Tasneef®
Life Environmentally Optimized

Guide for Shipyard with Facilities for LNG Fuelled Ships Survey, Repair and Conversion

Effective from 1/1/2020

Emirates Classification Society (Tasneef)
Aldar HQ 19th Floor,
Al Raha Beach, Abu Dhabi, UAE
Abu Dhabi, United Arab Emirates

Phone (+971) 2 692 2333
Fax (+971) 2 445 433
P.O. Box. 111155
info@tasneef.ae

GENERAL CONDITIONS

Definitions:

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case.

"IACS" means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

"Rules" in these General Conditions means the documents below issued by the Society:

(i) Rules for the Classification of Ships or other special units;
(ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
(iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
(iv) Guides to carry out particular activities connected with Services;
(v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"Ship" means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
(i) sets forth and develops Rules;
(ii) publishes the Register of Ships;
(iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various Governments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatement. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:
(i) in the selection of its Surveyors
(ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of the specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as part of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certification and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaworthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structur e, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certifi cation or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, t he Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any st atutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the righ t to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorisation of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of cl ass, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.

Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's c lients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific propert y of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificat es, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty t o ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.

In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

Index

Index

Index

1 PREAMBLE

In these years, stricter emission limits are increasingly entering into force in many areas and worldwide. In order to comply with all of them, a solution proposed to the marine industry is the use of alternative fuels like LNG.

Compared with conventional marine fuels such as heavy fuel oils and distillate fuels as marine diesel oil (MDO) or marine gas oil (MGO), LNG differs significantly in term of properties, characteristics and behaviour.

For these reasons it is essential that all the operations related to LNG fuelled ships are undertaken with diligence and due attention is paid to prevent leakage of LNG liquid or vapour.

During LNG fuelled ship's lifecycle, it is not only important to have available proper bunkering facilities, but also shipyards for survey, repair and conversion of gas fuelled ships able to comply with the requirements for LNG operations.

Since many LNG fuelled ships are, for instance, cruise ships and ferries, it is therefore important to organize also those shipyards, usually fit for passenger ships refurbishments, for the safe management of all the necessary LNG processes.

The shipyard is to be carefully designed; dedicated safety and operational procedures are to be developed, implemented and executed by trained personnel.

2 FIELD OF APPLICATION

2.1 Application

The aim of this guide is to provide information, requirements and procedures for shipyard with facilities for LNG fuelled ships survey, repair and conversion in order to achieve the necessary high level of safety, integrity and reliability.

Main matters covered by this guide are the followings:

- Typical LNG plant operations
- Shipyard organization
- Risk assessment
- LNG hazards
- Emergency operations
- Training

2.2 Rules, standards and guidelines

These guides are to be used in conjunction with the following rules, standards and guidelines as reference:

- IGF Code, International Code of Safety for Ships using Gases or other Low-flashpoint Fuels
- Tasneef Rules (in particular Part A, Ch.3, Sec. 9, Part C, Ch.1, App. 7)
- Tasneef Guide for survey during construction, commissioning and sea trials of LNG gas fuelled ships
- Tasneef Guide for the Risk Assessment for Gas fuelled Ships Projects
- ISO 16901:2015 Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface
- ISO/TS 17969:2015 Petroleum, petrochemical and natural gas industries - Guidelines on competency for personnel
- ISO/TS 18683:2015 Guidelines for systems and installations for supply of LNG as fuel to ships
- ISO 23208:2017 Cryogenic vessels — Cleanliness for cryogenic service
- ISO 28460:2010 Installation and equipment for liquefied natural gas - Ship-to-shore interface and port operations
- IEC 31010:2019 Risk management — Risk assessment techniques
- SGMF – Various dedicated guidelines about gas fuelled ship operations

3 ABBREVIATIONS AND DEFINITIONS

- BLEVE: boiling liquid expanding vapour explosion. When LNG, standing under pressure close to its boiling point, is released abruptly (sudden total pressure relief), a vehement physical expansion process occurs. This process releases immense forces and leads to large and extensive damage.
- BOG: Boil Off Gas. Certain amount of gas vaporized due to the heat flux.
- BS: Bunker Station. Space for LNG bunkering equipped with LNG bunker header connection for receiving LNG and vapour header connection for returning vapour to shore during LNG loading operation, if applicable.
- Cryogenic fluid: gas which is partially liquid because of its low temperature.
- FSHS: Fuel Storage Hold Space. Space containing fuel tanks and tank connection space.
- GVU: Gas Valve Unit. Fuel gas supply control unit to consumers.
- LFL: Lower Flammability Limit. Lower end of the concentration range over which a flammable mixture of gas or vapour in air can be ignited at a given temperature and pressure.
- LNG: Liquefied Natural Gas.
- PIC: Person in Charge.

- POAC: Person in Overall Advisory Control: a trained and experienced person appointed in advance to oversee and manage the operations related to LNG plant maintenance.
- RPT: Rapid Phase Transition. It occurs when a liquid turns into vapour very rapidly.
- TCS: Tank Connection Space. Space containing all LNG and vapour tank connections and valves.

4 BRIEF INTRODUCTION TO LNG

Natural gas comes from reservoirs beneath the earth's surface.

The main component of natural gas is methane. Methane is composed of one carbon and four hydrogen atoms (CH_4). When natural gas is produced from the earth, it includes many other molecules, like ethane, propane, butane. Small quantities of nitrogen, oxygen, carbon dioxide, sulphur compounds, and water may also be found in natural gas.

Liquefied natural gas (LNG) is natural gas that is cooled to the point that it condenses to a liquid, which occurs at a temperature of approximately -161°C and at atmospheric pressure. Liquefaction reduces the volume by about 600 times thus making it more economical to transport.

The liquefaction process requires the removal of some of the non-methane components such as water and carbon dioxide from the produced natural gas to prevent them from forming solids when the gas is cooled to LNG temperature. As a result, LNG is typically made up mostly of methane.

LNG is odourless, colourless, non-corrosive, and non-toxic. However, as with any gaseous material besides air and oxygen, the natural gas vaporized from LNG can cause asphyxiation in an unventilated confinement.

At -161°C, the vapour is denser than air, and become lighter than air at around – 110 °C. Therefore a release of LNG initially results in a flammable gas cloud that spreads by gravity in low lying areas until it warms and becomes buoyant. The cold natural gas can also be mixed with air and form a flammable cloud. In this case, the flammable cloud is not buoyant, but it drifts with wind and is diluted by atmospheric turbulence and diffusion.

LNG for fuel supply may be delivered at elevated pressure and at a pressure exceeding the boiling point at atmospheric conditions.

Release of LNG under such conditions, results in an instantaneous flashing and a much higher vapour release and larger gas clouds.

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

Natural gas has a flammable range between 5% and 15 % when mixed with air.

Natural gas has a flashpoint of – 187°C, and a self-ignition temperature of approximately 540°C compared with a flashpoint of 55°C and a self-ignition temperature of 300°C for marine gas oil (MGO).

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

Main hazards associated with LNG are therefore:

- fire, deflagration or confined explosion from ignited natural gas evaporating from spilled LNG
- brittle fracture of the steel structure exposed to LNG spills
- frostbite from liquid or cold vapour spills
- asphyxiation from vapour release
- over-pressure of transfer systems caused by thermal expansion or vaporisation of trapped LNG (the thermal expansion coefficient of LNG is high 1 to 600)
- possible rapid phase transition caused by LNG spilled into water
- possible boiling liquid expanding vapour explosion (BLEVE) of a pressurized fuel tank subjected to a fire.

5 LNG PLANT

5.1 Introduction

The safety in operation of the LNG plant depends on the care and attention of all crewmembers on board and personnel ashore. Many safety precautions are a matter of common sense and good housekeeping. However, records show that even experienced operators sometimes neglect safety precautions due to sound familiarity with the LNG plant operation. Therefore, shipyard operators is to be as well aware that all the necessary operations have been carried out properly.

At least the following basic rules are to be followed at all times:

- avoid to use any equipment that seems to be potentially unsafe or dangerous. It is always necessary to inform this condition immediately and to fill a proper record
- perform testing of all safety equipment and devices on regular basis
- don't ignore any unusual or suspicious circumstances. Minor indicators often appear before a major failure occurs
- don't undervalue the fire hazard of gaseous products

5.2 Main equipment

A gas fuelled ship is usually equipped with the following main items related to the LNG:

- Gas engines or dual fuel engines
- Gas boiler or dual fuel boilers
- LNG fuel storage tanks
- LNG vaporizers
- LNG gas heaters
- Vapour, tank safety, line safety valves
- Water-glycol heating system
- Nitrogen generator
- Nitrogen holding tank
- Gas detection system
- Ventilating system
- Gas valves units, fuel piping and safety valves
- Electrical equipment in hazardous areas
- Ventilation systems

Since most of the above equipment are to be inspected and overhauled, the shipyard has to provide dedicated procedures for the disassembly and dedicated cryogenic and mechanical workshops for their maintenance.

5.3 Types of cryogenic tanks

According to the IGF Code there are four types of tanks allowed to be used for the containment of LNG, three independent type tanks A, B and C, and membrane tanks. An independent tank means that it is not integrated with the structural strength of the hull and it carries its own weight. In general, the independent type C tank is designed to handle pressure.

Independent type A tanks are usually designed as a prismatic tank. A complete secondary barrier is needed to be able to catch any leakage and prevent thermal conditions from affecting the hull.

Independent type B tank can be found as a Moss-Rosenberg spherical tank or as a prismatic tank. Only a partial secondary barrier is required. Usually any leakage is collected at the bottom of the tank, where the partial secondary barrier is found.

Independent type C tank is a pressurized vessel. No second barrier is required, since usually type C tanks are built using an inner shell of nickel or aluminium alloy steel, a vacuum insulation layer and an outer shell. Pressures up to 10 bar are allowed for containment of liquefied gases, although usually LNG is stored at a pressure ranging from slightly above atmospheric to about 5 bar. With sufficiently high pressure, the pressure difference is used to feed the engines. When storing at low pressures, pressure build-up units are added to the system.

Due to the margin available for pressure build-up, it is possible to find this type of tank installed without a vapour return line.

The membrane tanks are usually in the hull shape of ship and lined internally with a primary membrane. Underneath the primary membrane are successively lined-up one layer of insulation (primary insulation), another membrane (metallic or composite, called secondary membrane) and another insulation (secondary insulation), directly beared onto the inner hull (conventional LNG carriers case) or any other structure which is part of ship's structure and constitute the structural body of the tank.

Most of the ships currently using LNG as a fuel have independent type C tanks installed for storage. Designs for membrane, type A and B tanks have been proposed, since especially for larger vessels they provide a significant benefit in hull space.

There are different scenarios for the location of the cryogenic tanks like above deck, below deck, bow, stern and amidships.

Recommendations of this guide are for any kind of LNG plant, but basically based on C type tank.

5.4 LNG plant typical layout

A LNG plant is designed to receive, to hold and to process LNG. The LNG plant includes several separate rooms which are, i.e., the Bunker Station (BS), the Fuel Storage Hold Space (FSHS) and, the Tank Connection Space (TCS). In complex systems, separated Valve Box (VB), Cold Box (CB) and Gas Handling Room (GHR) can be found. These spaces are defined as hazardous areas where an explosive gas/air mixture may accumulate.

It is therefore important to set up all the necessary procedures to ensure these spaces are gas free before to issue the permit to work inside.

Spaces may be inerted with nitrogen. Nitrogen is an asphyxiating gas, when mixed with air it lowers its oxygen concentration. All personnel in charge of the fuel gas plant should know the precautions necessary to prevent accidents that may have fatal consequences.

In general, access to the hazardous areas for maintenance and repair is prohibited until they are designated as a non hazardous area; only authorized personnel with special advice and suitable PPE are allowed to enter the hazardous area for maintenance reason (for PPE details please refer to [6.11.2.9]). Control of activities into the onboard designated hazardous area should be controlled and restricted to authorized personnel only.

Each LNG fuel storage tank not arranged over the weather deck, is fully enclosed in a Fuel Storage Hold pace (FSHS) and fitted with a Tank Connection Space (TCS), enclosing all pipe connections and the access into the LNG tank.

The FSHS is an enclosed space, free from flammable materials and arranged and equipped according to relevant Rules and Regulations. The TCS contains all LNG and vapour tank connections with their shut-off valves, vent line connections with vent valve arrangement, all tank instrumentation and purge connections for each pipe section.

The space containing fuel containment system is to be separated from the machinery spaces of category A or other rooms with high fire risks. For type C tanks, the fuel storage hold space may be considered as a cofferdam.

The air-lock is therefore required to separate the FSHS (fuel containment system) from the machinery space.

The access to the fuel-gas plant could be arranged via an air-lock, depending on the LNG plant lay out and relevant hazardous areas. The entrance into the air-lock from the non hazardous area is fitted with a gas-tight door.

Bunker stations are usually one for each ship side and equipped with a LNG bunker header connection for receiving LNG and a vapour header connection for returning vapour during LNG loading operation if appropriate and accepted by the LNG supplier.

Each header connection of the bunker stations is fitted with an ESD shut-off valve, line relief valves, and purge and test connection, instrumentation for local and remote monitoring and control.

If not located over the weather deck, the entrance to the BS from the air-lock is fitted with a gas-tight door.

For reference, please refer to schematic layout in figure 1 and figure 2. To simplify the scheme only bunkering, BOG/LNG fuel gas service are shown (for instance heating media system is not represented).

For other operations details, please refer to Chapter 6.

