LNG Bunkering Safety Zone implementation – Suggested elements for Safety Zone implementation. The elements presented are only an example set for demonstration on how a Safety Zone may be established even I areas of port integration with populated areas. A risk assessment should always be the basis for the establishment of such elements.

Referring to the example in figures 9.19 and 9.20, the following measures could be considered for the implementation and enforcement of the Safety Zone:

1. Confirm the Safety Zone as outlined in 9.3.6, verifying elements from the LNGBMP
2. Define physical barriers where feasible, as shown in figure 9.20, at the top ends of the berth.
3. Introduce Warning Signs, with information on both ends of the berth.
4. Include all commercial areas inside the Safety Zone, ensuring Ventilation intakes not in operation and isolated.
5. Place mobile/portable traffic lights, automated and, if possible ESD-connected, to halt traffic in the event of an accident.

The procedure above would have to be the result of a risk assessment, respecting the safeguards discussed and in place.

Such a bunkering operation would preferably take place at times when restaurants would still be closed and with minimum typical traffic intensity.

Even though ISO/TS 18683 and ISO 20519 definition is clear in indicating define Safety Zone as ***the area around the bunkering station where only dedicated and essential personnel and activities are allowed during bunkering,*** it should be possible to consider crossing of a Safety Zone area, if sufficient safeguards and risk mitigation measures are put in place.

2) Other ships and the Safety Zone

Another possible implementation challenge that may arise during LNG bunkering operation is the possibility for other ships intending to cross the Safety Zone. How to consider this situation should be a possibility addressed in the context of a risk assessment. Figures 9.21 illustrate this situation and (vessel identified with nr.3), adding 2 more vessels: one at berth, inside the Safety Zone (nr.4) and another in the vicinity of the Safety Zone (nr.6).

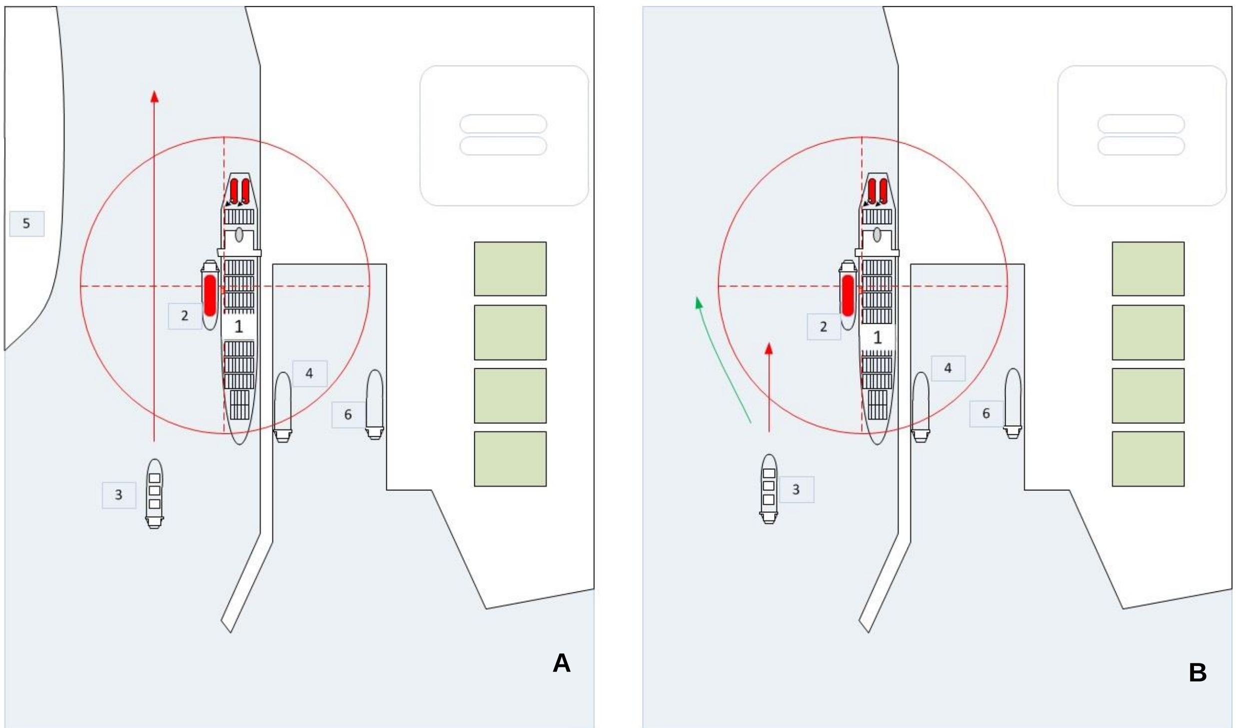


Figure 9.21 (left) and 9.22 (right) – LNG Bunkering Safety Zone implementation – Representation of two different situations where a vessels intends to cross the Safety Zone.

For vessel nr.3, in situation "A" (figure 9.21), the restricted channel gives it no chance to deviate from the Safety Zone, whereas in "B" this is not the case and sufficient clear waters exist to avoid crossing the Safety Zone established for the STS operation, should it be signalled. PAAs should ensure that both these situations are addressed.

Should passing through the Safety Zone be inevitable (situation "A"), there should be in place a procedure to make the Safety Zone limits well visible and to allow the passing vessel to do so in the safest way possible. On the other hand for passing vessels which have the option to pass farther they should be directed to do so, avoiding the Safety Zone.

All communications to be done should be established in the port radio call frequency.

An alternative would be to create a Marine Exclusion zone, as defined in figure 9.3 (SGMF Guidelines v2, 2016, [35]), introducing a higher disruption in the port activities and operations, but making it possible to prevent any passages through the Safety Zone (see figures 9.23 and 9.24, below).

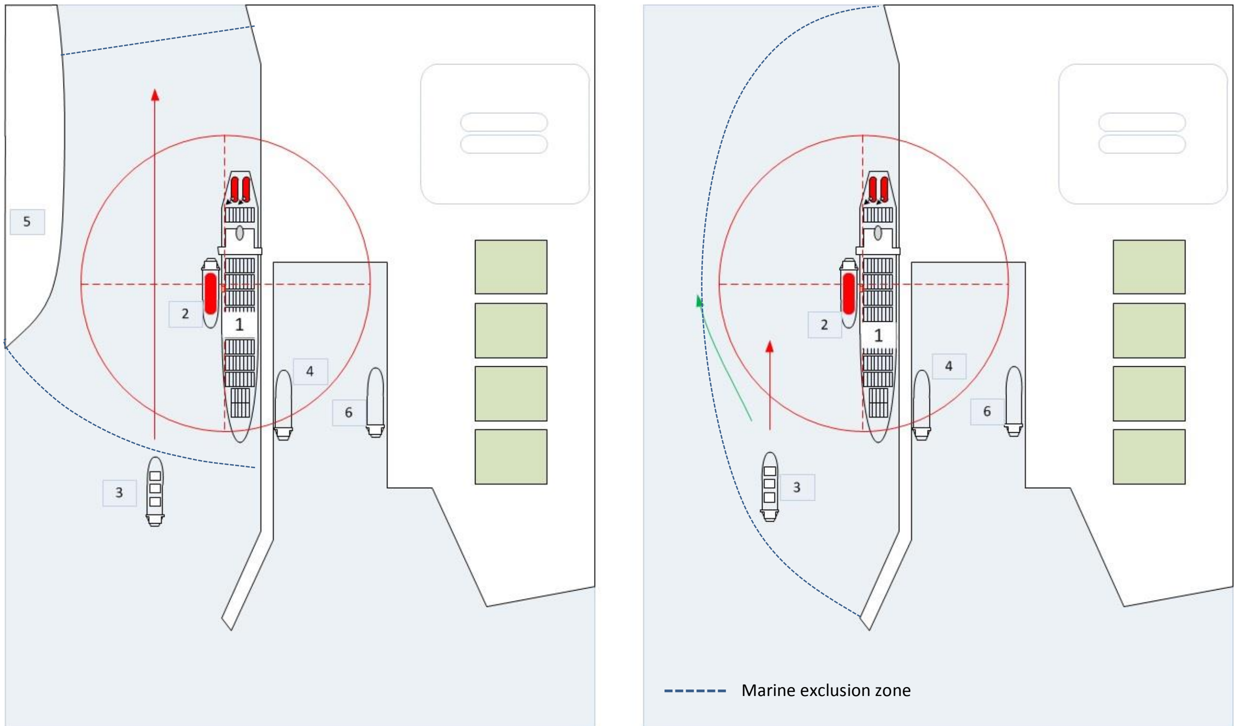


Figure 9.23 (left) and 9.24 (right) – LNG Bunkering Safety Zone implementation – Marine exclusion zones designed to avoid the proximity of the passing by vessel.

For passing vessels the following possibilities are available to PAAs which, for allowing other ships to pass the Safety Zone, can establish

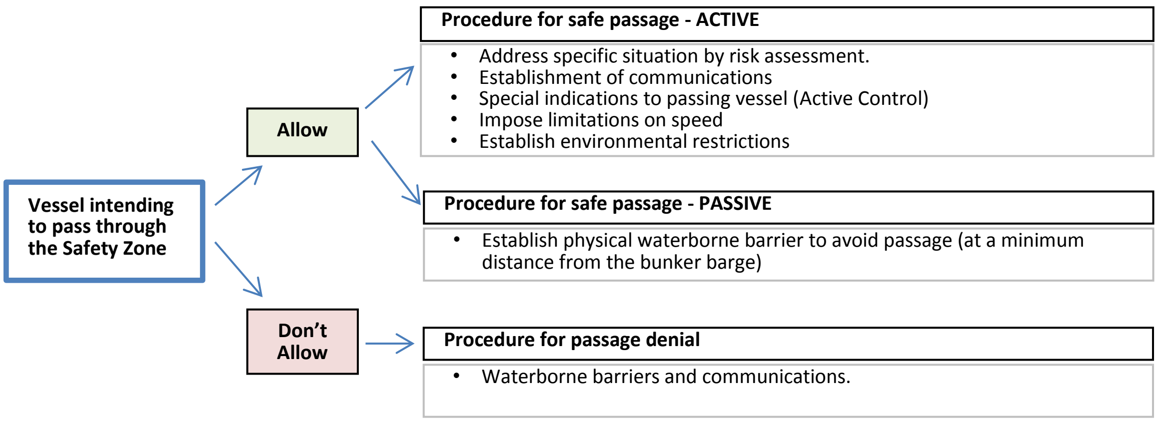


Figure 9.25 – Vessel passing through Safety Zone – Options to PAA for consideration to vessels intending to pass through the Safety Zone.

For vessel nr.4, at berth, just inside the Safety Zone, there should be given indication for special protective measures to be implemented. The establishment of communications and the designation of a point of contact onboard should be the main measures to consider. In the event of an accidental LNG release it is important to disseminate alarm and give the possibility for other vessels within the Safety Zone, or in a nearby location, to shut-down ventilation and establish other measures for the immediate mitigation of ignition risk.

For vessel nr.6, at berth in a nearby location, the measures to consider should be judge by the PAA. In principle, as a good practice orientation, should the vessel be just outside the Safety Zone, the procedure to implement should be exactly the same as with nr.4.

It is important that the Safety Zone is not regarded as a fixed boundary where risk increases from “no risk” to “maximum risk” just by crossing the virtual boundary of the Safety Zone. More than the geometric exercise of the Safety Distance it should be important to check for actual meaningful protection within the Safety Zone and in its vicinity, where justifiable and appropriate.

Finally, for every case presented, it is important to make note that each port will necessarily present a different specific reality and context. Each port will be different in terms of spatial planning, restrictions, intensity of nautical traffic or operations within the port area in a multi-operator environment. All measures should however be taken, in cooperation between operators and PAAs, so that LNG bunkering takes place at a location and time where and when less disturbance is expected.

9.4 Security Zone

Unlike Hazardous Zones and Safety Zone, which are determined by the probability of presence of explosive atmosphere in the respective control zones, and the need to mitigate the risk of ignition and accident escalation, the Security Zone addresses external factors.

9.4.1 References

The reference standards for the definition of the Security Zone are:

ISO/TS 18683:2015 Guidelines for systems and installations for supply of LNG as fuel to ships	ISO	http://www.iso.org/iso/ (available for purchase)	The Security Zone is introduced in both documents, with a definition: *The security zone where ship traffic and other activities should be monitored during bunkering will always be larger than the safety zone. Physical barriers preventing other ships to approach the bunkering (e. g. like breakwaters) can be reflected in the definition of the security zone*
EN ISO 20519 - Specification for bunkering of liquefied natural gas fuelled vessels	ISO	http://www.iso.org/iso/ (available for purchase)	
IACS Rec 142 LNG Bunkering Guidelines	IACS	http://www.iacs.org.uk/publications/recommendations/ (available for free)	IACS Rec.142 and SGMF Guidelines, share the same definition: *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.*
SGMF **LNG Bunkering Guidelines** Safety Guidelines **Version 1** February 2015 **Version 2** April 2017	SGMF	www.sgmf.org (available for purchase)	

9.4.2 Definitions

As defined in ISO standards ISO/TS 18683 and ISO 20519:

The security zone is a zone *where ship traffic and other activities should be* <u>*monitored*</u> *during bunkering,* making the note that it should *always be larger than the safety zone.*

The term "monitored" in the definition is the most important term with regards to the Security Zone. It brings the responsibility to the PAA to monitor the activities in the vicinity of the LNG bunkering operation, developing the necessary measures to mitigate any risk of these activities affecting the LNG bunkering operation.

9.4.3 Objective

The objectives of the Security Area are:

- Monitor other activities and operations in the vicinity of the LNG bunkering location.
- Identify potential risks to the LNG bunkering operation derived from activities in course or planned to take place in the port area.
- Define an area where special provisions are possible, over a limited period of time, shortly before the LNG bunkering location until shortly after (from pre-bunkering stage to post-bunkering).

The following activities, external to the Safety Zone, but in the vicinity of the LNG bunkering location, should be considered to be monitored during the establishment of the Security Zone:

- Other ship/ship passing in the vicinity of the bunkering location.
- Ships at berth in nearby position
- Surrounding road traffic, industrial plants, factories and public facilities, including restaurants, shopping centres and other commercial.
- Vehicle movement inside the port area
- Drones
- Cranes and other loading/unloading operations
- Construction and maintenance works
- Works on electricity distribution/junction boxes
- Utilities and telecommunication activities and infrastructure

9.4.4 Calculation

The Security Zone is not directly related to LNG vapour cloud dispersion, nor is it the result of concerns with regards to the probability of explosive atmospheres. It is a control zone defined following the operational evaluation in the vicinity of the LNG bunkering area, to mitigate any risks of impacts from external factors.

The only important geometry constraint for the Security Zone is that it should not be inferior to the Safety Zone.

9.4.5 Approval

The Security Zone is the responsibility of the PAA, reflecting the situational awareness of the port area in any given moment.

It is suggested as good practice that an internal approval process should be developed by PAAs to ensure that the definition of a Security Zone is a documented procedure of shared responsibility within the PAA.

Definition and approval of the Security Zone should be based on the elements provided by the Operators, remarkably on the proposed safety zone.

9.4.6 Enforcement

PAAs should enforce Security Zones by either physical barriers or by communications with all the points of contact/responsible coordinators involved in the port activities to monitor. It is important, more than the guarantee of physical barriers, that all activities are monitored and that communications are established with each different operators to ensure early warning and alarm dissemination in the event of any problems with the bunkering operation.

9.5 Meaningful Protection

The Concept of Meaningful Protection involves the combination of the all the three above defined Control Zones. It recognizes that only by an effective implementation and control of all control zones it will be possible to achieve Meaningful Protection to the LNG bunkering operation, surrounding populations, infrastructure and activities.

Below, the diagram in figure 9.26, presents the different control zones, and PAA evaluation, contributing collectively to define meaningful protection during LNG bunkering operation.

Figure 9.26 – Meaningful Protection

The Concept of Meaningful Protection will be especially relevant for the establishment of the Safety Zone, in particular where a given calculated Safety Zone is defined and implemented, including in its vicinity potential ignition elements or locations with significant gas trapping probability.

In fact, regardless the calculation methodology followed for a Safety Zone there is nothing that can replace the on-site judgement of context, operations, ongoing construction works, modifications, amongst other local and time dependent effects that should be judged in conjunction by operators and PAAs prior to LNG bunkering operations.

The main starting point, for the Safety Zone definition, should be the calculation elements, either derived from deterministic or probabilistic methodologies. From the calculations a more or less regular Safety Zone should be determined and approved. Whether this Safety Zone is, in fact, providing meaningful protection against possible hazardous outcomes of an LNG accidental release should however take an additional element into account: <u>the shared judgement of the onsite situational awareness</u>.

Example of application of the Meaningful Protection example:

Figures 9.27 and 9.28, below, include an example of the application of the Meaningful Protection concept. In “A” it is represented a regular circular shaped Safety Distance, with a radius calculated following any given maximum credible release scenario. It can be seen in the same situation “A” that several elements nearby the bunkering location, yet outside the Safety Zone, are either potential ignition sources or gas trapping points where explosive atmospheres can easily be created following the passage of an LNG dispersing cloud.

Everything in “A” is according to the existing reference framework for LNG bunkering. The Safety Zone is established according to any of the reference calculation methodologies and the implementation should present no major challenges.

A reading of the surrounding area, just outside the safety zone, identifies a transforming station/ junction box, a ventilation intake point for a commercial area and a harbouring basin, in the vicinity, not fully covered by the safety zone.

Together, operators and PAA, determine that notwithstanding the conformity of the Safety Zone, calculated by the relevant applicable methodologies, its implementation should consider the need to include also the above listed elements.

In “B” (figure 9.28) the Safety Zone is expanded on the basis of the understanding between operators and PAA that an increased level of protection would be provided through an adapted modification of the Safety Zone, as calculated, to also incorporate the elements of concern.

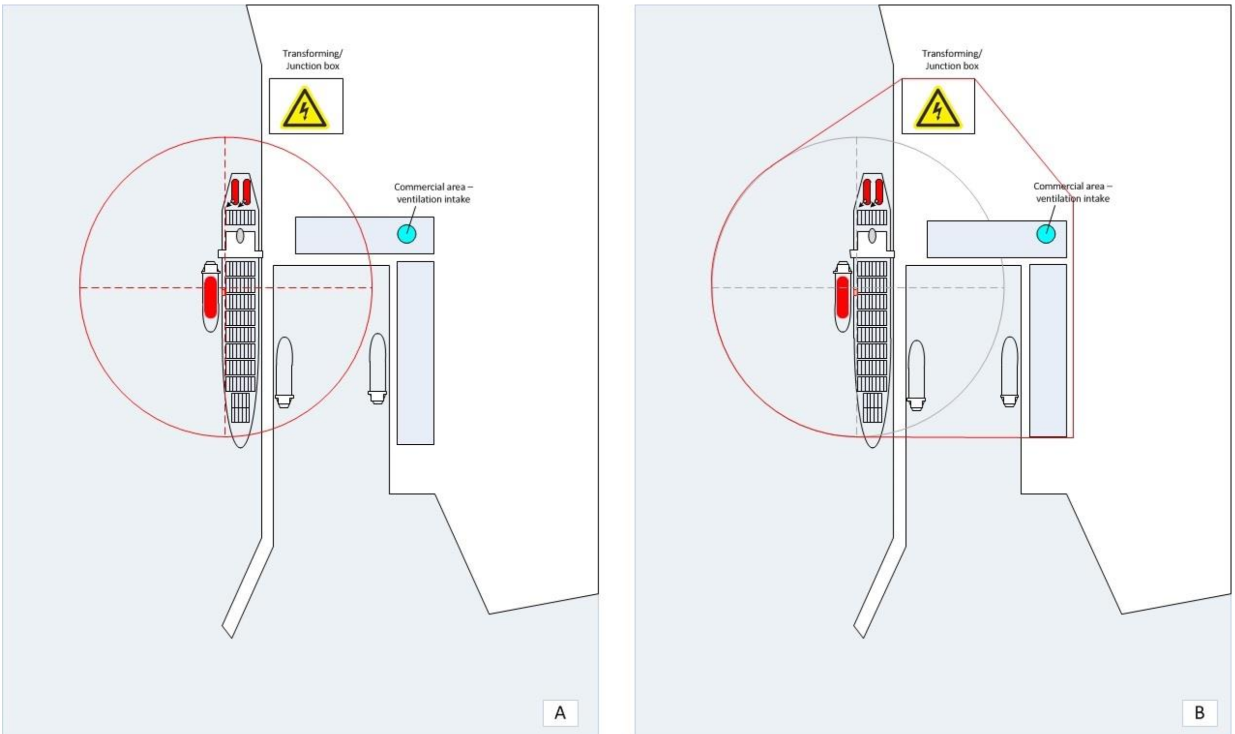


Figure 9.27 and 9.28 – Setting the Safety Zone – Meaningful protection – Calculated Safety Zone (A) vs Adapted Safety Zone for Meaningful Protection.

Challenges may then result from the implementation of actual protective measures on the Transforming/ Junction-Box, ventilation intake or ships at berth in nearby location.

Different ports will of course present different contexts, activities or operational situations which may be well addressed by the Security Area concept, with the monitoring of other nearby activities (see section 9.4). In the example presented in figures 9.27 and 9.28 the Security Area concept would be deemed potentially insufficient. There would in fact be no risk to the LNG Bunkering operation solely due to the Transforming Station, Ventilation intake or even other ships at berth in nearby location.

Figure 9.29, below, shows the suggested collective set of control zones to implement in the presented LNG bunkering exampled to STS transfer.

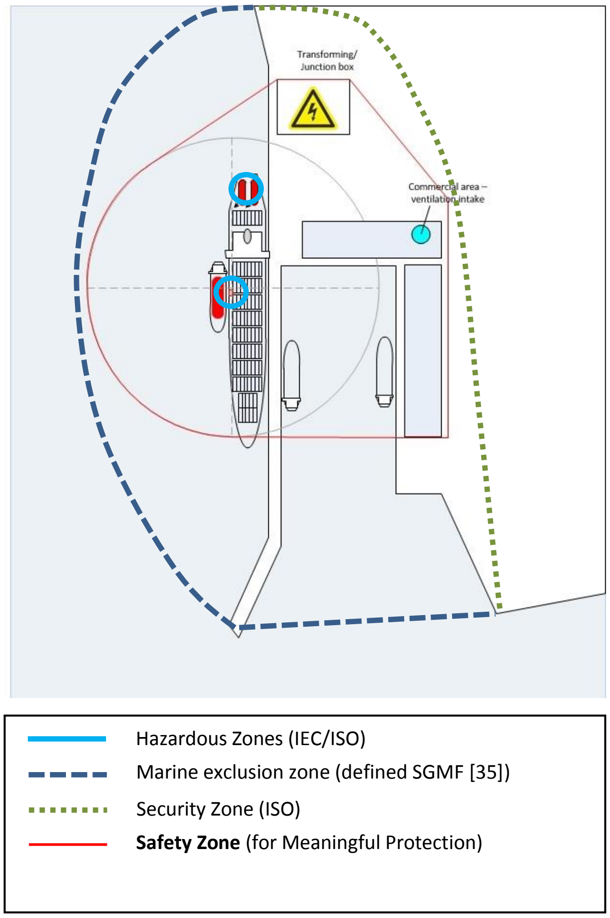


Figure 9.29 – Setting the Safety Zone – Meaningful protection

The procedure below is suggested for the confirmation of Safety Zones, respecting the concept for Meaningful Protection and the authorization procedure (section 9.3.6):

1. **Stakeholders identified**, with operators and PAA considering all relevant information to confirm the Safety Zone, prior to LNG bunkering operation. Safety Zone as approved in the LNGBMP.
2. **Indicative flammability range based on published research and LNG vapour dispersion studies** (e.g. SGMF, LR, BV, etc.), with consideration for different operating/weather example parameters, and using different computational model sources.

   (Stakeholders can model the actual situation to provide a more site specific range)
3. **Reasons/Controls to increase or decrease the dispersion range** identified, and investigated with respect to Impact

   (Supported by expert judgement, dispersion modelling and/or QRA, as appropriate, wrt site operational and weather specifics)
4. **Proposed Safety Zone** informed by 1 and 2
5. Stakeholders discuss and **agree on the Safety Zone to be set**.

9.6 Control Zones in LNG Fuelling

Control Zones in LNG fuelling should follow the exact same principles as in LNG bunkering. The same methodologies are applicable for definition of Hazardous Zones, which are dependent on design elements where the frequency of occurrence of explosive atmospheres is known. As defined in section 9.2, these elements will include connections, manifolds, venting and PRVs.

The main evident factors which are likely to influence the shape of control zones, when compared to LNG bunkering, are:

(1). Much lower LNG flow rates transferred to receiving ship, as the evaporator onboard feeds directly a DF generator.

(2). Longer period of stay, potentially during the whole stay of the ship at berth, providing LNG to DF generator onboard.

Above, (1) is an indicator for a potentially reduced safety zone, corresponding to a very small credible release scenario resulting from an accidental release.

On the other hand (2) above should give indication to an extended Security Zone. With trailer present close to the ship for longer periods the need to account for, control and monitor other operations and activities is reinforced.

Figure 9.30, to the right, shows the relevant control zones to consider for LNG fuelling operations.

Figures 9.31 and 9.32, below, represent an LNG fuelling operation, with LNG supplied to a ship from an LNG truck.

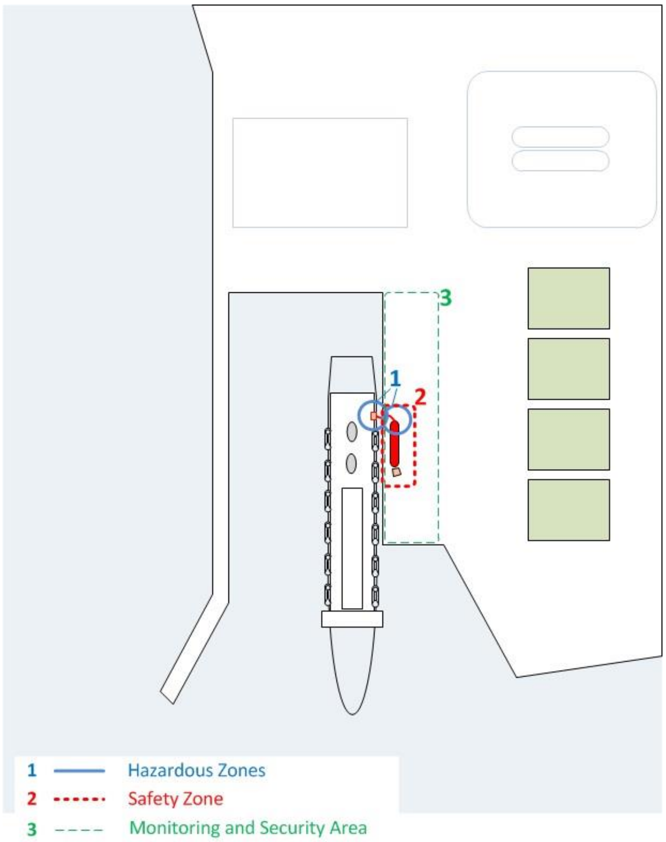
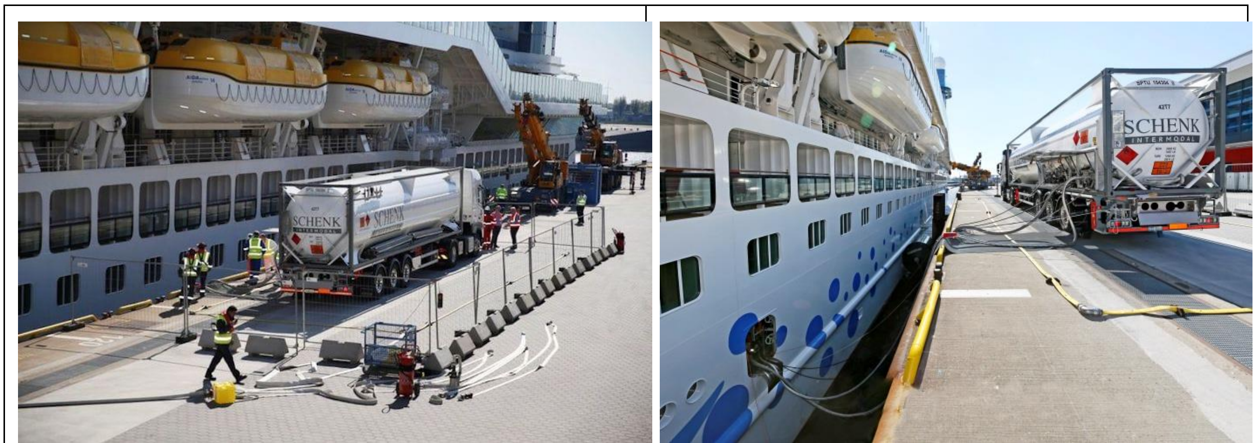


Figure 9.30 – Control Zones in LNG fuelling



Figures 9.31 and 9.32 – LNG Fuelling operation – to be noted the safeguards in place with the Security Zone well noted with concrete traffic barriers (to mitigate risks from external factors).

9.7 Good Practice in Control Zones

The present section summarizes the main good practice elements regarding Control Zones applicable in LNG Bunkering.

9.7.1 Generic First Principles

R9.1. Control Zones are fundamental principles for Safety in LNG bunkering operations. PAAs should support their evaluation of proposed Safety D Generic first principles that should be observed in all control zones determination:

- **Control Zones act as layers of defence – Only working collectively and effectively implemented they will provide the necessary safeguard and risk mitigation.**
- **There is no hierarchy amongst Control Zones – No control zone is more relevant than the other. They address different risks and only collectively it is possible to ensure safe LNG bunkering operation.**
- **The Safety Zone must be larger than the Hazardous Zone(s) in all three dimensions.**
- **The Monitoring and Security Area must be larger than the Safety Zone.**
- **Hazardous Zones are present at all times, whilst Safety Zones and Monitoring and Security Areas will be present only during Operations.**
- **The only measure of adequacy for a Safety Zone should be the level of protection granted by its implementation. The different calculation methodologies for Safety zones will only provide estimated flammability extents. There is the need to evaluate the local conditions, infrastructure and ensure that the calculated Safety Distance is adequate for the intended protection.**
- **Factors affecting the calculation of Safety Distances:**
    1. **Bunkering parameters (pressure, temperature)**
    2. **Potential for excessive BOG generation.**
    3. **Weather factors (in particular wind)**
    4. **Other activities nearby (remarkably those involving also safety distances)**
    5. **Local infrastructure**
    6. **Receiving ship characteristics**
    7. **Implemented safeguards, resulting from risk assessment**
- **PAAs should have procedures for the evaluation, support in implementation, control and enforcement of Control Zones.**
- **Controls Zones are only effective if effectively controlled and enforced.**

R9.2. Fixed Safety Distances, established/fixed for ship type (RSO) of LNG bunkering mode (STS, TTS, and PTS) are not recommended. All Safety Zones should be supported by calculations based on assumptions that closely reflect local conditions.

R9.3. In addition to the first principles presented in the previous page, and to the general procedure suggested above, in the diagram of figure 9.4, the present Guidance <u>Control Zones “minimum requirements” and “meaningful protection” should necessarily be considered together:</u>

a. **<u>Minimum requirements</u> will be derived directly from standards, direct/numerical calculations or modelling. References can be given for minimum required control zones and area definition.**

b. **<u>Meaningful protection</u> is based on the implementation of the minimum requirements, adding to it a critical iterative judgement of the situational**

scenario, infrastructure and local conditions at the time of LNG bunkering operation. This will be the concept further explored in section 9.5.

R9.4. The following share of responsibilities should be considered as good practice for the definition, approval and implementation/enforcement of Control Zones:

Table 9.15 – Responsibilities in Control Zones

	Calculate/Determine	Plan	Approve	Implement	Control
Hazardous Zone	**BFO/RSO**	**N/A**	**PAA, for the bunkering interface** (Hazardous Zones on the ship side approved as per Ship Certification/Flag approval)	**RSO/BFO**	**PAA**
Safety Zone	**BFO/RSO**	**BFO/PAA**	**PAA**	**BFO,** with PAA support	**PAA**
Security Zone	**PAA**	**PAA**	**PAA** (internal approval procedure)	**PAA**	**PAA**

Different arrangements are possible from those in table 9.15, above, and may be accepted based on agreement between PAA and operators.

9.7.2 Hazardous Zone

R9.5. Approval of Hazardous Zones is of the responsibility of the PAA during the evaluation of the project proposal, in the course of the permitting process.

The following elements should be checked for approval of Hazardous Zones by PAAs:

a. **Identification of all Hazardous Areas in suitable diagrams/plans where the whole LNG bunkering system is represented. Zones 1 and 2 should be clearly identified and related to the following elements in the bunkering system**

   i. **Bunkering manifolds, their flanged connections or containment coamings**

   ii. **Flanged connections along the bunkering line**

   iii. **Venting lines, GCUs**

   iv. **ERC**

   v. **QC/DC bunkering connectors**

   vi. **Any flanged connection along the bunkering transfer system**

   vii. **Bunkering articulated arms, in particular where swivel LNG piping joints are present, mechanical elbows and other articulated connections.**

b. **Identification of the references for each Hazardous Zone presented. One or more of the references below should be presented:**

   i. **IEC 60079-10-1, indicating which assumptions were followed for the definition of the Hazardous Zone extent.**

ii. IGF/IGC Code, making reference to the code, in particular indicating pressure and temperature windows defined for the bunkering. The reasoning behind this note is, in particular, relevant to check compatible physical p-t conditions between LNG delivered and LNG

iii. Other Codes, in particular if national/regional standards have been followed, other than IEC/EN related.

iv. CFD, identifying the responsible person for the calculations, the code used, assumptions followed, verification & validation procedures, including convergence of model, mesh refinement location, boundary conditions.

R9.6. LNG Bunkering management Plan, to be checked for reference to Hazardous Zones, in particular provisions for its establishment and control.

R9.7. Enforcement of Hazardous Zones should be done during in-service inspection of LNG bunkering facilities for Ex-proof confirmation of the whole inventory of electrical equipment used

To support in this task, PAAs should request to operators a full updatable inventory for Ex-proof equipment, consisting of a list of electrical equipment that can subject to verification/check for Ex-proof conformity. Only electrical equipment contained in that list should be present in operation.

Other potential ignition sources, other than electrical equipment should be looked for.

Upon any finding which may raise concern regarding to insufficient ignition source mitigation, the LNG bunkering operation should be halted until the findings are resolved.

R9.8. In-service inspections for Control Zone enforcement should be conducted with minimum impact in the planned course for the LNG bunkering operation, not leading to unnecessary undue delays to all operators involved.

9.7.3 Safety Zone

R9.9. Approval of Safety Zone is of the responsibility of the PAA during Permitting, subject to Confirmation prior to each Operation, at Pre-Bunkering phase:

a. Permitting: During presentation of the project/facility for Permitting, where the intended Safety Zones should be specifically indicated in the LNG Bunkering Management Plan. Operators will include the calculation

b. Pre-Bunkering: Prior to LNG bunkering operation, PAA should check consistency with permit approved Safety Zone.

R9.10. The following elements should be checked for approval of Safety Zones by PAAs:

a. Permitting (Approval of Safety Zone):

i. **Identification of Safety Zone in suitable diagrams/plans where the whole LNG bunkering system is represented, including surrounding infrastructure elements. All relevant areas within the proposed Safety Zone should be clearly identified with the indication of points of contact for each area.**

Areas in the vicinity of the Safety Zone should also be clearly identified in particular indicating the existence of: 1) Hazardous Zones; 2) Populated areas; 3) Potential Ignition sources or 4) Gas trapping points.

