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

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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

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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”).

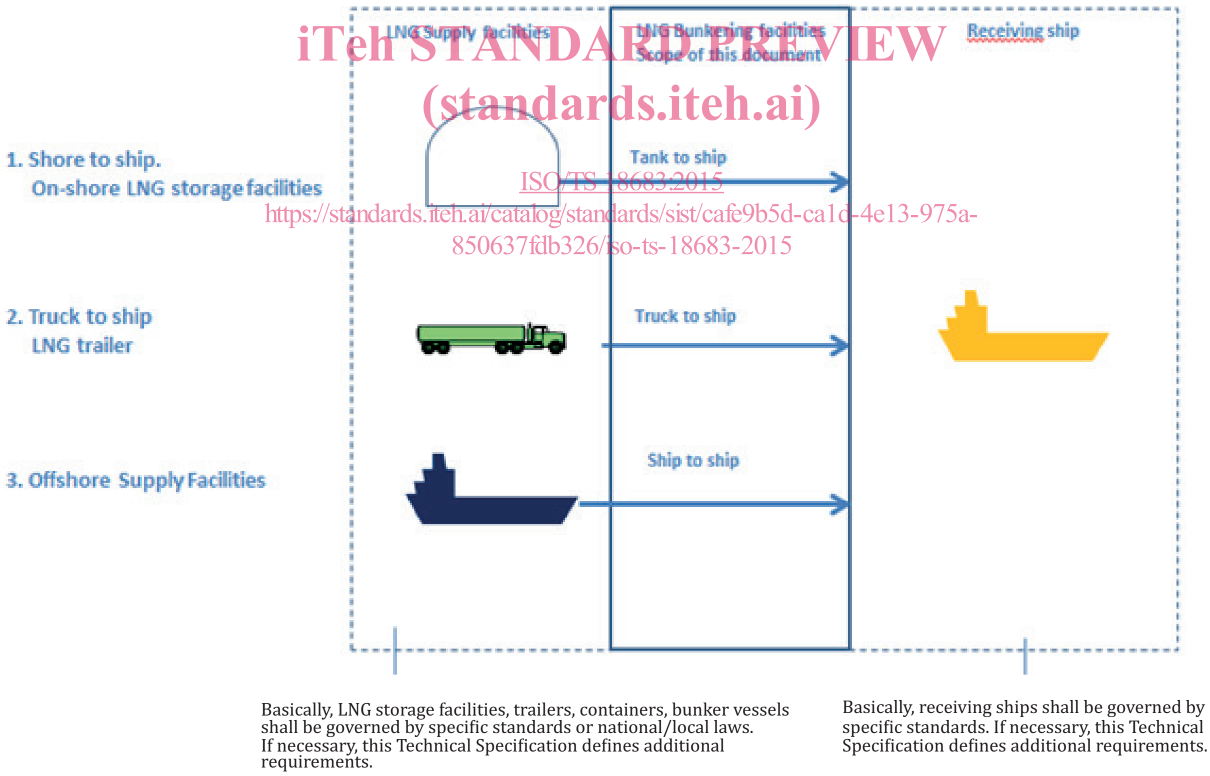

Figure 2 — Standard bunkering scenarios

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.