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Petroleum and natural gas industries — Guidelines for the marine interfaces of hybrid LNG terminals

Pétrole et industries du gaz naturel — Lignes directrices pour les interfaces de terminaux hybrides de GNL

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 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 petroleum, petrochemical and natural gas industries*.

Introduction

The recent expansion of the LNG industry has led to the development of marine LNG facilities and transfer systems that differ from conventional LNG facility designs. These LNG transfer facilities can require additional or alternative systems and/or operational procedures to enable their safe operation. This Technical Report is intended to provide guidance for aspects of these facilities not covered by current standards and guidelines.

Petroleum and natural gas industries — Guidelines for the marine interfaces of hybrid LNG terminals

1 Scope

This Technical Report provides guidance for installations, equipment and operation at the ship to terminal and ship to ship interface for hybrid floating and fixed LNG terminals that might not comply with the description of "Conventional LNG Terminal" included in ISO 28460.

This Technical Report is intended to be read in conjunction with ISO 28460 to ensure the safe and efficient LNG transfer operation at these marine facilities.

This Technical Report also addresses high pressure natural gas (HPNG) at the transfer interface at facilities where liquefaction or regasification is undertaken, but does not describe requirements for the process plant generally forming part of the terminal facility.

These guidelines are based around facilities that are currently in operation or under development.

2 Terms, definitions, and abbreviated terms

2.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

2.1.1
as low as reasonably practicable
ALARP
reducing a risk to a level that represents the point, objectively assessed, at which the time, trouble, difficulty, and cost of further reduction becomes unreasonably disproportionate to the additional risk reduction obtained

2.1.2
conventional onshore LNG terminal
LNG export or receiving terminal that is located on-shore and that has a marine transfer facility for the loading or unloading of LNG carriers in a harbour or other sheltered coastal location

Note 1 to entry: A conventional onshore LNG terminal typically includes marine transfer facility comprising a jetty equipped with loading arms or similar to enable the transfer of LNG between ship and shore.

2.1.3
double bank
to moor two vessels moored alongside each other at a terminal

Note 1 to entry: An example of double banking as part of a hybrid LNG terminal is where an LNGC moors and transfers LNG alongside an FSRU or FSU.

2.1.4
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

2.1.5
emergency release system
ERS
system that provides a positive means of quick release of LNG transfer systems and safe isolation between ship and terminal or between units, following a predefined procedure including an emergency shut-down (ESD)

Note 1 to entry: The operation of the emergency release system can be referred to as an “ESD II”.

2.1.6
emergency disconnect system
EDS
system that provides a positive means of quick release of HPNG transfer systems and safe isolation between terminal units or between terminal and ship, following a predefined procedure including an emergency shut-down (ESD)

2.1.7
emergency shut-down
ESD
method that safely and effectively stops the transfer of LNG or vapour or HPNG between terminal units or between terminal unit and LNGC

Note 1 to entry: The operation of this system can be referred to as an “ESD I”. Ship/shore ESD systems should not be confused with other emergency shut-down systems within the terminal or on board ship.

2.1.8
emergency disconnection coupler
EDC
coupler system that when adopted in HPNG transfer systems as part of EDS has combined routine maintenance and operation connection functionality and emergency disconnection functionality

2.1.9
floating storage and regasification unit
FSRU
floating unit for storage and regasification of LNG and for sending out HPNG and moored for prolonged periods as part of a hybrid LNG terminal

Note 1 to entry: FSRUs are often but not exclusively classified as sea-going vessels and can be purpose-built or be converted from a LNGC. Although designed to be moored long term as part of a terminal, FSRUs frequently have the capability to depart for periodic maintenance or in case of extreme weather.

2.1.10
floating storage unit
FSU
floating unit for storage of LNG and moored for prolonged periods as part of a hybrid LNG terminal

2.1.11
hybrid LNG terminal
LNG export or receiving terminal that is not wholly located onshore and has a marine transfer facility for the loading or unloading of LNG carriers and for transfer of HPNG to shore

Note 1 to entry: A hybrid LNG terminal can be located in a protected harbour, in a naturally sheltered coastal or near shore location, or in an unprotected near shore or offshore environment. The marine transfer facilities for hybrid LNG terminals can include fixed units such as jetties, platforms, and mooring structures. Marine transfer facilities can also include floating units such as FSRUs, FSUs, and LNGRVs. Transfer of LNG and/or HPNG can take place at a number of interfaces between fixed and floating units according to the terminal configuration.

2.1.12
liquefied natural gas regasification vessel
LNGRV
A sea-going vessel for storage and regasification of LNG and for sending out HPNG and moored for periods as part of a hybrid LNG terminal and also capable of operating as an LNGC supplying the hybrid LNG terminal

2.1.13
operating basis earthquake
OBE
maximum earthquake for which no damage is sustained and restart and safe operation can continue

2.1.14
safe shutdown earthquake
SSE
maximum earthquake event for which the essential terminal fail-safe functions and mechanisms are designed to be preserved but for which permanent damage can be expected provided that there is no loss of overall integrity and containment

2.1.15
rapid phase transition
RPT
explosive change in phase of liquid to vapour

Note 1 to entry: RPT can occur when LNG and water come into contact.

2.1.16
rollover
sudden mixing of two layers of LNG of different densities in a tank, resulting in massive vapour generation

2.1.17
spool piece
short length of pipe with flanges for matching the ship's manifold flange to the transfer system presentation flange

Note 1 to entry: Sometimes, reducer spool pieces are used to connect different diameters.

2.1.18
unit
discrete part of a hybrid LNG terminal which can be a fixed or floating structure

Note 1 to entry: Examples of a unit include FSRU, LNGRV, FSU or fixed platform.

2.2 Abbreviated terms

BOG	Boil off gas
CDI	Chemical Distribution Institute
CTMS	Custody transfer measurement system
EERP	Evacuation, escape, and rescue plan
EDC	Emergency disconnect coupler (HPNG)
EDS	Emergency disconnect system (HPNG)
ERC	Emergency release coupling (LNG)
ERS	Emergency release system (LNG)
ERM	Emergency response manual

ESD	Emergency shut-down
FES	Fire and explosion strategy
FSRU	Floating storage and regasification unit
FSU	Floating storage unit
GBS	Gravity based structures
GIIGNL	International Group of Natural Gas Importers
HPNG	High pressure natural gas
ICS	International Chamber of Shipping
IMO	International Maritime Organization
ISGOTT	International Safety Guide for Oil Tankers and Terminals
LNG	Liquefied natural gas
LNGC	Liquefied natural gas carrier
LNGRV	Liquefied natural gas regasification vessel
MLA	Marine loading arms
OBE	Operating basis earthquake
OCIMF	Oil Companies International Marine Forum
QC/DC	Quick connect/disconnect coupler
RPT	Rapid phase transition
SIGTTO	International Society of Gas Tanker and Terminal Operators
SSE	Safe shutdown earthquake
TOM	Terminal operating manual

3 Hazards of LNG and high pressure natural gas (HPNG) transfer

3.1 General

The transfer of LNG and HPNG at marine interfaces for hybrid LNG terminal operations results in a number of potential hazards and hazardous situations in respect of

— properties of LNG and HPNG, and

— the method and conditions of transfer.