Should different Safety Zones have been approved during Permitting, all should be included in the diagram view, with the reference to the parameters followed

ii. **Supporting Report with Calculations for the definition of the Safety Zone. One or more of the references below should be presented:**

(1). **<u>Analytical Calculations</u>, based on first principles calculation, following application of relevant mathematical formulation and geometry for dispersion visualization**

(2). **<u>ISO Methodologies</u>, following ISO/TS 18683, or ISO 20519, curves for ISO (a) or (b) methods, with the clear indication of the parameters assumed to read from the curve**

(3). **<u>Computational calculations/CFD</u>, identifying the responsible person for the calculations, the code used, assumptions followed and parameters used for modelling, verification & validation procedures, including convergence of model, with an RMS of less than 1E-5, mesh refinement location, boundary conditions.**

iii. **<u>LNG Bunkering Management Plan</u>, to be checked for reference to Safety Zones, in particular provisions for its establishment and control.**

b. <u>Pre-Bunkering (Confirmation of Safety Zone):</u>

i. Confirmation of LNG bunkering parameters, as indicated in the LNGBMP. Prior to initiation of LNG bunkering operation the Safety Zone must be Confirmed, taking into account the verification of the LNG bunkering parameters, local conditions, potential restrictions and other factors that may have to be accounted for by PAAs, in conjunction with Operators. (RSO and BFO).

ii. Safeguards, with the verification that safeguards contributing to the definition of the Safety Zone, possibly defined in a risk assessment, are implemented.

iii. Context Evaluation, considering any operational aspects which had not been foreseen during permitting, including any possible construction/maintenance works, temporary modifications,

R9.11. As per the above it is important to note that a Safety Zone should only be implemented if: <u>Approved and Confirmed</u>. Elements relevant to the Approval should be documented as part of the Permitting/Certification documents. Those relevant to the Confirmation should be part of the Authorization documents, i.e. supported by check-list procedure.

9.7.4 Security Zone

R9.12. The Security Zone is the responsibility of the PAA, reflecting the situational awareness of the port area in any given moment.

R9.13. It is suggested as good practice that an internal approval process should be developed by PAAs to ensure that the definition of a Security Zone is a documented procedure of shared responsibility within the PAA.

R9.14. Definition and approval of the Security Zone should be based on the elements provided by the Operators, remarkably on the proposed safety zone.

R9.15. PAAs should enforce Security Zones by either physical barriers or by communications with all the points of contact/responsible coordinators involved in the port activities to monitor. It is important, more than the guarantee of physical barriers, that all activities are monitored and that communications are established with each different operators to ensure early warning and alarm dissemination in the event of any problems with the bunkering operation.

9.7.5 Meaningful Protection

R9.16. The procedure below is suggested for the confirmation of Safety Zones, respecting the concept for Meaningful Protection and the authorization procedure (section 9.3.6):

a. **<u>Stakeholders identified</u>, with operators and PAA considering all relevant information to confirm the Safety Zone, prior to LNG bunkering operation. Safety Zone as approved in the LNGBMP.**

b. **<u>Indicative flammability range based on published research and LNG vapour dispersion studies</u> (e.g. SGMF, LR, BV, etc.), with consideration for different operating/weather example parameters, and using different computational model sources.**

   (Stakeholders can model the actual situation to provide a more site specific range)

c. **<u>Reasons/Controls to increase or decrease the dispersion range</u> identified, and investigated with respect to Impact**

   (Supported by expert judgement, dispersion modelling and/or QRA, as appropriate, wrt site operational and weather specifics)

d. **<u>Proposed Safety Zone</u> informed by 1 and 2**

e. **Stakeholders <u>discuss and agree on the Safety Zone to be set</u>.**

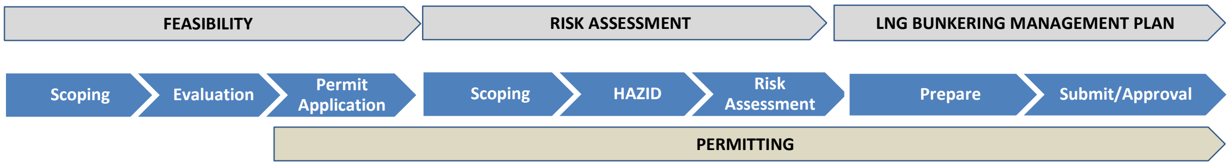
10. Process Map & Organization

The present section defines the Process Map and Responsibilities in a generic LNG Bunkering Process.

10.1 Process Flow – LNG Bunkering

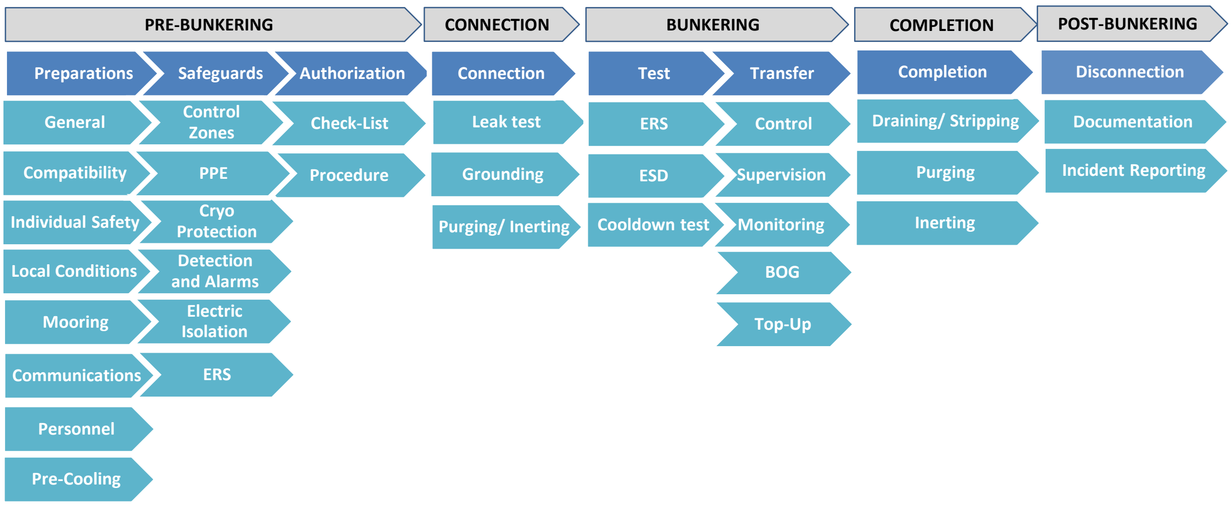
The Process Flow for LNG bunkering operation is generically described below, including the Planning and Operation phases.

10.1.1 Planning Stage



• Before developing a Feasibility Study for LNG Bunkering BFO/RSO have shared the Concept Project with PAA. • Location specific elements have been collected. • Technical solution feasibility has been assessed.	• All concept project elements defined from Feasibility Studies. • Risk Assessment methodology accepted and Risk Criteria informed by PAA/competent authorities. • Risk Assessment conducted with involvement of all Stakeholders • Possible Safeguards added to the LNG bunkering project.	• Complete LNG bunkering project (technical and operational) defined. • Elements for LNG Bunkering Management Plan to follow IACS Rec.142 (Sections 1.5 and

10.1.2 Operation



• Risk assessment has been conducted and the findings have been implemented. • LNG Bunker Management Plan has been established and is applicable to the ship. • Compatibility check demonstrates that the safety and bunkering systems of the bunkering facility and the ship to be bunkered match. • The necessary 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, boil-off handling and loading limit have been agreed between the supplier and the ship to be bunkered. • Initial checks of the bunkering and safety system are conducted to ensure a safe transfer of LNG during the bunkering phase.	• 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.	• The risk assessment has been conducted and the findings have been implemented. • An 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 necessary authorities have been informed regarding the LNG bunkering operation.

10.2 Responsibilities

10.2.1 PAA Responsibilities

PAA responsibilities in LNG Bunkering are listed in table 10.1, below.

Table 10.1 – PAA Responsibilities in LNG Bunkering

Port Role/Responsibility	Summary description
Develop a regulatory framework for LNG bunkering in the ports	The development of an adequate Port Regulation that is inclusive of LNG bunkering is the fundamental instrument for the development of this activity within a port. Ensure adequate integration of different LNG bunkering regulations, standards and guidelines. PAAs should, in this particular aspect, seek to ensure harmonization with other ports, at national, regional or global level, in the best interest of all parties involved.
Allow for adequate information on LNG bunker activities within the port by reporting procedures	Implementation of well-documented permitting procedures, including relevant provisions for management of modifications. Definition of adequate channels for communications, with the identification of the responsible Port representative(s), electronic address, or other that should be taken into account by RSO, BFO or other interested parties. Adequate information channel for reporting of incident and near-misses in LNG bunkering. Support to involved parties and other national competent authorities in the context of any LNG bunkering incident.
Develop restrictions on bunkering operations if necessary	Restrictions on bunkering operations can be of several types and dependent on different factors: • Risk Assessment based Restrictions and limitations may be the practical result from risk assessment results. These may be restrictions on bunkering parameters (pressure, flow rate, hose diameter) or restriction in other operational aspects. • Weather based Weather elements, such as wind, rain, temperature can determine possible operational envelopes. • Local harbour/maritime traffic Special local maritime traffic conditions can dictate restrictions to bunkering. PAAs should be able to aim for a balance of normal operating profiles within the port, whilst ensuring the sufficient safeguards for the LNG bunkering location. • Security restrictions Restrictions on LNG bunkering may arise from possible security related elements. Ports should avoid, to the extent possible, to favour

Port Role/Responsibility	Summary description
	restrictions in looking for safe LNG bunkering operations. It should be important to develop a favourable environment for this type of operations, based on a minimum restriction approach
Approval of Safety zone in way of the bunkering area	The safety zone is an important parameter that should be calculated by the BFO and approved by the PAA. It is important, as good practice, to allow sufficient freedom to the BFO to elaborate on LNG bunkering parameters, local safeguards and to submit the proposal to the PAA for evaluation and approval. It should be avoided, also in the terms of a good practice approach, a fixed safety distance applicable to all situations. This approach is not consistent with the mechanism that justifies the fixation of the safety distance, based on considerations on gas dispersion. Since this is fundamentally affected by environmental and local conditions, it is important to evaluate a proposed safety distance also in the light of these parameters.
Definition of Security Zone around bunkering location	The definition of the Security zone should be a responsibility of the PAA (eventually defined by the Administration and approved by the Port Authority. The fundamental objective of the Security Zone is to allow control of any possible element that may cause interference with the LNG bunkering operation. Maintenance of the Security Zone should be a responsibility of the PAA, allowing for an alternative security maintenance scheme if so agreed between all parties, subject to approval of the Port Authority.
Confirmation of Hazardous Zone	Surrounding the LNG bunkering manifold connections a hazardous area shall be defined at the responsibility of the BFO and RSO. Port Authorities should confirm by inspection that all personnel working and equipment used inside Hazardous Zones is adequately certified for the area in consideration. PPE and EX-proof material should be used. Even though a responsibility of the parties involved, the maintenance of the permitting should be based on periodic confirmation by PAAs that all safety procedures and measures are well kept in place and ensured by parties involved.
Approve and enforce additional control zones (in addition to Hazardous, Safety and Security Zone)	In addition to Safety Zone and Security Zone, other Control Zones may be defined to ensure the safe execution of LNG bunkering operations, These may involve navigation restricted areas or other control zones. It is important that the definition of relevant control zones is effective and adequately enforced. The definition of the relevant zones should take into account the local conditions and infrastructure that may influence the access control to these areas.
Establish passing distances for other ships during LNG bunkering	Either in context with Safety or Security zones, or even separately, the control of passing navigational traffic should be a concern of PAAs. The necessary measures should be developed,

Port Role/Responsibility	Summary description
	implemented and adequately enforced in order to restrict navigational traffic in the way of the LNG bunkering location. The need for control of passing navigational traffic will also vary according to the LNG bunkering type into consideration (STS at berth, STS at anchor, PTS, TTS) with all STS modes deserving the closest attention. Similarly to all control zones, also in the definition of passing distances for other ships the main objective is to avoid any external interference on the LNG bunkering operation.
Mooring requirements	Safe mooring during LNG bunkering operations is a fundamental element to allow a stable and secure LNG bunkering interface. It should be the role of the PAA to define the standard requirements for mooring, including under which conditions reinforced or special mooring should be considered. Mooring of the receiving ship and bunker facility, industry standards may be referenced (e.g. OCIMF Effective Mooring 3rd Edition 2010)
Develop environmental protection requirements	As mentioned in Section 3, LNG bunkering operations should deserve careful attention with regards to potential negative environmental impact. The adequate prevention of any methane release in connection/disconnection, inerting/purging, or even in pressure relief, depends mostly on the definition of good procedures for pre-bunkering, bunkering and post-bunkering phases, including consideration for equipment compatibility. It is important that PAAs establish as a minimum requirement that no venting is allowed. Adequate measures for control should also be developed.
LNG bunkering checklists	The implementation of LNG bunkering checklists is an important measure to ensure adequate documentation of important aspects of LNG bunkering operations. IAPH check-lists, ISO 20519 or their adaptation as include in the present Guidance, can be used for this purpose. It is the role of the Port Administration to ensure that adequate verification and treatment of validated check-lists is adequately done. This may be either part of the port regulations or a requirement derived from the permitting process.
Develop proposals for spatial planning and bunker locations	Concurrently with other competent authorities with responsibilities for land planning, use, classification and administration, PAAs should consider the need to integrate possible LNG bunkering locations into the spatial planning of the port. A possible approach is to determine pre-destined locations for LNG bunkering, allowing for easier prospective permitting processes. Important elements to take into account for spatial

Port Role/Responsibility	Summary description
	planning: • Waterways accessibility • Proximity of locations handling/storing hazardous substances • Emergency response facilities • Proximity of Populated areas and commercial services Commercial. • Areas of restricted security
Approve Spatial planning elements and LNG bunkering location	Based on elements developed in the proposal for spatial planning, above, it should be the role of the Port Authority, following the administrative proposal, to assess the compliance of the proposal with respect to major accident prevention requirements and other national port authority regulations.
Develop measures to allow possible simultaneous activities and operations (SIMOPs) during LNG bunkering	Simultaneous Operations (SIMOPs) are an important aspect to consider especially in LNG bunkering of larger ships with short turn-around times (such as passenger vessels and container ships). PAAs should be involved and dialogue with interested parties, from the beginning, in the development of the necessary measures to allow SIMOPs to be conducted in the safest operational environment possible. Port Administrations, as a good practice approach, can be involved with the role of finding and developing the necessary solutions, in support to BFO and RSO, that can support SIMOPs to take place
Approve SIMOPs	Port Authorities should be responsible for the approval of SIMOPs. This approval can however be distinguished in two levels: 1) Permitting and 2) Approval. In the first the BFO and RSO may be certified, within a given permit for operation, to undertake SIMOPs. On the second, Approval, the Port Authority should confirm that all necessary and agreed elements in the permit are well in place.
Develop general procedures for traffic control and restrictions in case of an LNG bunkering	Both to ensure the integrity of the Safety and Security zones (and any other control zones defined by the PAA) it is important to define relevant traffic control and restrictions. Amongst the measures for traffic control the following can be considered: • Visual signals and traffic indications • Speed limit (with possibility to vary speed limit indication depending on operational context). • Barriers to restrict traffic • Traffic lights for temporary restriction • Active manned traffic control • Traffic diversion The adequate degree of authority should be ensured to implement and enforce the defined Traffic restrictions.

Port Role/Responsibility	Summary description
Establish clarity on the roles and responsibilities between the involved parties	The adequate definition of responsibilities between all parties involved should be a central aspect of Port Regulations. In the absence of definition in relevant port instruments the responsibilities to be defined should take EN ISO 20519, the present guidance and Industry relevant guidelines. PAAs should also define clear internal division of responsibilities (permitting, inspections, emergency, amongst others)
Emergency Response Plan (internal) Approve internal LNG bunkering facility emergency response plan.	PAAs should, in cooperation with other relevant competent authorities, approve the Emergency Response Plan developed by the BFO. In approving the internal ERP PAAs should develop good practice to collect elements and check for compatibility of possible existing port emergency or contingency plans. This is particularly relevant and important for major accident scenarios, where good coordination between all parties is necessary.
Emergency Response Plan (external) Develop external emergency plan, based on internal LNG bunkering facility emergency response plan.	Based on the approved internal emergency plan developed and submitted for approval by the BFO, PAAs should develop/update their emergency plans. All ERPs should be aligned and adequate management of possible modifications should be ensured. The adequate reflection of the multi-operator environment should be a challenge addressed by PAAs when developing the external emergency plan.
Emergency Response Plan (external) Approve external emergency plan	In cooperation with other relevant competent authorities, Port Authority should approve the external ERP, taking into account all relevant ERPs existing in the multi-operator context of the port. The Port Authority should, in particular for this approval, and whenever major accident prevention aspects are relevant, liaise directly with the competent authorities responsible for that particular area.
Emergency Response Plan (training) Initiate an LNG trained and LNG prepared emergency response organization	In order to ensure adequate implementation of the Emergency Response Plan, PAAs should develop and put in practice an adequate training program to be undertaken by all relevant members of the emergency response organization. It is the responsibility of the PAA to ensure that all staff members directly or indirectly involved are aware of their roles in emergency. Training in LNG bunkering emergency & response should consider the involvement of all relevant operators involved in LNG bunkering.
Build adequate Enforcement capacity **Initiate an enforcement system by LNG trained enforcements officers**	Enforcement is an important factor to ensure that the relevant requirements are well implemented and complied with by the relevant parties involved in LNG bunkering. Requirements and relevant legal/technical provisions

Port Role/Responsibility	Summary description
	should therefore be enforceable, clear and well understood by all parties. It is also very important that the enforcement exercise takes into account the practical aspects, both in terms of equipment and cost-benefit of possible safeguard solutions.
Approve risk acceptance criteria	In the absence of relevant directly applicable risk acceptance criteria, the BFO, RSO or Port Administration may propose relevant risk criteria to be adopted. As a good practice approach, where better procedure is not available, the risk criteria should be subject to approval by the Port Authority. In approving the risk criteria, Port Authority should liaise in close cooperation with other relevant competent authorities involved in prevention of major accidents, or with responsibilities on civil and port protection.
Accreditation of the BFO Authorize /accredit bunkering facilities, once they have demonstrated that they are compliant and prepared	In pursuit of a transparent and equitable regulatory and administrative framework for the development of LNG bunkering in ports, PAAs should develop an LNG bunkering accreditation scheme. The scheme should be clear and allow for equal opportunities to all those that present intention or projects for LNG bunkering within the port. The following factors should be taken into account for the accreditation scheme: • Certification of LNG bunkering Equipment • Qualification of BFO personnel • Safety Management System implemented by the BFO • Number of available hours per year • Results of periodic in-service inspections
Qualification of the Person(s)-in-Charge (PICs)	Define the main elements to consider for the qualification of the Person-in-Charge (PIC). What competencies should be derived from the already IGF-defined responsibilities for the PICs should be a responsibility of PAAs. As a minimum it should be here considered that the RSO and BFO PICs should have equivalent qualification for LNG bunkering operation.
Restrictions for repairs and maintenance on LNG installations on board of ships	(Not directly related to LNG bunkering) Repairs and maintenance of LNG fuelled ships, either planned or non-planned, in designated areas or other locations within the port should be subject to consideration of the PAA. Subject is not related to LNG bunkering but it is of great relevance and importance in the context of operations with LNG fuelled ships

Port Role/Responsibility	Summary description
Safety requirements for LNG propelled ships on (dock)yards	Even if the repairs of LNG fuelled ships take part in dedicated shipyards, PAAs should be reassured that relevant precautions and procedures are followed in both unloading-inerting and commissioning-cooling-loading operations. Shipyards should be required to have relevant procedures in place to allow for safe repair works in LNG fuelled ships. Subject is not related to LNG bunkering but, for the same reason as the previous point, it is included in the present Guidance under Section 15, on Certification/Permit to Work.
Safety requirements for LNG propelled ship on a lay bye berth to avoid a BOG problem	In the context of the development and implementation of relevant provisions for methane release mitigation, PAAs consider the development of all necessary measures to reduce the amount of NG release to the atmosphere. Should an LNG fuelled ship be on a lay bye berth it should be possible to ensure that adequate measures are put in place to avoid difficult BOG management situations, in particular when LNG vapour pressures are such that PRVs are actuated allowing the pressure relief at cost of environmental impact of methane release to the atmosphere.

10.2.2 Planning Phase

10.2.2.1 Port Authority & Administration

As included in Table 10.1, above.

PAAs should develop an active support role during the Planning Phase for prospective LNG bunkering projects.

10.2.2.2 RSO and BFO

Responsibilities for RSO and BFO, during the Planning Phase are well detailed in IACS Rec.142, on which the Table 2 (Receiving ship operator (RSO) and bunkering facility organisation (BFO) responsibilities) provides a good overview of the main responsibilities for both Operators in preparation of LNG Bunkering Projects, including all relevant elements in preparation of Permitting Processes.

PAAs, whenever receiving declared intention from operators for the proposal of as LNG bunkering Project, should assist in the elements contained in IACS Rec.142, Table 2. Providing as much elements in advance as possible will benefit all parties in the development of a well prepared proposal.

10.2.3 Operational Phase

ISO 20519, IACS Rec. 142, and SGMF Guidelines define, collectively, the complete set of Responsibilities of the different parties involved in LNG bunkering operations.

The Figure in the next page presents a summary of the relevant responsibilities between all parties. The two PICs are represented, giving illustration to IGF and ISO20519 requirements/provisions. It hasn't been represented which of the PICs take the leading position. This has however to be determined in pre-bunkering conference.

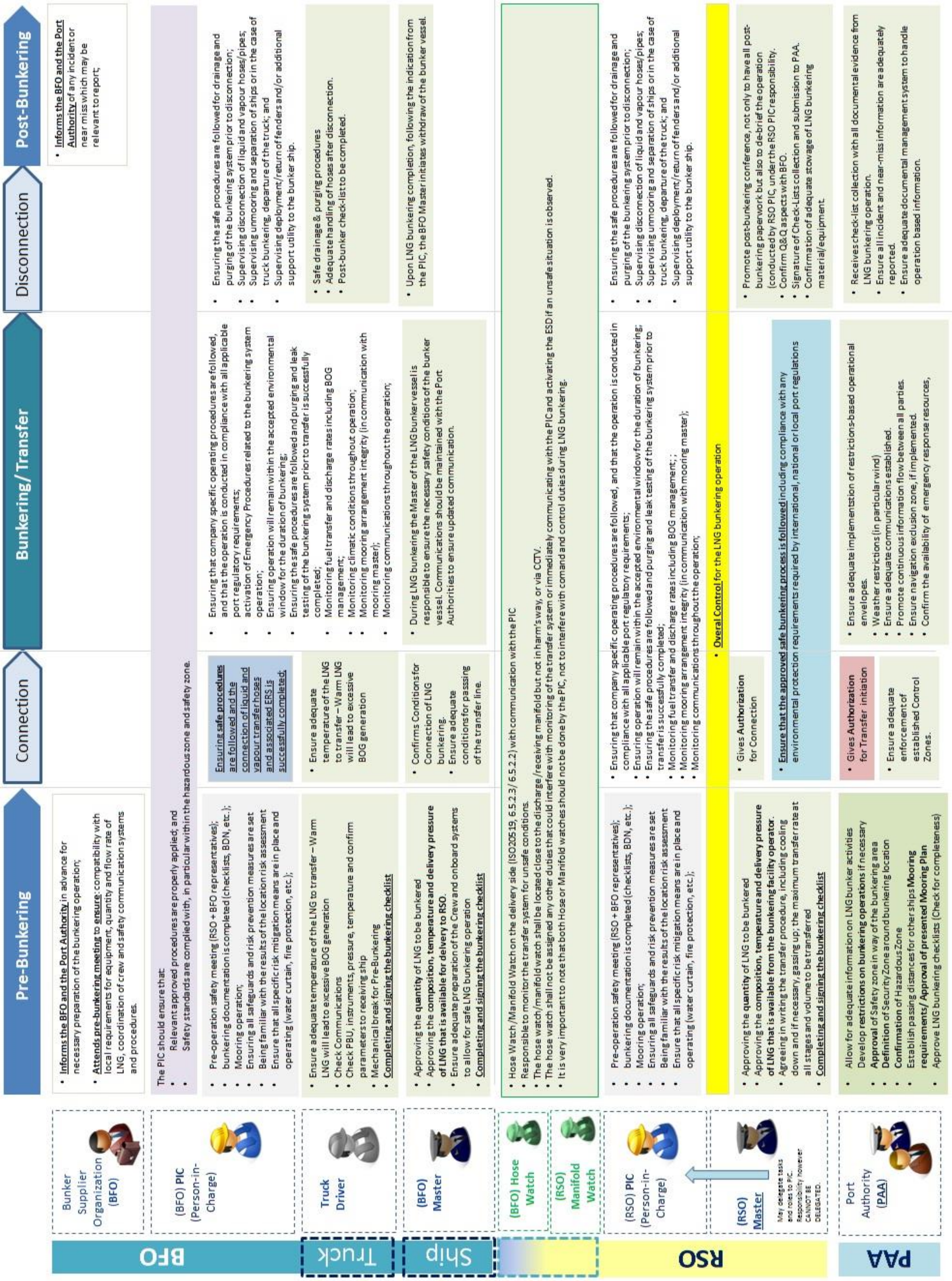


Figure 10.1 – LNG bunkering operational scenario - Responsibilities

10.3 LNG Bunker Management Plan (LNGBMP)

IACS Rec.142 defines an LNG Bunker Management Plan (LNGBMP) as an important element that PAAs should consider whenever assessing LNG bunkering projects, or

A bunker management plan, as defined in IACS Rec.142, should be compiled 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.

In this context, PAAs may have relevant information in the LNGBMP and, as recommended by the present Guidance, should give good consideration to I since the early stages of any given LNG bunkering project or activity.

The Bunker Management plan should be stored and maintained by both RSO and BFO (as transcribed from IACS Rec.142:

1. *Description of LNG, its handling hazards as a liquid or as a gas, including frostbite and asphyxiation, necessary safety equipment, personal protection equipment (PPE) and description of first aid measures*
2. *Description of the dangers of asphyxiation from inert gas on the ship*
3. *Bunkering safety instructions and emergency response plan*
4. *Description of the bunker facility LNG tank measurement and instrumentation system for level, pressure, and temperature control*
5. *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.*
6. *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*
7. *The description of all risk mitigation measures to comply with during an LNG bunkering*
8. *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*
9. *Descriptions and diagrams of the bunker facility LNG bunkering system, including, but not limited to, the following as applicable:*
    a. *Recirculating and vapour return line system*
    b. *LNG fuel tank cooling down procedure*
    c. *Procedure for collapsing the pressure of the receiving tank before and during bunkering*
    d. *LNG fuel tank pressure relief valve*
    e. *Ventilation and inlet/outlet location*
    f. *Inerting system and components*
    g. *Boil-off gas compressor or re-liquefaction system*
    h. *Gas detection system including locations of detectors and alarms*
    i. *List of alarms or safety indication systems linked to the gas fuel installation*
    j. *LNG transfer line and connectors*
    k. *Emergency Shutdown System description*
    l. *Communication systems and controls protocol.*

In addition to the above list of description and schematic drawings, the LNGBMP 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[80] and safety management plan.

[80] See IACS Rec.142, section 4.1.3.1 Bunkering safety instructions

10.4 Check-Lists

Check-Lists are fundamental tools to assist all stakeholders involved in LNG bunkering planning and operations. They allow for an adequate verification of the different stepwise procedures, being also important in documenting important steps in the whole LNG bunkering operation.

IAPH Check-Lists for LNG Bunkering have become an important reference in the context of LNG bunkering:

	**IAPH LNG Bunkering** Check-Lists **Check-lists for:** **Truck-to-Ship** **Ship-to-ship** **Port-to-Ship**	**IAPH**	http://www.lngbunkering.org/lng/bunker-checklists **(available for free)**	**IAPH's WPCI LNG working group has developed harmonized LNG bunker checklists for known LNG bunkering scenarios:** ship-to-ship, shore-to-ship and truck-to-ship**. These checklists reflect the extra requirements of ports with regard to LNG bunkering operations in or near their port environment. By using bunkering checklists, a high level of quality and responsibility of the LNG bunker operators can be ensured. Implemented harmonized bunker checklists will be of great benefit to the vessels bunkering LNG in different ports, as this will reduce the potential for confusion caused by having to comply with different rules and regulations in different ports.** **The IAPH check-lists are not guidelines themselves; nevertheless they are highly relevant references in establishing a quality structure, defining a procedural framework that can be used, with or without adaptations by all stakeholders involved in the LNG Bunkering process.** **In Annex-B of this Guidance the IAPH check-lists are included, adapted to include the relevant actions by the Port Authority when authorizing, overviewing or evaluating LNG bunkering operations.**

In addition to the above, ISO20519 includes also check-lists in Annex-A, (Part A to Part E), developed by ISO and SMGF for use with the standard. As indicated in ISO20519, alternative check lists may be used as long as they contain at least the same information that is listed in its attached check sheets.

In addition, ISO20519 provides for the possibility that sections 6.2.1 and 6.2.2 may be considered and checklist points that apply to those items may, in principle, only need to be conveyed once (and after any changes) need not be checked off after the first transfer if both parties involved in the transfer agree and local or national authorities allow the omission.

As an option; the checklists developed by SGMF and the International Association of Ports and Harbours (IAPH) published by SGMF in their 'Gas as a Marine Fuel Safety Guidelines, Bunkering' 2015 Version 1.0, February 2015 (www.sgmf.info) may be used in place of the ISO20519 checklists under the following conditions (as noted in the ISO instrument)

1) Both parties involved agree to use the alternative checklists

2) The competent authorizes permit their use

1. The checklists are used from pre-operations through completion of the transfer (no mixing of lists)

PAAs may consider the need to adapt Check-Lists to specific LNG bunkering projects proposed, where the existing references lack elements which may be considered relevant.

It is, above all things, important to note that the Check-List procedure agreed provides the necessary reassurance to all parties that all relevant procedures are being followed, that not step is left behind or forgotten. LNG bunkering, in all of its different modes and possibilities, is a complex operation. Only through a structured mapped check-list procedure it is possible to ensure that a complete coverage of all aspects is guaranteed.

PAAs should work together to ensure that the agreed Check-Lists reflect both Operators technical details and, concurrently, meet local requirements on Safety, SIMOPS, communications plan, amongst other points. Table

Table 10.2 – Possible Check-lists in LNG Bunkering

Check-List	Objective	When should be signed/ confirm?
Planning	Check list with all relevant elements for Permitting process. Check-list for the support of Operators in ensuring completeness of the permitting submissions for a prospective LNG bunkering project.	During finalization of the Concept project, with a view to complete the permitting process.
Risk Assessment	Check/Verify minimum requirements for Risk Assessment from ISO/TS18683	As a conclusion of the Risk Assessment Process. Should be done to ensure the adequate coverage of all elements listed in ISO/TS 18683.
Pre-Bunkering	Check-Item collection to obtain Authorization for Bunkering. Check items to perform prior to LNG transfer system connection.	Should be signed upon completion of all pre-bunkering operations. A simplified procedure could be taken into account that would consider
Bunkering	Checks to perform just immediately before LNG transfer is initiated	To be signed just before transfer is initiated
SIMOPS	To check preparedness from all parties to establish safe SIMOPS	At pre-SIMOPS meeting. Check-list should be filled in by SIMOPS Coordinator. Sent to PAA in advance for evaluation and preparation of pre-SIMOPS meeting.
Post-Bunkering	Checks to be performed after bunkering operation	Upon conclusion of operations.

11. Simultaneous Operations

The present Section provides guidance to PAAs considering safety and operational issues associated with SIMOPS while conducting LNG fuel transfer operations.

The subject of Simultaneous Operations has been debated extensively in the context of LNG bunkering operations, with the discussion often routed towards a purely Risk Assessment oriented evaluation. In fact the large variety of possible operations that may take place in simultaneous with LNG bunkering is very large and dependent on ship type and operational profile. A Risk Assessment is indeed a tool which is able to assist Operators and PAAs to best evaluate the possibility for safe SIMOPS. The culmination of the risk-based approach

It has also been noted that, due to the almost purely risk assessment orientation of the SIMOPS subject, many operators and ports have adopted precautionary restrictions on SIMOPS unless Risk Assessments were conducted to support possible SIMOPS authorizations. In some cases the precautionary measures are not even flexible to that level, with ports adopting full restrictions on SIMOPS without any possibility to consider even a risk assessment-based authorization.

The lack of standards and experience with SIMOPS has probably been determinant so far in the predominantly precautionary approach to this subject.

LNG fuelled ships are, from an operational perspective, just like any other ship. Restrictions for SIMOPS have a strong influence on the business profile of the ship, increasing turnaround times at port. There is therefore a strong driver to make SIMOPS viable and to ensure that other operations can be safely conducted whilst the ship is undertaking LNG bunkering.

The present Section proposes a good practice approach to allow SIMOPS to take place, on the basis of a structured risk and operation based decision-making process.

11.1 References

The following references were considered in particular for the present Section:

- DNVGL-RP-G105 Edition October 2015 - *Development and operation of liquefied natural gas bunkering facilities, Recommended Practice*, DNV GL, 2015
- USCG CG-OES Policy Letter No. 01-17 - Guidance for Evaluating Simultaneous Operations (SIMOPS) during Liquefied Natural Gas (LNG) Fuel Transfer Operations
- LGC NCOE Field Notice 01-2017 – 14-Aug-17 - Recommended Process For Analysing Risk Of Simultaneous Operations (SIMOPS) During Liquefied Natural Gas (LNG) Bunkering
- LNG Bunkering Guidelines IACS Recommendation n. 142, on LNG Bunkering, IACS, 2016.
- Society for Gas as a Marine Fuel (SGMF) (2017) - Gas as a marine fuel, safety guidelines, Bunkering Version 2.0, February 2015

11.2 SIMOPS Definition

For purpose this Guidance, SIMOPS is defined as an adaptation from USCG CG-OES Policy Letter No. 01-17 as ***two or more operations occurring simultaneously, one of which involves LNG bunkering operations, and the combination of which may present safety, environmental and security concerns.***

Other definitions are possible, such as IACS Rec. 142, where SIMOPS are defined as:

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.).

Having focused on *transfers between ship and shore,* IACS Rec. 142 recognizes however that *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.*

It is, in fact, possible to have SIMOPS occurring <u>on the ship-shore interface, on the ship side and on the port side</u>, nearby to the LNG bunkering location, possibly within the safety zone. For all these possibilities the definition, as adapted from the CG-OES Policy Letter No. 01-17 is the most complete and simple to adopt.

11.3 SIMOPS and Control Zones

From the definitions in section 11.2 it can be derived that SIMOPS may occur at any point within the established Control Zones for any give LNG Bunkering. Depending on which Control Zone the SIMOPS are falling they should be address in an appropriate manner. Figures 11.1 to 11.4 present typical SIMOPS situations, here addressed from a Control Zone perspective. Considerations on possible simultaneous operations should have

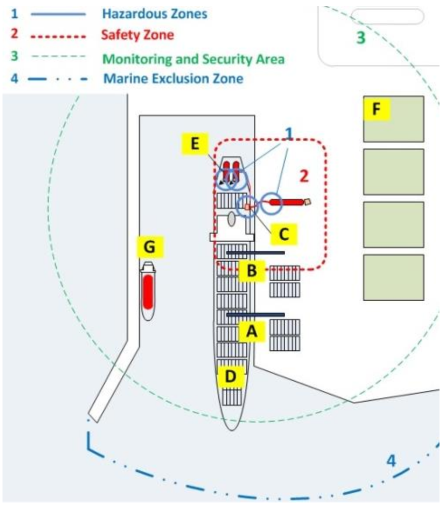


Figure 11.1 – SIMOPS and Control Zones (example – see considerations on SIMOPS on table 11.1) – containership generic case.

Figure 11.2 – Artist representation of LNG bunker vessel, in STS LNG bunkering onto containership, at berth in container terminal. (source: Shell)

Table 11.1 – SIMOPS and Control Zones (legend for figure 11.1)

Operation ID (figure 11.1)	**Short Description**	**SIMOPS consideration/ comments**
A	**Load-on/Load-off containers with overhead gantry crane** (separated from bunkering location by >2xSD)	Operation in the ship-shore interface, loading-on/off of containers. Located outside the Safety Zone (at a distance higher than 2 times the safety distance) SIMOPS should be considered <u>under adequate monitoring, following Security Zone provisions</u>. Crane can be operated respecting the Safety Zone boundary. Adequate communications to be established and operational setup for SIMOPS operations. NOTE: An evaluation on whether the crane operation would possibly impact on the LNG bunkering operation would always be possible in the context of a Risk Assessment. Being outside the Safety Zone, should it be adequately determined, it should very likely be beyond LFL reach in the case of an accidental LNG release followed by vapour dispersion. Other cargo operations falling outside the Safety Zone should follow the same approach.