Figure 1: Schematic layout - LNG plant with BOG compressor and separated GHU and CB

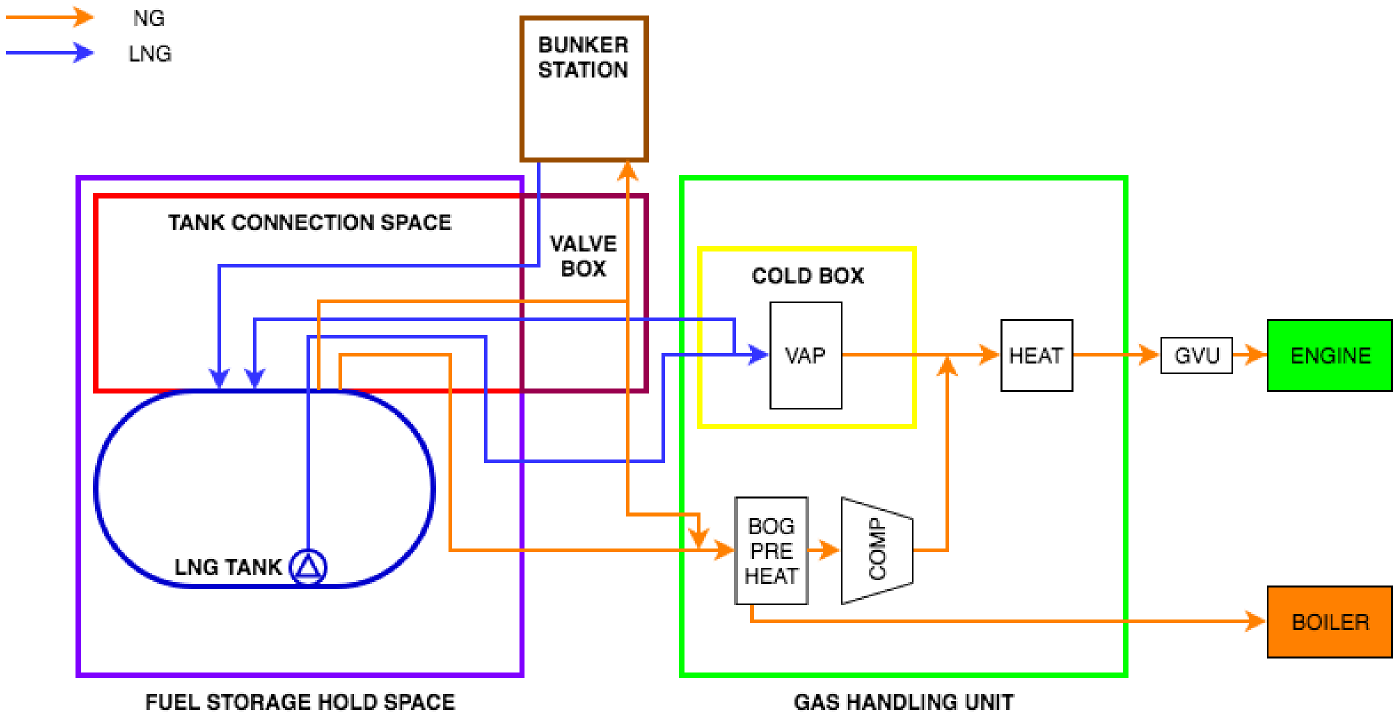
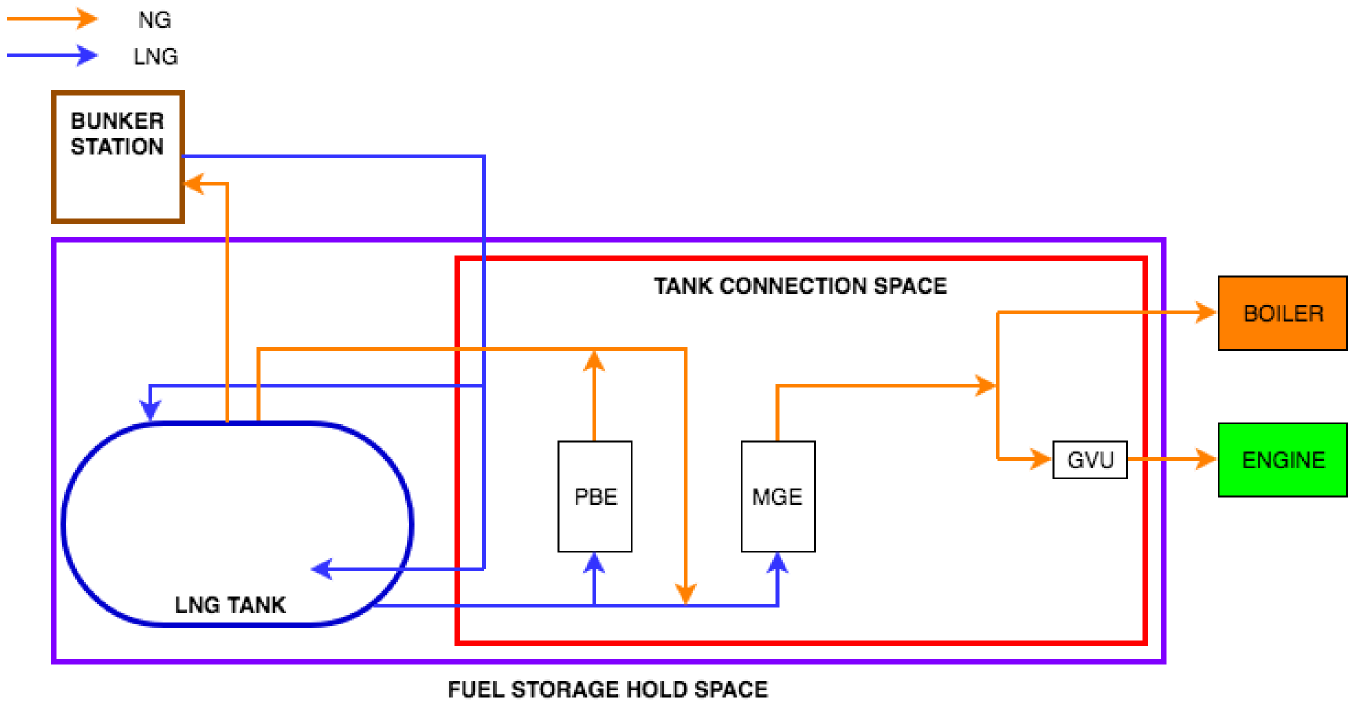


Figure 2: simple LNG plant with Pressure Built Unit and integrated tank connection space



PBU: Pressure Build up Evaporator

MGE: Main Gas Evaporator

6 LNG PLANT TYPICAL OPERATIONS FOR ENTERING LNG FUEL TANKS

6.1 Operations sequence

When necessary, due to the type of maintenance repair work to be carried out, preparatory operations for drydock start with the consumption of all remaining LNG and ends with the creation of the required tank atmosphere. On a voyage just prior to the drydock, it is necessary to consume LNG as much as possible in order to leave less residual LNG on board.

The usual operations sequence related to the drydock is the following:

1. Cruising (operating LNG fuel gas plant in order to consume as much as possible the LNG on board)
2. Stripping (LNG removal by LNG pumps, if any, and LNG tank pressurization)
3. Warming-up (recirculation of vapour via gas heater)
4. Inerting (replacement of vapour by nitrogen gas)
5. Aerating (replacement of nitrogen by dry air)
6. Drydock
7. Re-commissioning
8. Drying and inerting (replacement of air by nitrogen gas)
9. Cold Test/Stress Relief of Fuel Gas Plant (N_2 cool down, if necessary)
10. Gassing-up (replacement of nitrogen gas)
11. Cooling down (LNG spray into LNG tanks)
12. Bunkering (receiving LNG from LNG supply vessel)
13. Cruising (operating LNG fuel gas plant)

The shipyards is to be aware that proper procedures for each step are properly carried out and checked in order to perform safe maintenance works.

The evidence of the above is to be documented.

In case the ship is not able to perform all the necessary operations before starting the drydock, a dedicated set of regulations and procedures to ensure the highest safety standards is to be developed, including a risk assessment that should be prepared by the shipyard, and agreed with the Owner.

The shipyard should provide as well the procedure for acceptance of the ship.

It is furthermore necessary to obtain the necessary permissions from the Authorities and to agree the scope of works with the Owner prior to arrival. Authorities are also to review and approve the abovementioned risk assessment. Good communications between all the parties involved, ensures that the shipyard is ready for the drydock on the due date and the works completed within the scheduled time.

The competent authorities should authorize tank operations such as gas freeing of tanks and inerting on board the gas fuelled ship before and after maintenance in specific locations.

These locations, where the ship will carry out the inerting operations and aerating the tanks, should be therefore designated in advance (LNG terminal, or suitable installations, consumption and purging to the boilers is also one option), as it will be necessary to transfer the NG vapors to reception facilities (venting is not a normal operating procedure).

It has to be taken into duly consideration that all the abovementioned process are very time consuming.

6.2 LNG consumption and stripping

Before starting with preparations for drydock, it is useful to perform a routine cold spot check on the insulation of the LNG tanks. The TCS needs to be purged with dry air in order to raise the oxygen content to min 20 % vol before entering into. The LNG tanks need to be stripped, warmed-up, inerted and aerated before entering into for any inspection or maintenance work.

6.3 Warming up

After stripping operations, some residual LNG is still in the sumps. During the warming up operation, the residual amount of LNG is to be vaporized. This is obtained by injecting hot vapour into the LNG fuel storage tanks.

This operation needs to be performed carefully since some hydrocarbons can be found in the sumps in a liquid state even if temperature is well above -160 °C.

The warming up operation increases the LNG fuel storage tanks temperature above the dew point of the nitrogen that is to be deployed for the subsequent inerting operation. This condition is related to the vapour phase as well as to the LNG fuel storage tank shell and it is necessary to avoid condensation inside the LNG fuel storage tanks and in whole LNG cryogenic piping system.

It is critical to monitor the LNG fuel storage tanks and LNG cryogenic piping system for suitable movement during this operation. This equipment must freely move with their sliding supports on the foundations in order to avoid excessive stress. It is recommended to provide mapping points for ambient and cryogenic condition to evaluate equipment movements.

For LNG warming up it is possible to use different available equipment:

- fixed equipment installed onboard
- portable ventilation fan and heater

The vapour in excess produced during warming up can be consumed, as far as possible, in engines and then in boilers.

The LNG tanks pressure is to be maintained at a higher operation pressure, depending of the equipment being employed, in order to speed up the process.

During warming up no fuel gas supply is to be in operation.

In order to avoid excessive stress to LNG tanks, it is to be taken always into account the allowed temperature gradient (°C/h) according to LNG plant operational manual.

6.4 Inerting

LNG plant, including LNG fuel storage tanks, pipes and all related equipment are to be purged with nitrogen in order to remove all vapour in total prior to drydock. Before the inerting operation, the LNG tanks pressure is to be reduced; this should be done sending vapour to the boiler.

The purge operation is performed using remaining vapour as fuel gas in a boiler in order to avoid the release of vapour via the vent mast to the atmosphere.

The nitrogen gas needs to have a N_2 purity of about 97% vol and a dew point of about -45 °C. Nitrogen gas supply temperature is to be above vapour temperature inside the LNG tanks.

It is very important that all the LNG fuel storage tanks and related piping are properly and totally inerted in order to avoid any formation of an inflammable gas/air mixture.

This operation in total will consume some time. This operation is preferable to be carried out prior to a drydock period while at sea, commencing well in advance before drydock will be started.

For any further details, please refer to Manufacturer’s manual.

At the end of this operation, the mixture of nitrogen and gas may be vented, depending on the capability of the boiler. The allowable gas concentration in the nitrogen that can be vented in the atmosphere needs to be mutually agreed upon with the competent authorities.

6.5 Aerating

Before to enter into the LNG fuel storage tanks for inspection or repair, the nitrogen gas needs to be replaced by dry air. If the ship system does not allow for such service in connection with the aeration of the fuel gas plant, a portable drying unit and a portable ventilation fan need to be fitted for this operation by the shipyard.

The shipyard has to be therefore equipped as necessary. The portable units are to be connected by flexible hoses to the system.

The humidity content in the ambient air may cause condensation inside the LNG fuel gas plant, therefore the air needs to be dehumidified. Air entering the system needs to have a dew point of ≤ 20 °C below system temperature.

The dry air is normally heavier than the nitrogen in the system and therefore it is recommended to enter it in the LNG fuel storage tanks via the bottom filling line. The temperature of the air entering the LNG fuel storage tank is to be slightly below the nitrogen temperature inside the LNG fuel storage tank in order to ensure a good piston effect. The pressure is to be maintained low to improve the operation performance.

The nitrogen gets away from the LNG fuel storage tanks by means the vapour connections purging the piping system to a certain extend. Most of the nitrogen and finally the dry air escapes from the LNG fuel storage tanks via the emergency relief bypass tank valves.

The operation is to be considered finished when all LNG fuel storage tanks show a reading of oxygen ≥ 20 vol-%. A positive pressure are to be maintained in the LNG fuel storage tanks, therefore the ventilation fan with drying unit should be in operation through the drydock period. The shipyard is to be organized to ensure the equipment availability all the times.

The time required for this operation depends on the capacity of the portable ventilation fan employed in this operation.

If a LNG fuel storage tank inspection is to be carried out (inspection due to Class requirements, monitoring results, etc), it is necessary, of course before all, to open the manhole removing the manhole cover plate. This operation is to be performed carefully taking into consideration the LNG fuel storage tank pressure.

Dry air is to be supplied into the LNG fuel storage tanks at a certain pressure when the manhole is open in order to avoid entry of humidity from the ambient air.

Subject to the works or inspections to be carried out on the LNG plant, the remaining pipe sections not involved in the LNG fuel storage tank aerating operation need to be purged from the LNG fuel storage tanks onward to atmosphere as found appropriate.

The necessary double-block-and-bleed arrangement are to be kept in force throughout the maintenance and repair work.

Remote operated valves being part of the double block-and-bleed arrangement need to be blocked during all the inspection and maintenance period until normal operation condition is resumed. For further detail about block-and-bleed system please refer to 7.3.1.

All ventilation systems are to work as required by rules and regulations

Portable gas detectors capable of measuring flammable vapour concentrations in air, portable O_2 analysers and dew point meter are to be available,

The detectors are to have a valid certificate, to be calibrated and to be always available, Good practice requires calibration every three months.

6.6 Additional step in case of extensive maintenance work

In case of extensive maintenance work on the LNG fuel gas plant is carried out during the drydock, a cold test is to be performed prior re-commissioning.

Regardless the actual atmosphere in the fuel gas plant system, a nitrogen purge operation with warm nitrogen (GN_2) needs to be performed prior to a cold test or gassing up operation.

This GN_2 purge operation is necessary to eliminate any humidity in the the LNG plant. Using the onboard nitrogen plant it is possible usually to achieve a dew point around -40 °C. This condition is not enough to perform a nitrogen cold test since the remaining humidity condenses. Since an accumulation of water in the system is not acceptable, it is necessary to achieve a dew point ≤ -160 °C prior to the cold test.

To comply with this requirement it is necessary to perform a GN_2 purge with industrial nitrogen supplied from a LN_2 truck from ashore, which is able to provide a dew point well ≤-160°C. At the time of the start-up of this operation, the supply temperature of the GN_2 is to be around 20 °C above actual dew point in the fuel gas system in order to avoid condensation of any humidity in the system.

The shipyards is to organize this operation in advance.

The main objective of this operation is to release stresses in the LNG fuel storage tank systems and to check for leakages. This leakage detection is achievable only when the system is subject to cryogenic temperature.

Maintaining the temperature and pressure within proper limits is the most critical part of this operation.

To carry out a cold test, two different methods can be used:

- GN_2 entering the LNG plant within a range from ambient temperature down to ≥ -160 °C
- LN_2 sprayed directly into the LNG tanks

If GN_2 is provided, the LN_2 supplied by a LN_2 truck goes through an onshore vaporizer. The GN_2 passes through the LNG fuel gas plant in free flow condition.

The GN_2 supply temperature is to beset and controlled.

If LN_2 is provided, the LN_2 is sprayed directly into the LNG tanks via the spray nozzles.

