

LNG TERMINAL SAFE OPERATION MANAGEMENT

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Abstract:

This article presents the significance of LNG terminal safety issues in natural gas sea transport. It shows particular requirements for LNG transmission installations resulting from the specific properties of LNG. Out of the multi-layer critical safety areas comprising structural elements of the terminal safety system, possibilities to decrease the risk of emergency occurrence on LNG terminals have been selected. Tasks performed by the LNG terminal, together with its own personnel and the outside one, have been defined. General theses for LNG terminal safety have been formulated.

Key words: terminal, LNG, operation, safety, gas carrier, unloading, personnel

INTRODUCTION

At present, deliveries of natural gas (LNG) by sea transport comprise about 25% of the international natural gas trade turnover in the world [1]. Natural gas LNG consisting mainly of methane (up to 98%) after condensation takes up c.a. 600 times less space, which enables economic sea transport with the use of vessels. specially designed for this purpose The intended by PGNiG S.A. (Polish Oil and Gas Company) diversification of gas deliveries to Poland envisages reaching such a state when 1/3 of the gas will be of domestic origin, 1/3 will be imported from the East and 1/3 from the Scandinavia via the LNG terminal in Świnoujście. The switching-in of the terminal to the national transmission net is planned for the year 2013 whereas the technological start-up of the terminal should take place a year later i.e. 30th June 2014 [13].

Poland lacks specialist personnel as well as experience in LNG terminal operation Therefore, the problem of safe LNG terminal operation should be considered as the safety of LNG installations for transmission and storing on land together with the safety of the ship performing the operation of LNG unloading.

SAFETY REQUIREMENTS IN LNG OPERATIONS

Potential fire-explosion hazards connected with transportation, storing or application of LNG result mainly from the properties of this substance, and especially from [2, 4]:

1. At atmospheric pressure depending on the composition, LNG boiling temperature is about -162°C , at which LNG vapours are much heavier than air.
2. Small amounts of LNG liquid phase get changed into a cloud of gas of big volume. in the case of LNG leakage from high pressure equipment and installations or pipes, it will get released into the atmosphere. This process is connected with extensive mixing with air. LNG is not a toxic gas, it is categorized as green-

house gas whose emission into the atmosphere influences the global warming effect.

3. LNG is inflammable(within the range of 5.3%-14%of its concentration in the air)
4. contact of living organisms with liquid LNG of -160°C destroys their biological tissues.
5. A direct contact of LNG with water is followed by a phenomenon of a rapid transition of the liquid phase into vapour (flameless explosion)

Safety in LNG operations is covered by a multi-level protection, creating critical safety areas integrated with branch standards and regulations, which is illustrated in Figure 1 [6].

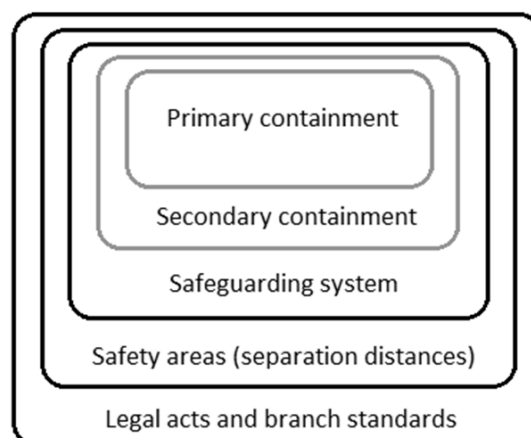


Fig. 1. Multilevel critical safety areas [6]

Four levels of safety requirements – the first and the second level of security, protection systems of monitoring, supervision and control as well as safety areas are applied in the whole LNG industrial chain i.e. production, condensation, sea transportation, storage and re-gasification, whereas legal acts and branch standards form a superior layer, comprising all the requirements [6].

1. Primary containment (the first level of security) is reached throughout the use of appropriate materials for the construction of containers and equipment and also throughout providing a correct technical design at each technological stage. This issue is governed by the PN-EN 1473:2002(U) regulation – “Installations and equipment for condensed natural gas designing on-land installations” [10].

