

PETROLEUM AND NATURAL GAS REGULATORY BOARD

NOTIFICATION

New Delhi, the 18th January 2018

G.S.R. No.: INFRA/T4S/LNG/05 - In exercise of the powers conferred by section 61 of the Petroleum and Natural Gas Regulatory Act, 2006 (19 of 2006), the Petroleum and Natural Gas Regulatory Board hereby makes the following Regulations, namely:-

1. Short title and commencement.

- (1) These regulations may be called the Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Regulations, 2017.
- (2) They shall come into force on the date of their publication in the Official Gazette.

2. Definitions.

- (1) In these regulations, unless the context otherwise requires,-
 - (a) “Act” means the Petroleum and Natural Gas Regulatory Board Act, 2006;
 - (b) “Board” means the Petroleum and Natural Gas Regulatory Board established under sub-section (1) of section 3 of the Act;
 - (c) “Boil off gas” (BOG) means the gas produced due to vaporisation of cryogenic liquid by heat conducted through the insulation;
 - (d) “bunkering” means the loading of a ship’s bunker or tank with liquid fuel for use in connection with propulsion or auxiliary equipment;
 - (e) “container” means a vessel for storing liquefied natural gas - such a vessel may be above, partially below, or totally below ground and may consist of an inner and outer tank;
 - (f) “container, pre-stressed concrete” means a concrete container which is considered to be pre-stressed when the stresses created by the different loading or loading combinations do not exceed allowable stresses;
 - (g) “compressed gas” means any permanent gas, liquefiable gas, or cryogenic liquid under pressure or gas mixture which in a closed pressure vessel exercise a pressure exceeding one atmosphere (gauge) at the maximum working temperature and includes Hydrogen Fluoride. In case of vessel without insulation or refrigeration, the maximum working temperature shall be considered as 55 OC ;

- (h) “critical temperature” means the temperature above which gas cannot be liquefied by the application of pressure alone;
- (i) “cryogenic liquid” means liquid form of permanent gas having normal boiling point below minus 150 0C;
- (j) “cryogenic pressure vessel” means a pressure vessel irrespective of water capacity intended for storage or transportation of cryogenic liquid and includes cold converters, vacuum insulated vessels, vacuum insulated storage or transport tanks and thermosyphon tanks”;
- (k) “design” includes drawings, calculations, specifications, codes and all other details necessary for complete description of the pressure vessel and its construction;
- (l) “design pressure” means the pressure used in the design of equipment, a container, or a vessel for the purpose of determining the minimum permissible thickness or physical characteristics of its different parts. Where applicable, static head shall be included in the design pressure to determine the thickness of any specific part;
- (m) “dyke” means a structure used to establish an impounding area;
- (n) “Emergency Release Coupler” (ERC) means the coupler fitted in each arm together with quick – acting flanking (double blocked) valves so that a dry-break release can be achieved in emergency situations;
- (o) “Emergency Shutdown System” (ESD) means a system that safely and effectively stops whole plant or an individual unit during abnormal situation or in emergency;
- (p) “failsafe” means a design feature that provides for the maintenance of safe operating conditions in the event of a malfunction of control devices or an interruption of an energy source;
- (q) “fired equipment” means any equipment in which the combustion of fuels takes place and includes, among others, fired boilers, fired heaters, internal combustion engines, certain integral heated vaporisers, the primary heat source for remote heated vaporisers, gas-fired oil foggers, fired regeneration heaters and flared vent stacks;
- (r) “flammability range” means the difference between the minimum and maximum percentage by volume of the gas in mixture with air that forms a flammable mixture at atmospheric pressure and ambient temperature;
- (s) “gas free” means the concentration of flammable or toxic gases or both if it is within the safe limits specified for persons to enter and carry out hot work in such vessels;

- (t) “hazardous fluid” means a LNG or liquid or gas that is flammable or toxic or corrosive;
- (u) “ignition source” means any item or substance capable of an energy release of type and magnitude sufficient to ignite any flammable mixture of gases or vapours that could occur at the site;
- (v) “impounding basin” means impounding basin container within or connected to an impounding area or spill collection area where liquid hydrocarbon spills can be collected and safely confined and controlled;
- (w) “impounding area” means an area that may be defined through the use of dykes or the topography at the site for the purpose of containing any accidental spill of LNG or flammable refrigerants;
- (x) “Liquefied Natural Gas” (LNG) means a fluid in the liquid state composed predominantly of methane (CH₄) and which may contain minor quantities of ethane, propane, nitrogen, or other components normally found in natural gas;
- (y) “LNG facility” means a group of one or more units or facilities, that is, unloading or loading, storage, regasification, associated systems like utilities, blow down, flare system, fire water storage and fire water network, control room and administration service buildings like workshop, fire station, laboratory, canteen etc.;
- (z) “Maximum Allowable Working Pressure” means the maximum gauge pressure permissible at the top of equipment, a container or a pressure vessel while operating at design temperature;
- (aa) “NDT” means Non Destructive Testing methods like Dye Penetration Inspection, Wet Fluorescent Magnetic Particle Inspection, Ultrasonic thickness checks, Ultrasonic Flaw Detection, Radiography, Hardness Test and other relevant Inspection procedures carried out to detect the defects in the welds and parent metal of the pressure vessel;
- (bb) “pressure vessel” means any closed metal container of whatever shape, intended for the storage and transport of any compressed gas which is subjected to internal pressure and whose water capacity exceeds one thousand liters and includes inter connecting parts and components thereof upto the first point of connection to the connected piping and fittings;
- (cc) “primary components” include those whose failure would permit leakage of the LNG being stored, those exposed to a temperature between (-510C) and (-1680C) and those subject to thermal shock but shall not be limited to the following parts of a single-wall tank or of the inner tank in a double-wall tank, namely, shell plates, bottom plates, roof plates, knuckle plates, compression rings, shell stiffeners, manways, and nozzles including reinforcement, shell anchors, pipe tubing, forging, and bolting. These are the parts of LNG

containers that are stressed to a significant level;

- (dd) “process plant” means the systems required to condition, liquefy or vaporise natural gas in all areas of application;
 - (ee) “safety relief device” means an automatic pressure relieving device actuated by the pressure upstream of the valve and characterized by fully opened pop action intended to prevent the rupture of a pressure vessel under certain conditions of exposure;
 - (ff) “secondary components” include those which will not be stressed to a significant level, those whose failure will not result in leakage of the LNG being stored or those exposed to the boil off gas and having a design metal temperature of (-51°C) or higher;
 - (gg) “source of ignition” means naked lights, fires, exposed incandescent materials, electric welding arcs, lamps, other than those specially approved for use in flammable atmosphere, or a spark or flame produced by any means;
 - (hh) “transfer area” is that portion of an LNG plant containing piping systems where LNG, flammable liquids, or flammable refrigerants are introduced into or removed from the facility, such as ship unloading areas, or where piping connections are routinely connected or disconnected. Transfer areas do not include product sampling devices or permanent plant piping;
 - (ii) “transfer system” includes transfer piping and cargo transfer system;
 - (jj) “vaporiser” means a heat transfer facility designed to introduce thermal energy in a controlled manner for changing a liquid to vapour or gaseous state;
 - (kk) “vessel” means a pressure vessel and includes a cryogenic pressure vessel;
 - (ll) “water capacity” means capacity in litres of the pressure vessel when completely filled with water at 150 C;
- (2) Words and expressions used and not defined in these regulations, but defined in the Act or in the rules or regulations made thereunder, shall have the meanings respectively assigned to them in the Act or in the rules or regulations, as the case may be;

3. Application.

Definitions of design, material and equipment, piping system components and fabrication, installation and testing, commissioning, corrosion control, operation and maintenance and safety of LNG facilities including jetty facilities shall be in accordance with the requirements of these regulations.

4. Scope.

- (1) Requirements of these regulations shall apply to all LNG facilities including terminals.
- (2) These regulations lay down minimum requirements of layout within the plant boundary for unloading or loading, storage, regasification, transfer and handling and tank truck loading facilities for LNG facilities.
- (3) These regulations covers safety in design and operational aspects of process systems, storage tanks, regasification facilities, ship shore interlock, berthing conditions for the ship, receiving facilities including jetty and port.
- (4) These regulations also cover engineering considerations in design, operations, maintenance, inspection and installations including fire protection and safety systems.

5. Objective.

These standards are intended to ensure uniform application of design principles and to guide in selection and application of materials and components, equipment and systems and uniform operation and maintenance of the LNG terminals or facilities and shall primarily focus on safety aspects of the employees, public and facilities associated with LNG terminals.

6. The standard.

Technical standards and specifications including safety standards (hereinafter referred to as standards) for Liquefied Natural Gas Facilities shall be as specified in Schedule - 1 which cover design and layout, electrical systems, process system, maintenance, inspection, competency assessment, fire prevention, leak detection, fighting system and safety management system.

7. Compliance to these regulations.

- (1) The Board shall monitor the compliance to these regulations either directly or through an accredited third party as per separate regulations on third party conformity assessment.
- (2) Any entity intending to set up LNG facilities shall make available its detailed plan including design consideration conforming to these regulations to PESO for their approval prior to seeking registration with the Board.
- (3) If an entity has laid, built, constructed, under construction or expanded the LNG terminal based on some other standard or is not meeting the requirements specified in these regulations, the entity shall carry out a detailed Quantitative Risk Analysis (QRA) of its infrastructure. The entity shall thereafter take approval from its Board for non-conformities and mitigation measures. The entity's Board approval along with the compliance report, mitigation measures and

implementation schedule shall be submitted to the Board within six months from the date of notification of these regulations.

¹[(4) The Board of the concerned entity, within ninety days of the notification of these regulations shall appoint one of its directors, who shall be responsible for ensuring compliance to these regulations]

8. Default and Consequences.

- (1) There shall be a system for ensuring compliance to the provision of these regulations through conduct of technical and safety audits during the construction, commissioning and operation phase.
- (2) In case of any deviation or shortfall including any of the following defaults, the entity shall be given time limit for rectification of such deviation, shortfall, default and in case of non-compliance, the entity shall be liable for any penal action under the provisions of the Act or termination of operation or termination of authorization.

9. Requirements under other statutes.

It shall be necessary to comply with all statutory rules, regulations and Acts in force as applicable and requisite approvals shall be obtained from the relevant competent authorities for LNG facilities.

10. Miscellaneous.

- (1) If any question arises as to the interpretation of these regulations, the same shall be decided by the Board.
- (2) The Board may at any time effect appropriate modifications in these regulations.
- (3) The Board may issue guidelines consistent with the Act to meet the objective of these regulations as deemed fit.

¹ Ins. by cl (i) of reg. (2), the Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Amendment Regulations, 2023 (w.e.f. 15.02.2023)

SCHEDULE 1

(see regulation 6)

Schedule - 1A : DESIGN AND LAYOUT OF FACILITIES

Schedule - 1B : ELECTRICAL SYSTEMS

Schedule - 1C : PROCESS SYSTEM

Schedule - 1D : MAINTENANCE AND INSPECTION

Schedule - 1E : COMPETENCY ASSURANCE AND ASSESSMENT

Schedule - 1F : FIRE PREVENTION, LEAK DETECTION AND FIGHTING SYSTEM

Schedule - 1G : SAFETY MANAGEMENT SYSTEM

Schedule - 1A

1.0 DESIGN AND LAYOUT OF FACILITIES

1.1. Philosophy

LNG Terminal lay out philosophy must consider location of the facilities at a site of suitable size, topography and configuration with a view to designing the same to minimise the hazards to persons, property and environment due to leaks and spills of LNG and other hazardous fluids at site. Before selecting a site, all site related characteristics which could affect the integrity and security of the facility shall be determined. A site must provide ease of access so that personnel, equipment, materials from offsite locations can reach the site for firefighting or controlling spill associated hazards or for the evacuation of the personnel.

1.2. Basic Information

1.2.1. Information on following items should be collected before proceeding with the development of overall plot plan.

- i. Terminal capacity
- ii. Process units and capacities
- iii. Process flow diagram indicating flow sequence
- iv. Utility requirements
- v. Unloading system along with tanker berthing system with capacity
- vi. LNG storage tanks, sizes and type of storage tanks
- vii. Other storage tanks
- viii. LNG transfer and vaporisation
- ix. Tank truck loading/unloading
- x. No. of flares
- xi. Provision for spill containment and leak control
- xii. Inter distances between the equipment
- xiii. Operating and maintenance philosophy for grouping of utilities
- xiv. Plant and non-plant buildings
- xv. Environmental considerations
- xvi. Fire station
- xvii. Chemical storage
- xviii. Ware house and open storage areas.

1.2.2. Information related to each item should include, but not limited to, following:

- i. Extreme temperatures and pressures for normal operations as well as emergency conditions.
- i. Concrete structures subject to cryogenic temperatures
- ii. Fail safe design
- iii. Structural requirement
- iv. Requirement of dyke and vapour barrier

- v. Shut off valves and relief devices.

1.2.3. Data on terminal and infrastructure facilities should be identified and collected before detailed layout activity is taken up. Due consideration should be given while deciding/finalising terminal layout to the following:

- i. Site location map
- ii. Seismic characteristics and investigation report.
- iii. Soil characteristics
- iv. Prevailing wind speed and direction over a period
- v. Meteorological data including corrosive characteristics of the air and frequency of lightening
- vi. Area topography contour map
- vii. High flood level in the area and worst flood occurrence.
- viii. Source of water supply and likely entry / exit point
- ix. Electric supply source and direction of entry point
- x. LNG entry point/ Gas exit point
- xi. Minimum inter distances between facilities as well as between facilities & boundaries
- xii. Storm water disposal point and effluent disposal point
- xiii. Approach roads to main Terminal areas
- xiv. Surrounding risks
- xv. Air routes and the proximity of the Airports.
- xvi. Environment impact assessment

1.2.4. Emergency communications equipment shall not be adversely affected by the operation of other devices/equipment in close proximity (electromagnetic compatibility). Emergency communications equipment shall not create additional hazards during an emergency situation GA control system to be protected against fire, blast and credible accident events, by location or otherwise, such that its ability to function is not impaired for the time taken to muster after a major accident event.

1.2.5. Facilities with the potential to generate waste e.g. process waste water, sanitary sewage or storm water should incorporate necessary precautions to avoid, minimize and control adverse impacts to health, safety or the environment.

1.2.6 Plans shall be developed that considers prevention, reduction, reuse, recovery, recycling, removal and disposal of wastes (including hazardous waste) generated during all project phases and modes of operation.

1.2.7 The project to address potential environmental impacts on existing conditions such as surface, groundwater and soils.

1.2.8 Plans shall be developed to minimize or reduce emissions as far as reasonably practicable, resulting from commissioning, testing activities and operation.

- 1.2.9** All escape routes including emergency exit doors to be readily accessible, non-slip, marked, signposted and clear of obstructions.
- 1.2.10** Markings and signs to be clearly visible if there is loss of artificial lighting outside daylight hours.
- 1.2.11** All escape doors shall be of a type that can easily be opened in an emergency situation.
- 1.2.12** Rescue breathing apparatus sets and other equipment necessary shall be located at strategic locations around the facilities to allow prompt rescue of personnel.
- 1.2.13** The communication systems shall be protected by, location of equipment, spatial diversity and equipment redundancy. Internal and external telecommunications in order to perform the emergency function defined by project requirements shall be confirmed between the Control Room, vessel/s and storage / pumping locations and Muster area.
- 1.2.14** PA / GA cables should be located so that they are protected against accidental loads as far as possible and shall be fire resistant to specifications. PA/GA system shall provide a means of alerting all personnel to the existence of an emergency situation, provide the means to communicate additional information to personnel during an emergency and shall be capable of operating without impairment for the minimum time required to escape to muster locations and then to evacuate to a place of safety after the start of a major accident.
- 1.2.15** The provision and minimum alarm noise level above local ambient is in accordance with design requirements. In areas with greater ambient noise levels, visual alarms shall also be provided.

1.3. Blocks

- 1.3.1.** In addition to points indicated in (NFPA 59A), as applicable, containment of potential spills of LNG or other hazardous liquid, especially in case of LNG storage and jetty area should also be considered.

1.3.2. Layout of Blocks / Facilities

The LNG may consist of the following basic blocks / facilities:

- i. The Jetty for berthing of ship and unloading/loading of LNG.
- ii. Unloading/loading line from Jetty to shore terminal.
- iii. LNG Storage
- iv. Re-gasification consisting of pumping and vaporisation.
- v. Tank truck loading/unloading
- vi. Utility Block
- vii. Fire Station
- viii. Flare system
- ix. Control Room
- x. Administrative Block
- xi. Workshop
- xii. Warehouse

- xiii. Electrical Substation.
- xiv. Laboratory
- xv. Road loading

1.4. Roads

Access to the moored ships shall be provided. If necessary, a separate road should lead to the berths in order to provide the crew with a free access to the ship.

- i. All process units and dyked enclosures of storage tanks shall be planned in separate blocks with roads all around for access and safety.
- ii. Primary traffic roads in the installation should be outside hazardous areas. Roads separating the blocks shall act as firebreaks.
- iii. Pedestrian pathways should be provided / marked alongside the primary traffic roads.
- iv. Alternative access shall be provided for each facility so that it can be approached for fire fighting in the event of blockage on one route.
- v. Road widths, gradient and turning radii at road junctions shall be designed to facilitate movement of the largest fire-fighting vehicle in the event of emergency.
- vi. Layout of the facilities shall be made to minimize truck traffic ingress in the plant.
- vii. Two road approaches from the highway / major road should be provided. Both these approaches should be available for receipt of assistance in emergency.
- viii. Conflict of people movement and vehicle movement shall be avoided.

1.5. Location

- i. The receiving terminal should be as close as possible to the unloading jetty.
- ii. The location shall minimize the level of risk outside the boundary plant taking into account adjacent existing and identified future developments

1.6. General Considerations

The layout shall consider two specific zones i.e. Gas Zone and Non-Gas Zone and identify the applicable blocks within each zone. Minimum inter-distances between blocks / facilities shall be maintained as specified in the regulations or as per the risk analysis studies whichever is higher.

1.7. Spacing requirement of LNG Tanks and Process Equipment

1.7.1. LNG Tank Spacing

- i. LNG tanks with capacity more than 265 m³ should be located at minimum distance of 0.7 times the container diameter from the property line but not less

than 30 meters. Minimum distance between adjacent LNG tanks should be 1/4 of sum of diameters of each tank. The distance between tanks should be further reviewed in accordance with Hazard assessment, but in no case it shall be less than the criteria mentioned above.

- ii. Inter distances between LNG Storage tank shall be as under:

Table - 1 Distances from Impoundment Areas to Buildings and Property Lines

Container Water Capacity (m³)	Minimum Distance from Edge of Impoundment or Container Drainage System to Buildings and Property Lines (m)	Minimum distance between adjacent containers (m)
<0.5	0	0
0.5-1.9	3	1
1.9-7.6	4.6	1.5
7.6-63	7.6	1.5
63-114	15	1.5
114-265	23	1/4 of the sum of the diameters of adjacent containers but not less than 1.5 m
>265	0.7 times the container diameter but not less than 30 m	1/4 of the sum of the diameters of adjacent containers but not less than 1.5 m

Table – 2 Distances from underground containers and Exposures

Container Water Capacity (m³)	Minimum Distance from Edge of Impoundment or Container Drainage System to Buildings and Property Lines (m)	Minimum distance between adjacent containers (m)
< 68.1	4.6	4.6
68.1 -114	7.6	4.6
> 114	12.2	4.6

- Note :
- i. A clear space of at 0.9 m shall be provided for access to all isolation valves serving multiple containers.
 - ii. Any LNG storage / process equipment of capacity more than 0.5 M³ shall not be located in buildings.

1.7.2. Vaporiser Spacing

Vaporisers and their primary heat sources unless the intermediate heat transfer fluid is non-flammable shall be located at least 15 m from any other source of ignition. In multiple vaporiser installations, an adjacent vaporiser or primary heat source is not considered to be a source of ignition. Integral heated vaporisers shall be located at least 30 m from a property line that may be built upon and at least 15 m from any impounded LNG, flammable liquid, flammable refrigerant or flammable gas storage containers or tanks. Remote heated, ambient and process vaporisers shall be located at least 30 m from a property line that can be built upon. Remote heated and ambient vaporisers may be located within impounding area. The inter distances in multiple heated vaporisers a clearance of at least 2 m shall be maintained.

1.7.3. Process Equipment Spacing

- i. For Process equipment spacing shall be in line with process design requirements keeping in view the operation, maintenance and safety considerations.
- ii. Fired equipment and other sources of ignition shall be located at least 15 m from any impounding area or container drainage system.

The minimum separation distances between various blocks, process units and other facilities shall be as per Annexure- II.

1.7.4. Unloading Facilities

1.7.4.1 General Requirements

- i. The LNG jetty should comply with the requirement as specified in “Site Selection and Design for LNG Ports and Jetties”- Information paper no. 14, February 1997 and also “Liquefied Gas Handling Principles on Ships and in Terminals” published by Society of International Gas Tankers and Terminals Operators (SIGTTO).
- ii. General cargo, other than ships’ stores for the LNG tanker, shall not be handled over a pier or dock within 30 m of the point of transfer connection while LNG are being transferred through piping systems. Ship bunkering shall not be permitted during LNG unloading operations.
- iii. Vehicle traffic shall be prohibited on the berth within minimum 30 m of the loading and unloading manifold while transfer operations are in progress. Warning signs or barricades shall be used to indicate that transfer operations are in progress.
- iv. Prior to transfer, the officer in charge of vessel cargo transfer and the officer in charge of the shore terminal shall inspect their respective facilities to ensure that transfer equipment is in the proper operating condition. Following this inspection, they shall meet and determine the transfer procedure, verify that adequate ship-to-shore communications exist, and review emergency procedures.
- v. Interlocking between ship and terminal control room to be established and the control of unloading operations shall be monitored from the terminal control room.
- vi. Terminal Security. An effective security regime should be in place to enforce the designated ignition exclusion zone and prevent unauthorised entry of personnel into the terminal and jetty area, whether by land or by sea.
- vii. Operating Limits. Operating criteria, expressed in terms of wind speed, wave height and current should be established for each jetty. Such limits should be developed according to ship size, mooring restraint and hard arm limits. Separate sets of limits should be established for:
 - (a) berthing,
 - (b) stopping cargo transfer,
 - (c) hard arm disconnection, and
 - (d) departure from the berth.

