

Guidelines for systems and installations for supply of LNG as fuel to ships

French title (not required)

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Foreword

OGP Draft 118683 was prepared by the OGP Interim Solution. OGP (International Association of Oil and Gas Producers) and ISO (International Organization for Standardization) have agreed this interim solution that responds to temporary industry uncertainties associated with trade regulations (EU and US) and their applicability to standardisation in the oil and gas sector. The interim solution will allow the continuation of the development of prioritised work items of ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

After publication of OGP Draft 118683, the ISO system will adopt this document to initiate the DTS ballot. For practical reasons, OGP Draft 118683 is cited as ISO/TS 18683 or this Technical Specification throughout the whole document and all references to ISO/TC 67 and ISO standards are maintained. This prevents that citations and references are converted back and forth each time this document is exchanged between the OGP Interim Solution and the ISO system with the risk of any errors that may occur.

There is an industry need to provide guidance for the equipment, systems, procedures and training for those parties engaged in the delivery of LNG as fuel to ships. Although there is some national experience in this activity, the intent of this Technical Specification is to help standardize the interface between the ship and the fuel supply facilities to ensure that a LNG fuelled ship can refuel in any port around the world with LNG fuel supply facilities. It is recognised that there is an urgency for this guidance to be in place and also that the solutions available are still at a relatively early stage of development and deployment. Accordingly this document has been issued for pre-standardization purposes with the intent to expand and update the document on a frequent basis as industry experience grows and to be developed into an ISO International Standard.

This document is being issued in the Technical Specification series of publications (according to the ISO/IEC Directives, Part 1, 3.1.1.1) as a “prospective standard for provisional application” in the field of systems and installations for supply of LNG as fuel to ships because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice can be gathered.

A review of this Technical Specification will be carried out not later than 3 years after its publication.

Introduction

The properties, characteristics and behaviour of LNG differ significantly from conventional marine fuels such as heavy fuel oils and distillate fuels as marine diesel oil (MDO) or marine gas oil (MGO).

For these reasons it is essential that all LNG bunkering operations are undertaken with diligence and due attention is paid to prevent leakage of LNG liquid or vapour and the control of sources of ignition. Therefore it is necessary that throughout the LNG bunkering chain each element is carefully designed, and has dedicated safety and operational procedures executed by trained personnel.

It is important that the basic requirements laid down in this Technical Specification are understood and applied to each operation in order to ensure the safe, secure and efficient transfer of LNG as a fuel to the ship.

The objective of this Technical Specification is to provide guidance for the planning and design of

- the bunkering facility,
- the ship/bunkering facility interface,
- procedures for connection and disconnection,
- the emergency shutdown interface, and
- the LNG bunkering process control,

and thereby ensuring that an LNG fuelled ship can refuel with a high level of safety, integrity and reliability regardless of the type of bunkering facility.

The LNG bunkering interface comprises 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.

This Technical Specification is based on the assumption that the receiving ships and LNG supply facilities are designed according to the relevant and applicable codes, regulations and guidelines such as the International Maritime Organization (IMO), the Society of International Gas Tankers and Terminal Operators (SIGTTO), the Oil Companies International Marine Forum (OCIMF) and other ISO, EN and NFPA standards during LNG bunkering. Relevant publications by these and other organizations are listed in the Bibliography.

It is not necessary that the provisions of this Technical Specification are applied retrospectively. It is recognized that national/local laws and regulations take precedence when they are in conflict with this Technical Specification.

Guidelines for systems and installations for supply of LNG as fuel to ships

1 Scope

This Technical Specification 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.

This Technical Specification provides requirements and recommendations for operator and crew competency, training, and the functional requirements for equipment necessary to ensure safe LNG bunkering operations of LNG fuelled ships.

This Technical Specification is applicable to bunkering of both seagoing and inland trading vessels. 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.

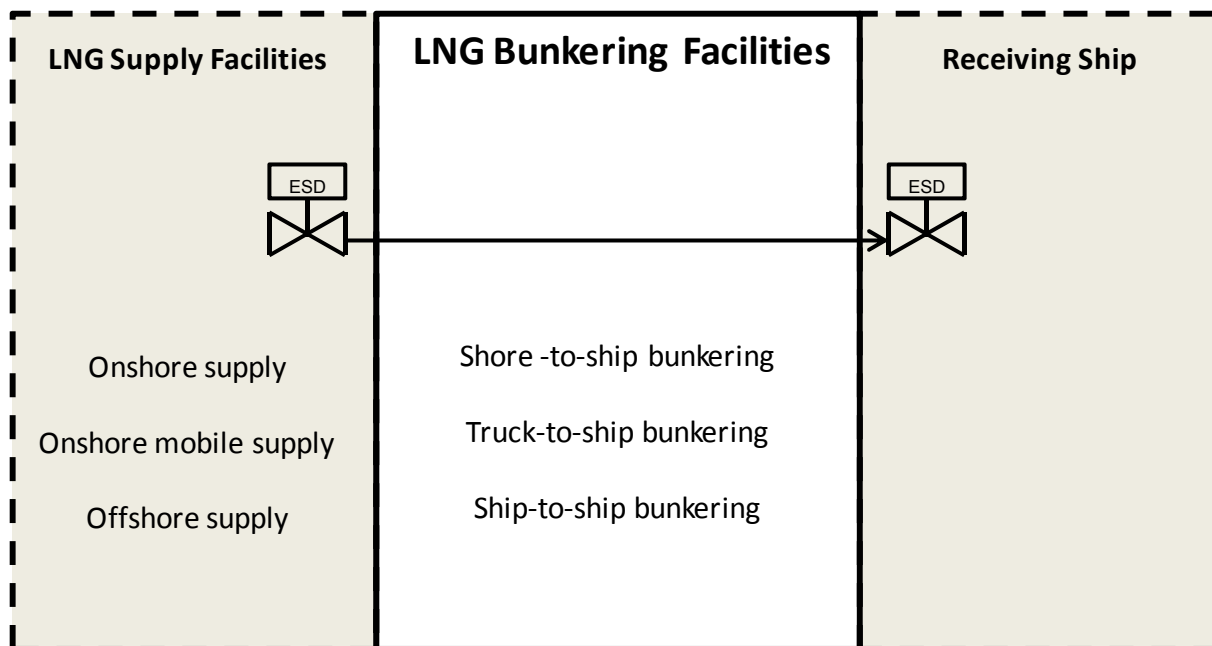


Figure 1 — Interfaces between bunkering facility and supply/receiving facilities

The use of containers, trailers or similar to load and store LNG to be used as fuel is not part of this Technical Specification.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC Guide 73, *Risk Management — Vocabulary*

ISO/TS 16901, *Guidance on performing risk assessments in the design of onshore LNG installations including the ship/shore interface*

ISO 16903, *Characteristics of LNG influencing design and material selection*

IMO IGF Code¹

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC Guide 73 and the following apply.

3.1.1

as low as reasonably practical

ALARP

reducing a risk to a level that represents the point, objectively assessed, at which the time, trouble, difficulty and cost of further reduction measures become unreasonably disproportionate to the additional risk reduction obtained

3.1.2

boiling liquid expanding vapour explosion

BLEVE

sudden release of the content of a vessel containing a pressurised flammable liquid followed by a fireball

Note 1 to entry: This hazard is not applicable to atmospheric LNG tanks, but to pressurised forms of hydrocarbon storage.

3.1.3

breakaway coupling

coupling which separates at a predetermined section when required and each separated section contains a self-closing shut-off valve, which seals automatically.

Note 1 to entry: A breakaway coupling can be activated automatically by excessive forces or through mechanical/hydraulic controls.

3.1.4

bunkering installation

pipework, process components, instrumentation and other hardware for the transfer of LNG from the supplier to the ship's manifold

3.1.5

consequence

outcome of an event

3.1.6

dry disconnect coupling

quick coupling which connects and disconnects with minimum LNG release and each separated section contains a self-closing shut-off valve, which seals automatically

3.1.7

emergency shut-down

ESD

method that safely and effectively stops the transfer of natural gas and vapour between the receiving ship and supply facilities

¹ The international code of safety for ships using gases or other low-flashpoint fuels is currently under development

3.1.8

hazard

potential source of harm

3.1.9

hazard identification

HAZID

brainstorming exercise using checklists where the potential hazards in a project are identified and gathered in a risk register for follow up in the project

3.1.13

impact assessment

assessment of how consequences (fires, explosions, etc.) do affect people, structures the environment, etc.

3.1.11

probability

extent to which an event is likely to occur

3.1.12

rapid phase transition

RPT

shock wave forces generated by instantaneous vaporization of LNG upon coming in contact with water.

3.1.13

risk

combination of the probability of occurrence of harm and the severity of that harm

3.1.14

risk analysis

systematic use of information to identify sources and to estimate the risk

3.1.15

risk assessment

overall process of risk analysis and risk evaluation

3.1.16

risk evaluation

procedure based on the risk analysis to determine whether the tolerable risk has been achieved

3.1.17

risk matrix

matrix portraying risk as the product of probability and consequence, used as the basis for risk determination

Note 1 to entry: Considerations for the assessment of probability are shown on the horizontal axis. Considerations for the assessment of consequence are shown on the vertical axis. Multiple consequence categories are included: impact on people, assets, environment and reputation. Plotting the intersection of the two considerations on the matrix provides an estimate of the risk.

3.1.18

risk ranking

outcome of a qualitative risk analysis with a numerical annotation of risk

Note 1 to entry: It allows accident scenarios and their risk to be ranked numerically so that the most severe risks are evident and can be addressed.

3.1.19

safety

freedom from unacceptable risk

3.1.20

safety zone

the area around the bunkering station where only dedicated and essential personnel and activities are allowed during bunkering

3.1.21

security zone

the area around the bunkering facility and ship where ship traffic and other activities are monitored (and controlled) to mitigate harmful effects..

