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Loading and unloading of liquefied natural gas (LNG) tank wagons and containers

Chargement et déchargement de wagons-citernes et conteneurs de gaz naturel liquéfié (GNL)

Reference number
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Contents

Foreword

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This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 9, *Production, transport and storage facilities for cryogenic liquefied gases*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 282, *Installation and equipment for LNG*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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.

Loading and unloading of liquefied natural gas (LNG) tank wagons and containers

1 Scope

This document provides requirements and recommendations for the design, construction and operation of newly installed liquefied natural gas (LNG) railway loading and unloading facilities for use on onshore LNG terminals, LNG satellite plants, handling LNG tank wagons or tank containers engaged in international trade.

The designated boundary limits of this document are between the LNG terminal's inlet/outlet piping headers at the beginning of the rail loading or unloading area and the rail track area used for LNG tank wagons and containers. It is applicable to all rail loading bays, weighbridge(s) and related subsystems.

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 16903, *Petroleum and natural gas industries — Characteristics of LNG, influencing the design, and material selection*

EN 1473:2021, *Installation and equipment for liquefied natural gas — Design of onshore installations*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
ageing
gradual change in the molecular composition of *LNG* (3.8) throughout the supply chain caused by differential evaporation because LNG has components with different boiling points

3.2
boil-off gas
BOG
natural gas (3.11) resulting from slow evaporation of *LNG* (3.8) at its equilibrium state or rapid evaporation of LNG, also called flashing, inside equipment

3.3
control room
core functional entity, and its associated physical structure, where operators are stationed to carry out centralized control, monitoring and administrative responsibilities

[SOURCE: ISO 11064-1:2000, 3.2]

3.4
emergency release coupling
ERC
device to provide a means of quick release of LNG transfer system when such action is required only as an emergency measure

[SOURCE: ISO/TR 17177:2015, 2.1.4]

3.5
ESD
emergency shutdown
system that safely and effectively stops the whole plant or individual units to minimize incident escalation

[SOURCE: ISO 20257-1:2020, 3.1.15, modified — "emergency shutdown" has been changed from a preferred term to an admitted term.]

3.6
flare
system to ignite the vapour on a safe location in a controlled manner

3.7
impounding basin
area defined at the site for collecting any accidental spill of hydrocarbons

3.8
LNG
liquefied natural gas
colourless and odourless cryogenic fluid in the liquid state at normal pressure composed predominantly of methane which can contain minor quantities of ethane, propane, butane, nitrogen, or other components normally found in *natural gas* (3.11)

Note 1 to entry: LNG is designated as "UN 1972" by United Nations.

[SOURCE: ISO 16903:2015, 3.3, modified — Note 1 to entry has been added.]

3.9
LNG tank wagon
railway goods wagon with a tank and loading or discharge arrangement for the transport of permanently mounted *LNG* (3.8)

3.10
LNG tank container
mobile tank for the transport of *LNG* (3.8) that may be mounted on railway wagons and may also be loaded or unloaded while mounted

3.11
natural gas
NG
complex gaseous mixture of hydrocarbons, primarily methane, but generally including ethane, propane and higher hydrocarbons, and some non-combustible gases such as nitrogen and carbon dioxide

[SOURCE: ISO 14532:2014, 2.1.1.1, modified — "includes" has been changed to "including"; note 1 to entry has been removed.]

3.12
quick connect disconnect coupler
QCDC
manual or hydraulic mechanical device used to connect the *transfer system* (3.14) to the *LNG tank wagon* (3.9) or *container* (3.10)

[SOURCE: ISO 16904:2016, 3.39, modified — "cargo manifold" has been changed to "LNG tank wagon or container"; "without employing bolts" at the end of the definition has been removed.]

3.13
transfer
loading or unloading operation

3.14
transfer system
flexible (hose) or rigid (articulated arm) system used for transferring *LNG* (3.8) between the terminal and *LNG tank wagon* (3.9) or *container* (3.10)

Note 1 to entry: It can be referred to as a "loading arm or loading hose" or "unloading arm or unloading hose".

4 Equipment design

4.1 LNG tank wagon

It is presupposed that the LNG tank wagon is designed, homologated, tested and equipped according to the requirements of dangerous goods transport of the national regulatory body following the UN transport recommendations (orange book, e.g. RID for Europe and MED) and that regular inspections and maintenance are performed according to the applicable laws and regulations for dangerous goods applicable for LNG UN1972.