Operation ID (figure 11.1)	Short Description	SIMOPS consideration/ comments
B	**Load-on/Load-off containers with overhead gantry crane** (inside the Safety Zone)	Operation in the ship-shore interface, loading-on/off of containers. Located inside the Safety Zone. Special consideration to be given to crane operation and Ex-proof classification. <u>Simultaneous Operation can be considered, subject to special Risk Assessment and design of adequate protective measures.</u> <u>Risk</u>
C	**Corrective Maintenance operation inside the Ship bunker station (Hazardous Zone)**	Corrective maintenance operation inside the Safety Zone. No simultaneous operation should be allowed inside the Hazardous Zones during bunkering operation. <u>SIMOPS inside Hazardous Zones are not recommended without a Quantitative Risk Assessment.</u> (Note: LGC NCOE Field Notice 01-2017 also recommends a QRA to be conducted [43] – PAAs may consider this reference. It is however important to note that QRA should result in protective measures/safeguards that should be duly implemented and certified before any SIMOPS are considered in this location.
D	**Corrective Maintenance operation inside the Ship (outside Control Zone reach)**	Corrective maintenance or other operation inside the ship should only be considered if an evaluation of possible impact in the LNG bunkering operation is made. Other operations, even outside control zones, that have a potential to impact LNG bunkering, should be considered SIMOPS and be adequately addressed. Operations with the potential to affect the ship's ability to respond in emergency situations shouldn't be allowed. (examples of such operations may be: i. maintenance of electrical distribution systems ii. testing of alarms iii. propulsion system iv. ballast operation v. testing of stabilizers
E	**Operation on Hazardous Zone, onboard**	Same consideration as in "C". Operations onboard on any Hazardous Zones (e.g. fuel storage space) should not be without a QRA. <u>SIMOPS inside Hazardous Zones are not recommended without a Quantitative Risk Assessment.</u> (Note: LGC NCOE Field Notice 01-2017 also recommends a QRA to be conducted [43] – PAAs may consider this reference. It is however important to note that QRA should result in protective measures/safeguards that should be duly implemented and certified before any SIMOPS are considered in this location.
F	**Operation outside the LNG bunkering scenario, occurring at a nearby warehouse/infrastructure**	Operation outside the LNG bunkering scenario, occurring at a nearby warehouse/infrastructure. Operation taking place within Security Area – should therefore be monitored. It is however important to define who will be responsible for the monitoring of an operation not involving the RSO/BFO but that may have a potential effect in the LNG bunkering operation in the event of an accident.

Operation ID (figure 11.1)	Short Description	SIMOPS consideration/ comments
G	**Operation outside the LNG bunkering scenario, occurring at a nearby berth – handling of hazardous substances**	Operation outside the LNG bunkering scenario – handling of hazardous substances. Operation taking place within Security Area – should therefore be monitored. It is however important to define who will be responsible for the monitoring of an operation not involving the RSO/BFO but that may have a potential effect in the LNG bunkering operation in the event of an accident.

In the table above, for the generic example of a containership involved in SIMOPS, it is possible to see a suggested approach to classify simultaneous operations with due consideration for their location in the established Control Zones.

A relevant note should here be made for the Security Zone, where operations may take place that are not involving either BFO or RSO. In these cases PAA should have a clear situational awareness of the multi-operation scenario that may take place within the Security Zone. Communications should be ensured amongst all those operating in the Security Area with the objective to ensure adequate alarm dissemination in the event of an accident in the vicinity of the LNG bunkering location (see in particular cases F and G in Table 11.1.

In the case of figure 11.1 a containership is considered. Another remarkable case for potential SIMOPS evaluation would be a passenger ship (containership or RO-PAX) with embarkation/disembarkation of passengers. Figure 11.3, below, includes a generic LNG fuelling scenario, where an LNG ruck feeds a DF generator inside the ship during the whole stay of the ship at berth. In the case presented the passenger embarkation/disembarkation is operated just above the LNG fuel truck/manifold hazardous area. In this particular case the SIMOPS situation would be present also throughout the whole stay of the ship at berth, as long as the LNG fuelling operation was ongoing and the passenger gangway accessible.

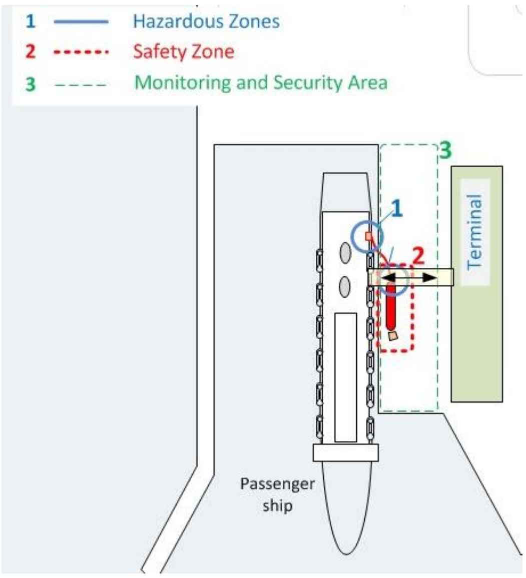


Figure 11.3 – SIMOPS and Control Zones (example – see considerations on SIMOPS on table 11.3) – passenger ship generic case – passenger embarkation/disembarkation during LNG fuelling

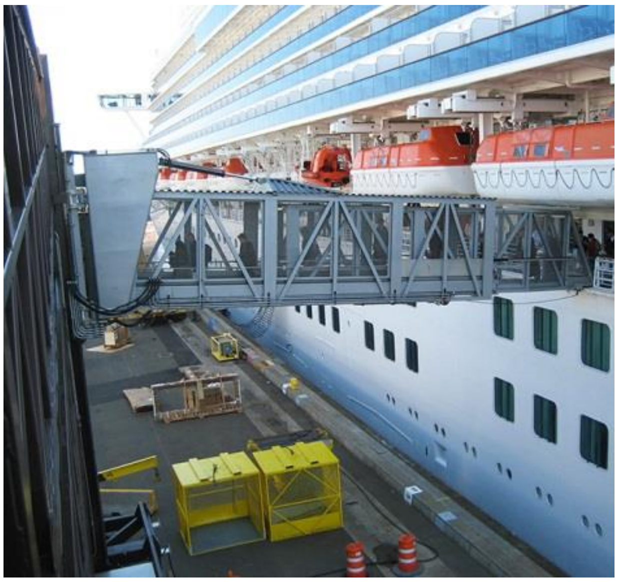


Figure 11.4 – Enclosed Gangway to access a passenger ship at main deck level – enclosed gangways have the potential to protect passengers in the event of an accidental LNG release.

In the particular case presented in 11.3, the LNG fuelling location is dictated by the onboard intake manifold, which will direct the LNG to an evaporator onboard. The passenger embarkation/ disembarkation is dictated by the relevant access location in the side shell of the passenger ship. The design constraints are therefore evident.

In the particular case the gangway is crossing the hazardous zone (a zone where explosive atmospheres will be present with a known frequency of occurrence). It is important to design an adequate safeguard to guarantee passenger safety and, ultimately, an acceptable risk level during passenger embarkation/disembarkation.

For the purpose above a QRA should be conducted that would allow to design the best safeguards to be implemented. In the case presented an enclosed gangway (as the one presented in figure 11.4 would be a natural barrier to design, preferably based on consequence scenario modelling.

11.4 USCG Risk-Based Approach

The recent publication of a relevant reference on SIMOPS may be considered by PAAs:

- LGC NCOE Field Notice 01-2017 – 14-Aug-17 - *Recommended Process For Analysing Risk Of Simultaneous Operations (SIMOPS) During Liquefied Natural Gas (LNG) Bunkering*

A predominantly risk-based SIMOPS evaluation process is presented below, with the significant steps defined and summarized, as taken from the reference document. Hazardous area qualitative risk classification is associated with SIMOP complexity identification.

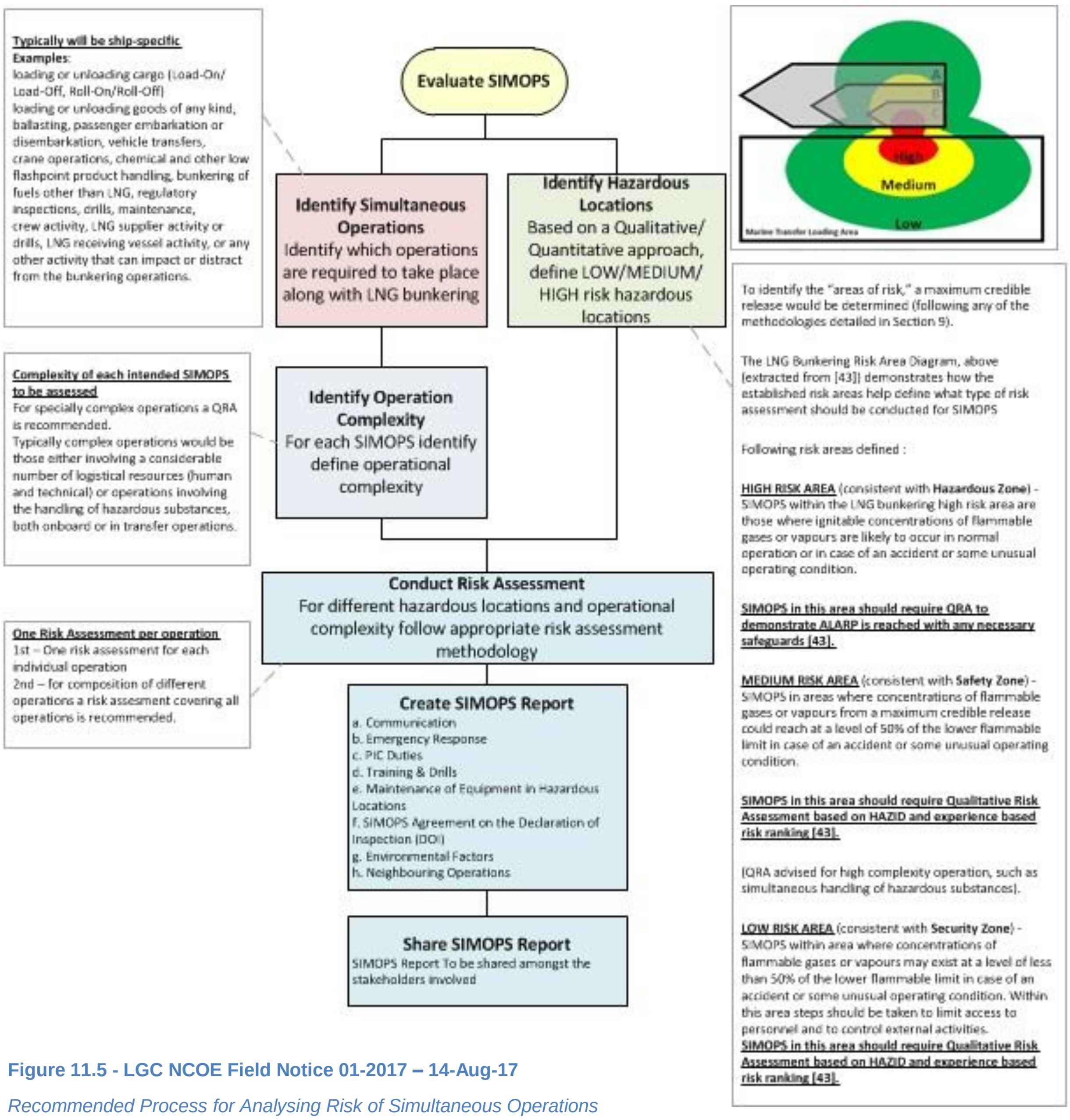


Figure 11.5 - LGC NCOE Field Notice 01-2017 – 14-Aug-17

Recommended Process for Analysing Risk of Simultaneous Operations (SIMOPS) During Liquefied Natural Gas (LNG) Bunkering **- Summary diagram**

The LGC NCOE Field Notice 01-2017 presents a key-approach which is predominantly risk-based, based on area classification (consistent with the control zones, as summarized in the diagram of figure representing the culmination of the risk assessment orientation to allow for SIMOPS to take place.

The Area Classification included in this reference document presents a good indication on a possible qualitative/quantitative preliminary evaluation of Risk through the adoption of LOW to HIGH risk classifications which can, in a way, be related in consistency with the Control Zones classification from ISO/TS 18683 and 20519 (see table 11.2).

Table 11.2 – Risk Areas - LGC NCOE Field Notice 01-2017

RISK Areas	**Recommendation on SIMOPS**
HIGH RISK AREA (consistent with Hazardous Zone) - SIMOPS within the LNG bunkering high risk area are those where ignitable concentrations of flammable gases or vapours are likely to occur in normal operation or in case of an accident or some unusual operating condition.	SIMOPS in this area should require QRA to demonstrate ALARP is reached with any necessary safeguards.
MEDIUM RISK AREA (consistent with Safety Zone) - SIMOPS in areas where concentrations of flammable gases or vapours from a maximum credible release could reach at a level of 50% of the lower flammable limit in case of an accident or some unusual operating condition.	SIMOPS in this area should require Qualitative Risk Assessment based on HAZID and experience based risk ranking.
LOW RISK AREA (partly consistent with Security Zone) - SIMOPS within area where concentrations of flammable gases or vapours may exist at a level of less than 50% of the lower flammable limit in case of an accident or some unusual operating condition. Within this area steps should be taken to limit access to personnel and to control external activities.	SIMOPS in this area should require Qualitative Risk Assessment based on HAZID and experience based risk ranking.

For all cases above: (QRA advised for high complexity operation, such as simultaneous handling of hazardous substances) [43].

11.5 Good Practice for SIMOPS

11.5.1 Background Elements

The previous section provides a relevant reference to allow the consideration of SIMOPS during LNG bunkering, inside the Safety Zone or onboard, for ships that have evaluated the operations through a preliminary Risk Assessment. The Risk Assessment will however only be a tool to assess SIMOPS that can be foreseen from the Planning Phase, providing a view of the attained risk levels, demonstrating ALARP for the different SIMOPS and related hazardous scenarios. The reference presents, in this sense, a recommendation which should be regarded as a reference in the development of LNG bunkering SIMOPS scenarios which can be well planned in advance, as part of the planning phase for LNG bunkering Operations. For Pre-Bunkering stage, should SIMOPS be requested in, or very close to the Safety Zone, which haven't been assessed with regards to risk, what option would be available to PAAs? Probably a non-authorization would have to be deemed in this case, taking into account all relevant elements provided by operators.

Operational context scenarios are however diverse and the possibility for SIMOPS to be required that haven't been fully evaluated in advance, or even subject to a Risk Assessment, may be very likely to occur. In addition, another situation can be considered as very likely: the case where a risk base justified operation is

How to derive the process for SIMOPS consideration when no Risk Assessment elements are present? How to consider a request for SIMOPS, such as a ballast operation for trim correction, when no Risk Assessment has been developed for this? One way to answer is not to allow the SIMOPS, imposing an operational restriction. Another way is to develop an operational approach to allow for SIMOPS even when formal risk assessments (QRA or QualRA) are available. This would also accommodate for those situations where some deviations occur from the conditions established in the initial Risk Assessment.

The proposal, in the present section, drafted as good practice recommendation, follows the same inspirational line as in LGC NCOE Field Notice 01-2017, adding one further element of more operational nature, including: 1) a SIMOPS meeting pre-bunkering, 2) the possibility to allow SIMOPS in the Safety and Security Zones, even when deviations to the formal risk assessment occur, 3) a SIMOPS Supervisor/Coordinator, 4) a Staged Approach Authorization of SIMOPS and 5) an Operational map proposal. All elements are detailed in sections 11.5.2 and 11.5.3.

11.5.2 Staged Approach for SIMOPS Authorization

The diagram in figure 11.6 presents a staged approach for SIMOPS evaluation and authorization, considering the different Control Zones. From the Planning Phase down to the Operational stage, for LNG bunkering execution, the diagram below outlines a process structure to evaluate and authorize SIMOPS

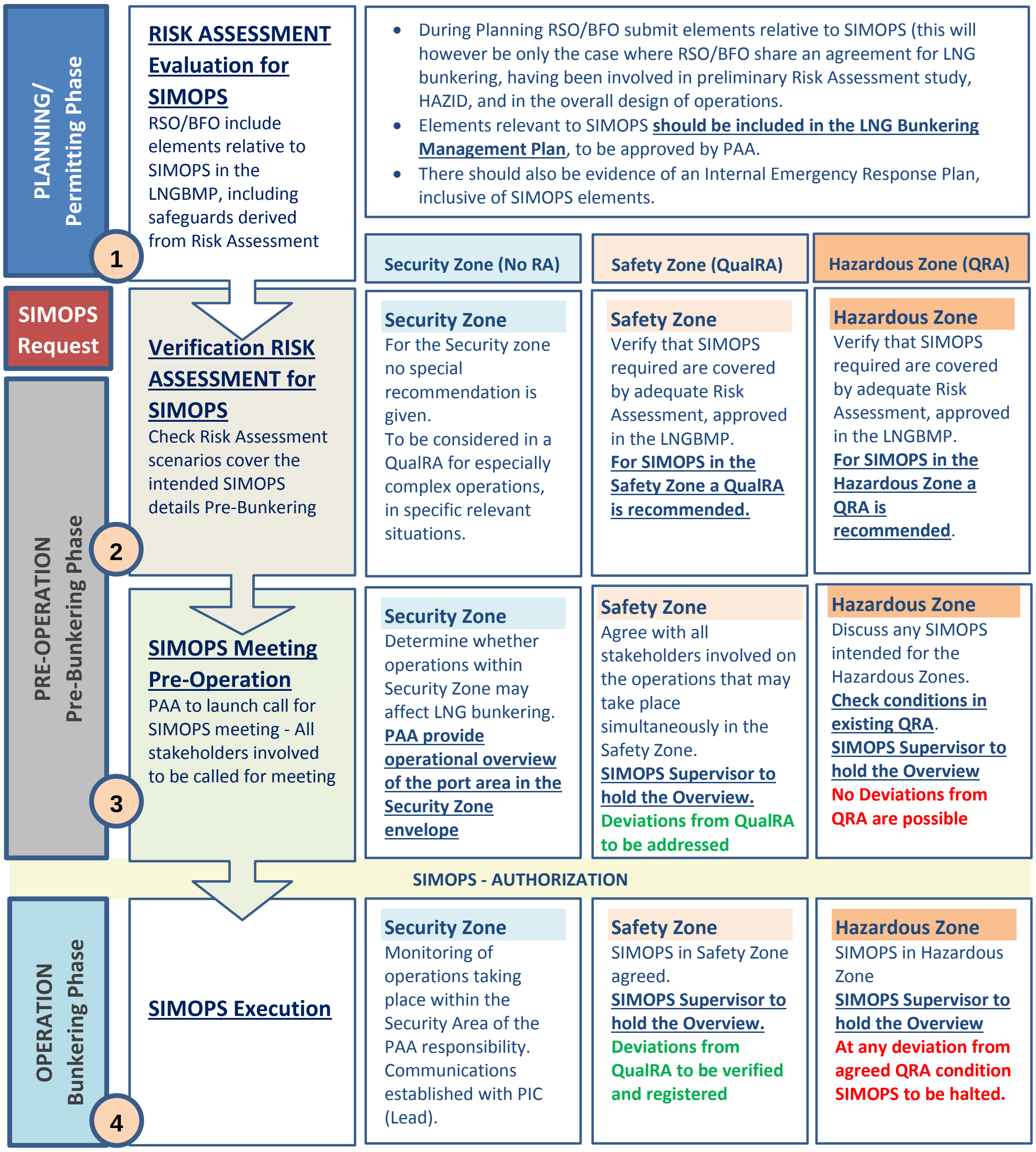


Figure 11.6 – Staged Approach Authorization for SIMOPS in LNG Bunkering Operations

The diagram in Figure 11.6 follows the Risk Area approached recommended in LGC NCOE Field Notice 01-2017, with the clear advantage to have segregated decision-making structures, depending where SIMOPS are intended to take place. Not only the decision-making for PAA authorization is suggested to be different, also the actual organization for LNG bunkering operation is different, with the coordination done by PAA for Operations taking place in the Security Zone, whilst a designated SIMOPS Supervisor should be considered for SIMOPS directly in the Ship-Shore interface or inside the RSO, either within the Safety Zone or in the Hazardous Zone.

As recommended by LGC NCOE document the good practice here suggested also point for a QRA anytime SIMOPS are intended inside the Hazardous Zone, and a QualRA for those intended to take place in the Safety Zone.

The Staged Approach leads to SIMOPS authorization and is structured from the Planning Stage (leading to Permitting) down to the Bunkering Operation Stage. The concept behind the structured staged approach is to ensure the check for consistency between approved SIMOPS conditions and verified conditions prior to LNG Bunkering Operation.

In the context of the present Guidance it is suggested that small deviations to the approved Qualitative Risk Assessment (QualRA) may be considered, provided these are discussed in a SIMOPS Meeting, in preparation for LNG Bunkering Operation.

11.5.3 SIMOPS Operational Diagram

The diagram in figure 11.7, below, presents a flow-diagram with the operational diagram suggested for SIMOPS in LNG bunkering. Table 11.3, explains each stage (each column) of the recommended operational diagram.

The diagram assumes 2 (two) PICs (as envisaged in the IGF Code) and introduces the SIMOPS Supervisory Role as an element to ensure adequate overview, communications and alarm dissemination through all the involved stakeholders in the operation. The SIMOPS Supervisor role is described in 11.5.4.

The operational diagram should only be regarded as guidance to the implementation of actual control provisions for SIMOPS in LNG bunkering. Other operational arrangements are possible. The diagram below, with the SIMOPS Supervisor, reflects (according to the diagram in 11.6) the case where simultaneous operations are planned to take place in the Safety Zone or Hazardous Zone.

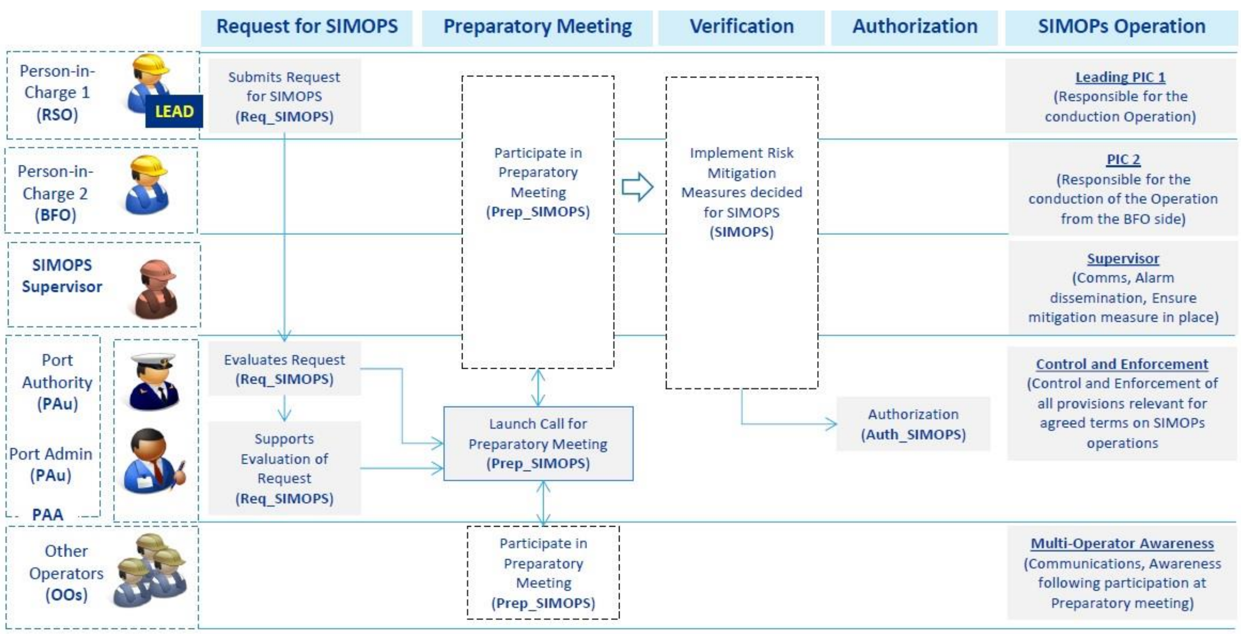


Figure 11.7 –SIMOPS in LNG Bunkering Operations – Recommended Operational Diagram

Figure 11.3 –SIMOPS Operational Diagram description

Short Description	Who	Action
Request for SIMOPS	**PIC – RSO (PIC Lead)**	• Person-in-Charge 1 (RSO – Lead PIC) requests SIMOPS in advance (48hrs is recommended, but a different advance notice time may be agreed with the PAA. • The Lead PIC is responsible to ensure that all information sent is consistent with the existing approved Risk Assessment pertaining to SIMOPS. • Request should describe with detail what type of SIMOPS is/are intended. • Request should also identify all stakeholders involved, with relevant contacts for all operators.
Evaluate SIMOPS Request	**PAA**	• SIMOPS request is evaluated – Consistency between request and existing information on Risk Assessment is done. • Evaluation of the overall operational scenario in the Port Area.
Call for SIMOPS Preparatory meeting	**PAA**	• With the information from the SIMOPS request, the PAA launches a call for SIMOPS Preparatory Meeting. • RSO, BFO, PAA, Other Operators should be present at the meeting to discuss possible operational aspects that should be addressed in advance.
SIMOPS Preparatory Meeting	**PAA BFO RSO Operators**	• For SIMOPS in the Safety Zone, should any differences be noted between assumptions in a • Only existing approved Risk Assessment elements should be considered. The SIMOPS Preparatory meeting is not intended to be a substitute for a HAZID or an informal risk assessment.
Verification Implementation of Risk Mitigation Measures	**PAA BFO RSO**	• Implementation of Risk Mitigation Measures. • Protective Measures and Safeguards should reflect the existing Risk Assessment.
Authorization	**PAA**	• Authorization for SIMOPS to be issued upon positive confirmation that all agreed safeguards and protective measures have been implemented.

11.5.4 SIMOPS Supervisor

The diagram assumes 2 (two) PICs (as envisaged in the IGF Code) and introduces the SIMOPS Supervisory Role as an element to ensure adequate overview, communications and alarm dissemination through all the involved stakeholders in the operation.

The need for a SIMOPS Supervisor is a reflection of the need to release both PICs from the responsibility of SIMOPS overview and coordination. This should be a task with which the PICs should not be distracted. It is not only important that the PICs are not over-burdened but it should also be possible to have a dedicated person responsible for the overview of the operational context, with communications with all the operators involved in simultaneous operations.

Alarm dissemination is another important responsibility of the SIMOPS Supervisor, ensuring that in the event of an accident all involved operators receive indications that allow immediate emergency action.

The recommendation for a SIMOPS Supervisor should ensure an adequate organization for emergency, in SIMOPS context, is ensured.

12. Bunkering Operation

The present section is dedicated to the operational aspects of LNG bunkering, based on the organizational considerations and good practice suggested in section 10.

All references to operational aspects, nomenclature and procedures are consistent with those in IACS Rec. 142 (2015) [3] and SGMF Guidelines v2 (2017) [35]. Remarks strictly relevant to PAAs in the course of the relevant supervisory and control functions are identified in section 12.9, as suggested good practice for PAAs during LNG bunkering operation.

The standard LNG bunkering procedure can be considered to be well established today, with a significant number of LNG fuel bunkering operations to LNG fuelled ships. Industry guidance (as IACS and SGMF) outlines today the good practice procedures in bunkering operations, streamlining the processes and identifying the major relevant steps in the operation. The different LNG bunkering modes have, to some extent, all been put in practice and experience has been gained by operators

Having the above in consideration, the present Chapter, and all sections contained herein, do not present colliding provisions or any technical aspects which are not consistent with industry guidance. It is the purpose of Chapter 12 to provide information to PAAs on the different LNG bunkering modes, generic LNG bunkering process and, more importantly, to suggest good practice procedures for PAAs in the control of LNG bunkering, highlighting the main critical aspects that should be regarded closely from a port authority perspective.

Authorization of LNG bunkering operations will be a responsibility of PAAs. How this “Authorization” takes place, as a result of which process, using which defined communication channels and, finally, based on which documented procedure will this “Authorization” be based upon. Surely Certification of equipment, Training of personnel, amongst other aspects, will be relevant, but it is important to define the exact points where the role of PAAs may be more than a purely passive one, with control checks and support, e.g. in the implementation and enforcement of Control Zones.

Section 12.1 presents different LNG bunkering modes and arrangements, further detailing the LNG bunkering modes which have already been outlined in section 2.5, in particular focusing the TTS, PTS and STS bunkering modes. Section 12.2 is included with an informative set of diagrams for a generic LNG bunkering/fuel transfer operation. Section12.3 outlines in detail the generic LNG bunkering process, from pre-bunkering to the final steps upon completion of the operation, underlining the aspects most relevant to PAAs in their supervisory and control functions in LNG bunkering. Section 12.4, following from section 3, highlight the main element for sustainability of LNG bunkering operations: BOG management. From a business and environmental perspective, management of LNG boil-off is an important element to consider throughout the whole bunkering operation. Minimization of BOG should be one of the main optimization criteria for LNG bunkering..

12.1 LNG Bunkering Methods

Having already introduced the different LNG bunkering modes, in section 2.5, these are now presented in more detail, including important aspects which affect the operational performance of the different LNG bunkering methods. In addition, for each bunkering method, single line diagrams are presented to illustrate generic arrangements. Type-C and atmospheric tanks are considered, with the main differences highlighted and illustrated in the different bunkering methods.

12.1.1 Truck-to-Ship (TTS)

Truck-to-Ship (TTS) LNG bunkering has been a largely adopted method for the initial LNG bunkering implementation. With ships having a small to moderate demand for LNG, of a few hundred cubic meters, TTS has provided for a flexible option, responding to a limited demand. Experience has been gained in procedures and operation with added value to the safe adoption of LNG as fuel.

LNG bunkering TTS operations are carried out from typically standardised LNG trucks (of around 40 to 80m^3). With an increasing need for LNG, especially by ships with increased LNG fuel capacity, more than one truck may be required to bunker a single ship, depending on the required bunker volume. This may be achieved either in a sequential manner or, alternatively, through a common bunkering manifold. On either option the challenges of TTS become noticeable, with increased complexity of operations and largely increased operation time lengths.

As presented in table 2.21, TTS method may be applied to bunkering volume up to 200-400m3, depending on the maximum required turn-around times.

Table 12.1, below, summarizes the main operational aspects of TTS, including also the most relevant limitations.

Table 12.1 – TTS LNG bunkering mode – Summary table

Truck-to-Ship - TTS	
Short Description	LNG truck connected to the receiving ship on the quayside, using a flexible hose, assisted typically by a hose-handling manual cantilever crane.
Typical Volumes (V) [21]	V ≈ 50-100m3
Typical Bunker transfer rates (V) [21]	Q ≈ 40-60m3/h
Operational characteristics and possibilities	• Operational Flexibility, with bunkering possible in different locations within the same port, serving different ships in different conditions. • Operation highly dependent on the transfer capacity of the truck, typically small (see above). • Possible to deliver LNG very close to receiving ship, minimizing: – heat transfer through the bunkering hose – pressure drop along the bunkering line – trapped volume, • Limited Infrastructure requirements, with no necessary • Possibility to adjust delivered volumes (Nr. of trucks) to different client needs. • Possibility to adapt to different safety requirements. • Possibility to serve different LNG fuel users on point-to-point delivery • RO-RO/PAX ferries may be bunkered from a location in main car/cargo deck. Control for such operation to be
Limitations	• Limited capacity of trucks: approximately 40-80 m3 is likely to dictate multi-truck operation. • Limited flow-rates (900-1200l/hr) • Significant impact on other operations involving passengers and/or cargo. • Limited movement on the quay-side, mostly influenced by the presence of the bunker truck(s). • Exposure to roadside eventual limitations (permitting, physical limitations, traffic related, etc.)

Figure 12.1 – TTS Bunkering. Truck-to-ship LNG delivery of LNG, with truck ashore, alongside of the ship, at berth.

Figure 12.2 – TTS Bunkering. Truck-to-ship LNG delivery of LNG, with truck ashore. Additional truck for inerting.

Figure 12.3 – TTS Bunkering. Two truck via comon bunkering manifold.

Figure 12.4 – TTS Bunkering. Truck-to-ship LNG delivery of LNG, with truck ashore. It can be noted from this figure how the footprint of the LNG TTS operation may affect the quayside availability for any othe operations.

Figure 12.5 and 12.6 – TTS Bunkering by multiple trucks, via common manifold. It can be seen how the complexity of the operation is increased, not only with significant number of connection to common manifold but also with a significant number of personnel. To the technical challenge there is also an organizational one.

Figure 12.7 – Port-to-Ship (PTS) Bunkering. LNG bunkering fixed installation fed by LNG fuel trucks. This is, in practice, an alternative to improve the LNG delivery rate and volumes to the receiving ship. The fixed installation works here as a buffer station.

Figure 12.8 – LNG trainler semi-fixed installation. Despite not being a purely TTS bunkering operation it gives evidence on how felxible LNG trucks and trailer can be. Here a semi-fixed installation that may be used for LNG bunkering or fuelling. Typically an installation for LNG consumption more than bunkering/transfer.

Figures 12.9 and 12.10, on the next page, give single-line representations of LNG bunkering generic setup for TTS operation.

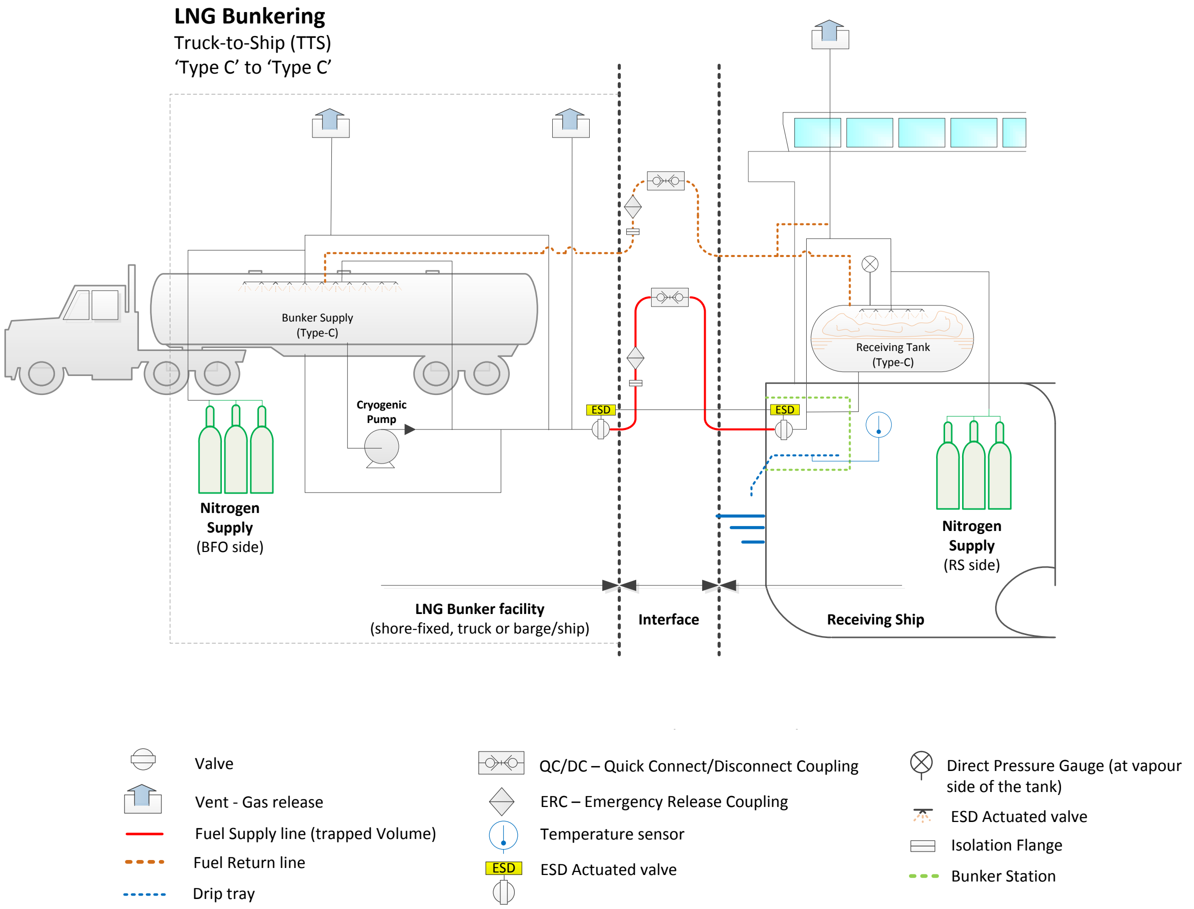


Figure 12.9 – TTS Bunkering – single line diagram for generic representation

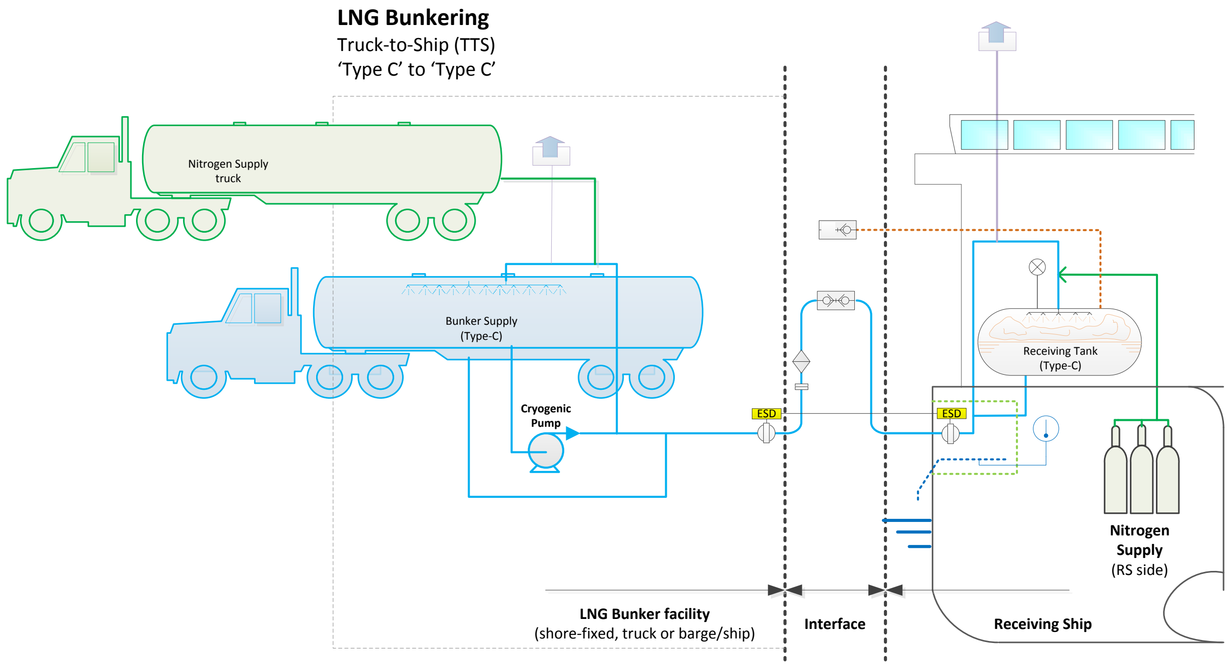


Figure 12.10 – TTS Bunkering – single line diagram for generic representation (including additional truck for inerting services)

12.1.2 Ship-to-Ship (TTS)

Table 12.2, below, summarizes the main operational aspects of STS, including also the most relevant limitations.

