TECHNICAL SPECIFICATION

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Second edition
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Guidelines for safety and risk assessment of LNG fuel bunkering operations

Lignes directrices pour la sécurité et l'évaluation des risques des opérations de soutage de GNL

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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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 9, *Liquefied natural gas installations and equipment*.

This second edition cancels and replaces the first edition (ISO/TS 18683:2015), which has been technically revised.

The main changes are as follows:

— title and scope restricted to Guidelines for safety and risk assessment of LNG fuel bunkering operations;

— list of bunkering supply scenarios updated with experience gained since 2015 in Clause 4;

— addition of concept of design stage risk assessment and operational risk assessment in 7.1;

— addition of Quantitative Consequence Assessment in 7.2;

— addition of roles and responsibilities of stakeholders in 7.3;

— design requirements removed from Clause 8 to avoid duplication with ISO 20519;

— individual Risk Criteria added in Annex A;

— three methods added to determine safety zone in Annex B;

— to avoid duplication with ISO 20519, the following clauses and annexes have been removed:

  — Clause 9 Requirements to components and systems;

  — Clause 11 Requirements for documentation;

  — Annex C Functional requirements;

— Annex D Sample Ship supplier checklist;

— Annex E Sample LNG delivery note;

— Annex F Arrangement and types of presenting connection;

— Annex G Dry disconnect coupling.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 important 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 document 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 document is to provide guidance for the risk assessment of LNG fuel bunkering operations and thereby ensuring that an LNG fuelled vessel and bunkering supply facilities are operating with a high level of safety, integrity, and reliability regardless of the type of bunkering supply scenario.

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 document is based on the assumption that the receiving ships and LNG bunkering 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 for Gas as a Marine Fuel (SGMF) and other recognized documents during LNG bunkering. Relevant publications by these and other organizations are listed in the Bibliography.

This document should be combined with the requirements set on ISO 20519.

In cases where the distance to third parties is too close and the risk exceeds acceptance criteria, the bunkering location should not to be considered.

Guidelines for safety and risk assessment of LNG fuel bunkering operations

1 Scope

This document gives guidance on the risk-based approach to follow for the design and operation of the LNG bunker transfer system, including the interface between the LNG bunkering supply facilities and receiving LNG fuelled vessels.

This document provides requirements and recommendations for the development of a bunkering site and facility and the LNG bunker transfer system, providing the minimum functional requirements qualified by a structured risk assessment approach taking into consideration LNG properties and behaviour, simultaneous operations and all parties involved in the operation.

This document is applicable to bunkering of both seagoing and inland trading vessels. It covers LNG bunkering from shore or ship, mobile to ship and ship to ship LNG supply scenarios, as described in Clause 4.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

ISO 20519, *Ships and marine technology — Specification for bunkering of liquefied natural gas fuelled vessels*

IMO, IGF Code of Safety for Ships using Gases or other Low flashpoint fuels

IMO, IGC International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

IMO, International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

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.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

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 pressurized flammable liquid followed by a fireball

3.1.3
bunkering
process of transferring fuel to a ship

3.1.4
bunkering facility
system designed to be used to transfer/bunker liquefied gas as fuel to a gas-fuelled vessel

Note 1 to entry: It may consist of a floating, shore-based, fixed or mobile fuel-supply facility, such as a bunker vessel, terminal or road tanker.

3.1.5
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

3.1.6
competent authority
organization or organizations that implement the requirements of legislation and regulate installations that must comply with the requirements of legislation

3.1.7
consequence
outcome of an event

3.1.8
drip tray
spill containment manufactured of material that can tolerate cryogenic temperatures

3.1.9
emergency shut-down
ESD
method that safely and effectively stops the bunker/transfer of natural gas and vapour between the supply facilities and receiving ship

3.1.10
gas-fuelled vessel
GFV
vessel using gas as marine fuel

3.1.11
hazard
potential source of harm

3.1.12
hazard identification
HAZID
brainstorming exercise using checklists where the potential hazards in a project are identified and gathered in a risk register for follow up in the project

3.1.13
impact assessment
assessment of how consequences (fires, explosions, etc.) affect people, structures the environment, etc.