The dimensions of an LNG tank wagon shall be chosen in a way that payload and tank volume are corresponding when loaded with LNG.

LNG tank wagons shall be equipped with cabinets on both sides of the wagon which contain the operating valves and connections. These cabinets should be executed to work as drip trays.

4.2 LNG tank container

It is presupposed that the LNG tank container is designed, tested and equipped according to the requirements of IMO-IMDG or requirements of the valid national regulatory body following the UN transport recommendations (orange book, e.g. RID for Europe and MED) and that regular inspections and maintenance shall be performed according to the applicable laws and regulations for dangerous goods mandatory for LNG UN1972.

The dimensions of a tank container shall be chosen in a way that payload and tank volume are corresponding when loaded with LNG.

Tank containers shall be equipped with cabinets which contain the operating valves and connections. These shall be provided on the side or at the face of the tank container. These cabinets should be executed to work as drip trays.

4.3 Tanks for LNG tank wagons and tank containers

Tanks for the transport of LNG shall provide the following connections:

— product connection liquid phase;

— product connection vapour phase;

— drive away protection;

— electric earthing connecting point;

— air connection, if pneumatic valves are used for the LNG tank wagon.

Tanks shall provide the following equipment:

— overpressure protection valve;

— thermal relief valves on lines between block valves;

— closing installation for first closure valves in case the wagon moves.

It can be useful to provide a regasification or pressurizing circuit to speed up the discharge in case no external source of pressure is available.

The tank of the wagon or container shall be insulated to minimize boil-off gas during possible transportation time as it reduces the thermal ingress from the environment and thus significantly reduces the associated safety risks.

NOTE Information on the design of vacuum insulated tanks is given in the ISO 20421 series.

The tank shall be designed in order to withstand liquid nitrogen (for commissioning) temperatures on the low range and up to +50 °C on the high range.

The manufacturer of the tank shall provide for its appropriate operation:

— approval of the tank by a surveying institute including calculation of the shell;

— operating manual including a description of the tank;

— loading data sheet of initial filling, holding time and payload;

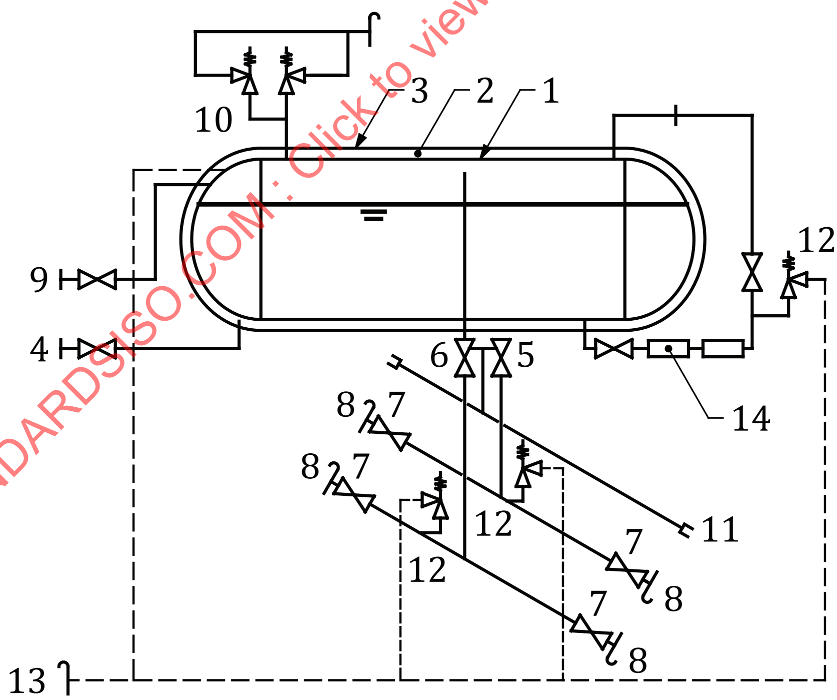
— loading data sheet of initial pressure and holding time;

— flow schemes;

— information about spare parts.

Loading of an LNG tank wagon or container can be controlled by scales or by using level-check valves (if level-loading) to prevent overloading.

The basic layout of tanks for LNG tank wagons or tank containers is shown in Figure 1 and Figure 2. Examples of an LNG tank wagon and an LNG tank container are given in Figure 3 and Figure 4.



