



**BUREAU
VERITAS**

Guidelines on LNG Bunkering

July 2014

**Guidance Note
NI 618 DT R00 E**

**Marine & Offshore Division
92571 Neuilly sur Seine Cedex – France
Tel: + 33 (0)1 55 24 70 00 – Fax: + 33 (0)1 55 24 70 25
Marine website: <http://www.veristar.com>
Email: veristarinfo@bureauveritas.com
© 2014 Bureau Veritas - All rights reserved**



**BUREAU
VERITAS**

ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine & Offshore Division (the "Society") is the classification ("Classification") of any ship or vessel or offshore unit or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- "prepares and publishes Rules for classification, Guidance Notes and other documents ("Rules");
- "issues Certificates, Attestations and Reports following its interventions ("Certificates");
- "publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as "Certification".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as "Services". The party and/or its representative requesting the services is hereinafter referred to as the "Client". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Ship-builder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraisal given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisal is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - **It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisal or cause to modify its scope.**

2.4. - The Client is to give to the Society all access and information necessary for the safe and efficient performance of the requested Services. The Client is the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out.

ARTICLE 3

3.1. - **The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are a collection of minimum requirements but not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.**

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - **The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.**

3.3. - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

3.4. - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- "reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- "conducts surveys at the place of their construction;
- "classes Units and enters their class in its Register;
- "surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - **The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.**

5.2. - **The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for. In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.**

5.3. - **The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder.**

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

MARINE & OFFSHORE DIVISION GENERAL CONDITIONS

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - **If the Services of the Society or their omission cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee. These limits apply regardless of fault including breach of contract, breach of warranty, tort, strict liability, breach of statute, etc.**

The Society bears no liability for indirect or consequential loss whether arising naturally or not as a consequence of the Services or their omission such as loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred. Time is to be interrupted thereafter with the same periodicity.

ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - **Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.**

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

7.4. - The contract for classification and/or certification of a Unit cannot be transferred neither assigned.

ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve, for the part carried out, the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. - **Overdue amounts are increased as of right by interest in accordance with the applicable legislation.**

8.3. - **The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.**

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- "Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the classification file consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit ;
- "copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- "the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, may be passed on to IACS (International Association of Classification Societies) according to the association working rules;
- "the certificates, documents and information relative to the Units classed with the Society may be reviewed during certifying bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France, or to another Court as deemed fit by the Society.

12.3. - **Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.**

ARTICLE 13

13.1. - **These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement. They are not varied by any purchase order or other document of the Client serving similar purpose.**

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

TABLE OF CONTENTS

1.	Introduction	5
2.	Scope	5
3.	International Rules and Regulations on LNG bunkering	6
3.1	IMO _____	6
3.2	EU _____	6
3.3	OTHER REGULATIONS AND RECOMMENDATIONS _____	6
4.	Definitions	7
4.1	Atmospheric tanks _____	7
4.2	Bunkering facility _____	7
4.3	Bunkering facility organization (BFO) _____	7
4.4	Emergency shut-down (ESD) _____	7
4.5	Emergency release coupling (ERC) _____	8
4.6	Exclusion zone _____	8
4.7	Hazardous zone (bunkering-related) _____	8
4.8	LNG Bunkering _____	8
4.9	LNG vapour return _____	9
4.10	LNG transfer system _____	9
4.11	Person in Charge (PIC) _____	9
4.12	Receiving Ship _____	9
4.13	Receiving ship operator (RSO) _____	9
4.14	Safety zone _____	9
4.15	Type C tanks _____	10
5.	Main safety aspects of LNG bunkering	10
5.1	LNG properties _____	10
5.2	LNG boil-off gas _____	10

5.3	Hazards in connexion with LNG bunkering_____	12
6.	Description of typical ship bunkering arrangements	12
6.1	Ship to ship LNG bunkering_____	12
6.2	Truck to ship LNG bunkering_____	12
6.3	Terminal (or shore-based facility) to ship LNG bunkering_____	13
6.4	Examples of ship bunkering arrangements_____	13
6.5	LNG / vapour transfer system_____	17
7.	General framework to be established before setting up a LNG bunkering project	17
7.1	General_____	17
7.2	Actions to be performed by the receiving ship operator (RSO) and the bunkering facility organization (BFO)_____	17
7.3	Identification of requirements from Port Authorities, Local Authorities or National Authorities_____	19
7.3.1	Port Authorities	19
7.3.2	National and local Authorities	19
7.4	Specific design requirements for bunkering systems_____	19
7.4.1	General.....	19
7.4.2	Bunkering arrangements.....	20
7.4.3	ERC – ESD systems.....	21
7.4.4	Communication systems.....	22
7.4.5	Bunkering transfer rate	22
ANNEX 1 - Compatibility between receiving ship and bunkering facility		24
1.	General_____	24
2.	Ship to ship_____	24
3.	Truck to ship_____	24

ANNEX 2 - Guidelines for developing an LNG bunkering procedure **25**

- 1. Objectives** **25**
- 2. Content** **25**
- A) Introduction** **25**
- Applicable Rules, Regulations, Guidelines, Procedures** **26**
- Glossary - abbreviations** **26**
- B) Responsibility** **26**
- C) Conditions to be fulfilled before the first bunkering operation** **27**
- Approval** **27**
- Hazardous zone, safety zone and exclusion zone** **27**
- Compatibility between the ship, the berthing / mooring facilities and the bunkering facilities** **28**
- Limiting ambient conditions** **28**
- Lighting conditions** **28**
- Safety instructions** **29**
- Safety check-lists** **29**
- Fire-fighting equipment** **29**
- Instructions for bunkering operations** **29**
- D) Safety conditions to be fulfilled before each bunkering operation** **31**
- Ambient conditions within the permissible limits** **31**
- Delimitation of the safety zone** **31**
- Put in place signboards with warning instructions** **31**
- ESD systems are to be connected and tested for proper operation** **31**
- E) Safety conditions to be observed during the bunkering operation** **32**
- F) Safety conditions to be observed after the bunkering operation** **32**

ANNEX 3 - Guidelines for safety assessment **33**

- 1. Objectives** **33**
- 2. Method** **33**
- 3. Content of the safety assessment** **34**

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

4.	Scope of the HAZOP analysis _____	<u>35</u>
-----------	--	------------------

	ANNEX 4 – Guidelines for developing a Management Plan for emergency situations	<u>36</u>
--	---	------------------

1.	Objectives _____	<u>36</u>
2.	Content _____	<u>36</u>

	LNG Bunkering	NI 618
---	----------------------	---------------

1. Introduction

The purpose of the present Guidelines is to provide recommendations on LNG bunkering, helping the different stakeholders to get the necessary authorizations (permits) from the Local Authorities and Port Authorities to conduct LNG bunkering operations.

The Guidelines cover in particular the following aspects:

- general framework to be established in connection with the Port Authorities and the Bunkering Organizations before any commercial operation, either occasional or regular,
- conditions to be observed before, during and after each bunkering operation,
- management of emergency situations.

These Guidelines are issued assuming that the Port has already assessed the safety and environmental impact of the bunkering facilities and operations and established a set of general principles governing LNG bunkering operations, in particular as regards:

- areas(s) of the Port where LNG bunkering may be carried out
- types (passenger ships, cargo ships) and size of ships allowed to be bunkered in the Port
- receiving ship LNG tank capacity limitation (if any)
- bunkering facility LNG tank capacity limitation (if any)
- bunkering operational limitations (if any), such as amount or flow rate
- simultaneous passenger / cargo transfer and bunkering operations
- limitations for weather and other external conditions in which LNG transfers are allowed: sea state, wind, visibility, etc.
- safety distances

2. Scope

These Guidelines cover the LNG bunkering of sea going ships from a LNG bunkering facility, which may be a bunkering ship, a tank-truck or a shore-based bunkering facility.

