TECHNICAL SPECIFICATION

ISO/TS 18683

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

Lignes directrices pour les systèmes et installations de distribution de gaz naturel liquide comme carburant pour navires

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for the petroleum, petrochemical and natural gas industries*.

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 to control all 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 following 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:

— bunkering facility;

— ship/bunkering facility interface;

— procedures for connection and disconnection;

— monitoring procedures during bunkering;

— emergency shutdown interface;

— LNG bunkering process control.

The LNG bunkering interface 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), ISO, EN, and NFPA standards and the Society of International Gas Tankers and Terminal Operators (SIGTTO), the Oil Companies International Marine Forum (OCIMF), and other recognized documents during LNG bunkering. Relevant publications by these and other organizations are listed in the Bibliography.

It has to be recognized that in cases where the distance to third parties is too close and the risk exceeds acceptance criteria, the bunkering location is not to be considered.

It is not necessary that the provisions of this Technical Specification are applied retroactively. 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, for the roles and responsibilities of the ship crew and bunkering personnel during LNG bunkering operations, and the functional requirements for equipment necessary to ensure safe LNG bunkering operations of LNG fuelled ships.

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.

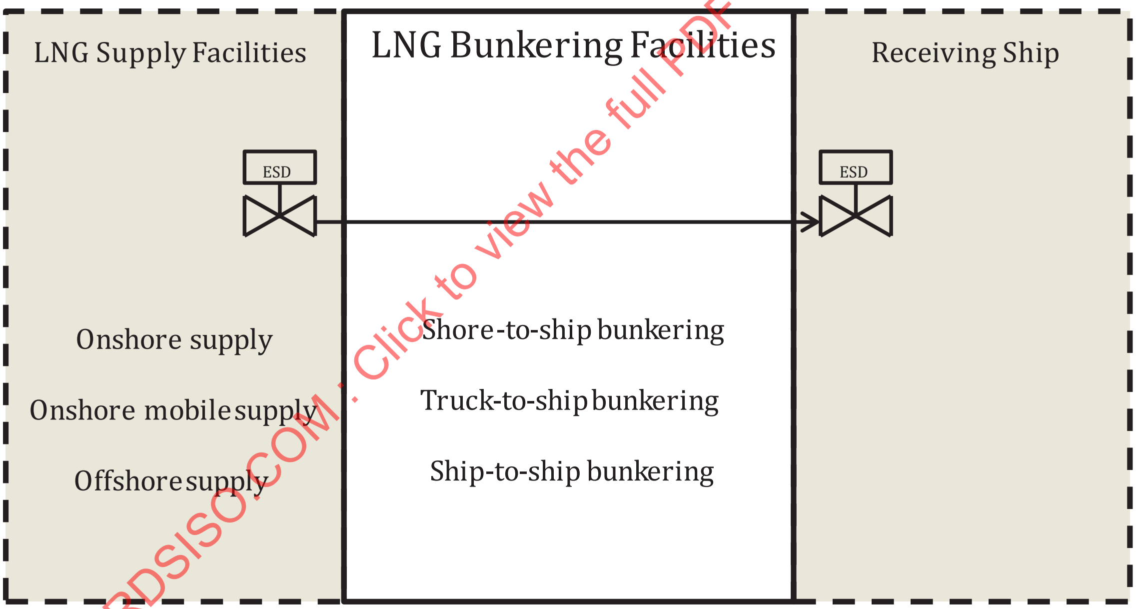


Figure 1 — Interfaces between bunkering facility and supply/receiving facilities

The use of portable storage tanks such as containers, trailers, or similar to load and store LNG on board ships to be used as fuel is not part of this Technical Specification.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 — Guidelines for use in standards*

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

ISO 17776, *Petroleum and natural gas industries — Offshore production installations — Guidelines on tools and techniques for hazard identification and risk assessment*

ISO 31010, *Risk management — Guidelines on principles and implementation of risk management*

IMO, *IGF Code of Safety for Ships using Gases or other Low flashpoint fuels*[1)]

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

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 though mechanical/hydraulic controls.

3.1.4
bunkering
process of transferring fuel to a ship

3.1.5
bunkering installation
piping, process components, instrumentation, and other hardware for the transfer of LNG from the supplier to the ships manifold

3.1.6
bunkering site
location dedicated for bunkering comprising the bunkering installations, port and jetty, and other facilities and equipment that should be considered in the planning of bunkering

3.1.7
consequence
outcome of an event

3.1.8
container
portable tank unit

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

3.1.9
drip tray
spill containment produced of material that can tolerate cryogenic temperatures

3.1.10
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

3.1.11
emergency shut-down
ESD
method that safely and effectively stops the transfer of natural gas and vapour between the receiving ship and supply facilities

3.1.12
hazard
potential source of harm

3.1.13
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

3.1.14
impact assessment
assessment of how consequences (fires, explosions, etc.) affect people, structures the environment, etc.