Hazard management should be as described in Clause 8.

3.2 Hazards of LNG

Reference should be made to ISO 16903[1)] for guidance on the characteristics of LNG influencing design and material selection, including the general hazards of handling LNG.

1) To be published.

Potential hazards arising from the transfer of LNG for hybrid LNG terminals should be subject to risk assessment taking into account the following:

— cryogenic temperatures, which can cause cold injury to people (frostbite), and also brittle fracture to non-cryogenic materials such as carbon steel;

— pool fire, flash fire, explosion, or asphyxiation from leaks or spillage of LNG;

— surge pressure in LNG transfer systems;

— overpressure resulting in shock waves, caused by rapid phase transition (RPT) of LNG interacting with water;

— overpressure due to expansion or vaporization of trapped LNG;

— mechanical damage due to thermal stresses caused by uncontrolled cool-down of piping and transfer systems;

— rollover.

3.3 Hazards of high pressure natural gas

The potential hazards arising from the transfer of HPNG for hybrid floating and offshore LNG terminals should be subject to risk assessment taking into account the following:

— jet fire, flash fire, or confined vapour cloud explosion;

— asphyxiation;

— stored energy in high pressures systems;

— high noise level from release of HPNG;

— temperature drop caused by the release of HPNG (Joule-Thomson effect);

— mechanical damage due to vibration from high gas velocities in piping and transfer systems.

NOTE The flammability, explosion, and asphyxiation hazards of HPNG are similar to natural gas (NG), but the pressures used to transfer and export the HPNG result in very significant additional hazards due to the velocity and momentum of jet releases and also due to the effects of sudden release of stored energy from a highly pressurized system. High pressure gas release can entrain air, which if ignited, will result in a jet fire.

3.4 Potential hazardous situations associated with hybrid LNG terminal operations

In addition to the hazardous situations for conventional onshore LNG terminals set out in ISO 28460:2010, Clause 5, the following potentially hazardous situations should be considered for operational and contingency planning for hybrid terminals:

— LNG and HPNG transfer operations in close proximity to process equipment;

— simultaneous operations;

— venting and flaring;

— sloshing effects in partially loaded floating storage facilities;

— boil off gas (BOG) management and tank pressure control;

— flange and valve leaks for HPNG transfer systems including any failure or spurious release of the emergency disconnection system (EDS), if fitted, on the HPNG transfer system;

— relative motions at interfaces as a result of the terminal configuration (e.g. double banking, tandem, weather-vaning at turret or yoke mooring) and the resulting mechanical stresses and fatigue;

— metocean conditions and seismic events including:
  — earthquake;
  — tsunami;
  — icebergs;
  — extreme weather events such as tropical cyclones, tornadoes or squalls.

NOTE 1 HPNG gas transfer arms between FSRUs and fixed platforms have at some locations been fitted with emergency disconnection system (EDS), which provide an automated function similar to that of an emergency release coupling (ERC) for LNG transfer arms. Unlike the LNG ERC, HPNG EDS systems have typically combined ERS and QC/DC.

NOTE 2 The motion of floating units incorporating LNG storage can be influenced by the amount of LNG inventory.

NOTE 3 Floating regasification and storage units (FSRUs) may be configured either as permanently moored facilities, or alternatively, the FSRU can have the capability to depart for LNG supply, trading purposes, or to depart in advance of extreme metocean conditions.

4 Siting of facility

NOTE The siting considerations for conventional onshore LNG terminals listed in ISO 28460 ought to be taken into consideration, where applicable.

4.1 General

Site selection for the facility should be based upon a study in accordance with LNG industry best practice.

This study should include a risk assessment undertaken by a multi-discipline team with regard to identifying and mitigating risks to acceptable levels.

The multi-discipline team should include, as a minimum, expertise and experience of the following:

— marine and port operations;
— LNG carrier and terminal operations;
— metocean conditions;
— design and engineering of marine terminal infrastructure;
— risk assessment and hazard management.

4.2 Metocean conditions

Design and operation of the facility should take into account the environmental conditions at the site.

As a minimum, the following metocean parameters should be taken into consideration:

— wave heights, periods and directions;
— tsunamis;
— current speed and direction throughout the water column;
— wind speed and directions including incidence of tropical storms and local squalls;
— sea ice, icebergs, snow, and ice accretion;
— water level including tidal variations;

— water temperature and quality;

— air temperature and humidity.

Environmental operating limits should be established for each operation including for approach of LNGC, berthing, mooring, transfer of LNG and/or HPNG, unberthing and departure. Where the terminal includes an FSRU or other floating unit, environmental operating limits should also be established for the FSRU to remain at the facility.

If the FSRU is not capable of remaining safety moored under conditions likely to occur during the operational life of the terminal, contingency plans and procedures should be established in order that the FSRU can safely depart in advance of forecast weather conditions that exceed pre-determined limits.

Potential weather downtime for transfer of LNG and/or HPNG should be assessed against operational requirements and long term observed metocean data or hindcast data for the location.

NOTE 1 Metocean parameters appropriate to design, construction, and maintenance of fixed structures are normally defined for a range of design situations with performance requirements appropriate to the probability of occurrence of the parameter or joint probability of combinations of a number of parameters.

NOTE 2 BS 6349–1-1 provides guidance on planning of coastal maritime infrastructure for ships, including recommendations on environmental data gathering, and incorporation of operational and safety considerations into design, including the requirements for consultation with operational staff at the design stage and the incorporation of design stage information into the terminal operating manual (TOM).

NOTE 3 Where a floating unit is permanently moored in locations subject to exceptionally adverse metocean events such as hurricanes or cyclones, it is normally required to consider specific performance requirements for "survivability" with some degree of permissible limited damage or temporary loss of serviceability provided there is no risk to personnel, essential safely systems remain operable, and there is no loss of containment or release of LNG or HPNG.