Since the LN_2 is at low temperature, the nitrogen spills into the LNG fuel storage tanks and distributes itself. The goal is to get a good distribution effect of the cold high density LN_2.

In this way, a minimum allowable target temperature of -160 °C is achievable. It is necessary to carefully take under control the temperature inside the LNG fuel storage tanks by adjusting the spray capacity.

Also during this operation, it is important to control the LNG fuel storage tanks and cryogenic piping system for proper movement. This arrangement of the equipment must allow for free movement on their sliding supports to avoid excessive stress. It is recommended to provide mapping points for ambient and cryogenic condition to take under control the movements.

It is useful to draw up a document about commissioning operations details. This document needs to include data on LN_2 or GN_2 like supply capacity and temperature over LNG tank temperature in order to monitor the performance.

In order to avoid excessive stress to LNG tanks, it is to be taken always into account the allowed temperature gradient (°C/h) according to LNG plant operational manual.

If GN_2 is provided, the temperature gradient is controlled by modifying the GN_2 supply capacity and supply temperature condition. In addition, it is recommended to distribute GN_2 to the individual LNG tanks as appropriate operating the manual liquid bunker valve in the bunker station.

If LN_2 is provided, it is possible to manage the temperature gradient just by adjusting the LN_2 transfer rate.

During this operation, portable equipment for leak detection is to be available.

When the vapour temperature inside the LNG tanks is around -140 °C, the cold test is concluded.

The time needed for this operation largely depends on the liquid nitrogen (LN_2) supply condition from shore.

Since usually the quality of LN_2 from a truck is of good industrial standard, this allow to skip the gassing-up operation in case ship commissioning follows this cold test.

Therefore LNG could be sprayed directly into the LNG tanks regardless of temperature condition.

6.7 Re-commissioning

After the drydock period, the total LNG fuel-gas plant is under air atmosphere. Before to close the LNG tanks it is necessary to remove any humidity, water and possibly other impurities and to carry out a final inspection for confirmation.

Before to start the re-commissioning it is necessary to check that the LNG fuel gas plant is ready to operate any equipment fitted and that the ventilation system is switched on.

In particular the following systems, including the safety and protection devices, are to be checked in working order:

- Gas and fire detection systems
- Ventilation systems
- Instrument air system.
- Inert gas system
- Heating system

Furthermore it is necessary to be sure that all units that have been serviced during the drydock are correctly assembled and that the system is ready for operation.

- Check that all covers are properly mounted.
- Check that all tools and loose parts have been removed.
- Check the rotation direction of electric pumps and motors if the power supply cables have been disconnected during the stoppage.
- Check the positions of the manual maintenance valves.
- Close the maintenance hatches

Before to start the gassing up operation it is necessary to check that humidity and possible water is totally removed and oxygen is depleted to the desired values.

The aim of this operation is to replace the nitrogen in order to provide for a clean vapour atmosphere and therefore for a high quality of fuel gas for the onboard consumers.

The last step in this re-commissioning is the cooling down to the cryogenic temperature of the LNG plant until LNG storage tanks and TCS, that means all the LNG plants parts working with LNG at cryogenic temperature. This operation allows to perform the LNG bunkering maintaining the thermal stress in the system well below the acceptable stress level.

6.8 Drying and inerting

After LNG plant survey and maintenance, it is necessary to perform drying and inerting process before putting into service the LNG system.

Drying is necessary to replace humidity and inerting is necessary to replace the oxygen and to avoid the formation of gas/air mixtures when starting the gassing up operation.

The air inside the LNG tanks and LNG plant is to be replaced by warm nitrogen gas. Nitrogen is supplied or from the onboard nitrogen plant or from nitrogen storage ashore. The shipyards is to be organized to supply nitrogen if necessary.

The air/nitrogen gas mixture is vented to atmosphere.

It is recommended to start this operation well in advance before next LNG bunker operation.

6.9 Gassing-up

Before to start the gassing up operation, air is to be replaced by nitrogen gas totally.

The gassing-up is performed with warm LNG vapour received from the LNG supplier.

The warm LNG vapour goes in the LNG tanks from the top and the nitrogen goes out from the LNG tanks at the bottom and sent to atmosphere or to the boilers.

The aim of this operation is to achieve hydrocarbon concentration of ≥ 98 vol-% in the LNG plant.

The vapour (GNG) is supplied from ashore or from a ship. Vapour start-up flow capacity, supply pressure, supply temperature, ramping down procedure and other details are to be agreed with the supplier and communicated and taken under control constantly.

At the beginning of the process, the vapour temperature is to be around 20 °C and the supply pressure is to be above of LNG fuel storage tank pressure to ensure the required flow capacity.

During this operation nitrogen exits the LNG fuel storage tanks and is vented to atmosphere for a certain time. The vapour concentration in term of hydrocarbons is to be monitored for each LNG fuel storage tank to follow up the progress in the gassing up operation.

When the vapour concentration is increasing above a certain limit, the vapour/nitrogen mixture is to be re-routed to the boilers.

The vapour generation is to be such as to avoid an excessive venting capacity and the the pressure limits is to be not exceeded.

Proper purging operation for bunker station, spray, vapour and fuel gas piping are to be carried out as well before to start the cooling down operation.

It is to be taken into consideration that the gassing up of the LNG fuel storage tanks is a time consuming operation.

6.10 Cooling down

The cooling down operation is necessary to avoid any cold shock and thermal stress to the system and an excessive development of vapour during LNG bunker operation.

It is important during this operation to monitor the maximum allowable cooling down gradient.

In order to avoid excessive stress to LNG Tanks, it is to be taken always into account the allowed temperature gradient (°C/h) according to LNG plant operational manual.

Carrying out a proper procedure reduces the wear and tear of the material and ensures the integrity and reliability of the LNG plant.

It is critical to monitor the LNG tanks and LNG cryogenic piping system for suitable movement during this operation. This equipment must freely move with their sliding supports on the foundations in order to avoid excessive stress. It is recommended to provide mapping points for ambient and cryogenic condition to evaluate equipment movements.

Liquid and gas lines of each vessels and equipment are to be inspected for any unexpected cold spot (e.g. where pipeline are insulated or in way of pipeline supports), any unexpected gas leakage and any unexpected cold spot of the different spaces were the lines running (if any).

LNG is received from a LNG supplier via a LNG hose connection to the bunker station. LNG is supplied by the bunker header and sent to the LNG fuel storage tanks.

The vapour is to be sent to the boilers, when nitrogen in vapour is low as required. Vapour can be sent then directly to the engines when the composition is as required.

The cooling down can be terminated when a temperature around -130 °C is achieved at the LNG tank bottom. Please always refer to Maker’s operational manual for the right figure.

The range of the required LNG supply pressure at ship’s bunker station need to be agreed with the LNG supplier to ensure proper spray pattern at the in-tank spray nozzles. A perfect spray pattern is essential for a successful cool-down operation.

6.11 Bunker operations

LNG bunker operations are to be in compliance with rules or regulations of the regulatory bodies or local authorities and the dedicated risk assessment.

The Port Authorities and other interested parties are to be informed and to agree bunker operation in due time before the start of the planned LNG bunker operation. A bunker pre-meeting with all parties needs to be arranged.

Many guidelines are already developed about these issues, please refer to the relevant ones. In the following section only topic issues related to the shipyard organization are highlighted.

6.11.1 Bunker equipment

LNG supply can be from a shore facility or from a bunker ship.

Of course, depending from the availability and Owner's requirements, the shipyard can evaluate to be equipped with LNG bunkering facilities as well.

In any case, safety considerations, such as simultaneous other activities (SIMOPs) and hazards that occur in the shipyard, are to be carefully taken into account before to plan how to bunker the ship after the drydock.

6.11.2 Bunkering from the Shipyard

A shipyard is to consider carefully the opportunity to be equipped with a facility for LNG bunkering.

In this case, the facilities are to follow all the requirements for ashore facilities plus all the requirements in connection with the ship bunkering according to local and international rules.

This guideline, in fact, is based on the assumption that LNG supply/receiving facilities in the shipyard, if any, are designed according to the relevant and applicable codes, regulations and guidelines such as the International Maritime Organization (IMO), the Society of International Gas Tankers and Terminal Operators (SIGTTO), the Oil Companies International Marine Forum (OCIMF), the Society for Gas as a Marine Fuel (SGMF), and other ISO, EN and NFPA standards.

Over these considerations, different facilities are available as follows:

- Fixed Installation Ashore: Fixed installations provide a bunker supply connection directly at shipyard quay of the LNG fuelled ship. LNG is supplied from a storage tank located in or near the shipyard. The LNG is transferred from the bunker supply connection to the ship through hoses or a moveable arm.
- Mobile Tanks Ashore: Mobile LNG supply tanks can allow LNG fuelled ships to refuel at shipyard quay if the shipyard is not outfitted with a fixed LNG supply infrastructure. The mobile tanks can be brought to the quay of the LNG fuelled ship for bunkering through hoses. It has to be taken into consideration that mobile tanks capacity is quite limited. This solution is therefore applicable only in case of small LNG fuel storage tanks onboard.

6.11.2.1 Fendering, ship separation and cryogenic spill protection

A fender system is to be provided to maintain separation and prevent damage to the receiving ship and to the facility. Mooring lines and fenders are to be insulated such that an arc cannot occur. The facility is to be equipped with drip trays and water curtains as necessary to prevent damage occurring from cryogenic liquid spills. The facility also is to be designed such that leaks or spills will not be directed onto the receiving ship's structure.

A pontoon, between supplier and receiver may be required as well.

6.11.2.2 Bunker hose and fittings

The bunker hose is usually provided by the supplier. It is to be properly long and flexible in order to ensure that the hose is safely connected to both the supplier's manifold and the receiving ship's manifold during normal relative movements. The supplier provides a proper bunker connection at the hose end compatible the receiving ship's connection.

The hose is to be fitted with a quick connection and able to be released in case of not acceptable movement without any damage or LNG spill. The hose is to remain sealed until the connection is made.

Also the receiver end of the hose is usually with an emergency release system.

Many standards and guidelines have been developed or are under discussion about bunkering devices for LNG transfer for gas fuelled ships bunkering.

Just to mention a few, please refer to:

- ISO 20519:2017 - Specification for bunkering of liquefied natural gas fuelled vessels
- ISO/TS 18683:2015 Guidelines for systems and installations for supply of LNG as fuel to ships
- IACS Recommendation on LNG bunkering (Rec.142)
- EN 1474-2:2009 Design and testing of marine transfer systems. Design and testing of transfer hoses
- EN 12434:2000 Cryogenic flexible hoses,
- BS 4089:1999 Metallic hose assemblies for liquid petroleum gases and liquefied natural gases
- SGMF LNG Bunkering Safety Guidelines
- Directive 2014/94/EC on the deployment of alternative fuels infrastructure

6.11.2.3 Hose handling

The LNG and vapour hoses are typically supplied and handled by the shore side bunkering facility with the assistance of the receiving ship's crew. The supplier is usually equipped with a hose handling crane or other lifting equipment to lift the end of the hoses to the receiving ship's bunker station. For ships with particular bunker stations arrangement, it could be necessary to equip directly the ship with a davit or crane to raise the end of the bunker hoses to the bunker station.

Loading arms can also be used for LNG transfer to the receiving ship instead of bunker hoses. Loading arms are generally designed with a rigid structure with swivel joints to allow for articulation of the LNG connection and relative movements between the receiving ship and the supplier, and may include a powered emergency release system.

LNG fluid can pass through either a flexible hose supported within the arm or solid pipes with swivel joints. Loading arms are typically more mechanically automated and eliminate some of the handling issues that are present with hoses, but loading arms can induce higher reaction forces on the bunker manifold that need to be considered in the design of the bunker station.

6.11.2.4 Monitoring and control

The LNG supplier and the receiving ship are to be equipped with an emergency shutdown system. A complete emergency shutdown is to be initiated from either the receiving ship or the supplier. The supplier and receiver tanks are to have a separate monitoring systems, but constant communication is to be ensured constantly during the bunkering.

Communications in LNG bunkering should be able to ensure safe operation under normal conditions, allowing all parts involved to share information.

Therefore a communication system with back-up should be provided between the bunkering facility and the receiving ship.

The components of the communication system located in hazardous and safety zones should be type approved according to IEC 60079.

6.11.2.5 Fire protection

The LNG supplier is to be equipped with a firefighting system. Typical systems included portable and fixed dry chemical systems and/or fixed water spray systems. Different regulations for these systems will apply depending on the supplier facility (barge, ship, shore facility).

6.11.2.6 Inerting and purging requirements for hoses and pipes

Before the bunkering operation, hoses and associated piping system are to be inerted with nitrogen gas and then purged with LNG vapour. As reverse process, after each bunkering, the hoses and associated piping system are to be purged with LNG vapour and then inerted with nitrogen.

It is possible to perform these processes separately or while the bunker hose is connected to both manifolds if the arrangement and capabilities of the receiving ship and the supplier allow it.

Inerting and purging procedures are to be agreed in advance.

6.11.2.7 Ignition sources, safety zones and vent mast locations

It is necessary to eliminate any source of ignition in the vicinity of the bunkering operation before bunkering. This means that other simultaneously operations in the shipyard that should be source of ignition are to be organized in safe distance or stopped with a proper dedicated procedure. To ensure this, it is therefore necessary to establish a safety zone around the bunkering operation. Access near the bunker station and other high risk areas is to be allowed only to authorized personnel.

6.11.2.8 Lighting, platforms and other outfit

The supplier is to arrange adequate lighting to ensure a safe working environment. If adequate lighting cannot be provided at night or during inclement weather, bunkering is not allowed. Both the supplier and the receiving ship are to be equipped with all necessary safety equipment.

6.11.2.9 Personal Protective Equipment

All personnel involved directly with LNG handling operations should wear personal protective equipment (PPE).

In case of LNG, as in any other case, the selection of appropriate PPE is therefore based upon the hazard assessment. Procedures for selection of PPE include:

- Identifying the potential hazards (Material Safety Data Sheets identify LNG health hazards and provide guidance for PPE, LNG handling, first aid, firefighting measures and firefighting equipment)
- Determining the types of protective equipment available for the present hazards.
- Evaluating the effectiveness of the PPE
- Selecting appropriate protective equipment.
- Providing a variety of sizes to properly fit all users
- Selecting equipment that is compatible with other PPE

All personnel involved directly with LNG handling operations is to wear at least the following personal protective equipment (PPE):

- safety shoes
- antistatic protective clothing which must cover all of the arms and legs
- helmet with face shield
- gloves suitable for low temperature

- any other suitable clothing to protect against LNG drips, spray, spills, leaks, by contact with the cold pipes, hoses, or equipment

Working in a shipyard, the above is to be in addition to the common personal protective equipment for hearing protection, respiratory protection, personal fall protection equipment

PPE is be in compliance with main rules like:

- REGULATION (EU) 2016/425 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC
- OSHA standards - 29 CFR Subpart I - Personal Protective Equipment (PPE)
- EN 342:2017 - Protective clothing - Ensembles and garments for protection against cold
- EN 511:2006 - Protective gloves against cold
- EN 166:2004 - Personal eye-protection - specifications
- EN 397:2013 - Industrial safety helmets
- EN 1149-5:2018 - Protective clothing – Electrostatic properties Part 5: Material performance and design requirements
- ISO 20345:2011 - Personal protective equipment - safety footwear
- ISO 13688:2013 - Protective clothing - General requirements

After hazard assessment and PPE selection, it is necessary to prepare relevant procedures for cleaning, maintenance and replacement of PPE and to deliver dedicated training to the employees.