3.1.15
individual risk
probability on an annual basis for an individual to be killed due to accidental events arising from the activity

3.1.16
linkspan
type of drawbridge used mainly in the operation of moving vehicles on and off a RO-RO vessel or ferry

3.1.17
probability
extent to which an event is likely to occur

3.1.18
rapid phase transition
RPT
shock wave forces generated by instantaneous vaporization of LNG upon coming in contact with water

3.1.19
risk
combination of the probability of occurrence of harm and the severity of that harm

3.1.20
risk analysis
systematic use of information to identify sources and to estimate the risk

3.1.21
risk assessment
overall process of risk analysis and risk evaluation

3.1.22
risk contour
two dimensional representation of risk (e.g. IR) on a map

3.1.23
risk evaluation
procedure based on the risk analysis to determine whether the tolerable risk has been achieved

3.1.24
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 addressing impact on people, assets, environment, and reputation. Plotting the intersection of the two considerations on the matrix provides an estimate of the risk.

3.1.25
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.

3.1.26
safety
freedom from unacceptable risk

3.1.27
safety zone
area around the bunkering station where only dedicated and essential personnel and activities are allowed during bunkering

3.1.28
security zone
area around the bunkering facility and ship where ship traffic and other activities are monitored (and controlled) to mitigate harmful effects

3.1.29
stakeholder
any individual, group, or organization that can affect, be affected by, or perceive itself to be affected by, a risk

3.1.30
tolerable risk
risk which is accepted in a given context based on the current values of society

3.1.31
topping up
final sequence of LNG transfer to ensure correct filling level in receiving tank

3.1.32
water curtain
sprinkler arrangement to protect steel surfaces from direct contact with LNG

3.1.33
white water/mist/fog
mist/fog that will be generated by condensing humidity in air when in contact with cold surfaces during bunkering

Note 1 to entry: This fog will reduce visibility and can mask minor leaks.

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
HSE	health, safety, and environment
IR	individual risk
LNG	liquefied natural gas
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

NOTE LNG is defined in EN 1160.

4 Bunkering scenarios

Selection of the bunkering configuration should reflect the following factors:

a) LNG bunkering volumes and transfer rates;

b) simultaneous transfer of other bunker fuels;

c) possible interference with other activities in the port area;

d) transfer equipment;

e) type of receiving ship;

f) possible risk areas according to risk analysis, which shows distance to terminal, gangways, and linkspan, etc., which is of importance for third-party personnel;

g) 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 and therefore, a QRA might not be required.

In case of bunkering during cargo operations, bunkering with passengers on-board or embarking/disembarking acceptance is required by all parties (such as authorities, terminal, ship and bunkering operator, and supplier operator) and shall be supported by a dedicated QRA which shall address the effects of the simultaneous operations.

NOTE The risk assessment addressing simultaneous operations and passengers as described in 7.3 is to be carried out as part of the planning and permitting process for the operation.

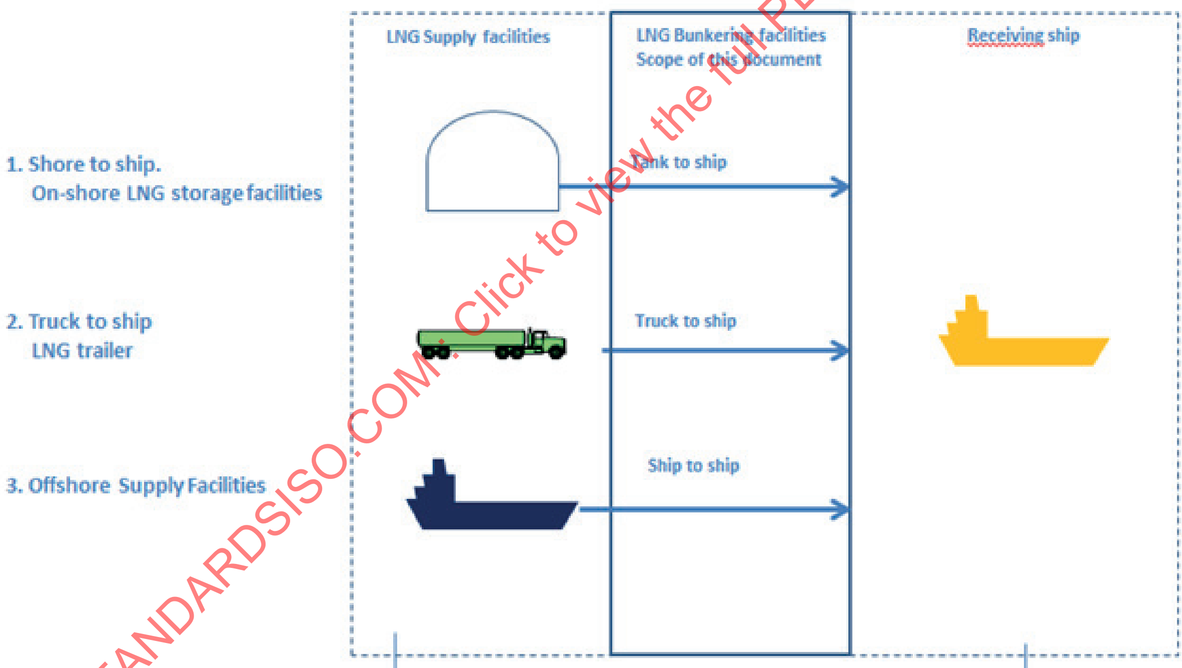
This QRA are dedicated to bunkering operations for a specific location and shall demonstrate that the risk is acceptable.