Key

⊢ closure, flange or coupler

——— product line or operational line

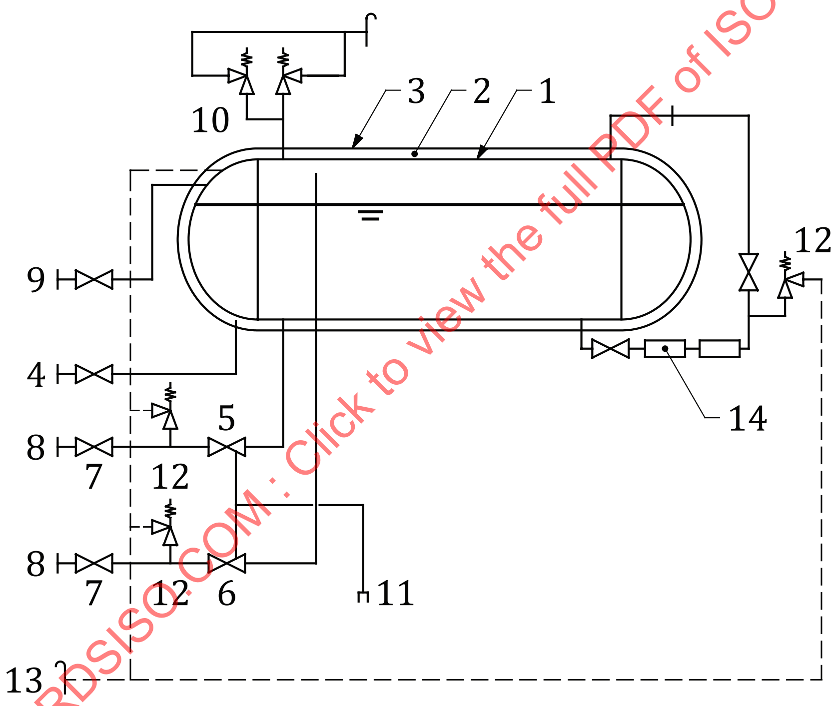
valve

– – – return line for thermal expansion

1 tank shell

2 insulation
3 outer shell
4 test valve for vacuum (if applicable)
5 foot valve
6 gas return valve
7 side valves
8 connecting coupler (if applicable) or connecting flange
9 test lines for level loading
10 safety valves
11 pneumatic control of foot valve and gas-exchange valve
12 thermal expansion safety valve
13 connection to connect boil-off
14 evaporator/heat exchanger (if applicable)

Figure 1 — LNG tank wagon/container with connections on the side



Key

⊢ closure, flange or coupler
——— product line or operational line
—⋈— valve
– – – return line for thermal expansion
1 tank shell
2 insulation
3 outer shell
4 test valve for vacuum (if applicable)
5 foot valve
6 gas return valve
7 side valves
8 connecting coupler (if applicable) or connecting flange

9 test lines for level loading
10 safety valves
11 pneumatic control of foot valve and gas-exchange valve
12 thermal expansion safety valve
13 connection to connect boil-off
14 evaporator/heat exchanger (if applicable)

Figure 2 — Tank container with connections on the end

Figure 3 — Example of an LNG tank wagon

Figure 4 — Example of an LNG tank container

4.4 Loading or unloading bay configuration

The loading or unloading bay:

a) shall be equipped with a flexible hose or loading arm, which may be equipped with a cryogenic QCDC, dry break coupler, or similar;

b) shall have means of preventing leaks at hose or arm rupture such as an ERC, cryogenic break away coupling or other measures;

c) shall be equipped with shut-off valves or ESD valves;

d) shall allow for complete purging of the loading arm or hose after loading or unloading back to the header with nitrogen to avoid emissions;

e) shall allow for accurate loading or unloading, via flowmeters (e.g. Coriolis), both on liquid and vapour return line and/or (dynamic) weighbridge; another custody transfer flow meter may be considered;

f) shall be equipped with liquid, vapour, nitrogen and ground earthing connections;

