

PETROLEUM AND NATURAL GAS REGULATORY BOARD

NOTIFICATION

New Delhi, 15th February, 2019

F. No. PNGRB/Tech/6-T4SLPG/(1)/2019. 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 LPG Storage, Handling and Bottling Facilities) Regulations, 2019.
- (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 (19 of 2006);
 - (b) “Approved Type”, in respect of an equipment, means the specific approval for use of the equipment under specified conditions by competent authority or authorized person, in this behalf, as the case may be;
 - (c) “Area Classification” means a method of classifying an area zone wise or group wise based on the presence of explosive gas or vapour – air mixture vis-a-vis the requirement of precautions for construction and use of electrical apparatus;
 - (d) Board” means the Petroleum and Natural Gas Regulatory Board established under sub-section (1) of section 3 of the Act;
 - (e) “Bonding” means the process by which two electrical conducting bodies are connected using a conductor to maintain electrical continuity to prevent sparking between two conducting bodies;
 - (f) “Bullet” means a horizontal cylindrical pressure vessel used for storage or transportation of LPG by rail or road;
 - (g) “Chapter” means the Chapter of the Schedule in which it occurs;
 - (h) “Compressed Gas” means any permanent gas, liquefiable gas or gas dissolved in liquid under pressure or gas mixture which in a closed container exercises a pressure either exceeding 2.5 kg/sq.cm. abs @ 15 oC or a pressure exceeding 3.0 kg/Sq.cm. abs @ 50 oC, or both;
 - (i) “Cylinder” means a portable LPG container up to 1000 liters water capacity used

for both domestic and industrial purposes;

- (j) “Design Pressure” means the saturated vapour pressure at design temperature;
- (k) “Explosive mixture” means a mixture of combustion agent (oxidizing product-gas, vapour, liquid or solid) and a fuel (oxidisable product - gas, liquid or solid) in such proportions that it could give rise to a very rapid and lively oxidization reaction liberating more energy than is dissipated through conduction and convection;
- (l) “Earthing” means the provision of a safe path of electrical current to ground, in order to protect structures, plant and equipment from the effects of stray electrical current, and electrostatics discharge;
- (m) “Filling Ratio” is the ratio of weight of LPG in a container to the weight of water the same container can hold at 15° C;
- (n) “Fire safe” as applied to valves, means the concept of controlling the leakage to an acceptable level after damage encountered during and after the fire achieved by dual seating;
- (o) “Fire proofing” means an insulation that provides a degree of fire resistance to protect substrates like vessels, piping and structures for a predetermined time period against fire;
- (p) “Flammability” means the percentage of volume of any flammable vapour in air-vapour mixtures capable to form an explosive mixture;
- (q) “Flammable (or Inflammable)” means any substance which when tested in a specified manner will ignite when mixed with air on contact with a flame and will support combustion;
- (r) “Gas-Free” means the concentration of flammable or toxic gases, or both in a pressure vessel or pipeline is within the safe limits specified for persons to enter and carryout hot work in such vessel or pipeline;
- (s) Hazardous area: An area shall be deemed to be a hazardous area, where-
 - (i) petroleum having flash point below 65°C or any flammable gas or vapour in a concentration capable of ignition is likely to be present; and
 - (ii) petroleum or any flammable liquid having flash point above 65°C is likely to be refined, blended, handled or stored at or above its flash point;
- (t) “Horton Sphere” means a spherical pressure vessel used for storage of LPG;
- (u) “Hot Work” means an activity which may produce enough heat to ignite a flammable air-hydrocarbon mixture or a flammable substance;
- (v) “Kerb Wall” means a wall of appropriate height and size constructed of suitable material and designed to contain the LPG spillage and to direct it to a safe location around the storage vessel;