Table 12.2 – STS LNG bunkering mode – Summary table

Ship-to-Ship - STS	
Short Description	LNG is delivered to the receiving vessels by another ship, boat or barge, moored alongside on the opposite side to the quay. LNG delivery hose is handled by the bunker.
Typical Volumes (V) [21]	V ≈ 100-6500m3
Typical Bunker transfer rates (V) [21]	Q ≈ 500-1000m3/h
Operational characteristics	• Generally does not interfere with cargo/passenger handling operations. Simultaneous Operations (SIMOPS) concept is favoured. • Most favourable option for LNG bunkering, especially for ships with a short port turnaround time. • Larger delivery capacity and higher rates than TTS method. • Operational flexibility – bunkering can take place alongside, with receiving vessel moored, at anchor or at station
Limitations	• Initial investment costs involving design, procurement, construction and operation of an LNG fuelled vessel/barge. • Significant impact in life-cycle cost figures for the specific LNG bunker business. • Limited size for bunker vessel, conditioned by port limitations

Figure 12.11 – Ship-to-Ship (PTS) Bunkering.

Figure 12.12 – Ship-to-Ship (PTS) Bunkering.

STS bunkering has been a growing operational option for increasing LNG bunkering demands, both in capacity and flow rates. As LNG fuelled ships grow in LNG capacity the need for increased LNG bunkering capacity is also expected to increase.

STS LNG bunkering represent a particular challenge for PAAs, accounting for the need to consider adequate nautical risk studies that can evaluate and assess the risks in the best possible way. This will not only allow choosing for the best LNG bunkering location but will also contribute to determine the best navigation route for the bunker vessel, whilst in restricted waters.

Figures 12.13 to 12.15, on the next page, give single-line representations of LNG bunkering generic setup for STS operation.

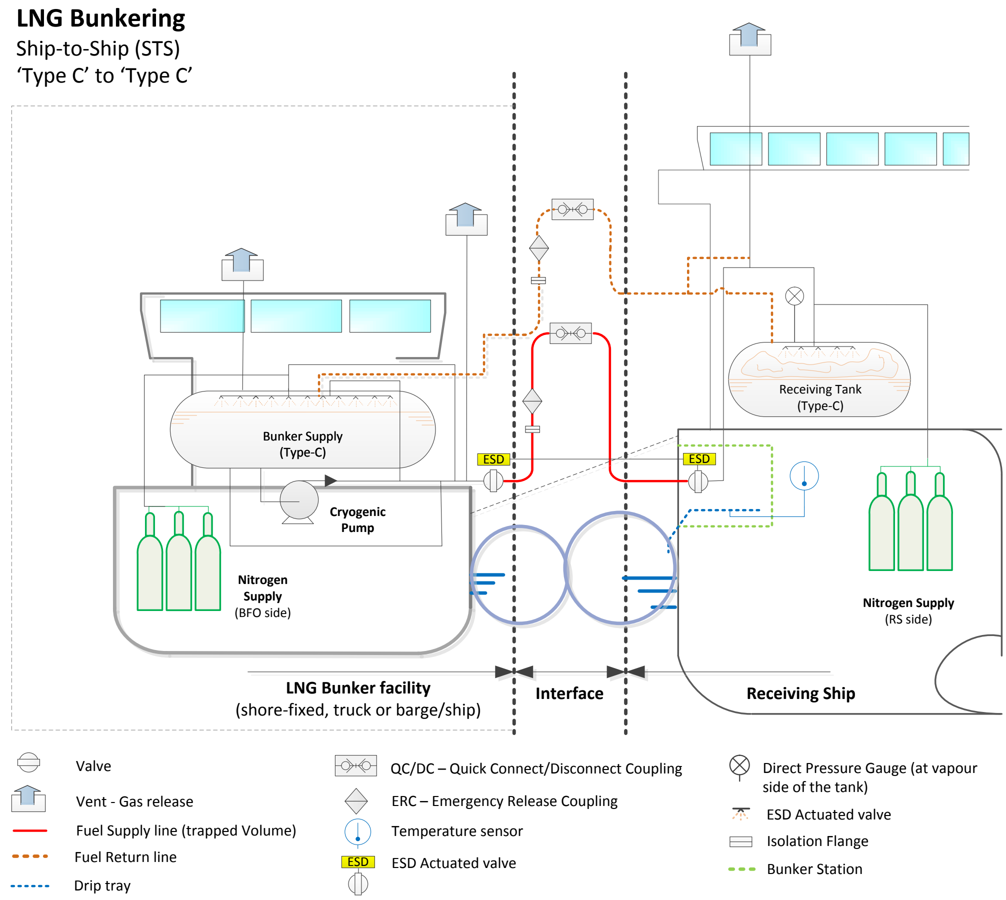


Figure 12.13 – STS Bunkering – single line diagram for generic representation

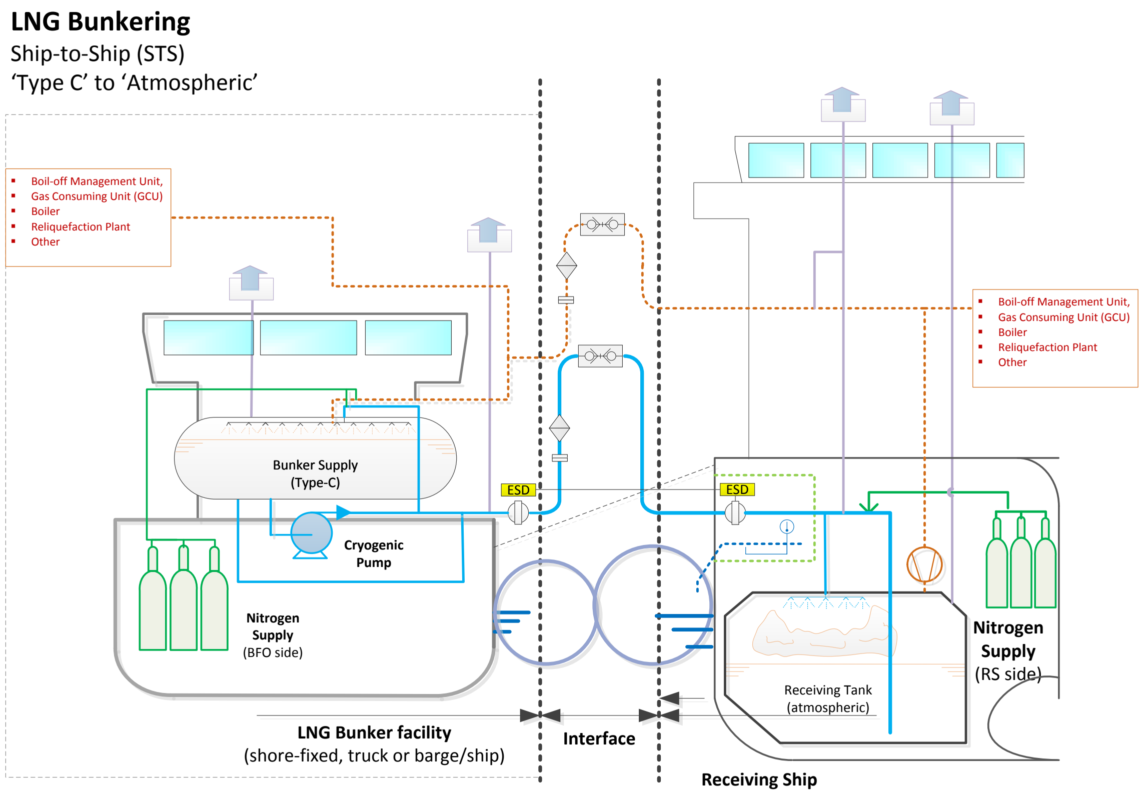


Figure 12.14 – TTS Bunkering – single line diagram for generic representation

(Type-C tant to atmospheric receiving)

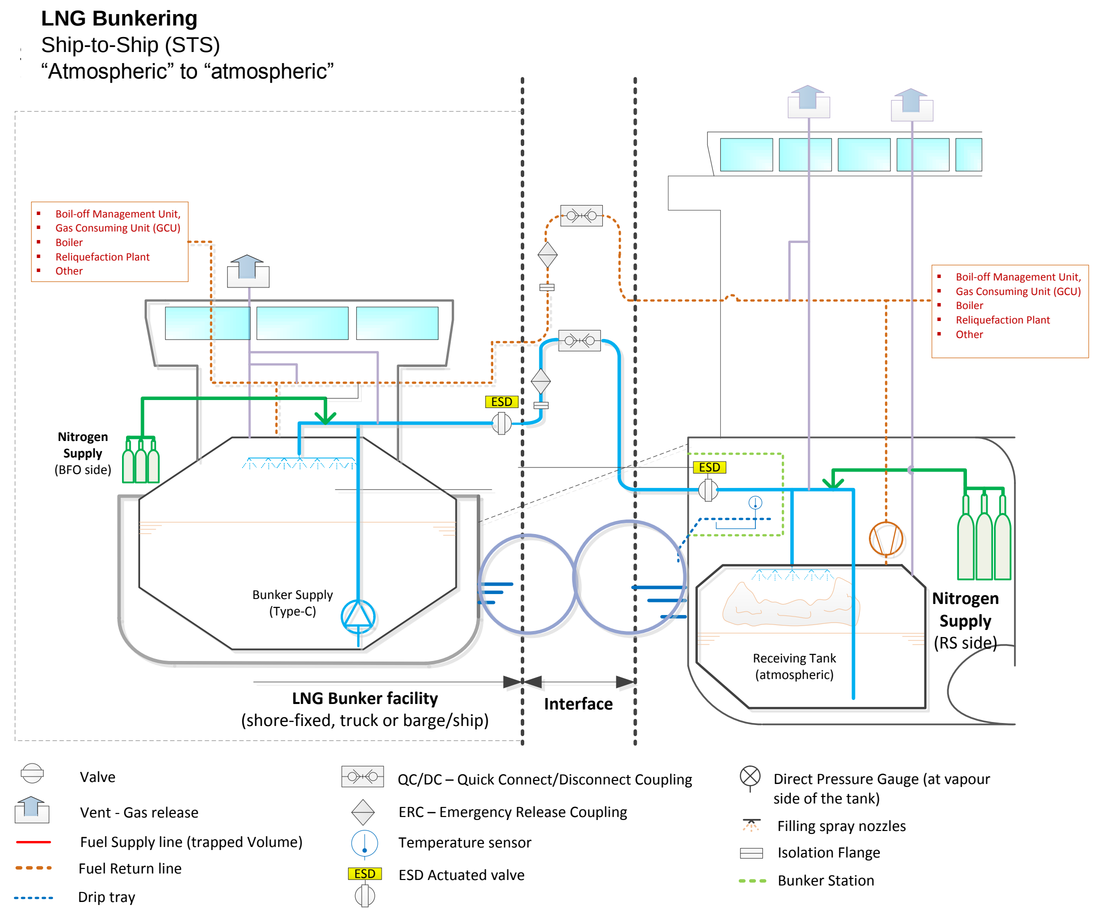


Figure 12.15 – STS Bunkering – single line diagram for generic representation (including additional truck for inerting services)

12.1.3 Port-to-Ship (PTS)

Table 12.3, below, summarizes the main operational aspects of STS, including also the most relevant limitations.

Table 12.3 – STS LNG bunkering mode – Summary table

Port-to-Ship - PTS	
Short Description	LNG is either bunkered directly from a small storage unit (LNG tank) of LNG fuel, small station, or from an import or export terminal.
Typical Volumes (V) [21]	V ≈ 500-20000m3
Typical Bunker transfer rates (V) [21]	Q ≈ 1000-2000m3/h
Operational characteristics	• Possibility to deliver larger LNG volumes, at higher rates. • Good option for ports with stable, long-term bunkering demand
Limitations	• From operational perspective it may be difficult to get the LNG fuelled receiving vessel to the Terminal. • Proximity of larger LNG terminal may not be easy to guarantee. • Calculation of available LNG for delivery, in small storage tanks, can be difficult unless pre-established contract exist

Figures 12.16 and 12.18, on the next page, give single-line representations of LNG bunkering generic setup for TTS operation.

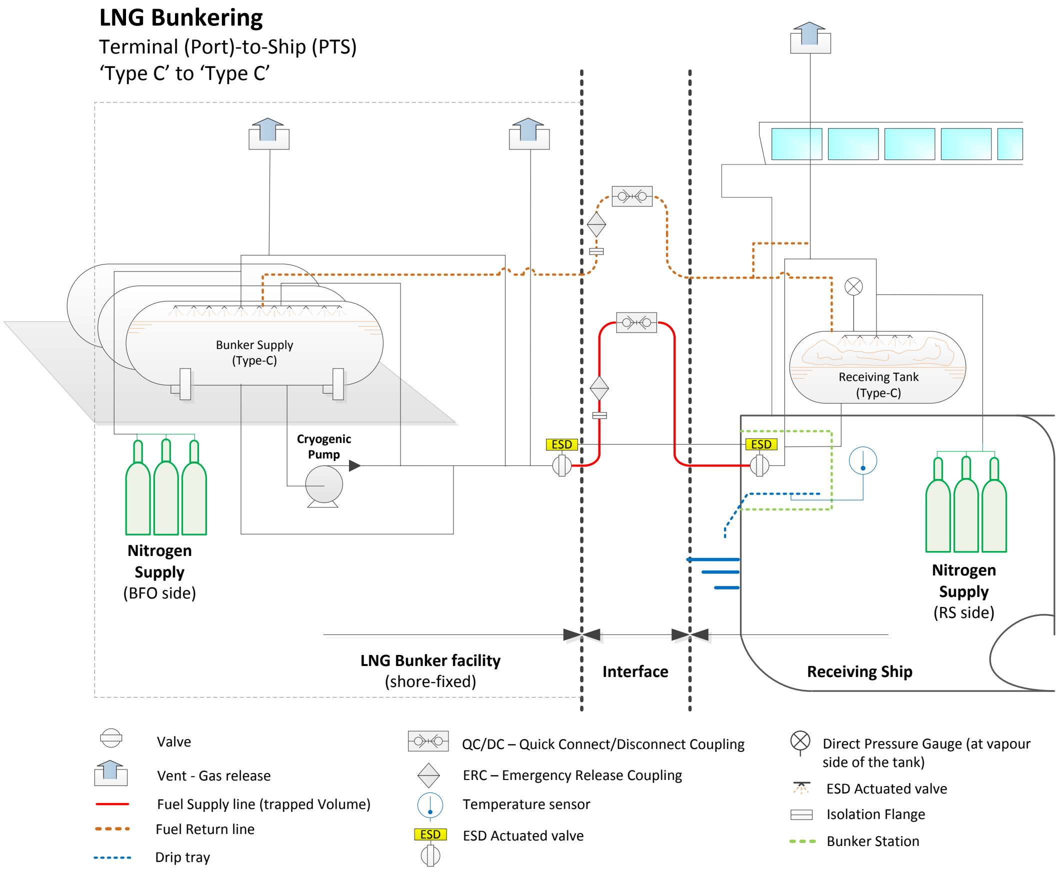


Figure 12.16 – PTS Bunkering – single line diagram for generic representation

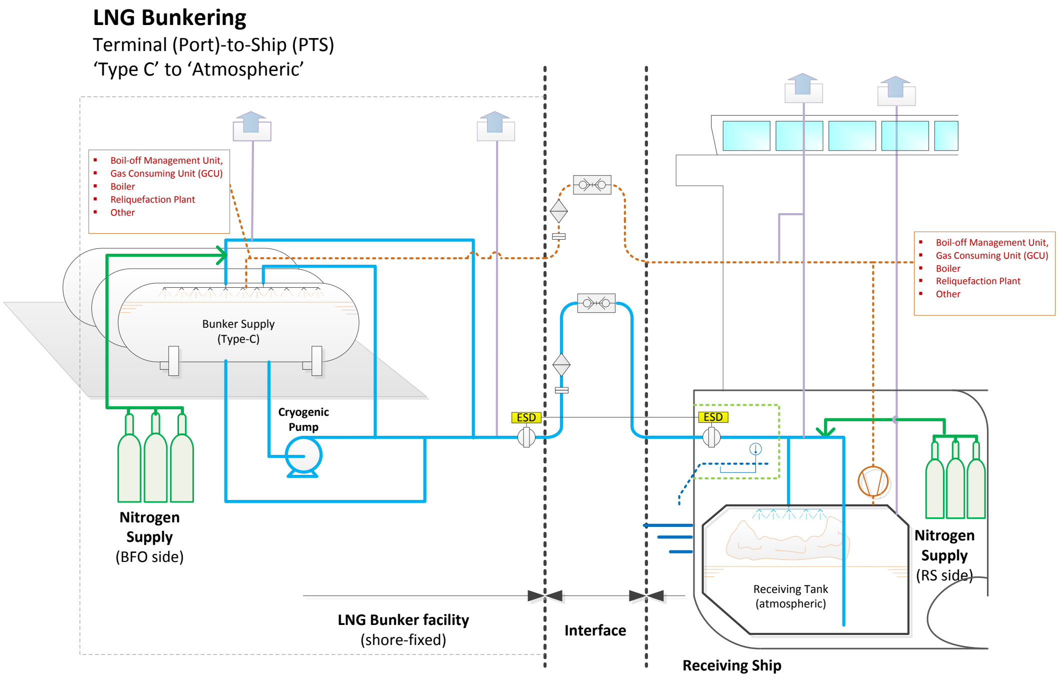


Figure 12.17 – PTS Bunkering – single line diagram for generic representation

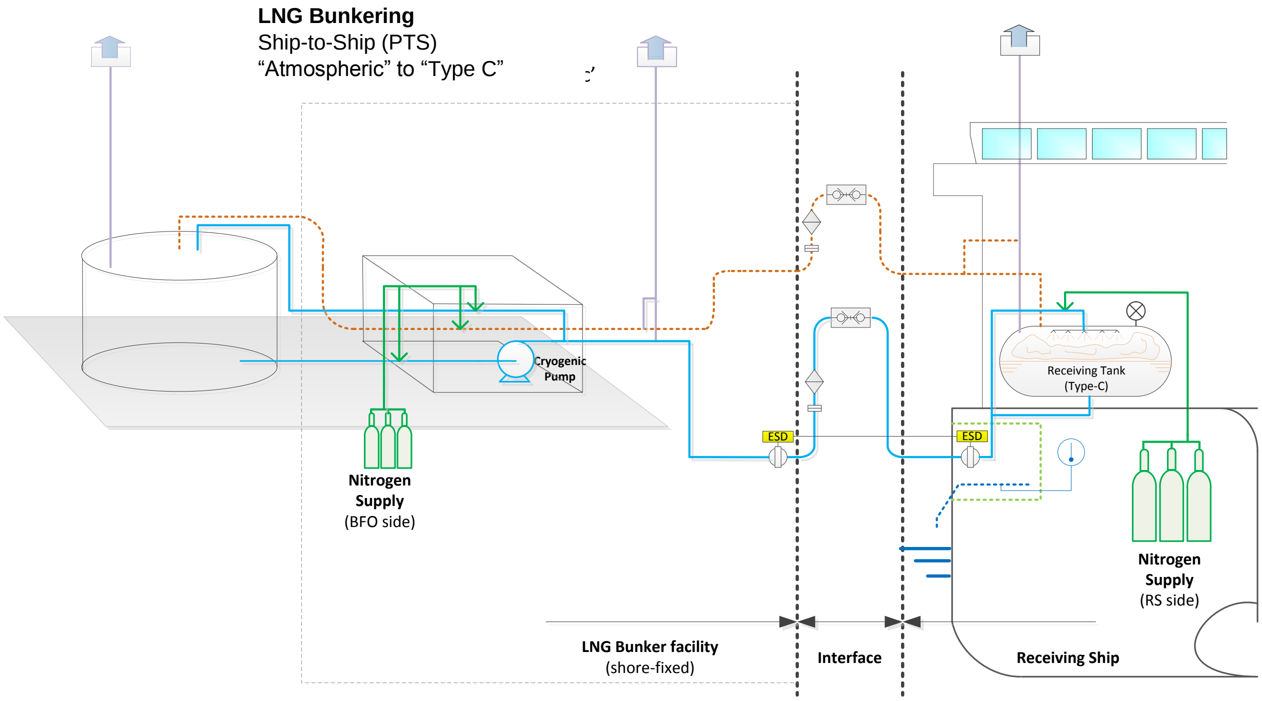


Figure 12.18 – PTS Bunkering – single line diagram for generic representation

12.2 Bunkering Procedure

Even though not directly involved in the direct LNG bunkering operation, PAAs should have a clear structured perception of which different steps take part during LNG transfer. For that purpose, and having a generic LNG bunkering single-line "type-C to type-C" arrangement, as represented in figure 12.19, below, the generic LNG bunkering operation is presented in this section to best support PAA in the understanding of the generic different stages involved.

Initially all valves are closed as shown in the diagram. The transfer hose is not connected until step three but included in this diagram. The first step takes place during ship mooring or in the case of ship---to---ship transfer during the bunker vessels mooring up against the receiving ship. Discharging unit can be either: terminal, truck or bunker vessel/barge. Variations in design and layout can take place, but overall this is a representative example of a layout and it gives a good basis for explaining the bunkering procedure.

To be noted, in particular, that different arrangements are possible that will in practice be implemented, with different technological solutions, connectors, hose length, GCUs, storage, control mechanisms, manifolds, etc. The main objective of the present section is to differentiate between the different operational stages during LNG bunkering: 1) Initial Cooling; 2) Connection; 3) Inerting, 4) Purging, 5) Filling sequence; 6) Stripping; 7) Inerting (final inerting of bunkering lines).

It is possible that, under specific project arrangements and risk assessment, some of the phases generically represented in this section, may either not take place, or be done differently, bases on the specific technological details in place.

Figure 12.19 represents the complete system on a generic Port-to-Ship arrangement. The valves indicated only provide the representation of the

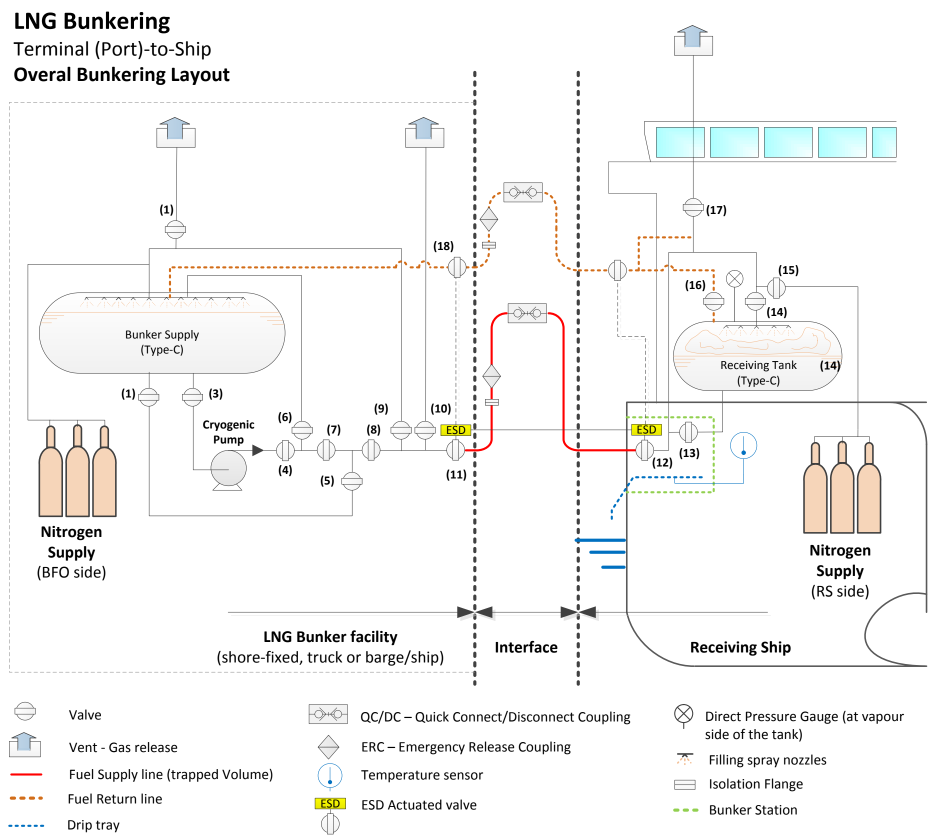


Figure 12.19 – Generic LNG Bunkering arrangement
(Full system representation)

12.2.1 Step 1 – Initial Precooling 1

Filling lines are precooled in advance to operation. Valves V2, V5, V8 and V9 are opened. The system needs to be cooled down slowly, otherwise one part will contract and another not. Improper cooling could also lead to pipe cracking. The precooling sequence depends on cargo pump, design of the discharging unit and size of installation. Cold LNG (blue) exits tank 1 form the bottom, and slowly "pushes" the warmer NG (red) in the pipes into the top of tank 1.

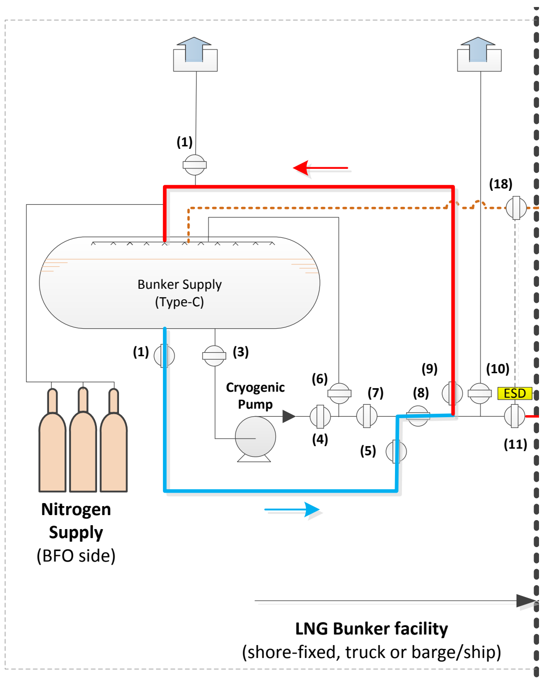


Figure 12.20 – Generic LNG Bunkering arrangement – Step 1 – Initial Pre-Cooling

During this stage both units must check temperature and pressure of their respective LNG tanks. Within the tank, temperature is directly correlated with pressure. If the temperature of the receiving tank is significantly higher than the discharging, there will be an initial excessive vaporization when starting to transfer LNG. This will likely increase the tank pressure and potentially trigger the pressure relief valve to open if the pressure exceeds the set limit. For his reason, the pressure of both tanks must be reduced prior to the bunkering in case of a high receiving tank temperature. In addition, it is also here important to note, when the levels in the receiving tank are low, the rate of evaporation and heat ingress to the tank increases, causing a higher-pressure build-up.

The transfer of LNG requires a certain pressure difference, which generally is determined by the pump/PBU and the pressure in the receiving tank. The larger the pressure difference, the more efficient the transfer. For TTS bunkering with flow rates of around 50 m^3/h, a typical transfer pump can deliver at around 4 barg. In a warm tank, the pressure may be as high as 5 barg. To be able to conduct the transfer you need a lower pressure in the receiving tank than what is delivered by the pump.

12.2.2 Step 2--- Initial Precooling 2

The fixed speed cargo pump at the discharging unit also requires precooling. Valves in step 1 remain opened and additionally valves V3, V4 and V6 are opened. For transfers where the pressure difference between the discharging and receiving unit is greater than 2barg, tank 1 pressure will be utilized as a driving force. This makes the cargo pump redundant.

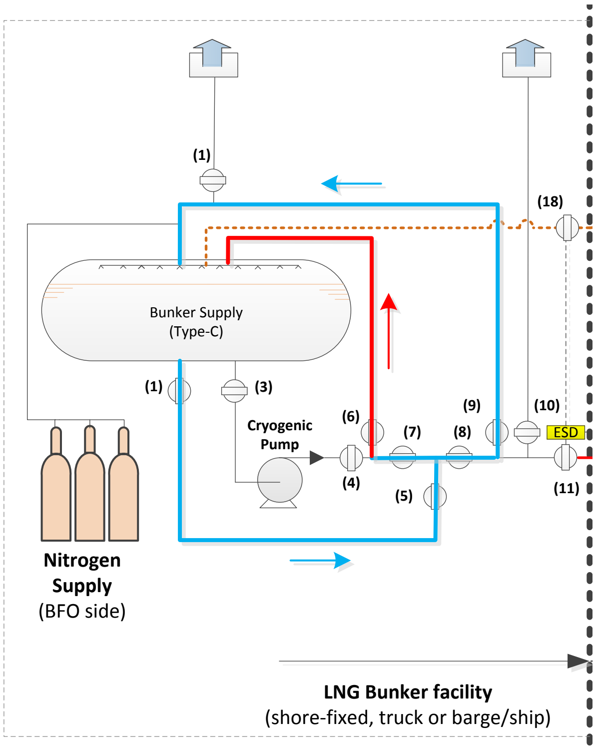


Figure 12.21 – Generic LNG Bunkering arrangement – Step 1 – Initial Pre-Cooling 2

12.2.3 Step 3 – Connection of Bunker Hose

All previously opened valves are now closed. Dedicated discharging units may be fitted with specialized hose handling equipment (i.e. hose crane) or loading arms, to deliver the bunker hose to the receiving ship. The hose is connected to the manifold. Each manifold are to be earthed and the receiving ship shall be equipped with an insulating flange near the coupling to prevent a possible ignition source due to electrostatic build-up. One or two flexible hoses will be connected between the units – one liquid filling hose and one vapour return hose if needed. For smaller transfers with capacities range of around 50-200m3/h, and where the receiving tank is a type C tank with the possibility of sequential filling, a vapour-return hose will generally not be needed. For larger transfer rates a vapour return line may be used in order to decrease the time of the bunkering.

12.2.4 Step 4 - Inerting the Connected System

Inert gas, nitrogen (green), is used to remove moisture and oxygen (below 4%) from tank 2 and associated piping. Inerting is accomplished by sequential pressurization and depressurization of the system with nitrogen. Presence of moisture in the tanks or pipes will create hydrates, which is a form of ice lumps that will be difficult to remove from the system. Oxygen in the system would here produce an explosive atmosphere inside the LNG transfer line leading to a hazardous situation that needs to be avoided through inerting. Valves opened: V10, V11, V12 and V16.

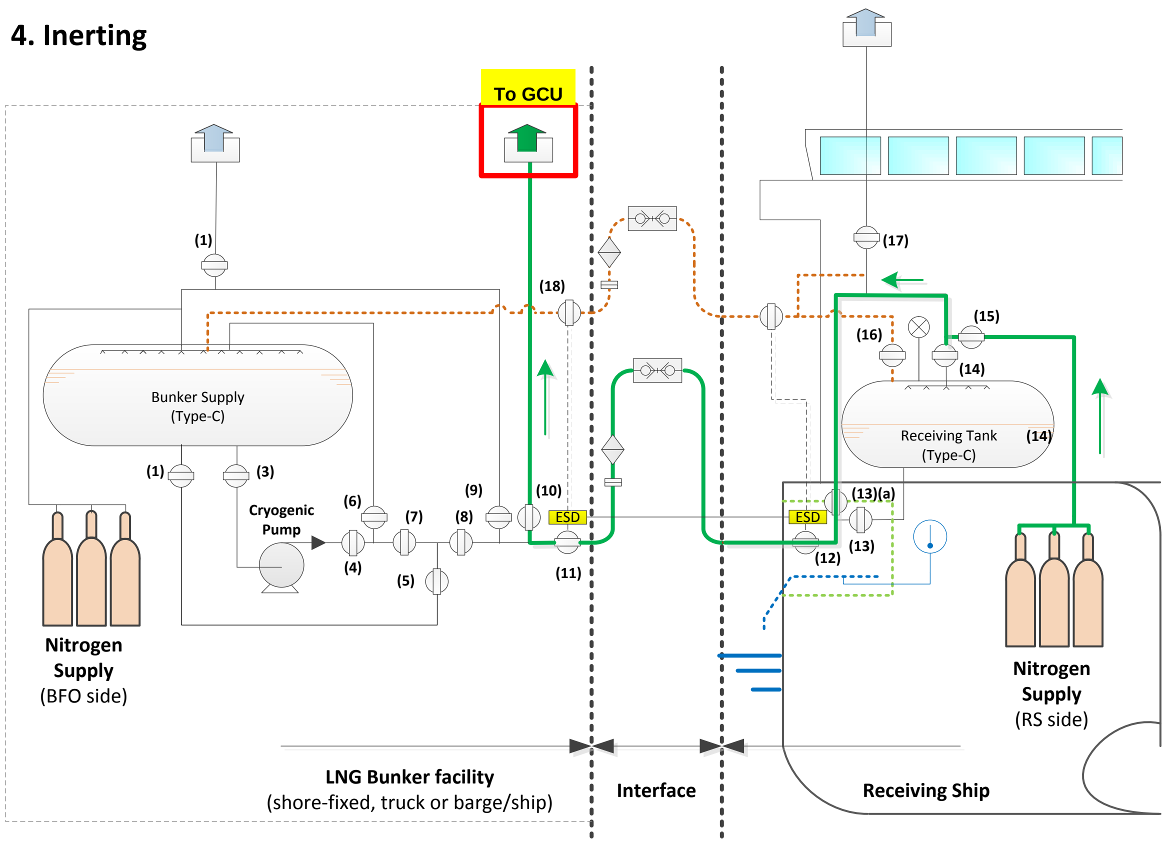


Figure 12.22 – Generic LNG Bunkering arrangement – Step 4 – Inerting

12.2.5 Step 5 - Purging the Connected System

The remaining system is purged with NG (until it reaches 97-98% ratio), to remove remaining nitrogen according to engine specifications. Valve V16 is closed prior to purging. Valve V15 is opened, natural gas is now moving out from the receiving tank. Venting trace amount of methane through the mast should be subject to due consideration. Venting should not be allowed, and any possible necessary release of excessive LNG boil-off/gas should be done through a GCU/Oxidizer/Flare or equivalent system. Valve V10 should be closed quickly after the pipes have been cleaned so as not to let too much methane escape through the vent.