6.11.3 Shipyard compatibility in case of ship to ship transfer

In order to avoid further complications related to a fixed facility ashore inside the shipyard, it is possible to refill a gas fuelled ship with a LNG bunker ship.

An advantage of using an LNG bunker ship moored on the offshore side of the receiving ship is, in fact, that this isolates the bunkering operation from the shipyard area, which should reduce LNG bunkering's impact on other operations and can reduce the consequences of an LNG incident.

For a safe LNG bunkering it is necessary to check if there is compatibility between the LNG supplier, the ship and the shipyard.

Compatibility is related to many issues and due to the complexity of LNG bunkering. Please note that it is more important to confirm compatibility than for oil fuel bunkering. Therefore a ship compatibility assessment is to be carried out before any LNG bunkering operations.

Compatibility is to be confirmed in writing prior to the start of bunkering as part of the bunkering procedures. An easy way to do this is to fill out a checklist to confirm compatibility before each bunkering operation.

A compatibility assessment is to include at least the following:

- The ship is to be safely moored and proper fenders and space is to be ensure between the ship and the supplier facility in order to prevent damages.
- The relative freeboard of the ship is to ensure proper hoses arrangement between bunker supply connection to the bunker receiving connection with sufficient slack to allow for any expected relative motion between the two. Any restrictions on freeboard should be noted.
- The size and scope of the hazardous areas on both the supply source and the receiving ship are to be agreed and compatible. The aim is to keep any sources of ignition outside of the other's hazardous area.
- Volume, pressure, and temperature of the supply source are to be compatible with the tanks on the receiving ship.
- Verification of compatibility of the connections between receiving vessel and hoses and ESD methods.

Communications equipment is to be compatible and the required connections and interfaces are to be provided so that the bunker supplier, the receiver and the shipyard can monitor the bunkering operation and are able to initiate an emergency shutdown of the complete transfer operation.

6.11.4 Regulatory framework

LNG bunkering for a gas fuelled ship is a quite new process with a series of risks and hazards that are to be carefully evaluate and to be covered by relevant and dedicated rules.

Many new regulations and requirements are being developed and implemented and therefore it is necessary to be constantly updated about any new regulatory framework.

The main organizations involved in LNG bunkering matters are the Flag Administration and Port Authorities.

Flag Administrations have primary responsibility for enforcing international and national regulations related to the bunkering systems, processes, and procedures.

It has to be taken into account that national regulations can be more restrictive than international regulations.

Port Authorities are actively involved in the LNG bunkering process because they are the locations where the actual bunkering process takes place and, thus, any of the risks to life, environment, and property are strictly connected to their waters.

Port Authorities define requirements about bunker procedure, locations where bunkering is permitted, restrictions on bunkering times and weather conditions, simultaneous operations, bunkering supply facility, training, required documentation, acceptability of risk assessments, permits, etc.

Since Port Authorities and local jurisdictions within such as port authorities, harbour masters, and local and regional governments have authority over the bunkering process, it is important to better understand in advance which are the parties directly involved and to discuss and agree with them all the necessary details.

In this phase, detailed consultation and collaboration with the classification society and the regulatory organizations are recommended. All parties involved in the project development should be prepared to submit detailed designs, reports, analyses and procedures to the multiple reviewing organizations.

7 LNG PLANT EXTRAORDINARY OPERATIONS

7.1 Scenarios related to LNG fuelled ships

A LNG fuelled ship, usually organizes the periodic drydock far in advance.

In the voyage prior the drydock, the ship starts the preparatory operations at sea in order to proceed with inspections and repairs inside the LNG tanks, if necessary, as soon as ready in the shipyard.

In these phases, relevant LNG processes are carried out by ship's crew and as already detailed in the previous part of this guide.

But over the normal conditions, it is necessary to take into account also the following scenarios:

- Gas fuelled ship that performed the LNG consumption but still some LNG is onboard
- Gas fuelled ship going in drydock for an urgent repair with LNG tanks full
- Gas fuelled ship going in the drydock for unplanned works in emergency (i.e. collision)

In these cases, the shipyard is to be able to manage the LNG complete stripping or to perform repairs with the ship not gas free.

Of course, the abovementioned situations are not advisable, but the shipyard is to be ready and equipped to face them by means dedicated procedure, training and auditing scheme and with suitable risk assessment in place, discussed and agreed with Owners and Port Authorities.

For instance, in preparation of this event, it could be useful, first of all, to fill a proper checklist to define the condition of the ship on its entry into the yard, like amount of LNG on board, guaranteed holding time, temperature, pressure, etc.

Please note that in case of "emergency", there is a natural pressure increase on the ship crew, Owner and the shipyard to get the work done quickly. These time pressures may lead to lower standards of safety and decision making that does not consider all eventualities. The presence of cargo or passengers may heighten the consequences should a process go wrong in any way.

7.2 Additional equipment for gassed up ship

In case a ship is not able to arrive in the shipyard in the requested conditions (aereated LNG tanks and LNG system purging), the shipyard is to be able to manage the LNG remained on board, in case the ship is not autonomous into to perform this task or it is not permitted by the local rules.

At least the following facilities have to be taken into consideration.

7.2.1 LNG debunkering

If it is necessary to transfer LNG from the ship due to a casualty, a suitable receptor is to be provided.

The use of portable cryogenic tanks, either on a trailer or in a 40 feet frame, can be a solution. The disadvantage is that the volume per tank is limited to about 40 m^3 each, making it only applicable for very small quantities of LNG (<300 m^3).

Even if dedicated LNG bunker ships are still not so available everywhere, it is possible to organize a ship to ship transfer for LNG debunkering.

During ship to ship transfer, the receiving ship lies side by side with the discharging ship. Using an aerial hose configuration, LNG is transferred from the discharging tank to the tank of the recovering ship.

Since usually the design focus for LNG fuel systems is solely on loading, debunkering can usually only be done through a pressure decant.

It is therefore necessary to choose the appropriate solution take into consideration the ship LNG plant layout since this operation could be extremely long.

A solution could be also to arrange an LNG storage inside the shipyard. The facilities, in that case, are to be designed and verified according to relevant rules and standards for shore LNG facilities.

This guide, in fact, is based on the assumption that LNG supply/receiving facilities in the shipyard, if any, are designed according to the relevant and applicable codes, regulations and guidelines such as the International Maritime Organization (IMO), the Society of International Gas Tankers and Terminal Operators (SIGTTO), The Society for Gas as a Marine Fuel (SGMF), the Oil Companies International

Marine Forum (OCIMF) and other ISO, EN and NFPA standards.

The above solution anyway is not able to solve the problem related to the fact that the gas fuelled ships are usually not designed to transfer LNG from ship to shore and that the process should be time consuming regardless the final receiver.

It becomes clear from the above that for tanks ranging in volume over 300 m^3 there are currently very limited options to efficiently deliver and store extracted LNG.

The alternative feasible option is to burn the LNG on board at a safe point under monitoring.

7.2.2 Pressure management

Even if LNG tanks are designed to stay cool, they cannot provide perfect insulation against warming. Heat slowly affects the tanks, which causes the LNG inside to evaporate and produces boil-off gas.

Natural gas remains liquefied by staying at a consistent pressure, but when boil-off occurs and it returns to gas, the larger volume of gas increases the tank pressure. While the tanks are designed to handle the rise over short distances, prolonged pressure increases cannot be managed effectively and require alternative solutions.

LNG tank pressure and temperature are to be therefore maintained at all times within their design range by acceptable means, such as:

1. A dual fuel diesel engine plant for propulsion and power generation
2. A single gas fuel engine plant for propulsion and power generation
3. A gas turbine plant for propulsion and power generation
4. A re-liquefaction system
5. A gas combustion unit
6. Other approved BOG utilization units, such as an auxiliary steam boiler capable of burning boil-off vapors
7. Gas fuel storage tank pressure accumulation whereby the bunker tank fuel is allowed to warm up and increase in pressure.

Venting of fuel vapour for control of the tank pressure is not acceptable except in emergency situations.

In case of a gas fuelled ships, when they are in drydock, method from 1 to 3 are not applicable.

Method 4 is usually not installed on gas fuelled ships since method 5 is preferred. Anyway to burn BOG during a long drydock could be not always allowed or in any case a waste of fuel.

Therefore it could be useful to provide in shipyard premise, additional equipment and services to perform work on gassed up ships, for example a re-liquefaction plant, gas combustion unit or bunkering system for pressure management.

It is understood that re-liquefaction systems are likely not installed in gas fuelled ships. Therefore it could be useful to install it ashore in the shipyard for LNG pressure management.

The re-liquefaction system typically comprises a vapour BOG/LNG (condensate) circuit, which is vapour from the LNG tanks and LNG return to the LNG tanks and a refrigeration circuit for cooling down and re-liquefying the boil-off vapour.

The system is to be designed and equipped with at least the following:

- Fixed gas detection and alarm system
- Ventilation system for re-liquefaction unit compartment
- Gas fuel piping systems
- Gas compressors
- Gas heaters
- Gas storage pressure vessels
- Control and monitoring system
- Emergency shutdown arrangements
- Electric bonding (earthing) arrangement

A Failure Modes and Effects Analysis (FMEA) is to be developed to determine possible failures and their effects in the safe operation of the re-liquefaction unit. Operating and maintenance instruction manuals and testing procedures are to be approved and be available.

Impurities in the boil-off gas, as well as nitrogen, may be separated prior to the return of LNG from the re-liquefaction plant to the LNG tanks.

Refrigeration systems are to be provided with environmentally acceptable refrigerants. The use of ozone depleting refrigerants and those refrigerants contributing to the global warming potential, as defined by relevant Rules, is not acceptable.

In any case, Owner's tank pressure (BOG) management plan is to be submitted to the shipyard for review in advance, since the shipyard needs to decide how credible the owner's BOG management plan is by understanding how it works before arrival of the ship at the yard.

7.3 Operation in partial LNG plant

Sometimes it could be necessary to perform inspection or maintenance operations just in a partial part of the LNG plant with the ship not in gas free condition.

In that case, this area is to be properly insulated from the remaining plant and necessary conditions to work are to be achieved.

7.3.1 Block-and-bleed system

In order to achieve and to maintain a safe working environment it is necessary to arrange a block-and-bleed systems in order to separate the part of the fuel gas plant under maintenance and repair work from the remaining part of the fuel gas plant staying in service.

Double block and bleed valve means a set of two valves in series in a pipe and a third valve enabling the pressure release from the pipe between those two valves. The arrangement may also consist of a two-way valve and a closing valve instead of three separate valves.

The piping section of a block-and-bleed section is to be under nitrogen atmosphere, with a permanent vent to atmosphere during the whole inspection or maintenance period.

It is therefore necessary to keep this block-and-bleed system in force until the pipe system is closed and inerted again.

Block-and-bleed valves need to be marked clearly and not to be opened during maintenance work.

7.3.2 Equipment overhauled during drydock

A shipyard equipped for gas fuelled ships maintenance, is to take into account that many equipment need to be overhauled and tested during drydock and sometimes dismounted and disembarked.

In case of drydock for Class renewal, some inspections are mandatory as per Rules.

Relevant procedure are to be therefore drawing up and agreed with the Owner in due time and necessary conditions ensured during any inspection or maintenance operation.

For instance, at least at the Class renewal survey, all piping for fuel storage, fuel bunkering, and fuel supply such as venting, compressing, refrigerating, liquefying, heating storing, burning or otherwise handling the fuel and liquid nitrogen installations are to be examined.

Removal of insulation from the piping and opening for examination may be required. Where deemed suspect, a hydrostatic test to 1.25 times the Maximum Allowable Relief Valve Setting (MARVS) for the pipeline is to be carried out. After reassembly, the complete piping is to be tested for leaks.

Please note that LNG gases can leak at least from the following:

- flanges and other connectors not properly connected and tightened
- valve stems, glands and packings
- pressure and temperature relief systems
- pipework and equipment damaged by impact, vibration, stress and/or corrosion
- areas of poor or incomplete welding on fuel or vapour pipework

All emergency shut-down valves, check valves, lock and bleed valves, master gas valves, remote operating valves, isolating valves for pressure relief valves in the fuel storage, fuel bunkering, and fuel supply piping systems are to be examined and proven operable. A random selection of valves is to be opened for examination.

Operational test of the shutdown of ESD protected machinery spaces are to be carried out.

The Emergency Shut Down (ESD) system to be fitted for ESD protected machinery spaces includes inter alias the safety intervention for:

- low-liquid level in gas fuel tank
- ventilated ducting for gas fuel supply piping
- ventilation in ESD protected machinery space
- engine failure
- concurrent activation of two gas detectors inside machinery space
- remotely actuated valves' control actuating medium
- low temperature in the drip tray
- low temperature in the bilge well located in the tank connection space
- air lock ventilation
- manually activated emergency shutdown of engine

The pressure relief valves for the fuel storage tanks are to be opened for examination, adjusted, and function tested according to Class requirements for renewal survey.

A random selection of pressure relief valves for the fuel supply and bunkering piping are to be opened for examination, adjusted, and function tested.

The pressure/vacuum relief valves, rupture disc and other pressure relief devices for interbarrier spaces and hold spaces are to be opened, examined, tested and readjusted as necessary, depending on their design.

Fuel pumps, compressors, process pressure vessels, inert gas generators, heat exchangers and other components used in connection with fuel handling are to be examined.

Visual examination of the complete inert gas generating system or inert gas storage and relevant distribution system is to be carried out.

Examination of electrical equipment is to be carried out according ot IEC standard and to include the physical condition of electrical cables and supports, intrinsically safe, explosion proof, or increased safety features of electrical equipment.

An electrical insulation resistance test of the circuits terminating in, or passing through, the hazardous zones and spaces is to be carried out according to IEC standard.

Gas detectors, temperature sensors, pressure sensors, level indicators, and other equipment providing input to the fuel safety system are to be tested with simulation test to confirm satisfactory operating condition.

Simulation test of shutdown system for the gas supply, and disconnection of all electrical equipment or installations not of a certified safe type is to be carried out as far as practicable.