3.1.22

stakeholder

any individual, group or organization that can affect, be affected by, or perceive itself to be affected by, a risk

3.1.23

tolerable risk

risk which is accepted in a given context based on the current values of society

3.1.24

topping up

final sequence of LNG transfer to ensure correct filling level in receiving tank

3.2 Abbreviated terms

AIS	automatic identification system
ALARP	as low as reasonably practical
BLEVE	boiling liquid expanding vapour explosion
ERC	emergency release coupling
ESD	emergency shut-down
ESDV	emergency shut-down valve
FMEA	failure mode and effects analysis
HAZID	hazard identification
HFO	heavy fuel oil
LNG	liquefied natural gas
NOTE	LNG is defined in EN 1160.
MGO	marine gas oil
MSDS	material safety data sheets
PPE	personal protective equipment
QA/QC	quality assurance/quality control
QC/DC	quick connect/disconnect coupling
QRA	quantitative risk assessment
RPT	rapid phase transition

TLV threshold limit values for chemicals

4 Bunkering scenarios

Selection of the bunkering configuration should reflect the following factors:

- a) the LNG bunkering volumes and transfer rates;
- b) the simultaneous transfer of other bunker fuels;
- c) possible interference with other activities in the port area;
- d) the transfer equipment;
- e) the type of receiving ship;
- f) met-ocean factors.

Three standard LNG bunkering scenarios have been considered in this Technical Specification; see also Figure 2. In the base case it is assumed that bunkering is carried out without simultaneous cargo operations and without passengers on board. In case of bunkering during cargo operations a quantitative risk assessment² shall be performed to address effects of the simultaneous operations.

Bunkering with passengers on-board requires acceptance by all parties (authorities, ship and bunkering operator and supplier) and shall be supported by a QRA².

These scenarios differ in the transfer equipment, the station keeping of both the discharging and receiving facilities and storage tanks:

- scenario 1: LNG bunkering via pipeline from onshore supply facilities permanently installed (“shore to ship LNG bunkering”);
- scenario 2: LNG bunkering from onshore trucks;
- scenario 3: LNG bunkering from offshore supply facilities (“ship to ship LNG bunkering”).

² The risk assessment addressing simultaneous operations and passengers shall be carried out as part of the planning and permitting process for the operation

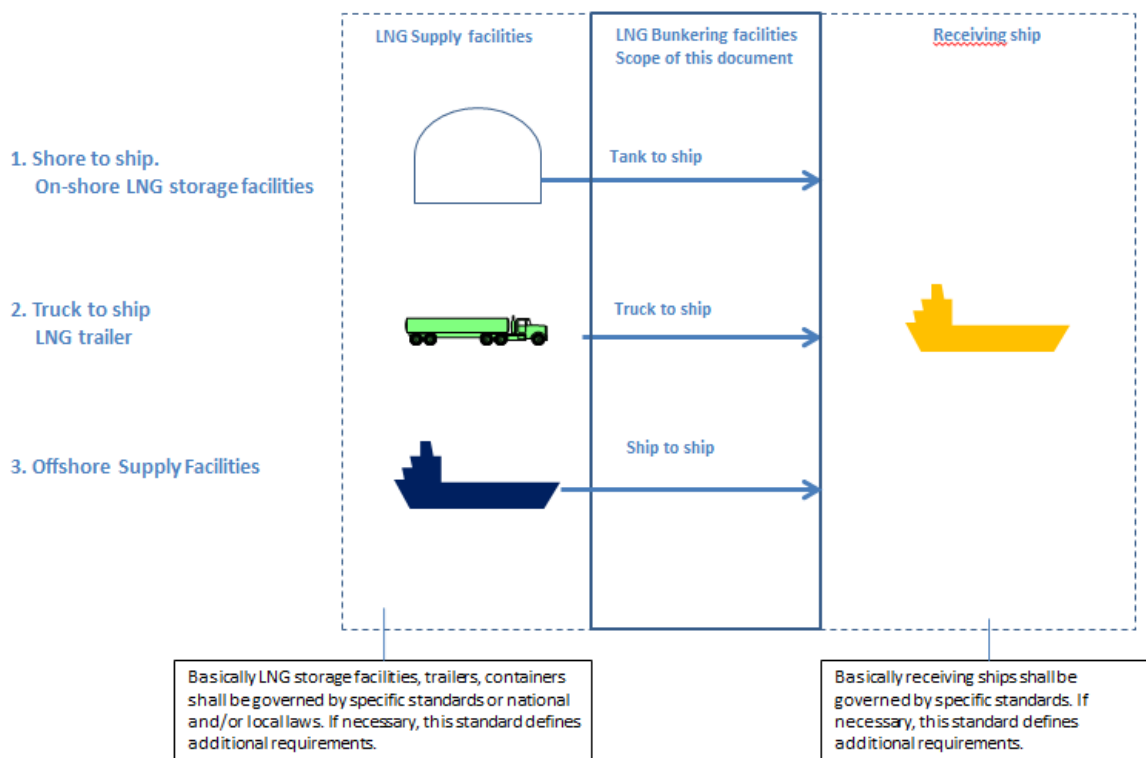


Figure 2 —Standard bunkering scenarios

5 Properties and behaviour of LNG

5.1 General

The properties, characteristics and behaviour of LNG differ significantly from conventional marine fuels such as heavy fuel oils (HFO) and distillate fuels as marine gas oil (MGO), etc. For these reasons it is essential that all LNG bunkering operations are undertaken with diligence and due attention is paid to prevent leakage of LNG liquid or vapour and sources of ignition in the vicinity of the bunkering operation are strictly controlled. Therefore it is necessary that throughout LNG bunkering chain each element is carefully designed, and has dedicated safety, operational and maintenance procedures executed by trained personnel.

5.2 Description and hazards of LNG

Description of LNG is fully covered in ISO 16903, but for the purposes of LNG bunkering the most important characteristics compared with marine gas fuel are described in this subclause.

At atmospheric pressure, depending upon composition, LNG boils at approximately $-160\text{ }^{\circ}\text{C}$. Released LNG will form a boiling pool at the ground where the evaporation rate (and vapour generation) depends on the heat transfer to the pool.

At this temperature, the vapour is denser than air, becoming lighter than air at approximately $-110\text{ }^{\circ}\text{C}$. Therefore a release of LNG will initially result in a flammable gas cloud that spreads by gravity in low lying areas until it warms and becomes buoyant. The cold natural gas can also be mixed with air and form a flammable cloud. In this case the flammable cloud will not become buoyant, but will drift with wind and be diluted by atmospheric turbulence and diffusion.

LNG for fuel supply may be delivered at elevated pressure and at a pressure exceeding the boiling point at atmospheric conditions (e.g., at 5 bar and at $-155\text{ }^{\circ}\text{C}$). Release of LNG under such conditions, will result in instantaneous flashing and a much higher vapour release and larger gas clouds.

LNG can cause brittle fracture if spilled on unprotected carbon steel. It has a flashpoint lower than any ambient temperature that can be encountered.

Natural gas has a flammable range between 5 % and 15 % when mixed with air.

Natural gas has a flashpoint of $-187\text{ }^{\circ}\text{C}$, and a self-ignition temperature of approximately $650\text{ }^{\circ}\text{C}$, compared with a flashpoint in excess of $60\text{ }^{\circ}\text{C}$ and a self-ignition temperature of $300\text{ }^{\circ}\text{C}$ for marine gas oil (MGO) or a gas oil vapour/aerosol air mixture.

Methane has a very high greenhouse gas potential and venting to the atmosphere shall not be part of normal operations.

Hazards associated with LNG are:

- fire, deflagration or confined explosion from ignited natural gas evaporating from spilled LNG;
- brittle fracture of the steel structure exposed to LNG spills;
- frostbite from liquid or cold vapour spills;
- asphyxiation from vapour release;
- over-pressure of transfer systems caused by thermal expansion or vaporisation of trapped LNG;

NOTE The thermal expansion coefficient of LNG is high.

- possible rapid phase transition caused by LNG spilled into water;
- possible BLEVE of a pressurized fuel tank subjected to a fire.

5.3 Potential hazardous situations associated with LNG transfer

The planning, design, and operation should focus on prevention of release of LNG and vapour, avoid occupational accidents related to the handling of equipment. The risk and hazards related to the LNG bunkering are closely linked to the potential rate of release in accidental situations, and factors such as transfer rates, inventories in hoses and piping, protective systems such as ESD and spill protection are essential.

5.4 Composition of LNG as a bunker fuel

The specification of the LNG supplied as fuel shall be agreed between the supplier and receiver, and documentation supplied.

6 Safety

6.1 Objectives

Safety shall be the primary objective for the planning, design and operation of facilities for the delivery of LNG as marine fuel taking into consideration simultaneous operations and the interaction with third parties.

The safety of the bunkering operation shall not be compromised by commercial requirements.

6.2 General safety principles

The planning, design, procurement, construction and operation should be implemented in quality, health, safety and environmental management systems.

6.3 Approach

The safety targets for the operation of the bunkering scenarios shall be demonstrated by meeting the requirements as defined in Clauses 8, 9, 10, and 11, and qualified by a risk assessment as outlined in Clause 7.

7 Risk assessment

7.1 General

The development of a bunkering facility shall be conducted with high focus on safety for personnel and normally comprises:

- definition of study basis;
- establishing safety distances for the operation;
- performing risk assessment of the operation;
- verification that design is in accordance with recognized standards and that agreed safeguards are implemented.

An assessment of risk to personnel and environment shall be carried out as a part of the development of the bunkering facility.