- (w) "Liquefied Petroleum Gas (LPG)" means a mixture of light hydrocarbons containing propane, isobutene, normal butane, butylene, or such other substance which is gaseous at normal ambient temperature and atmospheric pressure but may be condensed to liquid state at normal ambient temperature by the application of pressure and conforms to IS:4576 or IS 14861";
 - (x) "LPG facilities" means a group of one or more units or facilities i.e. unloading or loading, storage, pumps, compressors, bottling, receipt or dispatch through pipelines and like other facilities and associated systems like utilities, fire water storage and fire water network, control room, administration service buildings, stores and like other associated system;
 - (y) "Process unit" means a unit having integrated sequence of operation, physical and chemical and may involve preparation, separation, purification, or change in state, energy content or composition;
 - (z) "Purging into service" is the replacement of air in a closed system by an inert substance and replacement of the later by combustible gas, vapour, or liquid;
 - (aa) "Purging out of service" is the replacement of normal combustible content of a closed system by an inert substance, and replacement of the later by air;
 - (bb) "Schedule" means the Schedule appended to these regulations;
 - (cc) "Shall" indicates that the provision in which it occurs is mandatory;
 - (dd) "Should" indicates that the provision in which it occurs is recommendatory but not mandatory;
 - (ee) "Tare Weight" means the weight of the cylinder together with any fitting permanently attached to it including the weight of valve;
 - (ff) "Maximum Working Pressure" is saturated vapour pressure at design temperature;
 - (gg) "Water Capacity" means the maximum volume of water in litre that a container can hold at 15 oC; and
 - (hh) "Vessel" means a pressure vessel used for more than 1000 liters water capacity for storage or transportation of LPG.
- (2) Words and expressions used and not defined in these regulations, but defined in the Act or in the rules or other regulations made there under, shall have the meanings respectively assigned to them in the Act or in the rules or such other regulations, as the case may be.

3. Scope:

- (1) Requirements of these regulations shall apply to all existing and new LPG storage, handling and bottling facilities including at refineries, gas processing plants and LPG pipelines. The process units at refineries and gas processing plants as well as LPG pipelines are not included in these Regulations. For LPG pipelines and its

associated facilities, the PNGRB (Technical Standards and Specifications including Safety Standards for Petroleum and Petroleum Products Pipelines) Regulations, 2016 shall be applied.

- (2) These regulations cover the minimum requirements for engineering and safety considerations in layout, design, storage, LPG tank trucks, pipelines, bulk handling, operating procedures, bottling operations, maintenance, inspection, safety management system, fire protection facilities, competence assurance, emergency management plan, gas monitoring system of LPG Storage, Handling and Bottling Facilities.

4. Application:

Definitions, layout, design, storage, LPG tank trucks, pipelines, bulk handling, operating procedures, bottling operations, maintenance, inspection, safety management system, fire protection facilities, competence assurance, emergency management plan, gas monitoring system of LPG Storage, Handling and Bottling Facilities. shall be construed in accordance with the requirements of these regulations.

5. Objective:

The standards specified in these regulations are intended to ensure uniform application of design principles in layout, material and equipment selection, construction and like other activity, adoption of standard operating procedures, proper maintenance, inspections, competence assurance for safe operation of the LPG Storage, Handling and Bottling Facilities and shall primarily focus on safety aspects of the employees, public and facilities associated with LPG Storage, Handling and Bottling.

6. The standard: -

- (1) Technical standards and specifications including safety standards (hereinafter in these regulations referred to as standards) for LPG Storage, Handling and Bottling Facilities are as specified in Schedule-I which cover layout, design, storage, LPG tank trucks, pipelines, bulk handling, operating procedures, bottling operations, maintenance, inspection, fire protection facilities, competence assurance, emergency management plan, gas monitoring system and safety management system.
- (2) The standards for capacity up-to 100 MT and maximum bottling of 20 MT per day on design, layout, storage, loading or unloading, operation LPG storage, handling and bottling are specified in Schedule – 2 and, Schedule – 2 also specifies the additional minimum safety requirements on design, layout, storage, loading or unloading, operation at LPG installations having Bulk Storage, exceeding 100 MT but limited to 300 MT for aboveground storage and, also for 450 MT in mounded or in combination of aboveground and mounded storage of LPG with total bottling quantity not exceeding 50 MT per shift of 8 hours and for LPG Storage, Handling and Bottling Facilities exceeding either of the above limits, Schedule – 1 shall be applicable.

- (3) The standards for Refrigerated LPG Storage facilities are as specified in Schedule – 3 which covers the minimum safety requirements for Design, Layout, Operation, Maintenance and like other matters.
- (4) The standards for design, layout, operation and maintenance of Unlined underground rock cavern storage for petroleum and liquefied petroleum gas are as specified in in Schedule – 4.

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 concerned regulations on third party conformity assessment.
- (2) Any entity intending to set up LPG facilities, installation shall make available the self-certification of its detailed plan including design consideration conforming to these regulations to PESO for their approval.
- (3) If an entity has laid, built, expanded or has under construction the LPG facilities 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 and the entity shall thereafter take approval from its highest decision-making body or 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 PNGRB (Board) within six months from the date of notification of these regulations in the official gazette.