Permanently installed gas detectors are fitted in:

- the tank connection spaces
- all ducts around fuel pipes
- machinery spaces containing gas piping, gas equipment or gas consumers
- compressor rooms and fuel preparation rooms
- other enclosed spaces containing fuel piping or other fuel equipment without ducting
- other enclosed or semi-enclosed spaces where fuel vapours may accumulate including interbarrier spaces and fuel storage hold spaces of independent tanks other than type C
- airlocks
- gas heating circuit expansion tanks
- motor rooms associated with the fuel systems
- at ventilation inlets to accommodation and machinery spaces if required based on the risk assessment

Pressure, temperature and level indicating equipment are to be calibrated in accordance with the manufacturer's requirements.

Visual examination of the entire gas fuel supply system from the storage tank to the consumers including passages into accommodation spaces, if any, is to be checked.
Tank connection space, Fuel storage tank, supply and bunkering piping including insulation and or ventilating duct is to be checked to confirm that no damage has occurred and that all fitting, insulation and instrument connection are in order.

Fuel storage tanks are to be examined in accordance with Rules.
The condition of the outer shell of the tank, as accessible, and of the insulation where fitted, is to be checked. The insulation is to be maintained in place without sign of damage or detachment in order to remain effective.
The foundation of the tank is to be examined as well to check that neither deficiency nor deformation occurred.
The inspection/survey plan shall identify elements to be examined and/or validated during surveys throughout the liquefied gas fuel containment system's life and, in particular, any necessary in-service survey, maintenance and testing that was assumed when selecting liquefied gas fuel containment system design parameters.
The inspection/survey plan may include specific critical locations.
Vacuum insulated independent fuel storage tanks of type C need not be examined internally. Where fitted, the vacuum monitoring system should be examined and records should be reviewed.

Please note that he LNG storage tanks are not always necessary to be enter at each drydock, in fact internal examination at renewal surveys may be waived if permitted by the Rules. If monitoring equipment is in operation and NDT results are good, the internal, examination may not be necessary.

For more details, please refer to Tasneef Rules Pt A, Ch 3, Sec 9 - Scope of survey of gas Fuelled ships than liquefied gas carriers, IACS Recommendation No. 148, IACS Unified Requirement UR Z16.

7.3.3 Nitrogen purging within LNG fuel-gas plant piping

In case of extraordinary inspections and repair works, it is necessary to get the gas free condition achievable by nitrogen purge operation while the remaining part of the system is not gas free.

The equipment and its associated piping system subject to maintenance and repair work needs to be isolated from the remaining part of the fuel gas plant.

The isolation between the part of the fuel gas plant remaining in service and the part subject to maintenance and repair works is to be ensured by a double block-and bleed valve arrangement. Before to start the nitrogen purge operation, relevant equipment and its associated pipe section of the LNG plant are to be depressurized and maintained at ambient temperature.

The vapour inside the equipment and its associated pipe section is to be nitrogen purged preferably towards the boilers. The nitrogen pressure inside the purge section of the LNG plant is to be monitored constantly.

When the methane concentration is low as requested, the vented gas/nitrogen mixture is to be guided towards the vent mast. Gas samples are to be taken at various sample points and dead ends to ensure proper working condition.

When the gas concentration is below the allowable limit (methane content <5 vol%), the nitrogen purge operation can be stopped. The nitrogen pressure in the relevant pipe section is to be relieved to atmosphere.

Ventilation of the LNG plant spaces is to be maintained in full operation.

7.3.4 Purging of boiler and engine gas feed line

The fuel gas system for boilers and engines is designed for a calculated fuel gas working pressure.

All feed piping need to be depressurized and purged toward the boiler. Due to the fact that this part of the purge system is dealing with high pressure, a separation between the high pressure and low pressure vent lines is to be done and pressure on both sides of the separation valve is to be measured.

7.3.5 Single LNG tank inspection

It may be necessary to carry out an inspection or repair work in a single LNG fuel storage tank while the ship is not gas free.

The relevant LNG fuel storage tank needs to be stripped, warmed-up, inerted and aerated before entering into repair and maintenance work. This work could include replacement of LNG pumps and other repair work.

Before to enter in any confined space like tank and TCS, air ventilation is to be provided for at least 30 air changes/h and the confined space is to be measured gas free.

Safety plan and safety instruction need to be followed.

Before to start the preparations for LNG fuel storage tank inspection, a routine cold spot check on the LNG fuel storage tank insulation is to be carried out. The LNG fuel storage tank needs to be isolated from the rest of the LNG plant.

To perform stripping operation it is possible to transfer the LNG into another LNG fuel storage tank in service. After that, it is necessary to vaporize the remaining LNG before to start the warming-up operation.

Warming-up is achieved by recirculation of vapour in the LNG fuel storage tank by means a portable spark free ventilation fan and a portable heater certified for this operation. The shipyards is to be equipped as necessary.

After that, it is possible to start the inerting operation.

When inerting operation is terminated, aeration of the LNG fuel storage tank with dry air can start.

Dry air is to be supplied into the LNG fuel storage tank and shall continue during the whole inspection or maintenance period. A sufficiently long flexible hose is to be put into the LNG fuel storage tank to ensure proper ventilation.

After completion of inspection or repair and maintenance work, the above operation are to be carried out in a reverse sequence, i.e. drying/inerting followed by gassing-up and cooling down operation.

For more details, please refer to dedicated section of this guide for each step.

8 SHIPYARD ORGANIZATION

8.1 General overview

In order to find out which shipyards are the most appropriate location for a gas fuelled ship survey, repair and conversion, several areas need to be taken into account.

The most important factor is the geographic location of the shipyard, in term of strategic market of gas fuelled ships interested in a drydock on their route (type, dimensions), LNG availability, achievable safety according to shipyard layout, interaction with other activities within the port, present and future regulations to be fulfilled.

Despite the many risks and considerations that need to be assessed, LNG has nevertheless proved to be a safe choice of fuel and throughout the history of maritime LNG transport, there have been few incidents and almost no accidents. It must be remembered though, that LNG is still a hazardous substance and the safety record is thus the result of stringent safety efforts, which have continuously surrounded the handling of LNG in maritime business. Continuing this record of safe handling is of utmost importance and this can only be achieved through risk awareness, operational training, adequate safety distances and well prepared contingency plans on all levels.

8.2 Regulations for reference

Survey, repair and conversion of a gas fuelled ship is a quite new process with a series of risks and hazards that are to be carefully evaluate and to be covered by relevant and dedicated rules.

Many new regulations and requirements are under development for many LNG processes (bunkering, storage) but not dedicated to gas fuelled ship maintenance and dedicated shipyard.

It is therefore recommended to refer to existing Regulations applicable to similar fields to look into further details beyond this guide.

Dedicated guidelines have been developed or are under discussion by SGMF, Other relevant guidelines for reference are by SIGTTO.

8.2.1 European Rules for reference

A reference Rules to take into consideration is the Directive 2012/18/EU of the European Parliament on the control of major-accident hazards involving dangerous substances.

Since there are hazards related to LNG processes, shipyards working with gas fuelled ship should be considered as industrial activities related to dangerous substances.

In light of the above, a shipyard is obliged to take all necessary measures to prevent major accidents and to limit their consequences for human health and the environment.

The shipyard is to prove to the competent authority, at any time, in particular for the purposes of inspections and controls, that the operator has taken all necessary measures as specified in the mentioned Directive.

First of all, the shipyard has to send a notification to the competent authority containing information sufficient to identify the dangerous substances involved or likely to be present, the quantity and physical form of the dangerous substance and the related activities.

The notification must include also the immediate environment of the shipyard, and factors likely to cause a major accident or to aggravate the consequences (areas and developments that could be the source of or increase the risk or consequences of a major accident and of domino effects).

The shipyard has to draw up a document in writing setting out the major-accident prevention policy (MAPP) and to ensure that it is properly implemented. The MAPP shall be designed to ensure a high level of protection of human health and the environment. It shall be proportionate to the major-accident hazards. It shall include the operator's overall aims and principles of action, the role and responsibility of management, as well as the commitment towards continuously improving the control of major-accident hazards, and ensuring a high level of protection. The shipyard shall periodically review and where necessary update the MAPP, at least every five years.

The MAPP shall be implemented by appropriate means, structures and by a safety management system, proportionate to the major-accident hazards, and the complexity of the organization or the activities of the establishment.

The shipyard has to produce also a safety report for the purposes of:

- demonstrating that a MAPP and a safety management system for implementing it have been put into effect
- demonstrating that major-accident hazards and possible major-accident scenarios have been identified and that the necessary measures have been taken to prevent such accidents and to limit their consequences for human health and the environment
- demonstrating that adequate safety and reliability have been taken into account in the design, construction, operation and maintenance of any installation, storage facility, equipment and infrastructure connected with its operation which are linked to major-accident hazards inside the establishment;
- demonstrating that internal emergency plans have been drawn up and supplying information to enable the external emergency plan to be drawn up
- providing sufficient information to the competent authority to enable decisions to be made regarding the siting of new activities or developments around existing establishments.

A shipyard shall be not authorized to use or bringing into use of any establishment, installation or storage facility, or any part thereof where the measures taken by the operator for the prevention and mitigation of major accidents are seriously deficient.

The shipyard is to be controlled by a system of inspections.

Inspections shall be appropriate to the type of establishment concerned and they shall be sufficient for a planned and systematic examination of the systems being employed at the establishment, whether of a technical, organisational or managerial nature, so as to ensure in particular that:

- the shipyard can demonstrate that it has taken appropriate measures, in connection with the various activities of the establishment, to prevent major accidents
- the shipyard can demonstrate that it has provided appropriate means for limiting the consequences of major accidents, on-site and off-site
- the data and information contained in the safety report, or any other report submitted, adequately reflects the conditions in the establishment.

8.3 Shipyard general precautions

To ensure that safety of both the ship and the personnel is maintained during a shipyard survey or repair on a LNG fuelled ship, it is essential that shipyard and Company personnel (crew and Owner's superintendents) are conversant with each other's systems and requirements .

All works are to be carefully coordinated in order to avoid any risk or danger from conflicting demands and communication ensured among the parties about all repair and safety matters.

Therefore all the main items related to safety and shipyard responsibilities are to be clearly defined in the repair contract.

At least the following is to be included in the repair contract:

- the arrival condition of the ship, in particular LNG fuel storage tanks and LNG plant is to be documented to the shipyard
- shipyard responsibility about the status of all tanks and spaces and the responsibility to maintain and document the status throughout the whole repair period
- shipyard responsibility for assessing, supervising and monitoring all aspects of work prior to and after each individual job, in particular the ones related to the LNG plant.
- shipyard and ship responsibility to properly isolate the work site, in particular area related to LNG, from any potential hazards and to ensure that the work site remains properly isolated for the duration of the job
- procedures relating to gas free certificates and hot work permits that are to be strictly maintained
- transfers of LNG is to be properly coordinated with other repair activities
- procedure to be assured about works coordination
- appropriate safety measures are to be enforced
- any significant change of plan is to be approved by all parties concerned (shipyard, ship, subcontractors etc.) to ensure that the implications for safety are properly addressed
- adequate fire-fighting capability is to be maintained throughout the repair period
- electrical equipment in gas-dangerous spaces and zones are to be certified, in satisfactory condition and properly maintained
- adequate lighting are to be maintained
- welding machines are to be properly electrically bonded
- scaffolding and staging are to be safe to use, also in connection with hazardous area and possible ignition source
- lifting operations are to be carried out safely
- emergency exit/access from/to the ship is to be clearly marked and maintained throughout the repair period
- testing of LNG plant is to be properly coordinated with other repair activities
- hazardous materials are to be handled in a safe manner
- shipyard responsibility for regular cleaning of and removal of debris especially hazardous from the ship
- high standards of house keeping and cleanness are to be maintained
- correct PPE is to be worn by all parties at all times while on board

8.3.1 Arrival condition

Before the arrival, it is recommended the shipyard to ask to the owner the following information:

- Owner’s tank pressure (BOG) management plan for review
- Measurements of tank level, temperature and pressure
- The fuel tank design including the tank volume, PRV pressure (MARVs), holding time and changing pressure rate in case the Owner’s management plan fails
- Owner’s (safety) control philosophy including a system overview/description, hierarchies, alarms, interlocks, by-passes, P&IDs and where isolations can be made
- Expected duration of the drydock
- Work needing to be done (and any skill levels or specialised/additional equipment/material required)
- Safety documentation like HAZID, HAZOP studies.

It is recommended the ship is to arrive in the shipyard with all LNG tanks, ballast tanks, void spaces, pipe tunnels, cofferdams, pump rooms and empty fuel tanks in a clean and gas free safe for entry condition and safe for hot work condition, in accordance with local regulations.

Prior to entry into the shipyard, it is necessary to check with the local Port Authority Rules if it is necessary that an independent certified chemist test all LNG lines and tanks. On completion of the tests appropriate gas-free certificate is to be issued.

It is important that any tank and space which is not certified as being safe for entry or safe for hot work is clearly identified as such.

The continuing maintenance and verification of the status of any tank or space throughout the repair period is the responsibility of the shipyard.

8.3.1.1 Non gas-free repairs

If in exceptional circumstances and where no viable alternative exists, it is necessary to carry out ship repairs with the ship in non gas-free condition, the shipyards is to be ready for relevant LNG preparation operations.

No hot work are be carried out within a safety distance from of a non-gas free space.

No repair involving hot work are to be carried out within the entire LNG plant area, or on decks above such spaces, unless such spaces and pipelines are properly certificated gas free and suitable for hot work.

In relevant area, proper ventilation and gas detection system, including personal devices for operators, are to be always available and in operation.

8.3.2 Subcontractors

The shipyard safety management system is to include procedures to ensure that subcontractors employed by both shipyard and Owner are in compliance with shipyard requirements.

Each subcontractor is to provide its safety management manual based on which the shipyard will draw up the final one.

The shipyards is to be continuously updated where work is carried out by contracted personnel.

8.3.3 Daily meeting

In order to ensure proper communication among the involved parties, daily meeting are to be organized.

Daily meetings are to be attended by:

- the ship repair manager
- ship officers and supervisory personnel
- shipyard supervisory personnel
- subcontractors
- shipyard safety officer and safety staff

The purpose of the meeting is to:

- verify the ship status and related LNG equipment
- review all work permits which have been issued
- coordinate all work done by the shipyard, contractors and ship crew in order to ensure that safe working conditions prevail in all areas
- review all systems and equipment tests and coordinate these
- define priorities in case a conflict exists between various activities, in particular related to LNG plant
- review all system or equipment tests and coordinate these
- discuss any violation of safety measures noticed during the previous day, identify the cause of the incident and the action to be taken to prevent reoccurrence
- review any own or other ships movements that could impact on safety or progress of the repairs

8.3.4 Safety inspections

The shipyard is to have a system of regular inspections to ensure that safe working conditions are maintained including:

- Inspection in hot work areas at least half an hour before the work and half an hour after the work is carried out in order to confirm that the conditions stated in the hot work permit are maintained
- inspection of work areas during each shift
- monitoring of unsafe acts
- daily house keeping inspection to ensure that all walkways are clear from obstructions
- regular inspection of all the gas hoses in order to check that no joints are inside enclosed spaces and that the hoses are equipped with proper non return safety valves

8.3.5 Responsibility

In general, many organizations are involved in the gas fuelled ship drydock: the shipyard, the ship, LNG plant supplier, subcontractors as well as authorities.