NOTE 4 Tsunami hazard assessment is particularly important for FSRUs or other floating units in shallow water. The interaction of a tsunami with a shallow coastline or harbour gives rise to very significant changes in water level.

4.3 Geological conditions and hazards

Design and operation of the facility should take into account as minimum, the following geological conditions and hazards:

— bathymetry;

— soil conditions;

— seabed morphology and sedimentation;

— seabed instability and landslides;

— seismicity (including OBE and SSE earthquake events and any associated events).

Seismic performance criteria for each unit of the facility and transfer system should be determined by risk assessment and in accordance with applicable local regulations and codes.

NOTE EN 1473 and NFPA 59A provide principles for determining seismic performance levels for conventional fixed onshore terminals which can also be appropriate to define requirements for marine interfaces for FSRU terminals. The definitions included in 2.1 are taken from EN 1473 for onshore LNG terminals which utilizes performance criteria for OBE and SSE.

4.4 Environmental and socio-economic impacts

The environmental and social impact of development and operation of the facility at any site should be assessed in accordance with applicable local regulations and with local authorities (port, marine, other state organizations).

5 Marine transfer systems

5.1 General

The selection and design of the marine transfer system for hybrid LNG terminals should take into account the following, according to the proposed operations and location of the facility:

— the transfer operation (e.g. HPNG or LNG, rate of transfer, floating-to-floating or floating–to-fixed);

— required operational availability;

— limiting operational environmental conditions;

— limiting environmental conditions for extreme events, including survivability under exceptionally adverse metocean events;

— range of sizes of vessels to be accommodated;

— dynamic motion between the facility and LNGCs;

— emergency shut-down (ESD I) and release system (ESD II) for LNG and EDS for HPNG, if fitted;

— effect on FSRU or other floating unit structural integrity and stability in the case of installation of transfer equipment for conversion as part of a hybrid terminal;

— transit conditions for transfer equipment installed on floating units;

— seismic performance criteria under OBE and SSE (if any).

Transfer system selection and design should take into account the need to reduce risks during operation and maintenance “as low as reasonably practicable” (ALARP).

For novel transfer systems, technology assessment and qualification as described in EN 1474-3, Clause 5 should be implemented.

NOTE Principles of hazard management are described in Clause 8.

5.2 Marine loading arms (MLAs) for LNG and HPNG

5.2.1 Marine loading arms for LNG

Design and testing of MLAs for LNG service should be in accordance with EN 1474-1[2)].

For MLAs installed on fixed jetty or any other fixed structure, transfer operations should be as required by ISO 28460.

When MLAs are installed at an exposed location where dynamic motion between units and/or LNG carriers is foreseen, the additional provisions of EN 1474-3 should be applied to take into account dynamic loading from the motion response of the floating system under wave action. For FSRUs, in addition to the location of initial and future deployment, dynamic loads in combination with wind loads during transit should also be taken into account.

The MLAs may be equipped with a system to facilitate connection and disconnection of the transfer system under the maximum expected motions between the two units.

2) EN 1474-1 will be replaced with ISO 16904.

When the MLAs are installed on a unit or part of the terminal classed as a ship (such as an FSRU), the LNG MLA can be subject to additional qualification and testing arising from classification society requirements.

NOTE 1 Marine loading arms complying with EN 1474–1[2] have been used for the transfer of LNG at conventional LNG terminals. Development of hybrid LNG terminals has led to the requirement for the development of alternative transfer systems including the installation of marine loading arms on FSRUs and other floating units.

NOTE 2 Transfer systems installed on-board an FSRU/FSU or other floating unit subject to classification society rules and requirements are not typically treated as a class item apart from support columns and any structural modifications to the ship. However, the requirements arising from installation on a ship need to be taken into account in design, manufacture, and testing of the transfer systems. In such circumstances, it is important for the owner of the classed unit to define the level of testing, inspection, and certification required for the scope of the transfer system which is not in class.

5.2.2 Marine loading arms for high pressure natural gas (HPNG MLA)

5.2.2.1 General

Relevant aspects of ISO 16904[3] and OCIMF design and construction specification for marine loading arms should be applied to the design and operation of MLAs for HPNG.

The design should take into account the need to safely relieve stored energy and purge gas in the disconnection systems under both normal and emergency decoupling operations.

Isolation, depressurization, and purging should take place prior to opening of the connection and release of the HPNG MLA.

If an HPNG emergency disconnection system (EDS) is provided, the system should provide for automatic retraction and stowage to retract the HPNG MLA from the immediate location of the HP manifold of the vessel, so that the manifold and arm are both clear from any damage arising from further motion or displacement across the marine interface. Critical equipment on the facility should also be protected against damage by the dynamic motion of the arm if it is released under abnormal conditions.

The maximum flow rate through the transfer system should be such that, no harmful vibrations or excessive noise occur during operation. This should be assessed taking into account the arrangement of the complete piping system.

NOTE Examples of typical arrangements for HPNG MLA isolation and relief systems are provided in Figure A.4.

Maximum operating flow rate should take into account allowable pressure drops at minimum and maximum operating pressures of the complete HPNG piping system from regasification unit to gas network. Current HPNG MLAs in service are of 30 cm (12 inch) diameter. Typically design temperature ranges are within −40 °C and +80 °C.

5.3 Marine hose transfer systems

5.3.1 Hose systems for LNG transfer

Marine hose transfer systems between LNGC and FSRUs or other floating terminal units should comply with EN 1474-2 and EN 1474-3.

The OCIMF Ship to Ship Transfer Guide provides guidance on ship to ship LNG transfer and can be applicable to FSRUs and LNGRVs in inshore waters.

3) To be published.

5.3.2 Hose systems for HPNG transfer

Hose systems for HPNG transfer systems have been proposed at marine interfaces of some hybrid terminals.

NOTE Relevant aspects of EN 1474–3 can be applicable in developing a system design philosophy for HPNG hoses in conjunction with ISO 13628-2 which includes provisions for flexible jumper hoses in subsea and offshore topsides applications.

Additionally, depending on the situation, ANSI/API RP17b and ISO 14113 can be used.

6 Marine operations

6.1 General

The general recommendations of ISO 28460 for planning and conducting marine operations should be followed where applicable including provisions for

— adoption of best industry practices including those of OCIMF, SIGTTO, and PIANC,

— ship-terminal compatibility studies prior to first-time LNGC arrival, and

— detailed passage planning including risk assessment and hazard management.

Clause 6 identifies where additional guidelines can be needed for a hybrid marine terminal.