The following 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”).



Basically, LNG storage facilities, trailers, containers, bunker vessels shall be governed by specific standards or national/local laws. If necessary, this Technical Specification defines additional requirements.

Basically, receiving ships shall be governed by specific standards. If necessary, this Technical Specification defines additional requirements.

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 such 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 that sources of ignition in the vicinity (i.e. inside the safety zone) 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 °C. Released LNG will form a boiling pool on the ground or on the water 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 °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 slowly 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.

Cold surfaces in the bunkering system can cause mist or fog by condensing humidity in the air that might mask a release.

LNG for fuel supply may be delivered at elevated pressure and at a temperature exceeding the boiling point at atmospheric conditions (e.g. at 5 bar and at −155 °C). Release of LNG under such conditions will result in instantaneous flashing and larger vapour release compared to evaporation from liquid pools.

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 °C and a high self-ignition temperature (theoretically, approximately 540 °C while experiments indicate that 600 °C is more realistic). The properties of traditional fuels are different; MGO (marine gas oil) has a flashpoint in excess of 60 °C and a self-ignition temperature of 300 °C for marine gas oil (MGO) or a gas oil vapour/aerosol air mixture.

The ignition energy of natural gas/air mixtures is 0,25 mJ which is lower than most other hydrocarbons.

Natural gas releases are not easily ignited by hot surfaces that ignite most FO fires in engine room but low energy sparks represents a higher risk.

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

The following are hazards associated with LNG:

— fire, deflagration, or confined explosion from ignited natural gas evaporating from spilled LNG;

— vapour dispersion and remote flash fire;

— 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 vaporization of trapped LNG;

NOTE The thermal expansion coefficient of LNG is high.

— possible RPT (rapid phase transition) caused by LNG spilled into water;

— possible BLEVE of a pressurized tanks subjected to a fire.

NOTE This hazard is not applicable to atmospheric LNG tanks, only to pressurized forms of hydrocarbon storage.

5.3 Potential hazardous situations associated with LNG transfer

The planning, design, and operation should focus on preventing release of LNG and vapour and avoiding 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 detection systems, 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 upon between the supplier and receiver and documentation shall be 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 Clause 8, Clause 9, Clause 10, and Clause 11, and qualified by a risk assessment as outlined in Clause 7.

7 Risk assessment

7.1 General

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

— 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 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), and

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 Clause 8 to Clause 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 shall be supported by a QRA and also requires acceptance by all parties.

The schematic approach is illustrated in Figure 3.