Each one of these organizations is responsible for the assessment and decisions of their relevant part in the drydock.

All parties involved in the gas fuelled ship drydock is to clearly define their rules and responsibilities.

This includes the designation of the persons directly responsible for the safety aspects in this operation.

The responsibilities and functions of all parties must be coordinated with each other and shall go well hand-in-hand.

An organization chart shall appoint the responsible parties, define the way of communication and the applicable checklists.

8.4 Cryogenic workshop

A shipyard with facilities for LNG fuelled ships repair and conversion is to be equipped with a dedicated cryogenic workshop where to perform all the necessary maintenance to cryogenic equipment, with its own qualified personnel or maker’s specialists.

The cleanliness is an important factor to take into account.

Therefore it is necessary to define an acceptable level of surface and particle contamination to minimize the risk of malfunction of equipment and ensure safety against ignition.

In the cryogenic workshop, environmental conditions are to be continuously taken under control (humidity, temperature, etc).

8.4.1 General requirements

Chips, foreign matter, and major potentially loose particles such as oxide scale and weld spatter are not acceptable.

Particles visible under daylight or white light without magnification are not acceptable. Depending upon the design of the system, more stringent requirements for particle size may be required to avoid malfunction of equipment.

Free water shall not be detectable by visual examination.

8.4.2 Cleaning procedure

Any cleaning procedure may be used, providing the requirements of 8.4.1 are met. If solvent for cleaning agents are used, they shall be compatible with all materials to be clean.

8.4.3 Cleanliness evaluation

An inspection and sampling method shall be selected to ensure that the requirements of 8.4.1 are met. It shall take into account the cleaning procedure to be used, the equipment to be cleaned and its level of contamination.

The method of inspection shall not itself result in contamination levels greater than those specified in 8.4.1. The cleanliness evaluation method shall be documented and the results obtained shall be recorded.

8.4.4 Post-cleaning protection

After cleaning, items shall be protected to maintain their clean condition until used. To reduce the risk of condensing any atmospheric moisture during storage, consideration shall be given to purging and sealing the equipment.

Any packaging, plugs, etc. that can contact the clean surfaces shall be clean and removable without leaving any residue. Any packaging material shall be strong enough to resist the expected handling and storage conditions and be able to be sealed and waterproof.

Any protective gas used shall be dry, and oil and dust free.

Any pressurizing gas shall be kept at low pressure compatible with the strength of the packaging.

8.5 Welding procedures

Working with gas fuelled ships, the shipyard is to take into consideration that for cryogenic plant austenitic steels are used.

Austenitic grades 304, 304L, 316, 316L, 321 and 347 are usually required when the design temperature is below -105°C.

The shipyard is to be therefore able to demonstrate additional capabilities for this kind of welding.

8.5.1 Austenitic steel

Most stainless steels are considered to have good weldability and may be welded by several welding processes including the arc welding processes, resistance welding, electron and laser beam welding, friction welding and brazing. For any of these processes, joint surfaces and any filler metal must be clean.

The coefficient of thermal expansion for the austenitic types is 50% greater than that of carbon steel and this must be considered to minimize distortion. The low thermal and electrical conductivity of austenitic stainless steel is generally helpful in welding. Less welding heat is required to make a weld because the heat is not conducted away from a joint as rapidly as in carbon steel. In resistance welding, lower current can be used because resistivity is higher.

The austenitic stainless steels contain 16-26% Cr, 8-24% Ni + Mn, up to 0.40% C and small amounts of a few other elements such as Mo, Ti, Nb (Cb) and Ta. The balance between the Cr and Ni + Mn is normally adjusted to provide a microstructure of 90-100% austenite. These alloys are characterized by good strength and high toughness over a wide temperature range

Filler metals for these alloys should generally match the base metal but for most alloys, provide a microstructure with some ferrite to avoid hot cracking.

To achieve this, Type 308 is used for Type 302 and 304 and Type 347 for Type 321. The others should be welded with matching filler. Type 347 can also be welded with Type 308H filler. These filler materials are available as coated electrodes, solid bare wire and cored wire. Type 321 is available on a limited basis as solid and cored wire.

Two problems are associated with welds in the austenitic stainless steels:

- sensitization of the weld heat affected zone
- hot cracking of weld metal.

8.5.1.1 Sensitization

Sensitization leads to intergranular corrosion in the heat affected zone.

Sensitization is caused by chromium carbide formation and precipitation at grain boundaries in the heat affected zone in a certain high temperature range.

Since most carbon is found near grain boundaries, chromium carbide formation removes some chromium from solution near the grain boundaries, thereby reducing the corrosion resistance of these local areas.

This problem can be remedied by using low carbon base material and filler material to reduce the amount of carbon available to combine with chromium.

Welds should be made without preheat and with minimum heat input to shorten the time in the sensitization temperature range.

The degree of carbide precipitation increases with:

- Higher carbon content
- Time at the critical mid-range temperatures

Welding naturally produces a temperature gradient in the steel. It ranges from melting temperature at the weld to room temperature some distance from the weld. A narrow zone on each side of the weld remains in the sensitizing temperature range for sufficient time for precipitation to occur.

8.5.1.2 Hot cracking:

Hot cracking is caused by low melting materials such as metallic compounds of sulphur and phosphorous which tend to penetrate grain boundaries. When these compounds are present in the weld or heat affected zone, they will penetrate grain boundaries and cracks will appear as the weld cools and shrinkage stresses develop.
Hot cracking can be prevented by adjusting the composition of the base material and filler material to obtain a microstructure with a small amount of ferrite in the austenite matrix. The ferrite provides ferriteaustenite grain boundaries which are able to control the sulphur and phosphorous compounds so they do not permit hot cracking.

8.5.1.3 Special requirements

Special ventilation and/or exhaust are required when welding high chromium alloys such as stainless steels. Fumes from the normal use of stainless steel filler materials contain significant quantities of chromium compounds.

Before using, it is mandatory to read and to understand the material safety data sheet (MSDS) for the filler material to be used.

8.5.2 Welding operators

Personnel involved in austenitic steel welding are to be fully aware of the operating conditions and parameters of the welding process employed; furthermore, such personnel may be required to be specially certified.
Welding operators are to follow certified working procedure specifications (WPS).

8.5.3 Non-destructive examinations (NDE) operators

Personnel involved in austenitic steel welding control are to have adequate experience and be qualified according to a recognised scheme.
Nondestructive examination is to be performed using calibrated equipment of suitable type and according to approved procedures and recognised standards.
Personnel responsible for the preparation and approval of NDT procedures are to be qualified.

8.5.4 Organization

When welding activity is subcontracted, the shipyard is responsible for the correct application of the requirements also as regards the subcontractors and is to perform the appropriate quality inspections.

8.6 Regulations for maintenance works

8.6.1 Ship hazardous area zones

According to IEC standard, area classification is a method of analysing and classifying the areas where explosive gas atmospheres may occur onboard. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas.

8.6.1.1 Hazardous area zone 0

Zone 0 is an area in which an explosive gas atmosphere or a flammable gas or vapour is present continuously or is present for long periods.

This zone includes, but is not limited to the interiors of fuel tanks, any pipework for pressure- relief or other venting systems for fuel tanks, pipes and equipment containing fuel.

8.6.1.2 Hazardous area zone 1

Zone 1 is an area in which an explosive gas atmosphere or a flammable gas or vapour is likely to occur in normal operation.

This zone includes, but is not limited to:

- tank connection spaces, fuel storage hold spaces and interbarrier spaces
- fuel preparation room arranged with ventilation
- areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, bunker manifold valve, other fuel valve, fuel pipe flange, fuel preparation room ventilation outlets and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation
- areas on open deck or semi-enclosed spaces on deck, within 1,5 m of fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into zone 1 spaces
- areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck
- enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations
- the ESD-protected machinery space is considered a non-hazardous area during normal operation, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1
- a space protected by an airlock is considered as nonhazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1
- except for type C tanks, an area within 2.4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.

8.6.1.3 Hazardous area zone 2

Zone 2 is an area in which an explosive gas atmosphere or a flammable gas or vapour is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.

This zone includes, but is not limited to areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 and space containing bolted hatch to tank connection space.

8.6.2 Regulations for enclosed space entry

Under normal operational circumstances, personnel is not to enter LNG fuel storage tanks, fuel storage hold spaces, void spaces, tank connection spaces or other enclosed spaces where gas or flammable vapours may accumulate, unless the gas content of the atmosphere in such space is determined by means of fixed or portable equipment to ensure oxygen sufficiency and absence of an explosive atmosphere.

Personnel entering any space designated as a hazardous area is not to introduce any potential source of ignition into the space unless it has been certified gas-free and maintained in that condition.

Entry into tanks and confined spaces is to be carefully controlled for atmospheric conditions and means of rescue.

A personnel tracking system for any personnel entering a tank or a confined space is to be established.

Personnel entering a tank or a confined space is to be properly trained.

8.6.3 Regulations for hot work

Hot work in the vicinity of LNG fuel storage tanks, fuel piping and insulation systems that may be flammable, contaminated with hydrocarbons, or that may give off toxic fumes as a product of combustion is only to be undertaken after the area has been secured and proven safe for hot work and all approvals have been obtained.

For hot work it is intended any operation producing flames, sparks or heat including cutting, welding, brazing, grinding, sawing, torch soldering, thawing frozen pipes, applying roof covering etc.

8.6.3.1 General Hot Work means (IMO)

Hot work means any work requiring the use of electric arc or gas welding equipment, cutting burner equipment or other forms of naked flame, as well as heating or spark generating tools, regardless of where it is carried out on board a ship.

The Safety Management System (SMS) on board should include adequate guidance on control of hot work and should be robust enough to ensure compliance. Absence of guidance should be regarded as prohibition, rather than approval.

Whenever possible, a space such as a workshop where conditions are deemed safe, should be designated for hot work to be performed and first consideration given to performing any hot work in that space.

Hot work performed outside that space should be subject to the following considerations:

- The master or designated safety officer should be responsible for deciding whether hot work is justified and whether it can be conducted safely.
- A permit-to-work system should be employed.
- Hot work procedures should take account of national laws or regulations or other national
- safety and health rules.
- A responsible officer, not involved in the hot work, should be designated to ensure that safe procedures are followed.
- A written plan for the operation should be agreed by all who will have responsibilities in
- connection with the hot work.
- The work area should be carefully prepared and isolated before hot work commences.
- Fire safety precautions should be reviewed, including fire equipment preparations, setting a fire watch in adjacent compartments and areas, and fire-extinguishing measures.
- Isolation of the work area and fire precautions should be continued until the risk of fire no longer exists.

Please refer to IMO MSC/Circ.1084 “PRINCIPLES FOR HOT WORK ON BOARD ALL TYPES OF SHIPS”.

8.6.3.2 Hot Work for IGF code and FSS Code

The IGF Code (IGF code 18.7.1) requires that “hot work in the vicinity of fuel tanks, fuel piping and insulation systems that may be flammable, contaminated with hydrocarbons, or that may give off toxic fumes as a product of combustion shall only be undertaken after the area has been secured and proven safe for hot work and all approvals have been obtained”

In FSS code (chapter 5, 2.1.4) “Gas-free is a condition in a tank/piping where the content of hydrocarbon or flammable vapour is less than 1% of the lower flammable limit (LEL), the oxygen content is at least 21%, and no toxic gases are present”.

8.6.3.3 Hot Work statements

Mainly all the Port Authorities have their own permit procedures and requirement to do “Hot Work on a ship”

In the gas industry it’s in general to use a “Hot work procedure” before starting any work on an installation.

Hot Work permit is to be properly filled out, displayed on site and returned to the employee supervisor when the hot work is complete. Permits contain a checklist to be completed prior to commencing hot work activities and also the conclusion of the hot work.
Hot work permit is to be released at least one time a day.

8.6.3.4 Fire prevention

During the hot work, a fire watch is to be granted in the hot work area in order to monitor the work area for the beginning of potential, unwanted fires both during and after hot work.

A fire watch must remain in the area for minimum 30 minutes after hot work has been completed to assure that all metal surfaces are cool and there are no smouldering materials.

Designated individuals must be trained and familiar with the operation of portable fire extinguishers and methods to activate building fire alarm systems.

Please refer to the following standard for more details about hot work fire prevention:

- National Fire Protection Association Standard 51B “Hot Work Guidelines”
- International Fire Code 2003 Edition Chapter 26 “Welding and other Hot Work”
- Code for Fire Safety Systems (FSS code)

8.6.4 Inspection and maintenance onboard

During inspection or maintenance operations, the following recommendations are to be taken into account:

- readings on oxygen content and dew point are to be controlled frequently
- calibrated instruments are to be used
- access to the LNG fuel storage tanks is to be achieved in safe
- the atmosphere in the LNG fuel storage tank is to be kept dry and any risk of condensation of humidity is to be avoided
- LNG fuel storage tanks environment is to be monitored permanently
- appropriate instruments, tools and materials are to be used
- damage to any other equipment is to be avoided
- ventilation is to be ensured

8.6.5 Completion of repairs

All personnel must be vigilant to ensure that all the ships systems are been restored to their optimum seagoing condition and properly recommissioned prior to final testing.

The recommissioning is the direct responsibility of the shipyards and responsible officers on board, regardless of who carried out the repair work, and therefore they should establish prior to start up:

- which are the respective responsibilities of shipyard and ship personnel
- that is safe to start the machinery
- the integrity of the machinery and any systems attached to it
- that there is adequate supply of fuel, lubrication, cooling water, etc.
- that a Hazard Analysis Form associated with the activity has been worked out.
- that the personal wears the appropriate protective equipment

8.7 Security

To manage LNG represents always an issue in terms of security.
The shipyard is to prepare and follow one or more manuals of written procedures to provide security when a gas fuelled ship is in the shipyards or debunkering/bunkering facilities or re-liquefaction plant are inside the shipyard.
The procedures must include at least:

- a description and schedule of security inspections and patrols performed
- a list of security personnel positions or responsibilities utilized at the shipyard.
- a brief description of the duties associated with each security personnel position or responsibility
- instructions for actions to be taken, including notification of other appropriate plant personnel and law enforcement officials, when there is any indication of an actual or attempted breach of security
- methods for determining which persons are allowed access to the shipyard
- identification of all persons entering the shipyard, including methods at least as effective as picture badges
- liaison with local law enforcement officials to keep them informed about security procedures in force

8.7.1 Protective enclosures

The shipyard should be surrounded by a protective enclosure

Protective enclosures may not be located near features outside of the facility, such as trees, poles, or buildings, which could be used to breach the security.