2. Secondary containment (the second level of security), is reached throughout the appropriate construction of containers guaranteeing, in the case of lack of tightness or LNG leakages, isolation and securing the leakage. In practice, containers of the SCT, DCT, FCT type have been applied [2].

3. The purpose of safeguarding systems is to minimize the frequency of LNG leakages and the relief of leakage effects if they do take place. At this security level, LNG operators introduce systems detecting leakages of gas, liquefied gas, systems for detecting fires, alarm systems, monitoring of processes, systems of emergency switching-off of equipment or processes equipment for firefighting. Safety management systems based on risk analysis required by Directive 96/82 EC called SEVESO II and 2003/105/EC are also applied [5].

4. Safety areas (separation distances) should be determined by appropriate regulations, so that LNG installations were located in a safe distance from human settlements, public places, neighbouring industrial plants. Currently, there is a lack of sufficient legal regulations determining safe distances from other constructions and sites not only in Poland but also in Europe. In Canada, according to regulations for LNG storing, it is required to assess the risk including the description of emergency plans comprising NG releases, fire and explosions using the Preliminary Hazard and Operability Study to identify potential hazards. On the basis of the risk evaluation study, the operator is obliged to ensure all possible safety systems (technical and organizational) preventing a potential industrial emergency. The results of such an analysis play an important role in the planning and site planning processes basing first of all on the emergency plans, and directly connected with them, ranges of areas of overpressure wave generated by an explosion, heat radiation, flight trajectory of parts of equipment ripped by an explosion or the ranges of propagation of the LNG release cloud [12]. In the case of a leakage of LNG from pressurized equipment, it will be released into the atmosphere as in the jet form. This process is connected with intensive mixing with the air. Then a big part of the

LNG in the released cloud will be initially in the form of an aerosol. Next, as a result of mixing with the air it will gradually evaporate. The combustion point of the gas – air mixture created as a result of LNG leakage may be reached when the concentration of natural gas in the mixture is between 5% to 15% of the cloud volume [1]. Then the released LNG cloud when it meets on its way an effective source of combustion may undergo the UVCE (Unconfined Vapour Cloud Explosion) – which is an explosion of vapour in an unrestricted space. The concentration of the natural gas in the released LNG significantly differs, starting from the high values occurring at the centre of the cloud and directly over the ground to very low ones on the verges of the cloud. The maximum concentration of the natural gas in the cloud depends mainly on the total volume of the air mixed with the gas and the speed of mixing. The latter one depends on the Pasquill stability class [10] and the degree of turbulences during the process of mixing. The physical size of the visibility range of the cloud of the released LNG will to a high extent depend on the LNG mass, dispersion time and atmospheric conditions [2].

5. Legal acts and branch regulations are to oblige LNG operators to apply operational procedures, technological overhauls of equipment, personnel training, getting ready for emergencies all of which is regulated by the 96/82 EC Directive. Such organizations as SIGITO (Society of International Gas Tanker and Terminal Operators), GPA (Gas Processors Association) publish an extensive number of materials on the safety of LNG terminals on the basis of the experience in the branch, indicating and recommending the best practical methods decreasing the risk of occurrence of dangerous situations. The introduction by the LNG operators the so-far non-obligatory the ISO 9000 (quality system) and ISO 14000 (system of environmental protection management) standards and OHSAS 16000 (workplace safety system) will undoubtedly add to the increase of safety in LNG terminal operation [10, 11].

The LNG terminal safety system comprises the safety of people, natural environment, property and security of facilities is a dynamic system which undergoes improvements. Changing technologies, legislature and recommendations resulting from branch experience and more and more modern methods of training cause systematic increase in efficiency and launching improvements into the safety system as it is shown in Figure 2 [1].