3.1.14
individual risk
probability on an annual basis for an individual to be killed due to accidental events arising from the activity

3.1.15
mist
fog
cloud that will be generated by condensing humidity in air when in contact with cold surfaces during bunkering

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

3.1.16
monitoring and security area
area around the bunkering facility and ship where ship traffic and other activities are monitored (and controlled) to mitigate harmful effects

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
receiver
one or more organizations with ownership, operational and/or legal interests in a gas-fuelled vessel

Note 1 to entry: The receiver can be the vessel owner(s), the charterer or the operator.

[SOURCE: Reference [24]]

3.1.20
risk
combination of the probability of occurrence of harm and the severity of that harm

3.1.21
risk analysis
systematic use of information to identify sources and to estimate the risk

3.1.22
risk assessment
overall process of risk analysis and risk evaluation

3.1.23
risk contour
two-dimensional representation of risk (e.g. individual risk on a map)

3.1.24
risk evaluation
procedure based on the risk analysis to determine whether the tolerable risk has been achieved

3.1.25
safety
freedom from unacceptable risk

3.1.26
safety zone
area around the bunkering station where only dedicated and essential personnel and activities are allowed during bunkering

3.1.27
stakeholder
individual, group, or organization that can affect, be affected by, or perceive itself to be affected by a risk

3.28
supplier
one or more organizations with ownership, operational and/ or legal interests in a bunkering facility

Note 1 to entry: The supplier can be the bunker vessel owner, charterer or operator; the LNG bunkering terminal owner or operator; the road tanker fleet manager; the LNG producer; and so on.

[SOURCE: Reference [24]]

3.1.29
tolerable risk
risk that is accepted in a given context based on the current values of society

3.1.30
topping up
final sequence of LNG transfer to ensure correct filling level in receiving tank

3.1.31
water curtain
sprinkler arrangement to protect steel surfaces from direct contact with LNG

3.2 Abbreviated terms

BASiL	bunkering area safety information for LNG
ERC	emergency release coupling
ERS	emergency release system
HFO	heavy fuel oil
HSE	health, safety, and environment
IMO	international maritime organization
LNG	liquefied natural gas
MGO	marine gas oil
PPE	personal protective equipment
QualRA	qualitative risk assessment
QCA	quantitative consequence assessment
QRA	quantitative risk assessment
SGMF	society for gas as marine fuel
SIMOPS	simultaneous operations
STCW	seafarers' training, certification and watch-keeping

NOTE LNG is defined in ISO 16903.

4 Bunkering supply scenarios

Selection of the bunkering supply scenario should consider the following factors:

a) LNG process conditions (e.g. LNG bunkering volumes, transfer rates and LNG pressure and temperature);

b) simultaneous operations (e.g. loading/unloading cargo, embarkation of passengers, transfer of other bunker fuels);

c) possible interference with other activities in the bunkering location (e.g. port area);

d) bunker transfer equipment;

e) type of receiving LNG fuelled ship and bunkering facility;

f) safety studies undertaken for the bunkering operations (e.g. risk assessment and safety zone defined in Clause 7);

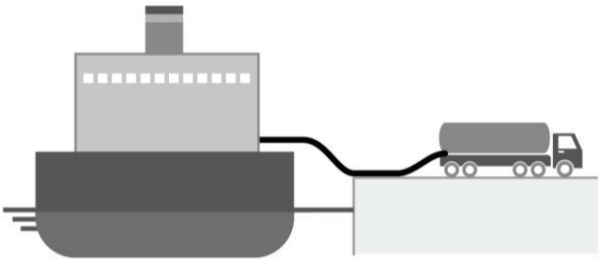
g) local conditions (e.g. weather, traffic).

Three typical LNG bunkering supply scenarios have been considered in this document (see Figure 1):

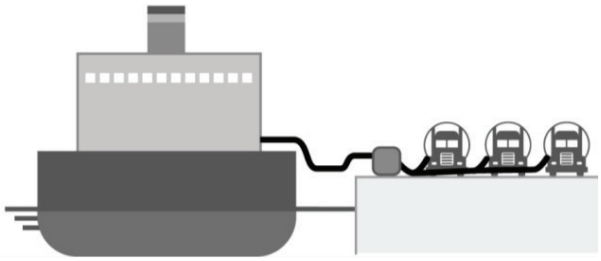
— Mobile-to-Ship: An LNG bunkering operation to a gas-fuelled vessel from a mobile bunkering facility located onshore. Mobile bunkering facilities can consist of a truck, rail car or other mobile device (including portable tanks) used to bunker LNG (see Figure 1).