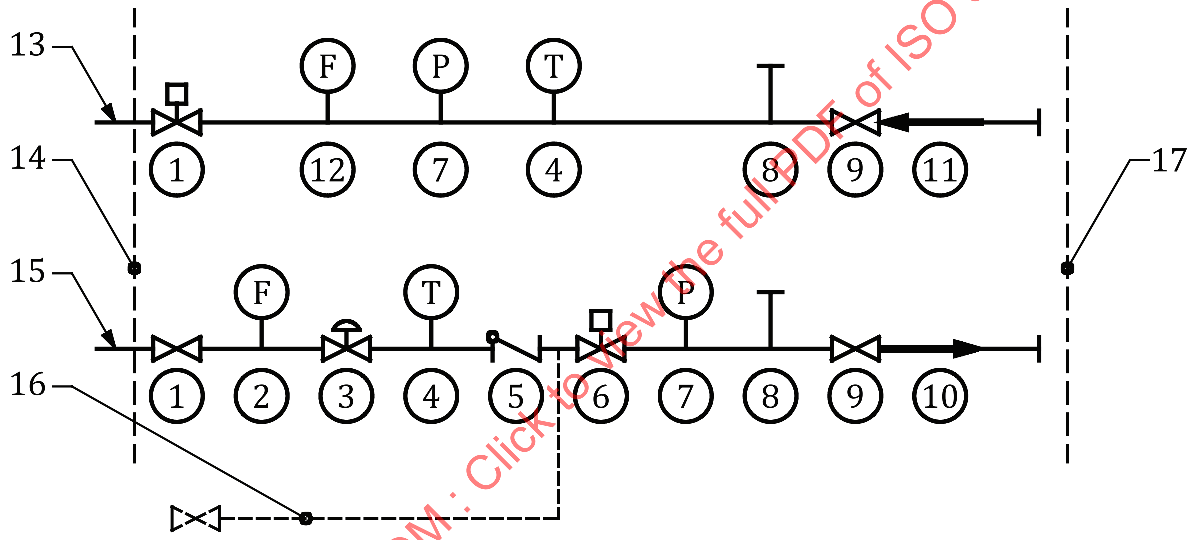
g) shall be equipped with instrument air connection if the LNG tank wagon or container is equipped with pneumatic foot valves;

h) shall be equipped with an instrument air connection hose with suitable coupling to connect to the pneumatically actuated foot valve of the LNG tank wagon or container, if the LNG tank wagon or container is equipped with pneumatic valves;

i) shall be connected to the terminal's control system;

j) shall be connected to LNG spill channelling facilities (see 5.1.4).

A typical arrangement of an LNG tank wagon or container loading system is shown in Figure 5.



Key

1 block valve (if required)
2 flow meter LNG
3 flow control valve
4 temperature measurement device
5 check valve
6 ESD valve
7 pressure measurement device
8 nitrogen connection
9 block valve
10 LNG hose/loading arm
11 BOG hose/lading arm
12 flow meter BOG (if required)
13 BOG
14 terminal

15 LNG
16 recirculation line (if required)
17 tank wagon/container

NOTE For simplicity, pressure safety valves (PSVs) are not depicted in this figure.

Figure 5 — Schematic arrangement of LNG tank wagon or container loading system

4.5 Connection couplings

4.5.1 Type and size of connections

For connecting several LNG tank wagons, any type of connection, for example, flanges (according to ISO 7005-1), threaded (various types exist globally) or quick couplings (according to ISO 21593) may be used.

The supplier, forwarder and receiver of LNG shall agree on the type of connection in advance.

In order to maximize compatibility and uniformity across different terminals and countries, the following connection sizes should be used:

— 3” for the LNG line;

— 2” for the vapor return line

Liquid and vapor lines shall have nozzles of different sizes to exclude the possibility of erroneously connecting a vapour line to a liquid nozzle and vice versa.

4.5.2 Quick connect disconnect coupler (QCDC)

The coupling shall consist of a nozzle (hose unit) and a receptacle (tank unit) The nozzle allows quick and dry connection and disconnection of the LNG loading system to the receptacle mounted on the manifold of the LNG tank wagon or container.

The design of the QCDC may cater for a dry break coupling according to ISO 21593.

This document specifies the technical requirements to disconnect and connect LNG loading systems and provides the detailed design construction and testing requirements for QCDC dry break couplings.

The main interface seal is located between the LNG tank wagon or container and the loading station. The interface seal shall be exchangeable for replacement purposes. The interface seal between the LNG tank wagon or container and loading station shall be located at the loading station.

4.5.3 Emergency release coupling (ERC)

To avoid damage of equipment and escalation of the risk, an ERC, or other equivalent measures, shall be used as a safety device for both LNG and gas vapor return lines.

Both sections of the ERC shall be equipped with shut off valves to avoid spills of LNG. Both ERCs should be activated at the same time if technically possible (e.g. trigger cable assembly, pneumatic trigger).