At least two accesses must be provided in each protective enclosure and be located to minimize the escape distance in the event of emergency.

Each access must be locked unless it is continuously guarded. During normal operations, an access may be unlocked only by persons designated in writing by the operator. During an emergency, a means must be readily available to all facility personnel within the protective enclosure to open each access.

8.7.2 Protective enclosure construction

Each protective enclosure must have sufficient strength and configuration to obstruct unauthorized access to the facilities enclosed.

Openings in or under protective enclosures must be secured by grates, doors or covers of construction and fastening of sufficient strength such that the integrity of the protective enclosure is not reduced by any opening.

8.7.3 Security communications

A means must be provided for prompt communications between personnel having supervisory security duties and law enforcement officials and for direct communications between all on duty personnel having security duties and all control rooms and control stations.

8.7.4 Security monitoring

Each protective enclosure and the area inside the shipyard must be monitored for the presence of unauthorized persons. Monitoring must be by visual observation in accordance with the schedule in the security procedures or by security warning systems that continuously transmit data to an attended location.

8.7.5 Warning signs

Warning signs must be conspicuously placed along each protective enclosure at intervals so that at least one sign is recognizable at night from a distance of 30 m from any way that could reasonably be used to approach the enclosure.

Signs must be marked with at least the following on a background of sharply contrasting colour:

The words “NO TRESPASSING,” or words of comparable meaning.

9 RISK ASSESSMENT

9.1 Risk assessment framework

9.1.1 Introduction

Safety is to be the primary objective for the planning, design and operation of facilities for the maintenance of LNG fuelled ship, taking into consideration simultaneous operations and the interaction with third parties.

The development of a shipyard with facilities for LNG fuelled ships is to be conducted with high focus on safety for personnel and it is to include:

- definition of study basis
- establishing safety distances for the operation
- performing risk assessment of the operations
- verification that design is in accordance with recognized standards and that agreed safeguards are implemented

The risk assessment is to be carried out as a part of the modification or development of the shipyard facility.

Due to the fact that shipyards with facilities for LNG fuelled ships survey, repair and conversion are shipyards working with IGF code ships and that this scenario is developing on these years, there are still no clear rules about all the concerned issues.

All risk are not always covered by prescriptive requirements and therefore risk assessment activities have to be conducted to ensure that the risks not covered by the prescriptive requirements are addressed such that they are ‘designed out’ as far as possible, and if not, ‘As Low As Reasonably Practicable’ (ALARP concept).

The risk assessment is to be undertaken using acceptable and recognized techniques, and the risks and their mitigation are to be documented.

Shipyard physical layout and all the foreseen maintenance operations are to be included in the risk assessment and maintenance.

Typically, the risks associated with maintenance operations are controlled by job specific risk assessments before the activity is undertaken.

Risk assessment is to be updated in case of any changes to the shipyard arrangement or operations. This helps ensure the risks are maintained ALARP throughout the drydock period.

The final scope of the risk assessment is to be agreed with appropriate stakeholders, like the competent Authorities, and guided by applicable rules.

The risk assessment can also address risk for material loss, down-time and reputation as per operator’s requirement.

The risk assessment shall be carried out in agreement with recognized standards, such as Tasneef “Guide for Risk Analysis”, ISO 31010:2019, ISO 17776:2016, ISO/TS 16901:2015.

The main steps in the risk assessment are:

a) identify what can go wrong (hazard identification)
b) assess the effect (consequence and impact assessment)
c) assess the likelihood (frequency assessment)
d) decide if the risk tolerable, or identify risk reducing measures

The risk analysis is to be carried out with a dedicated multi-disciplinary team ensuring an objective and independent assessment.

9.1.2 General approach

Within the scope of arrangement of shipyard with facilities for LNG fuelled ships survey, repair and conversion, all or some of the following stages of the risk assessment activity may be followed:

- Qualitative, where frequency and severity are estimated according to attributes expressing quality or kind (e.g. high, low, medium etc.);
- Semi-quantitative, where frequency and severity are estimated approximately within numerical ranges;
- Quantitative, where full quantification of frequencies and consequences is carried out.

The three approaches require an increasing order of detail, complexity, resources and background information/data to retrieve.

A broad, qualitative risk assessment should be carried out at the initial stages. The usual qualitative methods like HAZID/FMECA/HAZOP are normally sufficient to broadly categorize the risks according to the risk matrix agreed among the stakeholders, and to suggest alternatives for risk reduction. As the work progresses, becomes more complex and shows multi-faceted aspects, the need of more in-depth and accurate assessments usually arises.

If, already at this preliminary stage, the ALARP is not proven, or special critical issues are highlighted, then the risk team must consider additional and/or alternative mitigation measures (safeguards) and reevaluate the risk. A proposed operation cannot be ‘accepted’ until ALARP is achieved. In this regard, additional studies need to be undertaken to help decide if existing, additional or alternative measures could achieve the necessary risk reduction.

When considering mitigation measures the following hierarchy of mitigation must apply:

- firstly, measures to prevent the release of LNG
- secondly, measures to protect against the consequences of a release of LNG.

In addition, when considering mitigation (i.e. safeguards) engineering solutions must take preference over procedural controls. This helps promote an inherently safer design. Furthermore, passive measures must take preference over active measures. For example, a passive measure is one where no manual or automated action is required for it to function on demand and as intended. By contrast, an active measure requires some means of activation for it to operate. Both passive and active measures may be required to demonstrate that the risk has been mitigated as necessary.

If qualitative methods are not sufficient to evaluate the risk, a quantitative approach is needed. The scope and depth of the quantitative analysis depends on the problems under study. In general, it is preferable to give precedence to the consequence analysis over the likelihood analysis, for various reasons:

- data about gas fuelled ships drydock are not yet available, whilst the development of consequence models has reached a mature stage;
- however, the standard risk measure from QRA i.e. likelihood x severity may be useful when comparing two competitive solutions, taking proper account of the uncertainties.

9.1.3 Technical approach

Any relevant scenario may be approached according to various techniques to be agreed with relevant Authorities.

A general guidance can be found in the following.

9.1.3.1 Failure Databases

In general, as mentioned above, the consequence analysis ought to have priority over the probabilistic analysis. However, probabilistic databases can be useful to select the scenarios to simulate. Those scenarios can resort to publicly available databases to obtain the most frequent equivalent area of the leak. If such data are not available or are too uncertain, the equivalent area ought to be subject to a sensitivity analysis. It is to be noted, however, that usually such databases are not specific for LNG systems, but for generic hydrocarbon industries.

9.1.3.2 Consequence Models

Hazards associated with LNG are described in [10.1].

In general, the first and foremost risk to deal with is related to loss of containment, causing liquid spills and gas releases in various degrees according to the extent of the event.

In the former case, the liquid LNG would then undergo a change of state to gas. The consequences of both phenomena within the surrounding environment (brittle failure and vapour cloud) have to be assessed. For this purpose, it is necessary to resort to software tools based on valid physical principles and officially validated.

Various commercial tools are available to model LNG releases; simplified tools can be sufficient for releases in open spaces without significant obstacles, but for complex physical phenomena and geometries, Computational Fluid Dynamics (CFD) tools are normally needed.

The simulation in general requires at least the following information:

- LNG or gas pressure and temperature
- Environmental parameters (temperature, pressure, humidity)
- Leakage area
- LNG or gas flowrate
- Time required to isolate the leak, inferred from the characteristics of the envisaged safety systems : gas detectors, isolation valves, ESD and detection time for operator actions
- Geometry and material of affected equipment and surrounding environment;
- Existence of ignition sources for the vapors

9.2 SIMOP – SIMultaneous Operation

SIMOP – SIMultaneous Operation is the survey or repair of LNG plant in a gas fuelled ship drydock plus one or several other activities carried out simultaneously whose interferences may effect safety, integrity and reliability.

It is expected that SIMOPs during a gas fuelled ship drydock always occur.

SIMOP is to be continuously reviewed in order to identify potential interferences and to understand if it is necessary to implement any measure before to proceed with the activity.

It has to be taken into account that it is unavoidable that certain kind of SIMOP cannot be carried out during drydock.

SIMOPs can take place anywhere around the shipyard, including on the ship, on the quayside, or in surrounding waters.

Main SIMOPs are the followings:

1. Regular SIMOPs
2. Non-standard but planned SIMOPs
3. Non-standard and unplanned SIMOPs
4. External activities SIMOPs

Planned SIMOPs (Regular & Non-standard)

- personnel/crew movements
- hull cleaning and painting
- underwater survey
- welding and grinding
- machinery maintenance
- life boat maintenance
- cherry picker operations
- refurbishment working
- equipment loading/unloading
- loading/unloading of hazardous cargoes
- shipyard activities
- use of non-intrinsically safe electric or sparking machinery or tools
- equipment testing

Non-standard operation

- LNG Debunkering/Bunkering
- Drydock with ship not gas free
- Ship conversion
- Extensive steelwork

All of these operations have their own precautions.

All the above-mentioned SIMOPs or other relevant ones are to be risk assessed and approved (or forbidden or delayed).

It has to be taken into account that, if it possible to evaluate significantly in advance regular and planned SIMOPs before the drydock, it is necessary to be ready to risk assess unplanned and external SIMOPs immediately.

Of course, much more attention is to be paid to unusual activities that might significantly increase the consequences of an incident.

In order to manage these kind of operations, it is necessary to appoint one or more Person in Charge (PIC) for each activity and a Person in Overall Advisory Control (POAC) too. POAC is a trained and experienced person who controls where SIMOPs interaction may adversely impact safety, ship integrity and/or the environment.

The main responsibilities of the PIC/POAC are:

- to evaluate the SIMOPs, and in case of an event, imminent or in progress, that can increase risks or makes the process unsafe, to stop the drydock operations
- to check that only authorised personnel (trained, required for their role and properly equipped) are within the safety zone
- to ensure that necessary risk mitigations, are in force during the drydock period.
- To communicate continuously and in a clear and effective way with all parties involved

The safety zone is a defined area around the ship and the LNG plant where the majority of leak events can occur and where flammable gas can be a risk.

The safety zone is established to identify where there could be a risk for the personnel, the environment and the equipment and to minimize it.

This is to be ensured taking under control all the activities within the safety zone and observing and assessing the risks of activities within the monitoring and security area.

Typical control measures in the safety zone are the following:

- non-essential people and vehicle movements are to be avoided
- personnel is to protected by proper PPE
- ignition sources are to be avoided or in case to be under control

- communication among the POAC/PIC(s) and all the parties involved are to be ensured all the times

Each SIMOP usually has an associated area where concerning hazards can occur, like the following:

- areas of the shipyards where other operations are carried out
- areas of the shipyards with LNG storage
- hazardous zones around any non-intrinsically safe electrical equipment
- areas where untrained people are present

If it is demonstrated that the LNG plant safety zones doesn't overlap with these SIMOPs risk areas, it means that there is no interaction between the two activities.

Anyway, it is to be taken into account that SIMOPs is to be extended also outside the safety zone in case the consequences of a LNG releases outside that area can induce high risks.

SIMOPs, by definition, can generate additional risks introducing further hazards, increasing the likelihood of an LNG/gas leak, and/or escalating an event, by increasing the severity of consequences.

With reference to SIMOPs, the risk assessment is therefore mainly about to introduce barriers between the threats and the consequences.

A threat is an event that has the potential to cause a hazard such as a release of LNG.

A hazard is an event that has the potential to cause harm or damage, such as a piping leakage.

Consequences are the potential outcomes if a hazard occurs.

Actions are to be included therefore to prevent or mitigate these consequences.

Barriers are engineering solutions, procedural controls, passive and active measures, training for personnel, which stop a threat or prevent or mitigate the consequences.

With a gas fuelled ship under maintenance, a LNG spill, a gas release or an overpressure in the LNG plant can occur. There are therefore many potential threats that can be caused by SIMOPs during a drydock.

When a LNG leakage occurs, different scenarios are possible. Some of these scenarios result in no further impacts while others may escalate to become more serious by impacting additional items of equipment, personnel or the surrounding environment.

Usually multiple barriers are implemented in order to increase the consequences prevention or mitigation, but it has to be taken carefully into account that since each barrier can fail, there are circumstances where each barrier fail is “aligned” with the following one allowing a free path from the threat to the hazard.

Main goal is to implement the right barriers in the right place at the right time.

9.2.1 Management Systems

Many parties are involved in the drydock operations and any SIMOPs.

They are to be aware about the preliminary drydock program in advance and to agree specific operation in details on a day-to-day basis.

Far in advance, the shipyard is to have the following documentation available:

- ship SMS where allowable operations and risk management processes are described and approved according to ISM (International Safety Management)
- authorisation, permitting or licensing process for LNG plant maintenance under which the authorised local/national authority allow the mooring of the gas fuelled ship and the permit to work on it within a specified area;

On a day-to-day basis, the shipyards and the ship must confirm that the drydock takes place as stated in their drydock management.

The competent authorities have the duty to monitor that SIMOP and drydock operations are according to the procedures and the SIMOP risk assessment, and in negative case, the power to withdraw the permit.

Anyway competent authorities are to provide general guidance to all ships about what they require in these situations, for example, schemes of work, permit to work systems and/or specific formats of risk assessment, to streamline this process.

9.2.2 Planning for SIMOPs

Competent authorities are to be involved into the drawing up or at least the review of the plans for a shipyard with facilities for LNG fuelled ships survey, repair and conversion to ensure the safety of personnel inside the shipyard and that the other activities in the close repair or port are not affected.

The result of this planning process can suggest that some activities cannot be performed or are to be performed with limitations, when a gas fuelled ship is inside the shipyard, or additional equipment, personnel or training are required.

The SIMOP is to be also ship specific. Depending of the ship type (cruise ship, ferry, LNG carrier, etc) different SIMOP are to be considered or possible.

9.2.3 Considerations for shipyard planning and design

Shipyard design is to be primarily about workshops and equipment arrangement with reference to the safety zone with the ship in the drydock or the moored at the shipyard pier.

SIMOPs usually are not related with an increase of the potential dispersion distances but can increase the likelihood or the potential consequences of an LNG leak.

SIMOPs assessments therefore need to reflect:

- Case studies about when a SIMOP is not able to be as planned and the consequences on the drydock operations; please taking into account that more operations are carried out simultaneously, greater is the probability of a failure
- If much more people are exposed to any hazards that might arise during an incident in case of SIMOP.
- if a SIMOP can increase the potential for ignition of a gas cloud
- if SIMOPs can cause an escalation of a hazardous event even if it is not caused by the SIMOPs

Shipyard design is to take into account which kind of maintenance operations are allowed, mainly in case of not gas free ship and in which conditions.

Another matter to take into consideration is, for instance, weather and local climate.

An humid climate can make difficult drying operations in LNG fuel storage tanks and let humidity enters where not allowed.

High temperatures may result in a disadvantage with reference to all the cryogenic systems and produce unfavourable expansion of components.

