ISO/TS 16901:2022(E)

Date: 2022-09-13

ISO TC 67/SC 9/WG 11

Date: 2022-07-26

Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface

Guide pourRecommandations sur l'évaluation des risques dans la conception d'installations terrestres pour le GNL en incluant l'interface terre/navire

Publication stage

A model manuscript of a draft International Standard (known as "The Rice Model") is available at

Contents

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 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*~~, *Oil and* ~~*offshore structures for petroleum, petrochemical and natural*~~ *gas industries including lower carbon energy*, Subcommittee SC 9, *Liquefied natural gas installations and equipment*.

This second edition cancels and replaces the first edition (ISO/TS 16901:2015), which has been ~~editorially~~technically revised.

The main changes are as follows:

— reference to IGF code added ~~in~~to the scope;

— references updated in ~~Chapter~~ Clause 2 and the bibliography;

— definitions added for HSE critical activity and HSE critical element.

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.

Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface

1 Scope

This ~~Technical Specification~~document provides a common approach and guidance to those undertaking assessment of the major safety hazards as part of the planning, design, and operation of LNG facilities onshore and at shoreline using risk-based methods and standards, to enable a safe design and operation of LNG facilities. The environmental risks associated with an LNG release are not addressed in this ~~Technical Specification~~document.

This ~~Technical Specification~~document is ~~aimed to be applied~~ applicable both to export and import terminals~~,~~ but can be applicable to other facilities such as satellite and peak shaving plants.

~~It applies~~This document is applicable to all facilities inside the perimeter of the terminal and all hazardous materials including LNG and associated products: LPG, ~~pressurised~~pressurized natural gas, odorizers, and other flammable or hazardous products handled within the terminal.

The navigation risks and LNG tanker intrinsic operation risks are recognised, but they are not in the scope of this ~~Technical Specification.~~document. Hazards arising from interfaces between port and facility and ship are addressed and requirements are normally given by port authorities. It is assumed that LNG carriers are designed according to the IGC code, and that LNG fuelled vessels receiving bunker fuel are designed according to IGF code.

Border between port operation and LNG facility is when the ship/shore link (SSL) is established.

~~It~~This document is not intended to specify acceptable levels of risk; however, examples of tolerable levels of risk are referenced.

~~This Technical Specification is not intended to be used retrospectively.~~

~~It is recognised that national and/or local laws, regulations, and guidelines take precedence where they are in conflict with this Technical Specification.~~

~~Reference is made to~~See IEC 31010 and ISO 17776 with regard to general risk assessment methods, while this ~~Technical Specification~~document focuses on the specific needs scenarios and practices within the LNG industry.

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 17776:2016, *Petroleum and natural gas industries — Offshore production installations — Guidelines on tools and techniques for hazard identification and risk assessment*~~

3 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
as low as reasonably practicable
ALARP
reducing a *risk* (3.28) 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

3.2
boiling liquid expanding vapour explosion
BLEVE
sudden release of the content of a vessel containing a pressurisedpressurized flammable liquid followed by a fireball

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

[SOURCE: ISO/TS 18683, 3.1.2], modified — Note to entry added.]

3.3
bow-tie
pictorial representation of how a hazard can be hypothetically released and further developed into a number of *consequences* (3.6)

Note 1 to entry: The left-hand side of the diagram is constructed from the fault tree (causal) analysis and involves those threats associated with the hazard, the controls associated with each threat, and any factors that escalate likelihood. The right-hand side of the diagram is constructed from the hazard event tree (consequence) analysis and involves escalation factors and recovery preparedness measures. The centre of the bow-tie is commonly referred to as the "top event".

3.4
cost to avert a fatality
CAF
value calculated by dividing the costs to install and operate the protection/*mitigation* (3.20) by the reduction in *potential loss* (3.22) of life (PLL)

Note 1 to entry: It is a measure of effectiveness of the protection/mitigation.

3.5
computational fluid dynamics
CFD
numerical methods and algorithms to solve and analyse problems that involve fluid flows

3.6
consequence
outcome of an event

3.7
cost benefit analysis
CBA
means used to assess the relative cost and benefit of a number of *risk* (3.28) reduction alternatives

Note 1 to entry: The ranking of the risk reduction alternatives evaluated is usually shown graphically.

3.8
design accidental load
DAL
most severe accidental load that the function or system ~~shall be~~is able to withstand during a required period of time, in order to meet the defined *risk* (3.28) acceptance criteria

3.9
explosion barrier
structural barrier installed to prevent explosion damage in adjacent areas

~~Note 1 to entry: A wall is an example of an explosion barrier.~~

EXAMPLE A wall.

3.10
***F*/*N* curve**
FN
plot of cumulative frequency versus *N* or more persons that sustain a given level of harm from defined sources of hazards

3.11
failure mode and effect analysis
FMEA
analytically derived identification of the conceivable equipment failure modes and the potential adverse effects of those modes on the system and mission

Note 1 to entry: It is primarily used as a design tool for review of critical components.

3.12
fatal accident rate
FAR
number of fatalities per 100 million hours exposure for a certain activity

3.13
harm
physical injury or damage to the health of people or damage to property or the environment

3.14
hazard
potential source of *harm* (3.13)

3.15
hazard identification
HAZID
brainstorming exercise using checklists the hazards in a project are identified and gathered in a *risk register* (3.39) for follow up in the project

3.16
hazard and operability study
HAZOP
systematic approach by an interdisciplinary team to identify hazards and operability problems occurring as a result of deviations from the intended range of process conditions

Note 1 to entry: It consists of four steps: definition, preparation, documentation/follow up and examination to manage a hazard completely.