1.7.4.2 The ships should be berthed in such way that in case of emergency the ship can sail out head on immediately. All other instructions and procedures of Port Regulatory Authority are to be observed.

- i. A jetty shall be earmarked for LNG unloading/loading and if other liquefied gases and petroleum products are also proposed to be handled at the same jetty, risk assessment shall be carried out for consideration in design basis as well as the minimum inter distance requirements between various facilities at jetty. Further, the minimum distance between the jetties shall be finalized based on the risk analysis or recommendations of port authorities whichever is higher.

- ii. The number and size of the berths should be determined by the quantity of LNG delivered, the size of the ships, time intervals between two ships & site conditions. The berths may be installed either parallel or perpendicular to the bank at the end of the jetty depending on the water depth, prevailing wind speed and the location of the basin.
- iii. The berth may include either simple dolphins or sophisticated platform which includes the unloading arms. Access to the moored ships shall be provided. If necessary, a separate road may lead to the berths in order to provide the crew with a free access to the ship.
- iv. Mooring layout. The jetty should provide mooring points of strength and in an array which would permit all LNG carriers using the terminal to be held alongside in all conditions of wind and currents.
- v. Exclusion of ignition Sources: No uncontrolled ignition source should be within a predetermined safe area, centred on the LNG carrier's cargo manifold. The minimum area from which all ignition sources must be excluded should be determined from the design considerations and dispersion studies envisaged in the risk analysis report.
- vi. A pier or dock used for pipeline transfer of LNG shall be located so that any marine vessel being loaded or unloaded is at least 30 m from any bridge crossing a navigable waterway. The loading or unloading manifolds shall be at least 60m from such a bridge.
- vii. LNG and flammable refrigerant loading and unloading connections shall be at least 15 m from uncontrolled sources of ignition, process areas, storage containers, control room and important plant structures. This does not apply to structures or equipment directly associated with the transfer operation.
- viii. Quick Release Hooks. All mooring points should be equipped with quick release hooks. Multiple hook assemblies should be provided at those points where multiple mooring lines are deployed so that not more than one mooring line is attached to a single hook.

1.8. LNG Road Tanker Loading / Unloading Facilities

- i. The layout of the LNG facilities including the arrangement and location of plant roads, walkways, doors and operating equipment shall be designed to permit personnel and equipment to reach any area affected by fire rapidly and effectively. The layout shall permit access from at least two directions.
- ii. LNG tank lorry loading gantry shall be covered and located in a separate block and shall not be grouped with other facilities.
- iii. Adequate space for turning of tank Lorries shall be provided which is commensurate with the capacities of the tank trucks. However, the space for turning of tank Lorries with minimum radius of 20 M to be provided.
- iv. Maximum number of LNG tank lorry bays shall be restricted to 8 in one group. Separation distance between the two groups shall not be less than 30 M.

- v. The layout of the loading location shall be such that tank truck being loaded shall be in drive out position.
- vi. The weigh bridge of adequate capacity shall be provided and proper manoeuvrability for vehicles.
- vii. The consideration to be given for the dedicated parking area for LNG tank trucks with controlled access of other vehicles. The parking area shall be located in a secured area and provided with adequate no. of hydrants / monitors to cover the entire parking area. The suitable arrangement for safe venting of vapor generated during waiting period in the parking area, preferably to a closed system should be considered.
- viii. Escape routes shall be specified and marked in LNG plants for evacuation of employees in emergency. Properly laid out roads around various facilities shall be provided within the installation area for smooth access of fire tenders etc. in case of emergency.

1.8.1. Confinement

Confined or partially confined zones shall be avoided as far as possible, in particular:

- i. Gas and LNG pipe-work shall not be situated in enclosed culverts when it is possible to avoid this for example where road bridges cross pipe ways;
- ii. The space situated under the base slab of raised tanks, if any, shall be sufficiently high to allow air to circulate;
- iii. Where cable culverts are used they shall be filled with compacted sand and covered with flat slabs featuring ventilation holes to minimise the possibility of flammable gases travelling along the culverts through voids above the sand. As the sand settles the slabs will sink. They can be restored to their original elevation by adding sand.

1.8.2. Impounding basin

The extent of the impounding basins and spillage collection channel for LNG and hydrocarbon pipe-work and equipment shall be evaluated as a part of the hazard assessment. In general it has been found that the collection of spill from interconnecting LNG and hydrocarbons piping, without branch, flanges or instrument connections, is not justified by hazard assessment. If required, it shall be designed to accommodate potential leaks that will be identified in the hazard assessment. Possible LNG spills should be drained into impounding basins, with foam generators or other measures for improved evaporation control. The location of the impounding basin with respect to adjacent equipment shall have regard to the hazard assessment and heat flux. In addition, means for limiting evaporation and reducing the rate of burning of ignited spills and consequences should be considered.

1.8.3. Control Room And Substation:

- i. The minimum distance of 60 m shall be maintained from ¹[an process area] substation to LNG Storage Tank and process area
- ii. In case, control room ²[****] substation is within 60 metres from LNG Storage Tank and process area due to operational requirement, it shall be made blast proof and safety measures as recommended in risk assessment study shall be taken.

1.8.4. Buildings And Structures

Buildings or structural enclosures in which LNG, flammable refrigerant and gases are handled shall be of lightweight, non-combustible construction with non-load-bearing walls.

2.0 STORAGE TANK

The Liquefied Natural gas is stored at about -159°C to -168°C . LNG tanks are required to be designed to ensure proper liquid retention, gas tightness, thermal insulation and environment safety.

2.1. Selection Criterion

2.1.1 The selection of storage tanks shall be decided based on the location, adjacent installations, habitation on the surrounding, operational, environmental, safety and reliability considerations. The main criteria for selection of the type of tank shall be decided based on the risk analysis study and the level of risk it is posing on the surrounding.

2.1.2 The following list summarises a number of loading conditions and considerations that have influence on the selection of the type of storage tank.

- i. The factors which are not subjected to control:
 - a) Wind
 - b) Snow, Climate
 - c) Objects flying from outside the plant.
- ii. The factors that are subjected to limited control
 - a) Earth quake – OBE/SSE event
 - b) In plant flying objects
 - c) Maintenance Hazards
 - d) Pressure waves from internal plant explosions

¹ Subs. by sub-cl.(a) of cl (ii) of reg. (2), the Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Amendment Regulations, 2023 (w.e.f. 15.02.2023)

² The words and expression mentioned are omitted by sub-cl.(b) of cl (ii) of reg. (2), *ibid.* (w.e.f. 15.02.2023)

- e) Fire in bund or at adjacent tank or at plant.
 - f) Overfill, Overpressure (process), block discharge
 - g) Roll over
 - h) Major metal failure e.g. brittle failure
 - i) Minor metal failure e.g. leakage
 - j) Metal fatigue, Corrosion
 - k) Failure of pipe work attached to bottom, shell or roof
 - l) Foundation collapse.
- iii. The factors that are subjected to full control
- a) Proximity of other plant
 - b) Proximity of control rooms, offices and other buildings within plant
 - c) Proximity of habitation outside plant
 - d) National or local authority requirements
 - e) Requirements of the applied design codes.

2.1.3 There is no limit on the height of the tank envisaged other than engineering and aviation considerations.

2.1.4 No capacity restriction for LNG tank is envisaged considering the technological developments in this area.

2.2. The tanks shall be designed as per EN14620 or API 620 and API 625. The impounding Area and Drainage System and Capacity shall be in accordance with NFPA 59A.

2.3. Maximum allowable working pressure should include a suitable margin above the operating pressure and maximum allowable vacuum.

2.3.1. Material of construction:

The material for various parts of LNG container which will be in contact with LNG or cold vapour shall be physically and chemically compatible with LNG. Any of the materials authorised for service at (-) 168°C by the ASME Boiler and Pressure Vessel Code shall be permitted. Normally, for single containment tank, improved 9% Ni steel / Austenitic stainless steel / Aluminium Magnesium alloy are used. For double, or full containment tanks, 9% Ni steel with impact testing is used. In case of membrane tanks, normally austenitic stainless steel is used as material of construction for membranes.

2.3.2. Liquid loading

- i. The maximum filling volume of LNG container must take into consideration the expansion of the liquid due to reduction in pressure to avoid overfilling.
- ii. For double containment and full containment, the primary container shall be designed for a liquid load at the minimum design temperature specified. The design level shall be the maximum liquid level specified or the level 0.5 m below the top of the shell, whichever is lower.
- iii. The outer tank for Double containment, Full containment and membrane tanks, shall be designed to contain the maximum liquid content of the primary container at the minimum design temperature specified. Outer concrete tank shall have 9% nickel steel secondary bottom and 9% nickel steel insulated 'Thermal Corner Protection' (TCP) alternatively, austenitic stainless steel can be used for membrane tanks as specified in EN 14620. These are linked together. The top of the TCP is anchored into pre-stressed concrete wall, at least 5 meters above the base slab.

2.3.3. Insulation

- i. The LNG tanks shall be adequately insulated in order to minimise the boil off gas generation due to heat leak from ambient. The extent of insulation depends on boil off considerations for which the storage tank is designed. Proper insulation shall be ensured in tank base, tank shell, tank roof, suspended deck etc.
- ii. The possibility of an adjacent tank fire must be taken into consideration when designing insulation for LNG storage tanks. Tank spacing, water deluge systems, quantity and hazard index of LNG contents must be considered when specifying insulating materials

2.3.4. Soil Protection

- i. The soil under the on ground LNG storage tank shall not be allowed to become cold. To prevent such occurrence heating system shall be provided in the foundation to maintain the tank foundation at its coldest location within acceptable temperature range i.e. +5°C to +10°C with an automatic on/off switch system. As an alternative to electrical bottom heating system free ventilated tank bottom by elevated structure is also used. Also slope shall be ensured for the paved portion below the tank from centre to periphery to avoid accumulation of liquid. Gas detectors shall be provided for detection of any leakage and accumulation below the tank.
- ii. Electrical heating system shall consist of a number of independent parallel circuits so designed that electrical failure of any one circuit does not affect power supply to the remaining circuits. Electrical heating shall be so designed that in the case of electrical failure of a main power supply cable or a power transformer, sufficient time is available to repair before damage occurs due to excessive cooling. Alternatively, provision for connecting a standby heating power source should be made.

2.3.5. Leak Detection

Leak detection facility shall be provided in the space between primary container and secondary container. Liquid may be present in the annular/ insulated space due to spillage from inner tank or leak of the inner tank. Temperature sensors shall be used for leak detection. A system alarm shall be provided if there is a malfunction in the monitoring system.

2.3.6. Pressure and Vacuum relief system

The following guidelines for the design of pressure and vacuum relief system of cryogenic LNG tanks shall be provided;

- i. Pressure relief valve shall be entirely separate from the vacuum relief valve. Pressure relief valve shall relieve from inner tank. In order to take care of malfunction/ maintenance of any of the relief valves due to blockage in the sensor line, one extra relief valve (n+1) shall be installed. Pilot operated pressure relief valves are preferred over pallet operated relief valves. Suitable system/ mechanical interlocks shall be provided to ensure that the requisite no of PRV in line all the time.
- ii. Vacuum relief valves (n+1 philosophy) shall relieve into the space between the outer roof and suspended roof. Pilot operated vacuum relief valves are not acceptable for vacuum protection as the valve action is not fail safe against main valve diaphragm or bellows rupture. Conventional pallet type vacuum relief valves shall only be used. Suitable system/ mechanical interlocks shall be provided to ensure that the requisite no of VRV in line all the time.
- iii. Relief valves or rupture disc to atmosphere should be adequately sized which shall be capable of discharging flow rates from any likely combination of the following :
 - a) evaporation due to heat input in tank, equipment and recirculation lines;
 - b) displacement due to filling at maximum possible flow-rate or return gas from carrier during loading;
 - c) flash at filling;
 - d) variations in atmospheric pressure;
 - e) vapourised LNG in de-super heaters;
 - f) recirculation from a submerged pump;
 - g) roll-over.

to relieve the worst case emergency flows, assuming that all outlets from the tank are closed, including the outlet to flares and also boil off gas. Vapours may safely be disposed to atmosphere, provided that this can be accomplished without

creating problems like, formation of flammable mixture at ground level or on elevated structure where personnel are likely to be present and in no case it shall be less than 3 m from nearest platform.

- iv. Provision shall be made to inject nitrogen or dry chemical powder at the mouth of pressure safety relief valve discharge.
- v. Vacuum relief should be based on: withdrawal of liquid at the maximum rate, withdrawal of vapour at the maximum compressor suction rate, variation in atmospheric pressure etc.
- vi. A hot flare shall be provided for system to maintain pressure. The flare stack should be continuously purged in order to avoid air ingress and shall be provided with pilot burner.
- vii. Provision shall be made to maintain the internal pressure of LNG container within the limits set by the design specification by releasing to flare via a pressure control valve installed in the BOG line from tank to compressor. Factors that shall be considered in sizing of flare system shall include the following:
- viii. Operational upsets, such as failure of control device / BOG compressor tripping etc.
- ix. Vapour displacement and flash vaporisation during filling
- x. Drop in barometric pressure
- xi. Reduction in vapour pressure resulting from the introduction of sub cooled LNG into vapour space.
- xii. For the pressurised systems, the safety relief valve vent shall be so positioned to release the hydrocarbon at safe height.
- xiii. Relief from tank PSV shall not form a cloud on the tank and the PSV discharge shall be routed to safe height in accordance with dispersion study and risk analysis.

2.3.7. Tank Roll Over

2.3.7.1. Under certain conditions "roll over" of the liquid in the LNG tank can occur resulting in the rapid evolution of a large quantity of vapour with the potential to over pressurise the tank. Stratification can occur in an LNG tank if the density of the liquid cargo charged to the tank is significantly different from the left over LNG in the tank. Inlet piping must be designed to avoid stratification of LNG. This can be done by having top and bottom fill lines to inject denser LNG at the top and lighter LNG at bottom. This can also be done by providing distribution holes along the fill line extending to the bottom. Temperature sensors are put to monitor the temperature of the liquid throughout the liquid height at regular intervals. Provision for density measurement on tank shall be provided for the entire height of the tank.

2.3.7.2. For taking care of over pressurisation due to roll over, one of the following options shall be provided, namely :-

- i. Calculation of pressure relief valves or Flare/vent system shall to be designed to account for rollover scenario;
- ii. Rupture disc if provided on the tank with isolation valve (lock open condition) releasing to atmosphere;

- a) Means to check rupture disc integrity should be provided. Fragments of the rupture disc should not fall into the tank;
- b) Failure of the rupture disc shall trip all the boil off gas compressors automatically.

2.3.8. Over-Fill of Inner Tank

- i. Two independent type level measuring instruments shall be provided. The level instrument shall be equipped to provide remote reading and high level alarm signals in the control room. In addition, an independent transmitter for high level alarm and high - high level alarm with cut off shall be provided. The high - high level should be hard wired directly to close the liquid inlet valves to the tank.
- ii. The tank shall not be provided with overflow arrangement.

2.3.9. The membrane containment tank systems shall also meet the additional requirements as specified in NFPA 59A.

2.3.10. Dyke

- i. Dyke shall be provided for the following types of LNG storage tanks
 - a) Single containment tank
 - b) Double containment with metallic outer tank
 - c) Full containment with metallic outer tank
 - d) Membrane tank with metallic outer tank

Dyke is not required for full containment or membrane containment tanks with prestressed concrete wall.

2.3.11. Other Considerations

- i. Where cryogenic storage tanks are located near process plants with a likelihood of exploding process equipment, the impact of flying object on the tank, one 4" valve travelling at 160 km/h (object of 50 kg weight with a speed of 45 m/sec) shall be considered.
- ii. For the tank located within the flight path of an airport, the impact of a small aircraft or component shall be taken care of.
- iii. Impact of explosion wave due to major leak from a nearby natural gas pipeline or a major spill of LNG may also be considered.
- iv. Failure of inner tank: Where a sudden failure of inner tank is considered, the outer tank shall be designed to withstand the consequent impact loading.
- v. Earthquakes: The risk level is determined on the basis of the seismic classification of the location. The data pertaining to the seismic activity level having been ascertained, the structure is to be designed taking into consideration of IS-1893 and other relevant codes.

- vi. Rainfall runoff from the tank roof should be directed to a curbing and collecting system around the outer edge of the roof. Collected rainwater shall be carried by a drainage piping system that directs the rainwater away from any LNG spill carrying surfaces and to graded drainage areas that are beyond (outside) the ring road.

2.3.12. Nozzles

There shall be no penetrations except for anchor straps, of the primary and secondary container base or shell walls for LNG tanks to ensure fluid tightness

In addition to the nozzles used for regular operations like liquid inlet, pump outlet, vapour outlet and instrument connections the following provision shall also be provided.

- i. Nitrogen connections for:
 - a) inertisation of inner tank
 - b) outer tank and insulating material.
- ii. Chill down connections for the inner tank.
- iii. Depressurisation and purging of the in-tank pump column.

2.4 Instrumentation and Process Control for Tanks

The instrumentation shall be suitable for the temperature at which LNG is stored. All instrumentation shall be designed for replacement or repair under tank operating conditions in a hazardous gas zone area. Instrumentation for storage facilities shall be designed in such a way that the system attains fail-safe condition in case of power or instrument air failure.

The Level instrumentation for ESD function shall be separate and independent of the device for monitoring.

2.4.1. Level

- i. LNG containers shall be equipped with two independent liquid level gauging devices to monitor tank levels .
- ii. Each system shall have High and High High Level alarms.
- iii. Local Level indication should be available at grade apart from remote indication in the control room.
- iv. Density variation shall be considered in the selection of gauging devices.

2.4.2. Pressure

- i. The storage tank shall be provided with pressure transmitters to continuously monitor and control pressure with an indication in the control room and indication in field at grade level.

- ii. Instrument for detecting High Pressure shall be independent of the tank pressure monitoring instrument.
- iii. The sequence for over pressure control and protection shall be as follows:
 - a) High pressure alarms
 - b) Increasing the BOG system to the full load.
 - c) Further increase in pressure shall be controlled by releasing to Flare.
 - d) Further increase in pressure shall be controlled by closing of inlet automated valve.
 - e) The final over pressure protection shall be PSV and tank design pressure.

All the above pressure control and actuation shall be on independent pressure transmitters.

- iv. Independent Pressure transmitters shall be provided for low pressure detection that will trip the boil off gas compressors.
- v. In the event of continued drop in tank pressure, three layers of protection against vacuum shall be provided.
 - a) The trip of the BOG compressors.
 - b) The trip of the pumps.
 - c) Automatic admission of natural gas from outside source into the tank vapour space.
 - d) In the unlikely event this is not sufficient, a set of vacuum breakers installed will admit air into the space between the suspended deck and outer roof to prevent permanent damage to the tank.
- vi. The independent pressure transmitters shall be provided for the natural gas admission for vacuum protection.

2.4.3. Temperature

- i. As LNG is a product of varied compositions, it would be necessary to measure temperature of liquid and vapour over the full tank height; the sensors being located at 2 meter intervals or every 10% interval of the tank height, whichever is less.
- ii. Measuring and recording the formation of layers of liquid with different temperatures should warn the operator of a possible roll over phenomenon.
- iii. In addition, for monitoring of the initial chill down operation, temperature elements are required to be provided at tank base and shell of both the primary and secondary containers.
- iv. These temperature elements must be provided at various heights and at various locations of the base to ensure monitoring and proper chilling of the tanks.

2.4.4. Gas Detectors

Automatic gas detection system for monitoring leakage of LNG to be installed. Adequate number of gas alarm sensors shall be placed on the tank roof in the vicinity of roof nozzles and locations where the possibility of gas or liquid release exists including below elevated tanks. The facility shall be equipped with Emergency shutdown system. The ESD should be able to operate remotely / locally. Need for any automatic actuation of ESD may be assessed based on risk perceptions.

2.4.5. Leak Detectors

- i. Monitoring leaks through the primary container in double containment systems shall be provided by one of the following means :
 - a) Temperature measurement sensors in annular/insulated space.
 - b) Gas detection
- ii. The arrangement shall have redundancy to prevent spurious alarms.
- iii. Tank external leak / spillage detection shall be installed at every location where leaks are credible. These detectors may activate appropriate process shutdowns or isolation, activate remote operated fire protection systems or initiate emergency actions by Operators.
- iv. The following leak detection devices shall be considered:
 - a) Low temperature sensors for LNG spills.
 - b) Flammable gas detection of IR type. Battery limit fences shall have open path type detectors.
 - c) Flame detectors of the UV/IR type
 - d) Heat temperature detectors for protection of tank relief valve fires and activation of tail pipe extinguishing packages, if provided.
 - e) Smoke detectors of the ionisation type
 - f) CCTV systems in unmanned areas and unloading Jetty, capable of detecting vapour clouds, fitted with motion sensor alarms.
 - g) Communication system between field operators, Jetty terminal and pipeline dispatching centre.