The risk assessment can also address risk for material loss, down-time and reputation as per operator's requirement.

The risk assessment shall be carried out in agreement with recognized standards, such as ISO 31010, ISO 17776 and ISO 16901.

The main steps in the risk assessment shall be to:

- a) identify what can go wrong (hazard identification);
- b) assess the effect (consequence and impact assessment);
- c) assess the likelihood (frequency assessment);
- d) decide if the risk tolerable, or identify risk reducing measures.

The risk analysis shall be carried out with a team ensuring an objective and independent assessment.

As a minimum a qualitative risk assessment shall be carried out as outlined in 7.2. This is the minimum requirement for bunkering installations complying with the defined standard bunkering scenarios in Clause 4 and meeting all requirements in Clauses 8 to 11.

For bunkering installations deviating from the standard bunkering scenarios defined in Clause 4 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 requirements for the quantitative risk assessment are outlined in 7.3. Bunkering with passengers on board also requires acceptance by all parties.

The schematic approach is illustrated in Figure 3.

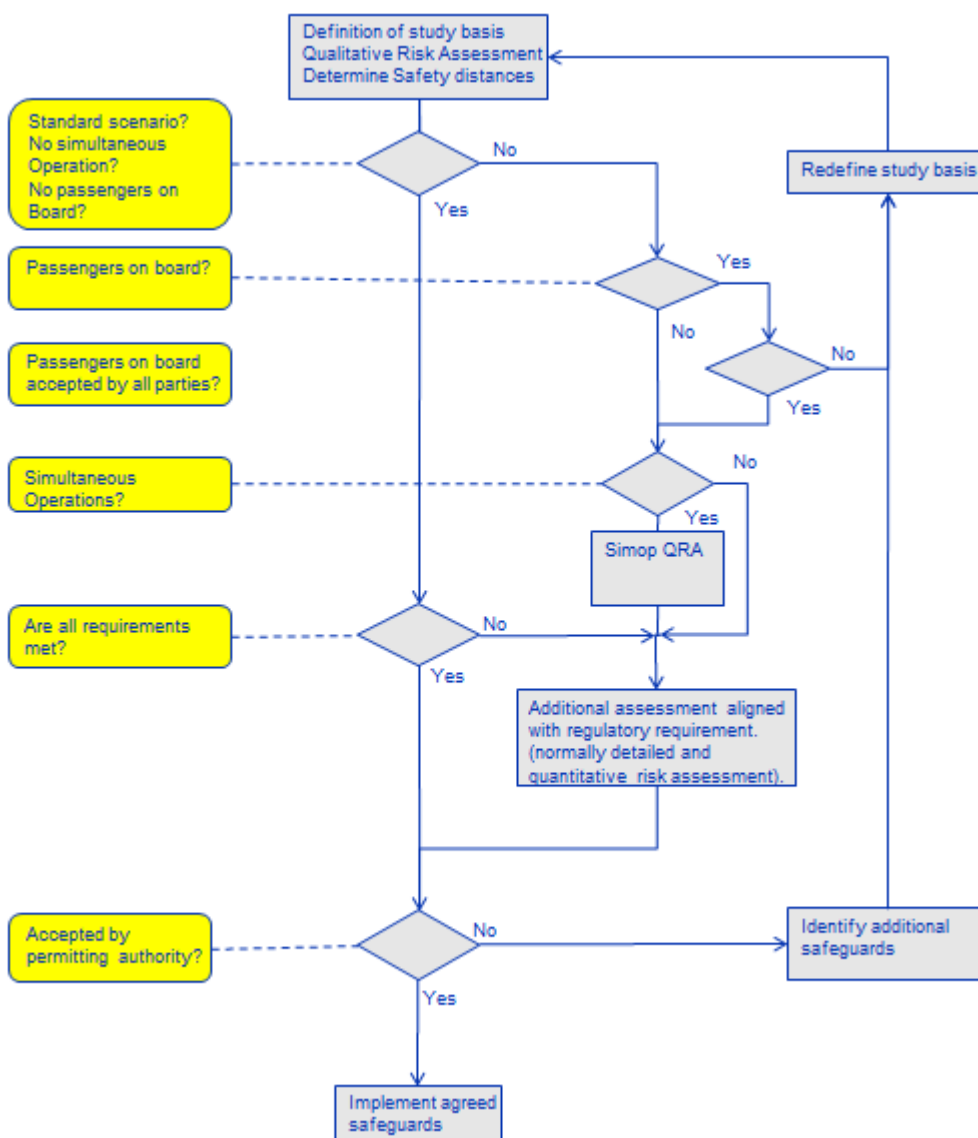


Figure 3 — Schematic approach of risk assessment

7.2 Qualitative risk assessment

7.2.1 Main steps

A qualitative risk assessment for a LNG bunkering facility and operation shall as a minimum comprise the following activities:

- a) Definition of study basis and familiarization with the design and planned operation of the bunkering facility.
- b) Calculation of dispersion distances to determine safety zones and security zones.
- c) A 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 both accidental and intentional spills and consider/identify technical and operational safeguards.
- d) Reporting.

The qualitative risk assessment shall consider all possible bunkering configurations reflecting the variety of ships to be bunkered.

7.2.2 Study basis

The basis for the qualitative risk assessment of the bunkering facility shall as a minimum comprise:

- a) description and layout of the bunkering installation;
- b) description of other simultaneous activities and stakeholders and third parties in the area;
- c) description of all systems, components with regard to function, design, and operational procedures and relevant operational experience;
- d) description of operations and operational limitations;
- e) organization of the bunkering activities with clear definitions of roles and responsibilities for the ship crew and bunkering personnel;
- f) identification of authority stakeholders;
- g) 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.

Important issues that are not defined in the available documentation shall be recorded as assumptions (with a description of the rationale) and be reflected in the operational plans.

The risk assessment team shall familiarise with the study basis through

- document review, interviews with key personnel; and
- by actively involving personnel with key knowledge of the design and operation in the risk workshop to provide required information.

A summary of the study basis with additional assumptions shall be recorded and incorporated as a part of the risk assessment report.

7.2.3 HAZID

7.2.3.1 General

The HAZID (hazard identification) is the core of the qualitative risk assessment. The HAZID shall be carried out as a work-shop reviewing the possible hazardous events that can occur, based on previous accident experience and judgment. A well planned and comprehensive HAZID is the critical and important basis for the risk assessment process.

The HAZID technique is a:

- 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;
- rapid identification and description process only.

7.2.3.2 HAZID team

The HAZID study is carried out by a team representing different disciplines, knowing the facility and is familiar with the HAZID process. The HAZID team shall involve a facilitator supported by experienced representatives from different disciplines. The following disciplines shall be represented:

- a) LNG operational experience;
- b) marine expertise;
- c) bunkering experience;
- d) local knowledge;
- e) other specialist should be available “on call”;
- f) 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.

7.2.3.3 HAZID workshop

7.2.3.3.1 Workshop methodology

The HAZID workshop shall systematically review all elements of the system and all operational sequences with the aim to

- Identify potentially hazardous events.
- Assess of 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 to be considered to be applied.
- Identify hazards and safeguards that need to be followed up later in the project.
- Identify maximum credible accidental release, (i.e. release scenarios that that shall be the basis for definition of the safety zones.
- Identify need for PPE for the personnel involved in the operation.

7.2.3.3.2 Hazardous events

The HAZID shall as a minimum consider the following hazardous events:

- a) LNG releases:
 - 1) failure of QC/DC or ERC equipment;
 - 2) hose or loading arm failure due to:
 - design flaws;
 - excessive loads due to dropped objects or collision and impacts from ships or trucks;
 - ships mooring failure;

- 3) pressure surge in transfer lines;
 - 4) releases from piping systems;
 - 5) incorrectly planned or performed maintenance;
 - 6) incorrect operational procedures including:
 - cooling down;
 - connection;
 - 7) over-filling and over-pressurization of ships bunker tanks (e.g. by flashing, incorrect bunker rate or bunkering procedure);
 - 8) over-pressure of transfer systems caused by thermal expansion or vaporization of trapped LNG;
 - 9) possible rollover in bunker tanks caused by loading LNG of different densities.
- b) Ignition sources:
- 1) electrical hazards;
 - 2) other ignition sources;
 - 3) activities inside the safety zone;
 - 4) gas dispersion beyond the safety zone.
- c) Release of nitrogen, asphyxiation.

7.2.3.3.3 Hazardous effects

Hazardous effects following the initial events shall be considered. These shall include:

- a) Fire hazards:
- 1) structural failure and escalation due to high temperatures;
 - 2) injuries to personnel;
 - 3) damage to equipment;
 - 4) ignition of secondary fires;
 - 5) potential BLEVE of pressurized fuel tank subjected to a fire.
- b) Possible vapour cloud deflagration/flash fires:
- 1) damage to equipment and escalation;
 - 2) injury to personnel;
 - 3) damage to fire-fighting equipment and safeguards.
- c) Cryogenic hazards:
- 1) structural failures incl. brittle fracture of the steel structure exposed to LNG spills;

- 2) frostbite or asphyxiation from liquid or cold vapour spills;
- 3) possible rapid phase transition caused by LNG spilled into water.

7.2.3.3.4 Action plan

The HAZID shall produce a list of hazards, ranked with respect to consequence and likelihood, recommendations for risk reducing measures and an action plan for follow up.

Safeguards to be considered in the HAZID should as a minimum include:

- 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.

The action plan addresses each recommendation developed along the HAZID meeting and shall be tracked for its assessment and implementation.

7.2.3.3.5 Workshop 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.

7.2.3.4 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 (see 7.3). 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.

The risk matrix as shown in Annex A shall be used unless the authorities/ operator has agreed to select other risk matrix.