4.6 LNG transfer hoses or arms

The transfer of LNG from a terminal to an LNG tank wagon or container is the transfer from a static position to a potentially moving part.

LNG transfer equipment can be either a rigid loading arm or a flexible hose.

Rigid loading arms and hoses should be supported to keep the connections aligned when moving to avoid burdening the connection with a weight or torque.

It shall be ensured that hoses are not damaged by handling during connection and disconnection (by hose dragging on the ground). A hose handling equipment should be employed.

A leak test with N_2 should be conducted before each loading operation as it significantly reduces the risk of leak during loading or unloading.

During ramp up (increasing flow) a visual check for leakage should be conducted.

Special provision should be made in order to prevent small spills of LNG to protect the rails, the rail bed, the undercarriage and adjacent structures by e.g. drip trays from embrittlement.

The parking position for hoses or loading arms may be detected by usage of proximity sensors.

4.7 General process design requirements

4.7.1 General

The system may be designed for both LNG tank wagons and tank containers. More specifically, the rail loading or unloading system may enable loading or unloading different types of cryogenic LNG tank wagon and tank containers. The possibility of accommodating multiple locations of interface (i.e. nozzles position and/or distance between LNG tank wagons or containers) may be considered during the design of the system.

The planned system shall be operated in cryogenic conditions. Therefore, the system may be designed so that it is possible to continuously recirculate LNG via a cold circulation line even when the railway loading system is not used. In that case, the recirculation flow should be assessed considering the pumping heat and the heat ingress from the environment, according to the maximum external site conditions. The system shall be able to handle its incoming content which can contain air or inert gases or unmeasured BOG composition. Nitrogen purging should be used in order to eliminate any moisture or oxygen (air-related) content prior to the connection of the manifold to the LNG tank wagon or tank container.

The material selection, such as coupling and piping, shall be in accordance with ISO 16903.

The system for process works should consist of a loading header, a filling facility, a BOG return header and an auxiliary utilities system.

In order to prevent LNG vapour from entering the environment, the system shall make it possible to handle the boil-off gas from the LNG tank wagons or containers undergoing loading and unloading.

4.7.2 Overfill detection and overpressurization

The system shall be designed in such a way that LNG overfill and potential overflow into the BOG header is either avoided or mitigated. To avoid overfilling of an LNG tank wagon or container, an overfill detection in the vapour return line should be included in the design.

Overfilling avoidance can be achieved on the terminal side via the flowmeters and/or with a weighing bridge.

Overfill detection can be achieved with a temperature transmitter or switch on the BOG line located as close as possible to the LNG tank wagon or container vapor nozzle.

Additionally, a differential pressure level gauge may be used on the LNG tank wagon or container as a means to avoid overfilling.

The vapour return line shall also be designed for liquid. The used vapour return loading arm or hose shall be designed for LNG.

The system shall be designed such that overpressurization of the LNG tank wagon or container during loading is not possible e.g. via a pressure control loop (pressure control valve and pressure transmitter).

Between two liquid line block valves a thermal relief valve shall be installed. A pressure safety valve shall be installed wherever an overpressurization of the piping system is possible. For related information on safety valves and isolation philosophy, see EN 1473:2021, 7.4.7 and 7.4.12.

The system for process works may include a drain thermal relief (DTR) header which collects the release from thermal relief valves, the liquid content when draining the LNG line and/or hose loading arms and the liquid LNG in case of an LNG tank wagon or container overfill and returns them to the terminal. It may also include a low-pressure vent (LPV) header which collects the reliefs of pressure safety valves on vapour lines and all the vents and returns them to the terminal [BOG system or storage tank(s) or flare]. In general, such operational emissions shall be recovered and/or safely treated (flared) to ensure minimal environmental impact.

The whole loading or unloading operation (cooling, filling and final loading) may be sequenced and carried out automatically using a local control system or integrated into the terminal's control system (e.g. DCS). A database or registry should be used to log the details of the LNG tank wagons or containers (e.g. net weight, inspection).

All safety-related instruments and equipment of the LNG tank wagon or container loading or unloading area shall be fully integrated into the existing safety instrumented system (SIS) of the terminal.

NOTE The safety instrumented system (SIS) is specified in EN 1473:2021, 7.5.1.3.

Prior to filling, an LNG tank wagon or container may be either cold (a heel of LNG in the container) or warm (ambient temperatures). For accommodating the latter case, system design provisions or an operational procedure shall be in place to cool-down the container in a steady and controlled manner.