2.4.6. Density Meters

- i. Density Meters shall be provided on the storage tanks to check the homogeneity of LNG.
- ii. The density of LNG in the Tank shall be monitored at all levels and analysis performed to alert the operator of any density layering.

2.4.7. The Linear and Rotational inner tank movement should be considered in the design for the relative movement of the liquid container with respect to outer tank.

2.4.8. A provision in the tank for endoscopic inspection (through insertion of camera) should also be considered. This will be helpful to know the health of the tank in the absence of visual inspection of the tank.

2.4.9. An Uninterruptible Power Supply (UPS), with battery back-up shall be provided to all critical instrumentation control and safety (F&G) systems so that plant may be kept safe in case of emergencies.

3.0 REGASSIFICATION FACILITY

3.1 Vaporisers and Connected Piping

- i. Vaporisers shall be designed for working pressure at least equal to the maximum discharge pressure of the LNG pump or pressurized container system supplying them, whichever is greater.
- ii. Manifold vaporisers shall have both inlet and discharge block valves at each vaporiser.
- iii. The outlet valve of each vaporiser, piping components and relief valves installed upstream of each vaporiser outlet valve shall be suitable for operation at LNG temperature
- iv. Suitable automatic equipment shall be provided to prevent the discharge of either LNG or vaporized gas into a distribution system at a temperature either above or below the design temperature of the send out system. Such automatic equipment shall be independent of all other flow control systems and shall incorporate shut down valves used only for contingency purposes.
- v. Isolation of an idle manifold vaporiser to prevent leakage of LNG into that vaporiser shall be accomplished with two inlet valves with safe bleed arrangement in between.
- vi. Each heated vaporiser shall be provided with safety interlock to shut off the heat source from a location at least 15 m distant from the vaporiser. The device shall also be operable at its installed location.
- vii. A shutoff valve to be installed on the LNG line inlet to a heated vaporiser to be at least 15 m away from the vaporiser. This shutoff valve shall be operable either at installed location or from a remote location and the valve shall be protected from becoming inoperable due to external icing conditions.
- viii. If a flammable intermediate fluid is used with a remote heated vaporiser, shutoff valves shall be provided on both the hot and cold lines of the intermediate fluid system. The controls for these valves shall be located at least 15 m from the vaporiser.
- ix. The vaporisers shall be fitted with local as well as control room indications for pressure and temperature of both fluid streams at inlet and outlet.
- x. Instrumentation for storage, pumping and vaporization facilities shall be designed for failsafe condition in case of power or instrument air failure.

3.2. Relief Devices on Vaporisers

- i. Each vaporiser shall be provided with safety relief valves sized in accordance with the following as applicable :
 - a) The relief valve capacity of heated or process vaporisers shall be such that the relief valves will discharge 110 percent of rated vaporiser natural gas flow capacity without allowing the pressure to rise more than 10 percent above the vaporiser maximum allowable working pressure.
 - b) The relief valve capacity of ambient vaporisers shall be such that the relief valves will discharge at least 150 percent of rated vaporiser natural gas flow capacity without allowing the pressure to rise more than 10 percent above the vaporiser maximum allowable working pressure.
- ii. Relief valves on heated vaporisers shall be so located that they are not subjected to temperature exceeding 60 °C during normal operation unless designed to withstand higher temperature.
- iii. The discharges from the relief valves shall be located at a safe height from adjoining operating platform.
- iv. The safety relief valves may discharge directly to the atmosphere to a safe location. If this is not possible, the discharge of the safety relief valves shall be routed to the flare or to the vent.

4.0 LOADING / UNLOADING ARM AND MARINE FACILITIES

4.1. Loading / Unloading Arms

- i. Unloading arm consist of pipe length connected to each other by swivel joints, moved by hydraulic actuators. The connection of the arm end to the ship crossovers flange shall be provided with a special automatic ERC (Emergency Release Coupler) device. During emergency this automatic device will come into operation and de-coupling system gets activated.
- ii. Each unloading arm shall be fitted with an Emergency Release System (ERS) able to be interlinked to the ship's ESD system. This system must operate in two stages; the first stage stops LNG pumping and closes block valves in the pipelines; the second stage entails automatic activation of the dry-break coupling at the ERC together with its quick-acting flanking valves. The ERS System should conform to an accepted industry standard.
- iii. Provision should be given to collect the LNG from the unloading arm to a closed system by way of providing blow down vessel or any other suitable arrangement. No drain shall be open to atmosphere.
- iv. The size of the arms depends on the unloading flow rate.

4.1.1 Flexible Hoses

- i. Flexible hoses may be used to make small temporary connections for the transfer of LNG and other cryogenic liquids such as refrigerant and liquid nitrogen, for example when emptying or filling road tankers of LNG or liquid nitrogen and they can also be used for transfer operations between small LNG carriers and LNG satellite plants. The use of flexible hoses shall be in accordance with the hazard assessment as per EN-1473.
- ii. Flexible hoses shall not exceed 15 m in length and 0.5 m³ in volume. Their design pressure shall be limited to PN 40.
- iii. Flexible hoses shall not be used for the routine transfer of LNG between large LNG carriers and shore at conventional LNG terminals.
- iv. Flexible hoses shall be designed in accordance with relevant codes and/or standards, such as EN 12434.

4.2. Loading/ Unloading Line

- i. The unloading and transfer lines for LNG should have minimum number of flange joints (expansion bellow system should be avoided, expansion loop shall be provided). Consideration should be given to provide cold sensors for flanges of size 200 mm and above as well as where there are clusters of flanges.
- ii. Length of the unloading line should be kept minimum. In case it is not feasible, alternative options available are:
 - a) To have additional line running parallel
 - b) To have booster pump
 - c) Increase size of line
- iii. The unloading line should be kept in cold condition to avoid stress and cyclic fatigue due to frequent warm-up and cooling down operation.
- iv. In case of unloading line is used for loading also adequate safety measures to be provided in engineering and design and risk assessment should be done in addition to the requirements as specified in clause 6.0 - Piping.
 - a) Quantative risk analysis (QRA)
 - b) Hazarad and Operability study (HAZOP)
 - c) Standard Operating Procedures (SOP)
 - d) Surge analysis
 - e) Interlock logics

5.0 FLARE

The following major process components and function shall comprise pressure relief and blow down system.

- i. Emergency/operational flare system for LNG regasification system (vapour)
- ii. Flare equipment including stack, tip and flame front generator.
- iii. Flare System with flare stack

The following shall be the criteria for designing various equipment under these systems.

5.1 Flare Header

5.1.1. Following systems are connected to flare header:

- i. Blow-down from LNG vaporisers
- ii. Relief from LNG recondenser
- iii. Relief from BOG compressors
- iv. Relief from Fuel Gas System
- v. Blow-down from LNG Tanks vapor system
- vi. Blow-down from Natural gas send out header.

5.1.2. However the relief from the following system shall be given to atmosphere to avoid increase of flare load:

- i. LNG vaporisers (SCV, Shell & Tube)
- ii. LNG Storage Tanks
- iii. Natural gas send out header

5.2 Emergency Depressuring

5.2.1 A depressurising system shall be provided to reduce the internal pressure, reduce the effect of leakage and avoid the risk of failure of LNG, hydrocarbon refrigerant or gas filled pressure vessels and piping from external radiation.

5.2.2 Devices for depressurising high pressure equipment shall allow the pressure of one or more item of equipment to be reduced quickly. These gases shall be sent to the flare system which shall be capable of handling the low temperatures generated during depressurising.

6.0 PIPING

6.1. All Nozzles for the Piping requirements for an LNG tank shall be from the top. Side penetration shall be avoided to minimise risk of serious leakage. The piping requirements includes the following but not limited to:

- i. Fill lines

- ii. Withdrawal line (Intank pump column)
 - iii. Boil-off line to remove LNG vapour.
 - iv. Cool down line for initial cooling of tanks during commissioning of the tank.
 - v. Nitrogen purge lines to purge the inner tank and annular space.
 - vi. Nitrogen purging line for pump column and foot valve sealing.
 - vii. Instrument nozzles.
 - viii. Pressure make-up line.
 - ix. Pump re-circulation line.
 - x. Purge release vent line.
 - xi. Pressure relief valve line
 - xii. Vacuum relief line
- 6.2.** LNG lines are normally fully filled lines. However, during specific operating conditions could result in differential temperatures at the top and bottom of the pipe causing bowing of pipes and potential spills. Piping design should include stress analysis, expansion loops, and supports as well as proper piping and equipment cool down procedures should address differential contraction covering all anticipated operation and upset conditions.
- 6.3.** Physical phenomenon such as surge pressure in LNG receipt and transfer lines, flashing and two phase flow shall be addressed in the piping and equipment design. ESD valves shall be fail-safe and fire safe.
- 6.4.** Piping loads and thermal expansion / contraction of piping should not be transferred to the Tank nozzle connections. Bellows expansion joints should be avoided in LNG lines.
- 6.5.** Valves shall be designed and manufactured for Cryogenic service. Extended bonnet valves are used in cryogenic service with stems in the vertical position.
- 6.6.** LNG heats up and expands, if confined to a fixed volume. Hence any potentially blocked piping or equipment should be provided with thermal expansion relief valves with discharge to closed system.
- 6.7.** Inlet piping shall be designed to minimize stratification/ layering of LNG [Stratification occurs when heavier LNG has been added at the bottom of a tank with partially filled lighter LNG or lighter LNG added at the top of the heavier LNG or due to ageing (storing for long duration) of LNG. This leads to sudden and rapid release of vapour, called Roll-over].
- i. This can be prevented by having two fill lines one ending at the top of the tank and other extending to the bottom, to inject denser LNG at the top and lighter LNG at the bottom. Mixing nozzles may also be used to avoid stratification.
 - ii. Rollover conditions shall be prevented by active management of stored LNG which includes monitoring temperatures and densities, mixing the tank contents by appropriate top and bottom filling or by circulation.
- 6.8.** Vaporiser piping involves high flow rates, pressures as well as transition from cryogenic piping materials to carbon steel material. This could result in embrittlement failure if cold

gas or liquid were to come in contact with carbon steel , in case of failure of process interlocks.

- 6.9.** The effect of low temperature fluid spills on adjacent plant, equipment and structural steel shall be assessed and measures taken to prevent incident escalation and/or endangerment of emergency response personnel, through suitable selection of materials of construction or by embrittlement protection.

Such protection shall be achieved by an appropriate material selection (concrete, stainless steel etc.) or by a insulating with material that will protect the equipment and structural supports from cold shock. Insulation shall be designed and installed in accordance with appropriate standards and provision taken to protect outer surfaces from wear and tear.

- 6.10.** Equipment and structural support elements should be protected in such a way that their function and form are not adversely affected during the plant operation.

7.0 DESIGN OF LNG TRUCK LOADING FACILITY

7.1. Description

- 7.1.1.** The purpose of LNG road loading system is to transfer LNG from the storage tanks to tank truck to deliver LNG to other sites via road transportation. The LNG road loading shall be manually operated system, where all activities shall be done in presence of trained personnel. LNG for loading into the tank trucks shall be tapped off from the LNG In-tank Pump discharge. LNG vapour return from the tanker shall be routed to the BOG suction header. When no loading will be in progress the recirculation will be maintained in the LNG filling line, through a recirculation line for maintaining chilled condition. The loading facility to be provided with the LNG liquid loading arm and vapour return arm. For monitoring of uniform chilling of the LNG feed line during no-loading situation, suitable number of skin temperature indications with alarm shall be provided in the control room.

- 7.1.2.** The LNG road tanker shall be double walled vacuum insulated cryogenic vessels suitable for transport at cryogenic conditions. The tank truck for road movement shall be designed, constructed and tested in accordance with the Static and Mobile Pressure Vessels (Unfired) Rules, 2016 as amended from time to time.

- 7.1.3.** Truck Loading facility should consist of the following:

- i. LNG filling line, Vapor return line & a recirculation line with adequate instrumentation
- ii. Liquid/Vapour Loading arm, Batch Flow meter & Control Valve
- iii. Weigh Bridge/ Flow meter for Custody transfer

- iv. Sick Tanker unloading facility

7.2. Design Considerations of LNG Loading / Unloading Facilities

7.2.1 Loading Facility

Each loading station shall consist of the following:

- i. Automatic flow control valve or suitable control mechanism meeting similar functional requirements & non return valve shall be provided in LNG loading lines.
- ii. A vapour return line with an isolation valve connected back to the storage vessel/ BOG line with NRV.
- iii. The proper tanker earthing connection shall be provided.
- iv. Properly designed loading arm shall be provided at the end of filling and vapour return lines for connecting to the tank truck. The loading arm end connection type shall be CGA LNG 300 or flanged type. The loading arms shall be provided with breakaway couplings. These arms shall be of approved type and tested as per OEM recommendations.
- v. Weigh bridges of suitable capacity for tanker weighment shall be provided.

7.2.2 Tanker Unloading Facility

- i. The tanker unloading shall be done by any of the following methods:
 - a) Utilising vapours from BOG compressors discharge.
 - b) Utilizing the gas from the pressurized gas (send out) network with proper pressure control.
 - c) Utilizing tanker pressure building coil.
 - d) Dedicated unloading compressors/pumps.
- ii. A suitable protection shall be considered for tanker / system over-pressurization and due considerations of impact of high temperature.
- iii. All drains, vents and safety valve discharges shall be routed to the closed system/flare system. In case of non-availability of flare system, the discharge from safety valve shall be vented to atmosphere at a safe location minimum at an elevation of 3 meter above the nearest working platform for effective dispersion of hydrocarbons. The dedicated drain and vent connections to be provided for the loading and vapour arms. Operational requirement is that after every loading operation, before disconnection, the liquid holdup in the LNG liquid and vapor arms are required to be drained, depressurized and purged. The provision of Drain Pipe can be considered. The liquids

collected in the Drain Pipe would gradually vaporize. Nitrogen connection can be provided to facilitate the vaporization process.

7.3. Other Considerations

7.3.1 Safety System

- i. The gantry shall have gas and spill detector at potential spillage and gas emission locations. There shall be flame detectors which shall cover the entire gantry and detect any fire. In addition, there shall be manual call points at appropriate locations.
- ii. The fire and gas detection shall be considered as follows:
 - a) Fire detectors
 - b) Gas detectors
 - c) Low temperature (spill) detector
- iii. The signals generated from the detectors shall be integrated with the ESD system.
- iv. The shutdown valves to be provided for all the process incoming and outgoing lines to/from loading gantry and shall be located at least 15 meters away from the loading gantry at an easily accessible location.
- v. The Emergency Shutdown (ESD) philosophy shall be designed to initiate appropriate shutdown action on detection of any emergency situation or through detector signal.
- vi. Emergency push button or hand switch shall be provided in Control room and also in field at safe location for manual actuation of ESD system and fire water spray system by operator in case of emergency. The field related button/switch to be provided on either end of the gantry at easily accessible locations.
- vii. ESD shall be caused in case of either of the following:
 - a) Signals from two detectors of different types of gas or spill or flame
 - b) Initiation of manual call points
 - c) Hand switches provided in the field as well as in the Operator Console & Control Room.

In addition, the following logic shall also be performed to stop individual tanker filling operation

- a) Gas detection will stop filling operation.
- b) Earth relay contact indicating inadequate earthing of the truck will stop filling operation.

In addition to above, fire water spray with deluge system shall also provided in the gantry which is activated either automatically (either Flame/Fire detector or Quartzoid bulb assembly) or manually by manual switches.

7.3.2 Safety Precautions

Following precaution should be taken due to associated hazards during transfer of LNG to or from a tank truck.

- i. No source of ignition must be allowed in the area where product transfer operations are carried out.
- ii. Fire extinguishers suitable for combating LNG fires shall be placed near the tank trucks during transfer operations.
- iii. The first operation after positioning the truck should be to provide proper earthing connection of the tanker. Earthing shall be disconnected just before the release of the truck.
- iv. While disconnecting arm, connections shall be loosened only slightly at first to allow release of trapped pressure, if any.
- v. Always use personal protective equipment (Cryogenic suits, flame retardant overalls etc) while making or breaking the connections to avoid cold burns.
- vi. The master switch shall be put off immediately after parking the truck in position. No electrical switch on the truck shall be turned "on" or "off" during the transfer operation.
- vii. No repairs shall be made on the truck while it is in the loading area.
- viii. Availability of wheel chokes.
- ix. Filling/transfer operations shall be stopped immediately in the event of -
 - a) Uncontrolled leakage occurring
 - b) A fire occurring in the vicinity
 - c) Lightning and thunder storm

Provision to stop the Filling/transfer operations shall be available from field as well as remote location. Stop switch in field shall be located at a safe distance (minimum 15 meters away) from the source of hazard to be protected.

7.4. Drain and Vents

Drain and vents shall be provided to meet all the requirement of draining, purging, venting etc. Appropriate system shall be provided to handle the discharge from the TSV's also.

7.5 Requirements for LNG Installations using ASME Containers for stationary applications

The requirements for installation, design, fabrication, and siting of LNG installations using containers of 379 m³ capacity and less constructed in accordance with the ASME *Boiler and Pressure Vessel Code or Gas Cylinder Rules* for vehicle fueling and commercial and industrial applications shall be as specified in Annexure- I.

Schedule – 1B

8.0 Electrical Systems

8.1 Design Philosophy

- i. The selection of electrical equipment and systems shall be governed by fitness for purpose, safety, reliability, maintainability, during service life and compatibility with specified future expansion, design margins, suitability for environment, economic considerations and past service history.
- ii. The design and engineering of the electrical installation shall be in accordance with established codes, specifications, sound engineering practices and shall meet the statutory requirements of National and Local Regulations.
- iii. Electrical equipment and materials shall comply with their relevant Specification, Data sheet and Project Specification and the latest edition of the following codes and standards (including any amendments) applicable shall be followed.
- iv. All Electrical equipment, systems and their installation shall be designed for operation under site conditions as required.
- v. All equipment and materials shall be suitable for operation in service conditions typical of a LNG plant within a coastal environment in the tropics.
- vi. Switchgear Room shall be forced ventilated, VFD/UPS Room shall be Air-Conditioned, and Battery Room shall be ventilated with Exhaust Fans. However failure of cooling or ventilation shall not affect the operation of this equipment.
- vii. VRLA battery room shall be air conditioned to maintain specified temperature.
- viii. For the purpose of electrical grounding calculations (soil electrical resistivity) and cable rating calculations (soil thermal resistivity), the data of the area shall be used.

- ix. In areas where the soil may become contaminated due to hydrocarbon spillage electrical cables shall not be installed underground or shall be installed in suitable concrete duct banks.
- x. All areas within battery limits shall be classified for the degree and extent of hazard from flammable materials. Classification of hazardous areas for all locations shall be done in accordance with area classification drawing and guidelines indicated therein.

8.2 System Design

The distribution system shall be designed considering all possible factors affecting the choice of the system to be adopted such as required continuity of supply, flexibility of operation, reliability of supply from available power sources, total load and the concentration of individual loads. The design of electrical system shall include the following :

- i. The design of electrical system for LNG receipt storage and re-gasification facility shall include the following:
 - a) Site Conditions
 - b) Details of power source
 - c) Planning and basic power distribution system and single line diagram
 - d) Protection-metering-control
 - e) Electrical substation Design for New substation
 - f) Electrical equipment design
 - g) Illumination system
 - h) Earthing system
 - i) Lightning protection system
 - j) Electrical equipment for hazardous area
 - k) Statutory approvals
 - l) Cable sizing
- ii. Cabling system – underground and above ground including cable tray support and routing through pipe racks
 - a) Power system studies
 - b) Heat tracing system as applicable
- iii. The designed electrical system shall facilitate and provide:

- a) Standard products application
 - b) Safety to personnel and equipment
 - c) Reliability of services
 - d) Constructability access
 - e) Cabling access
 - f) Minimum fire risk
 - g) Cost effectiveness
 - h) Ease of maintenance and convenience of operation
- iv. Adequate provision for changes during design development and for future expansion and modification (as appropriate engineering margins and or space provisions)
 - v. Automatic protection of all electrical equipment and isolation of faulty system through selective relaying systems or intelligent control devices.
 - vi. Remote control and monitoring facilities & interfacing for selected devices with other discipline systems.
 - vii. Lock out Tag out (LOTO) provisions as applicable.
 - viii. Maximum interchangeability of equipment.
 - ix. Fail safe features.

8.3 System Studies

Study / Calculation shall be carried out to substantiate the selection and sizing of all electrical facilities in the LNG receipt, storage and regasification facilities. Study should include minimum but not limited the following:

- i. Plant and Unit electrical load
- ii. Load Flow, Fault calculation and large motor starting studies.
- iii. Feeder and circuit voltage drop
- iv. Relay settings and coordination
- v. Earthing
- vi. Lighting calculation and lightning study (Protection of structures against lightning)
- vii. Transient stability study
- viii. Reacceleration and auto changeover study
- ix. Load shedding study
- x. Power factor and Harmonic study (if required).
- xi. Control and protection schemes

- xii. Synchronizing Scheme
- xiii. Block diagram for fire alarm system
- xiv. Speech diagram and block diagram for communication system
- xv. Area classification drawings

8.4 Power Supply

8.4.1 Main Power Sources and Systems:

The main power source shall be captive power generation or connected to the grid. The voltage level of proposed primary distribution (33KV or other) and utility grid shall be as per plant generation and respective grid supply level. The number and schemes of indoor switchboards shall be governed both from considerations of power distribution capacity and also from considerations of process loading under abnormal plant operating conditions.