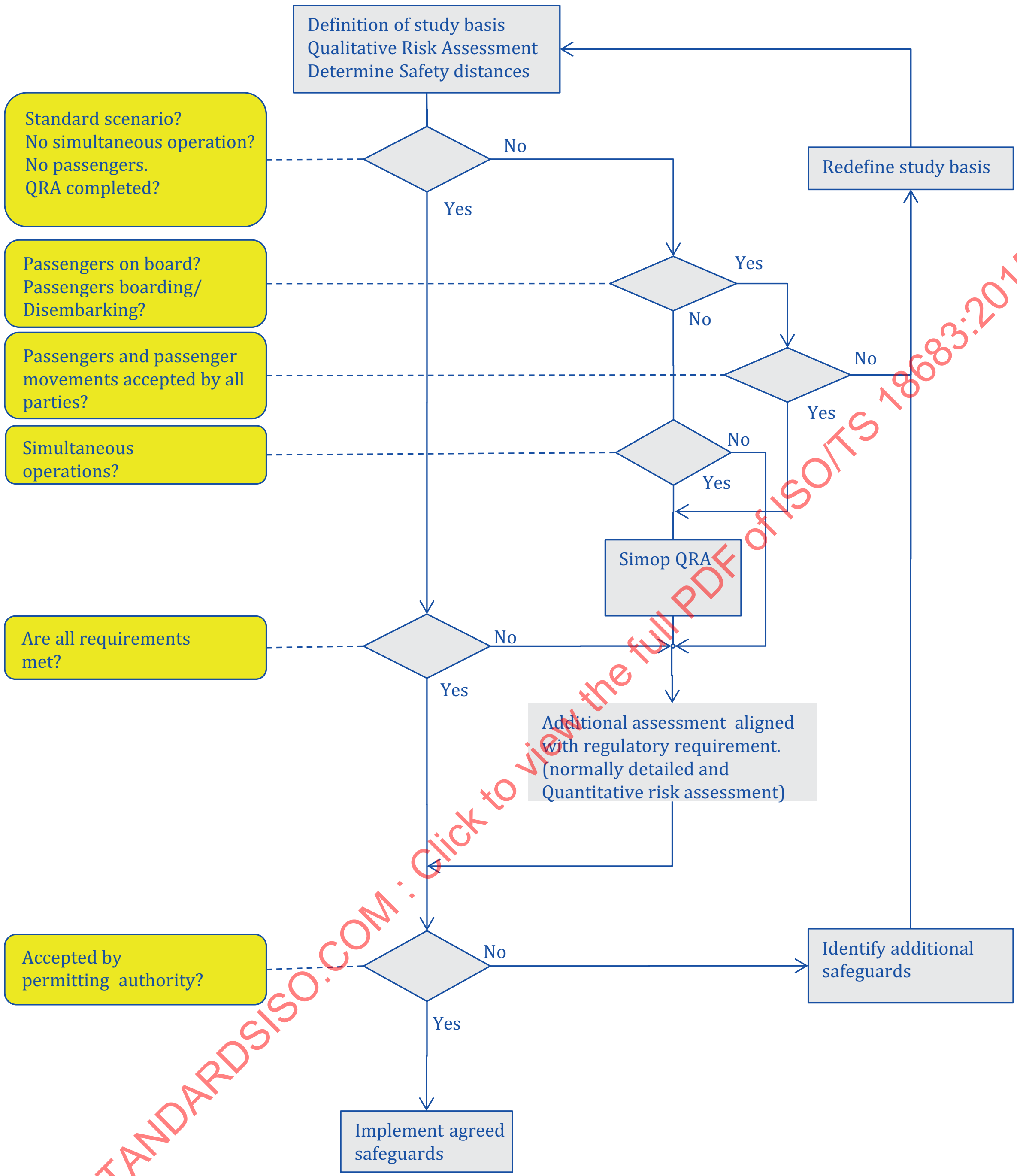


Figure 3 — Schematic approach of risk assessment

7.2 Qualitative risk assessment

7.2.1 Main steps

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

a) definition of study basis and familiarization with the design and planned operation of the bunkering facility;

b) HAZID review with the purpose of identifying hazards and assess the risks using a risk matrix. The HAZID shall also identify risk reducing measures for all hazards representing medium or high risks. The HAZID should consider accidental spills and consider/identify technical and operational safeguards. The HAZID shall also determine maximum credible release scenarios as a basis for the determination of the safety zones;

c) determination of safety zones and security zones (these may later be revised with reference to QRA);

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 of the following:

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 itself with the study basis through the following:

— document review, interviews with key personnel;

— 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 workshop 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, and

— rapid identification and description process only.

7.2.3.2 HAZID team

The HAZID study is carried out by a team representing different disciplines with knowledge of the plans for the facility and its operation and familiarity 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 following aims.

— Identify potentially hazardous events.

— Assess these events with regard to consequence and likelihood and rank the risks. The process of risk ranking is normally performed using a risk matrix (see Annex A).

— Identify and assess potential risk-reducing measures.

— Identify hazards and safeguards that need to be followed up later in the project.

— Identify maximum credible accidental release (i.e. release scenarios that shall be the basis for definition of the safety zones).

— Identify need for PPE for the personnel involved in the operation.

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 the following:

      — design flaws;

      — wear, tear, and fatigue;

      — excessive loads due to dropped objects or collision and impacts from ships or trucks;

      — ships mooring failure;

      — unplanned movement of the truck;

   3) pressure surge in transfer lines;

   4) releases from piping systems;

   5) incorrectly planned or performed maintenance;

   6) incorrect operational procedures including the following:

      — cooling down;

      — connection;

   7) failure to detect releases masked by mist and fog due to cold surfaces;

   8) failure to detect releases at low level due to location of gas and leak detectors;

   9) over-filling and over-pressurization of ships bunker tanks (e.g. by flashing, incorrect bunker rate, or bunkering procedure);

   10) over-pressure of transfer systems caused by thermal expansion or vaporization of trapped LNG;

   11) 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;

d) events caused by human error.

7.2.3.3.3 Hazardous effects

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

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 LNG containment 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 including brittle fracture of the steel structure exposed to LNG spills;

2) frostbite from liquid or cold vapour spills;

d) other hazards:

1) asphyxiation;

2) 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 the following:

a) training of involved personnel;

b) maintenance planning;

c) cryogenic spill protection;

d) personal protective equipment for operators;

e) evacuation plans;

f) fire-fighting equipment;

g) shore to ship and ship to ship communication plan;

h) elimination or minimization of ignition sources, including the use of isolation elements.

The action plan addresses each recommendation developed along the HAZID meeting and shall be followed up 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 control ignition sources and 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 safety zone shall normally be conservatively determined as the predicted distance to LFL for the maximum credible release as defined in the HAZID (refer to 7.2.3).

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

— transfer rates and inventory in the bunkering facilities;

— operational modes;

— implemented safeguards;

— properties of the LNG in the bunkering system (temperature, pressure).

As an alternative, a smaller safety zone can be defined based on a risk based assessment.