Rain (spray) loading - loading LNG in a liquid state through the vapour connection, which leads to steaming the product thus cooling down the tank- is one possibility to achieve this, if the LNG tank wagon or tank container allows for it.

4.7.3 Loading and unloading process

The loading or unloading may be either automated or manual. It shall comprise of a ramp-up section, a full filling rate section and a ramp-down section.

Loading LNG from the terminal to tank wagons or containers is typically executed with dedicated LNG pump(s).

Unloading from LNG tank wagons or containers to the terminal is typically executed via:

— unloading pumps located on the terminal;

— unloading pumps located on the LNG tank wagons or containers; or

— pressurizing the LNG tank wagons or containers with on-board vaporizers.

For pump requirements ISO 16904 may be used.

NOTE See EN 1473:2021, Clause 6 for more information on risk management

4.7.4 Quantity and quality measurement

Various, novel or contemporary measuring technologies can be considered for the continuous or intermittent measurement of LNG flow and quality.

The facility shall be equipped with metering systems enabling commercial LNG transactions of the quantity (e.g. volumetric or mass meters) and quality measurement (e.g. calorific value) of the LNG loaded to LNG tank wagons or containers, in accordance with OIML (International Organisation of Legal Metrology) standards.

The tracks of the rail loading area can be equipped with one or multiple static weighbridges to control the weight of LNG to be loaded or unloaded and determine the loaded quantity.

Optionally, the weighbridge may be of the dynamic type installed in dedicated sidings and shall be able to weigh the whole length of the LNG tank wagon or container in motion.

New online measuring technologies are under development such as laser Doppler velocimetry (LDV) for flow measurement and Raman spectroscopy for quality.

Intermittent, off-line quality measurement involves the sampling of LNG.

It can be considered to sample and/or calculate the LNG quality based on prediction tools.

4.7.5 Sampling

Samples for quality verification, if any, may be taken at various locations as agreed among the parties concerned. When sampling of LNG for analysis is carried out, it should be in accordance with the procedures provided in ISO 8943.

The LNG collected in liquid state shall be instantly conditioned to gaseous state, to its entirety (without any partial vaporization or loss of molecular components) to ensure a representative sample. As defined in ISO 8943, there are two methods of sampling LNG: continuous and intermittent.

Load port samples may be used for quality determination if the sampling equipment is not available on-site, provided that ageing is taken into account.

4.7.6 Predicting LNG quality change due to ageing

Various prediction tools can be applied to calculate the amount of boil-off gas and simulate the rate of ageing once the original LNG composition is measured and the heat ingress is estimated. These tools can predict and estimate the LNG quality at the delivery point and help to manage the ageing during the operation. See ISO 23306 for more information.

5 Leak and fire management

5.1 Leak avoidance, detection and management

5.1.1 General

A general risk assessment shall be performed as part of the overall LNG terminal design and shall include the LNG railway loading and unloading facilities.

5.1.2 Avoidance

There are several technical and operational means to avoid an LNG leak on the rail loading area.

Modern types of couplings, valves and instrumentation are the following:

a) emergency break-away couplings that shut off LNG flow in the event of an LNG tank wagon or container movement;

b) quick connect disconnect coupling as described in 4.5.2;

c) fail-to-close foot valve and gas return valve at the event of loss of instrument air;

d) fail-to-close valves on the loading bay;

e) fire-rated instrumentation, so that external fire cannot melt away instruments and valves;

f) ESD interlink (electronic or pneumatic) that isolates the tank wagon in case of a process upset and avoid escalation of the hazard.

Periodical inspection and testing of piping and equipment on the terminal shall be carried out by specifically trained shift operators or dedicated external third-party inspectors, as per the terminal's continuous inspection plan.

An inspection of the LNG tank wagon and its equipment shall be carried out. Additionally, a pre-arrival or pre-loading check of the LNG tank wagon or container should be carried out to check overall integrity and safety functions such as checklists, inspection of connection points, verification certificates of relief valve(s) before registration for loading at the terminal. Periodically, a functional test of the function of the LNG tank wagon ESD valves shall be carried out. See EN 1473:2021 for additional guidance.

5.1.3 Gas detection

LNG leaks can be detected with various types of on field devices.

There are different types of detectors, with gas detectors (electrochemical sensor technology) being the most suitable for the LNG tank wagon or container loading area.

Low temperature detection is also an option usually for larger spills and thus fit for the impounding basins and related ground channels.