It is assumed that the receiving ship and the bunkering facility comply with all applicable Rules and Regulations. Their design and arrangement are not covered by the Guidelines.

The National and/or local regulations and the classification rules take precedence over these Guidelines.

3. International Rules and Regulations on LNG bunkering

The following Rules, Regulations, Guidelines and other documents should be considered:

3.1 IMO

- [1] Resolution MSC.285(86) INTERIM GUIDELINES ON SAFETY FOR NATURAL GAS-FUELLED ENGINE INSTALLATIONS IN SHIPS
- [2] Draft IGF Code (version dated 24.04.2014)
- [3] IGC Code (for the bunker ship)

3.2 EU

- [4] European Maritime Safety Agency (EMSA) - Study on Standards and Rules for Bunkering of Gas-Fuelled Ships
- [5] DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the deployment of alternative fuels infrastructure ref. PE-CONS No/YY - 2013/0012 (COD)
- [6] European Commission Actions towards a comprehensive EU framework on LNG for shipping ref. SWD(2013) 4 final

3.3 OTHER REGULATIONS AND RECOMMENDATIONS

- [7] USCG Regulations 33 CFR 127 Waterfront facilities handling liquefied natural gas and liquefied hazardous gas
- [8] USCG Guidelines for liquefied natural gas fuel transfer operations and training of personnel on vessels using natural gas as fuel – draft ref. 16715 CG-OES Policy Letter No. 012-14
- [9] USCG Guidance related to vessels and waterfront facilities conducting liquefied natural gas (LNG) marine fuel transfer (bunkering) operations – draft ref. 16715 CG-OES Policy Letter No. 02-14
- [10] SIGTTO ESD arrangements & linked ship / shore systems for liquefied gas carriers
- [11] ISO/TS 18683 Guidelines for systems and installations for supply of LNG as fuel to ships
- [12] ISO/DIS 16903 Characteristics of LNG influencing design and material selection
- [13] ISO/PDTS 16901 guidance on performing risk assessment in the design of onshore LNG installations including the ship-shore interface
- [14] ISO/PRF TR 22302 Natural gas -- Calculation of methane number
- [15] ICS / OCIMF / SIGTTO Ship-to-Ship Transfer Guide (Liquefied Gases)
- [16] OCIMF / SIGTTO Recommendations for manifolds for Liquefied Gas Carriers
- [17] IAPH guidance on harmonized approach of risk perimeters (to be published)
- [18] IAPH checklists for LNG bunkering
- [19] EN 1473 Installation and equipment for liquefied natural gas Design of onshore installations

	LNG Bunkering	NI 618
---	----------------------	---------------

- [20] EN 1474-1 Installation and equipment for liquefied natural gas - Design and testing of marine transfer systems - Part 1: Design and testing of transfer arms
- [21] EN 1474-2 Installation and equipment for liquefied natural gas - Design and testing of marine transfer systems - Part 2: Design and testing of transfer hoses
- [22] EN ISO 28460 Petroleum and natural gas industries — Installation and equipment for liquefied natural gas — Ship-to-shore interface and port operations
- [23] EN ISO DIS 1604 Design and testing of LNG marine transfer arms for conventional onshore terminals

4. Definitions

The following definitions will be used in the present Guidelines:

4.1 Atmospheric tanks

Atmospheric tanks means tanks of the types A or B or membrane tanks as defined in:

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

4.2 Bunkering facility

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) and tank truck

Some bunkering facilities are designed to handle the LNG vapour return.

4.3 Bunkering facility organization (BFO)

The Bunkering Facility Organization (BFO) is the organization in charge of the operation of the bunkering facility.

4.4 Emergency shut-down (ESD)

An emergency shut-down (ESD) is a method or system that safely and effectively stops the transfer of LNG (and vapour as applicable) between the receiving ship and the LNG bunkering facility in the event of an emergency during the bunkering operation and put the system in a safe stand-by condition. The control systems involved in the ESD can be activated automatically or manually.

Note: This ESD should not be confused with the emergency shut-down systems within the bunkering facility or on board receiving ship.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

4.5 Emergency release coupling (ERC)

An emergency release coupling (ERC) is a coupling located on the receiving ship bunkering manifold or on the LNG transfer system, which separates at a predetermined section when required, each separated section containing a self-closing shut-off valve, which seals automatically.

An emergency release coupling can be activated:

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

4.6 Exclusion zone

The exclusion zone is an area around the LNG transfer system and bunkering connections where access and certain activities are excluded or restricted during the bunkering operations, as a result of the risk analysis. The exclusion zone encompasses the safety zone.

Note: Exclusion zones are also referred to as security zones.

4.7 Hazardous zone (bunkering-related)

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

- the receiving ship in accordance with IGF Code, regulation 12.5
 - the bunkering ship in accordance with IGC Code, regulation 1.3.17
- and where gas may be present as a result of the bunkering operation. They include in particular:
1. 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
 2. 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;
 3. semi-enclosed bunkering stations; and
 4. areas within 1.5 m surrounding spaces listed in 1., 2. and 3. above.

The bunkering-related hazardous zone also includes similar areas on the tank-truck or shore-based bunkering facility.

4.8 LNG Bunkering

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

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

4.9 LNG vapour return

A LNG vapour return line is a connection between the bunkering facility and the receiving ship to prevent pressure increase in the receiving tank due to the liquid transfer and associated boil-off.

4.10 LNG transfer system

LNG transfer system is a system used to connect the bunkering facility and the receiving ship in order to transfer LNG only or both LNG and vapours.

The LNG transfer system includes:

- rigid pipes, hoses, swivels, valves, couplings
- supporting structure
- handling system and its control / monitoring system

It also includes the compressors or blowers intended for the boil-off gas pressure management, when required.

The LNG transfer system does not include safety systems such as fire-fighting, water curtain, etc.

4.11 Person in Charge (PIC)

The Person in Charge (PIC) is a person who is responsible for the bunkering operation. One PIC is to be designated for the receiving ship; one PIC is to be designated for the bunkering facility.

4.12 Receiving Ship

Receiving ship is the ship that receives LNG fuel.

4.13 Receiving ship operator (RSO)

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

4.14 Safety zone

The safety zone is a zone around the bunkering facility, the bunkering station of the receiving ship and the LNG transfer system, where the only activities performed are the bunkering operations and related activities and where measures are taken to prevent leakage of LNG / vapour and to control sources of ignition.

4.15 Type C tanks

Type C tanks means tanks as defined in:

- IGC Code, regulations 4.23
- IGF Codes, regulations 6.4.15.3.

5. Main safety aspects of LNG bunkering

5.1 LNG properties

LNG Composition

LNG is a cryogenic liquefied mixture of hydrocarbons composed predominantly of methane and which can contain minor quantities of ethane ($\leq 13\%$), propane ($\leq 4\%$), butanes, pentanes, nitrogen ($\leq 1\%$) or other components normally found in natural gas extracted from gas fields.

LNG density

The density of LNG depends on the composition and usually ranges from 420 kg/m³ to 470 kg/m³ at atmospheric pressure.

LNG temperature

LNG has a boiling temperature depending on composition and usually ranging from $-166\text{ }^{\circ}\text{C}$ to $-157\text{ }^{\circ}\text{C}$ at atmospheric pressure.

5.2 LNG boil-off gas

Composition of LNG boil-off gas

The composition of the boil-off gas depends on the composition of the liquid. It changes in the course of time, because of the differences in the boiling points of each LNG component, ranging from $-196\text{ }^{\circ}\text{C}$ to $+69\text{ }^{\circ}\text{C}$. The main components of boil-off gas are methane and nitrogen. Other components, in smaller amounts, are ethane and propane. See Table 1 below.