The risk analysis shall primarily be carried out with respect to consequences for people, but operator/ authorities can require that risk to assets, environment and reputation shall also be addressed.

The risk matrix should reflect the company, national and international regulations and practices.

7.2.4 Determination of safety zones

A safety zone shall be established around the bunkering station/facilities 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.

The minimum safety zone shall be defined as the area around the bunkering facilities where the likelihood of flammable mixtures due to LNG or natural gas releases from the bunkering exceeds 10^{-6} per bunkering operation (or criteria agreed with authorities).

This requires a probabilistic assessment of all release scenarios and can require extensive analyses.

A simpler and more direct approach is to conservatively determine the safety distances based on the dispersion of gas from a maximum credible release of LNG or natural gas.

The release scenario to be considered should be identified in the HAZID reflecting the project specific factors such as:

- transfer rates and inventory in the bunkering facilities;
- operational modes;
- implemented safeguards;
- properties of the LNG in the bunkering system (temperature, pressure).

The process of determining safety distances is described Annex B.

7.2.5 Determination of security zones

A security zone shall be minimised based on the findings from the HAZID in order to:

- a) Monitor and control external activities e.g. ship movements, that can lead to incidents threatening the operation.
- b) Identify areas where accidental effects for personnel can occur. As a result this may limit access for personnel, and/or specific actions in the emergency response plan.

7.2.6 Reporting

The HAZID and the qualitative risk assessment shall be documented in a report that as a minimum describe:

- a) the study basis including description of design, operations and assumptions being made;
- b) description of the working process incl. 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.

7.3 Quantitative risk assessment

7.3.1 Main steps

In cases where the bunkering scenario deviates from the standard scenarios defined in Clause 4, or where all requirements as specified in Clauses 8 to 11 cannot be met, deviations should be assessed as agreed with authorities. Normally this requires a comprehensive quantitative risk assessment to:

- a) confirm safety zones;
- b) demonstrate that overall safety targets are met;
- c) evaluate and select safeguards and risk reducing measures.

Risk is defined in ISO 17776 as combination of the probability of an event and the consequences of the event. To be able to demonstrate that numeric acceptance criteria are met, it is necessary to express the risk in numerical terms, i.e. the consequences and their associated probability shall be determined.

The first part of the risk assessment is similar to the qualitative risk assessment, i.e. to establish study basis and perform a HAZID to identify and screen potential hazardous situations.

The different steps in the risk assessment are described in ISO 16901. Particular concerns related to LNG bunkering are described in this subclause.

7.3.2 Establish study basis

The study basis as defined in 7.2.2 shall be elaborated.

The safety acceptance criteria as indicated in the risk matrix shall be expanded to provide guidance on the limits for acceptability of risk to personnel and numerical acceptance criteria for risk shall be established for risk to personnel and environment.

The acceptance criteria shall be defined for the project in agreement with authority requirements and be derived from risks normally accepted in the society for first, second and third party personnel.

The risk acceptance criteria shall as a minimum meet the requirements given in Annex A unless the owner and/regulator requires other criteria.

In addition it is recommended that the ALARP principle is adopted. This implies that the risk shall be reduced to a level which is as low as reasonably practicable and this involves balancing reduction in risk against the time, trouble, and difficulty.

The study basis shall be specific with regards to additional safeguards that shall be implemented to compensate for not meeting all functional requirements. Physical barriers shall be given more credit compared to operational measures.

7.3.3 HAZID

The initial HAZID as described in 7.2.3 shall be revisited with particular focus on differentiation between minor events (e.g., leaks with small direct impact, but potential for escalation) and major failures.

Further, the HAZID shall assess the effects of safeguards to arrest escalation and the possible chain of events.

The HAZID report shall include a list of medium and high risk hazard that shall be analysed numerically.

7.3.4 Quantitative risk assessment

7.3.4.1 General

The risk arising from the identified hazards shall be analysed with regard to consequence and frequency. The risk assessment shall be based on normal and accepted qualitative and quantitative risk assessment techniques as given in ISO 31010, ISO 17776 and ISO 16901.

7.3.4.2 Consequence modelling

The consequence modelling evaluates the resulting effects if the accidents occur, and their impact on personnel, equipment and structures, the environment or business.

The consequence assessment shall be carried out using recognized consequence modelling tools capable of determining the impact and effects of the identified hazards:

- fire radiation contours;
- blast pressure contours;
- dispersion contours.

These results are compared to the impact criteria recognized by the authorities and used in practice by the industries (e.g. fire radiation with or without escape and shelter).

7.3.5 Frequency analysis

The frequency analysis estimates how likely it is for the accidents to occur. The frequencies are based on equipment counts and frequencies of the different operation combined with experience data for incidents and component failure. In the absence of experience data information from comparable operations or equipment can be used supplemented by theoretical modelling.

7.3.6 Risk assessment

When the frequencies and consequences of each modelled event have been estimated, they shall be combined to measure the overall risk. Generally the risk is expressed in:

- Individual risk: the risk experienced by an individual person.
- Group (or societal) risk: the risk experienced by the whole group of people exposed to the hazard.

Risk and dispersion contours provide guidance for the determination of safety zones and exclusion zones.

The estimated risk shall be compared with the criteria, it is judged whether the operation meets the criteria and also to assess if risk reducing measures are required. This should encompass exclusion zones for non-essential crew, passengers, need for PPE.

7.3.7 QRA report

The risk assessment shall be documented and all data, methodologies and model assumptions shall be listed.

The level of detail in the report shall ensure that:

- a) the analysis can be reproduced in order to assess sensitivities, future modifications in response to requests from operator or authorities;
- b) study assumptions, operational safety measures, and key findings can be implemented in operational procedures, training programs and emergency plans.

The QRA report shall be submitted to authorities as part of the permitting documentation.

8 Functional requirements for LNG bunkering system

8.1 General

The functional requirements for LNG bunkering facilities and operations have been formulated based on the assumption that international recognized standards and good engineering practices for LNG facilities are adopted and met both for the shore and the ship-systems. A condensed check list has been included in Annex C Annex C as a guide for the planning of the operation. The functional requirements are numbered as [Fx] for easy cross-referencing in the checklist of Annex C Annex C. The contents of the checklist in Annex C should be adapted to reflect the bunkering scenario.

8.2 Design and operation basis

The bunkering system shall be designed and operated to ensure safe delivery of the required quantity of LNG at a given rate, taking into account:

- a) interface between ship and supplier;
- b) tank pressure control and boil off gas management;

NOTE Boil off gas may or may not be returned to the supplier.

- c) transfer rate;
- d) duration of the operation;
- e) pressure and temperature in bunkering facilities;
- f) acceptable safety zones and possible limitations in port activities;
- g) regulatory requirements;
- h) environmental conditions.

These factors shall be documented by the developer to serve as a basis for the design and operation and as part of the documentation for the permitting process.

The bunkering operations shall be conducted under the control of a recognised safety management system as a minimum.

8.3 Compatibility between supplier and ship

[F1] The compatibility between supplier and ship shall be checked and documented prior to bunkering operations. This check shall address:

- a) agreement on quantity and properties of supplied LNG (see Annex E and **Error! Reference source not found.**)
- b) safe and effective mooring/immobilising of the trucks;
- c) compatibility of ESD and communication systems;
- d) compatibility of manifold flanges (see Annex F);
- e) operational envelope;

- f) compatibility of hazardous zoning and ventilation;
- g) spill protection systems;
- h) compatibility of safety management systems.

The compatibility check shall be signed off by both parties prior to the operation (see 8.5.2 h)).

8.4 Prevention of releases of LNG or natural gas to the atmosphere

The system shall be designed and operated to prevent release of LNG or natural gas. This can lead to hazardous situations that can threaten safety of life, property or the environment. Further, the system shall be designed such that release due to accidents or abnormal conditions is minimized.

[F2] The system is arranged so that the system can be commissioned, decommissioned and operated (purged and inerted) without release of LNG or natural gas to the atmosphere. Operating procedures for these operations shall be established.

[F3] LNG transfer shall be carried out in closed systems where the components are connected and leak tested before LNG transfer is started.

8.5 Safety

8.5.1 General

In order to ensure that the bunkering operation can be conducted in a safe way the following minimum requirements in Clause 8 shall be met. These requirements form three layers of defence:

- a) Requirements for operations, systems and components aiming at prevention of accidental LNG or natural gas releases that could develop into hazardous situations.
- b) Requirements to contain and control hazardous situations in the case that a release occurs and thereby prevent/minimize the harmful effects.
- c) Establish emergency preparedness procedures and plans to minimize consequences and harmful effects in situations that are not contained by the second layer of defence.

8.5.2 Functional requirements to reduce risk of accidental release of LNG and natural gas

The functional requirements to reduce the risk of accidental release of LNG and natural gas include that:

- a) [F4] The design shall reflect operating temperature and pressure and shall be in accordance with recognized standards.
- b) [F5] The design shall reflect the required operational envelope (motions, weather, and visibility).
- c) [F6] The transfer system shall be capable of being drained, de-pressurised and inerted before connections and disconnections are made.
- d) [F7] The bunkering transfer system shall be designed to avoid liquid lock (trapped liquids).
- e) [F8] Operating procedures shall be established and documented to define the bunkering process, and ensure that components and systems are operated in a safe way within their design parameters during all operational phases such as:
 - 1) preparations for bunkering;
 - 2) use of personal protective equipment (PPE);

- 3) monitoring and control of ship traffic and other activities within the security zone to that can influence the bunkering process. This shall be aligned with regulatory requirements.
 - 4) equipment and procedures for safe mooring;
 - 5) connection and inerting/purging;
 - 6) avoid the release of inert gas representing a risk for asphyxiation
 - 7) cool down/testing;
 - 8) monitoring of the operation;
 - 9) transfer;
 - 10) topping up and shutdown;
 - 11) draining/purging/inerting;
 - 12) disconnect;
 - 13) storage and handling of components.
- f) [F9] All systems and components shall be maintained and tested according to, as a minimum, vendor recommendation to maintain their integrity.
 - g) [F10] An organizational plan shall be prepared and implemented in operational plans and reflected in qualification requirements. The plan shall describe:
 - 1) organisation;
 - 2) roles and responsibilities for the ship crew and bunkering personnel;
 - 3) communication lines and language for communication.
 - h) [F11] Operating procedures shall include a checklist to be completed and signed by both parties prior to the commencement of bunkering (see Annex D).
 - i) [F12] Emergency equipment and personnel shall be mobilized in accordance with the emergency response plan described in 8.5.4.
 - j) [F13] Operating procedures shall not be applied as an alternative to a particular fitting, material or item of equipment.