— Shore-to-Ship: An LNG bunkering operation to a gas-fuelled vessel from a fixed bunkering facility or terminal (see Figure 1).

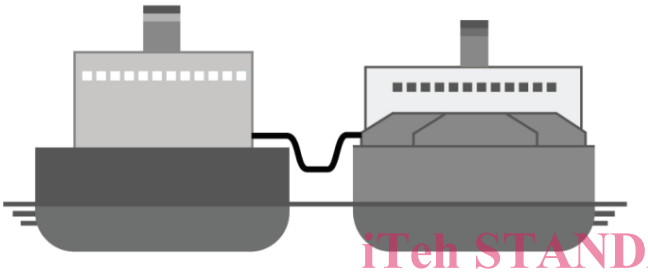
— Ship-to-Ship: An LNG bunkering operation to a gas-fuelled vessel from a floating storage or bunker vessel (see Figure 1).



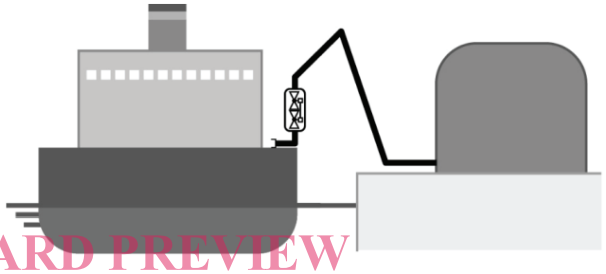
Receiver	Supplier
Gas-fuelled vessel	Bunkering facility
Mobile to Ship bunkering from a truck	



Receiver	Supplier
Gas-fuelled vessel	Bunkering facility
Mobile to Ship bunkering from multiple trucks/portable tanks, throughout a jointed manifold/pumping station	



Receiver	Supplier
Gas-fuelled vessel	Bunkering facility
Ship to ship bunkering from a floating storage or bunker vessel	



Receiver	Supplier
Gas-fuelled vessel	Bunkering facility
Shore to ship bunkering from a fixed bunkering facility/terminal	

Figure 1 — Typical LNG supply bunkering scenarios

5 Properties and behaviour of LNG

5.1 General

The properties, characteristics and behaviour of LNG differ significantly from conventional marine fuels for example HFO and MGO, etc. For these reasons, it is essential that all LNG bunkering operations are undertaken with diligence, that 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 the LNG bunkering supply chain, each element is carefully designed and has dedicated safety operational and maintenance procedures executed by trained and competent 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.

LNG for fuel supply may be delivered at an elevated pressure and at a temperature exceeding its 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. The vapour release will form a flammable cloud which at these temperatures is denser than air. The dispersing gas becomes lighter than air (buoyant) at approximately –110 °C so will drift with wind and be diluted by atmospheric turbulence and diffusion. The coldness of the gas will condense moisture in the air making the dispersing gas visible as a white cloud.

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

LNG can cause brittle fracture if spilled on unprotected carbon steel.

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. The properties of traditional fuels are different; MGO has a flashpoint in excess of 60 °C and a self-ignition temperature of 300 °C for 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 conventional fuel oil fires in engine rooms, but low energy sparks represent a higher risk.

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

The following are the main hazards associated with LNG applicable to bunkering operations:

— fire (pool fire, jet/torch fire, flash fire) explosion (in confined spaces) from ignited natural gas evaporating from spilled LNG;

— vapour dispersion;

— brittle fracture of the steel structure exposed to LNG spills;

— frostbite or cold burn from liquid or cold vapour spills;

— asphyxiation from vapour release;

— over-pressure or pressure surge of the bunker system caused by thermal expansion or vaporization of trapped LNG;

NOTE The thermal expansion coefficient of LNG is high.

— release in confined spaces causing over-pressure due to vaporization of liquid;

— possible RPT (rapid phase transition from liquid to gas);

— possible stratification with existing LNG in tanks (might later lead to inadvertent venting of gas);

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

5.3 Potential hazardous situations associated with LNG bunker 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.