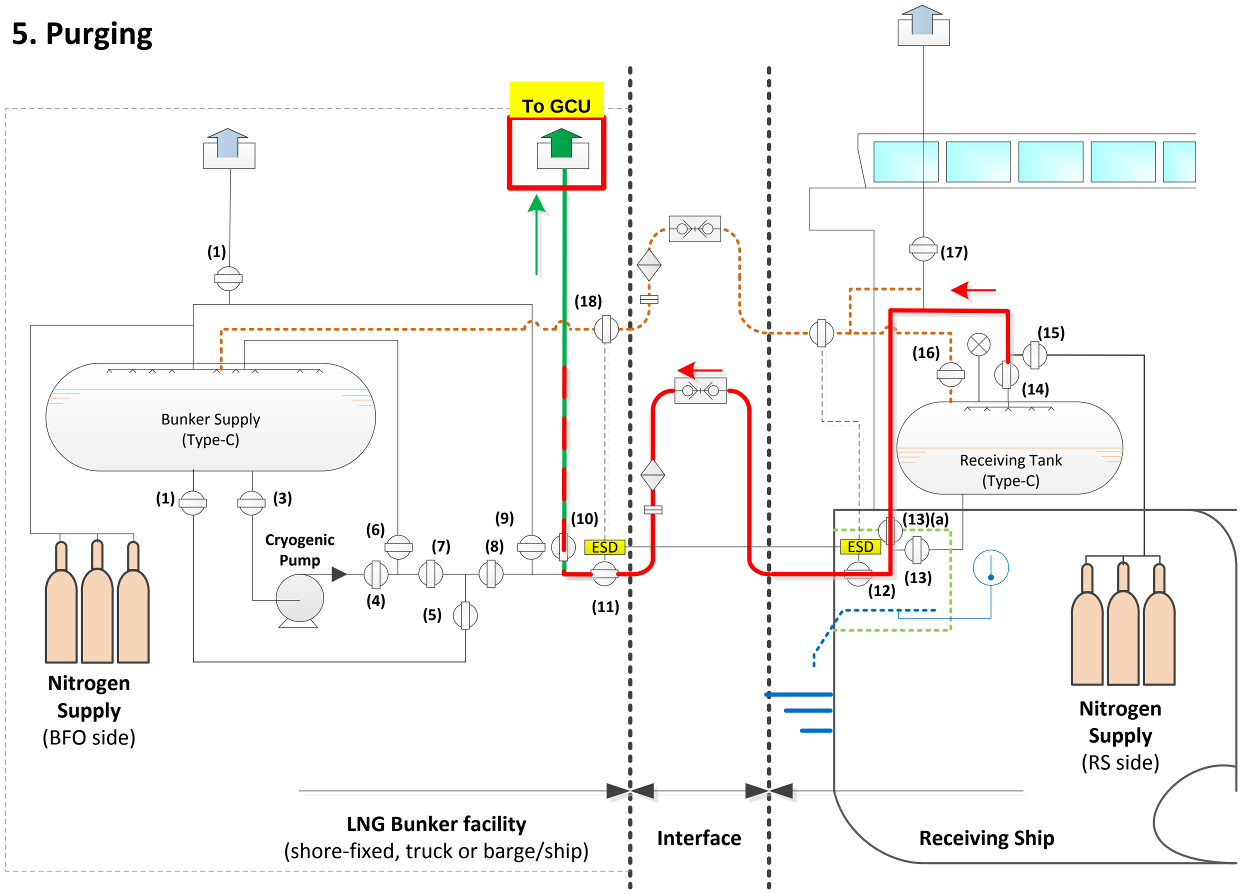


Figure 12.23 – Generic LNG Bunkering arrangement – Step 5 – Purging

12.2.6 Step 6 – Filling Sequence

For the filling sequence both bottom filling and top filling (the shower/spray) can be used. For top filling valve V15 remains open, for bottom filling it is closed and valve V13 is opened. To start the transfer from tank 1 to tank 2 valves V3, V4, V7, V8, V11 and V12 also have to be opened. Common practice is to start with top filling as this will reduce the pressure in the fuel tank, and then move over to bottom filling when a satisfying pressure is achieved. A high pressure in the receiving tank will make it harder for the LNG transfer to take place and the pump would have to work with higher pressure and higher energy consumption.

Transfer speed range from 100-1000m3/h depending on scenario, tanks and equipment, and whether bottom or top filling is used. Bottom filling can take much higher volumes than top filling. Bottom filling is therefore preferred with respect to time, but it is important that the tank pressure allows for this to take place. Sequential filling i.e. alterations between top and bottom filling during the transfer is also standard practice, to control the pressure in the receiving tank.

This rate can be withheld during the transfer until agreed amount is reached. The transfer is to be monitored on both ships with regards to system pressure, tank volume and equipment behaviour. This procedure is to be performed for each tank regardless of fuel type. Maximum level for filling the LNG tanks is 98% of total volume according to class rules, but is normally lower for system design reasons

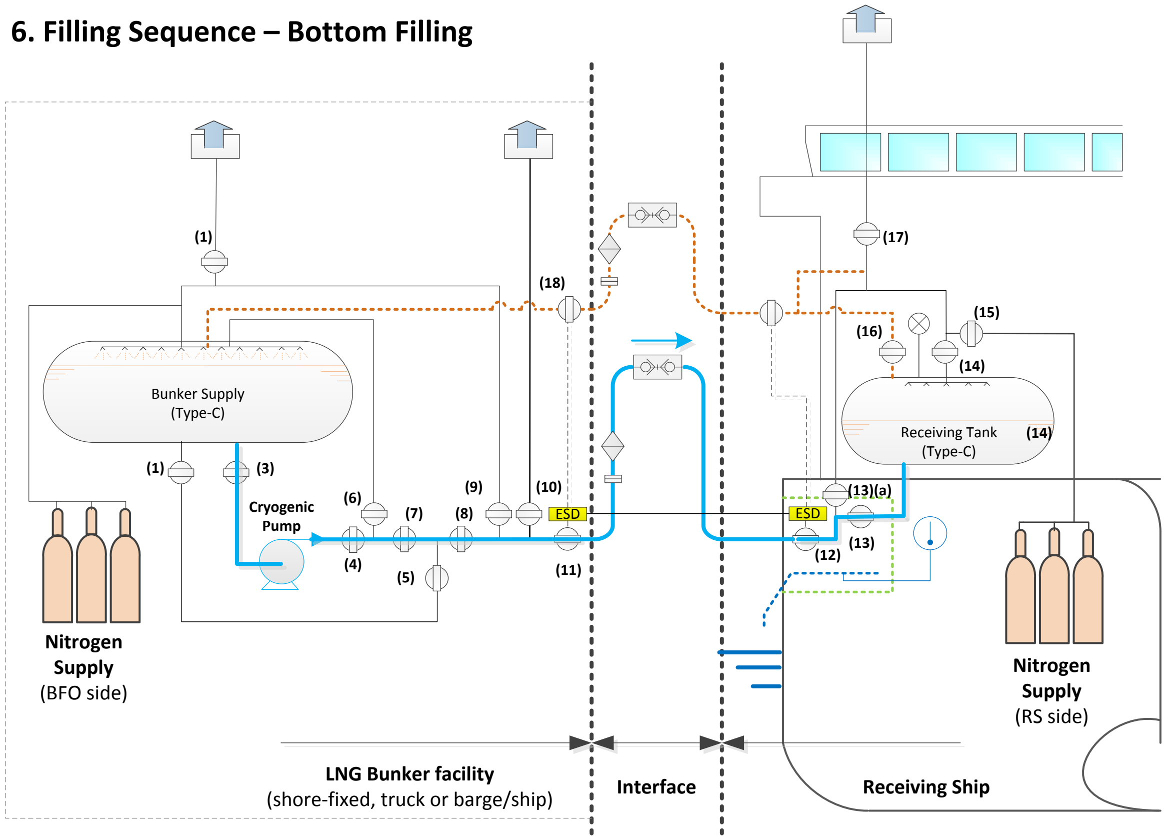


Figure 12.24 – Generic LNG Bunkering arrangement – Step 6 – Bottom filling

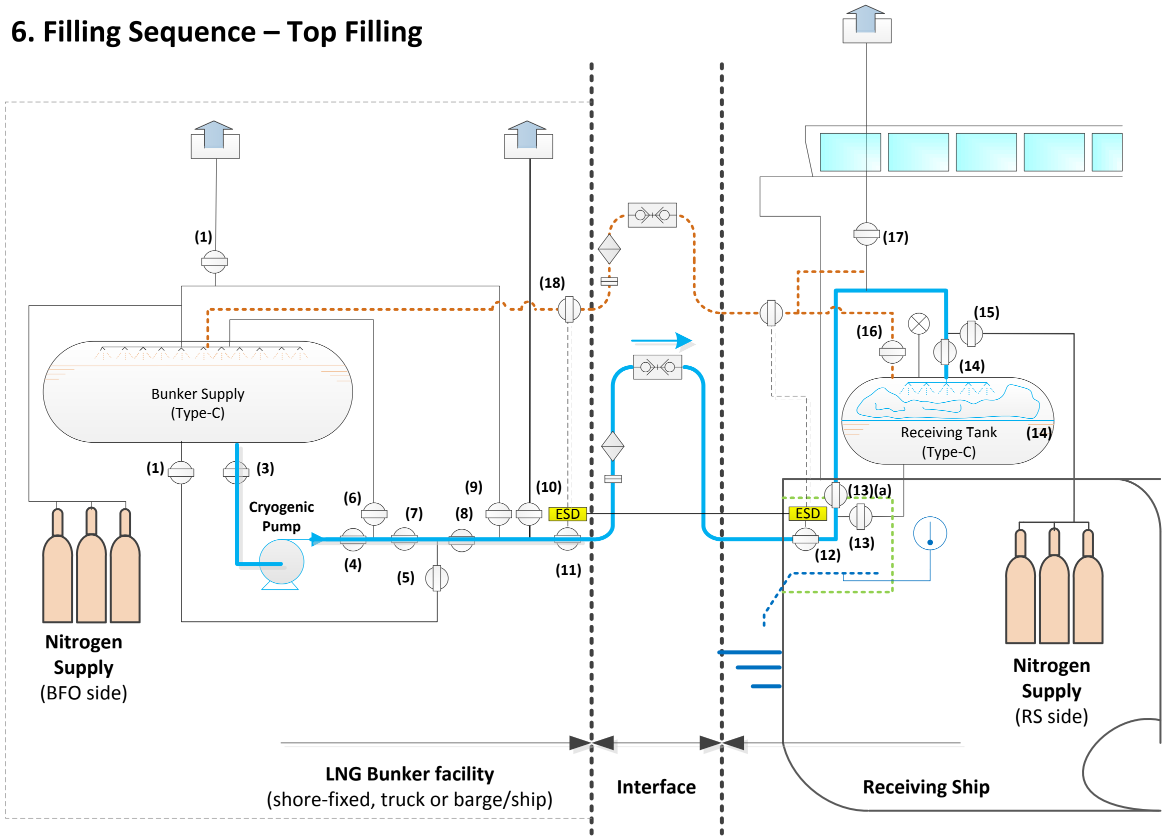


Figure 12.25 – Generic LNG Bunkering arrangement – Step 7 – Top filling

12.2.7 Step 7 – Liquid Line Stripping

The liquid that remains in the bunker hoses, after the pump has stopped, must be drained before disconnection. Valves V3, V4 and V11 on discharging unit are closed, while valve V6 is opened. This valve links to the top of the fuel tank. This process creates a pressure build-up due to a rise in temperature in the remaining liquid left in the pipes and hose. LNG residuals in these areas are forced into both tanks. Subsequent opening and closing of the shipside valve V12, pushes the remaining LNG into the receiving ships tanks.

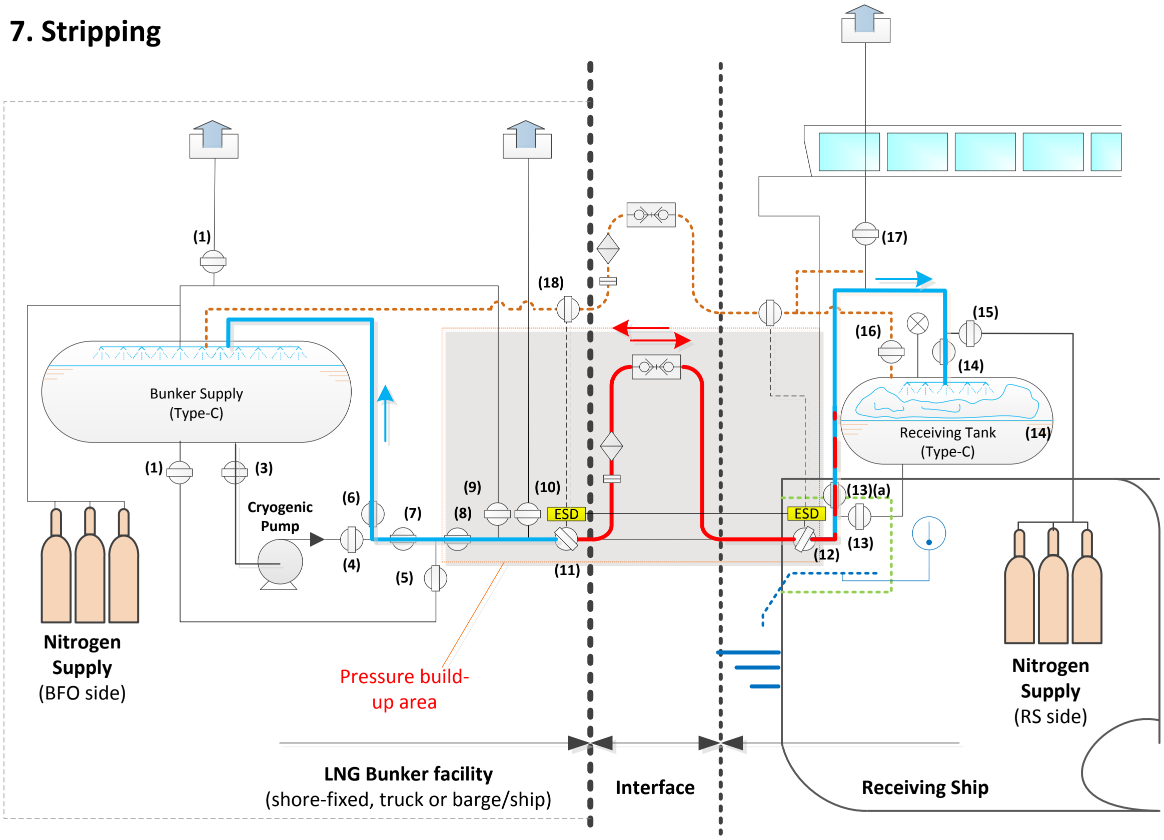


Figure 12.26 – Generic LNG Bunkering arrangement – Step 7 – Stripping

12.2.8 Step 8 – Inerting

In a process in everything similar to Step 4 the LNG bunkering line should be inerted in the end of operation, prior to disconnection.

12.3 LNG Bunkering Process

The diagram in figure 12.27, below, outlines the different stages of a generic LNG bunkering operation, from Pre-Bunkering to Post-Bunkering, including the different elements that should be expected in the adequate operational description of a time-sequence for LNG bunkering.

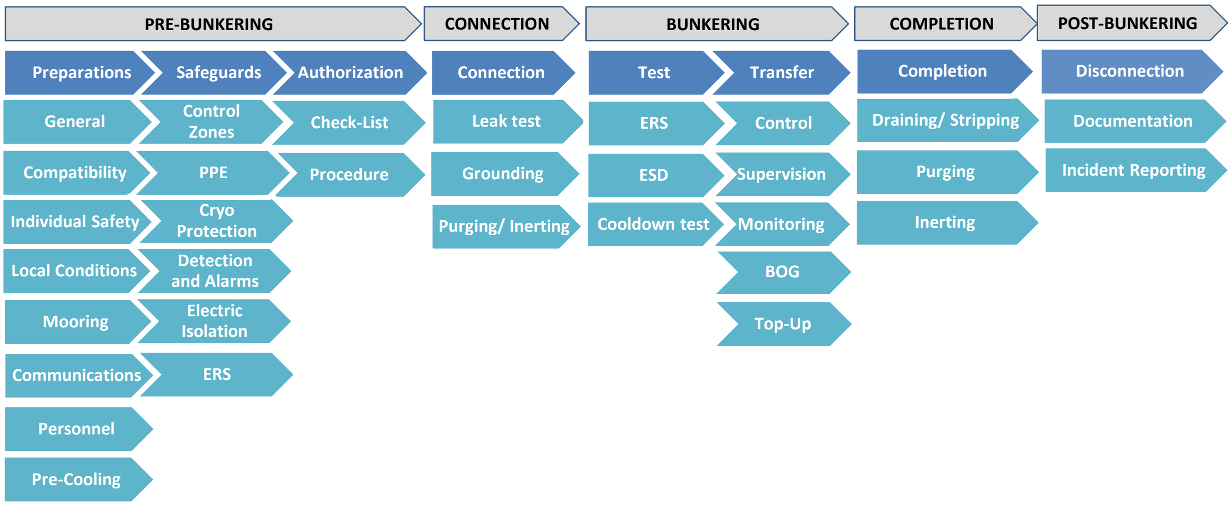


Figure 12.27 – Generic LNG Bunkering arrangement – Step 7 – Stripping

In the diagram above, in figure 12.26, it is possible to see all the elementary steps that compose a typical LNG bunkering operation. Detailing each of the operational elements above is not within the scope of the EMSA Guidance, with existing references today already providing, collectively, an excellent operational description of how the different aspects should be covered.

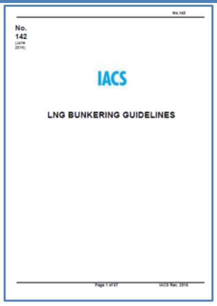
The industry has very recently built up significant experience and know-how and any transcription in this Guidance would lead to potential good operational practice, updated in thee reference documents listed below, failing to be updated in this Guidance. To avoid this from happening no transcriptions or adaptation of operational related text has been attempted in this section, only providing for the relevant references.

The following references should be taken into account for the full description of the LNG bunkering operational process:

Document		By	Available at	Short description/ Section for Transfer Procedures
	**EN ISO 20519 -** Specification for bunkering of liquefied natural gas fuelled vessels	ISO	http://www.iso.org/iso/ (available for purchase)	Section 6.5 – Transfer Procedures LNG Bunker Check-Lists in Annex • Fully consistent with the IGF Code (6.5.1) • Minimum staffing during bunkering (responsibility to the vessel captain/facility) – (6.5.2) • Always 2 PICs (one on either side of the bunkering line/operation) engaged in nothing else – (6.5.2.1) • Manifold Watch (on receiving vessel) – (6.5.2.2) • Hose watch (on bunker vessel/facility) – (6.5.2.3) • Check-list procedure (6.5.3) – Pre-Operation • LNG bunker supplier responsibility to inform RSO on local requirements (6.5.4) • PIC conference (6.5.5) – Decision on leading PIC • Bunker transfer equipment responsibility (6.5.6) • Communications (6.5.7) • Check-list procedure (6.5.8) – Pre-Bunkering • Purging/drainage of hose lines (6.5.9) • PPE (6.5.10) • LNG BDN (6.5.11) • Post Transfer Conference and check-list (6.5.12)

ISO 20519, as described before, should be taken as the main reference for the operational requirements that should be observed and verified in place by PAAs.

Other references will however, read in conjunction with ISO 20519, provide a much in-depth detail of operational procedures, covering all relevant elements, as represented in figure 12.25. These are identified below (IACS Rec.142, and SGMF Bunkering Guidelines):

Document		By	Available at	Short description/ Section for Transfer Procedures
	**IACS Rec 142** LNG Bunkering Guidelines	IACS	http://www.iacs.org.uk/publications/recommendations/ (available for free)	For IACS Section 1 Pre-bunkering phase 1.1 Definition 1.2 Goal 1.3 Functional requirements 1.4 General requirements 1.5 Preparation for bunker transfer 1.6 Pre-bunkering checklist 1.7 Connection of the transfer system Section 2 Bunkering phase 2.1 Definition 2.2 Goal 2.3 Functional requirements 2.4 General requirements Section 3 Bunkering completion phase 3.1 Definition 3.2 Goal 3.3 Functional requirements 3.4 Draining, purging and inerting sequence 3.5 Post-bunkering documentation
	**SGMF** **LNG Bunkering Guidelines** Safety Guidelines **Version 2** April 2017	SGMF	www.sgmf.org (available for purchase)	

12.4 LNG Vapour Management

Boil-Off Gas (BOG), a subject already addressed in Section 3, id here re-visited from an operational perspective, since BOG is very likely the most relevant parameter shaping LNG bunkering operations.

BOG is a relevant issue associated to LNG storage but not only. Also the differences in temperature between LNG supply and receiving tanks will dictate the LNG transfer mode, pressure and overall operation management. This has already been demonstrated before, in section 12.2., with the filling sequence highly dependent on temperature and pressure on both sides of the bunkering lines.

Typical boil-off rates are 0.1-0.5% per day in storage due to heat ingress (even in tanks with very good vacuum insulation. Additional BOG is formed when the LNG is transferred into tanks with higher pressures, half or partially-filled or even when part LNG is left in transfer/bunkering lines for too long. It is important to manage BOG that is generated therefore in:

3) Storage (in any of the LNG bunkering sides)
4) Transfer/bunkering lines
5) Distribution lines,

By removing boil-off gas (recondensing/ liquefying/ consuming), pressure and temperature are kept at controlled constant levels. If boil-off gas is not removed, pressure builds-up and – if not managed – would eventually lead to the opening of pressure relief systems, in what is called as “venting” (an event which can only be considered as an emergency.

But managing BOG is, in fact, more complex than it already seems: When boil-off gas is removed to maintain the pressure level, the methane number decreases because the LNG gets heavier. This is important for LNG as fuel customers because most engines require a minimum methane number to prevent knocking. It is important for the receiving ship to adequately maintain proper storage temperatures and pressures, compensating for some BOG with the showering of cold LNG by top-filling line

If not removed, boil-off gas can be contained under pressure. Pressure will be decreased by emptying the tank and/or refilling it with sub cooled LNG recondensing BOG. BOG is an important aspect in the LNG supply chain that must be taken into account during the complete life-cycle of LNG bunkering operations.

The BOG management required at various supply chain stages depends mainly on the pressure build-up that can be allowed in the supply chain from liquefaction to end-customer. Large LNG customers are mostly energy consumers/producers (like regas to power plants) using atmospheric storage (pressure slightly above 1 bar). Often the LNG is taken-off from these facilities in a gaseous form. Hence the large scale LNG supply requires significant BOG management all over the chain.

The BOG management system (removal) will help to keep LNG colder. LNG cold stored under atmospheric pressure can be delivered to any type of receiving ship LNG tank. On the other hand LNG stored under pressure (therefore warm) can only be delivered to a receiving ship LNG tank that has the same type of pressure storage unless BOG has been removed before. There are significant operational implications in having the right arrangement, and temperatures agreed to ensure adequate LNG transfer arrangement.

In the case of LNG fuelled ships using pressurized storage (type-C tanks), pressure-build up (by a PBU) can be a positive design aspect, as there would be no need for an LNG compressor to deal with the excessive BOG. On these terminals, BOG (pressure build-up) can be handled solely by sufficient throughput, sub cooled LNG and vapour collapse (top spray).

Table 12.4, below, identifies some of the relevant BOG mitigation measure, in the way to avoid excessive LNG vapour generation.

Table 12.4 – BOG mitigating measures

BOG mitigations	Mode	Advantage	Disadvantage
Top spray	LNG transfer	Effective, vapor collapse Low cost solution	Requires internals and topfill line + ESD valves Only if pressurized tank
Vapor return	LNG transfer	Relative low cost solution	Contributes to solution, but rarely a standalone solution (depending on flowrate)
BOG compressor	LNG transfer & storage	Allows BOG to be used as fuel gas/ regen gas or re-liquefy Enables to keep pressure constant Can be single BOG management mitigation method	Very costly Maintenance, reliability If subject to high flow changes, need an bypass to flare/vent
Minimize heat ingress	LNG transfer & storage	Effective Many options available (superinsulated/ vacuum/ PUR/ EPS/ PIR) Can be double containment (safety)	Contribute to solution, but rarely a standalone solution (depending on flowrate)
High throughput	LNG storage	Very effective No CAPEX	Contribute to solution, but rarely a standalone solution (depending on flowrate) Most effective with sub-cooled LNG Limited by customer demand and optimal parcel size
Pressurized storage	LNG storage	Allows more BOG accumulation. Could eliminate the need for pumps	Max volume constraints End-customer constraints
In tank Re-liquefying (coil)	LNG storage	Allows BOG intake Enables to keep pressure constant	Requires another cryogenic tank Coolant refilling required

13. Incident Reporting

13.1 Introduction

Incident reporting is legally enforced to inform the relevant authorities at international, national and local level about deaths, injuries, occupational diseases, spills and dangerous occurrences. This allows authorities to identify where and how risks arise, and whether they need to be investigated. Incident reporting serves multiple purposes, such as contribution to overall safety improvement by capturing the lessons learnt, continuous improvement of legislation, development of new technology/industry best practices, input to hazards identification (via statistical data), monitoring of environmental impact, …

For LNG bunkering activities, only limited experience has been gained from a few years of operation and thus only limited information for LNG bunkering related incidents is available today. One important LNG spillage during truck-to-ship bunkering happened in 2014, where approximately 100 kilograms of LNG leaked from the hose connection in the bunkering room on-board a passenger ship. In different media, this was referred to as a ‘wake-up call’ for the LNG bunkering sector, having a clean incident record before. Also SIGTTO identified two incidents involving LNG releases while draining and purging of the manifold. However, for LNG bunkering operations, clear and uniform requirements for incident reporting are missing, which makes current information on LNG bunkering incidents very limited.

Traditional marine fuel oil bunkering is mainly ship to ship bunkering, hence investigation of accidents is covered by Directive 2009/18/EC establishing the fundamental principles governing the investigation of accidents in the maritime sector. LNG as shipping fuel will involve other bunkering modes (i.e. terminal to ship and truck to ship), with a clear link with the shore side, where incident reporting requirements are partially in place via Seveso directive (if applicable), ADR requirements and specific port requirements.

This chapter gives an overview of the existing incident reporting requirements for LNG as fuel related activities at the shore side and water side (including shore/water interface), both for seagoing and inland waterway vessels, at an international, European and Member State level.

13.2 Shore Side

13.2.1 Onshore LNG installations

13.2.1.1 Seveso Directive

Land based small scale LNG installations (LNG fuel stations and small scale terminals) with storage above 50 tons of LNG - and thus the majority of small scale LNG installations - are subjected to the Seveso directive (2012/18/EU repealing Directive 96/82/EC). For the establishments in scope of this directive, two means of accidents reporting are in place (reporting by operators to competent authorities and the latter to the Commission).

Operators shall ensure that competent authorities are informed following a major accident[81]. Operators need to provide as a minimum, following information as soon as it becomes available: the circumstances of the accident; the dangerous substances involved; the data available for assessing the effects of the accident on man and the environment and the emergency measures taken. Additionally they need to inform competent authorities on the steps envisaged to alleviate the medium- and long-term effects of the accident and to prevent any recurrence of such an accident. Information is collected at Member State level by Competent Authorities.

[81] ‘major accident’ means an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of an establishment, and leading to serious, danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances;

Secondly, Member States need to formally report major accidents to the Commission according to Article 18 of the Seveso III Directive if the quantitative criteria of Annex VI are met. The quantitative criteria are specified for serious injury to persons, damage to environment, damage to property or cross border damage. Accidents or 'near misses' which Member States regard as being of particular technical interest for preventing major accidents and limiting their consequences and which do not meet the quantitative criteria above should also be notified to the Commission.

This information from major accidents (meeting the criteria of Annex VI) is captured within a European database, i.e. the Major Accident Reporting System (eMARS, see § 13.2.1.2).

The transport of LNG and LNG loading/unloading/bunkering activities outside Seveso establishments (such as truck to ship bunkering) are, in principle, not in scope of the Seveso Directive and thus do not have to be reported via eMARS.

Summarized, reporting to competent authorities is in place for LNG 'major accidents' (typically involving higher amounts of LNG). However, it is expected that the bulk of LNG leaks occurring during LNG bunkering activities will not be covered by the definition of major accident and thus clear incident reporting requirements for those incidents are missing. If criteria of Annex VI are met reporting by Member States to the commission is requested. For those incident types reporting structure is well established.

Worth to mention is that all high tier Seveso establishments (>200 tons of LNG) should have a safety management system in place which includes procedures for reporting major accidents and near misses, including their investigation and follow-up based on lessons learnt.

13.2.1.2 The Major Accident Reporting System (eMARS)

The Major Accident Reporting System (MARS and later renamed eMARS) was first established by the EU's Seveso Directive 82/501/EEC in 1982 and has remained in place with subsequent revisions to the Seveso Directive in effect today. The purpose of the eMARS is to facilitate the exchange of lessons learned from accidents and near misses involving dangerous substances in order to improve chemical accident prevention and mitigation of potential consequences **Error! Reference source not found.**.

eMARS contains reports of chemical accidents and near misses provided to the Major Accident and Hazards Bureau (MAHB) of the European Commission's Joint Research Centre from EU, OECD and UNECE countries. Reporting an event into eMARS is compulsory for EU Member States when a Seveso establishment is involved and the event meets the criteria of a "major accident", as defined in Annex VI of the Seveso III Directive (explained in §13.2.1.1). For non-EU OECD and UNECE countries reporting accidents to the eMARS database is voluntary. The information of the reported event is entered into eMARS directly by the official reporting authority of the country in which the accident occurred.

The eMARS database is freely accessible[82]. A search on LNG incidents in this database results in 4 major accidents, one accident took place at a peak shaving station, one at a liquefaction plant and two others were related to power supply and distribution. No LNG bunkering related incidents were found in this database.

13.2.2 LNG cargo transport via land

ADR, which regulates the transport of dangerous goods via road and railways and thus also covers LNG cargo transport via trucks, gives requirements for notification/reporting of incidents in § 1.8.5, '*Notifications of occurrences involving dangerous goods'* of the ADR **Error! Reference source not found.**. This paragraph mentions:

[82] eMARS is accessible via this link : https://emars.jrc.ec.europa.eu/?id=4

> *... 1.8.5.1 If a serious accident or incident takes place during loading, filling, carriage or unloading of dangerous goods on the territory of a Contracting Party, the loader, filler, carrier or consignee, respectively, shall ascertain that a report conforming to the model prescribed in 1.8.5.4 is made to the competent authority of the Contracting Party concerned at the latest one month after the occurrence....*

The ADR model report requires the following information to be completed after an incident: Information on carrier; transport mode (rail / road); date & location of occurrence; topography (gradient/tunnel/bridge/...); particular weather conditions; description of occurrence; dangerous goods involved; cause of occurrence and consequences of occurrence.

If necessary, the Contracting Party has to make a report to the UNECE to inform other contracting parties.

Since incidents during loading and unloading of dangerous goods are in scope according to § 1.8.5.1 of ADR, it can be assumed that LNG bunkering from trucks resorts under this definition.

LNG incidents have to be reported if more than 50 kg of LNG is released or if there was an imminent risk[83] of loss of product, if personal injury, material or environmental damage occurred, or if the authorities were involved.

Reported incidents are collected at National level, currently no European database exists for road accidents and incidents, contrary to railway. Recently some Member States (a.o. UK, France, the Netherlands, Belgium,) have joined forces on a voluntary basis to develop a common database with incident reports (this database will include accidents and incidents by road, railway and inland shipping). This initiative is in a pilot phase and it is yet unclear what the final outcome will be and if these data will be publically available.

13.3 Water Side

13.3.1 International level

IMO Requirements

The *International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code)* is adopted via resolution MSC.255(84) and became mandatory under SOLAS in 2010. Chapter 14 *Marine Safety Investigation Reports* requires that a marine safety investigation is conducted for every "very serious marine casualty", defined as a marine casualty involving the total loss of the ship or a death or severe damage to the environment. Furthermore, these reports have to be made available to the public and the shipping industry. The Code also recommends an investigation into other marine casualties and incidents, by the flag State of a ship involved, if it is considered likely that it would provide information that could be used to prevent future accidents.

Furthermore, in MSC-MEPC.3/circ. 4, IMO gives harmonized reporting procedures. This circular contains an overview of the data to be submitted into the IMO Global Integrated Shipping Information System (GISIS) - the *'Marine Casualties and Incidents'* module of the GISIS database collects data on marine casualties and incidents.

Since 17 June 2011, EU Member States have been uploading marine casualty data to the European Marine Casualty Information Platform, EMCIP (see 11.3.2.1), to improve data collection and analysis. At

[83] The imminent risk of loss of product is defined as 'if, owing to structural damage, the means of containment is no longer suitable for further carriage or if, for any other reason, a sufficient level of safety is no longer ensured (e.g. owing to distortion of tanks or containers, overturning of a tank or fire in the immediate vicinity)'.

the same time, at international level, countries are required to send accident investigation data and reports to the IMO's Global Integrated Shipping Information System, GISIS. To avoid the duplication of work entailed in reporting casualty data to two different systems, Member States proposed the development of a mechanism to enable the mandatory accident investigation data required by GISIS to be transferred to the IMO by EMCIP. This mechanism was developed at EMSA and, since April 2014, data has been transferred automatically from EMCIP to GISIS. EU Member States are now able to report to GISIS using EMCIP, without any additional workload.

13.3.2 European level

13.3.2.1 Seagoing vessels

European Marine Casualty Information Platform - EMCIP

Directive 2009/18/EC, establishing the fundamental principles governing the investigation of accidents in the maritime transport sector, requires member states to ensure safety-focused investigation systems, to investigate very serious marine casualties and decide on the investigation of others, as well as to send commonly structured investigation reports and to populate the European Marine Casualty Information Database (EMCIP). This means that data on marine casualties and incidents have to be stored in the European electronic database EMCIP.

EMCIP is a European electronic database for the storage, exchange and analysis of data on marine casualties and incidents. The investigative bodies of the Member States have to notify the Commission about marine casualties and incidents, and also have to provide the Commission with data resulting from safety investigations in accordance with the EMCIP database scheme.

EMCIP provides the means to store data and information related to marine casualties involving all types of ships and occupational accidents. It also enables the production of statistics and analysis of the technical, human, environmental and organizational factors involved in accidents at sea.

The database taxonomy has been developed by EMSA in consultation with the Member States, on the basis of European research and international recommended practice and procedures. Within the scope of Directive 2009/18/EC, from 17 June 2011, EMCIP notification by Member States of information on marine casualties and incidents and data resulting from safety investigations is mandatory. This allows the Agency to assist the Commission and Member States with initial analysis of such data, the development of trend monitoring mechanisms, proposals for safety recommendations, the improvement of existing European legislation and promotion of new technical requirements.

The EMCIP database is populated by the national competent authorities of the Member States acting as data providers. EMSA manages the system and accepts the communicated data before they are finally stored.

LNG bunkering accidents and incidents (truck to ship, terminal to ship and ship to ship) are covered by this Directive. If a ship is involved, then it is possible to report, but pure shore operations are not in scope. Currently the EMCIP structure and taxonomy has been updated to allow for adequate reporting on accident related to LNG as shipping fuel. It relates to taxonomy on propulsion types (BOG steam, BOG diesel electric, NOG dual fuel, dual fuel), LNG bunkering (ship to ship, truck to ship and terminal (shore) to ship). This update allows registering all water and water/shore interface related incidents.

13.3.2.2 Inland waterway vessels

Requirements for incident reporting for inland waterway vessels are described in ADN, § 1.8.5.1 – *Notifications of occurrences involving dangerous goods.* Similar to ADR, ADN requires the reporting of incidents if a certain amount of dangerous goods were released during loading, filling carriage or unloading of dangerous goods or if there was an imminent risk of loss of product, if personal injury, material or environmental damage occurred, or if the authorities were involved. This means that from a certain amount (i.e. ≥50 kg), LNG spills during LNG bunkering have to be reported.

ADN provides a model for report on occurrences during the carriage of dangerous goods, which is very similar to the ADR report model for transport via road/rail.