3.17
health, safety and environmental critical activity
HSE critical activity
activity or task ~~which~~that provides or maintains barriers

3.18
health, safety and environmental critical element
HSE critical element
component or system whose failure could cause or substantially contribute to the loss of integrity and safety of a system and whose purpose is to prevent or mitigate from the effects of hazards

3.19
impact assessment
assessment of how *consequences* (3.6) (fires, explosions, etc.) do affect people, structures the environment, etc.

3.20
mitigation
limitation of any negative *consequence* (3.6) of a particular event

3.21
Monte Carlo simulation
simulation having many repeats, each time with a different starting value, to obtain distribution function

3.22
potential loss
product of frequency and *harm* (3.13) summed over all the outcomes of a number of top events

3.23
probability
extent to which an event is likely to occur

3.24
probit
inverse cumulative distribution function associated with the standard normal distribution

Note 1 to entry: Probit is used in QRA to describe the relation between exposure, e.g. to radiation or toxics, and fraction fatalities.

3.25
protective measure
means used to reduce risk

3.26
quantitative risk assessment
QRA
techniques whichthat allow the *risk* (3.28) associated with a particular activity to be estimated in absolute quantitative terms rather than in relative terms such as high or low

Note 1 to entry: QRA may be used to determine all risk dimensions, including risk to personnel, risk to the environment, risk to the installation, and/or the assets and financial interests of the company. Reference is made toSee ISO 17776:2016, B.12.

3.27
residual risk
risk (3.28) remaining after *protective measures* (3.25) have been taken

3.28
risk
combination of the *probability* (3.23) of occurrence of *harm* (3.13) and the severity of that harm

3.29
risk analysis
systematic use of information to identify sources and to estimate the *risk* (3.28)

3.30
risk assessment
overall process of *risk analysis* (3.29) and *risk evaluation* (3.33)

3.31
risk contour
RC
two-dimensional representation of *risk* (3.28) on a map

Note 1 to entry: Also called individual risk contours (IRC) or location-specific risk (LSR).

3.32
risk criteria
terms of reference by which the significance of *risk* (3.28) is assessed

3.33
risk evaluation
procedure based on the *risk analysis* (3.29) to determine whether the *tolerable risk* (3.47) has been achieved

3.34
risk management
coordinated activities to direct and control an organization with regard to *risk* (3.28)

3.35
risk management system
set of elements of an organization's management system concerned with managing *risk* (3.28)

3.36
risk matrix
matrix portraying *risk* (3.28) as the product of *probability* (3.23) and *consequence* (3.6), used as the basis for risk determination

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

3.37
risk perception
way in which a *stakeholder* (3.46) views a *risk* (3.28) based on a set of values or concerns

3.38
risk ranking
outcome of a qualitative *risk analysis* (3.29) with a numerical annotation of *risk* (3.28)

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.

3.39
risk register
hazard management communication document that demonstrates that hazards have been identified, assessed, are being properly controlled, and that recovery preparedness measures are in place in the event control is ever lost

3.40
risk transect
RT
representation of *risk* (3.28) as a function of distance from the hazard

3.41
rollover
sudden mixing of two layers in a tank resulting to a massive vapour generation

3.42
rapid phase transition
RPT
explosive change from liquid into vapour phase

Note 1 to entry: When two liquids at two different temperatures come into contact, explosive forces can occur, given certain circumstances. This phenomenon, called rapid phase transition (RPT), can occur when LNG and water come into contact. Although no combustion occurs, this phenomenon has all the other characteristics of an explosion. RPTs resulting from an LNG spill on water have been both rare and with relatively limited *consequences* (3.6).

3.43
safety

freedom from unacceptable *risk* (3.28)

3.44
SIMOPS
concatenation of simultaneous operations

Note 1 to entry: SIMOPS often refers to events such as maintenance or construction work in an existing plant when there are more personnel near a live operating plant and who are exposed to a higher level of *risk* (3.28) than normal.

3.45
showstopper
event or *consequence* (3.6) that produces an unacceptable level of *risk* (3.28) such that the project cannot proceed and where the level of risk cannot be mitigated to an acceptable level

3.46
stakeholder
~~any~~ individual, group, or organization that can affect, be affected by, or perceive itself to be affected by a *risk* (3.28)

3.47
tolerable risk
risk (3.28) ~~which~~that is accepted in a given context based on the current values of society

~~4 Abbreviations~~

~~For the purposes of this Technical Specification, the following abbreviations apply:~~

3.48
individual risk
probability of being killed (or harmed at certain level) on an annual basis from all *hazards* (3.13)

3.49
potential loss of life
expected value of the number of fatalities per year (or over the life time of a project)

4 Abbreviated terms

ALARP	as low as reasonably practicable~~;~~
BLEVE	boiling liquid expanding vapour explosion~~;~~
CAF	cost to avert a fatality~~;~~
CFD	computational fluid dynamics~~;~~
CBA	cost benefit analysis~~;~~
DAL	design accidental load~~;~~
EDP	emergency depressuring~~;~~
ERC	emergency release coupling~~;~~
ESD	emergency shutdown~~;~~
ETA	event tree analysis~~;~~
FAR	fatal accident rate~~;~~
FEED	front-end engineering design~~;~~
FEM	finite element method~~;~~
FN	frequency vs number (of affected individuals~~);~~)
FMEA	failure mode and effect analysis~~;~~
FMECA	failure, modes, effects, and criticality analysis~~;~~
HAZID	hazard identification~~;~~
HAZOP	hazard and operability study~~;~~
HEMP	hazards and effects management process~~;~~
HSE	health, safety and environmental
IR	individual risk contour~~;~~
LSR	location-specific risk~~;~~
LOPA	layers of protection analysis~~;~~