NOTE 1 For hybrid LNG terminals, particular attention is needed for ship-shore compatibility studies prior to first-time LNGC arrival, especially where the berthing configuration or LNG transfer system varies significantly from conventional terminals.

NOTE 2 The PIANC report “Safety aspects affecting the berthing operations of tankers to oil and gas terminals” provides guidance on safety aspects for gas tankers that are relevant to port and terminal planning, design, and operations.

6.2 Terminal information

Each terminal should develop and maintain a comprehensive written terminal operating manual (TOM) according to the principles set out in IMO/ISGOTT, 15.3 and a separate emergency response manual (ERM) of IMO/ISGOTT, Clause 20. For a hybrid LNG terminal, the TOM, as a minimum, should include the following:

— facility description (port information and regulations);

— management structure and responsibilities;

— ship size and displacement limitations;

— ship manifold layout and strength capacity;

— safety, security, and emergency procedures;

— environmental limits on specific operations;

— emergency departure procedures;

— pilotage and tug operating requirements;

— mooring arrangement and berthing procedures;

— pre-transfer meeting and checklist requirements;

— cargo transfer procedures including maximum transfer rates.

Terminal information should be made available to appropriate parties, including in a format suitable for electronic transmission, according to procedures set out in IMO/ISGOTT, 15.4. Terminal information should be made available to the masters of visiting vessels before arrival at the facility.

NOTE According to the terminal configuration, it will be necessary to develop specific protocols on information storage and exchange, for example, where there is a shore operating team, an FSRU operating team, and an LNGC.

6.3 Marine exclusion zones

Marine exclusion zones require for safety and security (ISPS compliance) should take into account the particular security threats and navigation hazards associated with offshore locations.

6.4 Marine interface

6.4.1 General

In addition to the guidelines in ISO 28460, the provisions in 6.4.2 through 6.4.6 should be taken into account.

6.4.2 Mooring arrangements and fenders

Planning, design, operation, and maintenance for berthing and mooring of LNGCs and FSRUs should take into account the requirements and characteristics of hybrid LNG terminals compared to conventional LNG terminals with respect to

— exposed locations resulting in greater ship motions,

— double banked configurations resulting in greater relative motions across the marine interface (such as between an FSRU and an LNGC), and

— FSRUs, FSUs, or other similar units which are moored on a long term basis giving rise to additional requirements in respect of maintenance and inspection of moorings.

The mooring arrangement and number, size, and location of fenders should be determined by mooring analysis and a geometrical compatibility study of vessels calling at the facility taking into account environmental conditions and the effects of passing ships.

Fender berthing energy capacity should be determined based upon a recognized fender system design standard.

Pneumatic fenders for ship to ship applications including double banked FSRU and LNGC usage should be positioned in accordance with the ICS/CDI/OCIMF/SIGTTO “Ship to ship transfer guide for petroleum chemicals and liquefied gases”. Pneumatic fenders should not be located under LNG transfer systems or in any location that could be subject to accidental LNG splash.

The operation and management of the mooring arrangements should ensure that the LNGC, and FSRU or other floating unit remains secure in its position relative to the transfer system envelope of all marine interfaces with an LNG or HPNG transfer system.

Proposed mooring arrangements should be assessed using a validated calculation or simulation tool developed for this purpose, taking into consideration maximum environmental operating limits under which the LNGC, FSRU, or other floating unit will remain moored.

When terminal has a mooring system or systems which moors a unit for a prolonged period of time, these mooring systems should be inspected and maintained according to an approved plan which ensures the integrity and reliability of the mooring system.

The mooring arrangements should take into account the requirement for safe release for normal and emergency operations and also for maintenance activities for permanently moored FSRUs and FSUs.

System failure (whether a single component failure, system failure, or loss of power supply) should not result in the unexpected release of the mooring system and the subsequent uncontrolled drifting of an LNGC, FSRU or other floating unit.

NOTE 1 Recognized guidelines for fender selection and specification include BS 6349–4, PIANC and ISO 17357-1.

NOTE 2 OCIMF MEG3 can be applied as applicable to hybrid LNG terminals, although geometrical constraints and the requirements of long term or permanent mooring of FSRUs can lead to particular arrangements to be assessed on a case by case basis.

NOTE 3 Low friction liners to Panama fairleads have been proposed for exposed locations.

6.4.3 Berthing and mooring aids

Berthing and mooring aids should be provided based on the requirements of the LNGC and any floating units such as FSRUs and LNGRVs forming part of the terminal which will berth and unberth from time to time.

Information from metocean monitoring systems, mooring line tension monitoring, and similar information should be communicated to appropriate locations and units (according to operating philosophy).

NOTE 1 For terminals with FSRUs or FSUs and double banking, the scope of berthing and mooring aids can include speed of approach and mooring line tension monitoring for both the FSRU and the LNGC. Requirements for berthing aids for an FSRU or FSU will depend on the frequency of berthing and unberthing and the environmental conditions at the location.

NOTE 2 Integrated systems are preferred for berth monitoring and docking aid systems to enable effective distribution of information to required monitoring locations.

6.4.4 Manifold arrangements

LNG liquid and vapour manifolds should be in accordance with SIGTTO/OCIMF publication “Manifold recommendations for liquefied gas carriers”.

Some vessels can have manifolds that do not comply with SIGTTO/OCIMF manifold recommendations. Care should be taken to ensure that loads applied to the manifolds by transfer equipment remain compatible with the manifold strength capacity.

Manifolds for high pressure gas transfer should be specified to ANSI/ASME B16.5 for steel pipe flanges and flanged fittings, ANSI/ASME B31.3 for process piping guide, and/or equivalent international standard.

For FSRUs, the HPNG MLA should be safely separated from the gangway landing area for safe personnel access for normal and emergency evacuation conditions.

Separation distances between HPNG and LNG manifolds should allow safe operation and maintenance activities taking into account

— envelopes of arms during emergency disconnection, release, and retraction, and

— personal safety of maintenance personnel carrying out maintenance activities in the vicinity of continuous HPNG transfer operations (SIMOPS).

Bolted spool pieces should be fitted, such that presentation flanges can be removed for repair in case they can be damaged when connecting the cargo transfer system.

NOTE At a number of FSRUs, the manifold for MLAs of HPNG has been located forward, afterward, of gangway to achieve safe separation.

6.4.5 Electrical isolation

The requirements in IMO/ISGOTT, 11.9 and 17.6 should be adhered to.

6.4.6 Hose supports and handling

Hoses for ship to ship LNG transfer should be supported using saddles or other means to avoid mechanical damage or excessive wear to the hose itself or to manifolds and fittings. Lifting equipment of sufficient capacity should be provided for handling of hoses and associated fittings such as reducers and spool pieces.