13.3.3 National level

In some countries, national incident reporting requirements exist for the reporting of maritime accidents in general, applicable for seagoing vessels, inland waterway vessels, or both. Some examples are:

- Directive for registration of maritime accidents by the nautical administrator (*Richtlijn voor registratie van scheepsongevallen door de nautische beheerder (SOS formulier),* The Netherlands
- Act to Prevent Against Accidents on the North Sea (*Wet bestrijding ongevallen Noordzee – Artikel 4 Meldplicht)*

The requirements can apply to the whole country, a specific region or a specific waterway. The key data collected by these procedures are more or less the same as the databases discussed above (e.g. vessel, location, damage.) however the way of detailing and the way of reporting strongly varies and thus a uniform way to collect incident data is lacking.

13.3.4 Port level

For incidents occurring within a port area, port specific incident reporting procedures exists for incidents involving dangerous goods. These incident reporting requirements are mostly part of the ‘Dangerous Goods Codices’ of the ports. Similar as with the incident reporting on a national level, the level of details required according these port specific incident reporting procedures and the way of reporting differs between the ports.

14. Emergency, Preparedness & Response

14.1 Introduction

Having already addressed Safety aspects of LNG as Fuel in Section 8, where LNG hazards have been identified and LNG risk & safety has been addressed, the present section is focused on the last stage of an LNG bunkering incident escalation, following an LNG accidental release, followed by expected LNG evaporation and formation of dispersing cloud.

The present Section outlines a first informative section part with elements relevant for identification of Emergency Systems and, a second part with LNG Firefighting techniques relevant for LNG firefighting in LNG and, finally, one last part on Emergency Plans, outlining recommendations to PAAs with regards to good practice in Emergency Response Plans, with a particular focus on the need for integration between LNG bunkering Internal Emergency Plans (BFO/PAA) and External Emergency Plan (Emergency Services and competent local/national authorities).

14.2 Scope

Having already addressed Safety aspects of LNG as Fuel in Section 8, where LNG hazards have been identified and LNG risk & safety has been addressed, the present section is focused on the last stage of an LNG bunkering incident escalation, following an LNG accidental release and developing. The scope is indicated below, making use of the 3 Layers of Defence defined in ISO/TS 18683, as adapted below in a diagram below from DNV-GL Recommended Practice DNVGL-RP-G105 [41]

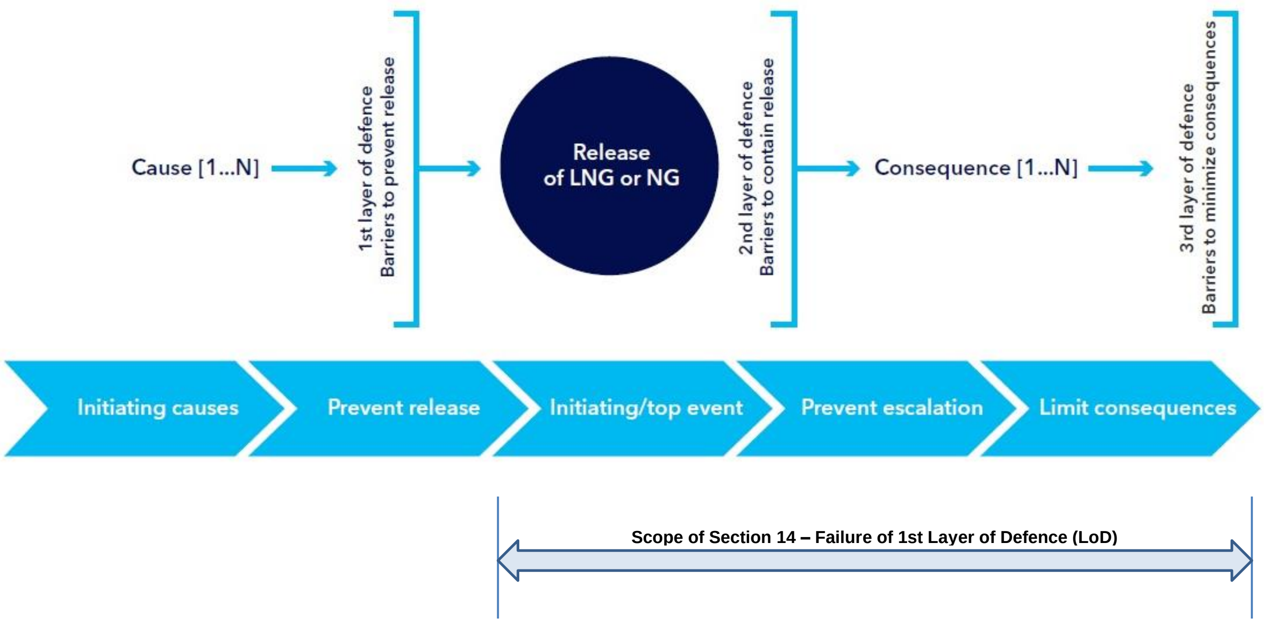


Figure 14.1 – LNG Bunkering Layers of Defence (source: DNVGL-RP-G105 [41]**).**

For the purpose of the present Guidance the scope for the Emergency Response activation should be considered the failure of the 1st LoD.

Systems composing the 1st LoD will be the constituent elements of the LNG bunkering transfer system: 1) hoses, 2) connectors, 3) supports, 4) loading arms and other elements as described in 14.3.1.

The 2nd LoD will follow the release event, or be actuated just before a high probability of release is verified (such as prior to a collision or other external accidental factor). This is the case of ESD systems, and ERC, with action in the bunkering line aiming to limit the amount of released LNG in the case of loss in the containment of the transfer line.

14.3 Emergency Systems

In spite of all technical and operational safeguards and measures, the possibility of an emergency situation shall always be taken into account. The safety concept as described in ISO/TS 18683 is here used to identify the relevant safeguards/barriers within the typical LNG bunkering/transfer system.

Figure 14.2, below, represents the escalation of an LNG bunkering incident with an accidental event line represented as a stepping-up on the severity of the incident through all the layers from normal process control, up to Emergency Response, the final stage of the mitigation action, following a release event. On Figure 14.3 the hierarchy of control and emergency systems is represented, for the particular case of LNG bunkering.

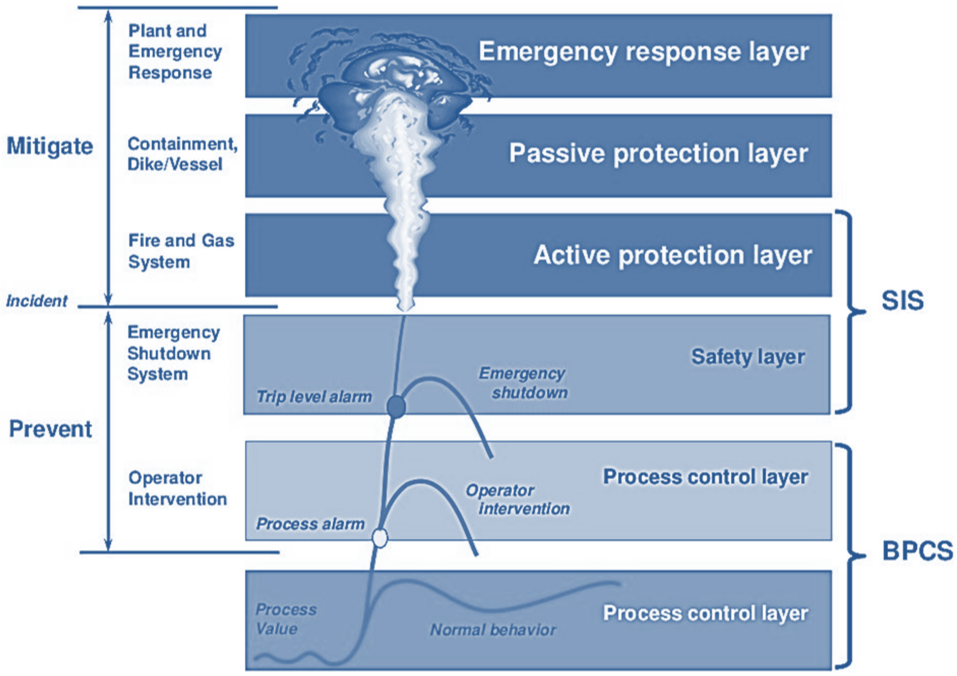


Figure 14.2 – LNG Bunkering Safeguard layers – normal operation, prevention, mitigation.

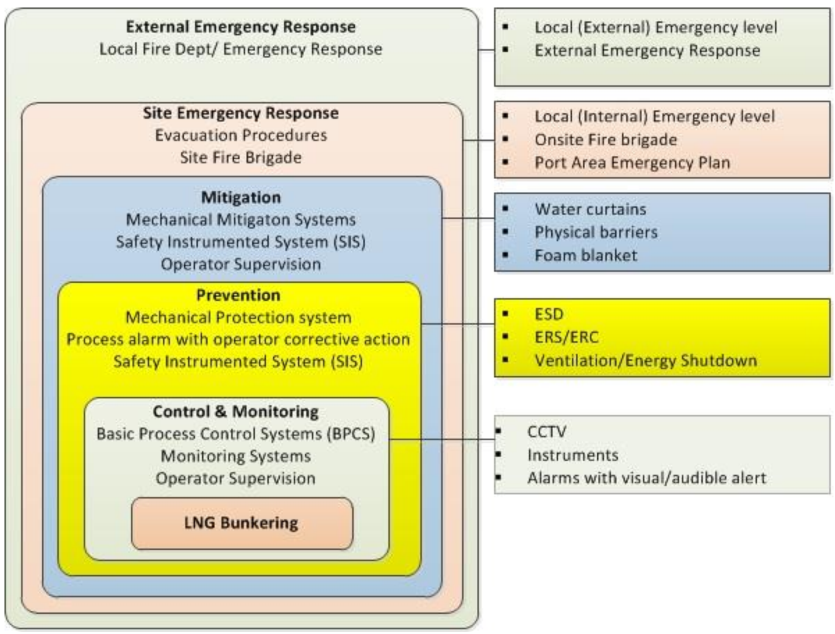


Figure 14.3 – LNG Bunkering Safeguard layers – normal operation, prevention, mitigation.

14.3.1 Emergency Systems – Layered Defence

Another way of representing the 3 Layers of Defence (LoDs) is through the diagram in figure 14.4 (below). The sequence is simple and also reflects the 3 layers as in figure 12.1: 1) Prevent release; 2) Contain release and 3) Extinguish fire. The sequence implies a staged failure of the different safeguards, first with the transfer system failing to contain the LNG, second with the ESD and ERC activated to further contain and minimize release and, third and final, with an ignition event leading to a fire.

Prevention and Mitigation safeguards must be in place to address the full layers of defence, with the emergency action flow, following an accidental release, able to reflect the

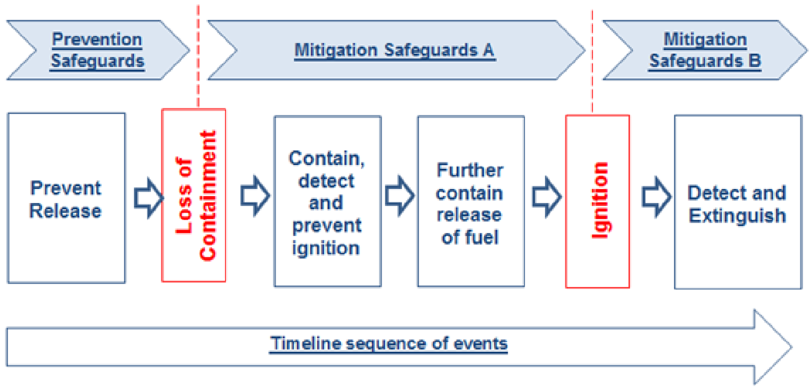


Figure 14.4 – LNG Bunkering Layers of Defence – Prevention and Mitigation Safeguards

14.3.2 1st Layer Safeguards (Prevention)

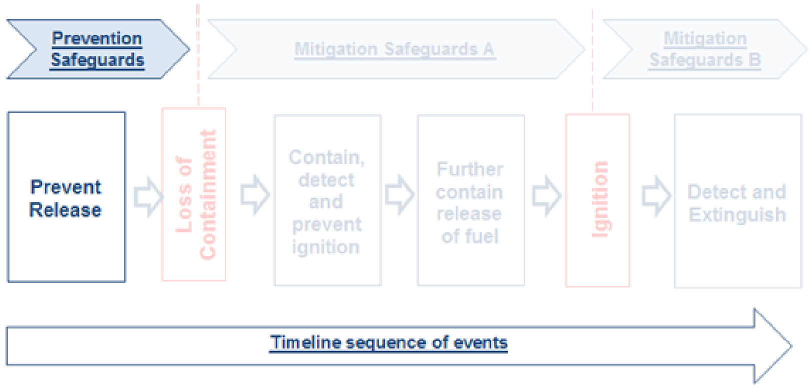


Figure 14.5 – LNG Bunkering Layers of Defence (1st Layer of Defence - Prevention)

1st Layer systems are not emergency systems in themselves but contribute to the overall safety of the LNG transfer system through adequate containment of LNG. They operate under normal parameters and should allow ensuring that no LNG is released or spilled during normal operation. The standard is, in fact, **zero-leak – zero-emission**, not only accounting for Safety but also for environmental aspects with the need to ensure adequate methane emission mitigation.

The 1st layer systems are all the transfer system components necessary to ensure the necessary goal for the **zero-leak – zero-emission** standards.

In the present Section two different types of 1st layer safeguards are listed: 1) Technological and 2) Operational (mostly as part of Pre-Bunkering procedures).

Table 14.1 includes a summary of technological 1st layer safeguards and, in table 14.2, some relevant operational 1st Layer measures are also listed.

Table 14.1 – LNG Bunkering Layers of Defence (1st Layer of Defence - Prevention)
(Technological Measures)

1st LoD System	Short description	Functional Requirements	Reference
Bunker hose	1st LoD system that allows transfer of LNG within proper containment element. Connected at both ends of the transfer system, with QC/DC connector	The bunker hoses shall be designed for cryogenic liquids, de-pressurisation, inerting and gas freeing. Correct hose length to take into consideration the vessel's relative freeboard changes and movements. The limiting parameter for the hose dimension is the flow velocity. The industry practice is for the flow velocity not to exceed 10 m/s.	ISO/TS 18683 (Tables 1 and 2) ISO 20519 (Table 1, Para 4.5.4) EN 1474-2 EN 12434 IACS Rec.142 Section 5.2.2
Loading arm (Hose Support/ saddles)	Hose suspension support to allow LNG bunkering hose to be handled avoiding mechanical damage and excessive bending of the hose. Act as a 1st LoD in the sense that it allows proper use of the bunkering hose, avoiding stresses due to bending.	If used, shall comply with and be designed to safely support the loads (static and dynamic) imposed by the LNG transfer operations during hose connection, transfer operations, and when the hose is disconnected under emergency conditions. They shall provide the necessary support so that the recommended bending radius recommended by the hose manufacturer is not exceeded.	EN 1474-1 EN 1474-3
QCDC bunker connectors	Quick Connect-Disconnect Coupling LNG bunkering connector. Standardization work ongoing. Fundamental 1st layer safeguard. Need to ensure the use of a standard type of QCDC connector for improved Safety levels.	The coupling consists of a Nozzle (male) and a receptacle (female). The nozzle allows quick connection and disconnection of the fuel supply hose to the receptacle, mounted on the LNG manifold. Connectors used shall be designed to operate as quick connect/disconnect couplings. Couplings, in nominal sizes up to 6", for flows up to 650 m3/h, and maximum flow rates of 10 m/s and shall conform to the functional requirements listed in ISO 20519. LNG Bunker connectors – QC/DC (Marine LNG fuel bunkering quick connect/ disconnect coupling), following the functional requirements outlined by ISO 20519, but taking the work up to the level of International Standard. NWIP ISO 21903	ISO 20519 (outline of functional requirements) ISO 21903 (under preparation)
Bunkering connections	Bunkering Connections are fundamental to ensure safe operation, leak free and all allowing for dry-disconnect. Disconnection after purging and inerting.	Bunkering connections shall all be arranged in order to allow dry disconnect operation and may be one of the following types: a. Flange bolting assembly, b. Manual coupler on standardized flange (without check valves), c. Hydraulic coupler on standardized flange (without check valves) or d. Dry connect / disconnect coupling.	ISO/TS 18683 (Tables 1 and 2) ISO 20519 (Table 1, Para 4.5.4)

1st LoD System	Short description	Functional Requirements	Reference
Vapour Return	Vapour return line allows excessive BOG in the receiving tank to be returned for condensation, liquefaction or GCU. Is here indicated as a 1st layer safeguard because it actually represents a mechanism to avoid release (due to excessive pressure in the receiving tank)	The vapour return line should follow all applicable requirements for the bunkering hose. 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 IACS Rec.142, section 2.4.6 of Chapter 3). The most relevant factors that will affect the amount of flash gas generation in a typical bunkering operation are as follows (IACS Rec. 142, Section 5.9): • *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* The LNG vapour return line will allow the collection of all excessive BOG to re-liquefaction, condensation or GCU.	IACS Rec. 142 Section 5.9.

Table 14.2 – LNG Bunkering Layers of Defence (1st Layer of Defence - Prevention)
(Operational Measures)

1st LoD System	Short description	Functional Requirements	Reference
Compatibility Assessment	1st LoD system that allows transfer of LNG within proper containment element. Connected at both ends of the transfer system, with QC/DC connector	Compatibility Assessment should consider as a minimum (IACS Rec.142, section 1.4.2) • *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*.	IACS Rec.142 Section 1.4.2 SGMF Guidelines Section 6.4.2

1st LoD System	Short description	Functional Requirements	Reference
Communications	Communications in LNG bunkering should be able to ensure safe operation under normal conditions, allowing all parts involved to share information	Communications should be guaranteed between BFO and RSO by, at least, 2 different communication means – one Main and one other for a contingency communication plan. A communication plan should be agreed between all parties involved prior to the start of operations. Communications equipment to be used within Hazardous Zones to be Ex-proof classified.	IACS Rec.142 Section 1.4.2 SGMF Guidelines Section 6.4.2

Even though the 1st Layer defence systems are not, in themselves, emergency systems, they are fundamental in defining the safe normal operation system where the containment of LNG is the most important functional design objective. The LNG transfer system is complemented by adequate procedures and training. Adequately mapped processes and trained staff are also, in themselves, 1st LoD safeguards.

14.3.3 2nd Layer Emergency Systems

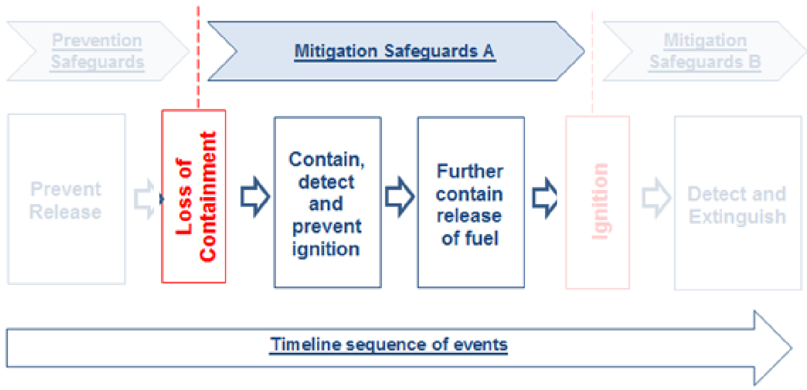


Figure 14.6 – LNG Bunkering Layers of Defence (2nd Layer of Defence – Mitigation A)

Following the accidental release of LNG, the 2nd LoD will act to contain the leakage as much as possible and to prevent the ignition of the fraction of released LNG. Such measures are here identified as "Mitigation A" measures. Only loss of containment of the LNG transfer system is considered.

3 (three) different "Mitigation A" measures are considered:

1. Automatic shut-down/ dry-breakaway – ESD/ERS.
2. Detection – Leakage Detection systems (CCTV, Gas detection, temperature)
3. Containment barrier – Water curtains, Cryogenic protection.

The 3 different groups of systems above all contribute to an immediate containment active and passive response in the event of an accidental LNG release during LNG bunkering. The first group will, in fact, work for an effective minimization of LNG release in the event of a rupture or other accidental event.

Table 14.3 – LNG Bunkering Layers of Defence (2nd Layer of Defence – Mitigation A)
(Operational Measures)

2nd LoD System	Short description	Functional Requirements	Reference
ERS/ ERC	The LNG transfer system shall be fitted with an emergency release system (ERS) and an emergency shut-down system (ESD) which are interconnected with a ship/shore or ship/ship ESD link to ensure the coordinated operation of both the ESD and ERS functions	The ERS shall be designed to protect the transfer system and the connections by disconnecting the transfer system, primarily should the ship drift out of their operating envelope. The ERS shall consist of an emergency release coupling (ERC), including interlocked isolating valves to minimise loss of LNG or NG when the ERC parts, and for transfer systems 4" or larger in diameter, sensors to monitor operating envelope 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). Following any breakaway event, the ERC should be able to ensure a zero-leak release.	IACS Rec.142 Section 1.5.9, 1.5.10 SGMF Guidelines ISO/TS 18683 (Functional requirement F18) ISO 20519 (Section 4.3)
ESD	An Emergency Shutdown system is a protective measure to ensure the emergency stop of the LNG transfer system through active isolation of the transfer line.	SIGTTO ESD definitions are : ESD-1 emergency shutdown stage 1 – shuts down the LNG transfer operation in a quick controlled manner by closing the shutdown valves and stopping the transfer pumps and other relevant equipment in ship and shore systems. Activation of ESD-1 shall set off visual and audible alarms. ESD-2 emergency shutdown stage 2 – shuts down the transfer operation (ESD-1) and uncouples the bunker hose/loading arms after closure of both the ERS isolation valves. The primary function of the ESD system is to stop liquid and vapour transfer and eliminate potential ignition sources in the event of a hazardous scenario in order to regain control of the situation. The ESD system shall bring the LNG transfer system to a safe condition. Typically, ESD system may be activated by the following: • fire or gas detection, • power failure, • receiving tank high level or abnormal pressure, • ship's drift,	IACS Rec.142 Section 1.5.9, 1.5.10 SGMF Guidelines ISO/TS 18683 (Functional requirement F18) ISO 20519 (Section 4.3) SIGTTO ESD Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carriers, SIGTTO First Edition 2009

2nd LoD System	Short description	Functional Requirements	Reference
		• manual signal and • Low temperature in the drip tray. • power failure • loss of communication	

Table 14.4 – LNG Bunkering Layers of Defence (2nd Layer of Defence – Mitigation A)
(Operational Measures)

2nd LoD System	Short description	Functional Requirements	Reference
Leakage Detection Systems	Leakage detection is the fundamental ability to detect loss of containment at the earliest opportunity so that the adequate mitigation and containment measures can be developed.	Gas detection equipment shall be installed where gas may accumulate and on the ventilation inlets. A gas dispersion analysis or physical smoke test shall be used to determine the best possible arrangement. The number and location of gas detectors in each space and for the different parts of the bunkering system shall be considered, taking size, layout and ventilation into account. From IACS Rec. 142 Section 5.4: *As a minimum, in an enclosed or semi enclosed bunker station (on the receiving ship) or discharging station (of the bunker facility), the following safety devices should be in place:* • ***Gas detector(s),*** *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 movement of transfer system during bunkering are visible.* **CCTV is likely to provide for an earlier response than gas detection, especially if gas dispersion leads to some delay between release and detection. CCTV will very likely allow for an immediate detection on visible LNG vapours.**	IACS Rec.142 Section 5.4 SGMF Guidelines ISO/TS 18683

Table 14.5 – LNG Bunkering Layers of Defence (2nd Layer of Defence – Mitigation A)
(Operational Measures)

2nd LoD System	Short description	Functional Requirements	Reference
Water Curtains	Water spray curtains are effective safeguard measures for thermal shielding, firefighting and, in the specific case of LNG accidental releases, followed of vapour cloud dispersion, can act as relevant barriers, modelling the dispersion patterns around the point of release and, as concluded in recent investigation, show strong potential for gas dispersion flammability extent reduction.	The water spray curtain is widely used as an inexpensive technique for controlling and mitigating many toxic and flammable vapours, with particular application in LNG Bunkering, as safeguard against LNG vapour dispersion and thermal shielding in the event of an ignition Several existing research references have shown that water curtains can reduce the concentration of LNG [46] vapour clouds and are able to interact with vapour clouds by imparting momentum, heat transfer, and air entrainment. Forced dispersion from the water curtains led to a reduction in the LNG vapour concentration. Following from studies dilution ratios of both water curtains, it is evident that the full **<u>cone spray</u>** is more effective at creating turbulence and, therefore, increasing mixing with air. However, the **<u>flat fan</u>** is effective in creating a solid barrier and, hence, pushing the vapour cloud upward and reducing the ground level concentration [46]. Important conclusions can today be solidly derived [46]: 1. **<u>the heat-transfer rate increases with the water flow rate</u>**; for droplet sizes ranging from 0.58 to 1.43 mm, a 0.94 mm droplet was noted to have the highest heat-transfer rate per water flow rate; 2. **<u>the higher the droplet temperature, the better the dispersion</u>**; a 313 K droplet temperature was the most optimal, and any droplet temperature below this showed signs of potential hazards with the LNG vapour cloud flowing around the water curtain because of insufficient heat transfer; and 3. **<u>the installation configurations have an optimal tilt angle with the wind</u>** (in that case, 60° compared to other angles), and the closer the nozzles are to the source, the better the interaction and forced dispersion of the vapour cloud.	[46]

2nd LoD System	Short description	Functional Requirements	Reference
Cryogenic barrier	Cryogenic barriers are fundamental 2nd LoD barriers, in particular to avoid brittle fracture structural damage of the ship in the way of the LNG leakage.	Different possibilities exist for cryogenic protection, with drip trays and side shell water curtains being the most widely applies A good example of functional requirements for drip trays can be found in DNVGL-RP-G105RP [41]: • *The surrounding structures shall not be exposed to unacceptable cooling in the case of a leakage of liquid gas.* • *Drip trays shall be fitted below liquid gas bunkering connections and where leakage may occur.* • *The drip trays shall be of appropriate material, such as stainless steel or aluminium.* • *The drip trays shall be dimensioned according to the maximum amount of spill rate, drain capacity and possible spray effects.* • *The arrangement should be drained to sea, protecting the deck, hull, jetty, pier or other related equipment.* • *The sufficient clearance for connection/disconnection and safe access to couplings with regard to the height of the presentation flange and vertical clearance from the drip tray needs to be ensured in the design.* • *Cryogenic protection for the shore side potentially exposed to LNG shall be evaluated.* • *Protection for other vessels alongside the receiving ship shall be considered, e.g. supply barges.* An alternative protective measure for cryogenic run-off or spray onto the hull's side plating is the use of a temporary water curtain. For the LNG transfer rates in a bunkering scenario, a flow rate of 0.5-1.0 m3/h per metre water curtain is recommended. The applicability shall be evaluated taking cold weather conditions and the potential for ice build-up into account.	DNVGL-RP-G105RP IACS Rec.142 SGMF Guidelines

14.3.4 3rd Layer Emergency Systems

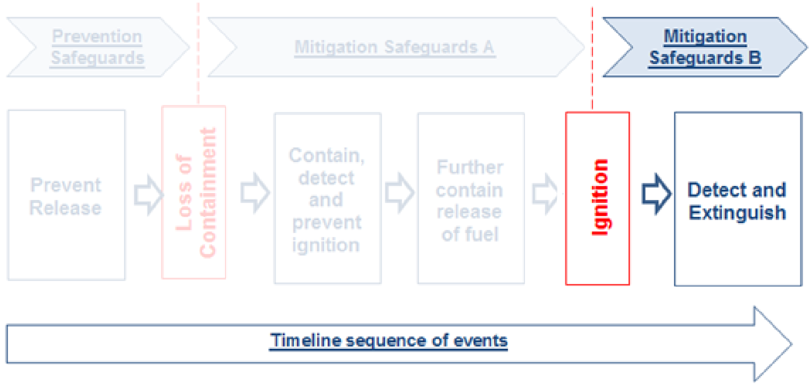


Figure 14.7 – LNG Bunkering Layers of Defence (3rd Layer of Defence – Mitigation B)

The final layer of defence (3rd LoD) in LNG Bunkering safety, following an accidental LNG spill and consequent gas dispersion and ignition, will be **fire protection and suppression systems.** Different requirements exist for minimum fire protection and extinguishing features in LNG bunkering.

The type and capacity of the fire protection and suppression systems installed in bunker stations depend on the location of the bunkering activity, volume of the transferred LNG, transfer rate and size of the ship(s).

The primary function of a fire protection system is to maintain the safety of personnel. Secondary considerations are to minimize loss and damage to assets.

The specific fire protection requirements shall be according to:

a. Receiving Ship: IGF Code and applicable class rules.
b. The IGC Code and applicable class rules (e.g. DNV GL Rules for Classification of Liquefied Gas Tankers and DNV GL Gas Bunker Vessel notation) for a bunker vessel
c. LNG truck: ADR 2017 (Section 8.1.4)
d. Local regulations (e.g. issued by port authorities) for fixed shore-based installations.

14.4 LNG Fire Safety and Firefighting

Following from 14.3.4, above, the present section briefly lists a few relevant aspects relevant to LNG fire protection and suppression.

The present section is not intended to serve as guidance on operational firefighting. It is intended only for information and for reference on the different options available for firefighting which can be considered more adequate to fight LNG fires.

14.4.1 Basic Principles & Procedures

The best firefighting approach in LNG bunkering is, just like with any other good industry safety practice:

- **To avoid a fire by**
  - Prohibit all sources of ignition in the safety zone (see section 8.1.6)
  - Ensure training programs up to date, inclusive of due consideration for LNG fire safety competencies.
  - Train all employees working with LNG.
  - Post "NO SMOKING" signs
  - Invest in the development of an Organization Safety Culture.

   – Disseminate information from case studies in LNG fire, causes, investigation work.

- **What to do if an LNG fire is present**
   – Sound the alarm.
   – Determine source of fire.
   – Execute the emergency plan of action
   – Isolate and contain the source of the fire.
   – Cool surfaces under radiation or encroaching flames with water.
   – Control and extinguish fire with appropriate equipment

14.4.2 Fire Extinguishing Agents

Table 14.6, below, includes a comprehensive significant Fire Extinguishing agents available today for the combat to LNG Fires. Which agent and which technique to apply would be mostly dependent on the type of LNG fire (see section 8.1.5).

Table 14.6 – LNG fires – Extinguishing Agents and main general fire extinguishing principles

Fire Extinguishing Medium	Short description/ comments
Water	1. Water **NOT TO BE USED** on a burning liquefied gas pool. 2. Use of water increases the vaporization of the liquid gas. 3. Use of water increases the rate of burning. There are however **relevant uses for Water in fighting liquefied gas fires**: 1. Can be used to cool surfaces exposed to radiation or affected by fire (very important use for water – e.g. in cooling a partially filled LNG Type-C tank exposed to flame impingement). 2. A diffused spray –water curtain –may be used to limit the thermal effect of radiation. 3. May be used to extinguish a jet of burning gas –in some instances. Mostly due to mechanical dispersion effect. **Fixed water deluge systems**: 1. Used when a quick application of large quantities of water are required. 2. Provide cooling or fire intensity control. 3. Used to cool surfaces and equipment: 4. Valves, critical structural components, plants and jetties, etc. 5. Designed to supply a layer of water over exposed surfaces. **Fixed monitors or hand held nozzles:** 1. Used to provide cooling water spray or foam for radiation protection during firefighting. 2. Used to deliver dry chemicals to more effectively suppress the fire. 3. Used to divert the vapour cloud away from the source of ignition
Dry Chemicals	**Very effective in suppressing small gas fires:** 1. Sodium bicarbonate 2. Potassium bicarbonate 3. Urea potassium bicarbonate A dry chemical based approach to LNG firefighting: – Bring the fire under control by vapour dispersion then use dry chemicals to extinguish the flames. – LNG carriers are required by the IGC to have fixed dry powder systems.

Fire Extinguishing Medium	Short description/ comments
	– The system should reach above-deck exposed cargo areas using hand hose lines or a combination monitor/hand hoses. In the IGC Code: – *Fixed dry chemical powder is fitted for fighting in the exposed cargo deck area with at least two hoses or monitors capable of reaching the manifold area* – *Hoses have a discharge rate of at least 3Kg/sec with the rate designed so one man can operate* – *Monitors have a discharge rate of not less that 10Kg/sec and a range of 10 to 40 meters depending on capacity,* – *Consists of two independent systems with remote control monitor to cover manifold area sufficient powder storage for a minimum discharge time of 45 sec.* Even if dry chemical might be very efficient at extinguishing smaller LNG fires, there should be caution exercised with regards to the LNG release source. Re-ignition will be possible as long as the source remains active. It is further important to avoid the spread of the released gas into nearby accessible confined spaces. Firefighting should be one of the major sections of the bunkering operation emergency response plans and personnel involved with bunkering should have training on what to do if a fire is encountered. Adjacent hot surfaces should be cooled with water before extinguishing the flame with dry chemicals. After extinguishing the fire, cool the adjacent surfaces with water. Customarily, jetty manifold spaces are protected by portable or fixed powder systems.
Foam	**1. Foam systems suppress fire by separating the fuel from the air.** **2. Use high expansion foam to flood the surface of the burning pool (confined area) to suppress radiation and reduce rate of vaporization.** **3. After vapour is dispersed, use dry chemicals to extinguish flames.** Foam: 1. Can reduce the horizontal range of the gas clouds of a confined pool. 2. Increases the vapour's buoyancy due to heat input from the foam. 3. May increase the vaporization rate as it diffuses into the liquid. 4. Foam: 5. Foam will not extinguish a liquefied gas fire. 6. For LNG, foam should only be used in confined areas. **High Expansion Foam (HEX)** In the case that a pool fire occurs, expansion foam, particularly high-expansion (HEX) foam, can be effective in controlling the LNG pool fire by blanketing the LNG pool surface, as a result preventing oxygen from reaching the fire and also acting as an insulator by reducing fire radiation from the pool fire. A HEX foam

Fire Extinguishing Medium	Short description/ comments
	application rate of 10 L min−1 m−2 is the most applicable, and the fire control time can be reduced with an increase in the application rate. The location of foam generation units and design are all crucial factors that should be considered. It is also important that the units are available and operational at all times.
Inertization	Inert gas is a non-reactive gas under particular conditions used on gas carriers and in terminals to prevent explosions: – Inter-barrier spaces – Cargo spaces: – Ships' holds – Onshore plant areas in which flammable gas may be detected. **Inert gas and CO2safety measures:** – Electrostatic charging can be produced when CO2is injected –can be the ignition source in a flammable space. – Once initial pressure flow has subsided, injecting an inert gas into a safety relief valve is an effective means of suppressing a vapour fire at a vent riser. – Keep the space sealed until it is sufficiently cooled and won't reignite when oxygen is introduced back into the space.

14.5 Emergency plans in LNG bunkering

The following sections provide PAAs with general good practice minimum requirements regarding Emergency

14.5.1 Emergency Response Plan

PAAs should ensure that, for all LNG Bunkering Projects/Activities:

- BFO draws up an internal emergency plan for the measures to be taken within the LNG bunkering Facility or whenever the LNG bunkering operation takes place, from the moment of its authorization to its conclusion;
- BFO supplies the necessary information to the competent authority, upon completion of the Internal Emergency Plan, to enable the latter to draw up external emergency plans;
- Local/National Authorities designated for that purpose by draw up an external emergency plan for the measures to be taken outside the establishment within an acceptable time frame following receipt of the necessary information from the operator pursuant to point (b).

Operators should comply with the obligations set out above within a reasonable period of time prior to the start of operation, or prior to the modifications leading to a change in the inventory of dangerous substances;

- containing and controlling incidents so as to minimise the effects, and to limit damage to human health, the environment and property;
- Implementing the necessary measures to protect human health and the environment from the effects of major accidents;
- Communicating the necessary information to the public and to the services or authorities concerned in the area;
- Providing for the restoration and clean-up of the environment following a major accident.

Emergency plans shall contain the information set in section 14.2, below.

PAAs should ensure that the internal emergency plans provided for in the context of new LNG bunkering projects/facilities are drawn up in consultation with the personnel working inside the establishment, including long-term relevant subcontracted personnel.

PAAs should ensure that operators and the general public concerned is given early opportunity to give its opinion on external emergency plans when they are being established or substantially modified.