8.4.2 Plant Emergency Power Sources and Systems

Emergency power supply shall be provided from Substation up to Emergency MCC to meet the Emergency lighting and critical services in plant area to permit safe shutdown in the event of main power failure.

8.5 Power Distribution

8.5.1 General

- i. A load summary shall be prepared for recording and calculating the electrical loads of the LNG receipt and storage facilities. The load summary shall indicate continuous, intermittent and stand-by loads.
- ii. This shall be used to verify the rating and numbers of transformers, switchgears etc. The current rating of switchboard bus bars shall also be determined accordingly.
- iii. Where secondary selective systems are provided, each transformer / incomer shall be rated in accordance with the above.

8.5.2 Main Power Distribution

- i. A substation shall be built at the site to cater all load (e.g. the storage tank and plant) requirement.
- ii. It should be provide with dual redundant power supply from, in its each Bus sections "A" & "B". (Rework)
- iii. Provide Normal and Emergency power supply of 415 V, 3ph, 4 wires to the lighting & Small power Distribution boards in the Tank battery limit to supply power to all lighting and convenience receptacle loads in tank area.

- iv. All Motor power cables from the Substation shall be provided and terminated on both sides.
- v. Emergency power supply backed by Emergency Diesel Engine (EDG) shall be provided.

8.6 Sub-station Design

8.6.1 General

- i. The substation shall be located in a safe area and outside the risk zone.
- ii. Consideration shall be given to vehicular traffic or any other factor that might affect the operation of the substation.
- iii. Substation buildings shall be force ventilated with filtered air and shall comprise elevated structures permitting the use of bottom entry switchgear with cable cellar for cable racking and trays below.
- iv. The cable cellar shall be 300 mm (minimum) above the approach road level and shall be paved and cemented. The cable cellar have a minimum clear height of 2.5 m and shall house all the cable trays and their supports.
- v. A separate entry of 3.0 m with rolling shutter shall be provided for drawing in all equipment for installation. The main entry for operating personal shall be preferably provided with double door system. The substation shall also have an emergency door opening outward.
- vi. Substation wall adjacent to the transformer bays shall be at-least 355 mm thick in case of brick construction or 230 mm thick in case of RCC construction.
- vii. Push button shall be provided in each transformer bay for tripping of the feeder breaker.
- viii. Substation building shall be without any columns within the switchgear room to ensure optimum space utilization.
- ix. Large batteries shall be housed in separate rooms but small batteries when enclosed in ventilated equipment cabinets shall be permitted in the switch room.
- x. VRLA batteries shall be located in Battery Room ventilated using Ex-d, IIC, T3 Exhaust Fans.
- xi. An access door shall lead directly to the outside from each switch room. Internal personnel doors may connect adjacent rooms.
- xii. Ventilation system of substation shall trip on activation of fire and gas detection signal. Flooring to the Battery room and walls up to 1.0 m height shall have acid / alkaline resistant protective material coating / tiling.

- xiii. Battery Room shall also house hydrogen detectors if applicable. Luminaires and Receptacles in Battery Room shall be Ex-d, IIC, T3 Type of protection.
- xiv. Heat sensitive electronic equipment like variable speed drives shall be located in a separate room provided with air conditioning.
- xv. The battery room shall be provided with minimum two exhaust fans and louvered opening in opposite wall.
- xvi. Substation shall have firefighting equipment, first aid boxes and other safety equipments as per statutory requirements. Mats of required voltage rating shall be provided around all switchboards and panels.
- xvii. The substation building shall be sized for housing all equipment like transformers, switchgears etc. The substation shall be sized to maintain adequate clearances between equipment as per IE rule.

8.6.2 Transformer Bay Layout

Oil filled transformers shall be located at grade level in fenced enclosures adjacent to the substation building and shall be provided with oil containment pits which shall be connected to the Common Oil soak pit as envisaged as per IS standard (NO.). This shall be located outside transformer bay. Firewalls shall be provided where required by codes and standards.

8.7 Hazardous Area

8.7.1 Electrical Equipment Selection in Hazardous Area

- i. Electrical equipment shall meet the requirements of the Indian Standard IS: 5571 – Guide for selection of electrical equipment for hazardous areas or the institute of petroleum model code of safe practice: Part 15, except that IEC 60079 Part 14 shall be followed for the selection of fluorescent fitting used in Gas Group IIC areas.
- ii. All the electrical equipment installed in hazardous area shall meet the requirements of relevant IS or IEC or CENELEC standards, whichever is followed for design for electrical systems.
- iii. All electrical equipment for hazardous area shall be certified by CMRI, PTB, BASEEFA, UL or FM or equivalent independent testing agency for the service and the area in which it is to be used. All indigenous flameproof equipments shall have BIS license. CCOE approval shall be obtained for equipment of non-Indian origin.

8.8 Equipment

8.8.1 Switchgear / Motor Control Centres / LV Distribution Boards

- i. Switchgear panels shall be of metal clad type with circuit breakers.

- ii. Switch gear panels shall have successfully passed internal arc test as per IEC-62271 or equivalent standards. Switch gears shall be equipped with at-least one spare feeder of each type or 20% of each type whichever is higher shall be provided on each bus section.
- iii. Motor feeders rated greater than 22 kW shall be provided with a separate core-balance current transformer for earth fault protection.
- iv. Where duplicate feeds are provided in HT and 415V switchboards, an automatic transfer scheme will be provided in order to switch to the alternative feeder if a failure occurs in one supply feeder. Protection shall be provided to prevent transfer in the case of a fault downstream of the circuit breaker. The automatic transfer systems shall be independent for each switchboard and shall include time delay such that transfer takes place at level before transfer at LV is affected. Return to normal after main power restoration shall be manual. Exceeding the switchgear fault rating during momentary paralleling shall be permitted for a nominal short duration.
- v. Lighting and small power distribution boards shall be located in buildings and at strategic locations outdoor around the Tank & BOP areas. The distribution boards shall be suitable for indoor or outdoor use and the hazardous area classification in which they are to be installed.
- vi. Automatic motor re-acceleration/ restarting following voltage dips shall not be provided unless specifically warranted by process requirements.
- vii. Power system monitoring, control and protection shall be in accordance with project specifications and protection philosophy shall be in accordance. Emergency Shut Down (ESD) systems and emergency stops shall be hard wired back to the switchgear/MCC.
- viii. In PMCC&MCC, 20% spare feeders of each rating and type or minimum one feeder of each rating and type having all components in each bus section. All switchgear shall be loaded to 80% of incoming rating at the end of design completion.
- ix. All incoming cable to switchgear shall be suitable for the incoming current rating.

8.8.2 Protective Relays

- i. Protective relays for incoming feeders, bus ties and motors having rating 90kW and above shall be numerical type. Other Auxiliary relays, lock-out relays and Timer relays considered will be of standard Electro-mechanical type.
- ii. Meters, Protection relays and other components shall be as per relevant metering and protection diagrams and designed and procured as per project specification.
- iii. Protective relaying philosophy shall be based on at-least a single contingency planning so that the relay system will provide fault clearing for one of the following:
 - a) Failure of either primary or backup relay function or the related control Circuit

- b) Failure of a circuit breaker to interrupt, including a faulty circuit breaker.
- iv. The protection relaying philosophy for 220 kV and 33 kV systems shall also include suitable main and backup schemes.

8.8.3 Power & Distribution Transformers

- i. Power and distribution transformers shall be designed and procured in accordance with project specification.
- ii. Transformer insulating oil shall be in accordance with project specification.
- iii. The cooling arrangement of all power transformers shall be ONAN/ONAF with the possible exception of the main generator step-up transformers and main distribution transformers, which will have cooling requirements as specified on the relevant data sheets. Where required, transformer cooling can also be of the OFAF type. The method of cooling shall be as specified in the data sheets.
- iv. The distribution transformers shall be ONAN type.
- v. Automatic on-load tap changers (OLTCs) shall be provided on the main transformers as required. OCTC (Off Circuit Tap Changer) shall be +/-5% in steps of 2.5%. Lighting transformers shall be Dry type, Air cooled mounted indoor.
- vi. For harmonic mitigation, use of transformers with special vector groups may be considered for supplying large non-linear loads such as VSD's and process heaters.

8.8.4 Emergency Diesel Generators:

- i. The electrical requirements for Emergency Diesel Generators shall be designed and procured in accordance with project specification. In addition to the above, Alternators shall be in accordance with typical Alternator data sheet. Emergency Diesel Generator set shall form an independent package, consisting of diesel engine, alternator, control panel and other auxiliary systems. Alternators shall be of Permanent magnet, Brushless and self-excited type. The stator and field winding insulation shall be uniform and Class F throughout, but the design temperature rise of the windings shall be to Class B limit.
- ii. All windings shall be with copper conductors, and the insulation shall be suitable for operation on an unearthed system. The automatic voltage regulator (AVR) shall be of the static type and shall be high speed compounded for parallel operation. It shall exhibit long term stability and freedom from drift. Generators shall be capable of withstanding without damage, a sudden three phase, a line-to-line, a line-to-earth or two-line-to-earth short-circuit, for a period of 3 seconds when operating at rated speed and with the excitation corresponding to 5% over voltage at no load. Emergency Diesel Generators shall have provision for forward and reverse synchronization and no-load test runs. The AMF panel shall be equipped with a PLC for automation and control.

8.8.5 Neutral Earthing Resistors

- i. The resistor elements shall be made of unbreakable, corrosion proof, joint-less stainless steel grid conforming to ASTM standard A240-304 or equivalent.
- ii. Neutral earthing resistors shall be in accordance with design specification. 6.6 KV earthing resistors shall be rated to withstand the maximum prospective earth fault current for duration of not less than 10 seconds with maximum temperature limited to 790 °C for stainless steel resistor elements, while limiting the temperature of aluminum conductor / bus bar to 350°C. Grids shall be mounted on steel rods insulated by special heat resistant insulating materials, suitable for the above temperature. Ceramic / porcelain insulator shall be used to insulate the resistor elements from the enclosure. The insulators and terminal bushings shall have adequate minimum creepage value (total and protected) for the required voltage grade.
- iii. The resistor elements shall be housed in a naturally ventilated sheet steel enclosure with minimum IP 31 degree of ingress protection and suitable for outdoor installation. The enclosure thickness shall not be less than 3mm.
- iv. The terminal for neutral and earthing connections shall be housed in a separate vermin proof, weatherproof terminal box with minimum IP-55 degree of ingress protection. The terminal box shall be provided with a separate bolted re-movable undrilled gland plate of non-magnetic material.
- v. Facility shall be provided to earth the enclosure at two points. The bottom of the enclosure shall be provided with a drain plug to remove water that may get collected in the enclosure.
- vi. Two ends of the resistor shall be brought out to suitable epoxy / porcelain bushing type terminals of adequate rating for the neutral and earth connections. The terminal shall be suitable for terminating the specified size of cables / earthing strip. Suitable anti-condensation space heater shall be provided inside the NGR enclosure to prevent condensation of moisture.
- vii. For the 6.6 kV system, the rating is 250 A, and for the 11 kV system (except generation) the rating is 250 A.

8.8.6 DC Supply Units

- i. DC supply units shall be switch mode power supply based and designed and procured accordingly. Redundant system using two sets of charger with two battery banks shall be utilized. Battery shall be Nickel Cadmium / flooded electrolyte Lead Acid/ VRLA type designed as per design specifications. Each battery bank shall be rated to give two hours back-up and shall be rated for 100% of the total load.

- ii. A common DC supply Unit shall be provided in substation for HT & LT Switchgear, PMCC, MCC, EMCC protection, Remote IO panel, EDG AMF panel, VSD MCC and tripping supplies of Transformer marshalling panel.

8.8.7 AC UPS for F&G, PAS and CCTV loads

Dual redundant AC UPS with battery back-up for 6hrs shall be provided to provide no break supplies to the Fire and gas system. UPS, ACDB, UPS batteries shall be located in DCS Control Room Extension.

8.8.8 Alarm Annuciations

All fault, tripped, alarm and equipment malfunction signals from the communicable relays should be accessible via a computer connected to the communication port in each switchgear/PMCC. In addition, certain signals shall bring up alarms/ indications on the Electrical Data Management System in a Central Control Centre (CCC) or in the DCS.

8.8.9 Variable Speed Drives

- i. Low & high voltage variable speed drive (VSD) equipment shall be in accordance with design project specification to be followed.
- ii. The requirement of variable speed drives shall be considered based on an economic and technical basis subject to process requirements.
- iii. Converter equipment controlling plant motors shall be located inside the substation, except the associated transformers and reactors, which shall be located outside within a transformer/reactor bay adjacent to the substation. For specific requirement, the transformer and rectifier may be housed within the substation.
- iv. Temperature of $22^{\circ}\text{C} \pm 2^{\circ}\text{C}$ & approximately 50% relative humidity to be maintained in VFD room. Converter equipment feeding air handling units for comfort air-conditioning and similar requirements maybe located close to the motor in the same room or may be mounted integral to the motor.

8.8.10 Motors and Motor Control Stations

- i. High voltage and low voltage motors shall be in accordance with project specification.
- ii. Motors generally shall be of the squirrel cage induction type and shall have a minimum service factor as defined in the data sheet for the specific motor, with Class F insulation and Class B temperature rise.
- iii. LV motors shall normally be selected to have ratings in accordance with the preferred rated output values of the primary series as listed in IEC 60072 and IS 325.
- iv. The enclosure of motor control station shall be in accordance with the hazardous area classification. Each motor shall be provided with a start/stop local control station

(LCS) installed on suitable steel support adjacent to the motor. There shall be exceptions for critical drives such as emergency dc lube oil pumps. For HVAC blowers, lock-off stop push buttons shall be provided for each blower outside the pressurization room in order to aid maintenance access. Each element for Start / Stop in LCS shall be provided with 2NO + 2NC contacts which shall be wired to terminals. Terminals shall be suitable to connect 2.5 sq.mm cables and shall be of cage clamp (spring loaded) type. LCS shall have stay-put stop and lock off stop features (padlocking).

- v. All LV motors shall be complying to IE2 Class of efficiency unless otherwise specified in Motor Datasheet.LCS for motors rated above 30 KW and motors driving agitators, compressors and blowers shall be provided with Ammeter. Ammeter shall have connection to a CT (1 amp secondary) located within the motor starter.
- vi. Start/stop control stations for all motors shall be located at about 1 meter above grade. A separate lock- off stop emergency pushbutton shall be located at ground level for each in-tank pump motor. Compressor motors shall be provided with emergency stop control station in the LCP.
- vii. Motors which have automatic process control or motors which are started from more than one location shall be provided with LCS incorporating Hand/Auto selector switch.
- viii. Motor operated valves and electric cranes shall be fully equipped with integral motor control gear.

8.8.11 EARTHING & LIGHTNING SYSTEM

- i. Earthing system shall provide low impedance earth paths for earth faults, static discharge and lightning protection. Earthing shall be as per IS : 3043.
- ii. Power system earthing, lightning protection and equipment bonding shall be achieved by overall common earthing system. All units shall be bonded together to form a single continuous earthing system. LNG system shall be connected with Plant earthing system at least two places.
- iii. The earthing system of LNG receipt and storage package shall comprise a buried grid of galvanized mild steel flat bar bonded together and sized to suit the maximum earth fault current for 0.5 second plus a 50% corrosion allowance as per standards. All such earthing system shall be bonded together. Each electrode shall be installed throughout cryogenic package area to ensure that the requisite value of resistance between equipment and the general mass of earth is obtained. Connections from the earthing grid rising above ground shall be galvanized mild flat steel bar. Thereon, earthing to local network and electrical equipment shall be carried out using PVC covered aluminum cable or galvanized mild steel

- iv. The metallic enclosure of all electrical equipment shall be bonded and earthed to the common earthing grid.
- v. In hazardous areas or where the equipment contains a hazardous liquid, the metallic enclosures of non- electrical equipment, vessels, tanks, structures, pipeline, etc., shall be bonded and earthed to the common plant earthing grid. Maximum values of resistance of equipment earthing systems to the general body of earth shall be as under :
 - a) General Earthing: 1 ohm
 - b) Earthing for Lightning Protection & Static Bonding: 10 ohms
- vi. Lightning protection shall be provided for all non-metallic and all metallic on continuously welded structures over 20 meters high and for all tall plant buildings.
- vii. Earthing of lighting and small power systems shall be by means of an earth conductor integral within the cable or conduit. Power circuits shall be earthed by a separate earth wire connected to the earthing grid.

8.8.12 LNG Tank earthing

Internal LNG tank earthing, In-tank pump casing earthing and Instrument casing earthing within the double wall LNG tank shall be connected to the main earthing system.

8.8.13 Instrument earthing

Separate earth bars above ground shall be provided for Instrument earthing in Tank & BOP area. Instrument earth may be connected to electrical earth at one point in earth pit only.

8.8.14 Lightning Protection

Lightning protection for cryogenic tank shall be carried out by using rolling sphere method as per IEC-62305. Lightning protection shall be provided as per the risk index analysis worked as per IS 2309. 50 x 6 mm Galvanized steel strip shall be provided for Lightning down conductor.

8.9 Lighting System

Plant lighting shall be designed and procured in accordance with project specification.

8.9.1 General Lighting

- i. Lighting in industrial plant hazardous and non-hazardous areas should be by means of fluorescent luminaries mounted on the structures, directly beneath beams or on platform mounted poles.

- ii. Where required general lighting for open areas with in non-hazardous areas shall be by means of high pressure sodium floodlight luminaries mounted on adjacent structures or on strategically located floodlight columns. High mast floodlighting installations shall also be used where appropriate.
- iii. Safety showers in plant areas shall be provided with green fluorescent fixtures for proper identification.
- iv. The following average intensity levels, measured 1 m above the floor level in a horizontal plane shall form the basis for the lighting design:

Area or Facility		Average Maintained Illumination Level, lux
Operating areas (Controls, Valves & Gauges)		100 - 200
Compressor houses at or near equipment		200
Stairways, platforms and walkways		60
Outdoor operational areas (Process areas, pipe racks, heat exchanger, flare etc.)		60
Outdoor Non-operational areas (At grade)		10
Tank farms		20
Main / Secondary roads		20
Pump houses, Sheds, Switches		100
Switchgear Room & UPS Room		150-200
Cable cellar Room		70
Battery rooms & transformer bays		100-150
Toilets and locker rooms		150
Control Room	General lighting/laboratories	400
	Rear of instrument panels, aux. and panel	200-300
	Outside, near entrances	150

8.9.2 Tank Farm Lighting

High mast floodlighting columns shall be located in non-hazardous locations outside tank farm bund walls. Local lighting may be provided as necessary in areas of regular plant operational activity.

8.9.3 Emergency Lighting

Emergency lighting of adequate intensity shall be provided at following locations or where ever the safety of persons or facilities may be endangered in the event of loss of normal main lighting :

- i. main access points
- ii. muster area
- iii. first aid station(s)
- iv. fire fighting area
- v. stairways and landings.

8.9.4 Lighting Control

Outdoor lighting circuits shall generally be controlled via latitude/longitude timed switches (astronomical type). Manual override shall be provided to permit maintenance. Indoor lighting shall be controlled locally by suitably located switches.

8.9.5 Aircraft Warning Lighting

The type of Aircraft warning lights shall be in accordance to International Civil Aviation Organization and local regulations. The aircraft warning lights shall be steady burning or flashing type with Fresnel lens type of red colour and shall be fitted at the highest points of the platform obstacles. These lights shall have intensity between 25 to 200 candelas and shall be installed in such a way that at least one light can be seen by pilots.

8.9.6 Power and Convenience Outlets

- i. Adequate no. of 415 V, 63 A, TP&N+E power outlets of switched socket type shall be provided at suitable locations to ensure accessibility with a 50 meters length of trailing cable to any point in the process area.
- ii. 240 V, 16 A, SP&N+E convenience outlets at suitable locations such that all principal equipment locations can be reached by use of 25 meters of extension cable.
- iii. Convenience outlets for hand lamp supplies with integral transformer, rating – 100 VA, 240/24 V (Centre point earthed), shall be provided near to the man holes of vessels, tanks columns etc. Convenience outlets shall be fed through earth leakage circuit breakers of 30 mA sensitivity.

8.9.7 Cables and Cable Installation

8.9.7.1 Cable Types

- i. High voltage and low voltage cables shall be designed and procured in accordance with project specification. All cables of all voltage grades shall have XLPE insulation.
- ii. Conductors 6 mm² and greater shall generally be aluminum (Copper may be selected on economic or technical considerations). Conductors smaller than 6 mm² shall be copper. Minimum size of power & motor feeder cable shall be 4 mm² and 2.5 mm² for lighting
- iii. All cables used above or below ground in industrial areas shall have non hygroscopic fillers, wire armoring, PVC overall sheath and FRLS type.
- iv. 6.6 KV, 11KV and 33KV grade cables shall be of earthed type (e.g. 3.8/6.6KV, 6.6/11KV & 19/33KV). Unearthed cables shall be used wherever required by specialized equipment e.g. VSD. Cables shall be provided with Conductor screen, insulation screen, and nonmetallic copper tape.
- v. All cables used above or below ground in industrial areas shall have non hygroscopic fillers, wire armoring and PVC overall sheath. Unarmored cables and wires may be used where proper mechanical protection (e.g. metallic conduit) is provided or where sheathed cables are installed above ceilings or below floors in non-industrial locations. Concealed metallic conduits shall be used for buildings where appropriate.
- vi. All cables shall be of FRLS type as per OISD guidelines/requirements. Cables for conduit installation shall be FRLS, PVC insulated, multi-stranded conductor.
- vii. Earthing of lighting and small power systems shall be by means of an earth conductor integral with the cable.