8.5.3 Requirements to contain hazardous situations

In the case that a hazardous situation occurs appropriate safeguards shall be implemented in order to detect that a release has occurred, reduce immediate consequences and prevent escalation. These safeguards vary, but shall at least comprise:

- a) [F14] Prevention of ignition of potential LNG or natural gas releases. This is accomplished by elimination of ignition sources in classified areas and by controlling activities in the safety zone for the bunkering operation.
- b) [F15] Elimination of the potential spark or high currents from static or galvanic cells when the bunkering system is connected or disconnected (see API 2003).
- c) [F16] Effective detection of release of LNG and natural gas.

- d) [F17] The transfer operation shall be capable of being stopped safely and effectively without release of liquid or vapour, either manually or automatically by an ESD signal. The ESD signal shall be transmitted both to the ship and to the supplier to ensure that appropriate actions are taken both on the bunkering system as well as on the receiving ship. The ESD system shall be appropriate for the size and type of facility and shall be activated by some or all of the following:
- 1) gas detection;
 - 2) fire detection;
 - 3) manual activation from ship and facility;
 - 4) ship drift/movement of supply vehicle;
 - 5) power failure;
 - 6) high level in receiving tank;
 - 7) abnormal pressure in transfer system.
- e) [F18]] The transfer system shall be capable of being disconnected rapidly to minimise damage to the transfer system in case of ships drift or vehicle movement. Therefore, the transfer system shall be equipped with an ERS (emergency release system) or breakaway coupling, or similar protective device. These should be designed to prevent damage to the components, spark generation and minimum release of LNG, if activated. The ERS may be linked to the ESD system where this may be referred to as ESD 2.
- f) [F19] The release of LNG or cold vapour should not lead to an escalation due to brittle fractures of steel structure. Arrangements shall be installed as required on bunkering facilities to collect and contain spills and thermal insulation or water sprays to protect structure. The ships bunkering station shall be protected against cryogenic spills according to the IGF code.
- g) [F20] Personnel shall use PPE (personnel protective equipment) as appropriate for the operations. The need for PPE shall be addressed as part of the HAZID (see 7.2.3).
- h) [F21] A safety zone shall be implemented around the bunkering operation into which only essential personnel shall have access (see **Error! Reference source not found.**).

[F22] A security zone shall be established around the bunkering facility based on the risk assessment and aligned with authority requirements. Activities in this area shall be monitored and controlled to reduce possible ignition sources and avoid collisions, impacts or other harmful effects on the bunkering operation.

8.5.4 Emergency preparedness

[F8.5.423] A contingency plan shall be in place outlining the requirements for:

- a) evacuation of personnel and third parties;
- b) mobilising fire-fighting;
- c) mobilising first aid, hospitals and ambulances;
- d) communication to authorities and third parties

[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. Key information from this plan related to access, evacuation, and ignition minimisation shall be communicated.

9 Requirements to components and systems

9.1 General

All systems and components shall be designed, manufactured, tested and installed in accordance with a recognized standard and applicable national regulations, and should be in accordance with a recognized quality management system.

Table 1 and Table 2 give an overview of relevant standards.

In the absence of recognized standard a recognized qualification program shall be adopted.

A quality management system should be applied to the following phases:

- a) organisation;
- b) design and procurement;
- c) equipment, shop manufacture;
- d) equipment, storage and transport;
- e) construction.

A specific quality control programme including inspection and tests as outlined in 9.2 shall be set up to monitor the quality throughout the different phases of the design, fabrication and construction.

9.2 Available standards for relevant components

Table 1 gives an overview of applicable standards to components of LNG bunkering transfer system related to onshore installations. Equivalent standards may be used.

Table 1 — Applicable standards to components of LNG bunkering transfer system related to onshore installations

Component	Function	Design	Qualification test	Tests	
Coupling	F3 – F8	Connection to ship's manifold	EN 1474-1, Clause 6	EN 1474-1, 8.2.3	EN 1474-1, 8.4.4
Hoses	F2	Transfer of LNG and natural gas	Offshore standards can be used for guidance (EN 1474- 2)	See ^a	
			EN 12434		
			BS 4089		
Swivel joints	F2	Product line articulation	EN 1474-1, 4.3	New design qualification	EN 1474-1, 8.4.1
Bearing	F2	Articulation of support structure	ISO 28460 – EN 1474-1, 4.4	ISO 28460 – EN 1474-1	EN 1474-1, 8.4.2
ERS	F17	Emergency disconnect	ISO 28460 – EN 1474-1, 5.5.2	ISO 28460 – EN 1474-1, 8.2.2	EN 1474-1, 8.4.3
Breakaway coupling	F17	Emergency disconnect	EN 1474-1, 5.5.2	EN 1474-1, 8.2.2	EN 1474-1, 8.4.3
Loading arms	F2	Loading system	ISO 28460 – EN 1474-1, Clause 4	N/A	ISO 28460 – EN 1474-1, 8.4.7
Transfer system	F2, F3, F4, F8, F9, F17, F18	LNG bunkering loading solution	ISO 28460	EN 1474-3	ISO 28460 – EN 1474-1
			EN 1160		
			EN1474-1		
			OCIMF Mooring Equipment Guidelines		
			IEC 60079		
			IGF Code		
			NFPA 70		
			NFPA 58		
			NFPA 59A		
			EN 13465		
			API 2003		
ISO/TS 16901					

^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 will be valid for the configurations covered by the agreed envelope only.

Table 4 gives an overview of applicable standards to components of LNG bunkering transfer system related to side by side installations. Equivalent standards may be used.

Table 2 — Applicable standards to components of LNG bunkering transfer system related to side by side installations

Component	Function		Design	Qualification test	Tests
Coupling	F3 – F8	Connection to ship's manifold	EN 1474-1, 6.9		
Hoses	F2	Transfer of LNG and natural gas	EN 1474-2	See ^a	
			EN 12434		
			BS 4089		
Swivel joints	F2	Product line articulation	EN 1474-3, 6.8	New design qualification	EN 1474-1, 8.4.1
Bearing	F2	Articulation of support structure	EN 1474-3, 6.8	ISO 28460 – EN 1474-1	EN 1474-1, 8.4.2
ERS	F17	Emergency disconnect	EN 1474-3, 6.9 and 7.5	ISO 28460 – EN 1474-1, 8.2.2	EN 1474-1, 8.4.3
Breakaway coupling	F17	Emergency disconnect	EN 1474-3, 6.9	EN 1474-1, 8.2.2	EN 1474-1, 8.4.3
Loading arms	F2	Loading system	EN 1474-3, Clause 6 and Clause 8	EN 1474-3, Clause 5	ISO 28460 – EN 1474-1, 8.4.7
Transfer system	F2, F3, F4, F8, F9, F17, F18	LNG bunkering loading solution	EN 1474-3, Clause 6 and Clause 8	EN 1474-3, Clause 5	ISO 28460 – EN 1474-1
			ISO 28460		
			EN 1160		
			EN 1474-1		
			OCIMF Mooring Equipment Guidelines		
			IEC 60079		
			IGC\IGF Code		
			NFPA 70		
			NFPA 58		
			NFPA 59A		
			EN 13465		
			API 2003		
ISO/TS 16901					
IEC 60092-502					

^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.

9.3 Presentation flange and connection

The bunkering system shall be designed to connect to a standard ANSI flange on which a counterpart coupler or spool piece can be fitted.

The location of the rapid disconnection device (break away couplings, ERS, or similar device(s)) shall not cause damage to the ship or bunkering facility.

Examples are shown in Annex F and Annex G.

10 Training

All personnel involved in LNG bunkering operations shall be adequately trained. Such training shall be appropriate for the purpose and a record of training shall be maintained.

Training shall be structured in accordance with written programmes, including such methods and media of delivery, procedures, assessment and course material as are necessary to achieve the required standard of competence.

Training schemes should be independently verified at least every five years to secure that they fulfil the requirements set out below. Training according to other, recognized, standards may be taken as equivalent to those outlined here as long as they fulfil the minimum requirements below.

Training shall be conducted by persons appropriately qualified and experienced.

If training or assessment is being carried out in the workplace this shall only be permitted if such training or assessment does not adversely affect normal operation, and time and attention can be safely dedicated to training or assessment.