The safety zone shall not be less than the hazardous areas and/or the minimum distance defined by authorities from any part of the bunkering installation

Examples of determining safety distances are described in Annex B.

7.2.5 Determination of security zones

A security zone shall be established 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 might 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, describes the following:

a) study basis including description of design, operations, and assumptions being made;

b) description of the working process including participants in the workshops;

c) summary of the identified hazards and the risk assessment;

d) release scenario to serve as a basis for determination of the safety zone;

e) determined safety distances;

f) definition of the security zones;

g) summary of follow up actions;

h) detailed records from the workshop.

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 Clause 8 to Clause 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, and

c) evaluate and select safeguards and risk reducing measures.

Risk is defined in ISO 17776 as the 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 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 with 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.

7.3.3 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 regulatory 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/or regulator require 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.

7.3.4 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 following 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 the following:

— individual risk: risk experienced by an individual person;

— group (or societal) risk: 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 with whether the operation meets the criteria or not and also to assess if risk reducing measures are required. This should encompass exclusion zones for non-essential crew, passengers, and 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 the following:

a) the analysis can be reproduced in order to assess sensitivities and 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 internationally recognized standards and good engineering practices for LNG facilities are adopted and met both for the shore and the ship-systems.

The functional requirements are numbered as [Fx] in this Technical Specification for easy cross-referencing.

NOTE A condensed list of all [Fx] (functional requirements) has been included in Annex C as a guide and checklist for the planning of the operation and 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 the following:

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;

i) activities on board the bunkered vessel.

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 recognized 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 the following:

a) agreement on quantity and properties of supplied LNG (see Annex D and Annex E);

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 hazard zoning and ventilation;

g) spill protection systems;

h) compatibility of safety management systems;

i) compatibility of communication procedures and protocols.

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 the safety of life, property, or environment. Further, the system shall be designed such that the 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 as follows.

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 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 the following:

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-pressurized, 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 the following:

   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 that can influence the bunkering process, which 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 to minimize the 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 operated, maintained, and tested according to the vendor recommendation, as a minimum, 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 the following:

   1) organization;

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

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. Selection of sensors and sensors location should consider possible presence of mist and fog that can mask the leak.

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) leak detection;

   3) fire detection;

   4) manual activation from ship and facility;

   5) ship drift/movement of supply vehicle;

   6) power failure;

   7) high level in receiving tank;

   8) abnormal pressure in transfer system.

e) [F18] The transfer system shall be capable of being disconnected rapidly to minimize damage to the transfer system in case of ships drifting 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 Annex B).

i) [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

[F23] A contingency plan shall be in place outlining the requirements for the following:

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 minimization 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) organization;

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

General standards for materials and components for LNG service are given in ISO/DIS 16904 and ISO 28921. Specific standards for components and systems are given below.

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 to 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		
			EN 1474-1		
			OCIMF Mooring Equipment Guidelines		
			IEC 60079		
			IGF Code		
			NFPA 70		
			NFPA 58		
			NFPA 59A		
			EN 13645		
			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 2 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 to F8	Connection to ship's manifold	EN 1474-3, 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 13645		
			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 confirm 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 the following:

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 w.r.t. recognition of different types of incidents and specific actions for each type of incident:

   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 minimize 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 the following:

a) 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) 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 the following:

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 the following:

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 the following:

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 within the limits of the component and/or system as documented by the manufacturers;

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 the following:

a) 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 the following, 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 is integrated with the operator's overall emergency response documentation for the receiving ship in the event of an emergency.

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 Annex D and Annex E).

Such documentation shall include the following:

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 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 [i.e. documents showing amount and composition of transferred LNG (see Annex D and Annex E)] should be kept for three years.

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.

Consequence					Increasing probability			
Severity rating	**People**	**Assets**	**Environ-ment**	**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				
1	Slight injury	Slight damage	Slight effect	Slight impact	Manage for continued improvement			
2	Minor injury	Minor damage	Minor effect	Limited impact				
3	Major injury	Local damage	Local effect	Considerable impact				
4	Single fatality	Major damage	Major effect	Major national impact	Incorporate risk-reducing measures		Fail to meet screening criteria	
5	Multiple fatalities	Extensive damage	Massive effect	Major international impact				

NOTE Reproduction of ISO 17776:2000, Table A.1.

Figure A.1 — Example of a risk matrix

Risk acceptance criteria shall be defined when a quantitative risk assessment (QRA) is required to

— meet authority requirements,

— assess the acceptance of non-standard scenarios, and

— assess deviations from the functional requirements.

The selected risk acceptance criteria shall be in agreement with requirements of the permitting authority.

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

Examples of risk acceptance criteria being used by authorities (e.g. in UK, Netherlands, Australia) adopting a risk based approach are summarized in Table A.1.