8.9.7.2 Cable Installation

- i. The default method of cable installation is to be installed above ground, laid on trays within dedicated levels of overhead pipe racks and on the sleepers of low level pipe ways.
- ii. In certain instances cables may be routed underground, these include:
 - a) High voltage distribution cables and associated control cables
 - b) Cables entering or leaving buildings
 - c) Cables in areas where ground contamination is unlikely and economic consideration precludes the erection of special cable supports
 - d) Cabling within the power generation area
 - e) Feeder cables to satellite substations.

- f) Cables routed underground shall be direct buried within offsite areas and installed in formed concrete trenches within process areas.
- iii. Power cables shall generally be laid on trays in a single layer with 150mm spacing for 11&6.6kV cables& bunched for 415V cables. Control cables may be bunched together. Cables shall be secured at required intervals.
- iv. Power (and associated control) and instrumentation. Telecommunication cables shall be run in their own racks. Electrical cables shall be where practical separated by at least 600 mm from instrumentation and telecommunication cables.
- v. In certain instances cables may be routed underground based on the site conditions. Cables routed underground shall be direct buried within offsite areas and installed in formed concrete trenches within process areas.
- vi. 33 kV cables shall be laid in a single layer at 300 mm center at a depth of 1050mm below grade.
- vii. 11/ 6.6 kV cables shall be laid in one or two layers at 150 mm centers and at a minimum depth of 900 mm below grade.
- viii. 415 V cables should be laid in up to three layers touching and at a minimum depth of 500 mm. Control cables and lightly loaded cables may be grouped together or laid between loaded cables.
- ix. All cables shall be laid on a sand bed with well compacted sand around and above. Concrete or earthenware tiles shall be laid above the cables in unpaved areas. Tiles are not required where cables are laid in formed concrete trenches. Trenches shall be sized to allow for a future 20% increase in cabling which shall be segregated and clearly marked. Trench walls preferably shall be chamfered at tee-offs to allow adequate bending radius.
- x. Where cables leave the main trenches and for road crossings they shall be run in duct banks of concrete encased HDPE ducting (150mm) spaced at 200mm centers, at a depth of 1000mm from grade level. Duct bank shall be as per Electrical Installation Standard for Cable Duct and Road Crossing
- xi. Where cables rise above grade to equipment they shall be protected by HDPE 'kick' sleeve up to 150 mm above grade and from there shall be run on rack or tray or secured by some other suitable means.
- xii. Cables shall be installed with spacing to minimize derating but consistent with the total space available. All cables shall be fitted with aluminum engraved identification tags at terminations, at 30m intervals over their entire length, at all points where they enter and leave ducts and at changes in cable direction etc.. The identification band shall show the complete cable number.

- xiii. Suitable route markers shall be provided to indicate trench locations and shall be located at 50m intervals and where the trench changes direction. When the trench is within paved areas, a red colored concrete cover shall be used to seal and mark cable routes.
- xiv. Cables shall be in one length where practical but cable joints may be installed when necessary. Cable joints shall be recorded and their locations accurately on 'as built' drawings. Above ground cable joints shall not be installed in hazardous areas. All underground through joints shall be PU filler type. Where cables pass through a building foundation, ducts, or an opening in the foundation, shall be used to permit entry. Cables entering a building aboveground shall pass through fire retardant barriers. Fire retardant coating shall be applied on cable joints. Where appropriate, particularly where cables transition process units, cables shall be treated with fire retardant coating. All remote operated shut-off valves within a fire zone, which are designed to limit the duration and severity of a fire by shutting off the fuel source, shall be powered using circuit integrity cables.
- xv. Adequate segregation shall be maintained between different services. In general power and instrumentation/telecommunication cable shall not be laid in the same trench. A separation of 600mm shall be maintained between parallel runs of instrument and electrical cables. Within substations, PIBs and plant areas, lighting and small power cables shall be multi-core XLPE insulated and terminated using compression type cable glands
- xvi. Cables from variable speed drives shall be run in separate cables trays and a separation of 600 mm shall be maintained between cables operating on sinusoidal supplies and cables connected to the output of variable speed drives. Cable racks and trays within close proximity of the cooling towers and desalination plants shall be UV resistant powdered coated galvanized mild steel. FRP cable trays can be utilized in non-hazardous areas of cooling towers and marine facilities. Above ground cables shall be supported by cable racks or trays. A clear space of 250 mm, measured from the top of the collar of the tray, shall be provided above cable trays to facilitate cable laying. Power cables shall generally be laid on racks or trays in a single layer. Control cables may be bunched together. Cables shall be secured at required intervals. Cable racks and trays shall be fabricated from steel and hot dipped galvanized after fabrication. Power (and associated control) and instrumentation/telecommunication cables shall be run in their own racks. Electrical cables shall be where practical separated by at least 600 mm from instrumentation and telecommunication cables except at switchgear/MCC and substations. All cables shall be terminated using an approved double compression cable gland which shall be nickel plated brass.
- xvii. All cable entry threads shall be BS conduit (ET) to BS 31. All Cable glands for Equipment located in zoned area shall be provided with Ex-d, IIC, T3 protection as a minimum requirement

8.10 Electrical Heat Tracing

Where necessary, electrical trace heating shall be provided for process pipelines. Electrical heat tracing shall be designed and procured in accordance with project specification. As far as practical, suitably certified self-regulating heating tapes shall be employed. Special types of heating (e.g. skin effect, impedance or induction heating) may be employed in particular application.

Schedule – 1C

9.0 PROCESS SYSTEM

9.1 Boil off Gas (BOG) & Reliquefaction

BOG system consists of boil – off gas recovery from the tanks, piping and to divert it into the LNG send out system or inject it into the pipeline transmission network. BOG is also used for vapour return to the ship tanks during unloading thereby avoiding pressure drop in the ship tanks. If vapour return to the ship tanks is not considered, the BOG system should be designed to handle this additional quantity also.

- i. During roll-over condition, the instantaneous BOG generation is substantially high and necessary provision shall be provided to protect the tank from overpressure as well as to take care of the safe discharge.
- ii. BOG Recovery/Utilisation Options:
 - a) Re-liquefaction & Recycle to Storage: Liquefaction process used in the LNG production plant may be used for re-liquefaction. Re-liquefaction process is less favourable compared to other facilities due to higher energy consumption.
 - b) Pressurisation & Mixing with gas discharged from the Terminal: The boil – off gas is compressed to the network pressure and mixed with the re-gasified product. But while mixing, low calorific value of the boil – off gas may reduce the heating value of the network gas.
 - c) Recondensation & incorporation into the regassified LNG: The recondensation is carried out using LNG cold released during vaporisation. Pressurisation of boil – off gas in the liquid phase instead of gaseous phase leads to energy savings, safer operation.
 - d) As a fuel gas in power generation process or internal use.
- iii. The receiving terminal shall be provided with flare system to enhance the plant safety. The flaring of BOG should be done only as a final solution when the normal BOG handling system is not available.

9.2 LNG Pumping

9.2.1. In-Tank Pumps

- i. The tanks are provided with in-tank submerged pumps, which are also known as primary pumps. These are provided as storage tanks have nozzles only at the top. Pumps as well as the electric motor are submerged in LNG. Lubrication and the cooling of the pump are done by LNG itself. These pumps are installed in wells, equipped with foot valves, which can be isolated to enable pump removal for maintenance. Arrangement for foot valve seal purge, well purge, well-draining and venting shall be provided.
- ii. If the network pressure is not too high, in tank pumps alone may be sufficient to bring up to the network pressure through vaporisers. If the pipeline network pressure is high, two stage pumping may be needed which also helps in BOG re liquefaction at intermediate pressure instead of compressing BOG vapours to the line pressure.
- iii. The discharge pressure of the in tank pump is usually guided by the re-condenser pressure. The design pressure of the pump would also consider the chill down requirements of the ship unloading line.

9.2.2. Send out Section

- i. In send out section, LNG is pumped and brought to a pressure slightly higher than the network pressure through secondary pumps and vaporised & warmed to a temperature above 0°C and metered before it is sent for distribution.
- ii. Secondary Pumps: These Pumps are used for pumping the LNG from the intermediate pressure to the network pressure through vaporisers. These are generally either horizontal or vertical, multistage turbine / submersible pumps.

9.2.3 Vaporisation

- i. Vaporisation is accomplished by the transfer of heat to LNG from water / ambient air / process stream. In the vaporisation process, LNG is heated to its bubble point, vaporised and then warmed up to the required temperature.
- ii. LNG vaporisers are to be designed based on the quantity of heat to be exchanged with LNG for its vaporisation, maximum LNG flow rate, amount of heat available in the heating medium, lowest temperature of the heating medium.
- iii. LNG outlet temperature should be monitored and controlled carefully in order to avoid any LNG or cold vapour passing into the network.
- iv. In case of vaporisers, where water is used as a medium, water outer temperature should be maintained higher than water freezing point.
- v. Submerged combustion vaporiser shall not be located in an enclosed structure / building to avoid accumulation of hazardous products of combustion.

9.2.4 LNG Cold Recovery

- i. LNG cold recovery system aims at recovering the part of the potential cold energy available in LNG so as to use it effectively in cold utilising plants.
- ii. In case of LNG cold recovery facility at the terminal, all the safety features provided on the LNG vaporisers shall be applicable.

Schedule – 1D

10.0 OPEARTION, MAINTENANCE AND INSPECTION

Each facility shall have a documented operating manual including operations, maintenance, training procedures, cooldown, purging, and record keeping, based on experience and conditions under which the LNG plant is operated, and a documented maintenance manual.

Each facility shall have written operating, maintenance, and training procedures based on experience, knowledge of similar facilities, and conditions under which they will be operated.

10.1 Basic Requirements

Each facility shall meet the following requirements:

- i. Have written procedures covering operation, maintenance, and training.
- ii. Keep up-to-date drawings of plant equipment, showing all revisions made after installation
- iii. Revise the plans and procedures as operating conditions or facility equipment require
- iv. Establish a written emergency plan
- v. Establish liaison with appropriate local authorities such as police, fire department, or hospitals and inform them of the emergency plans and their role in emergency situations
- vi. Analyze and document all safety-related malfunctions and incidents for the purpose of determining their causes and preventing the possibility of recurrence.
- vii. As per maintenance philosophy, the activities should be identified that would be contracted to third party contractors for maintenance and support
- viii. The activity supervisors shall be identified according to the level of supervision required.
- ix. These supervisors are given Safe supervisor training by designated staff and then they are put on the job.
- x. The contractors staff shall be engaged in toolbox talk given on relevant topics are held with the Contract holders and owners.
- xi. OEM service engineers are involved in critical overhauls for better quality assurance and for first time activities.

- 10.1.1** All LNG plant components shall be operated in accordance with the operating procedures manual.
- 10.1.2** The operating procedures manual shall be accessible to all plant personnel and shall be kept readily available in the operating control room. The operating manual shall be updated when there are changes in equipment or procedures.
- 10.1.3** The operating manual shall include procedures for the proper startup and shutdown of all components of the plant, including those for an initial startup of the LNG plant that will ensure that all components operate satisfactorily.
- 10.1.4** The operating manual shall include procedures for purging components, making components inert, and cooldown of components.
- 10.1.5** Procedures shall ensure that the cooldown of each system of components that is subjected to cryogenic temperatures is limited to a rate and distribution pattern that maintains the thermal stresses within the design limits of the system during the cooldown period.
- 10.1.6** The operating manual shall include procedures to ensure that each control system is adjusted to operate within its design limits
- 10.1.7** The operating manual of LNG plants with liquefaction facilities shall include procedures to maintain the temperatures, levels, pressures, pressure differentials, and flow rates for the following:
- i. Boilers
 - ii. Turbines and other prime movers
 - iii. Pumps, compressors, and expanders
 - iv. Purification and regeneration equipment
 - v. Equipment within cold boxes, within their design limits
- 10.1.8** The operating manual shall include procedures for the following:
- i. Maintaining the vaporization rate, temperature, and pressure so that the resultant gas is within the design tolerance of the vaporizer and the downstream piping
 - ii. Determining the existence of any abnormal conditions, and the response to these conditions in the plant.
 - iii. The safe transfer of LNG and hazardous fluids, including prevention of overfilling of containers
 - iv. Security

- v. For monitoring operations.
 - vi. Emergency preparedness and handling
- 10.1.9** Operation monitoring shall be carried out by watching or listening for warning alarms from an attended control center and by conducting inspections at least at the intervals set out in the written operating and inspection procedures.
- 10.1.10** Where the bottom of the outer tank is in contact with the soil, the heating system shall be monitored at least once a week to ensure that the 0°C isotherm is not penetrating the soil.
- 10.1.11** Any settlement in excess of that anticipated in the design shall be investigated and corrective action taken as required.
- 10.1.12** Each entity shall ensure that components in its LNG plant that could accumulate combustible mixtures are purged after being taken out of service and before being returned to service.
- 10.1.12** The periodic inspections and tests shall be carried out in accordance with generally accepted engineering practice / recommendations of Original Equipment Manufacturer to ensure that each component is in good operating condition.
- 10.1.13** The support system or foundation of each component shall be inspected at least annually to ensure that the support system or foundation is sound.
- 10.1.14** Each emergency power source at the facility shall be tested monthly for operability and annually to ensure that it is capable of performing at its intended operating capacity.
- 10.1.15** Each facility operator shall ensure that when a component is served by a single safety device only and the safety device is taken out of service for maintenance or repair, the component is also taken out of service.
- 10.1.16** The facility operator shall ensure that where the operation of a component that is taken out of service could cause a hazardous condition, a tag bearing the words “Do Not Operate,” or the equivalent thereto, is attached to the controls of the component. Wherever possible, the component shall be locked out.
- 10.1.17** Stop valves for isolating pressure or vacuum-relief valves shall be locked or sealed open. On each LNG container, no more than one stop valve shall be closed at one time. They shall not be operated except by an authorized person.
- 10.2 Marine Shipping and Receiving**
- 10.2.1** Vehicle traffic shall be prohibited on the pier or dock within 30 m of the loading and unloading manifold while transfer operations are in progress.
- 10.2.2** Warning signs or barricades shall be used to indicate that transfer operations are in progress.

- 10.2.3** Prior to transfer, the officer in charge of vessel cargo transfer and the person in charge of the shore terminal shall inspect their respective facilities to ensure that transfer equipment is in the proper operating condition.
- 10.2.4** Prior to transfer, the officer in charge of vessel cargo transfer and the person in charge of the shore terminal shall meet and determine the transfer procedure, verify that ship-to-shore communications exist, and review emergency procedures.
- 10.2.5** Where making bulk transfers into stationary storage containers, the LNG being transferred shall be compatible in composition or temperature and density with the LNG already in the container.
- 10.2.6** Where the composition or temperature and density are not compatible, means shall be taken to prevent stratification and vapor evolution that could cause rollover.
- 10.2.7** Where a mixing nozzle or agitation system is provided, it shall be designed to prevent rollover.

10.3 Loading or Unloading Operations

- 10.3.1** At least one qualified person shall be in constant attendance while loading or unloading is in progress.
- 10.3.2** Written procedures shall be available to cover all transfer operations and shall cover emergency as well as normal operating procedures.
- 10.3.3** Written procedures shall be kept up-to-date and available to all personnel engaged in transfer operations.
- 10.3.4** Sources of ignition, such as welding, flames, and unclassified electrical equipment, shall not be allowed in loading or unloading areas while transfer is in progress.
- 10.3.5** Loading and unloading areas shall be posted with signs that read “No Smoking.”
- 10.3.6** Where multiple products are loaded or unloaded at the same location, loading arms, hoses, or manifolds shall be identified or marked to indicate the product or products to be handled by each system.
- 10.3.7** Prior to transfer, gauge readings shall be obtained or inventory established to ensure that the receiving vessel cannot be overfilled, and levels shall be checked during transfer operations.
- 10.3.8** The transfer system shall be checked prior to use to ensure that valves are in the correct position, and pressure and temperature conditions shall be observed during the transfer operation.
- 10.3.9** The transfer system shall be checked prior to use to ensure that valves are in the correct position for transfer.

10.3.10 Transfer operations shall be commenced slowly and if any unusual variance in pressure or temperature occurs, transfer shall be stopped until the cause has been determined and corrected.

10.3.11 Pressure and temperature conditions shall be monitored during the transfer operation.

10.3.12 While tank car or tank vehicle loading or unloading operations are in progress, rail and vehicle traffic shall be prohibited within 7.6 m of LNG facilities or within 15 m of refrigerants whose vapors are heavier than air.

10.3.13 Prior to connecting a tank car, the car shall be checked and the brakes set, the derailer or switch properly positioned, and warning signs or lights placed as required.

10.3.14 The warning signs or lights shall not be removed or reset until the transfer is completed and the car disconnected.

10.3.15 Truck vehicle engines shall be shut off if not required for transfer operations.

10.3.16 Brakes shall be set and wheels checked prior to connecting for unloading or loading.

10.3.17 The engine shall not be started until the truck vehicle has been disconnected and any released vapors have dissipated.

10.3.18 Prior to loading LNG into a tank car or tank vehicle that is not in exclusive LNG service or contain a positive pressure, a test shall be made to determine the oxygen content in the container. If the oxygen content exceeds 2 percent by volume, the container shall not be loaded until it has been purged to below 2 percent oxygen by volume.

10.3.19 Prior to loading or unloading, a tank vehicle shall be positioned so that it can exit the area without backing up when the transfer operation is complete.

10.3.20 Tank cars and tank vehicles that are top-loaded through an open dome shall be bonded electrically to the fill piping or grounded prior to opening the dome.

10.3.21 Communications shall be provided at loading and unloading locations so that the operator can be in contact with other remotely located personnel who are associated with the loading or unloading operation.

10.3.22 Other Operations

- i. The discharge from depressurizing shall be directed to minimize exposure to personnel or equipment.
- ii. Taking an LNG container out of service shall not be regarded as a normal operation.
- iii. All such activities shall require the preparation of detailed procedures

10.3.23 Each operating company shall do the following:

- i. Keep the grounds of its LNG plant free from rubbish, debris, and other materials that could present a fire hazard
- ii. Ensure that the presence of foreign material contaminants or ice is avoided or controlled to maintain the operational safety of each LNG plant component
- iii. Maintain the grassed area of its LNG plant so that it does not create a fire hazard.
- iv. Ensure that fire control access routes within its LNG plant are unobstructed and reasonably maintained in all weather conditions

10.4 Maintenance Manual

10.4.1 Each facility operator shall prepare a written manual that sets out an inspection and maintenance programme for each component that is used in its facility.

10.4.2 The maintenance manual for facility components shall include the following:

- i. The manner of carrying out and the frequency of the inspections and tests as specified.
- ii. All procedures to be followed during repairs on a component that is operating while it is being repaired to ensure the safety of persons and property at the facility
- iii. Each facility operator shall conduct its maintenance programme in accordance with its written manual for facility components.

In addition, the history card of all critical equipments, instruments and systems shall be maintained.

10.5 Maintenance Workflow

- i. The objective of the work flow is to provide an integrated proactive and reactive work plan so that repair work is minimized and reliability and availability are optimized. Maintenance execution begins with the receipt of a work request and concludes with the close out of the work order.
- ii. Correct prioritization of work and proactively preparing activities through high quality work preparation, combined with accurate scheduling, will lead to a more stable work environment. This will reduce deferrals and breakdowns, improve integrity and safety, and provide additional job satisfaction and ownership to technicians.
- iii. The management and control of day-to-day maintenance on all process units and utilities of a site is to provide:
 - a) Support for a maintenance strategy based on doing programmed maintenance on time
 - b) Safe, healthy and environmentally sound execution of maintenance work,
 - c) Availability of equipment

- d) Business efficiency
- iv. The designated person for issue of work permit shall verify the execution of preparation activities before issue of the work permit.
- v. Maintenance work shall be undertaken in accordance with work permit requirements.
- vi. Inspection personnel should be notified on time at which moment witness or hold points set.
- vii. A verification of the HSE requirements should be carried as the maintenance execution includes HSE review and a toolbox talk as outlined in the work permit or work pack.
- viii. The maintenance supervisor should ensure that a toolbox talk is held before work commences.
- ix. Upon completion of the job, the job site should be left safe, clean and tidy. Any excess materials should be returned to the stores and tools should be cleaned and returned to the workshop or put away in the correct storage place.
- x. On a daily basis, the progress of work should be reported. If the work is not completed, it should continue the next working day after taking requisite permission and approval from work permit issuing personnel.
- xi. The work permit duly signed shall be returned to issuing authority on completion of job, removal of all material from site and handing over of facilities to user etc.

10.6 Maintenance Strategy

- i. The facilities should be designed for minimum maintenance intervention.
- ii. These maintenance requirements should be clearly defined and further optimized based on maintenance strategy reviews using tools such as reliability centred maintenance, Risk Based Inspection and Risk Assessment Matrix (RAM), after detailed equipment specifications are known.
- iii. The criticality of the equipment shall be taken into account during the maintenance strategy selection.
- iv. Appropriate diagnostic tools and staff competencies shall be provided to facilitate rapid fault finding and rectification and also to provide opportunistic maintenance during outages.
- v. Maintenance strategies shall maximize non-intrusive & on line data acquisition to support planning & analysis.
- vi. Special Critical Equipments shall have OEM defined performance standards which shall be periodically tested and verified.
- vii. Structural and pipeline survey and painting shall be done on a regular basis.

10.7 The entity shall prepare a written plan for preventive maintenance covering the scope, resources, periodicity etc. The corrective measures should include the preventive maintenance, scheduling, execution and closure.

10.8 Each facility should have well defined system for identification of spare part, rationalization and optimization to minimize any supply chain/logistics constraints & risks.