The installation location and number of detectors varies per site layout and per manufacturer's specification and requirements.

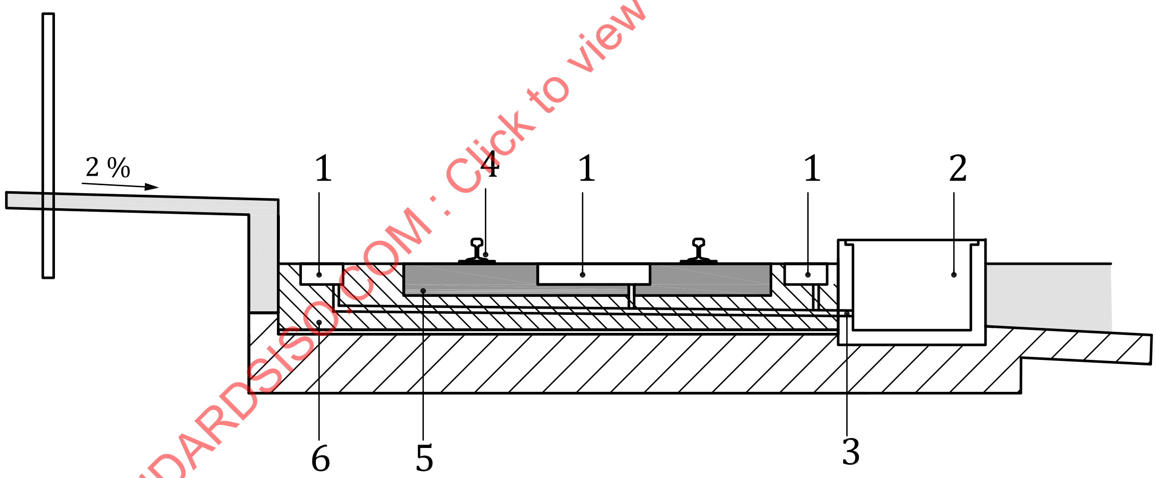
5.1.4 Management

A hazard assessment shall be performed. Typically, a leak may occur due to a faulty (e.g. untested) connection between the LNG tank wagon or container and the loading arm or hose.

Once a leak occurs within the rail loading area, there are several means to manage the liquid phase of the natural gas.

The liquid phase should be collected and channelled by spillage channels into dedicated reinforced-concrete impounding basins. The designer shall take special provisions so that the rail track civil works have sufficient slope to lead the leaking product towards the impounding basins.

A typical schematic arrangement of a dedicated rail tracks spillage channel is depicted in Figure 6.



Key

1 spill tray
2 concrete spillage channel
3 pipe
4 rail
5 rail element with metal grid
6 coarse aggregate

Figure 6 — Dedicated rail tracks spillage channel

In the event that liquid is flowing into the impounding basin(s), there are different means to reduce the evaporation rate of the LNG, e.g. foam, blanket.

To address large spills, the impounding basin capacity shall be determined by a risk analysis.

Typically, the impounding basin is sized as the biggest accommodated LNG tank wagon plus 10 % (volume fraction).

If using impounding areas, they shall be located so that the heat flux from a fire over the impounding area shall not cause major structural damage to any LNG tank wagon or container that could prevent their movement and removal from site.

5.2 Fire avoidance, detection and management strategies

5.2.1 Fire avoidance

There are several technical and operational means to avoid an LNG fire and its escalation on the rail loading area.

a) High-expansion foam systems may be applied on the impounding basin once LNG has ingressed thereinto.

b) Water spraying with water deluge systems of adjacent LNG tank wagons or containers can be applied when the in-between LNG tank wagon or container is on fire in order to keep them cool.

5.2.2 Fire detection

LNG fire can be detected with various types of on-field devices.

There are different types of fire detectors; heat-sensing (e.g. infrared or thermal camera), smoke-sensing, radiant-energy sensing and multi-sensor (heat and smoke).

The installation location and number of detectors varies per site layout and per manufacturer's specification and requirements.

5.2.3 Fire management

A complete risk assessment shall take place where the best options or solutions are selected.

A firefighting strategy involving persons should be avoided for large fires, due to the risk of injury or loss of life. Mitigation systems for large fires shall be designed to mitigate escalation or delay escalation, such that evacuation of the affected premises can be achieved timely.

An automatic dry powder system triggered by fire detectors may be used to extinguish fire on an LNG tank wagon or container.