Training for all personnel involved in the bunker operation shall as a minimum cover:

- a) properties and hazards of LNG relevant to the LNG bunkering operations;
- b) potential effects of mixing LNG with different properties;
- c) risk reducing measures;
- d) international or national regulations and guidelines regarding LNG fuel transfer operations;
- e) first aid specific to frost-bite and asphyxiation;
- f) safe operation of LNG fuel transfer equipment;
- g) procedures to be followed during normal LNG bunkering operations:
 - 1) pre-transfer procedures, tests and checks;
 - 2) safe connection procedure;
 - 3) checks and procedures during LNG bunkering operations,
 - 4) safe disconnection procedure;
 - 5) LNG fuel quantity and properties confirmation;
 - 6) management of operations other than LNG fuel transfer that can occur simultaneously with that transfer;
 - 7) routine maintenance and testing procedures;

- 8) all other procedures applied for the specific operation.
- h) understanding of non-standard operations and emergencies during LNG bunkering operations:
 - 1) immediate action to be taken in response to emergency situations that can occur during LNG fuel transfer operations including liquid and/or vapour leakage, fire, or emergency breakaway;
 - 2) management of vapour and/or liquid leaks to minimise risk to personnel and assets due to cryogenic temperatures and flammable atmospheres;
 - 3) emergency response plans.

11 Requirements for documentation

11.1 General

The goal of this Clause is to provide guidance on the documentation requirements associated with the bunkering facility (as defined in Clause 1) from design through to operation and maintenance.

11.2 Compliance statements

The compliance of design and installation of components/systems with applicable standards shall be documented by certificate and/or qualification records.

11.3 Design, fabrication and commissioning documentation

The design, fabrication and commissioning of the bunkering facility shall be documented in order to be able to safely operate and maintain the bunkering facility.

At a minimum, design and testing documentation for the bunkering facility should capture:

- a) the design basis consisting of criteria, parameters, assumptions and specifications associated with the components, materials, joining, fabrication, testing, commissioning and protection of the bunkering facility;
- b) the safety philosophy for the bunkering facility and its integration with those of the LNG supply facility and receiving ship;
- c) instructions and procedures prepared for the procurement, fabrication, installation, testing, commissioning, operation and maintenance of the bunkering facility;
- d) risk assessments undertaken during the design phase.

At a minimum, fabrication documentation for the bunkering facility should capture:

- a) conditions under which the fabrication was performed;
- b) QA/QC process and practices followed;
- c) associated testing (of materials, joining, integrity, etc.).

At a minimum, commissioning documentation for the bunkering facility should capture:

- a) conditions under which the commissioning was performed;
- b) QA/QC process and practices followed;

- c) results of the commissioning process and procedure and their alignment with specified requirements, specifications, parameters, and criteria.

11.4 Operational documentation

Documentation covering the operation of bunkering systems shall be prepared by the responsible parties. Such documentation shall be kept current and readily accessible to operating and maintenance personnel requiring them.

Bunkering facilities shall be operated in accordance with documented procedures that meet the requirements of applicable codes and regulations. The operators of the LNG supply facility and receiving ship shall incorporate, into their respective operational plans, practices and procedures for the safe and reliable operation of the bunkering facility. At a minimum, this operational plan should document:

- a) how the bunkering facility is to be operated within its design parameter;
- b) how the operation of the bunkering facility is integrated with the operation of the LNG supply facility and the receiving ship; and
- c) what operational records are necessary in order to be able to demonstrate the proper administration of operational plans;
- d) procedures and checklists for safe connection before start of transfer;
- e) procedures and checklists for safe disconnection and completion.
- f) emergency response plan.

11.5 Maintenance documentation

Documentation covering the maintenance of bunkering systems shall be prepared. Such documentation shall be kept current and readily accessible to relevant parties

Bunkering facilities shall be maintained in accordance with documented procedures that meet the requirements of applicable codes and regulations. The operator of the bunkering facility shall incorporate maintenance practices and procedures into its maintenance plans for the LNG supply facility for the continued safe and reliable operation of the bunkering facility. The maintenance plans for the bunkering facility should document:

- a) the maintenance activities that are to be performed on the bunkering facility in order to meet the requirements of applicable codes, standards and manufacturer's recommendations;
- b) what maintenance records are necessary in order to be able to demonstrate the proper administration of maintenance plans.

11.6 Emergency response documentation

Referring to functional requirement [F23], the operator of a LNG supply facility shall establish emergency response documentation that includes at a minimum:

- a) procedures for the safe control, shutdown or ESD of the bunkering facility in the event of an emergency at the LNG supply facility, on the receiving ship or with the bunkering facility;
- b) how the safe control, shutdown or ESD of the bunkering facility in the event of an emergency is integrated with the operator's overall emergency response documentation for the LNG supply facility.

The operator of a receiving ship shall establish emergency response documentation that includes at a minimum how the safe control, shutdown or ESD of the bunkering facility in the event of an emergency is integrated with the operator's overall emergency response documentation for the receiving ship.

11.7 Training documentation

The operator of the LNG bunkering facility and the receiving ship shall provide appropriate training of personnel who are responsible for the operation, maintenance, safety and emergency response associated with the bunkering facility to ensure that such personnel are adequately knowledgeable of such matters.) Documentation of the provided training and qualification of personnel shall be prepared and retained.

11.8 Delivery documentation of LNG properties and quantity

The supplier shall be prepared to provide documentation describing the properties and quantity of LNG fuel to be transferred (see **Error! Reference source not found.**).

Such documentation shall include:

- a) method used to determine the properties and quantity of the LNG transferred;
- b) certification associated with the measurement equipment or methodology used to determine transfer properties and quantity of LNG.

11.9 Retention of documentation

All technical, engineering, operational, maintenance and training documentation associated with the requirements of Clause 10 shall be prepared and retained for the life of the bunkering facility, or longer as appropriate. Other documentation, such as business transactional documents, is to be retained for a period determined by the operators of the LNG supply facility and the receiving ship. Bunkering notes shall be kept for 3 years as a minimum.

Annex A (normative)

Risk acceptance criteria

Risk acceptance criteria for qualitative risk assessment are normally presented as a risk matrix.

The risk matrix as shown in Figure A.1 shall be used unless the authorities/ operator have selected another risk matrix.

The risk analysis shall primarily be carried out with respect to consequences for people, but operator/ authorities can require that risk to assets, environment and reputation shall also be addressed.

Severity rating	Consequence				Increasing probability			
	People	Assets	Environment	Reputation	A	B	C	D
					Has occurred in E&P industry	Has occurred in operating company	Occurred several times a year in operating company	Occurred several times a year in location
0	Zero injury	Zero damage	Zero effect	Zero impact	Manage for continued improvement			
1	Slight injury	Slight damage	Slight effect	Slight impact				
2	Minor injury	Minor damage	Minor effect	Limited impact				
3	Major injury	Local damage	Local effect	Considerable impact	Incorporate risk-reducing measures		Fail to meet screening criteria	
4	Single fatality	Major damage	Major effect	Major national impact				
5	Multiple fatalities	Extensive damage	Massive effect	Major international impact				

Figure A.1 — Example of a risk matrix (source: Table A.1 of ISO 17776:2000)

Risk acceptance criteria for quantitative risk assessment of risk to personnel are normally expressed as annual individual risk (AIR) for the different groups of personnel exposed to the risk.

Acceptance criteria for risk being used by authorities adopting a risk based approach are summarised in Table A.1. These or other criteria as agreed between authorities and operator shall be used:

- when authorities require a quantitative risk assessment;
- to assess the acceptance of non-standard scenarios;
- to assess deviations from the functional requirements.

Table A.1 — Risk acceptance criteria

	Acceptance criteria	Comment
Individual risk 1 st party personnel	AIR < 10 ⁻⁵	Applies to crew and bunkering personnel
Individual risk 2 nd party personnel	AIR < 5 · 10 ⁻⁶	Port personnel
Individual risk 3 rd party personnel	AIR < 10 ⁻⁶	General public without involvement in the activity

Annex B (informative)

Determination of safety zones

A safety zone is required to be established around the bunkering station/facilities 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. This annex provides guidance on the determination of safety zones.

The minimum safety zone should be defined as the area around the bunkering facilities where the likelihood of flammable mixtures due to LNG or natural gas releases from the bunkering exceeds 10^{-6} per bunkering (or criteria agreed with authorities).

This requires a probabilistic assessment of all release scenarios from all equipment in the bunkering installation (piping, valves, connectors, arms, hoses etc.) and all operations. Normally this encompasses a Monte Carlo simulation assessing:

- the likelihood of the different release scenarios reflecting empirical failure data;
- outflow conditions;
- evaporation/flashing of LNG reflecting LNG properties, and heat transfer from ground/water;
- heavy gas dispersion;
- weather/wind conditions;
- properties of the LNG, reflecting release conditions.

The analysis requires access to validated dispersion models and will in most cases be a complex assessment

A simpler and more direct approach is to conservatively determine the safety distances based on the dispersion of gas from a maximum realistic release of LNG or natural gas as defined in the HAZID. This release scenario should be determined on a conservative, but realistic basis considering the operation and the implemented safeguards.

The dispersion assessment of this maximum, realistic release should reflect all relevant factors and is normally conducted using a recognised and validated consequence assessment tool.

The dispersion assessment should include the following steps.

- Determine the release rate and duration based on failure size, pressure, inventory, and effect of ESD. For large size failures the transfer rate should also be reflected until ESD is activated.
- Determine initial flash and vapour generation due to the pressure loss. For “warm” LNG the initial flashing will be significant.
- Determine the liquid LNG pool and the evaporation rate dependent on the properties of the ground or water.
- Determine whether the characteristic lengths of obstacles in the surroundings are such that vortex, recirculation or preferential direction for gas dispersion may occur. If that is the case the dispersion model chosen for the dispersion assessment below should be able to take such obstacle effects into account.

- Assess the dispersion (initially heavy gas dispersion when the cold vapour spreads by gravity followed by light gas turbulent mixing and diffusion in air reflecting the weather conditions).

As an illustration dispersion analysis has been included out for two different release scenarios:

Small release

A small release (10 mm) being detected and isolated by the ESD system. The duration is the time to detection and the time required to release the inventory between the ESDV.