Table 1: Boiling points of LNG components

Component	Boiling point (atmospheric pressure)
Nitrogen	$-196\text{ }^{\circ}\text{C}$
Methane	$-161\text{ }^{\circ}\text{C}$
Ethane	$-89\text{ }^{\circ}\text{C}$
Propane	$-42\text{ }^{\circ}\text{C}$
i-Butane	$-12\text{ }^{\circ}\text{C}$
n-Butane	$-1\text{ }^{\circ}\text{C}$
i-Pentane	$+28\text{ }^{\circ}\text{C}$
n-Pentane	$+36\text{ }^{\circ}\text{C}$
n-hexane	$+69\text{ }^{\circ}\text{C}$

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

Note 1: To calculate the composition of boil-off gas, the Peng-Robinson cubic equations of states can be used, with LNG composition and temperature as input data.

Note 2: The Nitrogen molar content in the gaseous phase can be much higher than in the liquid phase: e. g. 25% in the gaseous phase at atmospheric pressure, to be compared to 1% maximum in the liquid phase.

One volume of LNG produces approximately 575 volumes of gas at normal conditions (at 0 °C and 101 325 Pa) and 600 volumes at standard conditions (at 15 °C and same pressure).

Density of LNG boil-off gas

Density of LNG boil-off gas at atmospheric pressure is approximately:

- 0.67 kg/m³ at 20°C (pure methane),
- 0.72 kg/m³ at 0°C (pure methane),
- 1.2 kg/m³ at -113°C (pure methane),
- 1.8 kg/m³ at -161°C (pure methane),
- 1.2 kg/m³ at -87°C (80% methane, 20% nitrogen).

The above figures are to be compared to the density of air: 1.2 kg/m³ at 20°C and atmospheric pressure. It explains the different phases of gas dispersion in case of release:

- Cold boil-off gases below -113°C (pure methane) or -87°C (80% methane, 20% nitrogen) are denser than air and tend to descend in air or to spread over ground or obstacles.
- Heated by the environment, hot boil-off gases with temperature higher than mentioned above are lighter than air and tend to rise in atmosphere or to spread below roofs and upper decks.

Flammability

The flammability characteristics of pure methane are as follows:

- Flammable range of methane /air mixture is 5 % (LFL) to 15 % (HFL) by volume at ambient conditions.
- Auto-ignition temperature: 537 °C, higher than that of MGO (300°C)
- Minimum ignition energy: 0.25 mJ, lower than that of many hydrocarbons

Compared to pre-heated MGO, inflammation of natural gas on hot surface is less likely to happen than spark ignition.

LFL, auto-ignition temperature and minimum ignition energy of natural gas (containing hydrocarbons heavier than methane) are lower than the above figures.

Visibility

LNG vapors are not visible. However, LNG leaks in humid atmosphere generate visible mist or fog due to the condensation of air moisture.

	LNG Bunkering	NI 618
---	----------------------	---------------

5.3 Hazards in connexion with LNG bunkering

The primary hazards in connection with LNG bunkering are: LNG leakage or spill, vapour release, tank over-pressurization, overfilling or unexpected venting, which according to [11], may result in the following consequences :

- brittle fracture of the steel structure exposed to LNG spills;
- frostbite / cryogenic burning from liquid or cold vapour spills;
- fire, confined explosion and subsequent deflagration from ignited natural gas evaporating from spilled LNG;
- vapour dispersion and remote flash fire;
- over-pressure of transfer systems caused by thermal expansion or vaporization of trapped LNG;
- Note : The thermal expansion coefficient of LNG is high.
- asphyxiation from vapour release;
- possible rapid phase transition caused by LNG spilled into water.

6. Description of typical ship bunkering arrangements

6.1 Ship to ship LNG bunkering

LNG bunker ships are normally used when there is a significant volume of LNG to be transferred. Basically the capacity of an LNG bunker ship would be in the range of a few hundred to several thousand cubic meters.

The bunker ship will be loaded in a purpose-built, small-scale terminal or a standard LNG terminal adapted for small scale LNG carriers.

6.2 Truck to ship LNG bunkering

LNG bunkering operations are carried out from standardized LNG trucks (approximately 50 m³). More than one truck may be required to bunker a single ship, depending on the demanded bunker capacity. Basically, these bunkering procedures are manual and involve personnel both at shore and on-board the ship. The operations usually take a long time as the capacity of the transfer pumps on the truck is relatively small and might not match the required flow rate (typically 2 hours to bunker 50 m³ with one truck).

This is a flexible bunkering method as it offers the possibility for many different ships to be bunkered in different port locations. This method is recommended for an amount of LNG to be transferred of less than 100 m³ and when the commercial operation of the ship allows long duration for the bunkering. Another general aspect is that the truck can be parked relatively close to the bunkered ship, which minimizes the hose length.

6.3 Terminal (or shore-based facility) to ship LNG bunkering

A permanent bunkering facility may be used by ships with a fixed trade and berthing at the same pier for commercial operations like short sea shipping ferry ships or ro-ro ships.

LNG bunkering is taking place through a cryogenic rigid pipe and a flexible pipe or (a) loading arm(s) for final connection with the ship located in the bunkering terminal. The tanks for the storage of the LNG should be placed at a suitable distance, basically as close as possible to the bunkering terminal, to avoid having a very long cryogenic pipeline but incorporating a safety distance. The duration of the bunkering will depend on the rate of the transfer pumps which can be selected depending on the specific needs.

Number of qualified personnel on board of the ship will be similar to a truck to ship operation. At the shore side semi-automatic operation might be in place to reduce the exposure of personnel to the transfer operation.

6.4 Examples of ship bunkering arrangements

Possible ship bunkering options are given in Table 2 below with typical arrangements (Figures 1 to 5).

Table 2: Bunkering options and typical arrangements

		Bunkering facility				
		Type C tank			Atmospheric tank	
		Bunker ship	Tank truck	Shore-based	Bunker ship	Shore-based
Receiving ship	Type C tank	Fig.1	Fig.4	(*)	(*)	Fig.5
	Atmospheric tank	Fig.2	(*)	(*)	Fig.3	(*)

(*) This arrangement is possible but not shown.