Table A.1 — Examples of risk acceptance criteria

	Acceptance criteria	Comment
Individual risk first party personnel	IR < 10^{-5}	Applies to crew and bunkering personnel directly involved in the activity.
Individual risk second party personnel	IR < $5 \cdot 10^{-6}$	Port personnel and terminal personnel.
Individual risk third-party personnel with intermittent risk exposure	Risk contour for IR < $5 \cdot 10^{-6}$	Third-party personnel should not have access for prolonged period.
Individual risk third-party personnel with prolonged risk exposure	Risk contour for IR < 10^{-6}	General public without involvement in the activity. No residential areas, schools, hospitals, etc. inside this risk contour.

Annex B
(informative)

Determination of safety zones

B.1 General

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 zone.

The safety zone will normally be inside the security zone and encompass hazardous areas defined by IEC 60079-10-1 or other relevant regulations. Figure B.1 illustrates the relative location of the safety zone and the hazardous areas related to the bunkering facility.

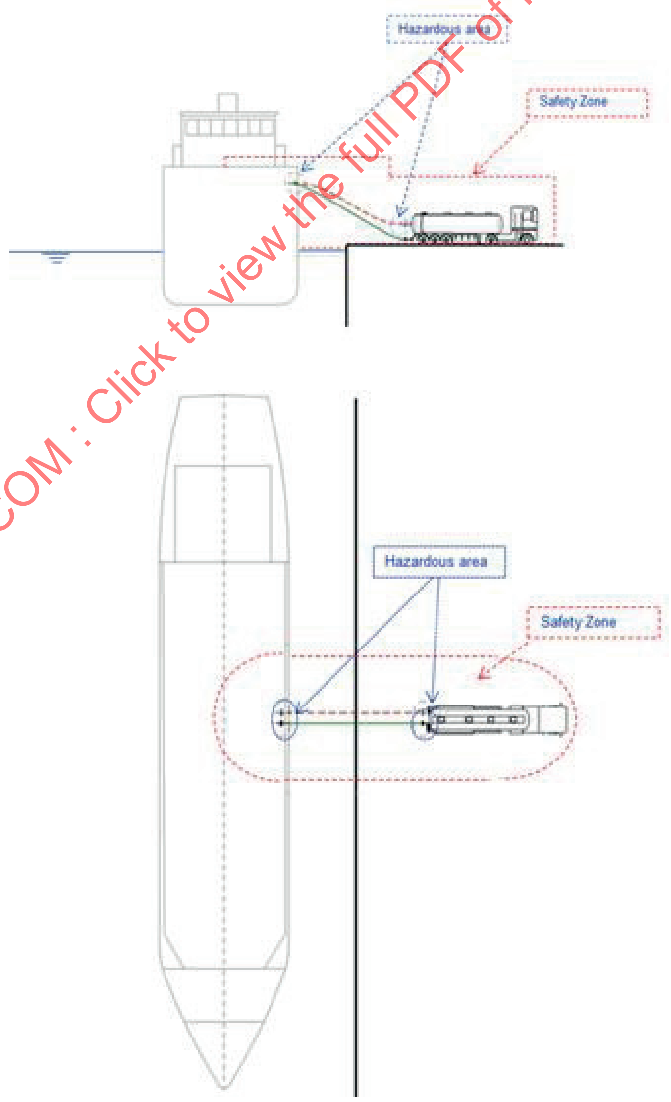


Figure B.1 — Example of possible location of hazardous area and safety zone

The security zone where ship traffic and other activities should be monitored during bunkering will always be larger than the safety zone. Physical barriers preventing other ships to approach the bunkering (e.g. like breakwaters) can be reflected in the definition of the security zone as is illustrated in Figure B.2.

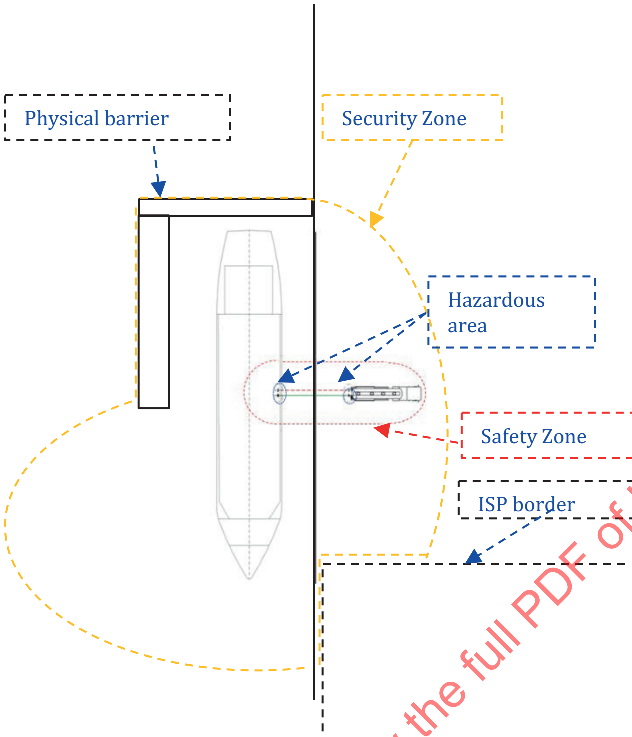


Figure B.2 — Example of plot plan showing security zones, safety zones, and hazardous area

The extent of the safety zone can be determined by the following:

a) deterministic approach calculating the distance to LFL based on a maximum credible release;

b) risk-based approach.