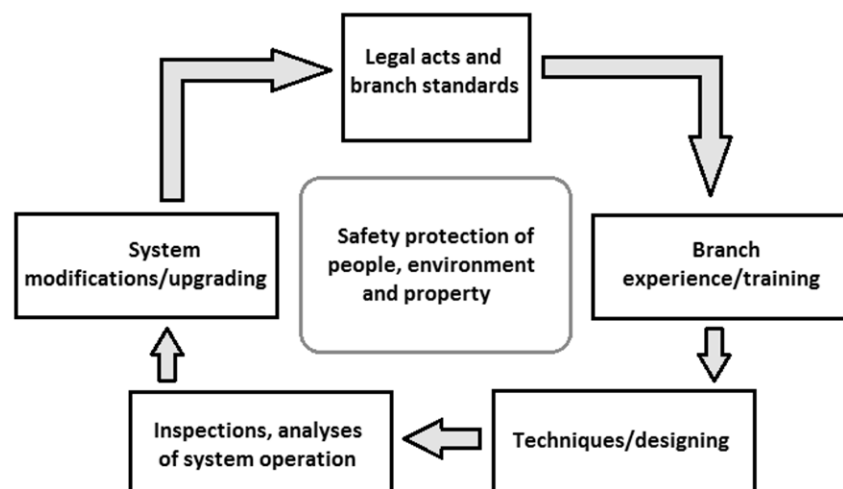


Fig. 2. General structure of the safety system [1]

POSSIBILITIES OF DECREASING THE RISK OF EMERGENCY OCCURRENCES AT LNG TERMINALS

The safety of LNG terminal operation should be considered together with the safety of a gas carrier performing the operations of LNG unloading. A vessel unloading LNG at a terminal can be a big threat. Thus, decreasing the possibility of emergencies on the ship leads to a decrease of emergency occurrence risk at the terminal.

The decrease of risk of emergency occurrence which can be dangerous for LNG operations

may take place when the vessel operating at the LNG terminal [9]:

- a. Possesses valid certificates, confirming its technical conditions, issued by classification institutions on the basis of periodical inspections.
- b. Is "safe" which is confirmed by safety inspections of the Port State Control or by the Flag State Control.
- c. Possesses positive results of audits performed with a view of safety by external auditors or charterers registered in the Vessel Inspection Questionnaire System.
- d. Has a crew whose competences are confirmed by certificates in compliance with the STCW convention as well as additional trainings e.g. on LNG carrier simulators (Full Mission)
- e. Uses the ISM system (system of safety management on a ship and in the company) – ISO 9000, ISO 14000, OHSAS 16000 introduced by the ship owner
- f. Should successfully go throughout a safety inspection performed by a safety inspector of the LNG terminal. Such an inspection should take place before the ship moors at the terminal.
- g. Goes through the procedure imposed by the IMO Check List – Ship/Shore Safety Plan.

Lowering the risk of emergency occurrence on the side of the terminal may be carried out throughout [3, 10, 11]:

- a. Applying to the standards of LNG activities in compliance with the SIGITO, OCIMF, IMO recommendations.
- b. Introducing the standards of ISO 9000 (quality system), ISO 14000 (environmental protection management system) and OHSAS 16000 (workplace safety system).
- c. Launching the management safety system based on risk analysis required by 96/82 EC Directive called SEVESO II and 2003/105/EC.
- d. Introduction of procedures for performed activities, routine maintenance and emergency activities as well as a system of permits for performing dangerous works.
- e. Preparing a procedure of actions in the case of different emergencies according to the PN-EN 1473 regulation, preparation of risk evaluation performed either in the quantitative or qualitative way using standard methods of risk evaluation. Risk evaluation should contain [7, 8]:
 - identification of internal and external risk sources,
 - classification and determination of areas endangered by explosion,
 - determination of emergency occurrence probability (e.g. uncontrolled leakage, fire, explosion),
 - evaluation of results including heat radiation, overpressure wave and the range of LNG cloud propagation,

– determination of indispensable safety systems.

- f. Terminal crew training regarding safety, operational and emergency procedures in compliance with the recommendations published in the SIGITO and OCIMF documents.
- g. Determining meteorological conditions at which LNG unloading operations performed by the ship will be stopped.
- h. Determination of safe ship mooring conditions at a terminal and appropriate assistance of tugboats at mooring operations.
- i. Emergency shut-down of LNG transfer operations from the ship; ESD1 (shuts down transfer operation regardless of where they were initiated- on the ship or at the terminal), ESD2 (shuts down the valves at the ship manifold connecting pipe with the terminal pipeline and automatically shuts down this connection).
- j. Preparation of emergency plans.
- k. Introduction of a permit system allowing the performance of specific works critical for the safety and risk management of dangerous operations based on market analysis at the workplace.