10.9 Well defined Roles & Responsibilities matrix should be available made for each machine as well as activity to be carried out in the workshop. The procedure for Audits and Review of the workshop shall be documented and adhered to.

11.0 Inspection

- i. Each facility shall have written inspection, testing and commissioning programme in place. Inspection shall include before commissioning during installation as well as during regular operation of the LNG facilities.
- ii. All documents related to design, installation procedure of the respective vendors and the manufacturer's instruction for pre-commissioning and commissioning of the equipment, systems, instruments, control systems etc. shall be properly stored and followed.
- iii. Inspection shall cover the review of test protocols and acceptance criteria that these are in accordance with the protocols and acceptance criteria specified in line with OEM specific requirements
- iv. Inspection shall cover that the equipment is installed in accordance with design, and any deviations documented and approved.
- v. All safety systems are installed inspected and tested as per design /OEM requirement.
- vi. Inspection shall cover that all safety devices are installed and are in working condition as per the design/ OEM requirements.
- vii. Inspection shall cover the verification of various safety interlocks, ESD provided in the design.
- viii. Inspection shall cover the adequacy of sealing systems.
- ix. Inspection shall cover the pressure and vacuum protection system.
- x. Inspection shall cover the electrical systems, check its integrity, earthing resistance, bonding etc.
- xi. Inspection shall cover the integrity of mechanical and rotating equipment.
- xii. The integrity and efficacy of gas detection, fire protection and fighting system, connected equipments shall be covered in the inspection.
- xiii. Inspection shall cover the efficacy of corrosion system.
- xiv. Inspections shall cover the bunds are installed where required and have connections to the open drainage system in accordance with the P&IDs.
- xv. Inspection shall cover and review the mechanical completion records that the PSVs are of the correct type and sizing as per the P&IDs/data sheets.
- xvi. Inspection shall cover location of inlet pipe-work to relieving devices in relation to potential restrictions (e.g. above liquid levels, vessel internals, etc.)
- xvii. Inspection shall cover and review P&IDs to check the position of isolation valves for relieving devices, their capacities. Further, no protected equipment may be isolated from the disposal system.
- xviii. Inspection to confirm by review of all vent locations (atmospheric vent from drums or equipment seals) that they vent to safe location and in the event of liquid carry over will not discharge to areas that may cause a hazard to personnel.
- xix. Inspection shall review the area classification layouts and associated studies to confirm that all possible hazards have been appropriately considered (including possible migration), the hazardous area drawings correctly account for the actual

location of the sources of release the hazardous areas have been appropriately defined.

- xx. Inspection shall cover that all ESD devices move to their safe condition on loss of system output, hydraulic power or instrument air. All ESDVs and actuators shall remain functional following an explosion or under fire conditions for a sufficient time period to perform their intended function.
- xxi. The maximum allowable back pressure and minimum design temperature of the relief system shall be checked for suitability for the highest identified flow rate.
- xxii. Control System shall include all status monitoring and actions to and from the Control Rooms.
- xxiii. Inspection to cover the escape and evacuation passages.
- xxiv. Inspection shall cover the emergency communication system for its effectiveness during emergency situations.
- xxv. Each cryogenic piping system shall be checked during and after cooldown stabilization for leaks in flanges, valves, and seals.

Schedule – 1E

12.0 Competence Assurance and Assessment

- 12.1** Every operating company shall develop, implement, and maintain a written training plan to instruct all LNG plant personnel with respect to the following:
- i. Carrying out the emergency procedures that relate to their duties at the LNG plant as set out in the procedure manual and providing first aid
 - ii. Permanent maintenance, operating, and supervisory personnel with respect to the following:
 - a) The basic operations carried out at the LNG plant
 - b) The characteristics and potential hazards of LNG and other hazardous fluids involved in operating and maintaining the LNG plant, including the serious danger from frostbite that can result upon contact with LNG or cold refrigerants
 - c) The methods of carrying out their duties of maintaining and operating the LNG plant as set out in the manual of operating, maintenance and transfer procedures
 - d) Fire prevention, including familiarization with the fire control plan of the LNG plant; fire fighting; the potential causes of fire in an LNG plant; the types, sizes, and likely consequences of a fire at an LNG plant
 - e) Recognizing situations when it is necessary for the person to obtain assistance in order to maintain the security of the LNG plant
- 12.2** Each operating company shall develop, implement, and maintain a written plan to keep personnel of its LNG plant up-to-date on the function of the systems, fire prevention, and security at the LNG plant.
- 12.3** The Refresher programmes for training of all personnel shall be conducted an interval not exceeding 2 years to keep personnel current on the knowledge and skills.
- 12.4** Every operating company shall maintain a record for each employee of its LNG plant that sets out the training given to the employee under this section.
- 12.5** Each operating company shall ensure that LNG plant personnel receive applicable training and have experience related to their assigned duties. Any person who has not completed the training or received experience shall be under the control of trained personnel.
- 12.6** For the design and fabrication of components, each operator shall use personnel who have demonstrated competence by training or experience in the design of comparable components and for fabrication who have demonstrated competence by training or experience in the fabrication of comparable components.

- 12.7** Supervisors and other personnel utilized for construction, installation, inspection, or testing must have demonstrated their capability to perform satisfactorily the assigned function by appropriate training in the methods and equipment to be used or related experience and accomplishments. Further their capability shall be assessed periodically.
- 12.8** Each operator shall utilize for operation or maintenance of components only those personnel who have demonstrated their capability to perform their assigned functions by successful completion of the training as specified and possess experience related to the assigned operation or maintenance function.
- 12.9** Corrosion control procedures including those for the design, installation, operation, and maintenance of cathodic protection systems, must be carried out by, or under the direction of, a person qualified by experience and training in corrosion control technology.
- 12.10** Personnel having security duties must be qualified to perform their assigned duties by successful completion of the training as specified.
- 12.11** Each operator shall follow a written plan to verify that personnel assigned operating, maintenance, security, or fire protection duties at the LNG plant do not have any physical condition that would impair performance of their assigned duties. The plan must be designed to detect both readily observable disorders, such as physical handicaps or injury, and conditions requiring professional examination for discovery.
- 12.12**
- i. Each entity shall provide and implement a written plan of initial training to instruct all permanent maintenance, operating, and supervisory personnel —
 - a) About the characteristics and hazards of LNG and other flammable fluids used or handled at the facility, including, with regard to LNG, low temperatures, flammability of mixtures with air, odorless vapor, boil off characteristics, and reaction to water and water spray;
 - b) About the potential hazards involved in operating and maintenance activities; and
 - c) To carry out aspects of the operating and maintenance procedures that relate to their assigned functions;
 - ii. All personnel of an LNG installation shall be trained to carry out the emergency procedures that relate to their assigned functions; and to give first-aid;
 - iii. All operating and appropriate supervisory personnel of an LNG installation shall be trained to understand detailed instructions on the facility operations, including controls, functions, and operating procedures; and to understand the LNG transfer procedures.
- 12.13** Personnel responsible for security at an LNG plant must be trained in accordance with a written plan of initial instruction to:
- i. Recognize breaches of security;

- ii. Carry out the security procedures that relate to their assigned duties;
- iii. Be familiar with basic plant operations and emergency procedures, as necessary to effectively perform their assigned duties; and
- iv. Recognize conditions where security assistance is needed.

12.14 All personnel involved in maintenance and operations of an LNG plant, including their immediate supervisors, must be trained in accordance with a written plan of initial instruction, including plant fire drills, to:

- i. Know and follow the fire prevention procedures as specified
- ii. Know the potential causes and areas of fire determined
- iii. Know the types, sizes, and predictable consequences of fire determined and
- iv. Know and be able to perform their assigned fire control duties according to the procedures and by proper use of equipment provided.
- v. Marine
- vi. TT Crew

12.15 Each entity shall maintain a system of records which —

- i. Provide evidence that the training programmes required by this subpart have been implemented; and
- ii. Provide evidence that personnel have undergone and satisfactorily completed the required training programmes.
- iii. Records must be maintained for one year after personnel are no longer assigned duties at the LNG plant.

Schedule – 1F

13.0 Fire Prevention, Leak Detection, Fire Fighting Facilities

13.1 General

- i. Fire protection shall be provided for all LNG facilities. The extent of such protection shall be determined by an evaluation based upon sound fire protection engineering principles, analysis of local conditions, hazards within the facility and exposure to or from other property. The evaluation shall determine as a minimum:
- ii. The type, quantity and location of equipment necessary for the detection and control of fires, leaks and spills of LNG, flammable refrigerants or flammable gases all potential fires non process and electrical fires.
- iii. The methods necessary for protection of the equipment and structures from the effects of the fire exposure.
- iv. The equipment's and process systems to be operated with the emergency shutdown (ESD) system.
- v. The type and location of sensors necessary for automatic operation of the emergency shutdown (ESD) systems or its subsystems.
- vi. The availability and duties of individual plant personnel and the availability of external response personnel operating an emergency.
- vii. The protective equipment and special training necessary by the individual plant personnel for their respective emergency duties.
- viii. The detailed procedure manual shall be prepared to cover the potential emergency conditions. Such procedure shall include but not necessarily be limited to the followings:
 - a) Shutdown or isolation of various equipment in full or partial and other applicable steps to ensure that the escape of gas or liquid is promptly cut off or reduced as much as possible.
 - b) Use of fire protection facilities.
 - c) Notification of public authorities.
 - d) First aid and
 - e) Duties of personnel.
 - f) Communication procedure in case of emergency

- ix. All personnel shall be trained in their respective duties contained in the emergency manual. Those personnel responsible for the use of fire protection or other prime emergency equipment shall be trained in the use of equipment. Refresher training of personnel shall be conducted at least on annual basis.
- x. The planning of effective fire control measures be co-ordinated with the authority having jurisdiction and emergency handling agencies such as fire and police departments who are expected to respond to such emergencies.

13.2 Fire proofing

- i. Fire proofing shall be used to protect equipment, typically: ESD valves, safety critical control equipment, vessels containing quantities of liquid hydrocarbon and structural supports, which on failure would escalation the incident and/or endanger the activities of emergency response personnel. Equipment which can receive thermal radiation, in excess of that defined below for a sufficient period to cause failure shall be provided with fire proofing protection. The fire proofing shall provide protection for the duration of the hazard event but shall as a minimum provide 90 min protection.

EQUIPMENT INSIDE BOUNDARY	MAXIMUM THERMAL RADIATION FLUX (kW/m²)
Concrete outer surface of adjacent storage tanks	32
Metal outer surface of adjacent storage tanks	15
The outer surfaces of adjacent pressure storage vessels and process facilities	15
Control rooms, Maintenance workshops, laboratories, warehouses etc.	8
Administrative buildings	5

- ii. Fire protection in the form of insulation or water deluge shall be provided for pressure vessels, which can receive thermal radiation fluxes in excess of that defined in Annex A, to prevent such vessels failing and releasing superheated liquid, which can result in a BLEVE.
- iii. It shall be recognised that pressure vessels subject to radiation from a major incident such as an LNG tank fire shall require protection for much more than 90

min. Protection for long duration incidents may not be achieved by insulation and a water deluge system is required.

- iv. The calculation of water deluge, insulation for fire protection of structures, etc. as protection against fires shall be performed for the fluid which gives rise to the highest radiation flux.
- v. Fire proofing should be designed and executed in accordance with GAP 2.5.1 or API 2218 or equivalent standards.

13.3 Leak detection

- i. Systems shall be provided to detect possible accidental events i.e. spillage, leakage, smoke, fire etc. which could occur in the plant.
- ii. The arrangement of detectors shall be such as to always provide redundancy and to prevent false and spurious alarms. Voting technique arrangement may be used. Events may include:
 - a) Earthquake - Where applicable seismic acceleration monitoring shall be provided, giving signals to automatically initiate the plant shutdown when the earthquake reaches a pre-defined level. This pre-defined level is chosen by the operator.
 - b) LNG spillage, gas leakage, flame and smoke.

These detection systems are intended to rapidly and reliably detect any LNG spillage or flammable gas leakage and any fire condition in the plant.

Continuously operating detection systems shall be installed at every location, outdoors and indoors, where leaks are credible.

- iii. Manual call points shall be provided in the hazardous plant areas, typically those plant areas covered by flame and/or combustible gas detectors, and provided on likely escape routes from these areas.

13.4 Active Protection

The active protection includes:

- i. fire water system i.e. mains network with hydrants and monitors;
- ii. spraying systems;
- iii. water curtains;
- iv. foam generators;
- v. fixed dry chemical powder systems;
- vi. fire fighting vehicle(s);
- vii. Portable/mobile fire extinguishers.

13.4.1 Fire water system

- i. Water has particular uses on an LNG plant. However, LNG pool fires are neither controlled nor extinguished by water. Application of water on a liquid surface will increase the vapour formation rate thus increasing the burning rate with negative consequences on fire control. In an LNG plant, under fire conditions, water may be used in great quantities for cooling storage tanks, equipment and structures which are subject to flame impingement or heat radiation due to a fire. As a result, the risk of escalation of the fire and deterioration of equipment can be reduced by early and concentrated cooling.
- ii. Plant surface water and fire water drainage systems and LNG spill collection systems shall be designed to minimize the possibility of fire water increasing the vaporization rate of any LNG spill. This may be achieved by plant area and fire water systems segregation. In the event that firewater run-off is contaminated provision shall be made to prevent the pollution of natural water-courses.
- iii. Fire water networks shall be provided around all sections of the plant. Water supply systems shall be designed in independent sections so that in case of maintenance or damage of a section the water supply to other sections is not interrupted. Both fire pumps should not discharge to the network through a single header.
- iv. All these networks, including fire hydrants shall be maintained primed under a minimum pressure of at least 7.0 kg/cm² at hydraulically farthest point by means of jockey pumps or an elevated tank. Special provisions shall be taken to avoid any damage due to freezing etc.
- v. Water supply systems shall be able to provide, at fire fighting system operating pressure, a water flow not less than that required by the fire fighting systems as per design plus an allowance of 100 l/s for hand hoses. The fire water supply shall be sufficient to address this incident, but shall not be less than 4 hour.
- vi. Number of pumps, Capacity of pumps, type of drive of pumps (diesel engine or motor driven) and stand by requirements of pumps shall be worked out on the basis of single major fire at LNG Terminal and Jetty each. In case of combined fire fighting facilities, the design shall consider simultaneous major fires at jetty and LNG terminal.
- vii. The fire fighting system shall be designed to handle the largest risk for 4 hours. In case of combined facilities, it shall be based on double risk i.e. one largest risk at LNG Terminal and Jetty each.
- viii. The water storage capacity of 4 hours shall be based on the design discharge capacity of fire water pumps.
- ix. LNG plants (particularly impounding basins) shall be equipped with drainage systems capable of draining the volumes of water generated by these systems.
- x. The maximum fire water flow rate at the LNG jetty irrespective of the LNG carrier size and LNG unloading rate, shall be calculated based on following :
 - a) Two tower monitors shall be provided @ 1500 GPM.
 - b) Two Jumbo curtain nozzles shall be provided at the front side of jetty head between LNG carrier and jetty head having application rate of 70 lpm/meter run of the jetty.

- c) Fire Protection of jetty manifold, drain, vessels @of 10.2 lpm/m².
- d) Supplementary hose requirement of 144 M³/hr.

13.4.2 Spraying system

- i. The importance of cooling each equipment item and the amount of water required shall depend on the hazard assessment.
- ii. Where required, spraying systems shall distribute the water flow evenly onto the exposed surfaces. In this way equipment subjected to radiation shall not reach unacceptably high local temperatures.
- iii. Recirculation of used water may be considered where practicable and shall depend on its ability to remove the transferred heat in a fire of long duration while keeping the integrity and working ability of the unit. Precautions should also be taken to ensure that flammable materials are not returned with the re-circulated water.
- iv. The calculation of the incident water flow on each unit shall be carried out on basis of received radiation flux for each scenario using appropriate validated models in order to limit the surface temperature consistent with the integrity of the structure.
- v. For the LNG storage tanks, water sprays shall be provided on the tank shell including the roof and the appurtenances on the tank. For single containment tanks, water application rate for the tank roof and walls shall be calculated using method detailed in Appendix 5 of IP Model Code of Safe Practice Part 9 of NFPA 15. The water application rate on the appurtenances shall be 10.2 lpm / m² as per this code. For double/full containment tanks, the water application rate for the tank roof/ outer shell shall be 3 lpm / m². No cooling is required for cooling the outer shell of tanks having concrete outer tank .
- vi. The water densities applicable to other equipment shall be as follows:
 - a) Vessels, structural members piping & valves manifolds: 10.2 lpm / m²
 - b) Pumps : 20.4 lpm / m²
- vii. The deluge valves on the water spray systems on the tanks as well as the pumps, compressors, vessels etc. shall be actuated automatically through a fire detection system installed around the facilities with provisions of manual actuation from Control Room or locally at site.

13.4.3 Water curtains

13.4.3.1 General

- i. Water curtains may be used to mitigate gas releases and protect against radiant heat.
- ii. The aim of a water curtain system is to rapidly lower the gas concentration of an LNG vapour cloud in order to attain the lower flammability limit of gas in air.
- iii. Water curtains transfer heat to the cold natural gas cloud through contact between LNG vapours and water droplets.
- iv. In addition water curtains entrain large volumes of air that transfer additional heat, dilute the LNG vapour cloud, thus enhance its buoyancy thus facilitating its dispersion.
- v. The effectiveness of a water curtain is reduced as the wind speed increases, but natural dispersion is increased at high wind velocities.

- vi. Effective performance of water curtains is dependent on many different conditions, i.e. nozzle type, water pressure, nozzle location, nozzle spacing.
- vii. Water curtains are known to mitigate heat radiation and gas cloud dispersion incidents. However they cannot be relied upon as the primary means of protection.

13.4.3.2 Characteristics and location

- i. Water curtains shall be positioned as per the hazard assessment.
- ii. Water curtains can be located as close as possible to the area of possible spill and concentration of LNG taking into account plant requirements. The possibility of water curtain droplets entering the impounding areas should be minimised in order to avoid an increase in the LNG evaporation rate.
- iii. Water curtains may be positioned around the impounding areas. In this way they act as a barrier for cold natural gas clouds originating from LNG leaks.
- iv. Nozzle spacing should follow vendors' recommendations.

13.4.4 Foam generation

- i. Fire fighting foams can be used to reduce the heat radiation from LNG pool fires and aid safer gas dispersion in the event that the leak does not ignite. The extent of their use will depend on the hazard assessment.
- ii. Foam generators shall be specifically designed to operate when engulfed in an LNG fire, unless the design of the system is such that the generator is protected from excessive heat flux. The design of the system shall prevent water in a liquid form from entering the impounding area.
- iii. Foam to be used shall be dry powder compatible and proven suitable with LNG fires in accordance with EN 12065. Typical expansion ratios should be in the order of 500:1.
- iv. LNG impounding basins or areas should be fitted with fixed foam generators to enable rapid response and remote activation.
- v. The volume of foam flow for LNG impounding basins or areas shall be determined in accordance with EN 12065 in order to reduce heat radiation, taking into account the possible failure of one generator and also the destruction rate of the foam due to fire. A foam retention device may be placed around the impounding basin or area where there is a risk of foam loss due to wind.
- vi. Foam agent reserves shall be situated in a place sheltered from heat radiation (from fire and solar). The foam agent storage capacity (Q) shall be at least equal to the sum of the following quantities:

$$Q = Q_1 + Q_2 + Q_3$$

Where

$$Q_1 = t \times r \times S$$

t is the foam agent procurement time (hours), (with a ceiling at 48 h);

r is the foam agent destruction rate (metres/hour) (for example $r = 0,11$ m/h);

$$Q = Q_1 + Q_2 + Q_3$$

Where

$$Q_1 = t \cdot r \cdot S$$

t is the foam agent procurement time (hours), (with a ceiling at 48 h);

r is the foam agent destruction rate (metres/hour) (for example $r = 0,11$ m/h);

S is the largest area to be covered (square meters);

Q_2 is the quantity necessary for periodic foam system tests. In the absence of other information, operation of the foam agent pumps at the maximum flow rate for 15 min is to be taken for determining this quantity;

Q_3 is the quantity necessary for first layer build-up

13.4.5 Portable foam equipment

The requirement for portable foam equipment shall be defined by the Hazard Assessment, when provided, portable foam – generating equipment connected to the firewater supply shall be equipped with enough hose to reach the most distant hazard they are expected to protect.

13.5 LNG fire extinguishing with dry powder

13.5.1 General

- i. Equipment for LNG fire fighting shall be in accordance with relevant codes and/or standards. The recommended extinguishing medium for LNG fires is dry powder.
- ii. To extinguish a burning pool of LNG, dry powder shall be applied above the surface of the liquid without allowing the powder to impinge and agitate the surface.
- iii. Agitation of the liquid surface will increase the burning rate due to the increase in vapour formation instead of extinguishing the fire.
- iv. To achieve optimum results in extinguishing an LNG fire, the fire's total area shall be covered immediately and all at once. Otherwise residual flames of LNG pool sectors can rapidly re-ignite gas emanating from the extinguished sectors. In addition, provisions shall be taken to cool any structure surfaces which could re-ignite the gas.
- v. Enough quantity of powder to allow a second shot in case of a re-ignition.

13.5.2 Types of dry powder

The dry powder shall be proven suitable for gas fire extinguishing; foam compatibility shall be in accordance with EN 12065.