The deterministic approach is based on a calculation of the distance to LFL for a maximum credible release conservatively defined as part of the HAZID.

If the probabilistic approach is used, this will normally result in a smaller safety zone compared to the distance to LFL for the maximum credible release. In such cases, the emergency response plan need to address scenarios where flammable gas might occur outside the safety zone.

Further, the safety distance shall never be zero and the safety zone shall never be less than the minimum distance as defined by national authorities and marine requirements for the receiving ship.

B.2 Deterministic assessment of the safety zone

The safety zone is defined as the area within the distance to LFL as determined by a recognized and validated dispersion model for the maximum credible release as defined as part of the HAZID.

The maximum credible release shall reflect the characteristics of the bunkering facility (dimensions, capacity, temperature, and pressure), as well as the safeguards that are implemented.

It should be recognized that the released gas will be cold and will be spread by gravity at ground level and that physical barriers like ship hulls or buildings will hinder the dispersion of the cloud, but also that gas might enter into safe areas through ventilation openings, doors, etc.

Examples of maximum credible releases are given below:

a) Release of the trapped inventory in the bunkering transfer line

A worst case scenario for a bunkering facility can be defined as the rupture of the bunkering line due to drift off of the ship due to a collision or a mooring failure. The determination of the maximum credible release in this example is based on the following arguments:

— collisions or loss of mooring is normally pre-warned and it is realistic to assume that ESD have been activated;

— ERS or break away couplings will be installed but it is assumed that one fails. For installations with multiple transfer lines, it is therefore assumed that the inventory in one line is released while the others will be protected by the ERS/Break away coupling.

Based on these assumptions, the release amount is determined as the inventory between the two ESD valves.

Figure B.3 shows the distance to LFL as a function of atmospheric LNG.

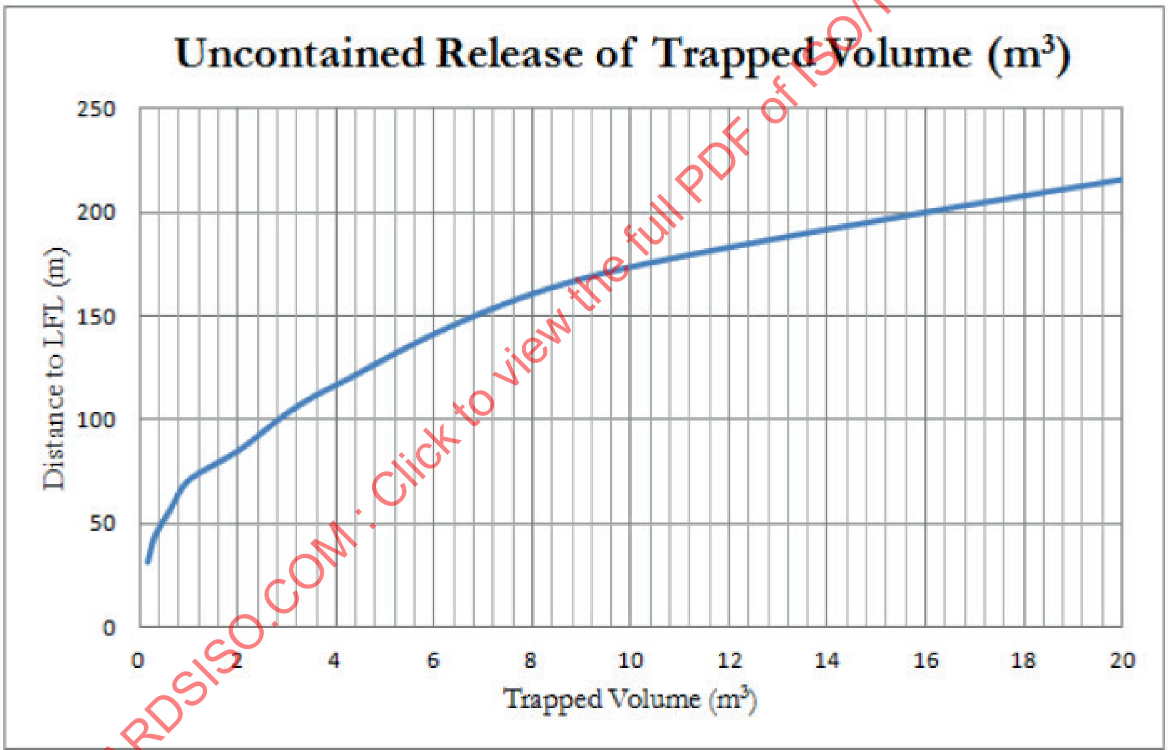


Figure B.3 — Distance to LFL as a function of the release volume

b) Release of LNG through a broken instrument connection

The maximum credible release is defined as a broken instrument connection. Such scenarios can occur without automatic detection and is conservatively represented by a continuous release through a 25 mm hole. ESD is not activated and the pressure inside the transfer system is maintained by the cargo pumps.