The LNG terminal management is obliged to prepare procedures of actions in the case of dangerous situation occurrence (LNG leakage, fire, explosion). When working on such procedures, the following should be taken into account [5]:

- a. Determination of a kind, quantity and location of equipment indispensable to detect an uncontrolled LNG leakage or fire.
- b. Identification of internal and external sources of risk.
- c. Determination of probability of an emergency occurrence (e.g. uncontrolled leakage, fire, explosion),
- d. Determination of ways of action of LNG terminal employees in the case of fire, explosion or an uncontrolled leakage),
- e. Classification and determination of areas endangered with an explosion.
- f. Carrying out a probable evaluation of effects taking into account heat radiation, the overpressure wave and the range of LNG cloud propagation.
- g. Determination of protection methods of construction facilities and process equipment against heat radiation during fire and/or explosion.
- h. Determination of requirements within water supply for firefighting needs.
- i. Determination of requirements for firefighting equipment and fire extinguishers.
- j. Introduction of systems sustaining the operation of facilities and process equipment in the case of technological break-down e.g. as a result of the lack of electricity supply etc.
- k. Determination of rules regarding personnel training for emergency situation occurrence.
- l. Determination of time schedule and carrying out drills for emergency situations (LNG terminal installations, pipelines or break-downs of the moored ship).
- m. Working-out a system for drawing conclusions from carried out practice emergency alarms and implementing these conclusions into the modified emergency plans

LNG TERMINAL PERSONNEL

Management of safe LNG terminal operation is connected with the personnel employed for operating technological installations of the terminal and the safety of the tasks to be performed by the personnel. Personnel employment of the terminal depends on [9]:

- a. National regulations.
- b. Port regulations and the structure of the port management.
- c. Number of unloading positions at the terminal.
- d. Terminal unloading capacity.
- e. Physical size of the terminal.
- f. Equipment installed at the terminal and requirements regarding their servicing.
- g. Level of advancement and amount of control-measurement equipment.
- h. Level of integration of the personnel employed at the terminal, abilities of particular employees to perform many tasks .
- i. Personnel abilities, skills and competences.
- j. Policy of the company regarding the employment of subcontractors.

When considering the issue of personnel employment at an LNG terminal, terminal management should take into account the number and frequency of tasks to be performed, qualifications that are required to perform such tasks, number of people necessary to perform particular tasks, time indispensable for performing the tasks taking into account shift work and also carry out market analysis connected with:

- a. Dangers resulting from LNG transfer from the ship to the terminal.
- b. Safety of the ship moored at the terminal.
- c. Detection of gas or liquefied LNG leakages.
- d. Detection of fire or smoke.
- e. wharf monitoring,
- f. Monitoring of the ship at the wharf.
- g. Monitoring of the part of cargo being currently unloaded and LNG pressures the process of transfer.
- h. Activation of emergency shut- down systems ESD1 and ESD2.
- i. Activation of emergency alarms and introduction of emergency procedures.
- j. Correct communication systems: terminal-ship and internal ones at the terminal.
- k. Protection of the facility from unauthorized persons, destruction acts, terrorist attack.
- l. System of control and supervision run by the authorized personnel present at the terminal.
- m. Protection of escape routes and their monitoring.
- n. Ability to react at emergency situations.

EXTERNAL PERSONNEL EMPLOYED AT LNG TERMINALS

Safety of a maritime LNG terminal is also influenced by people whose activities are indispensable for performing the task facing the terminal. As a rule, they should be qualified and trained in the safety issues. This group comprises:

- a. Sea pilots and dock pilots who bring the LNG carrier to port and LNG terminal wharf,
- b. Tugboat crews assisting the leading of the vessel to port. Tugboats used for the LNG vessel mooring operation or assisting the LNG carrier in the port must have an internal closed ventilation system.
- c. Wharfmen performing mooring and unmooring operations of the ship.