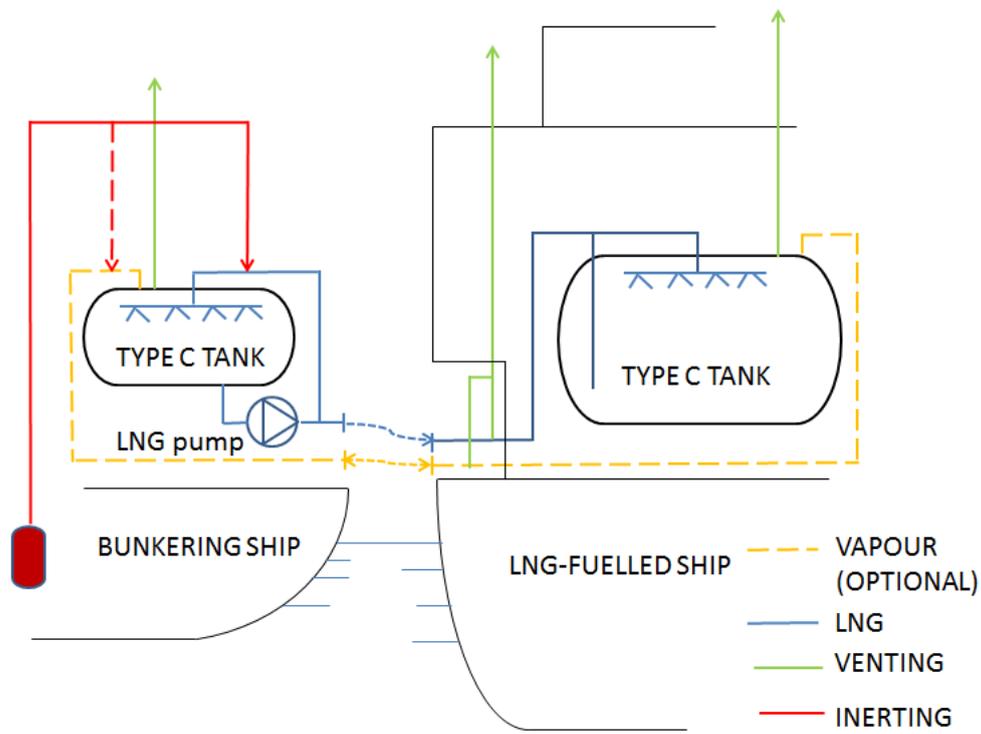


Figure 1
SHIP TO SHIP BUNKERING – TYPICAL ARRANGEMENT
BUNKERING SHIP AND LNG-FUELLED SHIP WITH TYPE C TANK

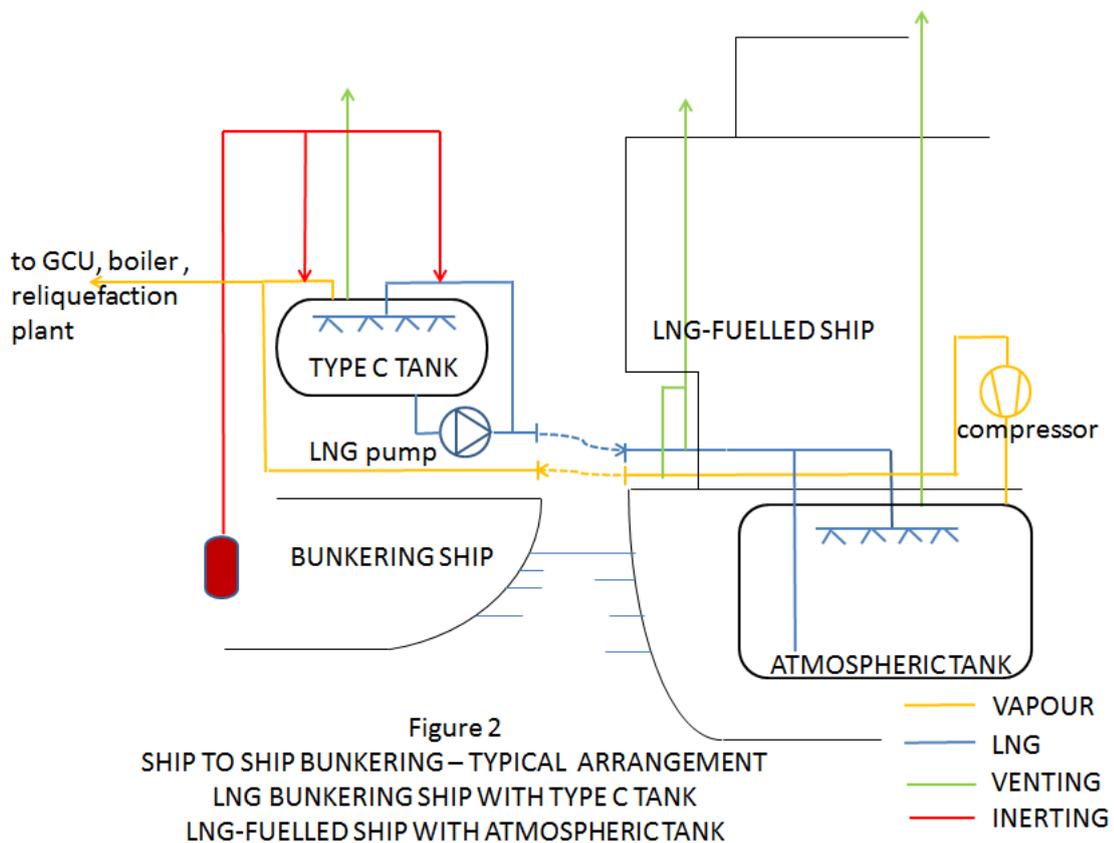
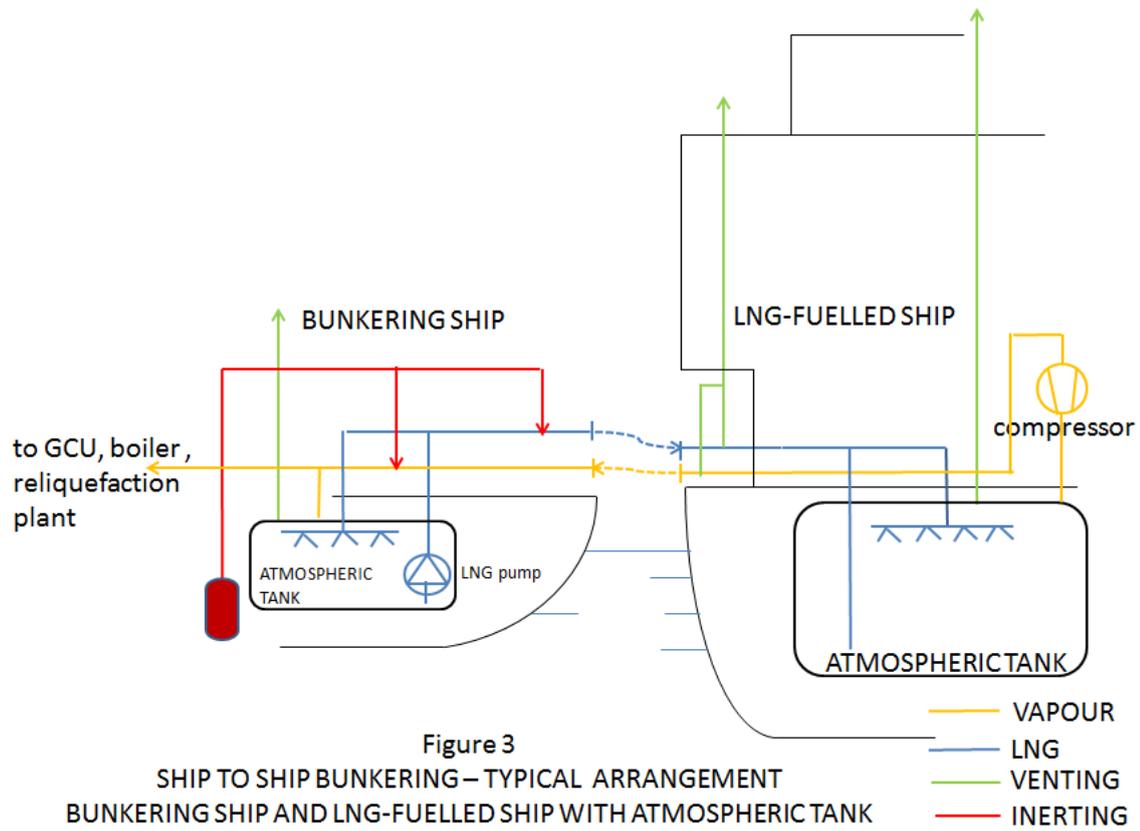


Figure 2
SHIP TO SHIP BUNKERING – TYPICAL ARRANGEMENT
LNG BUNKERING SHIP WITH TYPE C TANK
LNG-FUELLED SHIP WITH ATMOSPHERIC TANK