If the layout of the shipyard permanently changes, either through relocation of facilities or the construction of new facilities (including external facilities), the planning process needs to repeated.

10 OVERVIEW OF CRYOGENIC SAFETY HAZARDS

The hazards associated with LNG can be divided into two main categories: hazards associated with the fact that it is a cryogenic liquid and hazards that are due to the fact that natural gas is used as a fuel. As a liquid, LNG does not burn, however the big temperature difference with marine surroundings can cause a volatile situation. Once in gas form, the risks focus on the flammability of the natural gas. With a flammability range of approximately 5-15% the flammable cloud that can come to exist and can extend to quite a large area. It is vital to be continuously conscious of these risks during maintenance operation.

10.1 Cryogenic hazards

10.1.1 Health and process issue related to cryogenic temperatures

The cryogenic temperatures at which LNG is stored bring various hazards to both people and ships.

Serious injuries can occur to personnel if they come in contact with cryogenic liquids.

Skin contact with LNG results in effects similar to thermal burns and with exposure to sensitive areas, such as eyes, tissue can be damaged on contact. Prolonged contact with skin can result in frostbite and prolonged breathing of very cold air can damage lung tissue.

Physical contact is to be always avoided and suitable PPE provided.

For ships the risk is brittle fracture. Carbon steel which is commonly used in the construction of ships, becomes brittle at temperatures below -50°C. This can lead to the formation of cracks, reducing the yield strength significantly.

10.1.2 Rapid Phase Transition (RPT)

Rapid physical phase transition may occur when LNG liquid is rapidly converted to methane vapour after LNG liquid is spilled in water.

Small pockets of LNG that evaporate instantaneously when superheated in water create pressure pulses, which will travel at the speed of sound and decay as any other pressure pulse.

RPT is not characterized as a detonation since it does not involve any combustion. Rather, RPTs generate overpressures only capable of nearby window breakage.

10.1.3 Boiling Liquid Expanding Vapour Explosion (BLEVE)

LNG fuel storage tanks are designed to avoid a BLEVE, a little risk is only present in C type tanks.

Anyway in case the internal pressure increase above to the design pressure due to the LNG warming and there is a damage in the tank, BLEVE can occur.

For instance, the LNG inside the tank can warm up rapidly in case of insulation damages.

Independent type C tanks are designed to be able to contain a normal build-up of pressure for at least 15 days.

10.1.4 Rollover

Rollover is the process of rapid and sudden vapour increase inside an LNG fuel storage tank due to the mixing of stratified layers of different densities.

For instance, in case heavy LNG is loaded at the bottom of a tank, or lighter LNG at the top, the new LNG might not mix with the LNG present in the tank. Therefore stratification can occur. In this case only the top layer produces BOG and becomes heavier and heavier in density and therefore roll over occurs.

The consequence is an increased release of vapour.

It is possible to vent the additional vapour but in this case the hazards associated with a vapour cloud increase.

In order to prevent rollover it is necessary to promote the mixing loading LNG by means nozzles, to avoid prolong stoppage during LNG loading and to monitor continuously BOG rate.

10.1.5 Underwater release

If LNG is released underwater in any manner (ship collision, hull damage) it rises to the surface since it is lighter than water. Due to the heat ingress from the surrounding water, evaporation rate of LNG in contact with water is substantially higher than that from a dry surface

Furthermore, the LNG is free to spread over an indefinitely large area and the flammable cloud may extend for large distances downwind.

Since there are not many studies about this phenomena, it is recommended to perform a risk assessment with the interested parties and to provide gas detection equipment in relevant area of the shipyard in order to determine the safe distance from an emerging vapour cloud from an underwater release.

10.2 Vapour cloud hazards

10.2.1 Asphyxiation

When LNG heats up, it turns into vapour. This vapour creates hazards.

If the concentration of methane is high enough in the air, there is a potential for asphyxiation hazard for personnel in the immediate area, particularly if the release occurs in confined spaces.

10.2.2 Flammability

When cold LNG comes in contact with warmer air, it becomes a visible vapour cloud. As it continues to get warmer, the vapour cloud becomes lighter than air and rises. When LNG vapour mixes with air it has a flammable range between 5 % and 15 %.

To reach these limits there are many factors, like the amount of LNG released, wind, humidity .

LNG does not ignite without an ignition source, but also a very small source is enough, like a hot surface onboard the ship.

Ignition sources are normally assumed to be electrical equipment (including mobile/cell phones and high-power radio and radar) but can also include:

- static electricity generated by sand blasting and painting systems
- naked flames from welding, paint stripping and people smoking
- sparks from grinding, some electrical equipment, cranes and hoists
- vehicle engines and power generators (particularly gasoline/petrol-fuelled)

Examples of special precautions required to limit the probability of ignition sources coming into the hazardous area include:

- using intrinsically safe equipment, which cannot spark
- prohibiting people from bringing ignition sources within the area

It is recommended to provide to the shipyard adequate gas detection equipment in order to visualise the size and location of the cloud and flames.

10.2.3 Explosion

As a liquid, LNG is not explosive.

Ignition of an LNG vapour cloud can only cause an explosion in a confined space where overpressure can build up.

10.2.4 Pool fire

In case of large LNG spill, a LNG pool fire can occur.

If an LNG pool is on fire, the generated heat further increases the evaporation which intensifies the fire in return. More vapour leads to a higher burn intensity due to the fact that LNG can only burn in vapour or gas phase. Even if LNG is not flammable, due to the temperature difference, vapour can always be generated by a pool of LNG.

To establish the safety zone, the radiant heat should be therefore calculated.

10.2.5 Delayed ignition

When ignited in an unconfined area, the flame of LNG can burn back towards the spill, causing a pool fire.

It is to be taken into consideration that local gas pockets can be present in the vapour cloud area even if the average concentration of the vapour cloud is below the lower flammability limit.

To establish the safety zone it is recommended that the value of the Safe Flammability Limit (SFL) of 2.5% is used to determine the range of possible delayed ignition.

10.3 Environmental hazards

LNG is non-toxic and it is considered the most environmentally friendly fossil fuel, because it has the lowest CO_2 emissions per unit of energy.

Anyway, LNG is predominantly methane and methane is one of the most potent greenhouse gas in earth's atmosphere contributing to the global warming.

Therefore venting is to be applied only as a last resort.

It is therefore always recommended to flare a controlled release in order to release in the atmosphere only carbon dioxide. It also allows to maintain control over the situation as it prevents the formation of a vapour cloud.

Compared to oil based fuel, anyway in case of leakage, LNG disperses naturally since becomes lighter than air as it approaches ambient temperature and therefore the surrounding area is not contaminated.

11 EMERGENCY OPERATIONS

11.1 Safety zone

In order to manage the accidental vapour cloud, it is necessary to establish a safety zone.

The safety zone is the area where there are no more hazards due to the vapour cloud.

The safety zone perimeter is calculated taking into account also local factors such as weather and volume of LNG on the casualty. In general, the accuracy of the data available is insufficient for models based on Computer Fluid Dynamics to have any added value. Anyway the use of a computer model to calculate the safety zone perimeter for a specific situation is recommended.

The situation is be of course always under control with a proper gas detection system coverage.

For more details, please refer to IEC 60079-10 and IEC 60092-502

11.1.1 Hazards in the safety zone

In case the safety zone is established with regard to the flammability, the recommended Safe Flammability Limit (SFL) of 2.5% of gas per volume of air is to be fixed.

For the radiation of heat, values lower than 2.5 kW/m^2 can be mitigated with proper PPE. Therefore a safety zone should extent at least to these values.

Asphyxiation inside the vapour cloud is another issue to take into account.

Of course, in the safety area determination, also LNG pool hazards are to be included and evaluated.

11.2 Prevention

In order to manage the vapour cloud, it is recommended to start with the prevention.

Since LNG does not ignite without an ignition source, in case of a spill, the removal of the ignition sources, the use of water curtains and sprays to cool the surrounding objects is the first step.

Furthermore water can also be sprayed on the LNG pool itself in order to increase the vaporisation, even if this procedure increases also the vapour cloud and this is to be avoided in case of vulnerable area. The decision to apply water on an LNG pool is to be taken carefully.

Since the vapour cloud can increase in size, a new safety zone perimeter is to be established and responsible authorities informed before to get the final decision.

In order to limit the amount of released vapour, of course it is possible to stop the filling but only if it is allowed according to the relevant risk assessment.

11.3 Firefighting

In case it has been not possible to prevent the ignition, it is recommended to manage a controlled burn by means water sprays and curtains to cool the surroundings, including ship hull.

It is possible also to try to suffocate the flames: since the use of dry chemical powders is not always effective, foam is to be the preferred option.

The foam increases the vaporization first and therefore the fire intensity, then starts to suffocate it. Good chances of success are in case of confined pool. On the contrary, in case of LNG pool in open water, too much foam is required and therefore the solution is not more feasible.

As soon as the fire is extinguished, it is to take into consideration that the LNG pool can still produce vapour and the surrounding can be so hot to be another source of ignition.

11.4 Gas detection

Natural gas is colourless and odourless, therefore it is necessary to ensure a gas detection system in operation all the times and in each relevant location.

Since prevention is always better than correction, it is recommended to provide a remote detection system.

Usually gas detection equipment measures the methane content in part per million (ppm), but it is useful to evaluate also systems with infrared cameras that are able to display the presence of any LNG vapour and the vapour cloud size and direction. In this case, a monitoring team is to be organized and always in place.

There are available also infrared light remote detectors able to measure a certain ppm value. This is basically the same technology as thermal imagery, however due to the difference in output it is more suitable for detection of a sudden release.

Other detection methods, are semiconductor (metal oxide), thermal conductor and catalytic. These are used to detect gas in place, and not from a distance. This kind of detection is useful in the case of an unexpected release, but not suitable for monitoring a vapour cloud.

12 TRAINING

All personnel working in a shipyard with facilities for LNG fuelled ships survey, repair and conversion are to be familiar with the hazards involved and with all the emergency measures that might be required in the event of an accident and how to manage them.

12.1 Operations

12.1.1 Rules

Shipyard with facilities for LNG fuelled ships survey, repair and conversion is to be able to implement and manage procedures in the drydock area in compliance with international and local regulations.

These procedures are to be develop and followed in order to ensure that maintenance is conducted with a high level of safety, integrity and reliability with regards to the personnel involved and the environment.

Personnel working in the shipyard is to be aware at least about the following:

- International and local Rules about LNG
- The importance of safety, environmental and operating manuals: how to use them, the compliance with the rules, to identify a possible gap and amend it
- It is not possible to modify the original design of any system or procedure related to LNG without a proper risk assessment

12.1.2 Shipyard management

In order to assure that shipyard management is capable of effective organization and management of the shipyard, the following competences are to be ensured with a proper training process:

- To be aware which kind of training and competency is required by those staff responsible for drydock, why and how to ensure it
- To ensure that LNG specialists are employed for LNG equipment maintenance
- How to ensure the right communication among shipyard, Owner, crew and Authorities
- How to establish a good team working
- Which are the roles and responsibilities during a gas fuelled ship drydock.

All the above should be aligned with STCW standards and national regulations

12.1.3 Safety and operating procedures

In order to assure that shipyard personnel is able to identify the proper safety and operating procedures and how to implement them, the following competences are to be ensured with a proper training process:

- Which are the requirements for the safety and operating procedures and their reason
- How to apply the appropriate safety and operating procedures and where to find necessary details
- How to perform a risk assessment to improve a procedure (Please refer also to Tasneef “Guide for Risk Analysis”).

12.2 Risk management

12.2.1 Environment

In order to assure that shipyard personnel is able to understand risk assessment methodologies and how they are to be applied to the LNG operation to manage risks, the following competences are to be ensured with a proper training process:

- properties and characteristics of LNG
- hazards associated with LNG
- requirements for the use of electrical equipment in hazardous areas
- how to apply a risk assessment techniques and how to implement the findings
- when a risk assessment is to be performed in specific situations relating to a LNG operation
- to be aware that also risk assessments relating to commonly performed operations are to be regularly reviewed
- which kind of safety equipment are to be installed and in which location
- how to apply a gas detection system and which kind of environmental conditions can affect the performances

12.2.2 Communication and roles

In order to assure that shipyard personnel is able to implement effective communications to ensure safe and efficient operations, the following competences are to be ensured with a proper training process:

- which kind of information are to be exchanged, when and with whom
- communication methods

- how to record the information to monitor the processes
- which are the roles and responsibilities of the various persons and organizations involved during the drydock
- which is its job role during the drydock also with reference with safety
- how to report and record safety/environmental incidents

12.2.3 Equipment

In order to assure that shipyard personnel is able to ensure that any safety equipment and their associated systems are fit for purpose, the following competences are to be ensured with a proper training process:

- which equipment need to be certified and how to manage the certificates
- which kind of maintenance and calibration are required and how to manage the records for relevant equipment
- what is the Duty of Care concept, how this protects both persons and assets and which kind of precautions and actions are necessary
- the requirements for the use of electrical equipment in hazardous areas

12.2.4 Personal Protection

In order to assure that shipyard personnel is aware about which types of Personnel Protection Equipment (PPE) are to used when working with LNG fuelled ship, how to use them correctly, and how to check that the equipment is appropriate, the following competences are to be ensured with a proper training process:

- technical details of Personal Protective Equipment
- which kind of PPE are to be used when working with LNG
- to ensure that any person involved is aware about the risks and how to mitigate them with proper PPE.

12.3 Emergencies

12.3.1 Managing and responding to emergencies

In order to assure that shipyard personnel is able to understand all the potential hazards related to processes involving LNG and how to deal with them, the following competences are to be ensured with a proper training process:

- how to interpret potentially hazardous events that may occur during drydock operations and respond effectively
- principles of escalation where one hazardous event may lead to others
- principles of emergency evacuation, and the role of temporary refuges,
- plans to be modified for different weather and damage scenarios
- when to evacuate to a muster point
- how to coordinate with, and when to handover to, the local immediate responders and emergency services
- the purpose and operation of the gas venting and LNG discharge systems
- potential hazards resulting from trapped volumes of LNG and where they could occur
- how to safely isolate potential ignition sources
- how and when to initiate fixed and portable firefighting equipment
- how and when to fight a LNG fire
- the emergency procedures
- how to record any near miss/hazardous event
- fire-fighting techniques and equipment
- First Aid action to be taken in the event of personnel contact with LNG

12.4 Drydock specific operations

Before each gas fuelled ships drydock, it is necessary to provide and refresh specific training about the following:

- familiarisation with specific items of port/ship rules and regulations and their impact on the operations.
- familiarization with manufacturer equipment by means manuals and manufacturer training courses (i.e. LNG tank maintenance)
- which kind of LNG operations are allowed in shipyard and the risk assessments required to support them
- permit to work schemes
- the ship layout and the safety and security measures
- how to recognize, and correctly respond to, an emergency situation
- previous drydock accident or near miss accident analysis
- lesson learned