PAAs should ensure that internal and external emergency plans are reviewed, tested, and where necessary updated by the BFO and competent national/local authorities, respectively at suitable intervals of no longer than three years[84]. The review shall take into account changes occurring in the establishments concerned or within the emergency services concerned, new technical knowledge, and knowledge concerning the response to major accidents.

With regard to external emergency plans, PAAs shall take into account the need to facilitate enhanced cooperation with all stakeholders, national/local competent authorities.

PAAs should ensure that emergency plans are put into effect without delay by the operator and, if necessary, by the competent authority designated for this purpose when a major accident occurs, or when an uncontrolled event occurs which by its nature could reasonably be expected to lead to a major accident.

The competent authority may decide, giving reasons for their decision, in view of the information contained in the safety report, that the requirement to produce an external emergency plan under paragraph 1 shall not apply.

14.6 Data and Information to be included in the Emergency Plans

14.6.1 Internal emergency plans

The following elements should be included in Internal Emergency Plans:

- Names or positions of persons authorised to set emergency procedures in motion and the person in charge of and coordinating the on-site mitigation action;
- Name or position of the person with responsibility for liaising with the authority responsible for the external emergency plan;
- For foreseeable conditions or events which could be significant in bringing about a major accident, a description of the action which should be taken to control the conditions or events and to limit their consequences, including a description of the safety equipment and the resources available;
- Arrangements for limiting the risks to persons on site including how warnings are to be given and the actions persons are expected to take on receipt of a warning;
- Arrangements for providing early warning of the incident to the authority responsible for setting the external emergency plan in motion, the type of information which should be contained in an initial warning and the arrangements for the provision of more detailed information as it becomes available;
- where necessary, arrangements for training staff in the duties they will be expected to perform and, as appropriate, coordinating this with off-site emergency services;
- Arrangements for providing assistance with off-site mitigation action.
- An Emergency Response Plan should be prepared to address cryogenic hazards, potential cold burn injuries to personnel 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,

[84] Reference to Seveso III Emergency Plan update requirements

hospitals, local fire brigades, PIC, Master and selected personnel from the bunkering facility. As a minimum, the following situations should be covered where appropriate:

- LNG leakage and spill on the receiving ship, on the bunkering facility or 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

14.6.2 External emergency plans:

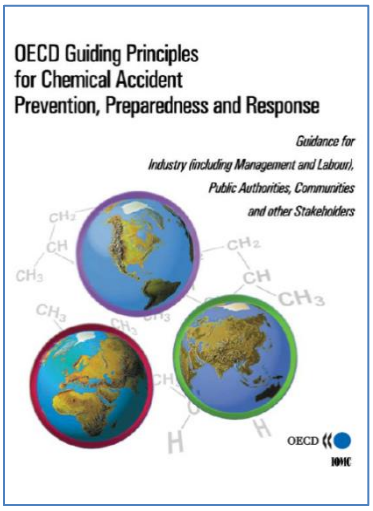
- Names or positions of persons authorised to set emergency procedures in motion and of persons authorised to take charge of and coordinate off-site action;
- Arrangements for receiving early warning of incidents, and alert and call-out procedures;
- Arrangements for coordinating resources necessary to implement the external emergency plan;
- Arrangements for providing assistance with on-site mitigation action;
- Arrangements for off-site mitigation action, including responses to major-accident scenarios as set out in the safety report and considering possible domino effects, including those having an impact on the environment;
- Arrangements for providing the public and any neighbouring establishments or sites with specific information relating to the accident and the behaviour which should be adopted;

14.7 OECD Guiding Principles in EPR

The following publication is recommended to PAAs in the support to development of Emergency Preparedness and Response Plans:

OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response, Guidance for Industry (including Management and Labour), Public Authorities, Communities, and other Stakeholders – 2nd Edition (2003) - OECD Environment, Health and Safety Publications.

That can be obtained online at http://www.oecd.org/chemicalsafety/chemical-accidents/guiding-principles-chemical-accident-prevention-preparedness-and-response.htm



The Guiding Principles for Chemical Accident Prevention, Preparedness and Response address issues related to:

- **Preventing** the occurrence of incidents involving hazardous substances;
- **Preparing** for accidents, and mitigating adverse effects of accidents, through emergency planning, land-use planning, and communication with the public;

- **Responding** to accidents that do occur in order to minimize the adverse consequences to health, the environment and property; and
- **Follow-up** to accidents, including initial clean-up activities, and accident reporting and
- investigation.

These principles provide advice to public authorities, industry, employees and their representatives as well as members of the public potentially affected in the event of an accident, and non-governmental organizations.

The Guiding Principles apply to all hazardous installations, i.e. fixed plants or sites that produce, process, use, handle, store or dispose of hazardous substances where there is a risk of an accident involving the hazardous substance(s).

The Principles also apply to transfer facilities where hazardous substances are loaded and/or unloaded, with direct application in this context to LNG bunkering projects. The transportation of hazardous substances external to a hazardous installation (by pipelines, road, rail, sea or air) has not been addressed, although many of the Principles can be applied.

The Guiding Principles are based on the assumption that all hazardous installations should be expected to comply with the same safety objectives regardless of size, location or whether the installation is publicly or privately owned. They have been developed with the understanding that there must be flexibility on their application due to significant differences which exist among countries such as legal and regulatory infrastructures, culture, and resource availability. In addition there may be differences in approach in applying the Principles to new and to existing installations. The Guiding Principles apply to a wide range of industries and types and sizes of installations.

15. Certification & Accreditation

Certification, in LNG bunkering, has a significantly wide scope. Taking into account the different options that we have today for LNG fuel transfer, it is also possible to determine the large possible

15.1 Introduction

In the context of Certification and Accreditation the present section focuses strictly on ISO20519 *Specification for bunkering of gas fuelled ships*, focusing in particular on the provision by this international standard for operators to consider demonstration of compliance with the standard through the adoption of an adequate management objective (ISO201519, Section 7). The objective, inscribed into an existing Management System (: ISO 9001, ISO 14001, ISM, ISO 29001 and API Spec Q1) would serve the purpose of demonstrating compliance with ISO20519.

In addition to this important provision from ISO 20519, also under section 7, one further suggested requirement for LNG Bunkering equipment quality reassurance is included:

> *Equipment used in the transfer system must conform to the standards listed for that equipment in the applicable sections of this standard and the manufacturer/fabricator of such equipment shall be certified compliant to one or more of the management systems listed in 7.1 or be listed on the API Composite List (for that piece of equipment)*
>
> *(ISO 20619, Section 7.2)*

The purpose of Section 15 of the present Guidance is to list significant references for LNG bunkering certification (of equipment, vessels, trucks) making reference back to Section 4 where several instruments were summarized.

Following the references on certification and in the light of the provisions inscribed in Section 7 of ISO20519, the present Guidance suggests, as a good practice, a simplified Accreditation Scheme intended for BFOs is included.

15.2 Definitions

Certification	**Certification** refers to the confirmation of certain characteristics of given equipment, in its whole or any of its parts, of a procedure, operation or personnel, often requiring a confirmation of conformity against an existing standard or regulation. In the context of LNG Bunkering, **Certification** refers primarily to the LNG fuel systems, equipment and personnel. Can be applicable to systems with different complexities, provided rules, standards and regulations exist for conformity evaluation. Note: Certification and Accreditation are terms often used interchangeably but they are not synonyms. See also 'Accreditation'.
Accreditation	**Accreditation** is the formal declaration by a neutral third party that the certification program is administered in a way that meets the relevant norms or standards of certification program (such as ISO/IEC accreditation standards[85]). Many nations have established specific bodies responsible for third-party independent accreditation. In the context of LNG Bunkering, **Accreditation** assures users of the competence and impartiality of the body accredited, responsible for the **certification** of LNG bunkering systems and equipment, processes and training. Note: Certification and Accreditation are terms often used interchangeably but they are not synonyms. See also 'Certification.

[85] Many accreditation bodies operate according to processes developed by the International Organization for Standardization (ISO) as specified in ISO/IEC 17011.[2] Accredited entities in specific sectors must provide evidence to the accreditation body that they conform to other standards in the same series:
ISO/IEC 17020: "General criteria for the operation of various types of bodies performing inspection" (2012)
ISO/IEC 17021: "Conformity assessment. Requirements for bodies providing audit and certification of management systems" (2011)
ISO/IEC 17024: "Conformity Assessment. General requirements for bodies operating certification of persons" (2012)
ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories" (2005)

15.3 Certification

The sections below indicate the relevant references for design and certification of LNG bunkering systems and equipment.

15.3.1 LNG Transfer Equipment

From ISO 20519, ISO/TS 18683:

Component	Function	Design	Qualification test	Tests
Coupling	Connection to ship's manifold	EN 1474-3:2008-12, 6.9		
Hoses	Transfer of LNG and natural gas	EN 1474-2 EN 12434 BS 4089	See[a]	
Swivel joints	Product line articulation	EN 1474-3:2008-12, 6.8	New design qualification	EN 1474-1:2008-12, 8.4.1
Bearing	Articulation of support structure	EN 1474-3:2008-12, 6.8	ISO 28460 EN 1474-1	EN 1474-1:2008-12, 8.4.2
ERS	Emergency disconnect	EN 1474-3:2008-12, 6.9 and 7.5	ISO 28460 EN 1474-1:2008-12, 8.2.2	EN 1474-1:2008-12, 8.4.3
Breakaway coupling	Emergency disconnect	EN 1474-3:2008-12, 6.9	EN 1474-1:2008-12, 8.2.2	EN 1474-1:2008-12, 8.4.3
Loading arms	Loading system	EN 1474-3:2008-12, Clause 6 and Clause 8	EN 1474-3:2008-12, Clause 5	ISO 28460 EN 1474-1:2008-12, 8.4.7
Transfer system	LNG bunkering loading solution	EN 1474-3:2008-12, Clause 6 and Clause 8 ISO 28460 EN 1160 EN 1474-1 OCIMF Mooring Equipment Guidelines IEC 60079 IGC/IGF Code NFPA 70 NFPA 58 NFPA 59A EN 13645 API 2003 ISO/TS 16901 IEC 60092-502	EN 1474-3:2008-12, Clause 5	ISO 28460 EN 1474-1

[a] **For hoses intended to be used in multiple LNG transfer configurations, due to the variety of the receiving ships for example, the criteria applied for their qualification according to EN 1474-2 shall be determined on the base of an agreed envelope to be defined between the manufacturer, the owner, and the qualification body. These criteria shall be defined prior to the official qualification testing campaign is started and the qualification shall be valid for the configurations covered by the agreed envelope only.**

15.3.2 Emergency Shutdown Systems (ESD)

Certification of ERS, ERC and ESD to follow the references below:

Emergency Release System (ERS)

The present Guidance refers to ERS, ERC and ESD in the terms presented in EN ISO 20519, where ERS is defined as a system comprised of two sub-systems/elements that allow the main functional requirement of quick/dry disconnect during bunkering operation, as a consequence of an emergency

Emergency Release System (ERS)
(EN ISO 20519, Section 4.3)
General Functional requirements for ERS include ERC and ESD systems. The approach in the standard is to consider both ERC and ESD as sub-components of the system.

Emergency Release Coupling (ERC)
(EN ISO 20519, Paragraph 4.3.2)
Coupling designed to allow hose separation when desired, as a consequence of a faulty, alarm or hazardous condition n LNG bunkering.

Emergency Shut-Down (ESD)
(EN ISO 20519, Section 4.3.9)
ESD systems to comply with minimum requirements in EN ISO 20519, Paragraph 4.3.9 (referring to SIGTTO document titled "ESD Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carriers, SIGTTO First Edition 2009"

15.3.3 LNG Bunkering Equipment Vessels

See Section 4

15.3.4 LNG Bunker Vessels

See Section 4

15.3.5 LNG Bunker Barges

Whilst rules have been developed for LNG bunker vessels, mostly derived from IGC and IGF Codes, barges seem not to have a dedicated of rules that apply directly to the carriage LNG fuel and bunkering services. This may impose a challenge in the harmonization of these floating craft that should be taken into consideration by PAAs

In general, however, barges intended for the carriage of liquefied gases in bulk are to comply with the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) as appropriate, or other national standard, as applicable to the non-propelled status of the vessel.

A special certificate attesting to the degree of compliance with the above codes or national standard may be issued upon request.

For manned barges, consideration is to be given for full compliance with the code. In all cases, it is the Owner's responsibility to determine the requirements of flag Administration and port Administration

15.3.6 LNG Trucks

LNG trucks must be fully compliant with ADR regulations and, if applicable, with the IMDG Code.

Every LNG truck must be super vacuum-insulated (i.e. double-walled tank with insulating material and vacuum atmosphere between the walls), must have three rear axles and be designed for maximum road stability.

The outer tank wall must be made of carbon steel or stainless steel with sufficient mechanical and thermal resistance. The mechanical resistance must be demonstrated by means of a safety impact study in which the resistance to lateral impact and overturning of the truck is determined. As regards fire resistance, the tank wall must be able to withstand temperatures of at least 700°C.

15.3.7 Equipment and Installations

See Section 4

15.4 BFO Accreditation Scheme

The present Section is outlined as a good practice advice in the context of LNG bunkering, in particular in the context of BFO recognition[86].

The simplified scheme, presented in Table 15.1, is intended to serve as an indicative example to PAAs in order to develop their own schemes, more or less in a modular approach.

The objective is the recognition of BFOs as competent organizations, complying with ISO20519.

BFO Recognition Scheme – Accreditation of Bunker Facility Organization		
A. General Provisions		**Notes**
A1	The proposed LNG bunker supplier recognition system scheme has been developed to verify compliance and conformity of BFO with standard ISO 20519:2017 *Specification for bunkering of liquefied natural gas fuelled vessels*.	
A2	The objectives of the Accreditation scheme are – To fully explore the potential of ISO 20519 in ensuring safety procedures and quality requirements for the bunker companies supplying LNG fuel for ships. – Ensure safe operations and periodical audit procedures in order to recognize and confirm implementation of ISO20519 by bunker suppliers. In the bunker supply chain, LNG bunker suppliers have to comply with the port's accreditation qualifications in order to attain a license for performing LNG bunker operations	References other than ISO20519 may be possible depending on PAA indication to certifying company, Class Society, Recognized Body, etc.
A3	Recognition of LNG bunker supplier may be carried out as a result of the requirements of maritime flag administration or on request of supplier itself. The recognition does not cover equipment design or modification activities, if any.	
A4	The recognition procedure should be initiated voluntarily by Operators/BFOs wishing to be accredited/ recognized for LNG bunkering operation, by a written application submitted by the Operator to the relevant certifying company.	The Certifying Company may belong to a list held by the PAA, or be part of a national/european list of recognized bodies.
A5	The following documents should be sent : 1. Company Identification information and organizational description, 2. Possible existing Recognition from another Port. 3. Evidence Certificate of company quality management system according to ISO 9001, ISO 14001, ISM, ISO 29001 or API Spec Q1, 4. Existing mapping of LNG bunkering procedures 5. Example of one of the company's LNGBMP. 6. LNG bunkering experience, including reference clients and identification of significant/relevant ships bunkered 7. List of BFO staff involved in LNG bunkering with documented professional experience and competence, 8. List of bunkering equipment including measuring, recording, communication and safety instruments the bunkering company is equipped with, 9. Company LNG bunkering instructions 10. Check-Lists for all types of LNG bunkering (and other potential processes),	List of documents not extensive. Represents only a recommendation, with a potential final list shorter or longer depending on the

[86] Based on publication no. 116/p Bunkering guidelines for LNG as marine fuel (Polish Registry of Shipping – PRS) – March 2017

	11. Procedures and Technologies for personal and environmental protection, 12. Record keeping and documentation of bunkering operations performed, 13. Risk Assessment report, including HAZID, HAZOP and evidence of different LNG bunkering modes implemented on the basis of risk assessment indication	
B. Requirements		**Notes**
B1	LNG bunkering operation carried out by the BFO, to the satisfaction of the recognition/accreditation scheme should be performed by qualified personnel with demonstrated competences and professional experience.	
B2	Certificates for LNG bunkering equipment, certified by manufacturers certified themselves by a relevant quality management system,	
B3	The LNG bunkering company, which has the quality management system based upon requirements of ISO 9001 (ISO 9001, ISO 14001, ISM, ISO 29001 or API Spec Q1), should, when applying for recognition, submit, together with the documents listed in p. 1.6, the respective documentation of quality system. Evaluation of the BFO will benefit from positive implementation of the subject quality system.	
B4	The BFO may be required to execute an LNG bunkering operation to demonstrate implemented procedures, check-lists, communications scheme, measures for BOG mitigation, amongst other aspects.	
C. Recognition Procedure		**Notes**
C1	Favourable results of appraisal of documentation submitted together with the application for recognition as well as satisfactory results of inspection for the compliance with ISO 20519:2017 *Specification for bunkering of gas fuelled ships* are the basis of LNG bunkering company recognition.	
C2	The purpose of the inspection is to ascertain that the requirements of Paragraph 2 are fulfilled and, in particular: .a) personnel qualifications, .b) equipment certificates with evidence of quality managed manufacturer .c) equipment and machines with proper control and recording instruments , .d) applicable manuals necessary for the safe LNG bunkering to be carried out, .e) proper communication, recording and monitoring technologies, .f) records and certification of the bunkering operations performed, .g) monitoring of the work(s) carried out and its quality, .h) work quality including safety assessment	
C3	Criteria for recognition is: .a) Compliance of BFO organization with ISO 20519 .b) Manufacturers of equipment used by BFO should be certified compliant to a relevant quality management system. .c) Satisfactory results from inspection in C2. .d) Documented procedures, as provided in B, verified and implemented.	

C4	Operation and detailed documentation of the quality assurance system when applied by LNG bunkering company, including keeping records thereon, is to be checked during the inspection as follows: .a) Active and positively verified quality management system acc. to ISO 9001, or alternative, .b) Certified quality assurance system (QAS) in place, including, but not limited to: i. Status with regards to key performance indicators (KPIs); i.e. operation and customer feedback report system; ii. Environmental performance system; iii. Near misses and incident reporting system; iv. Maintenance system for LNG bunker equipment; v. Training of personnel.	
C5	The LNG bunkering equipment and machines planned for operational or emergency use in bunkering operations is to be verified. The company is to provide free access surveyors/inspectors for necessary inspection and verification when required. The documents presented must include: .a) List of the equipment and machines as well as evidence of applicable and valid certification; .b) For all LNG bunkering equipment and machines, the evidence of regular, periodically required transparent maintenance in line with implemented quality assurance system;	
C6	The company personnel competences and trainings to be verified. The relevant certificates of competency are to be provided. The requirements with regards to professional educational topics must cover: i. LNG in general; ii. Knowledge of LNG safety standards; iii. Knowledge of LNG bunkering technical standards; iv. Knowledge of LNG bunkering guidelines or other legally required documents; v. LNG hazard identification vi. LNG risk & safety aspects; vii. LNG bunker operations risk characteristics; viii. Emergency response; ix. Operations manual of the bunker supply company in question;	
D. LNG Bunkering Management Plan (LNGBMP)		**Notes**
D1	LNGBMP to be verified as described in IACS Rec.142. Document Management within the LNGBMP to be organized according to IACS Rec.142. The documents confirming that required risk assessments (HAZID/HAZOP/QRA) has been conducted and analysed.	
D2	The documents with description of procedures that are stated in an LNGBMP. All procedures detailed in the LNGBMP to be result of actual verifications and recommendations resulting from Recognition process.	

E. Recognition		**Notes**
E1	Recognition Certificates for LNG Bunker BFO should be issued after positive completion of the submitted documentation and inspections with a validity to be agreed. During the period of validity of the Recognition Certificate, at least once a year, inspections or audits of the BFO should be conducted. Maintenance of the Recognition Certificate to be a function of the conditions verified at inspection/audit.	

16. Qualification & Training

16.1 LNG Bunkering - Training for the Interface

The STCW contains requirements in Section A/V3 tables A-V/3-1 and A-V/3-2 for a minimum standard of competence in basic and advanced training, respectively, for ships subject to the IGF Code. These tables can be considered highly relevant in setting the wider structure of competencies that should also be considered for the LNG bunkering interface below highlights the relevance of addressing the necessary harmonization of competencies in the context of LNG bunkering.

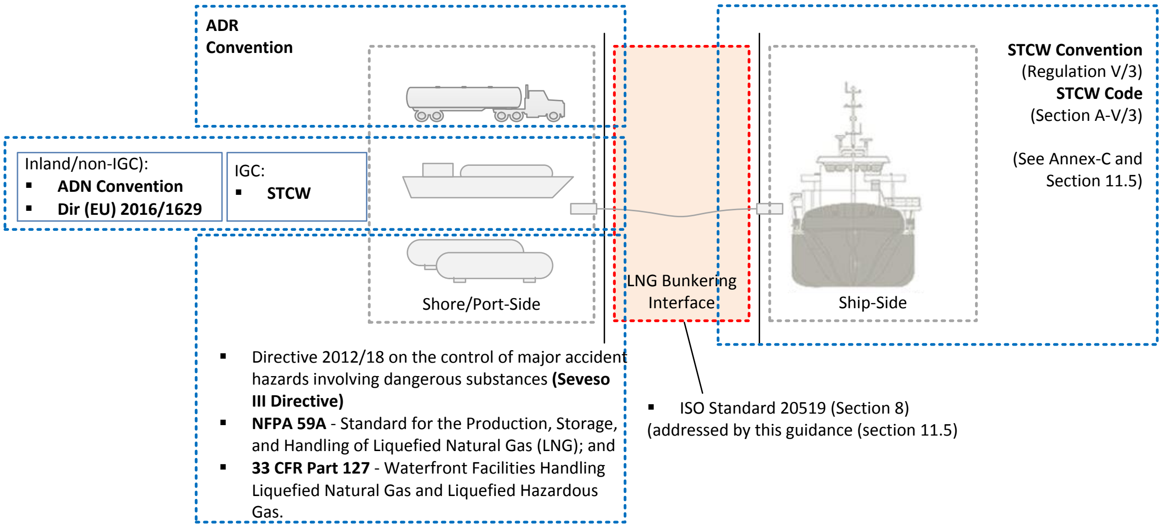


Figure 16.1 - Applicable references in Competencies and Training requirements – complexity of the LNG Bunkering interface

EN ISO 20519 highlights, in Section 8, that all crew members should be trained in the particular aspects of the Standard, as far as LNG bunkering procedures are concerned.

16.2 LNG Bunkering Training Matrix[87]

As a main reference for Qualification & Training, a Matrix has been built in the context of the European Sustainable Shipping Forum to better assist all parties willing to develop Qualification and Training schemes, based on relevant legal minimum requirements, for LNG bunkering.

The Training Matrix maps different regulatory regimes, addressing the complex interface of LNG Bunkering where different requirements co-exist, from the ship-side, port-side, fuel supplier side, etc. Finding conflicting points, and possible overlaps, is still the aim of the work together with the full mapping of the instruments governing the different parts of LNG bunkering operations when training and competencies development and recognition is concerned.

The Training Matrix defines the appropriate references for the training to be set up in different domains and activities of LNG as fuel, both on maritime and inland waterways, and road transport.

The matrix provides an overview of the requirements to all those in the logistic chain in order to identify the gaps and possible overlaps within the existing instruments, with the two main objectives to:

- *Maintain the high level of safety for the use of LNG*
- *Contribute to the definition of an EU framework*

[87] Training Matrix version 2.0, drafted by a joint cooperation between *Association Française du Gaz* (French Association of Gas) and Mission de coordination GNL (LNG Task Force), had already been first presented at the LNG sub-group 6th meeting but was now further elaborated and described with a view for integration in the current Guidance.

MATRIX on LNG Training

Domain	Activity	Category	Regulatory Instrument on Training & Competences - State of play	Observations
Maritime	LNG Vessels (LNG transport	Crew	- IGC Code - STCW convention - IMO Model Course – Advanced Training for Liquefied Gas Tanker Cargo Operations • Directive 2008/106/EC on the minimum level of training seafarers	To check Directive 2008/106/EC on minimum level of Bunkering training of seafarers
	Bunkering vessels	Crew	- Res MSC.392(95) : IGF Code, Part C-1, Part D - Res MSC.395(95):amendments to SOLAS Convention - Res MSC.396(95):amendments to STCW Convention-Res MSC.397(95):amendments to STCW Code - STCW.7/Circ.23 on interim guidance on training for seafarers on board ships using gases or other low-flashpoint fuels - Draft STCW Circular on amendments to Part B of STCW Code - Offer to develop an IMO model course on the special training requirements for seafarers on ships using gases or other low flashpoint fuels-Submitted by Norway	To identified the modification of Directive 2008/106/EC to apply the rules defined by IMO
Inland waterways	LNG fuelled vessels	Crew	- Directive 91/672 on the reciprocal recognition of national boat masters' certificates - Directive 96/50 on the harmonization of the conditions for obtaining national boat masters' certificates - CCNR: Regulation for Rhine navigation personnel (amendment coming into force on 1.07.2016) : special knowledge of crews (chapter4a) and content of training courses (annex E2) - Rhine Police Regulation (amendment in force 1.12.2015) : requirement of training certificates for crew	
	Transport of LNG	Crew	ADN 2015 agreement: additional training for boat master required - Directive 2008/68 on the inland transport of dangerous goods	Check the impact of ADN agreement as modified on EU legislation
Ports	LNG Bunkering operations	People involved in bunkering operation	- ISO TS 18683 (2015-01-15) Guidelines for systems and installations for supply of LNG as fuel to ships- Chapter 10 Training - Draft ISO/DIS 20519 LNG Bunkering	

Domain	Activity	Category	Regulatory Instrument on Training & Competences - State of play	Observations
			Standard (on consultation 05/02-05/05)- Chapter 8 Personnel training - CEN/TC 282 on LNG equipment and installation: ad hoc Group on Training - IACS Recommendation 142 on LNG Bunkering - Port regulations on bunkering and on dangerous goods - IAPH guidelines (version 3.6 Jan 2015): i. Truck to Shipping ii. Ship to Shipping iii. Bunker Station to Ship - Directive 2012/18 on the control of major accident hazards involving dangerous substances (Seveso III Directive) - CCNR: Standard for a LNG bunker checklist Truck to Ship Edition 1.0 - SGMF LNG Bunkering Competence Guidelines 2017 (available for purchase)	
		People on spot	- Port regulations and Safety Management System (SMS) - Health & safety regulations for workers	
	Transport of LNG	Driver	- ADR agreement - Directive 2008/68 on the inland transport of dangerous goods - ISO/DIS 16924.2 LNG stations for fuelling (19.5 training)-CEN/TC 326 refuelling stations	
Railway	Transport of LNG	Railways infrastructure manager and carriers	- RID agreement - Directive 2008/68 on the inland transport of dangerous goods	to be investigated
LNG Terminal	Unloading, loading & storage of LNG	LNG infrastructure operator	- Directive 2012/18 on the control of major accident hazards involving dangerous substances (Seveso III Directive) - National regulation concerning classified facilities regarding safety and environmental protection - ISO & EN standards (to be investigated) - Port regulation - SIGTTO/OCIMF recommendations	to be investigated with the ongoing works of CEN on standards

Domain	Activity	Category	Regulatory Instrument on Training & Competences - State of play	Observations
	Loading of Bunkering vessels, barges	LNG infrastructure operator	- Directive 2012/18 on the control of major accident hazards involving dangerous substances - - National regulation concerning classified facilities regarding safety and environmental protection - - Port regulations	to be investigated
		Bunker vessel crew	- IGC Code - STCW convention - IMO Model Course – Advanced Training for Liquefied Gas Tanker Cargo Operations (on revision) - Directive 2008/106/EC on the minimum level of training seafarers - -Port regulation	To check Directive 2008/106/EC
		Barge crew relevant to inland waterways regulation	- ADN 2015 agreement - Directive 2008/68 on the inland transport of dangerous goods -Directive 91/672 on the reciprocal recognition of national boat masters' certificates - Directive 96/50 on the harmonization of the conditions for obtaining national boat masters' certificates - CCNR: Regulation for Rhine navigation - personnel and Rhine Police Regulations - Port regulation	
	Loading of trucks	LNG infrastructure operator	- Directive 2012/18 on the control of major accident hazards involving dangerous substances (Seveso III directive) - National regulation concerning classified facilities regarding safety and - environmental protection - ISO and EN standards (to be investigated) - Port regulation	to be investigated with the ongoing work of CEN on standards
		Driver	- ADR agreement - -Directive 2008/68 on the inland transport of dangerous goods - -ISO-EN standards (to be investigated with the Commission decision on standards) - Port regulation	Check the impact of ADR agreement as modified on EU legislation

Domain	Activity	Category	Regulatory Instrument on Training & Competences - State of play	Observations
LNG fuel stations	Refuelling of trucks	LNG fuel stations operator	- Directive 2012/18 on the control of major accident hazards involving dangerous substances - National regulation concerning classified facilities regarding safety and environmental protection -ISO/DIS 16924.2 LNG stations for fuelling (19.5 training) - CEN/TC 326 refuelling stations	to be investigated with the ongoing work of CEN on standards
Customers deliveries	Unloading of trucks	Driver	- ADR agreement - Directive 2008/68 on the inland transport of dangerous goods - ISO-EN standards (to be investigated with the Commission decision on standards)	Check the impact of ADR agreement as modified on EU legislation

References

[1]. Study on the completion of an EU framework on LNG-fuelled ships and its relevant fuel provision infrastructure, LOT 1 Position paper: Towards harmonized EU LNG bunkering guidelines, DNV-GL, 2016

[2]. Study on the completion of an EU framework on LNG-fuelled ships and its relevant fuel provision infrastructure, LOT 1 Final Report, DNV-GL, 2016

[3]. LNG Bunkering Guidelines IACS Recommendation n. 142, on LNG Bunkering, IACS, 2016.

[4]. ISO/TS 18683:2015. (15-Jan. 2015). Guidelines for systems and installations for supply of LNG as fuel to ships. Technical Specification.

[5]. Society for Gas as a Marine Fuel (SGMF). (2015). Gas as a marine fuel, safety guidelines, Bunkering. Version 1.0, February 2015.

[6]. ISO 20519:2017. Ships and marine technology – Specification for bunkering of gas fuelled ships. (International Standard).

[7]. IEC 60079-10-1. (2015). Explosive atmospheres – Part 10-1: Classification of areas - Explosive gas atmospheres.

[8]. Directive 1999/92/EC - ATEX of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

[9]. API RP-500. 1997. Recommended practice for classification of locations for electrical installations at petroleum facilities classified as Class 1, Division 1 and Division 2. Washington. D.C: API.

[10]. API RP-505. 1997, Recommended practice for classification of locations at petroleum facilities classified as Class I, Zone 0, Zone 1 and Zone 2. Washington, D.C. API.

[11]. NFPA 497. 2012, Recommended practice for the classification of flammable liquids, gases or vapours and of hazardous (classified) locations for electrical installations in chemical process areas. Quincy, MA: NFPA.

[12]. IEC EN 60079-10-1 Ed.1.0, 2008. Electrical apparatus for explosive gas atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres. International Electrotechnical Commission.

[13]. Commission Decision 2010/769/EU of 13 December 2010 on the establishment of criteria for the use by liquefied natural gas carriers of technological methods as an alternative to using low sulphur marine fuels meeting the requirements of Article 4b of Council Directive 1999/32/EC relating to a reduction in the sulphur content of certain liquid fuels as amended by Directive 2005/33/EC of the European Parliament and of the Council on the sulphur content of marine fuels (OJ L 328, 14.12.2010, p. 15).

[14]. USCG CG-OES Policy Letter 02-14 - Guidance Related To Vessels And Waterfront Facilities Conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations

[15]. ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland waterways (Update version ADN January 2017)

[16]. ADR – European agreement concerning the International Carriage of Dangerous Goods by Road (Update version ADR January 2017)

[17]. Rhine Vessel Inspection Regulations (RVIR)

[18]. EU general risk assessment methodology (Action 5 of Multi-Annual Action Plan for the surveillance of products in the EU (COM(2013)76) – Document 2015-IMP-MSG-15 - 16 October 2015

[19]. http://www.ship-technology.com/projects/bit-viking-product-tanker /

[20]. http://www.lngworldnews.com/video-shells-lng-bunkering-vessel-almost-ready-for-ops/ and https://ec.europa.eu/inea/sites/inea/files/fiche_2014-eu-tm-0095-w_final.pdf

[21]. Safety Study, Chain analysis: *Supplying Flemish ports with LNG as a marine fuel, Analysis of safety aspects*, June 2012

[22]. https://www.dnvgl.com/maritime/lng/current-price-development-oil-and-gas.html

[23]. LNGi status update - Comprehensive insights on worldwide LNG bunkering availability and market data on LNG as fuel for ships – 29 May 2017 - available from https://www.dnvgl.com/maritime/download-confirmation/lng-vessels-in-operation.html

[24]. http://www.gie.eu/index.php/maps-data/gle-sslng-map

[25]. EN 1160 - *Installations And Equipment For Liquefied Natural Gas – General Characteristics Of Liquefied Natural Gas*, NBN, 1st edition, August 1996.

[26]. ABS LNG Bunkering Technical and Operational Advisory https://ww2.eagle.org/content/dam/eagle/publications

[27]. ESD Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carriers, SIGTTO First Edition 2009- SIGTTO

[28]. www.lngforshipping.eu

[29]. M. Kofod & S. Hartman, T. Mundt – *Review of Recent Well-to-Wake Greenhouse Gas Studies evaluating the use of LNG as a marine Fuel,* IMO MEPC/INF.15

[30]. LNG Access Code for Truck Loading for The Zeebrugge LNG Terminal - Based on version approved by the CREG on September 19th 2013 - Applicable as of January 1st 2014 – FLUXYS

[31]. Guidance for the Prevention of Rollover in LNG Ships – SIGTTO - First Edition 2012 - http://www.sigtto.org/publications/publications-and-downloads

[32]. International Gas Union 2014 – Small Scale LNG - http://www.igu.org/sites/default/files/node-page-field_file/SmallScaleLNG.pdf

[33]. Wang, Siyuan & Notteboom, Theo - *The role of port authorities in the development of LNG bunkering facilities in North European ports, 14 January 2015,* World Maritime University 2015

[34]. Verhoeven P (2010) A review of port authority functions: towards a renaissance? Marit Policy Manag 37:247–270

[35]. Society for Gas as a Marine Fuel (SGMF). (2017). Gas as a marine fuel, safety guidelines, Bunkering. Version 2.0, February 2015.

[36]. COM(2003) 515 final - Communication from The Commission *concerning the non-binding guide of good practice for implementing Directive 1999/92/EC of the European Parliament and of the Council on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres,* Brussels, 25.8.2003

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2003:0515:FIN:EN:PDF

[37]. Davies, P. (2016) - Bunkering LNG: Setting the Safety Zone, *7th Motorship Gas Fuelled Ships Conference, November 2016*

[38]. International Association of Oil & Gas Producers. (1-Mar 2010). Risk Assessment Data Directory – Process Release Frequencies. Report No. 434 – 1, 1 March 2010). Pertinent

data from this report is summarised in: Davies & Fort, (Sept 2012), LNG as Marine Fuel - Likelihood of LNG Releases, Journal of Marine Engineering and Technology.

[39]. PGS2 - TNO Yellow Book - Methods for the calculation of physical effects, due to releases of hazardous materials (liquids and gases) – CPR 14E (3rd Edition, 2005) - TNO - The Netherlands Organization of Applied Scientific Research

[40]. OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response, Guidance for Industry (including Management and Labour), Public Authorities, Communities, and other Stakeholders – 2nd Edition (2003) - OECD Environment, Health and Safety Publications.

[41]. DNVGL-RP-G105 Edition October 2015 - *Development and operation of liquefied natural gas bunkering facilities, Recommended Practice*, DNV GL, 2015

[42]. USCG CG-OES Policy Letter No. 01-17 - *Guidance for Evaluating Simultaneous Operations (SIMOPS) during Liquefied Natural Gas (LNG) Fuel Transfer Operations*

[43]. LGC NCOE Field Notice 01-2017 – 14-Aug-17 - Recommended Process For Analysing Risk Of Simultaneous Operations (SIMOPS) During Liquefied Natural Gas (LNG) Bunkering

[44]. An Overview of Leading Software Tools for QRA, American Society of Safety Engineers – Middle East Chapter (161), 7th Professional Development Conference & Exhibition, March 18-22, 2005

[45]. Reference Manual Bevi Risk Assessments version 3.2, National Institute of Public Health and the Environment (RIVM), Bilthoven, 2009. Digital copy: http://www.rivm.nl/dsresource?objectid=rivmp:22450&type=org&disposition=inline&ns_nc=1

[46]. Walter Chukwunonso Ikealumba and Hongwei Wu (2016) ***Some Recent Advances in Liquefied Natural Gas (LNG) Production, Spill, Dispersion***, and Safety School of Chemical and Petroleum Engineering, Curtin University

APPENDIX

Risk-based evaluation of Ports Feasibility for LNG Bunkering

Specification for Risk-based evaluation of Ports Feasibility for LNG Bunkering

1. Objective

The main objective of the present specification with the necessary studies on LNG bunkering infrastructures and/or small storage siting facilities in order to support a safe development of the LNG facilities of the relevant ports or port areas, thus promoting the development LNG bunkering in the region.