This scenario is typical for a leaking flange or connector.

This may be considered as a realistic maximum release for a bunkering facility where likelihood of rupture or mechanical damage to the bunkering system is considered extremely remote due to:

- the application of protective devices such as Dry break couplings,
- elimination of all activities that could cause mechanical damage,
- where the HAZID concludes that drift-off and excessive motions are extremely unlikely and this is accepted by authorities.

For bunkering facilities where other personnel may be present close to the bunkering facility, that can be threatened by a flash fire, a release diameter of 25 mm should be used to determine the safety zone.

Drift off; hose rupture after activation of ESD

In such cases it is realistic to assume that ESD is activated (pumps are stopped and ESDV closed) when a potential drift off situation is threatening. The ESD will be activated by position sensors and by manual actions. The LNG in the hose will be pressurized resulting in a pressurized outflow and the LNG can be “warm” i.e. at a temperature above $-160\text{ }^{\circ}\text{C}$, resulting in a significant flashing.

This is considered a realistic case for bunkering scenarios where ship collisions or external impacts can cause excessive motions between the vessel and the supplier.

The release and dispersion calculation should account for the outflow rate and the potential for instant flashing.

Guidance for the assessment of the flammable atmospheres can be found in IEC 60079-10-1, and ISO/ TS 16901.

Annex C (informative)

Functional requirements

The functional requirements can be met in different ways. The complexity of the selected solutions which should be agreed with authorities should reflect:

- the complexity of the operations;
- the equipment installed;
- the organization of the bunkering team;
- other activities in the area.

For a small scale, truck to ship operation with a bunkering crew comprising the truck driver and one cargo officer the key issues are different compared to a complex and instrumented operation.

Functional requirement	Short description	Status
F1	Compatibility check between supplier and ship	
F2	Can the system be commissioned and operated (purged and inerted) without release of LNG or natural gas to the atmosphere	
F3	Is the system closed and leak tested prior to bunkering	
F4	Design should reflect operating temperature and pressure and be in accordance with recognized standards	
F5	The design shall reflect the required operational envelope (motions, weather, visibility)	
F6	The transfer system shall be capable of being drained, de-pressurized and inerted before connections and disconnections are made	
F7	The bunkering transfer system shall be designed to avoid trapped liquid	
F8	Operating procedures shall be established and documented to define the bunkering process, and ensure that components and systems are operated in a safe way within their design parameters during all operational phases Note: for truck loading the procedures will normally be defined for the truck operation, but need to be aligned to specific ship requirements	
F9	All systems and components shall be maintained and tested according to, as a minimum, vendor recommendation to maintain their integrity	
F10	An organizational plan shall be prepared and implemented in operational plans and reflected in qualification requirements	
F11	Operating procedures shall include a checklist to be completed and signed by both parties prior to the commencement of bunkering	

Functional requirement	Short description	Status
F12	Emergency equipment and personnel shall be mobilized in accordance with the emergency response plan	
F13	Operating procedures shall not be applied as an alternative to a particular fitting, material or item of equipment	
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	
F15	Elimination of the potential spark or high currents from static or galvanic cells when the bunkering system is connected or disconnected	
F16	Effective detection of release of LNG and natural gas Note: Manual detection may be accepted for continuously monitored short duration operations	
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	
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)	
F19	The release of LNG or cold vapour should not lead to an escalation due to brittle fractures of steel structure	
F20	Personnel shall use PPE (personnel protective equipment) as appropriate for the operations.	
F21	A safety zone shall be implemented around the bunkering operation into which only essential personnel shall have access	
F22	Activities in the area adjacent to the bunkering operation shall be controlled to reduce possible ignition sources	
F23	A contingency plan shall be in place	
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	

Annex D
(informative)

Sample Ship supplier checklist

LNG bunkering truck/ship, shore /ship & ship/ship safety check-list

Receiving Vessel's Name

LNG Truck Id (if applicable

Bunker Vessel Name (if applicable)

Bunker Terminal Name (if applicable)

Date

Time

Bunkers to be transferred

Volume	Temperature	Pressure	Transfer rate	

Tanks to be loaded

Tank No.	Volume of tank @ X%	Volume in tank before loading	Available volume	Volume to be loaded	

Checks prior to berthing/internal transfer

Operational check	Ship	Supplier	Code (See legend below)	Remarks
Compatibility of hazardous zones when barge will come alongside completed by competent authority			P	Hazardous zone overlap onto vessels studied for compatibility for barge to vessel prior coming alongside
The barge and/or truck have the permission to carry out the LNG bunker operation			P	
The truck is securely parked with truck stops (if applicable)			A	
The ship is securely moored with fenders in good condition and no possibility of metal to metal contact			R	
Adequate electrical insulating means are in place in the barge-to-ship connection			A	
There is safe access between the receiver and supplier			R	
The terminal's/vessel's fire-fighting equipment is positioned and ready for immediate use				
Bunker hoses or arms and vessel lines are in good condition, properly rigged and appropriate for the service intended and pressure tested within a year prior			A	
The LNG transfer system is sufficiently isolated and drained and purged to allow safe removal of blank flanges prior to connection				% LFL-
The procedures for bunker handling have been agreed between parties				
The emergency signal and shutdown procedure to be used by the ship and shore have been explained and understood and compatible			A	Emergency Stop Signal: VHF/UHF Ch). Primary System: Backup System: Language:
Where a vapour return line is connected operating parameters have been agreed				
Independent high level alarms, if fitted, are operational and have been tested audio/visual alarms available in a permanently manned location /and/or/Manifold.				
There is sufficient suitable protective equipment (including self-contained breathing apparatus) and protective clothing ready for immediate use				
The gas detection equipment has been properly set for the bunker and is calibrated, tested and inspected and is in good order				

Information has been exchanged between ship and shore on the maximum/minimum temperatures/pressures of the bunkers to be handled				
Relief valves are set correctly and actual relief valve settings are clearly and visibly displayed			A	RV setting- Modified by – (if applicable)
Adequate lighting arrangement of all sections of bunker lines adequate for visual checks and confirmed				
Checks prior LNG bunkering				
The barge is securely moored			R	
Have all ships around been informed of fuel transfer operations				Signal- Flag-
Have other relevant parties such as Port Authorities been informed of fuel transfer operations				
The safety zone around the bunkering is clearly indicated and access controlled			R	
Inform bridge at the start and progress of the transfer			R	
Positive pressure is being maintained inside the accommodation, and air conditioning intakes, which may permit the entry of cargo vapours, are closed				
There is provision for an emergency escape			R	Arrangement-
The maximum wind and swell criteria for operations have been agreed				
Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging ship's tanks, or for line clearing into the ship				
The bunker loading rate is compatible with the automatic shutdown system, if in use				Agreed loading rate-
Bunker system gauges and alarms are correctly set and in good order. Approved tables used for calibration/ measurement				
Portable vapour detection instruments are readily available for the products being handled				
Material safety data sheets (MSDS) for the bunker transfer have been exchanged where requested and hazardous chemicals threshold limit values (TLV) identified.			A	Sulphur compounds/ smelling agents etc.
Bunker tanks are protected against inadvertent overfilling at all times while any loading operations are in progress				
Drip trays are in position with sufficient capacity and drained/water curtains in operation				
Initial line up has been checked by authorized person and unused bunker connections are blanked				
The transfer hose is properly rigged and fully bolted and secured to manifolds on ship and barge				Hose/arm test date- Supplier line tested- Receiver line tested-

Bunker tank contents will be monitored at regular intervals			R	
All portable electrical equipment use on deck is zone compliant				
Fixed radar/VHF/UHF transceivers and AIS (Automatic Identification System) equipment are on the correct power mode or switched off				
Smoking rooms have been identified and smoking restrictions are being observed				Ship- Barge-
Naked light regulations are being observed				
All external doors and ports in the accommodation are closed				
State method for line draining/purging between ship/barge (shore) on completion of bunkering				(state if wet hose/ acceptable if less than 30 % LFL)
The connection has been purged and pressure tested				Tested pressure- Time-
Emergency shutdown systems have been tested and are working properly. WARM ESD				ESD valve closure time -supplier -receiver
Manned rounds on deck and bunker lines checked during the cool down and loading operations for vapour mist and frosting of lines past isolation valves			R	
Access control exists and clearly marked for regions around breakaway/ERS couplings			A	
Emergency shutdown systems have been tested and are working properly. COLD ESD				ESD valve closure time -supplier -receiver

Guidelines for completing the LNG bunker checklist truck to ship

The presence of the letters 'A' or 'R' in the column entitled 'Code' indicates the following:

— A ('Agreement')

This indicates an agreement or procedure that should be identified in the 'Remarks' column of the checklist or communicated in some other mutually acceptable form.

— R ('Re-check')

This indicates items to be re-checked at appropriate intervals, as agreed between both parties, at periods stated in the declaration.

— P ('Permission')

This indicates that permission is to be granted by authorities.

The joint declaration should not be signed until both parties have checked and accepted their assigned responsibilities and accountabilities. When duly signed, this document is to be kept at least one year on board of the LNG receiving vessel.

DECLARATION

We have checked, where appropriate jointly, the items of the checklist in accordance with the instructions and have satisfied ourselves that the entries we have made are correct to the best of our knowledge.

We have also made arrangements to carry out repetitive checks as necessary and agreed that those items coded 'R' in the checklist should be re-checked at intervals not exceeding _____ hours.

If, to our knowledge, the status of any item changes, we will immediately inform the other party.

One copy of the completed checklist to be given to the barge/shore representative.