The guidance on hose length and handling given in ICS/CDI/OCIMF/SIGTTO "Ship to ship transfer guide for petroleum chemicals and liquefied gases" should be followed.

— Hose bending radius should be maintained within manufacturer's guidelines.

— The load restraint system should prevent excessive axial and torsional loads on the cargo hose end fittings.

— Restraints and guides should prevent chafing of the hose(s).

— Restraints and guides should minimize the risk of damage to handrails and other fittings in the event of emergency release.

7 Data and voice communications

Data and voice communications should comply with the requirements in IMO/ISGOTT, 4.8 and ISO 28460:2010, Clause 14, as applicable.

Requirements for integration of ESD and ERS systems and communication links should be based on the particular terminal arrangement of floating units and fixed units.

Specific studies based upon cause and effect considerations should be carried out to determine requirements, if any, for integration of HPNG and LNG transfer ESD and ERS systems.

NOTE Annex A gives examples of typical arrangements of ESD and ERS data communication including terminal configurations as shown in Annex B. These examples are intended to illustrate how systems between different floating units and fixed units can be integrated.

8 Hazard management

8.1 General

Design of the facility should be in accordance with applicable national regulations and design codes and requirements of Flag State/IMO and classification societies as applicable. However, additional hazard mitigation measures can be required to reduce risks to ALARP.

Risk assessment and ALARP demonstration should be in accordance with the guidelines given in ISO/TS 16901[4].

The hazardous situations described in Clause 4 should be taken into account.

A process safety management plan should be appropriate to handle a process plant located at the hybrid marine terminal that has a different focus from other safety management plans more dedicated to vessels and LNG Carriers.

8.2 Protection of leakage of LNG and HPNG

Protection should be provided to minimize the consequences of release of LNG and/or HPNG. This may be done by providing LNG spill containment, cold-spill protection of carbon steel structural members, water curtains, high pressure flange shields, or other appropriate measures. Mitigations should be added to HPNG lines, i.e. thermal protection to adjacent lines when required or sprinkler system.

4) To be published.

8.3 Fire and explosion hazard management

8.3.1 General

Fire and explosion evaluation and risk management for the terminal should comply with applicable national and international regulations, standards, and design codes taking into account hazardous situations associated with LNG and HPNG for hybrid marine terminals as described in Clause 3 and Clause 4.

In particular, where HPNG is transferred, the potential effect of high pressure jet fires should be taken into account.

Measures, equipment, and systems to reduce risk and consequences of fires and explosions should be identified by risk assessment and should include the following:

— zone and explosion — proof equipment, general reference is made to the IEC 60079 series;

— fire and leak detection;

— active fire protection;

— passive fire protection;

— explosion mitigation and protection systems;

— evacuation, escape, and rescue systems and procedures.

For FSRUs, FSUs, and LNGRVs that are classified as sea-going ships, in addition to the requirements of IMO/IGC and IMO/SOLAS, the additional hazards arising from any gas processing and continuous transfer of HPNG should be taken into account.

NOTE 1 Established national standards and industry guidelines for fire and explosion protection systems can be partly or wholly applicable to units of hybrid marine terminals and can provide appropriate principles from which to develop design and operation in conjunction with the guidance set out in this Technical Report.

EXAMPLE 1 For FSRUs, FSUs, and LNGRVs that are classified as sea-going ships, the fire protection and fire-fighting equipment, as a minimum, will be as required by the SOLAS Convention and the IGC Code subject to the additional requirements of the Classification Society and the Flag State according to the facility configuration.

EXAMPLE 2 For terminals which comprise onshore and fixed inshore structures for berthing and mooring FSRUs and LNGRVs, ISO 28460, EN 1473 or NFPA 59A, and IMO/ISGOTT provide a basis for developing the fire management system.

EXAMPLE 3 For fixed offshore installations and floating storage or production installations not classified as sea-going ships, ISO 13702 in conjunction with ISO 28460 and IMO/ISGOTT provide a basis for developing the fire and explosion control and mitigation strategies and systems.

NOTE 2 ISO 13702 identifies a requirement for two key strategies as follows, which can provide a suitable framework for developing measures for managing fire and explosion hazards for hybrid LNG terminals.

EXAMPLE 1 A fire and explosion strategy (FES) which uses information from a fire and explosion evaluation to determine the measures required to manage the hazardous events and the role of these measures.

EXAMPLE 2 An evacuation, escape, and rescue plan (EERP) which uses information from an evacuation, escape, and rescue study to determine escape routes and measures are required for rescue.

8.3.2 Firefighting and emergency response

Recommendations for the extent and type of jetty firefighting equipment for fixed installations for the berthing and mooring for LNG carriers should follow the same principles as described for jetties in ISO 28460, with the following additional considerations:

— fire on any part of the facility and on any LNGC berthed at the terminal;

— possible escalation between multiple adjacent floating units (LNGCs, FSRUs, LNGRVs, FSUs, etc.);

— means of escape, evacuation, and rescue for ship, fixed installation, and FSRU/LNGRV/FSU-based personnel;

— additional fire and explosion hazards associated with gas processing;

— the effect of firefighting water on facility stability/buoyancy.

The terminal should have an emergency response manual (ERM) as IMO/ISGOTT, 15.3 and complying with applicable national and international regulations and guidelines.

The ERM should be compiled in cooperation with the port authority and other local emergency services if applicable and should be made available to appropriate parties including the crew of LNGCs and any FSRU or similar unit forming part of the terminal. Emergency response procedures should be exchanged between double banked LNGC and FSRUs. Emergency response procedures should be practiced at regular intervals.

NOTE 1 Hybrid LNG terminals can be located at remote and/or offshore locations which require particular attention to be given to the response time and availability of support vessels, tugs, FiFi, and other logistical support required in connection with emergency response.

NOTE 2 For hybrid LNG terminals incorporating multiple floating units, including LNGCs, FSRUs, and LNGRVs, the emergency response might need to include the unberthing and departure of multiple vessels. Firefighting capacity and equipment (including tug firefighting class) need also to be evaluated to ensure risks are reduced ALARP for offshore and or multi-unit terminals.

9 Security

The minimum security requirements should be in accordance with the IMO ISPS and national regulations and as set out in ISO 28460.