All the Tasks address safety risk assessment issues regarding LNG bunkering of the gas-fuelled ships in the relevant PAA ports both from a regulatory and technological perspective.

2. Tasks

The aim of the contract resulting from this specification is twofold:

1. Describe the existing standards/regulations/guidelines related to LNG bunkering and those currently under development, affecting the ports on a national, regional and global scale. Provide a gap analysis identifying, documenting and comparing the differences between the existing requirements of current/on-going LNG bunkering related regulations. Provide recommendations how to overcome the identified gaps.
2. Develop framework for Qualitative and Quantitative Risk Assessments for LNG as fuel bunkering operations, for the identified port(s), taking into consideration specific features of each port such as number and type of ships calling at ports, type of operations, port location and surrounding infrastructures as well as other relevant variables for the establishment of each ports safety/risk profile.

The first point specified above is intended to address the policy and regulatory framework at international, regional and national levels, to define the policy and regulatory context of the relevant port(s).

The second focuses on the study and analysis of specific features of each port in order to assess the risks involved in LNG bunkering on a given port, against specific risk acceptance criteria, taking into consideration geo-morphological and meteorological characteristics affecting the ports, their operational profiles, e.g. types of trade, number of passengers, containers, total number of port calls.

The two points identified above are further subdivided in the present specifications into different Tasks ranging from Task 1 to Task 8 as per table below.

Task	Description
1	Gap Analysis Study of the Regulatory Frame and Evaluation of Applicable Standards to LNG as fuel for shipping
2	Feasibility Study
3	Definition of Risk Acceptance Criteria Study
4	Site Specific Data Description and Analysis Study
5	Nautical Analysis and Collision Risk Analysis Study
6	Hazard Identification – HAZID Study
7	Quantitative Risk Assessment (QRA) Study
8	Ship Collision Risk Study

Each Task, its technical description and expected deliverables, is described in the Appendix I attached to this specification.

The Tasks consist of both generic and port-specific studies, targeting different needs regarding the state of development of the LNG bunkering infrastructures and operations in the relevant port(s). The Tasks are independent amongst them and are non-overlapping. All the Tasks are related to Regulations, Standards, and Risk & Safety, consisting essentially of studies assisting the development and implementation of LNG bunkering facilities within the existing port areas. No engineering implementation studies or works are considered as part of these Tasks.

The Task(s) to be considered by PAAs will depend on the actual needs of each port and the relevant LNG facilities. The decision of the Task(s) to be developed will be based on the Case/Site/Country Specific Information (Annex-1) and considerations/objectives to be taken into account for each relevant Task as defined in Annex-2.

<table>
<tr><td>TASK 1</td><td>Gap Analysis Study of the Regulatory Frame and Evaluation of Applicable Standards to LNG as fuel for shipping</td></tr>
<tr><td>Introductory Note</td><td>The very first step to be given, with regards to a future Risk Assessment, would be the comprehensive description of the regulatory environment, existing standards and relevant procedures affecting the LNG business, in particular the LNG as fuel for shipping.

One of the key aspects in the regulatory description in LNG as a fuel for shipping, is that the bunkering will encompass both shore-side and ship-side regulatory environment. The same applies for land-based LNG standards, emergency procedures and other key aspects.

Following the previous point, a “gap analysis” is an essential exercise in order to realize what has to be done. It is important to identify the different areas where “gaps” exist. These may be of a regulatory nature, but also regarding standards, safety procedure, etc.

A comparison with other LNG related business activities (land based or LNG cargo shipping) is advisable.

In the specific case of the prospective Port the “gap” analysis should include all aspects related to the LNG bunkering for different segments of the shipping business, both cargo and passengers.

The safety and regulatory frames may vary significantly depending on the shipping segments considered and this should be considered.</td></tr>
<tr><td>Task technical Description</td><td>The overall objective of this Task is to analyse, further evaluate and propose solutions to the identified gaps and barriers, at regulatory level, taking into account:
(a) On-going work and preliminary results at the International Standardisation Organisation (ISO) and the International Maritime Organization (IMO)
(b) Work and initiatives that have been already undertaken at local and national level.

It should also identify key measure pursuing a strategic and operational harmonization with EU-wide LNG as an alternative fuel for shipping approach (beyond local rules and procedures already in place), including safety and security aspects of LNG storage, bunkering and handling (ports/supply side and ships). It is here important to note that LNG as fuel for shipping, in the wider Mediterranean, will benefit from the integration of lessons learnt at European level. The integration and alignment of regulatory initiatives, wherever possible, should be pursued in order to favour business environment with a fair regulatory playing field.

More specific objectives are:
• Further analyse the remaining gaps and barriers for a consolidated framework for LNG distribution, bunkering and in view of the most recent developments at international and European level (such as IMO, ISO and relevant existing EU legislation and EN standards)
• Specific attention shall go out to quantitative risk assessment, risk acceptance criteria, permitting processes, incident reporting
• The analysis for all gaps and barriers shall provide relevant data on key parameters such as costs and benefits for the affected parties etc.
• The study shall identify and elaborate possible policy actions, rules, standards and guidelines, in line with the timeframes of the relevant international regulations at IMO level (IGF Code, IC Code revision and other relevant related documents such as the STCW code, whereas LNG as fuel for shipping related elements are encountered.
• The study shall identify and assess potential impacts of actions in economic, environmental and social terms. The study shall discuss and validate results with all relevant stakeholders.</td></tr>
</table>

Expected Deliverables	1. List and description of all national legislation and specific regulations affecting or influencing the development of LNG bunkering facilities at ports. 2. Identification of regional/international regulations influencing PAA's country's LNG bunkering development (important to realise all relevant conventions to which the relevant PAA partner country is a contracting party). 3. Elaborate a Gap Analysis matrix, concerning three different Gap types: a) Technological, b) Regulatory, c) Harmonization 4. Propose measures to close the identified gaps.

<table>
<tr><th>TASK 2</th><th>Feasibility Study</th></tr>
<tr><td>Introductory Note</td><td>A Feasibility Study of LNG bunkering for the intended port(s) has the objective to bridge the gap between the perception of LNG advantages and opportunities as an alternative fuel for shipping, and the actual operational measures to develop and implement LNG bunkering infrastructure projects.

An important figure to determine whether LNG bunkering will represent a feasible business case is the estimated demand for LNG as fuel. For this estimation it is important to bear in mind several factors related not only to the regulatory environment (as addressed by Task 1) but also to the predictable trends in shipping (number of LNG fuelled vessels, trade patterns, etc.).

Having the demand estimated, based on a number of relevant assumptions, it is important to draw the possible logistic chains which will include inputs from the LNG demand estimation and from site-specific particulars.</td></tr>
<tr><td>Task technical Description</td><td>• Market study: forecast LNG bunkering demand for the intended port(s) based on shipping forecasts & energy market forecast, with particular highlight to the Mediterranean shipping.
• Market characterization to be considered, taking into account the Mediterranean short-sea shipping and possible deep-sea shipping routes should be explored, in particular for taking into account possible establishment of new market tendencies for LNG cargo supply
• The following factors shall be taken into account:
✓ Regulatory frame both at regional, European and international levels,
✓ LNG market relevant forecasts,
✓ number of estimated LNG ships trading in the Mediterranean
✓ number of LNG ship orders
✓ Social aspects
• Perform, at least, 3 (three) Cost-Benefit Analysis studies with existing relevant LNG bunkering facilities.
• Logistics model: model different supply chain options to provide LNG as bunker fuel.
• Interpretation and analysis of the main motivating and conditioning factors for LNG bunkering in the intended port(s).
• Draft recommendations for optimization of potential project and implementation of LNG bunkering facilities and operations.</td></tr>
<tr><td>Expected Deliverables</td><td>1. An integrated report addressing all aspects of providing LNG as bunker fuel
2. A list of concrete recommendations
3. An excel spreadsheet allowing ports to simulate, compare and calculate costs of future LNG supply chains, depending on different concept options for delivery.</td></tr>
</table>

<table>
<tr><th>TASK 3</th><th>Definition of Risk Acceptance Criteria Study</th></tr>
<tr><td>Introductory Note</td><td>Task 3 is only necessary if Risk Acceptance Criteria needs to be defined by the specific PAA. This would only be the case if the PAA country has no such criteria available within its legislative frame.

Risk Acceptance criteria is important to validate the results from the Risk Assessment. Without this a Risk Assessment exercise would have no effect whatsoever. Acceptable risk limits, for individual and societal risks need to be defined, should they not be in place already in the subject port national regulatory/legislative framework.

It is however always possible, for the specific port subject of the study, to consider reference to existing risk acceptance criteria, such as the UK HSE Risk Acceptance Criteria.</td></tr>
<tr><td>Task technical Description</td><td>The objective of Task 3 is to evaluate the availability of Risk Acceptance criteria to be used for Risk Assessment and:
• Where these are available: to evaluate the applicability of the existing criteria to the case of LNG bunkering small infrastructures within the wider port area, considering different bunkering modes (ship/barge-to-ship, truck-to-ship and terminal-to-ship.
• Where no criteria are in place: to propose adequate requirements for risk acceptance, preferably referring to existing accepted examples applied within the international frame.

As a reference for this study, the concepts of Individual and Societal risks, as defined in the UK HSE shall preferably be followed:
• <u>Location Specific Individual Risk contours</u> (LSIR)
• <u>Societal risk curves</u> (FN curves)

LSIR shows the geographical distribution of risk to an individual outdoors on a map of the quay and its surroundings. From these contours, the average individual risk at specified locations can then be determined. FN curves show the cumulative frequency (F) distribution of accidents causing different numbers (N) of fatalities, usually shown for convenience on a log-log plot.

The LSIR contours shall be calculated and plotted on a map for all three locations. Similarly, FN curves for the societal risk shall be produced for each location.

<u>Requirements to risk metrics</u>
• Need to be a good measure of the parameter we are interested in measuring:
  – Risk to human life, to the environment, or economical risk?
  – Does the measure give the answer to how the risk level changes?
• Must be possible to observe and quantify with reasonable certainty to enable us to record data and thereby observe changes and trends
• Must be sensitive to changes in risk, to allow us to detect changes early and thereby take actions
• Must be easy to understand and use for decision makers and other users
• Must be robust against manipulation

<u>Factors to consider when setting acceptance criteria:</u>
• Criterion must be possible to meet.
• Should be able to reflect changes in activity level.
• How are we going to measure risk? Is it possible to measure the risk?
• Is the risk level commonly accepted in the society, or not?
• Can the acceptance criterion be communicated internally and externally?</td></tr>
<tr><td>Expected Deliverables</td><td>• Report with brief description of the relevant existing Risk Acceptance criteria used
• Propose Risk Assessment Criteria, to be used a later stages to evaluate the risk arising from different LNG bunkering configurations
• Propose adequate form of risk presentation for assessment and</td></tr>
</table>

	internal/external information, allowing the verification/validation of risk results • Define bandwidth for ALARP (As Low as Reasonably Possible) in log-log graph, reflecting the risk acceptance criteria developed. • Develop a power-point presentation to assist informative sessions on the implementation of the risk assessment criteria at national level.

<table>
<tr><th>TASK 4</th><th>Site Specific Data Description and Analysis Study</th></tr>
<tr><td>Introductory Note</td><td>Task 4 aims at the compilation of all the available and necessary information on the port area and its surroundings, and the relevant modelling assumptions. The Data & Assumptions need to be described in a separate document and will serve as input for the actual siting study.

The present task will likely require the following documentation, when available, to be submitted to the study:
• Process Flow Diagrams (PFDs)
• General operating philosophy (operating parameters and process conditions)
• Safety concept
• Material Safety Datasheet (MSDS)
• Plot Plans;
• Layout of the proposed LNG bunkering installation
• Layout of surroundings (location specific)
• Meteorological data (average ambient temperature, average humidity, average wind speed and distribution of wind direction) (location specific)
• Local population both onshore and offshore if relevant (cruise ship population)

It is important that the intended modes for LNG bunkering are described:
• Ship-to-Ship (STS)
• Truck-to-Ship (TTS)
• Port-to-Ship (PTS)

The Process Flow Diagrams should reflect the total chain for the delivery of LNG to potential receiving vessels. The affected port areas must be identified, not only those designated for storage but also the ones where operational work is foreseen.</td></tr>
<tr><td>Task technical Description</td><td>1. Integration of all the site-specific information.
2. Integration of all intended process-specific information
3. Produce an LNG bunkering map, with the intended options for LNG supply to potential receiving vessels on any of the listed methods:
• Ship-to-Ship (STS)
• Truck-to-Ship (TTS)
• Port-to-Ship (PTS)
4. Draw all safety limits related to other port area activities (dangerous goods, packed cargo, traffic, heliport, etc). Use all relevant references for the definition of the safety zones. All references (international, national or port-specific guidance) must be presented and related.
5. Scenario characterization, including the identification of different LNG refuelling profiles, both in form and volume of demand/supply.
6. Provide an informative characterization of different refuelling profiles, identifying key-stakeholders, inter-relating with the above identified regulatory frame, listing the specific infrastructure needs and performing SWOT analysis for different types of LNG Bunkering: 1) Shore-to-Ship; 2) Ship (barge)-to-Ship and 3) Truck-to-Ship.</td></tr>
<tr><td>Expected Deliverables</td><td>1. Produce and propose a reference initial document/report with all the site-specific conditions to be completed and validated by the contracting part.
2. Produce and propose a reference final document/report with all the site-specific conditions to be accepted by the contracting part.</td></tr>
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<table>
<tr><th>TASK 5</th><th>Nautical Analysis and Collision Risk Analysis Study</th></tr>
<tr><td>Introductory Note</td><td>Due to nautical conditions, not all locations in the port are suitable for LNG bunker activities without extra precautions. This is especially relevant where ship-to-ship, or ship-to-ship LNG bunkering, is considered.
LNG bunkering on main waterways with an intense density of passing vessels should be regarded to see if a LNG bunkering on the planned location can be permitted.
It is important to consider that possible location for LNG bunkering infrastructure will have to take into consideration two central project drivers:
✓ Proximity to (L)NG storage and the possible installation of a re-liquefaction unit/plant.
✓ Protective location berth to avoid passing traffic within the port area (for instance, need to avoid proximity to ferry routes).
Recommendations following these two drivers will have to be considered.
The main question for the nautical safety part of this study is : "<u>Where in the port are restrictions necessary on LNG activities due to nautical circumstances</u>"
For the one location with the floating storage solution, a collision risk analysis will also have to be executed. The following additional data will be required:
– Nautical chart(s) of the port
– Characteristics (type, size) of the LNG carriers and LNG fuelled ships that visit the location
– Expected number of LNG fuelled ships visits and average presence time per call
– The annual number of ships that pass the considered location
– Subdivision of the passing traffic in ship types and sizes
– Representative passing speeds of ships along the LNG bunkering intended location, with LNG fuelled ships/barges alongside
– Representative passing distances of ships
– Mitigating measures planned to be in place (escort tugs, pilots, speed restriction, other restrictions while unloading of carrier, etc.)
– Any other relevant port information</td></tr>
<tr><td>Task technical Description</td><td>• Perform a desk study with input from above mentioned documents and develop in the scope of external safety and nautical safety, a port specific LNG bunker location suitability report, presented in a map.
• Develop possible Hazard Scenarios, taking into account the specific characteristics of the nautical traffic characteristics of the port and LNG bunkering site surroundings.
• For all cases where LNG floating storage units, or LNG bunker barges, are considered, perform a study of the potential preferred locations for LNG bunkering operations taking into account the necessary protective measures for avoidance of port passing traffic.
• Develop risk mitigation measures and safety guidance to assist project decision-making regarding protective location for port LNG bunkering infrastructures, whether at berth, ashore, or afloat.</td></tr>
<tr><td>Expected Deliverables</td><td>1. Report with the identification of all nautical related possible hazards and presentation of HAZID risk matrices for nautical related hazards.
2. Identify within an updated map of the wider port area and vicinity (within 5nm) the preferred LNG bunkering locations for:
✓ Ship-to-Ship (STS)
✓ Truck-to-Ship (TTS)
✓ Port-to-Ship (PTS)</td></tr>
</table>

<table>
<tr><th>TASK 6</th><th>Hazard Identification – HAZID Study</th></tr>
<tr><td>Introductory Note</td><td>Hazard identification (HAZID) is the process of identifying hazards, which forms the essential first step of a risk assessment.

During the hazard identification stage, the criteria used for the screening of the hazards will be established and possible hazards and accidents will be reviewed. For this purpose, the wider port area and intended/projected LNG bunkering facilities will be divided into several sections. Furthermore, the identified hazards will be classified into critical and non-critical hazards. It is of great importance that the hazards considered non-critical are clearly documented in order to demonstrate that the events in question could be safely disregarded.

Based on the facts compiled in the HAZID stage, the major hazard scenarios can be identified. Usually the hazard scenarios include <u>loss-of-containment/release, fire, explosion and dispersion situations</u></td></tr>
<tr><td>Task technical Description</td><td>Hazard Identification (HAZID) of LNG bunkering for a range of specific (market/ technical/ climatic) conditions. Both LNG bunkering of Cargo and Passenger Ships to be considered

Perform a Hazard Identification (HAZID), taking into account different LNG bunkering scenarios, LNG identifying and qualitatively evaluate the risks from those safety hazards considered to be the most critical events. This analysis shall be presented and summarised in a risk matrix where the most critical events will be evaluated in terms of likelihood of occurrence and consequence. This analysis, while considering safety procedures as well as training and qualification/ certification of all staff engaged in ships' operations (e.g. bunkering, maintenance, loading/unloading, etc.),

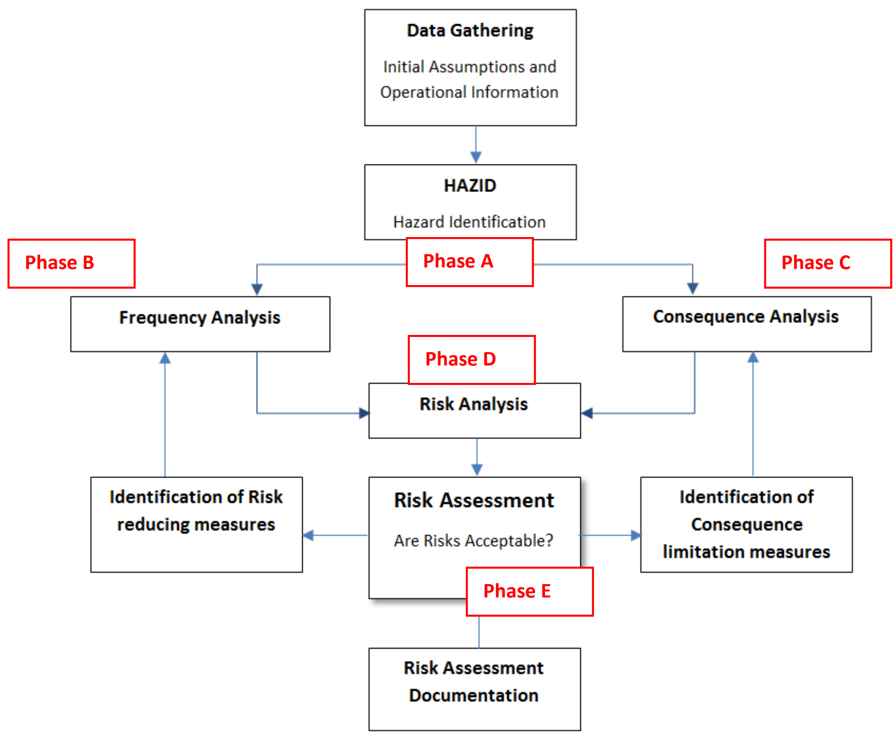
The HAZID exercise shall involve:
1. Technical visit to the port facilities and surrounding related areas At least a two day site visit shall be foreseen. The purpose of this visit is:
i. Familiarization with the different locations
ii. Data collection – completion of the input for the Data & Assumptions Register
iii. High level hazard identification session (HAZID) with local stakeholders
2. Brainstorming expert discussion regarding initiating events, sources, hazards, element criticality, safety measures, ignition/fire/explosion risks and, amongst others, dispersion cases.

The HAZID shall ensure that the risks of the actual system and the risks or issues with the potential locations are identified and discussed. Both the risk inherent to the system and thus applicable for all locations and the risks specific to each location shall be assessed in this activity.

Together with the technical site visit, this must ensure a full understanding of the location specific issues, the hazards involved and peculiarities that cannot be captured in the QRA.

The technical team that is going to deliver the study, coordinated by the study, shall be composed of the following elements:
• the design engineer in charge for the respective facility
• project manager (for new installations)
• plant engineer in charge
• maintenance engineer
• foreman/technician
• facilitator and minute taker.</td></tr>
</table>

	NOTE: The HAZID may have to be performed for generic installations, in the context of site-specific particulars. In practice, where no effective LNG bunkering infrastructure is in place, the HAZID exercise will take the shape of a study following all the steps described above, but for a generic LNG bunkering site. All the LNG bunkering modes shall be covered (ship-to-ship, truck-to-ship, port/pipeline-to-ship and LNG ISO-container embarkation.
Expected Deliverables	1. A listing of the major hazards, consequences as well as all the safeties (instrumental and operational) in place to prevent or mitigate them. 2. Location specific risks 3. Hazard Identification tables 4. Global risk matrix, following the HAZID table. 5. Recommendations

TASK 7	Quantitative Risk Assessment (QRA) Study
Introductory Note	A quantitative risk analysis (QRA) is a formalised specialist method for calculating individual, environmental, employee and public risk levels for comparison with regulatory risk criteria. The risk analysis (calculation) itself consists of the following phases **A. Hazard Identification** **B. Frequency estimation** **C. Consequence calculation** **D. Risk analysis** **E. Risk Assessment** NOTE: All the phases are described in the present Task with each of them containing specific indications with regards to technical details. Phase "A" is somewhat related to the HAZID study (Task 6) however here the modelling of the failure, following the HAZID, is also important. It will set the initial assumptions and physical circumstances for the Consequence calculation. It is important to note that the QRA work is expected to be highly determined by the Risk Analysis software and modelling techniques to be used. Other aspects are also to be considered as contributing significantly to this Task, namely the demonstrated experience in modelling specific loss-of-containment scenarios with LNG. Furthermore, with regards to the proposed risk analysis software, the study will have to demonstrate experience in using the software with reference to previous projects. The following simplified scheme identifies the necessary inter-relations between all the stages that need to be observed:  Figure – Quantitative Risk Assessment The Risk Assessment is to be performed against the specified criteria by the contracting party. If the Risk Assessment criteria are also part of the contracted work

<table>
<tr><td></td><td>(as defined in Task 3) this should here be used to assess the Risk Analysis results.</td></tr>
<tr><td>Task technical Description</td><td>
A. Hazard Identification

Identify the potential accidents that could result in loss of containment and subsequent LNG release.
Identification of the hazards and subsequent derivation of failure case scenarios for analysis against a standard release modelling methodology.
To define the LNG release events applying to each accident release scenario, representative loss of containment scenarios shall be modelled.

B. Frequency estimation

Estimate the event frequency per year for credible accident scenarios based on relevant historical failure frequencies (need to assume where no data exists, based on relevant empirical formulations). Tabulate the results.
Provide references for the failure data and indicate the applicability of the historical failure data to the actual items being considered.
The failure frequency/probability of proposed safety systems / mitigation measures shall be tabulated.
For each release scenario, a frequency of occurrence must be estimated.
NOTE: The dataset used for UK studies is the hydrocarbon release database (HCRD) which has been compiled by the UK Health and Safety Executive (HSE) over a 20 year period. It is considered the most extensive dataset of its type. Generic failure frequencies derived from the HCRD can be used.

C. Consequence Calculation

Assess the consequences for each of the identified loss of containment scenarios. The analysis of the LNG bunkering infrastructure, within the wider port area, shall be conducted on a sectional basis, grouping the processes within the facility into a series of sections where the various release sources have similar characteristics, and hence consequences.
Proposed consequence modelling techniques, methodology and software must be presented to the contracting party. Validation of software consequence modelling shall be presented against experimental results and/or real life observations. Validation for gas dispersion and pool fire modelling are important aspects to be demonstrated.
The following impacts are relevant to consider in the risk study:
✓ gas or LNG jet
✓ cold gas cloud
✓ heat radiation in case of fire
✓ overpressure in case of explosion
Reporting of consequences shall be done as required by the UK HSE in siting studies, i.e. effects of the most important scenarios will reported for two representative weather types (F2 and D5). Where a different
Dispersion results for small leaks shall be presented in the report. Small leaks typically have smaller effects than larger leaks but they occur more often. As such, it is important to understand the behaviour of an LNG cloud and consequences of ignition following a small release that can occur in daily operations (f.e. resulting from flange leaks). Therefore, dispersion graphs and effect zone visualisations will be provided for small leaks, to illustrate the extent of potential flammable clouds.

D. Risk Analysis
<u>Risk Calculation</u>:

The risk analysis stage of work shall involve combination of the previous stages / studies, together with the relevant background data (populations, meteorological data, impact criteria, etc.) to determine the risks to people both on and off site.
Specific risk analysis software shall be proposed, providing evidence of experience, adequacy and validation from experimental work and/or similar previous projects.

</td></tr>
</table>

	• Besides the dispersion and fire/blast modelling, several other sets of inputs are to be considered by the suggested software such as ignition probabilities, population data and meteorological data (weather condition, wind direction, etc.). • Risk calculations shall consider each release in turn and apply the above data to calculate risks to people outdoors. NOTE: Modelling of flammable impacts can be quite complex, with many possible final outcomes from a single release and ignition taking place at several locations. The calculations shall the required risk measures, calculating both individual risk at grid points and the societal group risk of each incident outcome. • All risks shall be summed to allow the presentation of the risk levels associated with the proposed LNG bunkering facilities/operations in an adequate way to assess a risk level (Location specific Individual risk contours, Societal risk (FN) curves, …). Typically this shall be performed according to the risk acceptance criteria accepted/contracted. NOTE: If Task 3 has been taken, the calculation and presentation of results need to be put together in such a way that allows the assessment to me made against the proposed/developed (and accepted) criteria. Risk Presentation: The risk analysis stage of work shall involve combination of the previous stages / studies.
Expected Deliverables	• Complete Risk Analysis report with the detailed findings, assumptions and calculations for each identified phase (A to E). • Risk Contours/ISO-curves for a) Location specific Individual risk contours (LSIR) b) Societal risk curves (FN curves) • Risk Assessment Report • Recommendations • Presentation of results to local authorities, identifying all stakeholders involved within possible Recommendation action items.

<table>
<tr><th>TASK 8</th><th>Ship Collision Risk Study</th></tr>
<tr><td>Introductory Note</td><td>A Ship Collision Risk study is a possible need where LNG bunkering barges, or floating storage units, are intended for the specific LNG bunkering operations.

The objective of the ship collision study is to determine the risk of a Loss of Containment (spill) of one of the cargo tanks of the power barge and/or unloading LNG carrier, caused by a ship collision. The same standard QRA approach is followed to calculate the risk; only the estimation of the frequency of a release of LNG due to a ship collision is assessed differently.

The estimation of a spill frequency is typically based on special modelling by dedicated software, integrating both estimation of spill frequencies and damages.

Task 8 differs from Task 5 by providing a quantitative estimation of the collision risk, where the later was aimed at the definition of LNG bunkering location, based on the qualitative analysis of vessel traffic within the port area.</td></tr>
<tr><td>Task technical Description</td><td>• Assess the collision risk involving LNG bunkering barge (LNG-bb) and/or LNG storage floating unit (LNG-FSU), with the vessel traffic passing by within the port area. Different vessel types must be considered (at least 5 different types of vessels, depending on the port specific operational profile). Vessel types can be taken from information provided in Task 5.
• Dedicated software for ship collision risk estimation shall be used where an Impact Energy Modelling approach shall be applied. The different ship types considered shall be grouped according to specific criteria (bow shape, length, displacement, or other) in order to cover an adequate and representative set of vessels characteristic of the given port activity. Impact energy shall be estimated for each group and then summarized to a weighted “average impact energy” for the vessel class.
• The methodology applied shall assume different failure modes and, as a minimum, the following shall be considered: 1) Steering Gear Failure and 2) Blackout. Estimated frequencies for these failure modes shall be based on relevant international failure statistics.
• The probability for one of the considered failure modes leading to an actual impact with the LNG-bb, or LNG-FSU shall be assumed to be function of the geometric probability of hitting these craft and the time available to implement mitigating actions:
    ✓ <u>Geometric probability of hitting a passing carrier</u>: The geometric probabilities are a function of the length of the potentially struck LNG-bb or FSU, the distance to passing shipping lanes and physical obstacles such as breakwaters or shallows.
    ✓ <u>Time to implement mitigating actions</u>: It shall be assumed that the probability of having time to implement mitigating action has a “Weibull” distribution.
• Different impact speeds and impact angles shall be studied for all the vessel types considered.
• For each of the selected striking ship sizes the resulting damage to the LNG-bb or LNG-FSU shall be determined by structural analysis for a series of impact cases where the apparent striking angles and the ship speeds have been varied. The damage is to be expressed as “indentation” levels: how many meters does the bow of the colliding ship penetrate the collided ship. For each combination of ship size, bow shape and impact angle a function shall be determined relating the indentation to the impact energy. As such for every scenario the expected indentation can be calculated. Indentation sizes will then correlate to different “Loss of Containment” scenarios.
• Consequence calculations are to be carried out for different expected hole/indentation sizes following collision.
• Calculate Risk following a standard QRA approach (as the one described in</td></tr>
</table>

	Task 6)
Expected Deliverables	1. Ship Collision risk analysis report 2. Recommendations for Collision Risk reduction

Annex - 1
Case/Site/Country Specific Information

<table>
<tr><td colspan="4">Case/Site/Country Specific Information
• The information provided in the present document is intended to draw the general context for the contracted study.</td></tr>
<tr><td>PAA</td><td colspan="3"></td></tr>
<tr><td>Port (1)</td><td colspan="3"></td></tr>
<tr><td rowspan="4">Geo-Climate Characteristics of the Port (2)</td><td>Coordinates</td><td colspan="2"></td></tr>
<tr><td>Climate</td><td colspan="2"></td></tr>
<tr><td>Surrounding Geomorphology</td><td colspan="2"></td></tr>
<tr><td>Surrounding Geography/ Populated Centres</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Trade Characteristics of the Port (3)</td><td>Containers (TEU)</td><td colspan="2"></td></tr>
<tr><td>General cargo (Ton)</td><td colspan="2"></td></tr>
<tr><td>Cruise (Nr.</td><td colspan="2"></td></tr>
<tr><td>Ferries (passengers and daily return</td><td colspan="2"></td></tr>
<tr><td>Other</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Intermodal characteristics of the Port</td><td>Road</td><td colspan="2"></td></tr>
<tr><td>Rail</td><td colspan="2"></td></tr>
<tr><td>Sea</td><td colspan="2"></td></tr>
<tr><td rowspan="10">Intended LNG Bunkering Operations (5)</td><td>Expected LNG bunkering volumes (m^3)</td><td colspan="2"></td></tr>
<tr><td rowspan="5">LNG bunkering modes</td><td>Ship to ship</td><td></td></tr>
<tr><td>Barge-to-Ship</td><td></td></tr>
<tr><td>Truck-to-ship</td><td></td></tr>
<tr><td>Port/Pipeline-to-ship</td><td></td></tr>
<tr><td>other</td><td></td></tr>
<tr><td>Storage Areas (nr. and capacity)</td><td colspan="2"></td></tr>
<tr><td>Refrigeration plant</td><td colspan="2"></td></tr>
<tr><td>LNG plant already in the port area?</td><td colspan="2"></td></tr>
<tr><td>Bunker barge characteristics</td><td colspan="2"></td></tr>
</table>

NOTES/Instructions:

(1). Indicate port(s) for which the study is intended.
(2). Characterize the climate and terrain characteristics of the port.
(3). To define the operational profile of the specific port(s) activities.
(4). Comment on the available multi-modal links converging in the port
(5). Characterize the LNG operations intended for the specified port and, if operations and infrastructure already developed, to provide indication of the existing LNG plant characteristics in the port, both in capacity and operational profile.

Appendix - III
Objectives of the Tasks

The table below recapitulates the objectives of each of the 8 Tasks and highlights the main considerations to be taken into account for each relevant Task. The table aims to assist in the choice of the relevant Task(s) to be performed for a given port/port area of the PAA country.

Task	Description	Objectives	When should it be considered
1	**Gap Analysis Study of the Regulatory Framework and Evaluation of Applicable Standards to LNG as fuel for shipping**	– Evaluate different needs regarding development and deployment of LNG as fuel for shipping: ✓ Regulations ✓ Standards ✓ Regulatory harmonization ✓ Administrative barriers ✓ Guidance and Procedures – Gap analysis to identify specific recommendations.	– At the very first stage of development of LNG as fuel for shipping, typically where there are no infrastructures yet in place. – Where regulations and standards need to be addressed prior to development of infrastructure. – For those countries which have had no experience with LNG as fuel for shipping and small scale LNG bunkering installations this is the advised tasks.
2	**Feasibility Study**	– Estimate the demand of LNG for a given port, based on-, ✓ Shipping forecasts ✓ Energy market forecast – Logistic model to provide LNG as bunker fuel	– At the very first stage of development of LNG as fuel for shipping, typically where there are no infrastructures yet in place – To understand whether LNG as bunker fuel is a feasible business case. – To estimate LNG volume demands.
3	**Definition of Risk Acceptance Criteria Study**	– Develop Risk Acceptance criteria to assess risk analysis studies. – To provide reference values for statutory reference – To define “Acceptable/Tolerable Risk”.	– When no national risk acceptance criteria is defined and incorporated within national legislative frame. – International criteria already exist and can be used in contracts. National framework should however, at least, be addressed to check for consistency.
4	**Site Specific Data Description and Analysis Study**	– To develop site specific documentation with all relevant information for Hazard Identification and risk studies.	– For every risk study it is important to define clearly the assumptions. –
5	**Nautical Analysis and Collision Risk Analysis Study**	– Study performed to address the risks posed to LNG bunkering operations by passing vessel traffic within the wider port area.	– When the location for LNG bunkering operations is deemed to be exposed to normal port seaborne traffic. – When operation of LNG bunker barges or floating storage units is envisaged.

6	**Hazard Identification – HAZID Study**	– Identification of possible Hazards related to LNG bunkering, transfer and transport operations. – To take an up-to-date picture of the present hazards and their possible effects – To analyse adequacy of existing safety measures and develop these to meet tolerable residual risk.	– Can be considered in all stages of the project, either before or after installation and development of infrastructures/ operational concept. – <u>When there is the need to understand the risks</u> and to develop adequate safety measures to mitigate them. – <u>Where hazards and their escalation need to be understood on a qualitative approach.</u>
7	**Quantitative Risk Assessment (QRA) Study**	– To quantify the Risk, following an accepted risk analysis methodology. – To assess the calculated Risk against reference Risk Assessment criteria – Prioritization of risks and development of safety measures for risk mitigation.	– <u>When there is the need to quantify the risks</u> and to implement <u>cost-effective</u> adequate safety measures to mitigate them to ALARP (As Low AS Reasonably Possible) levels. – <u>Where hazards and their escalation need to be understood on a quantitative approach.</u> To be assess – Typically where a statutory requirement is in place to demonstrate Risk levels acceptance.
8	**Ship Collision Risk Study**	– To identify and quantify the risk of ship collision events involving LNG bunker barge or other LNG floating storage unit. – To define safety measures for risk mitigation, including area definition for LNG bunkering operations	– Relevant when LNG bunker barge or LNG FSU is envisaged and/or intense traffic in the vicinity of the LNG bunker operation area. – <u>When there is the need to quantify the risks</u> and to implement <u>cost-effective</u> adequate safety to mitigate the risk of LNG incident resulting from <u>ship collision</u> within the port area and its vicinity.