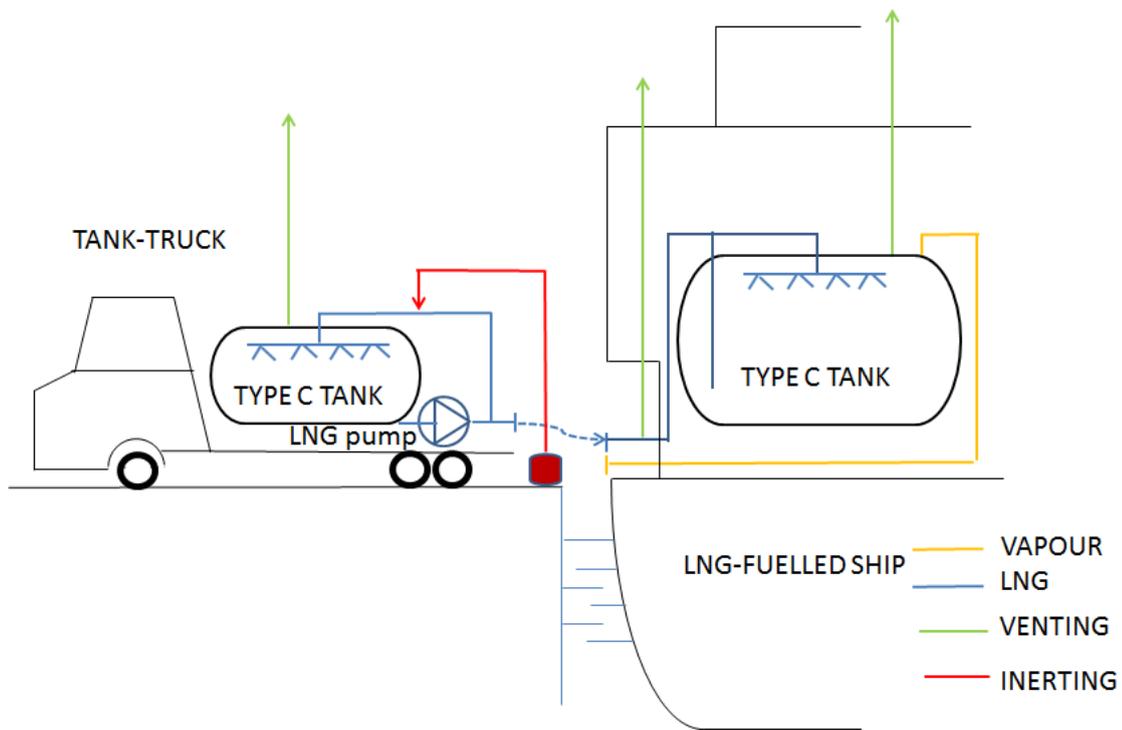


Figure 4
TRUCK TO SHIP BUNKERING – TYPICAL ARRANGEMENT
LNG-FUELLED SHIP WITH TYPE C TANK

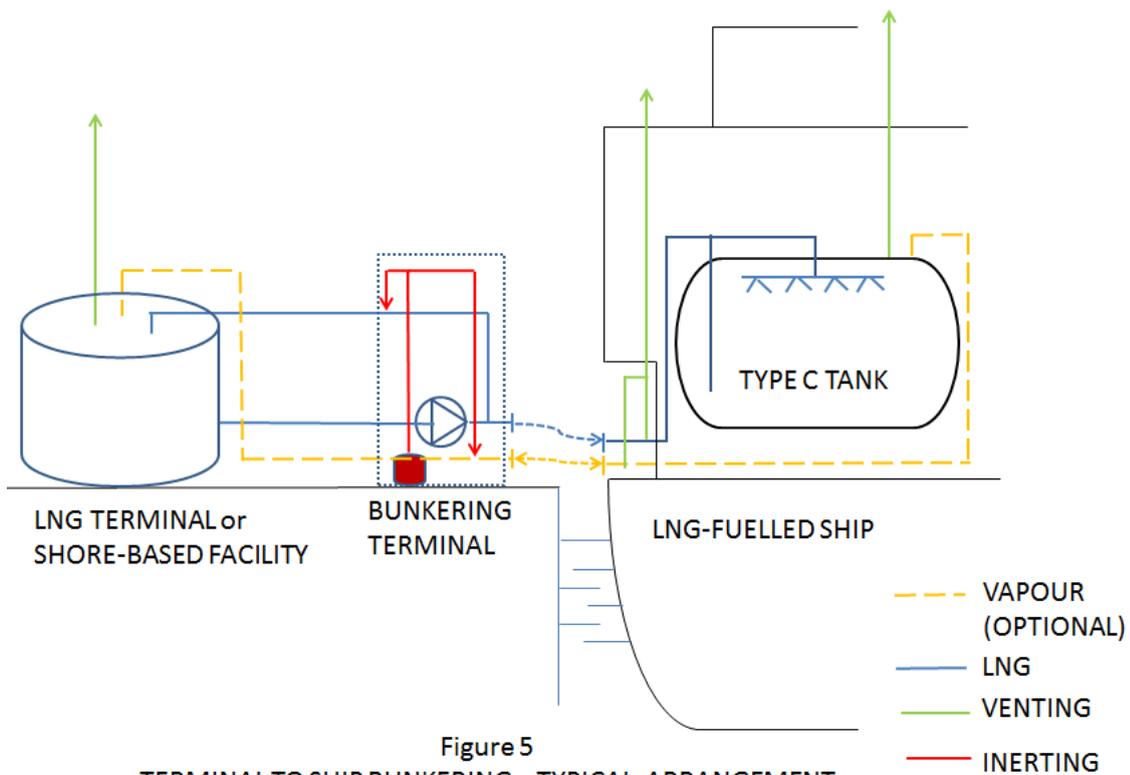


Figure 5
TERMINAL TO SHIP BUNKERING – TYPICAL ARRANGEMENT
LNG-FUELLED SHIP WITH TYPE C TANK

6.5 LNG / vapour transfer system

LNG / vapour transfer systems may consist of:

- One or more flexible hose(s) handled manually or with a lifting device
- an articulated transfer arm with rigid pipe sections and swivels
- a system combining transfer arms and flexible hoses

7. General framework to be established before setting up a LNG bunkering project

7.1 General

In order to get a LNG bunkering permit from the Port Authorities, the receiving ship operator (RSO) and the bunkering facility organization (BFO) are to:

1. perform the different actions mentioned in 7.2,
2. fulfil the Port Authority regulations as well as local and national regulations as per 7.3,
3. follow the design requirements provided in 7.4 for the LNG transfer system.

7.2 Actions to be performed by the receiving ship operator (RSO) and the bunkering facility organization (BFO)

Before setting up a ship bunkering project, the receiving ship operator (RSO) and bunkering facility organization (BFO) should perform the actions listed below (Table 3).

Table 3: Actions to be performed before setting up a ship bunkering project

N°	Actions	to be performed by:		Observations
		receiving ship operator (RSO)	bunkering facility organization (BFO)	
1.	Review the applicable International, National and Local Regulations, Port bylaws, classification Rules, standards, checklists, etc. relating to LNG bunkering	X	X	At the earliest stage of the project

 BUREAU VERITAS		LNG Bunkering			NI 618
2.	Identify all documents, information, analysis, procedures, licenses, accreditations, etc. required by Authorities	X	X	At the earliest stage of the project	
3.	Ensure that the bunkering equipment is approved by class (on-board equipment) or by relevant Authorities (on-shore equipment)		X	At the earliest stage of the project	
4.	Ensure that the receiving ship and the bunkering facility are compatible (see Annex 1)	X	X	This action should be carried out jointly by RSO and BFO.	
5.	Develop the LNG bunkering procedure for the concerned ship and bunkering facility (see Annex 2)	X	X	<ul style="list-style-type: none"> - The LNG bunkering procedure should take into account the instructions and check-lists issued by the Port. - This procedure should be developed jointly by RSO and BFO. 	
6.	Perform the Safety assessment and HAZOP study (see Annex 3)	X	X	<ul style="list-style-type: none"> - Only if required by the Port Authorities - Safety assessment and HAZOP study should involve RSO and BFO. 	
7.	Develop a Management Plan for emergency situations (see Annex 4)	X	X	This action should be carried out jointly by RSO and BFO.	
8.	Set up the organization in charge of the bunkering operations and provide adequate information, instructions and supervision to the persons involved in the LNG bunkering operations	X	X	<ul style="list-style-type: none"> - This action should be carried out jointly by RSO and BFO. - A common language should be agreed upon between RSO and BFO. 	
9.	Establish a training program in accordance with the Authorities requirements	X	X		

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

7.3 Identification of requirements from Port Authorities, Local Authorities or National Authorities

7.3.1 Port Authorities

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

- Accreditation of the BFO
- Qualification of the PICs
- Mooring of the receiving ship
- Mooring of the bunkering ship
- Immobilization / braking of the tank truck
- Access to the receiving ship
- Establishment of a Safety zone / Exclusion zone in way of the bunkering area
- Simultaneous LNG bunkering operation and commercial operations (cargo loading / unloading, passenger embarking / disembarking)
- Simultaneous LNG bunkering operation, FO / LO bunkering, and waste discharge operations
- Safety assessment and risk acceptance criteria
- Conditions in which LNG bunkering operations are allowed: weather conditions, sea state, wind speed, visibility, etc.