NOTE UNCLOS 4, Article 60 applies to offshore terminals located in the exclusive economic zone, and this permits the coastal state to establish reasonable safety zones around installations and structures and to take appropriate measures to ensure the safety both of navigation and of the installations and structures. The dimensions of the safety zones are determined by the coastal state, but do not exceed a distance of 500 meters around the installation measured from each point of their outer edge.

10 Access and egress

Principles of access and egress as set out for conventional terminals in ISO 28460 should be applied.

Where required, a safe means of personnel transfer should be provided for access from ship to ship and ship to shore or fixed structure as applicable.

Transfer of personnel between floating units and between floating units and LNGCs should be minimized and reference should be made to ICS/CDI/OCIMF/SIGTTO "Ship to ship transfer guide for petroleum chemicals and liquefied gases" for guidance on personnel transfer procedures and equipment.

Gangway and personnel transfer operations should be included in a safety plan in accordance with IMO/SOLAS 2.15.2.4 to 15.3 which should be displayed as IMO/SOLAS IMO/ISGOTT 20.2.4 and 9.9.2.5, 20.4.

Gangways should not retract on ESD II, but should be protected from damage by suitable measures (e.g. by shear bolts).

Access to the ship's manifold area for LNG and HPNG should be restricted to minimize risk to personnel.

11 Cargo transfer

11.1 General

11.1.1 Management and communication

Clause 11 gives guidance in addition to the requirements in ISO 28460:2010, Clause 15.

To ensure the safe and reliable management of cargo transfer, the management and communication structure between separate terminal units (e.g. floating units, onshore units, LNGC) should be taken into account.

NOTE Hybrid LNG terminals can have multiple operating parties for fixed onshore facilities and floating units such as an FSRU, FSU, onshore regasification or processing facility, pipeline operator. These parties need to operate under an integrated operating and safety philosophy.

11.1.2 Conditions to be fulfilled prior to the transfer of LNG

Reference should be made to ICS/CDI/OCIMF/SIGTTO "Ship to ship transfer guide for petroleum chemicals and liquefied gases" for guidance on checks to be completed prior to LNG transfer for ship to ship transfer.

11.1.3 Conditions to be fulfilled prior to the transfer of HPNG

Conditions to be fulfilled prior to the HPNG transfer should include that

— the ship/shore safety checklist is completed (as per ISO 28460/IMO/ISGOTT suitably modified for the terminal configuration and HPNG transfer),

— critical safety devices are tested and operational,

— the transfer system is connected and the connection leak-tested in accordance with approved procedures,

— the HPNG transfer systems are pressurized in accordance with approved procedures;

— communication links to confirm proper operation of the ESD signal are mutually tested,

— a functional test of the EDS (if fitted) actuation system is undertaken by the terminal (without actuation of the disconnect), and

— it is confirmed that the onshore pipeline is ready to receive HPNG.

11.1.4 Cargo transfer operations

Monitoring arrangements to ensure the safety of the system for HPNG cargo transfer should take into account the continuous cargo transfer for send-out gas.

Ballasting and moorings should be monitored and adjusted to maintain the draft, trim, and list of floating units of the hybrid terminal, such that HPNG loading arms stay within operating envelopes.

Where practicable, the HPNG cargo send out rates from the facility should be reconciled with pipeline transport rates to provide early warning on significant loss of HPNG containment or leakages in the send out and offshore or onshore pipeline infrastructure.

11.1.5 Normal disconnection

Normal disconnection for the LNG transfer system should be in accordance with ISO 28460:2010, 15.2.4, for arms. Normal disconnection of LNG hose transfer systems should follow the same principles and the guidelines included in ICS/CDI/OCIMF/SIGTTO "Ship to ship transfer guide for petroleum chemicals and liquefied gases".

Depressurization of the HPNG transfer systems should be carried out in accordance with approved procedures to ensure safe depressurization and inerting of the transfer system before physical disconnection.

11.2 Emergency shut-down and emergency release systems

11.2.1 General

LNG transfer systems between the terminal and LNGC should be fitted with an emergency shut-down (ESD) system and an emergency release system (ERS).

A similar emergency shut-down and disconnect system should be included in the HPNG transfer system at the marine interface, unless it is demonstrated not to be required by site specific risk assessment.

The emergency disconnect system (EDS) should protect the HPNG MLA against excessive drift caused by conditions, such as the following:

— extreme metocean conditions occurring at short notice such as squalls;

— earthquakes and or associated tsunamis which occur without warning;

— collision or impacts from passing ships;

— mooring line failure or accidental release of mooring lines due to lack of maintenance and/or operator error or other unforeseen reason;

— accidental operation of propulsion systems.

NOTE In considering the need for HPNG EDS, the reduction in risk of mechanical damage to the arm due to the events mentioned above needs to be balanced against the risk of spurious activation of the EDS due to mechanical or control system malfunction, lack of proper maintenance, or operator error.

11.2.2 Emergency shut-down and emergency release systems for LNG MLA

For exposed environments and in double banked ship to ship operations, the additional motions and relative velocities at the marine interface should be assessed and taken into account in determining the acceleration and velocity of drift in configuring design and operation of LNG MLA emergency shut-down and release systems.

ICS/CDI/OCIMF/SIGTTO "Ship to ship transfer guide for petroleum chemicals and liquefied gases" provides specific guidance for ESD and ERS for ship to ship LNG transfer and can be applicable to FSRUs and LNGRVs in inshore waters.

11.2.3 Emergency shut-down and emergency release systems for LNG transfer hoses

Emergency shut-down and emergency release systems for LNG transfer hose systems should be in accordance with EN 1474-3.

ICS/CDI/OCIMF/SIGTTO "Ship to ship transfer guide for petroleum chemicals and liquefied gases" provides specific guidance for ESD and ERS for ship to ship LNG transfer and can be applicable to FSRUs and LNGRVs in inshore waters.

11.2.4 Emergency shut-down and emergency disconnect systems for HPNG MLA

The HPNG MLA EDS, if fitted, should be designed to take into account drift accelerations and velocities that can occur based upon the particular characteristics of the local environment and terminal characteristics as set out for LNG MLAs in ISO 28460:2010, 15.3.

The HPNG MLA EDS should have appropriate safeguarding functions to prevent the following:

— accidental operation;

— spurious activation;

— failure on demand.

Emergency shut-down sequence should include time required for blow down and depressurization prior to decoupling.

The design and operation of the emergency disconnection coupler (EDC) should be based upon specific project requirements and risk assessment.

NOTE 1 In conventional LNG MLAs, the ERS comprises interlocking ESD II valves and an ERC. A separate QC/DC may be provided for normal connection and disconnection. Some existing HPNG MLAs have adopted an emergency disconnection coupler (EDC) based upon a similar configuration to a conventional QC/DC with dual QC/DC and EDC functionality.