For ship	For barge/jetty
Name	Name
Rank	Rank
Signature	Signature
Master's signature	
Date	Date
Time	Time

Record of repetitive checks

Date									
Time									
Initial ship									
Initial barge									

Remarks (to be used for additional remarks as required)

Example safety letter

Company _____

Terminal _____

Date _____

The Master SS/MV _____

Port _____

Dear Sir,

Responsibility for the safe conduct of operations while your ship is at this terminal rests jointly with you, as Master of the ship, and with the responsible Terminal Representative. We wish, therefore, before operations start, to seek your full co-operation and understanding on the safety requirements set out in the Ship/Shore Safety Check-List, which are based on safe practices that are widely accepted by the oil and tanker industries.

We expect you, and all under your command, to adhere strictly to these requirements throughout your ship's stay alongside this terminal and we, for our part, will ensure that our personnel do likewise, and co-operate fully with you in the mutual interest of safe and efficient operations.

Before the start of operations, and from time to time thereafter, for our mutual safety, a member of the terminal staff, where appropriate together with a Responsible Officer, will make a routine inspection of your ship to ensure that elements addressed within the scope of the Ship/Shore Safety Check-List are being managed in an acceptable manner. Where corrective action is needed, we will not agree to operations commencing or, should they have been started, we will require them to be stopped.

Similarly, if you consider that safety is being endangered by any action on the part of our staff or by any equipment under our control, you should demand immediate cessation of operations.

There can be no compromise with safety.

Please acknowledge receipt of this letter by countersigning and returning the attached copy.

Signed _____

Terminal Representative

Terminal Representative on duty is: _____

Position or title: _____

Contact details: _____

Signed _____

Master

SS/MV

Date/Time _____

Annex E
(informative)

Sample LNG delivery note

LNG Specification Delivery Specification

Annex to Offer ID: _____

By: _____

Owner/Operator: _____

1 LNG properties

Lower calorific (heating) value	MJ/kg	
Higher calorific (heating value	MJ/kg	
Bubble point temperature	°C	
Density at bubble point temperature	kg/m ³	
Pressure at bubble point temperature	bar (abs)	

2 LNG composition

Methane, CH ₄	% kg/kg	
Ethane, C ₂ H ₆	% kg/kg	
Propane, C ₃ H ₈	% kg/kg	
Isobutane, i C ₄ H ₁₀	% kg/kg	
N- Butane, n C ₄ H ₁₀	% kg/kg	
Pentane C ₅ H ₁₂	% kg/kg	
Nitrogen, N ₂	% kg/kg	
Particles	% kg/kg	
Negligible (<5 ppm) H ₂ S, hydrogen, ammonia, chlorine, fluorine, water		

3 Signature(s) as applicable

Supplier: _____

Signature: _____

Date: _____

Bunkering Company: _____

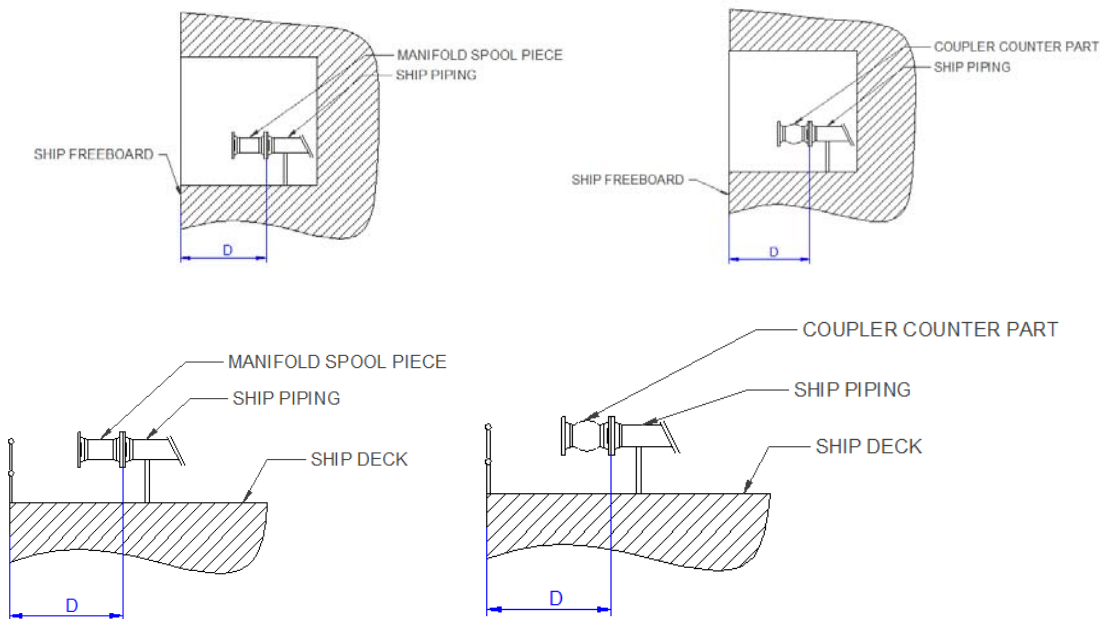
Signature: _____

Date: _____

Annex F (informative)

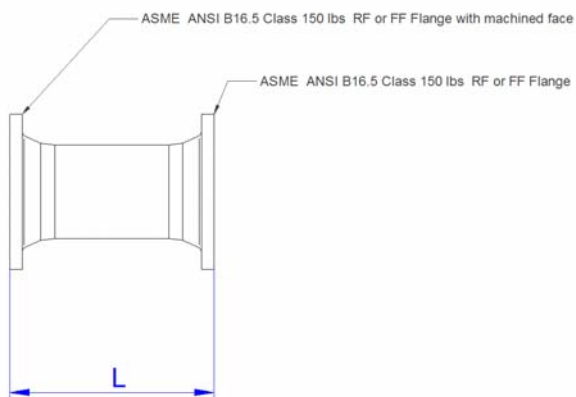
Arrangement and types of presenting connection

The connections can be located inside hull of the ship or on topside. In both cases the presenting connection is achieved through a spool piece or a coupler counterpart bolted to ANSI 150 RF flanged end of ship piping.



In case of spool piece solution, it should be ANSI 150 RF or FF flanged ends with machined face to accommodate cryogenic sealing of different couplings.

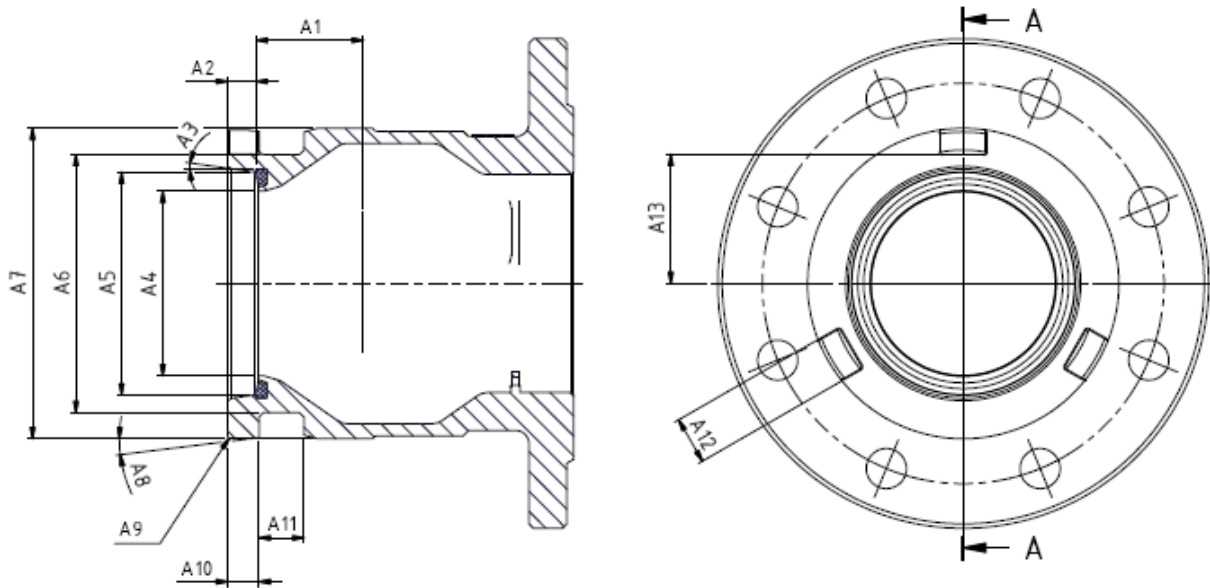
The distance L should be sufficient to allow clamping and/or bolting of the coupling device.



Annex G (informative)

Dimensions and tolerances

The dimensions of dry disconnect couplings should be as shown in Figure G.1.



Key: See Table G.1

Figure G.1 — Dry disconnect coupling measurements

Table G.1 — Dry disconnect coupling

Dimensions in millimetres

	DN 65	DN 100	DN 150
A1	34	43	68
A2	9,8-9,9	12,8-12,9	13,9-14,1
A3	8°	8°	8°
A4	58,7-58,8	83-83,1	133,5-133,7
A5	69,15-69,25	100,15-100,25	155,15-155,35
A6	81,8-82,0	115,8-116,0	191,8-192,2
A7	101,6-101,7	139,4-139,5	214,8-215,2
A8	7°	7°	7°
A9	R1.5	R1.5	R2
A10	9,0-9,1	14,0-14,1	16,9-17,1
A11	15,2-15,3	20,2-20,3	36,4-36,6
A12	15,4-15,6	20,4-20,6	38,0-38,2
A13	41,0-41,2	57,9-58,1	90,0-90,3

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- [6] API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*, Sixth Edition
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- [10] EN 13645, *Installations and equipment for liquefied natural gas – Design of onshore installations with a storage capacity between 5 t and 200 t*
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- [19] IMO *IGC Code*

³ Will be replaced by ISO 16903.

⁴ Will be replaced by ISO 16904.

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