7.3.2 National and local Authorities

Regulations from the following national and local Authorities are to be complied with:

- Onshore facilities Regulations
- National port regulations
- Regulations from terminal

7.4 Specific design requirements for bunkering systems

7.4.1 General

The LNG / vapour transfer system is to be designed and the bunkering procedure carried out so as to avoid the release of gas to the atmosphere.

The maximum LNG temperature that the receiving ship can handle is to be stated by the RSO in order to avoid excessive boil-off generation.

Arrangements are to be made for:

- purging and inerting the bunkering lines prior to the LNG transfer
- draining, purging and inerting the bunkering lines on completion of the LNG.

Attention is drawn to the inert gas used for purging / inerting, which may result in high inert gas content in the LNG tank of the receiving ship, which may affect the proper operation of engines.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

Accidental leakage from the LNG / vapour transfer systems including the connexions with the receiving ship bunkering manifold and with the bunkering facility are to be detected by appropriate means.

7.4.2 Bunkering arrangements

LNG and vapour transfer systems (rigid arm or flexible hose) should be fit for marine LNG bunkering operations and should be type-approved by the Society.

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

- potential movements between the receiving ship and the bunkering facility,
- operating envelope of transfer arms,
- minimum bending radius allowed for hoses,
- ESD system functionality.

If hoses are utilised they are as a minimum to comply with the requirements of IGC Code and EN 1474-2 standard. An enhanced type approval against a recognised industry standard for offshore flexible hoses can also be considered.

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

The methods of handling and storage of the transfer hoses are to be submitted to the Port for review.

A document containing the following information is to be kept by the owner of the hose:

- hose identification number,
- type approval certificate,
- date of initial entry into service,
- initial test certificate and all subsequent test reports and certificates,
- records of all transfer operations.

This document is to be made available during any survey by the Port.

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

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

Equipment utilised with the transfer system such as hose rests, saddles, coupling guidance systems shall be approved and tested both before and after installation. For emergency release couplings, see 6.4.3 below.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

Hose or rigid arm rests and saddles shall not put undue stress on the hoses, the rigid arms or on parts of the vessels manifold which are not designed for such loads. Alternatively the manifold area may be suitably reinforced. Details of the manifold loads should be submitted to the society for information and review.

7.4.3 ERC – ESD systems

The equipment to be shut down on ESD activation includes manifold valves on the receiving ship and bunkering facility and any pump or compressor.

Any activation of the ESD systems is to be implemented simultaneously on both bunkering facility and receiving ship. The timing sequence is to ensure that the involved pumps and vapour return compressors (if any) stop before the closure of any manifold valves.

Transfer arms and hoses are to be fitted with an emergency release coupling designed to minimize the release of LNG on emergency disconnection. The emergency release coupling is to be designed for:

- manual activation,
- automatic activation in case of excessive forces,
- automatic activation in case the safe working envelope of the loading arm is exceeded.

The bunkering line is to be designed and arranged to withstand the surge pressure that may result from the activation of the emergency release coupling and quick closing of ESD valves. If not demonstrated to be required at a higher value due to pressure surge considerations, a default time of 5 seconds from the trigger of the alarm to full closure of the ESD valves is to be adjusted, in accordance with IGF Code.

The alarms and safety actions required for the transfer system are given in Table 4 below.

Table 4: Alarms and safety actions required for the transfer system

Parameters	Alarm	Activation of the ESD systems	Automatic activation of the emergency release coupling
Low pressure in the supply tank	x	x	
Sudden pressure drop at the transfer pump discharge	x	x	
High level in the receiving tank	x	x	
High pressure in the receiving tank	x	x	
LNG leak detection or vapour detection (anywhere)	x	x	

 BUREAU VERITAS	LNG Bunkering			NI 618
Gas detection in the ducting around the bunkering lines	x	x		
Manual activation of the emergency release coupling	x	x		
Safe working envelope of the loading arm exceeded	x	x	x	

Justifications are to be submitted regarding the maximum axial and shear forces likely to be exerted on the emergency release coupling during the bunkering operations, taking into account the worst allowable conditions for current, waves and wind declared in the bunkering procedure.

The quick release coupling is to be subjected to a type test to confirm the values of axial and shear forces at which it automatically separates. The tightness of the self-closing shut-off valves after separation is to be checked.

The local manual activation position for the ESD system should be at a safe distance from the manifold and shall have a clear view of the manifold area.

If an automated system is employed then no personnel shall be permitted in the area of the manifold during cargo operations.

Adequate means, such as screens and drip trays made of suitable stainless steel and water curtains, shall be provided to protect the ship's hull and structure from the effects of release of LNG. In the event of activation of the ERC, the hoses must be adequately supported and protected to prevent potential damage, spark or rupture due to mechanical shocks.

A controlled manual shut down is always preferable to an emergency stop.

All electrical components of the emergency release coupling actuator and of the ESD systems are to be of a suitable safe type.

7.4.4 Communication systems

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

The components of the communication system located in hazardous and safety zones are to be of a suitable safe type.

7.4.5 Bunkering transfer rate

The bunkering transfer rate is to be kept within the capabilities of the bunkering facility and receiving ship.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

The maximum LNG transfer rate is to be justified, taking into consideration:

- the management of the BOG generated during bunkering
- the temperature of the LNG supplied to the ship.

Relevant calculations are to be submitted to the class society of the receiving ship for review.

Adequate provisions are to be made for the disposal of the additional boil off gas generated during the bunkering operation, without release to the atmosphere. This may be ensured by:

- considering the capacity of the available vapour spaces and allowable pressure build-up of both vessels or
- by burning additional volumes in boilers, gas combustion units or gas engines, or
- by reliquefaction.

The LNG velocity in the piping system is not to exceed 10 m/s in order to avoid the generation of static electricity and limit the heat transfer due to friction inside the pipes.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

ANNEX 1 - Compatibility between receiving ship and bunkering facility

As a part of the setting up of the ship bunkering project, the compatibility between the ship and the bunkering facility are to be ascertained as indicated below.

1. General

The compatibility should cover at least the following aspects:

- Ship mooring, maximum surging permitted (due to traffic)
- Pressure / temperature in the receiving ship LNG tanks vs. pressure / temperature in the bunker facility tank
- Vapour management
- Vapour return line pressure / temperature
- Delivery flow rate vs ship bunkering system (to avoid risk of over-pressure in the ship filling line and storage tanks)
- Type and size of hose connections and connection systems
- Monitoring, alarm, safety and emergency shut-down (ESD) systems of the ship vs. bunkering facility
- Earthing systems
- Communication systems and communication language
- Inert gas supply (by the receiving ship, the bunkering facility or a mobile supply unit)
- Acceptable LNG characteristics for the ship gas engines
- Emergency response plan

2. Ship to ship

- Possibility for safe mooring (berthing side and side by side)
- Relative freeboard difference
- Compatibility of the bunkering arm / hose operating amplitude with the ship bunkering station location

3. Truck to ship

- Adequacy of handling equipment for LNG / vapour transfer system
- Possibility for visual contact between ship operators and truck operator during the operations

ANNEX 2 - Guidelines for developing an LNG bunkering procedure

1. Objectives

The objective of the LNG bunkering procedure is to define the conditions to be observed to ensure a safe and time-efficient LNG transfer from the bunkering facility to the ship, without release of LNG or gas into the environment.