8. Default and Consequences:

¹[(1) There shall be an established comprehensive system to ensure compliance with the provisions of these regulations, encompassing the conduct of technical and safety audits throughout the stages of design, pre-construction, construction, commissioning, and operation, and also on an ongoing basis, as periodically specified. Details of any planned project along with Detailed Feasibility Report (DFR), layout, PESO approval and Environmental Clearance etc. as may be applicable, shall be submitted to Board at least one month prior to commencing the construction.

(2) The Board shall monitor the compliance with Technical Standards and Specifications, including Safety Standards, either directly or through an accredited third party via separate regulations on third-party conformity assessment.

(3) For the purpose of these Regulations, in event of any default or deviation or shortfall, the entity shall be liable to face the imposition of civil penalty as per Section 28 of the PNGRB Act, 2006 and/or suspension/termination of operation, as per following procedure:

(a) The Board shall issue a notice to the entity, allowing it a reasonable time period to

¹ Subs. by Cl(a), Reg 2, the Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for LPG Storage, Handling and Bottling Facilities) Amendment Regulations, 2025. (w.e.f. 23.07.2025)

fulfil its obligations under the regulations;

(b) No punitive action shall be taken in case remedial action is taken by the entity, to the satisfaction of the Board, within the time period specified by the Board;

(c) In case the entity fails to undertake remedial action within such time period, the Board may, after giving such entity an opportunity of being heard, by order in writing, direct that, without prejudice to any other penalty which the entity may be liable for, such entity shall pay, by way of civil penalty, an amount which shall not exceed one crore rupees for each contravention, and in case of a continuing failure, additional penalty which may extend to ten lakh rupees for every day. In addition, the Board, if it deems appropriate, may direct for suspension or termination of operations of the said entity.

(d) If the entity fails to comply with the directions passed by the Board, as provided in clause (c), the Board may take appropriate action as prescribed for offences and punishment under Chapter IX of the Act.

Provided that, notwithstanding anything contained in clauses (a) to (d) of sub-regulation (3), in cases

- (i) where the violation on the part of the entity poses an imminent danger to public safety or
- (ii) where the Board determines, in public interest or in the interest of State security, that it is so required,

the Board may, apart from requiring the entity to take immediate remedial action, also direct for immediate suspension of operations of the said entity and in such cases, an opportunity of being heard may be deferred and afforded subsequently to the entity by the Board.

Note 1: Planned projects shall include all greenfield projects and, in the case of brownfield projects, shall encompass any addition to storage, handling, or processing capacity, increase in manpower, or increase in risk level of any installation/facility.]

9. Requirements under other statutes:

It shall be necessary for an entity to comply with the provisions of statutory rules, regulations and Acts in force as applicable and requisite approvals shall be obtained from the relevant competent authorities for LPG Storage, Handling and Bottling Facilities and in case of non-compliance of such provision, the entity shall be liable to termination of operation.

10. Miscellaneous:

- (1) If any dispute arises with regard to the interpretation of any of the provisions of these Regulations, the matter may be referred to the Board and the decision of the Board on such matter shall be final.
- (2) The Board may at any time effect by order, published in the official gazette, appropriate modifications in these regulations to remove any difficulty in the proper implementation of any provision of these regulations.

- (3) The Board may issue guidelines, consistent with the Act to meet the objective of these regulations, as it may deem fit.

SCHEDULE -1

[See regulation 6(I)]

STANDARDS FOR LPG STORAGE, HANDLING AND BOTTLING FACILITIES

Contents of the Schedule:

This schedule is comprised of chapter respectively containing Layout and Design, LPG Tank Trucks (Requirements of Safety on Design and Fabrication and Fittings), Piping Safety in Installation and Maintenance of LPG Cylinders Manifold, Operating Procedures (Bulk Loading and Unloading), Bottling Operations, Operation, Maintenance and Inspection, Safety Management System, Fire Protection Facilities, Gas Monitoring System and Competence Assurance and Assessment

CHAPTER -I

LAYOUT and DESIGN

1.1 General:

The layout of the LPG 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 and the facilities within the premises shall permit access from at least two directions.

This Chapter and the general principles of layout of LPG storage, handling, and bottling facilities have been detailed in various facilities within LPG installation shall be located based on Table-I and Table-II in this Chapter.