13.5.3 Location of dry powder systems

Dry powder systems should be installed in an LNG plant near points of possible LNG and hydrocarbon leakage with regard to the hazard assessment and typically near the following units:

- i. loading/unloading areas as per EN 1532 ;
- ii. LNG pumps;
- iii. ESD valves;
- iv. tail pipes of tank PSV (fixed systems) alternatively nitrogen stuffing systems may be used.

13.5.4 Portable/mobile fire extinguishers

- i. The following types of extinguishers are foreseen:
 - a) foam type extinguishers in area where oil may be present (compressors building, hydraulic unit of transfer arms at the jetty);
 - b) carbon dioxide type extinguishers in electrical and instrumentation buildings;
 - c) dry chemical powder extinguishers in process areas.
- ii. The fire extinguishers shall comply with the requirements of the local regulations.
- iii. These extinguishers are installed in the critical locations along the circulation paths and/or platforms. Their position shall be on a recognised escape path from the identified hazard they are installed to mitigate.

13.5.5 Fire fighting vehicle

- i. Where external LNG experienced assistance in case of emergency is not available the plant shall be equipped with at least one fire fighting vehicle to give the required response in case of emergency.
- ii. This fire fighting vehicle will be fitted with:
 - a) foam system suitable for the anticipated type of fire;
 - b) dry chemical powder
- iii. Fireman protective clothing suitable for LNG service (splash and fire) shall be provided.
- iv. The vehicle shall be sufficiently equipped and manned to provide emergency response whilst waiting for off- site support.

13.6 Other requirements

13.6.1 Provisions to minimise hazards in buildings

- i. This is achieved by maintaining a continuous positive pressure ventilation in the electrical and instrumentation rooms of the buildings located inside the process areas.

- ii. In case of gas detection in the process areas, the operators in the control rooms have the possibility to shutdown remotely the HVAC of the affected buildings.
- iii. In case of gas detection at the building air inlet, the external fans are tripped and the louvers closed in order to prevent any gas entrance in the electrical and instrumentation rooms where a risk of ignition exists.

13.6.2 Fire cabinets / hoses boxes

- i. An accessible supply of fire fighting equipment shall be located where hydrants are intended for use by either plant personnel or the local fire brigade.
- ii. Equipment shall be stored in cabinets which are:
 - a) clearly identifiable
 - b) provided with means to securely store equipment;
 - c) suitably constructed and protected for the plant local environment;
 - d) naturally ventilated;
 - e) located so that personnel can gain access from a safe area.
- iii. Where provide cabinets and their required contents should be approved by the local fire authority. As a minimum each cabinet should be equipped with:
 - a) two adjustable mist/solid stream nozzles;
 - b) one hydrant spanner;
 - c) four coupling spanners;
 - d) two hose coupling gaskets;
 - e) four x 15 m lengths of fire hose;
 - f) a weatherproof list of contents.

Schedule – 1G

14.0 Safety Management System

14.1 The organization should establish a safety management system which shall be an integral part of the overall management system. Safety Management System (SMS) should be based on PDCA (Plan, Do, Check and Act) cycle which comprises of:

- i) Policy setting – includes policy, corporate acceptance of responsibility, objectives, requirements, strategies;
- ii) Organization – includes structure, accountability and safety culture, involvement of the workforce, systems for performing risk assessment;
- iii) Planning and execution – includes operational standards and procedures for controlling risks, permit to work, competence and training, selection & control over contractors, management of change, planning & control for emergencies and occupational health;
- iv) Measuring and evaluating – includes active monitoring, recording and investigation of incidents / accidents, auditing, handling of non-conformities;
- v) Continuous improvement – includes review and application of the lessons learnt. Safety management system should not degenerate into a paper exercise only, conducted solely to meet regulatory requirements.

14.2 Elements of Safety Management system

Safety management system should include at least the following basic elements:

- i) **Safety Organization-** Leadership and Management Commitment should be clearly visible in the SMS. Management should develop and endorse a written description of the company's safety and environmental policies and organizational structure that define responsibilities, authorities, and lines of communication required to implement the management programme. Management should review the safety and environmental management programme to determine if it continues to be suitable, adequate and effective at predetermined frequency. The management review should address the possible need for changes to policy, objectives, and other elements of the programme in light of programme audit results, changing circumstances and the commitment to continual improvement. Observations, conclusions and recommendations of management review should be documented.
- ii) **Safety Information-** Comprehensive safety and environmental information for the facility, which include documentation on process, mechanical and facility design, should be developed and maintained throughout the life of the facility.

- iii) **Process Hazard Analysis**-The purpose of Process Hazard Analysis (PHA) is to minimise the likelihood of the occurrence and the consequences of a dangerous substance release by identifying, evaluating and controlling the events that could lead to the release. Process hazards analysis should be performed for any facility to identify, evaluate, and reduce the likelihood and/or minimize the consequences of uncontrolled releases and other safety or environmental incidents. Human factors should also be considered in this analysis.

The process hazard analysis should be updated and revalidated by a team, having requisite back ground, at least every 5 years after the completion of initial process hazard analysis. Recommendations resulting from the PHA should be completed before start-up for a new process or facility, or modification in existing facility.

- iv) **Operating Procedures**- Written down operating procedures shall be available describing tasks to be performed, data to be recorded, operating conditions to be maintained, samples to be collected and safety and health precautions to be taken for safe operation. Operating procedures should be based on process safety information so that all known hazards are taken care of. The human factors associated with format, content, and intended use should be considered to minimize the likelihood of procedural error.

The operating procedures shall provide plant specific instructions on what steps to be taken or followed while carrying out Startup, Normal operation, Temporary operation, Normal shut-down and Emergency operation and shut-down.

Manuals of operating procedures shall be made available to the employees. Training shall be imparted to the operators on operating procedures and should be certified as competent.

All the documents in operating plan shall be controlled and amended with due authorisation. Whenever new document has been prescribed, all the old documents shall be destroyed.

When changes are made in facilities, operating procedures should be reviewed as part of the management of change procedure. In addition, operating procedures should be reviewed periodically to verify that they reflect current and actual operating practices. Operating manuals should be certified as updated by authorized / competent person every year.

- v) **Safe Work Practices** - The entity shall maintain procedures that address safe work practices to ensure the safe conduct of operating, maintenance, and emergency response activities and the control of materials that impact safety. These safe work practices may apply to multiple locations and will normally be in written form (safety manual, safety standards, work rules, etc.) but site-specific work practices shall be prepared and followed. In cases where an employee believes that following a procedure will cause an unsafe condition, one shall have authority to stop work and get permission to deviate. Deviations should be documented for future analysis.

- vi) **Training-** The training programme shall establish and implement programmes so that all personnel are trained to work safely and are aware of environmental considerations, in accordance with their duties and responsibilities.

Training shall address the operating procedures, the safe work practices, and the emergency response and control measures. Any change in facilities that requires new or modification of existing operating procedures may require training for the safe implementation of those procedures. Training should be provided by qualified instructors and documented.

The training provided to contract personnel should include applicable site-specific safety and environmental procedures and rules pertaining to the facility and the applicable provisions of emergency action plans.

The entity should verify contractor training utilizing a variety of methods, which may include audits of the contractor's environmental, health and safety training programmes; and operator observation of contractor work performance.

- vii) **Management of Change (MOC)** -There should be procedures to identify and control hazards associated with change and to maintain the accuracy of safety information. For each MOC, the operator shall identify the potential risks associated with the change and any required approvals prior to the introduction of such changes. The types of changes that a MOC procedure addresses shall include:

- a) technical,
- b) physical,
- c) procedural, and
- d) organizational.

This procedure shall consider permanent or temporary changes. The process shall incorporate planning for the effects of the change for each of these situations. These procedures should cover the following:

- a) The process and mechanical design basis for the proposed change.
- b) An analysis of the safety, health, and environmental considerations involved in the proposed change, including, as appropriate, a hazards analysis.
- c) The necessary revisions of the operating procedures, safe work practices, and training programme.
- d) Communication of the proposed change and the consequences of that change to appropriate personnel.
- e) The necessary revisions of the safety and environmental information.
- f) The duration of the change, if temporary.
- g) Required authorizations to effect the change.

- viii) **Contractors** -When selecting contractors, operators should obtain and evaluate information regarding a contractor's safety and environmental management policies and practices, and performance thereunder, and the contractor's procedures for selecting sub-contractors. The entity shall communicate their safety and environmental management system expectations to contractors and identify any specific safety or environmental management requirements they have for contractors.

Interfacing of SMS of various entities (operator, contractor / service provider, subcontractor and third-party) should be ensured through a well written bridging document. Entity shall document the clear roles and responsibilities with its contractors.

- ix) **Assurance of quality and mechanical integrity of critical equipment-** Procedures in place should be implemented so that critical equipment for any facility is designed, fabricated, installed, tested, inspected, monitored, and maintained in a manner consistent with appropriate service requirements, manufacturer's recommendations or industry standards. Entity shall maintain inspection and testing procedures for safety-related equipment. Human factors should be considered, particularly regarding equipment accessibility for operation, maintenance and testing.

- x) **Pre-startup Safety Review-**Before a new or modified unit is started, a systematic check should be made to ensure that the construction and equipment are in accordance with specifications; operating procedures have been reviewed; hazards analysis recommendations have been considered, addressed and implemented; and personnel have been trained. It should be ensured that programmes to address management of change are in place.

- xi) **Permit to Work (PTW) System-** PTW system is a formal written system used to control certain types of work which are identified as potentially hazardous. Essential features of permit-to-work systems are:
 - a) clear identification of who may authorize particular jobs (and any limits to their authority) and who is responsible for specifying the necessary precautions;
 - b) training and instruction in the issue, use and closure of permits;
 - c) monitoring and auditing to ensure that the system works as intended;
 - d) clear identification of the types of work considered hazardous;
 - e) clear and standardized identification of tasks, risk assessments, permitted task duration and supplemental or simultaneous activity and control measures.

- xii) **Emergency Planning and Response-** A comprehensive Emergency Response and Disaster Management Plan (ERDMP) shall be developed in accordance to the Petroleum and Natural Gas Regulatory Board (Codes of Practices for Emergency Response and Disaster Management Plan (ERDMP)) Regulations, 2010. The copies of the ERDMP for the LNG facilities including jetty shall be maintained at each installation. The emergency response planning shall have clear written procedures for expected actions during anticipated emergencies. Emergency response plan shall include operational and procedural requirements for various emergency scenarios that are relevant for the installation.

The emergency procedures shall include, at a minimum, emergencies that are anticipated from an operating malfunction, structural collapse of part of the LNG plant, personnel error, forces of nature, and activities carried on adjacent to the plant.

- i. The emergency procedures shall include but not be limited to procedures for responding to controllable emergencies, including the following:
 - a. The notifying of personnel
 - b. The use of equipment that is appropriate for handling of the emergency
 - c. The shutdown or isolation of various portions of the equipment
 - d. Other steps to ensure that the escape of gas or liquid is promptly cut off or reduced as much as possible
- ii. The emergency procedures shall include procedures for recognizing an uncontrollable emergency and for taking action to achieve the following:
 - a. Minimize harm to the personnel at the LNG plant and to the public
 - b. Provide prompt notification of the emergency to the appropriate local officials, including the possible need to evacuate persons from the vicinity of the LNG plant
- iii. The emergency procedures shall include procedures for coordinating with local officials in the preparation of an emergency evacuation plan that sets forth the steps necessary to protect the public in the event of an emergency, including the following:
 - a. Quantity and location of fire equipment throughout the LNG plant
 - b. Potential hazards at the LNG plant
 - c. Communication and emergency-control capabilities at the LNG plant
 - d. Status of each emergency
- xiii) **Incident Investigation and Analysis-** Procedures for investigation of all incidents as per the Petroleum and Natural Gas Regulatory Board (Codes of Practices for Emergency Response and Disaster Management Plan (ERDMP)) Regulations, 2010 shall be developed. Incident investigations should be initiated as promptly as possible, considering the necessity of securing the incident scene and protecting people and the environment. The intent of the investigation should be to learn from the incident and help prevent similar incidents. A corrective action programme should be established based on the findings of the investigation to prevent recurrence.
- xiv) **Compliance Audit-** Safety Audits are the periodic examination of the functioning of safety system. It gives an idea about how effectively the safety system is implemented and how they are being accomplished. It is the feed back mechanism that provides management with the status and measurement of effectiveness of the various safety system elements and activities and leads to the appropriate control over these efforts.

The audit programme and procedures should cover:

- a) The activities and areas to be considered in audits
- b) The frequency of audits
- c) The audit team
- d) How audits will be conducted
- e) Audit Reporting

The findings and conclusions of the audit should be provided to the management. Management should establish a system to determine and document the appropriate response to the findings and to assure satisfactory resolution. The audit report should be retained at least until the completion of the next audit.

- 14.3** List of Standards and References referred to in Schedule 1 shall be as given in Annexure III.

ANNEXURE I

Requirements for LNG Installations using ASME Containers for stationary applications

1.0 Scope

1.1 This chapter provides requirements for the installation, design, fabrication, and siting of LNG installations using containers of 379 m³ capacity and less constructed in accordance with the ASME *Boiler and Pressure Vessel Code or Gas Cylinder Rules* for vehicle fueling and commercial and industrial applications.

1.2 The maximum aggregate storage capacity shall be 1060 m³.

2.0 General Requirements.

2.1 Site preparation shall include provisions for retention of spilled LNG, within the limits of plant property, and for surface water drainage.

2.2 All-weather accessibility to the site for emergency services equipment shall be provided.

2.3 Storage and transfer equipment at unattended facilities shall be secured to prevent tampering.

2.4 Operating instructions identifying the location and operation of emergency controls shall be posted conspicuously in the facility area.

2.5 Designers, fabricators, and constructors of LNG facility equipment shall be competent in the design, fabrication, and construction of LNG containers, cryogenic equipment, piping systems, fire protection equipment, and other components of the facility.

2.6 Supervision shall be provided for the fabrication, construction, and acceptance tests of facility components necessary to ensure that facilities are in compliance with this standard.

2.7 Facilities transferring LNG during the night shall have adequate lighting at the transfer area as specified in clause 8.9.1 of Schedule 1 B.

2.8 The maximum allowable working pressure shall be specified for all pressure-containing components.

3.0 Containers

3.1 All piping that is a part of an LNG container, including piping between the inner and outer containers, shall be in accordance with either Section VIII of the ASME *Boiler and Pressure Vessel Code*, or ASME B 31.3, *Process Piping*.

3.2 Internal piping between the inner tank and the outer tank and within the insulation space shall be designed for the maximum allowable working pressure of the inner tank, with allowance for thermal stresses.

- 3.3** Bellows shall not be permitted within the insulation space.
- 3.4** Containers shall be double-walled, with the inner tank holding LNG surrounded by insulation contained within the outer tank.
- 3.5** The inner tank shall be of welded construction and in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, or Static and Mobile Pressure Vessels Rules and shall be stamped and certified.
- 3.6** The inner tank supports shall be designed for shipping, seismic, and operating loads.
- 3.7** The support system to accommodate the expansion and contraction of the inner tank shall be designed so that the resulting stresses imparted to the inner and outer tanks are within allowable limits as per design.
- 3.8** The outer tank shall be of welded construction using any of the following materials:
- i. Any of the carbon steels in Section VIII, Part UCS of the ASME *Boiler and Pressure Vessel Code or equivalent* at temperatures at or above the minimum allowable use temperature in Table 1A of the ASME *Boiler and Pressure Vessel Code*, Section II, Part D.
 - ii. Materials with a melting point below 1093°C where the container is buried or mounded.
- 3.9** Where vacuum insulation is used, the outer tank shall be designed by either of the following:
- i. The ASME *Boiler and Pressure Vessel Code*, Section VIII, Parts UG- 28, -29, -30, and -33 or equivalent, using an external pressure of not less than 15 psi (100 kPa) .
 - ii. The CGA 341, *Standard for Insulated Cargo Tank Specification for Cryogenic Liquids*.
- 3.10** Heads and spherical outer tanks that are formed in segments and assembled by welding shall be designed in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Parts UG-28, -29, -30, and -33 or equivalent, using an external pressure of 15 psi (100 kPa).
- 3.11** The outer tank shall be equipped with a relief device or other device to release internal pressure.
- i. **3.11.1** The discharge area shall be at least 0.0034 cm²/kg of the water capacity of the inner tank, but the area shall not exceed 2000 cm².
 - ii. **3.11.2** The relief device shall function at a pressure not exceeding the internal design pressure of the outer tank, the external design pressure of the inner tank, or 25 psi (172 kPa), whichever is less.
- 3.12** Thermal barriers shall be provided to prevent the outer tank from falling below its design temperature.

3.13 Seismic Design.

3.13.1 Shop-built containers designed and constructed in accordance with the ASME *Boiler and Pressure Vessel Code or equivalent*, and their support systems, shall be designed for the dynamic forces associated with horizontal and vertical accelerations as follows:

$$V = Z_c \times W \text{ for horizontal force}$$

$$P = 2/3 \times Z_c \times W \text{ for vertical force}$$

where:

Z_c = the seismic coefficient equal to $0.60 S_{DS}$

S_{DS} = the maximum design spectral acceleration determined in accordance with the non building structures provisions of the *NEHRP Recommended Provisions for Seismic Regulation for New Buildings and Other Structures*, using an importance factor, I , of 1.0, for the site class most representative of the site conditions where the LNG facility is located

W = the total weight of the container and its contents

3.13.2 Usage.

- i. The method of design described in 3.13.1 shall be used only where the natural period T of the shop-built container and its supporting system is less than 0.06 second.
- ii. If the natural period T is 0.6 or greater, than seismic design provisions of IS 1893 shall apply.

3.13.3 The container and its supports shall be designed for the resultant seismic forces in combination with the operating loads, using the allowable stresses increase shown in the code or standard used to design the container or its supports.

3.14 Each container shall be identified by the attachment of a nameplate(s) in an accessible location marked with the following:

- i. Manufacturer's name and date built
- ii. Nominal liquid capacity
- iii. Design pressure at the top of the container
- iv. Maximum permitted liquid density
- v. Maximum filling level
- vi. Minimum design temperature

3.15 All penetrations of storage containers shall be identified.

4.0 Container Filling

Containers designed to operate at a pressure in excess of 15 psi (100 kPa) shall be equipped with a device(s) that prevents the container from becoming liquid full or from covering the inlet of the relief device(s) with liquid when the pressure in the container reaches the set pressure of the relieving device(s) under all conditions.

5.0 Container Foundations and Supports

5.1 LNG container foundations shall be designed and constructed in accordance with *NFPA 5000, Building Construction and Safety Code or equivalent*.

5.2 The design of saddles and legs shall including shipping loads, erection loads, wind loads, and thermal loads.

5.3 Foundations and supports shall have a fire resistance rating of not less than 2 hours and shall be resistant to dislodgement by hose streams.

5.4 LNG storage containers installed in an area subject to flooding shall be secured to prevent the release of LNG or flotation of the container in the event of a flood.

6.0 Container Installation

6.1 LNG containers of 3.8 m³ and smaller shall be located as follows:

- i. 0.47 m³ or less, zero m from buildings and the line of adjoining property.
- ii. 3.8 m³ or less, 3.0 m from buildings and the line of adjoining property.

6.2 Minimum Distance

6.2.1 The minimum distance from edge of impoundment or container drainage system serving aboveground and mounded containers larger than 3.8 m³ to buildings and property lines that can be built upon and between containers shall be in accordance with Table 1.

Table 1- Distances from Impoundment Areas to Property Lines

That Can be Built Upon		
Container Water Capacity	Minimum Distance from Edge of Impoundment or Container Drainage System to Property Lines that can be Built Upon	Minimum Distance Between Storage Containers
m³	m	m

3.8–7.6	4.6	1.5
7.6–56.8	7.6	1.5
56.8–114	15	1.5
114–265	23	1/4 of the sum of the diameters of adjacent containers [1.5 m minimum]
>265 and upto 379	0.7 times the container diameter [30 m minimum]	

6.2.2 The distance from edge of impoundment or container drainage system to buildings to buildings or walls of concrete or masonry construction shall be reduced from the distance in Table 1 with the approval of the authority having jurisdiction with a minimum of 3 m.

6.3 Underground LNG tanks shall be installed in accordance with Table 2.

Table 2 Spacing of Underground LNG Containers

Container Water Capacity (gal)	Minimum Distance from Buildings and the Adjoining Property Line That can be Built Upon (m)	Distance Between Containers (m)
< 57	4.6	4.6
57 – <114	7.6	4.6
>114 and upto 379	12	4.6

6.4 Buried and underground containers shall be provided with means to prevent the 0°C isotherm from penetrating the soil.

- 6.5** Where heating systems are used, they shall be installed such that any heating element or temperature sensor used for control can be replaced.
- 6.6** All buried or mounded components in contact with the soil shall be constructed from material resistant to soil corrosion or protected to minimize corrosion.
- 6.7** A clear space of at least 0.9 m shall be provided for access to all isolation valves serving multiple containers.
- 6.8** LNG containers of greater than 0.5 m³ capacity shall not be located in buildings.
- 6.9** Points of transfer shall be located not less than 7.6 m from the following:
- i. the nearest important building not associated with the LNG facility
 - ii. the line of adjoining property that can be built upon
- 6.10** LNG tanks and their associated equipment shall not be located where exposed to failure of overhead electric power lines operating at over 600 volts.

7.0 Automatic Product Retention Valves

- 7.1** All liquid and vapor connections, except relief valve and instrument connections, shall be equipped with automatic failsafe product retention valves.
- 7.2** Automatic valves shall be designed to close on the occurrence of any of the following conditions:
- i. Fire detection or exposure
 - ii. Uncontrolled flow of LNG from the container
 - iii. Manual operation from a local and remote location
- 7.3** Connections used only for flow into the container shall be equipped with either two backflow valves, in series, or a product retention valve.
- 7.4** Appurtenances shall be installed as close to the container as practical so that a break resulting from external strain shall occur on the piping side of the appurtenance while maintaining intact the valve and piping on the container side of the appurtenance.