- d. Inspectors/experts who are to measure the amount of cargo on the ship and collect cargo samples from the ship.
- e. Safety inspectors of the ship owner or the charterer.
- f. Ship agents.
- g. Terminal equipment repair teams or ship maintenance crews.
- h. Customs officers,
- i. Port sanitary officers,
- j. Members of Firefighting Services.
- k. Ship suppliers (suppliers of food, spare parts).
- l. Port security officers and terminal security officers.

TASKS PERFORMED BY LNG TERMINAL

Management of LNG terminal safe operation requires filling the posts which are necessary for a safe operation of LNG unloading from the ship to the terminal, taking into account the safety of people, the environment and the property (ship/equipment and LNG terminal facilities) [5, 9]. Tasks of the LNG terminal crew at LNG unloading or loading comprise:

- a. Communication with the vessel before it arrives at the port.
- b. Mooring the ship at an appropriate position at the terminal.
- c. Servicing the operation of ship mooring.
- d. Checking and confirming safe mooring of the ship,
- e. Installation of a gangway allowing a safe access onto the ship.
- f. Preparation of the on-land installation of the LNG terminal for accepting the cargo from the ship.
- g. Organizing and participation at a conference on the ship before starting LNG transfer from the ship to the terminal.
- h. Fulfilling the checking procedure according to the Ship/Shore Safety Check List.
- i. Carrying out a cargo conference on the ship where the conditions of LNG transfer from the ship to the terminal are settled.
- j. Connecting the ship pipes to terminal installation.
- k. Collecting samples of LNG cargo from the ship.
- l. Measurement of containers on the ship and establishing the amount of the cargo.
- m. Establishing and monitoring communication systems between the ship and the terminal.
- n. Confirmation of the state of safe transfer throughout cyclic checking of the safety in compliance with the ship/shore safety check list.
- o. Continuous control and checking the position of the ship at the terminal.
- p. Continuous control and checking the mooring of the ship.
- q. Continuous control and checking the pipelines, valves and other installations in order to detect potential occurrence of LNG leakages.
- r. Regular checking of cargo level on the ship.
- s. Checking the water surface around the ship in case an uncontrolled leakage of oil or fuel from the ship takes place.
- t. Checking weather forecasts and hydro-meteorological conditions.
- u. Monitoring of the part of cargo being currently unloaded and pressures in pipelines receiving LNG at the terminal.

- v. Monitoring of emergency shut-down system installations, ESD1 and ESD2 and their switching-on if need arises.
- w. Reacting in dangerous situations:
 - fire on ship or at the terminal,
 - faulty operation of unloading systems or the ship power systems,
 - LNG leakage,
 - terrorist attack

and:

- 1) communication with port administration, both routine and emergency,
- 2) organization of ship emergency unmooring in the case of a threat on a major scale,
- 3) control and supervision over repair/maintenance teams of LNG terminal installations,
- 4) monitoring of people working at the terminal, ship crews and other persons indispensable for terminal and ship operation,
- 5) monitoring of escape routes,
- 6) carrying out the operations of safe disconnection of LNG transfer pipeline from the ship unloading installation after the unloading has been completed,
- 7) performing the operation of safe unmooring of the ship from the terminal wharf.

Due to the wide range of tasks and their importance from the safety point of view which the terminal crew has to undertake, a very important issue is the number of personnel for each task or integration of the terminal crew and training it for performing many tasks.

FINAL REMARKS

Safe LNG terminal operation management is an issue of great significance, of utmost importance due to the specifics and dangers connected with their safe operation.

Introduction of quality and safety standards recommended by OCIMF will undoubtedly lead to a decrease in the risk of emergency situation occurrence.

Trainings of crew/personnel with a view of safety and introduction of procedures of task performance as well as a system of permits for performing special tasks, prepared using the methods of risk analysis, will bring about a decrease in the risk of emergency situation occurrence.

Determination of procedures of actions in emergency situations and their regular, periodic practicing during practice emergency alarms is absolutely necessary and obligatory.

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