1.2 LOCATION AND SEPARATION DISTANCES:

1.2.1 LOCATION:

While assessing the suitability of any site for location of LPG installation, the following aspects shall be considered, namely: -

- (i) The location of residential quarters, other industries, railways, roads, waterways, overhead power lines, places of public assemblies and like other locations and such locations This shall be covered in risk analysis study of the proposed site and the study shall also be used to plan for emergency measures;
- (ii) Adequate availability of water from a reliable source or alternate arrangements proposed;
- (iii) The topographical nature of the site with specific reference to its effect on the accidental release of LPG;
- (iv) The availability of space for future extension of LPG facilities, if any, shall also comply with the safety norms; and

- (v) The meteorological data of the location including predominant wind direction and velocity, high flood level, temperatures, cyclone, earthquake and like other factors.

1.2.2 SEPARATION DISTANCES:

The separation distances for above ground storage vessels as given in Table- I and Table- II in this Chapter are the distances in plane between the nearest point on a vessel other than the filling or discharge line and a specified feature, e.g. adjacent vessel, site boundary and like other features.

1.3 LAYOUT:

The following aspects shall be considered while establishing layout of above ground LPG storage vessels and bullets or spheres are used for above ground storage of LPG; namely: -

- (i) The access of mobile firefighting equipment to the storage vessels shall be at least from two sides;
- (ii) Longitudinal axis of static storage vessels (above ground bullets) shall not be pointing pointed towards other vessels and vital equipment e.g. LPG cylinder sheds, tank lorry or tank wagon gantries, LPG pump house, first ROV of mounded vessels and buildings wherein control panels for fire and gas detection or actuation panels are situated;
- (iii) Storage vessels should be located in pre-dominant downwind of potential ignition sources at lower elevation;
- (iv) No foreign material or combustible substances shall be stored in storage area;
- (v) Storage vessels shall be laid out in single row in each group and
- (vi) Storage vessels shall not be located one above the other.

1.4 LPG STORAGE FACILITIES:

1.4.1 Confinement or Grading:

- (i) Kerb wall shall be provided around all sides of the storage vessel with concrete flooring of the ground and the concrete flooring under vessel shall extend upto minimum distance of $D/2$ or 5M from the vertical shadow of the storage vessel, whichever is higher, with a slope of 1:100 (min.);
- (ii) Grading of the ground underneath should be levelled and directed to an area connected with water seal away from the storage vessel;
- (iii) Kerb wall height shall be minimum 30 cm but shall not exceed 60 cm otherwise evaporation of spilled LPG may get affected;
- (iv) Spillage diversion area shall be located at a distance where the flames from fire will not impinge on the vessel and such distance shall not be less than 15 M from the nearest vessel and no accumulation of LPG shall be permitted underneath the storage vessel; and

- (v) In case of mounded vessels, a kerb wall of appropriate height and size and designed to contain the LPG spillage and to direct it to a safe location at appropriate distance shall be provided.

1.4.2 **Piping:**

Only piping associated with the storage vessels shall be located within the storage areas or between the storage area and the manifold system.

1.4.3 **Surface Drainage:**

In order to prevent the escape of spillage into the main drainage system, surface water from the storage area and from the manifold area shall be directed to the main drainage through a water seal to avoid the spread of LPG and in case, plant drain is discharging in the storm drain going outside the plant, then water seal shall also be provided at interconnecting sump inside the plant.

Water seal should have adequate capacity to drain fire fighting sprinkler water without over flowing. Water seal shall be provided with permanent water connection with metallic float for auto replenishment of water. LPG Plant shall prepare the drawing of complete plan drainage with water seal locations.

1.4.4 **Grouping:**

Vessels shall be arranged into groups, each having a maximum of six vessels and there shall be minimum spacing as specified in Table-I in this Chapter between adjacent vessels and each group shall be separated by roads on all four sides for easy access and emergency handling.

- 1.4.5 Spheres, bullets and mounded vessels shall be treated as separate groups. Groups shall be separated by minimum 30 M distance and such inter distance shall be measured between the vertical shadow of adjacent vessels of the concerned groups.

- 1.4.6 Top surfaces of all the vessels installed in a group shall be on the same elevation and separate manifolds with independent pumping facilities should be provided for groups with dissimilar elevation and in case manifold from two groups with dissimilar elevation are interconnected, they shall be connected through fail safe device like 3 way valves or equivalent system e.g. logic controlled or interlocked valves to prevent migration of LPG from vessels with higher elevation to the vessels at lower elevation due to gravitation and overfilling of vessel at lower elevation.