The distance to LFL as a function of the system pressure is shown in Figure B.4.

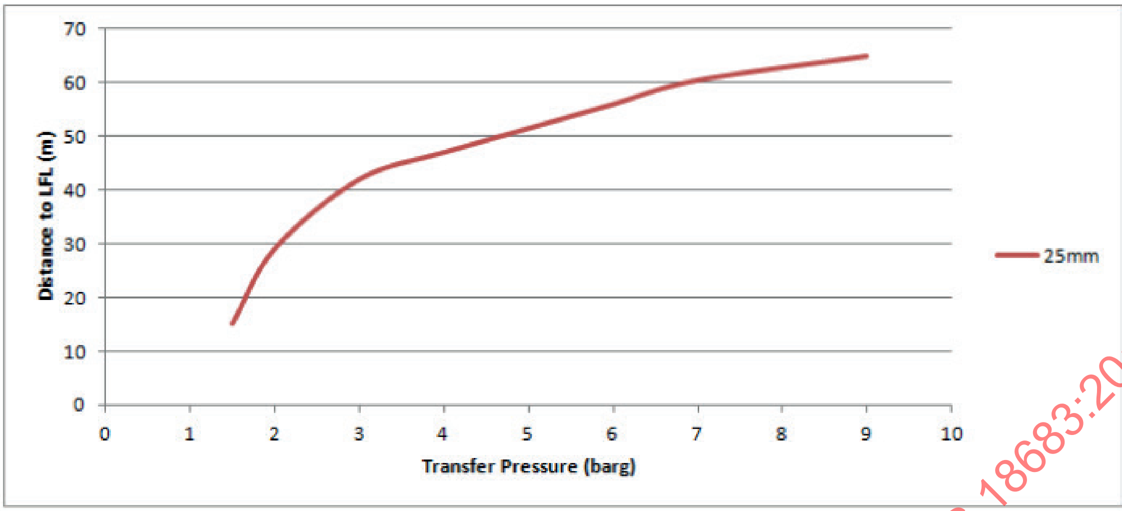


Figure B.4 — Distance to LFL as a function of the system pressure (25 mm hole)

B.3 Risk-based approach

A smaller safety zone may be accepted provided that it can be demonstrated by the QRA that risk acceptance criteria can be met for first, second, and third-party personnel.

— The risk assessment should address all release scenarios as identified in the HAZID and reflect validated (or conservative failure data).

— The risk assessment can recognize implemented, “hard-wired” safeguards based on conservative assumptions.

— The modelling of the release and dispersion need to take into account the following:

a) hole size reflecting the installed equipment and validated failure data;

NOTE If validated failure data is not available, conservative assumptions has to be made.

b) outflow conditions;

c) evaporation/flashing of LNG reflecting LNG properties and heat transfer from ground/water;

d) heavy gas dispersion;

e) weather/wind conditions;

f) properties of the LNG, reflecting release conditions.

— Ignition probabilities shall reflect installations and operations and be applied with reference to IEC 600079-10 for the following:

a) hazardous areas (Zone 1 or Zone 2);

b) inside the safety zone (Zone 2);

c) outside the safety zone.

— The risk assessment shall normally assume that the following:

a) first party personnel (crew and bunkering personnel) are continuously present in the safety zone during bunkering;

b) second party personnel (port and terminal operator, other ship crew) are continuously present directly outside the safety zone during bunkering;

c) third-party personnel (passengers and other persons visiting the site) can be present, but will not be continuously exposed to the risk;

d) third-party personnel continuously present (residential areas, schools hospitals) will be outside the risk contour for third-party acceptance.

— The risk assessment shall assess all hazard scenarios identified in the HAZID and, as a minimum, assess flash fires, jet fires, pool fires.

— The impact on personnel shall primarily assess the initial events. Escalating events will be delayed and the impact should consider the efficiency of evacuation and emergency preparedness.

— The risk assessment should consider the risk exposure for first, second, and third-party personnel.

If the risk is acceptable in accordance with the acceptance criteria (as agreed with authorities), the smaller safety zone is acceptable.

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 following:

— complexity of the operations;

— equipment installed;

— 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 to ensure that components and systems are operated in a safe way within their design parameters during all operational phases. For truck loading, the procedures will normally be defined for the truck operation but need to be aligned to specific ship requirements.	
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 (this may serve as a bunkering permit as required by authorities).	
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.	

Functional requirement	Short description	Status
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. Selection of sensors and sensors location should consider possible presence of mist and fog that might mask the leak. Manual detection may be accepted for continuously monitored short duration operations Manual detection in areas where water mist can occur shall not be accepted	
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	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, and ship/ship safety check-list

Receiving Vessel's Name

LNG Truck Id (if applicable)

Bunker Vessel Name (if applicable)

Bunker Barge 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 %	Allowable filling level at actual LNG Temperature and Pressure (IGF)	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	