6 Layout considerations

6.1 Safety separation distances

A quantitative risk assessment (QRA) may be used to define separation distances from buildings, the tank area, other typical equipment and public or semi-industrial installations according to EN 1473.

6.2 Typical equipment layout

The rail loading system shall be able to accommodate a train set of rail platforms of tank containers, as well as a train set of LNG tank wagons.

6.3 Buildings

Buildings shall be designed in accordance with the requirements described in EN 1473 where they shall be either sited outside the hazard-affected areas or designed to resist these accident scenarios.

7 Commissioning and start-up

Commissioning is generally defined as the activities performed in getting the facilities ready for normal operation.

All system components and assemblies shall be checked to demonstrate that the functional requirements are met and that their integrity is adequate for cool-down and start-up.

The following system components and assemblies shall be considered:

— the process system (valves, hoses, loading or unloading arms);

— the utility systems (nitrogen and instrument air);

— the instrumentation (flow, temperature, pressure measurement);

— the operations control system;

— The safety systems (ESD valves, earthing devices, relief valves, leak management system);

— the firefighting and fire and gas detection systems;

— the loading or unloading pumps (if available);

— the parking or locking devices and shunting system, if available;

— the electrical system.

The following construction requirements and conditions shall be verified:

— accessibility of operating equipment;

— insulation of piping and valves;

— identification and marking of system parts;

— rail tracks completeness (placement test of locomotive with LNG tank wagon or container);

— workability and completeness of safety systems.

As a minimum, the following tests shall be performed:

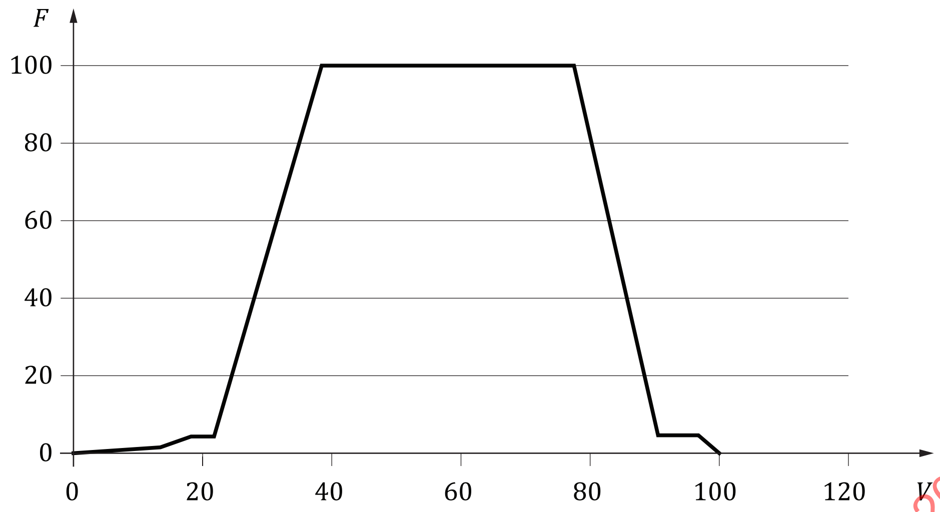
— pneumatic leak test;

— operating envelope, safe operation of hoses and/or loading or unloading arms;

— functional test;

— flow test - configuration of loading or unloading sequence (low flow start, ramp-up to max flow rate, flow reduction at the end of the load).

A depiction of the flow test is given in Figure 7.



Key

F flow (%)

V volume (%)

Figure 7 — flow test with flow as a function of volume

Upon successful completion of the commissioning activities, the railway LNG facilities are ready to begin LNG loading or unloading operations.

All activities shall be managed and executed by trained personnel. Training, knowledge and the awareness level of the personnel who are in charge of the execution of this kind of operations are important.

8 Operations

8.1 Initial checks

Prior to the LNG tank wagon or container locomotion at the loading or unloading bay, the following checks shall be performed:

— verification of LNG tank wagon or container type validity;

— visual inspection of the integrity and functionality of the LNG tank wagon or container;

— verification of terminal operational status;

— verification of the loading or unloading bay availability for operations;

— documentation check;

— leak test;

— sampling (vapour sample for content identification).

8.2 Weighing before loading or unloading operation

The following actions related to weighing shall be performed:

— recording of the weight data generated by the weighbridge controller;

— determination of the LNG quantity to be loaded or unloaded, the LNG tank wagon or container design information and the LNG composition.