The LNG bunkering procedure addresses the entire bunkering operations. A specific Management Plan is to be developed for the emergency operations. See Annex 4.

2. Content

The LNG bunkering procedure may include the following parts.

A) Introduction

Foreword

This procedure is intended only for the transfer of LNG between the bunkering facility and the ship mentioned below. After the first bunkering operations, additional technical and / or operational measures may be included in this procedure to improve the safety and the efficiency of the bunkering operations.

General information

Information on the ship

- Description of the ship
- LNG bunkering (filling) diagram
- LNG tanks : volume, design pressure, maximum service pressure, setting pressure of the safety valves
- Vapour return necessary or not and, where applicable, design data

Information on the bunkering facility (bunker ship or barge, truck, shore-based facility, terminal)

- Owner and operator of the bunkering facility
- Description of the bunkering facility
- LNG tank : volume, design pressure, maximum service pressure, setting pressure of the safety valves

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

Information on the bunkering equipment

- Description of the LNG transfer equipment (transfer arm, flexible hose handled manually or by means of a crane / davit)
- Connection principle
- Description of monitoring, alarm and safety (ESD) systems

Information on the bunkering operation

- Precise location
- Frequency / timetable
- Duration
- Volume to be transferred
- Filling rate
- Passengers on board the ship
- Other operations carried out during bunkering operations (cargo loading / unloading, passenger embarking / disembarking, FO bunkering, etc.)

Applicable Rules, Regulations, Guidelines, Procedures

The list of the documents which have been taken into account to draft the bunkering procedure is to be provided.

Glossary - abbreviations

B) Responsibility

A person in charge of the bunkering operation (PIC) should be designated for the receiving ship and for the bunkering facility.

The PICs should have adequate education, training and authorisation to ensure safe bunkering operations.

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

The PICs have to ensure that:

- relevant approved procedures are properly applied,
- safety standards are complied with, in particular within the hazardous zone and safety zone
- no actions are undertaken that could impair safety.

The bunkering procedure must be agreed upon between the receiving ship organization (RSO) and the bunkering facility organization (BFO) before starting any actions.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

A procedure on the assessment of the amount and quality of the LNG delivered to the receiving ship is to be established and agreed upon by the RSO and the BFO.

C) Conditions to be fulfilled before the first bunkering operation

Approval

An authorization is to be obtained from the Authorities before starting the first bunkering operations.

The bunkering operation is to be carried out in the area designated by the Port Authorities.

Hazardous zone, safety zone and exclusion zone

Hazardous zone, safety zone and exclusion zone as defined in 4.7, 4.14 and 4.6 respectively should be observed.

In the hazardous zone, only electrical equipment certified in accordance with IEC 60079-10-1:2008 is permitted. Other electrical equipment is to be de-energized prior to the bunkering operations. Attention is drawn to the following equipment which is not intrinsically safe and should therefore be disabled, except if otherwise justified:

- the radar equipment , which may be affected by high power densities,
- other electrical equipment of the ship, such as radio equipment and satellite communication equipment, when they may cause arcing.

The safety zone should extend on the sea and shore side to at least 25 m from LNG bunkering piping and pumping systems, and bunkering station boundaries. The extent of the safety zone may be modified, depending on the results of the safety analysis and associated studies.

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

- Access to the safety zone is restricted to the authorized staff, provided they are fitted with personal protective equipment (PPE) with anti-static properties and portable gas detector.
- Smoking is not permitted.
- Naked lights, mobile phones, cameras and other non-certified portable electrical equipment are strictly prohibited.
- Cranes and other lifting appliances are not to be operated.
- No vehicle (except the tank truck) is to be present in the safety zone.
- No ship or craft should normally enter the safety zone, except if duly authorized by the Port Authorities.
- Other possible sources of ignition are to be eliminated.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

The exclusion zone is to be set so that no unforeseen mechanical impact would affect the ship, the bunkering facility and the transfer system during bunkering operations.

Compatibility between the ship, the berthing / mooring facilities and the bunkering facilities

Before the first bunkering operation, it should be ascertained that the different compatibility requirements given in Annex 1 above are satisfied, in particular with respect to:

- the arrangement of the ship and berth mooring equipment (including fenders)
- the arrangement of the ship and bunker ship mooring equipment (in case of ship to ship bunkering)
- the type and size of the LNG transfer connections
- the ESD systems

Limiting ambient conditions

The limits of ambient conditions (weather, wind, sea state, currents) in which the bunkering operation can be safely performed are to be clearly stated.

Before starting the bunkering operations, the Person in Charge (PIC) of the bunkering is to ensure that the forecast for weather, wind, sea state and currents are acceptable to ensure safe conditions until the completion of the bunkering operations.

The bunkering operations can be started only if the PIC deems that the ambient conditions are acceptable. The PIC has also the responsibility to decide to proceed with, or to stop, the bunkering operation in case of sudden change of ambient conditions.

If ambient conditions are suddenly getting worse during the bunkering operations, the limits beyond which bunkering operations in progress have to be stopped should also be stated.

Lighting conditions

The minimum lighting conditions necessary for the bunkering operation are to be stated.

Where bunkering operations are carried out during night time, sufficient lighting is to be provided in way of the bunkering area. The lighting system is to be so arranged as to provide sufficient lighting, in particular:

- at any loading flange
- ESD system call points
- Communication systems

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

- Fire-fighting equipment
- Passage ways / gangways intended to be used by the personnel in charge of the bunkering operation
- Vent masts

Safety instructions

Detailed safety instructions are to be prepared, addressing the different cases of failures, malfunctions or external events (such as sudden change in the ambient conditions) that may occur during the bunkering process, as identified in the safety analysis and HAZOP referred to in Annex 3.

Personnel are required to have a good knowledge of the safety instruction content. The training program of the personnel involved in the bunkering is to be established accordingly.

The safety instructions should cover at least:

- Sudden change of ambient / sea conditions
- Loss of power (receiving ship or bunkering facility)
- Loss of monitoring / control / safety systems (ESD)
- Loss of communication
- Abnormal operating parameters

Safety check-lists

Specific check-lists covering all safety aspects of the bunkering operation are to be developed by the receiving ship operator in conjunction with the bunker facility organization. They should comply with the check-lists provided in ISO/DTS 18683 : **Guidelines for systems and installations for supply of LNG as fuel to ships.**

The check-lists are to be in agreement with those issued by the Port Authorities.

Fire-fighting equipment

The fire-fighting equipment required to be available during the bunkering operation is to be stated. This applies to:

- the receiving ship
- the bunkering facility
- the hazardous and safety zones (see C above).

Instructions for bunkering operations

Instructions for bunkering operations are to be prepared. They have to detail all the tasks to be carried out.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

Instructions for bunkering should address at least the following items:

Before connecting the LNG / vapour transfer system

- Instructions for mooring
- Instructions for grounding or isolation
- Instructions for checking the integrity (visual inspection) of the transfer system
- Instructions for connecting and checking ESD system
- Instructions for connecting and checking means of communications
- Instructions for various miscellaneous safety systems (check satisfactory operation) : water curtain, ventilation of the ship bunkering station, gas detection systems

Connection of the transfer system

- Instructions for handling the transfer system
- Instructions for installing and connecting hoses (e.g. minimum bending radius to be observed, installation of the emergency-release coupling, etc.)

Preliminary operations

- Instructions for inerting
- Instructions for visual inspection
- Instructions for testing the tightness of the transfer system assembly

Starting bunkering

- Instruction for controlling valves
- Instructions for cooling-down the bunkering lines
- Instructions for the LNG transfer itself

During bunkering

- Instructions for monitoring the operating parameters
- Instructions for controlling the transfer rate
- Instruction for topping-up

Stopping bunkering

- Instructions for stopping the pump, controlling valves

After bunkering

- Instructions for LNG draining
- Instructions for depressurization
- Instructions for purging / inerting the transfer system
- Instructions for disconnecting and handling the transfer system
- Instructions for storing the transfer hose

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

D) Safety conditions to be fulfilled before each bunkering operation

Ambient conditions within the permissible limits

Check that the ambient conditions are within the permissible limits.