NOTE 2 A high integrity pressure protection system (HIPPS) has been provided at some locations to protect the integrity and control pressure of terminal natural gas send out systems. On FSRUs, such a system may be installed after regasification plant and before the HPNG manifold on the FSRU or downstream on the jetty.

11.2.5 Safety and maintenance of transfer systems

For hybrid terminals with continuous transfer of HPNG from FSRU or other floating unit to shore, attention should be taken for inspection and maintenance of any equipment of HPNG transfer in continuous operation.

Maintenance and inspection procedures and plans should be prepared taking into account the manufacturer's recommendations for each system.

Attention should be given to the structural and manoeuvring parts of hard arms or to the handling and manoeuvring systems of hoses, in order to guarantee safe transfer operation, as well as disconnection of the transfer system and associated retraction systems.

The terminal operation and maintenance procedures should take into account safety requirements arising from simultaneous operations. Access to the ship's manifold area for LNG and HPNG should be restricted. Where essential operational checks are required, a procedure should be provided to allow for limited periodic access.

NOTE For LNG arms, typically, this might require stopping cargo transfer; and for HPNG with an EDS system, this might require depressurization of the HPNG arm.

Terminal design should take into consideration the requirements for maintenance including the need to disconnect HPNG transfer arms for periodic inspection and maintenance.

NOTE Typically, the design of the send out system is configured to minimize interruptions, for example, by redundancy in the HPNG transfer system.

In the event of failure of HPNG ESD and EDS, these systems have the potential to result in releases of HPNG with serious consequences.

These systems, including safety instrumented functions, should be maintained based on the terminal operation and maintenance procedures and manufacturer's recommendations, instructions, and schedules. This should include periodic testing of safety instrumented functions.

Records of testing, inspection and maintenance of safety critical systems should be maintained within the terminal safety management system.

Work should be undertaken only by personnel who have been suitably trained.

Policies for equipment's spare parts should be based on operator experience, equipment manufacturer's recommendation and/or reliability availability and maintainability studies.

12 Custody transfer measurement system

Custody transfer should be done in accordance with the commercial agreements between the parties.

Where applicable, level gauging systems should incorporate processing functionality that can allow for fluctuations in cargo level due to vessel motions.

For FSRU/LNGRV, the custody transfer measurement system (CTMS) should take into account offloading of LNG and send-out of HPNG simultaneously. In such case, a procedure should be established to measure the amount of energy handled.

CTMS for HPNG systems should incorporate a means to measure cargo composition energy value.

NOTE 1 ISO 10976 deals with on-board custody transfer. Complementary information can be found in the GIIGNL "Custody transfer handbook".

NOTE 2 In exposed and offshore locations, moored ships can be subject to more significant movements that for LNGCs at conventional terminals at sheltered locations. In such cases, fluctuating cargo levels introduce another uncertainty to the measurement process. Some level gauge manufacturers have introduced a filtering function to their level measurement device. In order to maintain the contractual accuracy of cargo level measurements, it is important to note that the adopted filtering function can vary from one environmental condition to the other, depending on prevailing sea conditions and the behaviour of the ship at the site location.

13 Provision and training of staff

In addition to the provisions of ISO 28460, the facility should ensure that staff has sufficient training in cargo handling procedures in order to conduct safe cargo transfer operations including ship to ship LNG transfer operations and handling of HPNG.

NOTE OCIMF/SIGTTO "Marine terminal operator competence and training guide (MTOCT)" provides guidance on operator competence management systems and training. There is no internationally accepted competence framework and training systems for FSRU crews to address activities not normally part of LNGC carrier operations such as regasification.

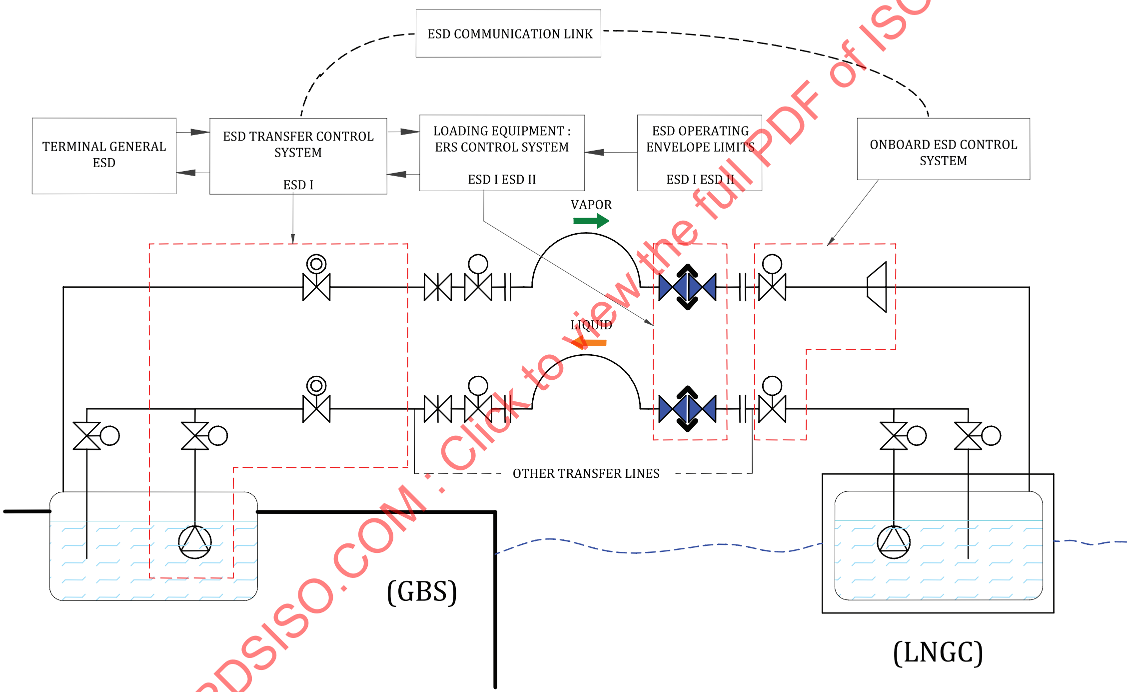
Annex A
(informative)

ESD I and ESD II systems — Typical arrangements

Figure A.1 to Figure A.3 show different LNG transfer configurations with control system interfaces involved in the emergency sequence ESD I and ESD II of the loading system.