8.0 LNG Spill Containment

- 8.1** Impoundment (dikes), topography, or other methods to direct LNG spills to a safe location and to prevent LNG spills from entering water drains, sewers, waterways, or any closed-top channel shall be used.
- 8.2** Flammable liquid storage tanks shall not be located within an LNG container impoundment area.

8.3 Impounding areas serving aboveground and mounded LNG containers shall have a minimum volumetric holding capacity including any useful holding capacity of the drainage area and with allowance made for the displacement of snow accumulation, other containers, and equipment, in accordance with the following:

- i. Where containers in the dike area are constructed or protected to prevent failure from spilled LNG and fire in the dike, the minimum holding of the dike shall be the volume of the largest container in the dike.
- ii. Where containers in the dike area not are constructed or protected to prevent failure from spilled LNG and fire in the dike, the minimum holding of the dike shall be the volume of the largest container in the dike.

8.4 Impounding areas shall be designed or equipped to clear rain or other water.

8.4.1 Where automatically controlled sump pumps are used, they shall be equipped with an automatic cutoff device that prevents their operation when exposed to LNG temperatures.

8.4.2 Piping, valves, and fittings whose failure could allow liquid to escape from the impounding area shall be designed to withstand continuous exposure to the temperature of LNG.

8.4.3 Where gravity drainage is employed for water removal, the gravity draining system shall be designed to prevent the escape of LNG by way of the drainage system.

9.0 Inspection

9.1 Prior to initial operation, containers shall be inspected to ensure compliance with the engineering design and material, fabrication, assembly, and test provisions of the chapter.

9.2 Inspectors shall be qualified in accordance with the code or standard applicable to the container and as specified in this standard.

10.0 Factory Testing of LNG Containers

10.1 The outer tank shall be leak tested.

10.2 Container piping shall be tested in accordance with ASME B 31.3, *Process Piping*.

11.0 Shipment of LNG Containers. Containers shall be shipped under a minimum internal pressure of 10 psi (69 kPa) inert gas.

12.0 Field Testing of LNG Containers

12.1 Containers and associated piping shall be leak tested prior to filling with LNG.

12.2 After acceptance tests are completed, there shall be no field welding on the LNG containers.

13.0 Welding on Containers.

13.1 Field welding shall be done on saddle plates or brackets provided for the purpose only.

13.2 Where repairs or modifications incorporating welding are required, they shall comply without the code or standard under which the container was fabricated.

13.3 Retesting by a method appropriate to the repair or modification shall be required only where the repair or modification is of such a nature that a retest actually tests the element affected and is necessary to demonstrate the adequacy of the repair or modification.

14.0 Piping

14.1 All piping that is part of an LNG container and the facility associated with the container for handling cryogenic liquid or flammable fluid shall be in accordance with ASME B 31.3, *Process Piping or equivalent*, and the following:

- i. Type F piping, spiral welded piping, and furnace butt-welded steel products shall not be permitted.
- ii. All welding or brazing shall be performed by personnel qualified to the requirements of the ASME *Boiler and Pressure Vessel Code*, Section IX or equivalent.
- iii. Oxygen-fuel gas welding shall not be permitted.
- iv. Brazing filler metal shall have a melting point exceeding 538°C.
- v. All piping and tubing shall be austenitic stainless steel for all services below -29°C.
- vi. All piping and piping components, except gaskets, seals, and packing, shall have a minimum melting point of 816°C.
- vii. Aluminum shall be used only downstream of a product retention valve in vaporiser service.
- viii. Compression-type couplings used where they can be subjected to temperatures below -29°C shall meet the requirements of ASME B 31.3, *Process Piping*, Section 315 or *equivalent*.
- ix. Stub-in branch connections shall not be permitted.
- x. Extended bonnet valves shall be used for all cryogenic liquid service, and they shall be installed so that the bonnet is at an angle of not more than 45 degrees from the upright vertical position.

14.2 The level of inspection of piping shall be specified.

15.0 Container Instrumentation

15.1 General

Instrumentation for LNG facilities shall be designed so that, in the event of power or instrument air failure, the system will go into a failsafe condition that can be maintained until the operators can take action to reactivate or secure the system.

15.2 Level Gauging

LNG containers shall be equipped with liquid level devices as follows:

- i. Containers of 3.79 m³ shall be equipped with two independent liquid level devices.
- ii. Containers smaller than 3.79 m³ shall be equipped with either a fixed length dip tube or other level devices.
- iii. Containers of 3.79 m³ shall have one liquid level device that provides a continuous level indication ranging from full to empty and shall be maintainable or replaceable without taking the container out of service.

15.3 Pressure Gauging and Control

15.3.1 Each container shall be equipped with a pressure gauge connected to the container at a point above the maximum liquid level that has a permanent mark indicating the maximum allowable working pressure (MAWP) of the container.

15.3.2 Vacuum-jacketed equipment shall be equipped with instruments or connections for checking the pressure in the annular space.

15.3.3 Safety relief valves shall be sized to include conditions resulting from operational upset, vapor displacement, and flash vaporization resulting from pump recirculation and fire.

15.4 Pressure relief valves shall communicate directly with the atmosphere.

15.5 Pressure relief valves shall be sized in accordance with 2.3.6 of these Regulations or CGA S-1.3, Pressure Relief Device Standards — Part 3 — Compressed Gas Storage Containers or as per design standard.

15.6 Inner container pressure relief valves shall have a manual full opening stop valve to isolate it from the container.

15.6.1 The stop valve shall be lockable or sealable in the fully open position.

15.6.2 The installation of pressure relief valves shall allow each relief valve to be isolated individually for testing or maintenance while maintaining the full relief capacities determined in 2.3.6 of these Regulations.

15.6.3 Where only one pressure relief valve is required, either a full-port opening three-way valve used under the pressure relief valve and its required spare or individual valves beneath each pressure relief valve shall be installed.

15.7 Stop valves under individual safety relief valves shall be locked or sealed when opened and shall not be opened or closed except by an authorized person.

15.8 Safety relief valve discharge stacks or vents shall be designed and installed to prevent an accumulation of water, ice, snow, or other foreign matter and, if arranged to discharge directly into the atmosphere, shall discharge vertically upward.

16.0 Fire Protection and Safety. The requirements of Sections 1F of these Regulations shall apply.

17.0 Gas Detectors. An operating portable flammable gas indicator shall be readily available.

18.0 Operations and Maintenance.

Each facility shall have written operating, maintenance, and training procedures based on experience, knowledge of similar facilities, and conditions under which they will be operated.

18.1 Basic Operations Requirements.

Each facility shall meet the following requirements:

- i. Have written procedures covering operation, maintenance, and training
- ii. Keep up-to-date drawings of plant equipment, showing all revisions made after installation
- iii. Revise the plans and procedures as operating conditions or facility equipment require
- iv. Establish a written emergency plan as part of the operations manual
- v. Establish liaison with appropriate local authorities such as police, fire department, or municipal works and inform them of the emergency plans and their role in emergency situations
- vi. Analyze and document all safety-related malfunctions and incidents for the purpose of determining their causes and preventing the possibility of recurrence

18.2 Operating Procedures Manual

18.2.1 Each facility shall have a written manual of operating procedures, including the following:

- i. Conducting a proper startup and shutdown of all components of the facility, including those for an initial startup of the LNG facility that will ensure that all components will operate satisfactorily
- ii. Purging and inerting components
- iii. Cooling down components
- iv. Ensuring that each control system is properly adjusted to operate within its design limits
- v. Maintaining the vaporization rate, temperature, and pressure so that the resultant gas is within the design tolerance of the vaporiser and the downstream piping
- vi. Determining the existence of any abnormal conditions and indicating the response to these conditions
- vii. Ensuring the safety of personnel and property while repairs are carried out whether or not equipment is in operation
- viii. Ensuring the safe transfer of hazardous fluids
- ix. Ensuring security at the LNG plant
- x. Monitoring operation by watching or listening for warning alarms from an attended control center and by conducting inspections on a planned, periodic basis
- xi. Monitoring the foundation heating system weekly

18.2.2 The manual shall be accessible to operating and maintenance personnel.

18.2.3 The manual shall be updated when changes in equipment or procedures are made.

18.2.4 The operations manual shall contain procedures to ensure the following:

- i. The cooldown of each system of components that is under its control, and that is subjected to cryogenic temperatures, is limited to a rate and distribution pattern that maintains the thermal stresses within the design limits of the system during the cooldown period, having regard to the performance of expansion and contraction devices.
- ii. Each facility has procedures to check each cryogenic piping system that is under its control during and after cooldown stabilization for leaks in areas where there are flanges, valves, and seals.

18.2.5 Each operations manual shall include purging procedures that when implemented minimize the presence of a combustible mixture in plant piping or equipment when a system is being placed into or taken out of operation.

18.2.6 The operations manual shall contain procedures for loading or unloading operations applicable to all transfers, including the following.

- i. Written procedures shall cover all transfer operations and shall cover emergency as well as normal operating procedures.
- ii. Written procedures shall be kept up-to-date and available to all personnel engaged in transfer operations.
- iii. Prior to transfer, gauge readings shall be obtained or inventory established to ensure that the receiving vessel cannot be overfilled.
- iv. Levels of the receiving vessel shall be checked during transfer operations.
- v. The transfer system shall be checked prior to use to ensure that valves are in the correct position.
- vi. Pressure and temperature conditions shall be observed during the transfer operation

18.2.7 Each operations manual for a facility that transfers LNG from or to a cargo tank vehicle or a tank car shall contain procedures for loading or unloading of tank car or tank vehicles, including the following:

- i. While tank car or tank vehicle loading or unloading operations are in progress, rail and vehicle traffic shall be prohibited within 25 ft (7.6 m) of LNG facilities or within 50 ft (15 m) of refrigerants whose vapors are heavier than air.
- ii. Prior to connecting a tank car, the car shall be checked and the brakes set, the derailer or switch properly positioned, and warning signs or lights placed as required.
- iii. The warning signs or lights shall not be removed or reset until the transfer is completed and the car disconnected.
- iv. Unless required for transfer operations, truck vehicle engines shall be shut off.
- v. Brakes shall be set and wheels checked prior to connecting for unloading or loading.
- vi. The engine shall not be started until the truck vehicle has been disconnected and any released vapors have dissipated.
- vii. Prior to loading LNG into a tank car or tank vehicle that is not in exclusive LNG service, a test shall be made to determine the oxygen content in the container.
- viii. If a tank car or tank vehicle in exclusive LNG service does not contain a positive pressure, it shall be tested for oxygen content.

- ix. If the oxygen content in either case exceeds 2 percent by volume, the container shall not be loaded until it has been purged to below 2 percent oxygen by volume.

18.3 Emergency Procedures.

18.3.1 Each facility shall have a written manual of emergency procedures included in the operations manual that shall include the types of emergencies that are anticipated from an operating malfunction, structural collapse of part of the facility, personnel error, forces of nature, and activities carried on adjacent to the facility, including the following:

- i. Procedures for responding to controllable emergencies, including notification of personnel and the use of equipment that is appropriate for handling of the emergency and the shutdown or isolation of various portions of the equipment and other applicable steps to ensure
- ii. that the escape of gas or liquid is promptly cut off or reduced as much as possible
- iii. Procedures for recognizing an uncontrollable emergency and for taking action to ensure that harm to the personnel at the facility and to the public is minimized
- iv. Procedures for the prompt notification of the emergency to the appropriate local officials, including the possible need to evacuate persons from the vicinity of the facility
- v. Procedures for coordinating with local officials in the preparation of an emergency evacuation plan that sets forth the steps necessary to protect the public in the event of an emergency

18.3.2 When local officials are contacted in an emergency, procedures shall include the method of notification of the following:

- i. The quantity and location of fire equipment throughout the facility
- ii. Potential hazards at the facility
- iii. Communication and emergency control capabilities of the facility
- iv. The status of each emergency

18.3.3 A comprehensive Emergency Response and Disaster Management Plan (ERDMP) shall be developed in accordance to the Petroleum and Natural Gas Regulatory Board (Codes of Practices for Emergency Response and Disaster Management Plan (ERDMP)) Regulations, 2010.

18.4 Maintenance

Each facility shall have written maintenance procedures based on experience, knowledge of similar facilities, and conditions under which they will be maintained.

18.4.1 Each facility operator shall carry out periodic inspection, tests, or both, as required on every component and its support system in service in its facility, to verify that it is maintained in accordance with the equipment manufacturer's recommendations and the following:

- i. The support system or foundation of each component shall be inspected at least annually to ensure that the support system or foundation is sound.

- ii. Each emergency power source at the facility shall be tested monthly to ensure that it is operational and annually to ensure that it is capable of performing at its intended operating capacity.
- iii. When a safety device serving a single component is taken out of service for maintenance or repair, the component shall also be taken out of service, except where the safety function is provided by an alternate means.
- iv. Where the operation of a component that is taken out of service could cause a hazardous condition, a tag bearing the words “Do Not Operate,” or the equivalent thereto, shall be attached to the controls of the component, or the component shall be locked out.
- v. Stop valves for isolating pressure or vacuum-relief valves shall be locked or sealed open and shall be operated only by an authorized person.
- vi. No more than one pressure or vacuum relief valve stop valve shall be closed at one time on an LNG container.

18.4.2 Maintenance Manual

- i. Each facility operator shall prepare a written manual that sets out an inspection and maintenance programme for each component that is used in its facility.
- ii. The maintenance manual for facility components shall include the following:
 - a) The manner of carrying out and the frequency of the inspections and tests as specified in 18.4.1.
 - b) A description of any other action in addition to those referred to in 18.4.2.ii. a) that is necessary to maintain the facility in accordance with this standard.
 - c) All procedures to be followed during repairs on a component that is operating while it is being repaired to ensure the safety of persons and property at the facility
- iii. Each facility operator shall conduct its maintenance programme in accordance with its written manual for facility components.

18.4.3 Facility Maintenance

- i. Each facility operator shall keep the grounds of its facility free from rubbish, debris, and other materials that could present a fire hazard.
- ii. Each facility operator shall ensure that the components of its facility are kept free from ice and other foreign materials that could impede their performance.
- iii. Each facility operator shall maintain the grassed area of its facility so that it does not create a fire hazard.
- iv. All fire-control access routes within an LNG facility shall be maintained and kept unobstructed in all weather conditions.

18.4.4 Repairs that are carried out on components of its facility shall be carried out in a manner that ensures the following:

- i. The integrity of the components is maintained, in accordance with this standard.
- ii. Components will operate in a safe manner.
- iii. The safety of personnel and property during a repair activity is maintained.

18.4.5 Each facility operator shall ensure that a control system that is out of service for 30 days or more is tested prior to returning it to service to ensure that it is in proper working order.

- i. Each facility operator shall ensure that the inspections and tests in this section are carried out at the intervals specified.
- ii. Control systems that are used seasonally shall be inspected and tested before use each season.
- iii. Control systems that are used as part of the fire protection system at the facility shall be inspected and tested in accordance with the applicable fire code.
- iv. Relief valves shall be inspected and set point tested at least once every 2 calendar years, with intervals not exceeding 30 months, to ensure that each valve relieves at the proper setting.
- v. The external surfaces of LNG storage tanks shall be inspected and tested as set out in the maintenance manual for the following:
 - a) Inner tank leakage
 - b) Soundness of insulation
 - c) Tank foundation heating to ensure that the structural integrity or safety of the tanks is not affected
- vi. LNG storage plants and, in particular, the storage container and its foundation shall be externally inspected after each major meteorological disturbance to ensure that the structural integrity of the plant is intact.

18.4.6 Maintenance Records

- i. Each facility operator shall maintain a record of the date and type of each maintenance activity performed.
- ii. Maintenance records shall be retained for as long as the facility is in service.

18.5 Training

The requirements as given in Schedule 1 E of these Regulations shall apply.

ANNEXURE II

¹[Table - Minimum separation Distance between Blocks/Facilities

(all distance in metre)

Sl. No.	From / To	1	2	3	4	5	6	7	8
1	Process Units	Note-1	Note-2	30	90	45	60	60	15
2	Process Control Room	Note-2	X	Note-3	90	45	30	30	X
3	LNG Storage Tanks	30	Note-3	(D1+D2)/4	90	30	60	0.7D	60
4	Flare (Note-4)	90	90	90	X	90	90	90	90
5	Bulk LNG Loading/ Unloading	45	45	30	90	Note 5	90	Note 5	30
6	Fire Station / First Aid Center	60	30	60	90	90	X	12	X
7	Boundary wall around installation	60	30	0.7D	90	30	12	X	15
8	Electrical Sub Station	15	X	60	90	30	X	15	X

General Notes to Table :

- i. All distances are in meters. ²[*****] ³["X"] means any distance suitable for constructional or operational convenience. ⁴["D" stands for diameter of the LNG storage tank.]

¹ Subs. by sub-cl.(a) of cl (iii) of reg. (2), the Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Amendment Regulations, 2023 (w.e.f. 15.02.2023)

² The words and expression mentioned are omitted by pt. (i) of sub-cl.(b) of cl (iii) of reg. (2), *ibid.* (w.e.f. 15.02.2023)

³ Supra 2 (w.e.f. 15.02.2023)

⁴ Supra 2 (w.e.f. 15.02.2023)

- ii. All distances shall be measured between the nearest points on the perimeter of each facility except ¹[in] case of tank vehicle loading / unloading area where the distance shall be from the center of nearest bay. ²[****]

Specific notes to Table :

Note-1: This shall be 36 meters considering the 6-meter wide road passing through the center. The edge of the road shall not be less than 15 meters away from the edge of the unit.

Note-2: Process control room to Process units / boiler house / heaters the minimum separation distance shall be 30 m. For a control room attached to single process unit or a boiler or a heater, the minimum separation distance shall be 16 m. For Gas processing plants, it shall be minimum 30 meters irrespective of whether it is for one or more units.

Note-3: Shall be 60 m for non-blast construction and 30 m for blast resistant construction.

Note-4: The distances specified are for the elevated flare. For ground flare, these distances shall be 150 m. ³[****]

⁴Note-5: (i) In case of bulk loading/unloading gantry, minimum separation distance between: -

(a) Tank wagon gantry to tank wagon gantry, tank truck gantry and boundary wall shall be 50 m.

(b) Tank truck gantry to tank truck gantry and boundary wall shall be 30m.

(ii) The number of LNG tank lorry bays in a single tank trunk gantry shall not exceed 8.”]

¹ Subs. by pt. (ii) of sub-cl.(b) of cl (iii) of reg. (2), the Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Amendment Regulations, 2023 (w.e.f. 15.02.2023)

² The words and expression mentioned are omitted by Supra 1 (w.e.f. 15.02.2023)

³ The words and expression mentioned are omitted by pt. (i) of sub-cl.(c) of cl (iii) of reg. (2), *ibid.* (w.e.f. 15.02.2023)

⁴ Ins. by pt. (ii) of sub-cl.(c) of cl (iii) of reg. (2), *ibid.* (w.e.f. 15.02.2023)

ANNEXURE III

LIST OF STANDARDS AND REFERENCES

Standard Number	Title of Standard
API 620	Design and Construction of Large Welded Low Pressure Storage Tanks
API 625	Tank Systems for Refrigerated Liquefied Gas Storage
ASME B31.3	Process Piping
CGA 341	Specification For Insulated Cargo Tank For Nonflammable Cryogenic Liquids
EN 14620	Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and (-)165°C
NFPA 59A	Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)
NFPA 5000	Building Construction and Safety Code
IS 3043	Code of Practice for Earthing
IS 1893	Criteria for Earthquake Resistant Design of Structures
IS 5571	Guide for selection and installation of electrical equipment in hazardous areas
IS 325	Three-Phase Induction Motors
IS 2309	Protection of Buildings and Allied Structures Against Lightning - Code Of Practice
IEC 60072	Dimensions and output series for rotating electrical machines
IEC 60079	Explosive Atmospheres
IEC 62271	High-voltage switchgear and controlgear
IEC 62305	Protection against lightning
BS 31	Specification for Steel Conduit and Fittings for Electrical Wiring
GAP 2.5.1	Fireproofing for Hydrocarbon Fire Exposures

API 2218	Fireproofing Practices in Petroleum and Petrochemical Processing Plants
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection
EN 12065	Installations and Equipment for Liquefied Natural Gas. Testing of foam concentrates designed for generation of medium and high expansion foam and of extinguishing powders used on liquefied natural gas fires
EN 1473	Installation and equipment for liquefied natural gas. Design of onshore installations
EN 12434	Cryogenic vessels. Cryogenic flexible hoses
EN 1532	Installation and Equipment for Liquefied Natural Gas. Ship to Shore Interface
SIGTTO	Society of International Gas Tankers and Terminals Operators
IEC	The International Electrotechnical Commission
IE Rules	Indian Electricity Rules
IP Model code of Safe Practices	Institute of Petroleum Model code of Safe Practices
Petroleum and Natural Gas Regulatory Board (Codes of Practices for Emergency Response and Disaster Management Plan) Regulations, 2010	
ASME Boiler and Pressure Vessel Code	

Vandana Sharma, Secy.
[ADVT.-III/4/Exty./402/17]

Footnote: The Principal regulations were notified in the official gazette vide F. No. INFRA/T4S/LNG/05, dated 18th January, 2018 and amended vide F. No. PNGRB/Tech/4-T4SLNG/(1)/2019 (P-3317) dated 15th February 2023