Delimitation of the safety zone

Set the boundaries of the safety zone.

Put in place signboards with warning instructions

The safety instructions are to be readily available or displayed in way of the bunkering area.

Signboards warning against the risks of fire / explosion (no smoking, no naked lights, no mobile phones, no cameras, etc.), injury by contact with cold LNG and inhalation of gas are to be posted:

- around the ship hazardous area
- around the bunkering facility hazardous area

The location of the signboards is to be clearly indicated on a dedicated plan.

ESD systems are to be connected and tested for proper operation.

Fire-fighting equipment is to be available.

Communication equipment is to be tested for proper operation.

Other safety systems are to be in operation

This concerns systems such as: removable drip trays with drain, water curtain, ventilation of the bunkering station, gas detection, etc.

Disable / de-energize non-certified electrical equipment located in hazardous zone

The electrical equipment located in hazardous zone and not certified for use in such areas is to be de-energized.

Grounding connections are to be made

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

E) Safety conditions to be observed during the bunkering operation

Check that operating parameters are within the permissible range

- Pressure, temperature, level in the receiving tank
- Transfer flow rate

Check that the ambient conditions remain within permissible limits

F) Safety conditions to be observed after the bunkering operation

Check that the LNG transfer system is properly drained, depressurized, purged and inerted before disconnection

ANNEX 3 - Guidelines for safety assessment

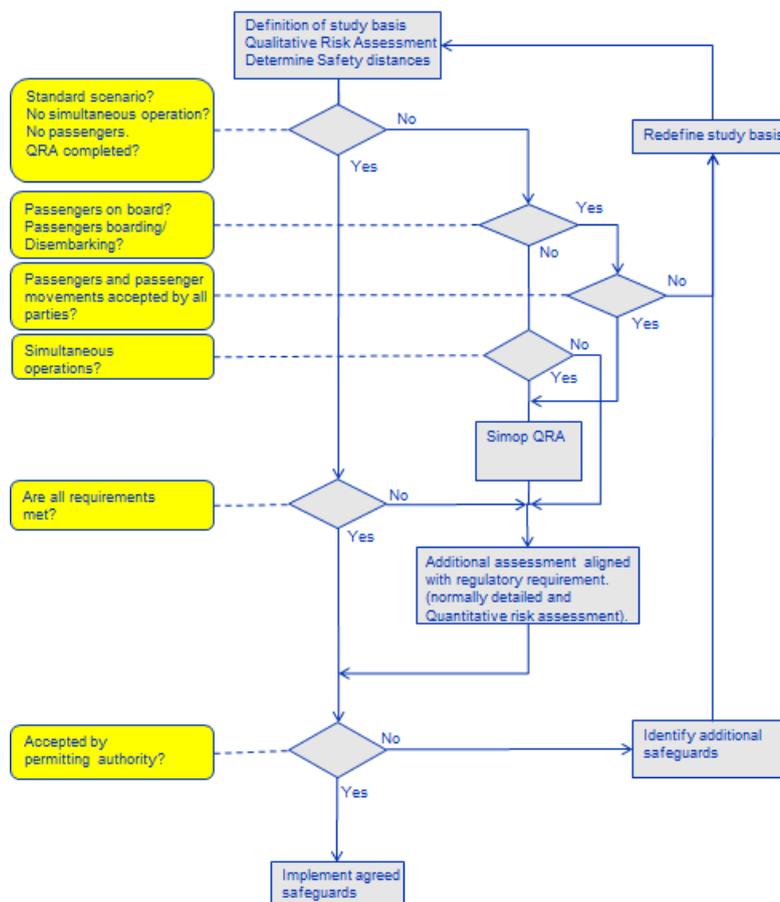
1. Objectives

The objective of the safety assessment is to demonstrate that the systems and installations for LNG bunkering and their operations are designed and planned so to provide a sufficient safety level.

2. Method

The safety analysis is to be developed in accordance with ISO/TS 18683.

The flowchart representing the process is as follows:



The safety assessment should be complemented with an HAZOP (Hazard and Operability) assessment after all safeguards have been implemented.

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

3. Content of the safety assessment

The safety assessment should include, but is not limited to:

- Design and operation specifications
- Communication on project to Port Authorities

If there are no simultaneous operations or deviations from minimum functional requirements and from scenario defined in ISO/TS 18683:

- Hazard identification with all parties (HAZID)
- List of design recommendations to be observed
- Safety and exclusion zones calculated as per ISO/TS 18683
- (Re)definition of design and operational process
- Hazard and Operability with all parties (HAZOP)
- List of procedural recommendations to be observed
- Emergency planning session with all parties and Port representatives
- Permit

If there are simultaneous operations or deviations from minimum functional requirement or from scenario defined in ISO/TS 18683:

- Hazard identification, including simultaneous operations, with all parties (HAZID)
- List of design recommendations to be observed
- Bow-Tie analysis : Medium and Major class scenario definition (ISO DTS 16901)
- Accepted Safety Level definition
- Safety and security zones calculated as per ISO/TS 18683
- Consequence studies; Explosion / Dispersion / Fire ; Domino effect
- Consequence analysis: Risk criteria; safety distances; safe arrangement; safe weather
- Frequency analysis - LOPA/ SIL analysis of critical systems with respect to Bow-Tie analysis
- (Re)definition of design and operational process
- Hazard and Operability with all parties (HAZOP)
- List of procedural recommendations to be observed
- Emergency planning session with all parties and Port representatives
- Permit

Note: Simultaneous operations are to be considered when the following operations are intended to be carried out simultaneously with the bunkering operations:

- Engine running
- Cargo handling
- Passenger embarking / disembarking
- Dangerous goods loading / unloading
- Chemical products handling
- Other low-flash point products handling

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

Simultaneous operations should be investigated at least in a cylindrical volume defined as follows:

- Horizontal base : area within 25 m from LNG bunkering piping / pumping systems and bunkering station boundaries
- Vertical extent: limited by the height of the port cranes serving the a.m. area.

4. Scope of the HAZOP analysis

Additional safety measures applicable to bunkering operations should be undertaken based upon a HAZOP in accordance with ISO 16901 and shall include but are not limited to:

- Joining together of the emergency shutdown systems of the BFO, RSO and transfer system involved
- Emergency procedures in the event of abnormal operations
- Leakage of hoses
- Overpressure of the containment system
- Emergency unmooring
- Emergency venting of vapour
- Additional protection for the vessel hulls in case of cargo leakage in way of the manifolds
- Emergency shut down and quick release protocol
- Requirements for outside assistance such as tugs
- The following phases are to be analysed:
 - Connection
 - Inerting of relevant pipe sections
 - Cooling down
 - Transfer start
 - Transfer at nominal flow
 - Transfer stop including topping-up
 - Draining
 - Inerting
 - Disconnection

 BUREAU VERITAS	LNG Bunkering	NI 618
---	----------------------	---------------

ANNEX 4 – Guidelines for developing a Management Plan for emergency situations

1. Objectives

The objective of the Management Plan for emergency situations is to list the different emergency situations which may occur and to describe, for each of them, the course of actions to be undertaken.

2. Content

The Management Plan is to cover all emergency situations identified in the HAZOP analysis. The following situations at least are to be addressed:

- LNG leakage and spill on the receiving ship, on the bunkering facility or on the LNG transfer system
- Gas detection
- Fire in the bunkering area (e.g. starting from the tank truck)
- Unexpected loosening of mooring lines
- Unexpected moving of the tank-truck
- Unexpected venting on the receiving ship or on the bunkering facility