Figure A.4 shows HPNG with transfer system on shore installation, with either relief gas towards the shore or towards the FSRU and location of ESD I and ESD II controls.

In Figure A.1, the ESD is separately controlled on jetty side and on ship side with their respective safety control systems. An ESD communication link between ship and shore is used to generate ESD on both sides at same time from any location side request. ESD I and ESD II of the loading system generates an ESD signal to both the shore and ship locations.



Key

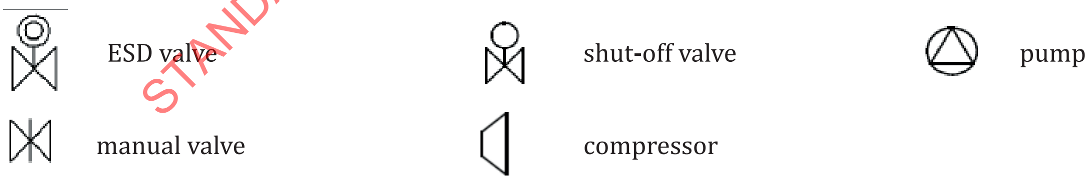
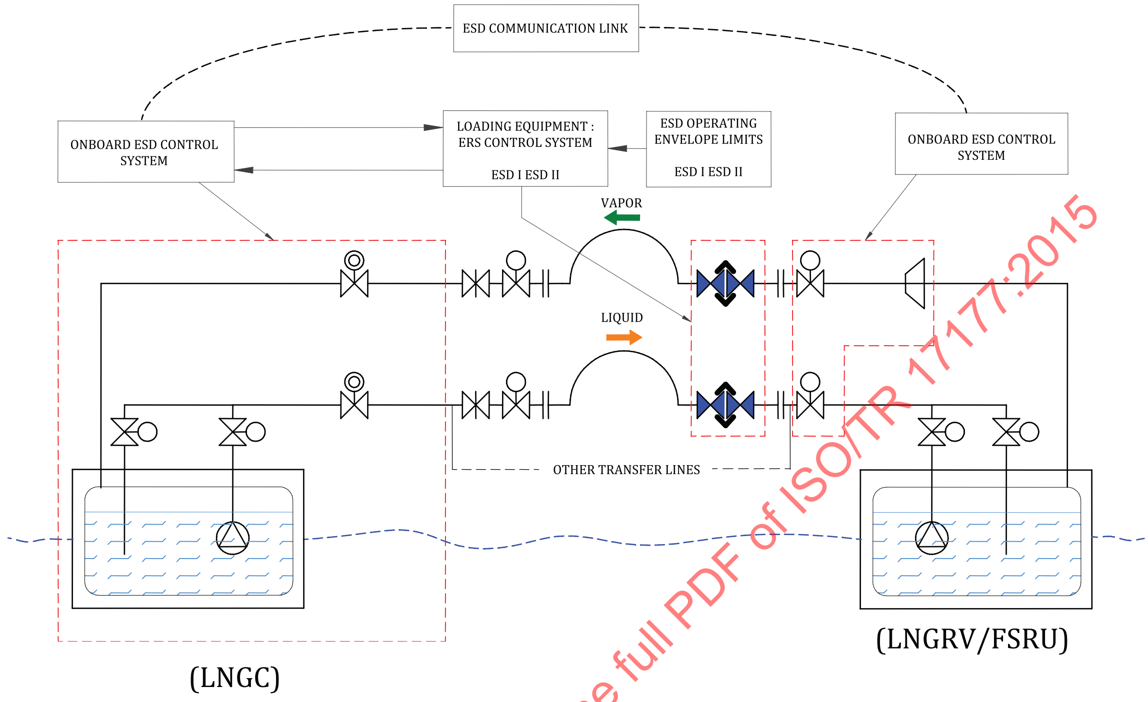


Figure A.1 — Ship to shore (refer to Figure B.3)

In Figure A.2, the ESD is separately controlled on each ship with their respective safety control systems. An ESD communication link between both ships is used to generate ESD on both sides at same time from any location side request. ESD I and ESD II of the loading system generates an ESD signal to both ships at the same time.

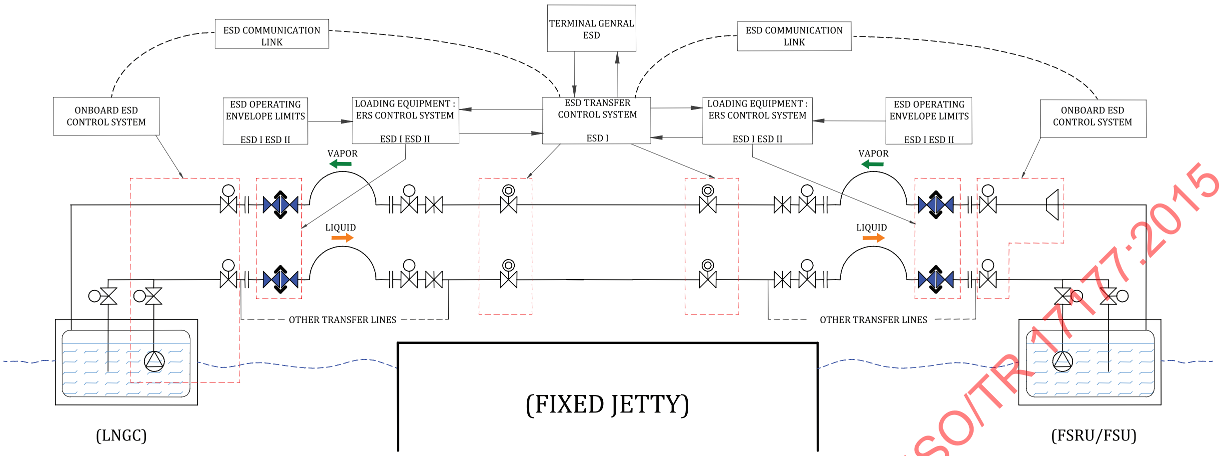


Key

- ESD valve
- shut-off valve
- pump
- manual valve
- compressor

Figure A.2 — Side to side or side by side (refer to Figure B.2 and Figure B.6)

In Figure A.3, the ESD is separately controlled on shore and on ship sides with their respective safety control systems. ESD communication links between ships and shore is used to generate ESD on the three sides at same time from any location side request. ESD I and ESD II of the loading system generates an ESD signal to the shore on the side where it is located. The configuration can be with or without storage on the shore or fixed jetty.



Key

ESD valve

shut-off valve

pump

manual valve

compressor

Figure A.3 — Ship to ship through jetty (refer to Figure B.1 and Figure B.7)