1.5 **LPG BULK LOADING AND UNLOADING FACILITIES:**

- 1.5.1 LPG tank lorry loading or unloading gantry shall be covered and located in a separate block and shall not be grouped with other petroleum products.
- 1.5.2 LPG loading or unloading rail gantries shall have separate rail spur and be grouped separately at least 50 M from other rail shunting facilities.
- 1.5.3 Space for turning with minimum radius of 20 M for tank lorries shall be provided commensurate with the capacities of the tank trucks.
- 1.5.4 LPG tank wagon loading or unloading shall be restricted to a maximum of half rake, not exceeding 600 tonnes and if full rake loading or unloading is envisaged this shall be done on two separate rail gantries separated by a minimum distance of 50M.

- 1.5.5 Maximum number of LPG tank lorry bays shall be restricted to 8 in one group and separation distance between the two groups shall not be less than 30 M.
- 1.5.6 For adequate permanent protection for tank lorry discharge, Pipeline island shall be provided and the minimum width of such pipeline island shall be 1 M.
- 1.5.7 The layout of the unloading location shall be such that tank truck being unloaded shall be in drive out position.
- 1.5.8 The weigh bridge of adequate capacity shall be provided with proper manoeuvrability for vehicles.
- 1.5.9 Tank truck shall be loaded or unloaded with suitable arrangement for cold flaring of hose or loading or unloading arm content, if used at the end of the operations.
- 1.5.10 LPG tank truck parking area (bulk or packed) shall be located in a secured area with entry or exit gates and the parking area shall be provided with adequate no. of hydrants or monitors to provide firefighting coverage for entire parking area from all sides and the parking area's entry or exit gates and the parking area shall be under real time visual supervision (security guard or CCTV cameras) and proper slotting or marking shall be done for safe parking of bulk and packed lorries in parking area.
- 1.5.11 Parking area shall be adequate for parking of bulk lorries and packed lorries so as to avoid parking of the bulk or packed trucks on the plant approach road and the parking area shall be adequate to accommodate (minimum) following requirements of the plant:-
 - (a) Bulk lorries required for 8 hours of maximum rated capacity of the plant bottling.
 - (b) In case of bulk loading location, bulk lorries required for 8 hours of maximum rated bulk loading capacity of the plant.
 - (c) Packed Lorries required for 4 hours of maximum rated capacity of the plant bottling.
 - (d) The requirement of parking area can be optimized based on the fleet management system. However, the bulk or packed lorries shall not be parked near the vicinity of the plant.

1.6 LPG BOTTLING FACILITIES:

- 1.6.1 LPG bottling facilities shall be located at a safe distance from other facilities with minimum ingress of traffic and upwind direction with respect to bulk storage and there shall not be any deep ditches excluding storm water drains in the surrounding areas at least within 15 M from storage sheds to avoid settling of LPG vapour.
- 1.6.2 LPG bottling section shall be of single storey and antistatic mastic flooring conforming to IS-8374 shall be provided in the LPG filling shed or cylinder storage including valve changing shed to avoid frictional sparks and the shed shall be supported by RCC columns alternatively structure steel columns, which shall be covered with concrete or fire-proofing material up to full height of columns and anti-static mastic coating up to 1.5 m (Min.) shall be done of the supporting columns of the shed.
- 1.6.3 Separate sheds for filled cylinders storage, valve changing and degassing shall be provided. Degassing unit can also be provided in valve change shed, however closed loop vent pipe arrangement shall be provided for venting out the gas released during water filling at a height not less than 1.5 m above the eaves of the shed. GMS sensor shall be provided in the degassing/ valve changing shed.
- 1.6.4 Vapour extraction system and GMS sensor shall be provided near degassing unit

- 1.6.5 Empty cylinders storage area shall be properly segregated from filling machines by 5 M (Min.) and the cylinders shall always be stacked vertically with maximum stack height of 1.5 m.
- 1.6.6 LPG cylinder filling machines and other related testing facilities shall be provided in sequential order.
- 1.6.7 Degassing shall be carried out at PESO approved facilities.
- 1.6.8 Cylinder storage shall be kept on or above grade and never below grade in cellar or basement.
- 1.6.9 Filled cylinders shall not be stored in the vicinity of cylinders containing other gases or hazardous substances.
- 1.6.10 Escape routes shall be specified and marked in LPG sheds for evacuation of employees in emergency.
- 1.6.11 There shall be sufficient no. of crossovers to avoid trapping of personnel in LPG sheds by conveyors, cylinders and other facilities and sufficient no. of escape routes shall be provided.
- 1.6.12 All steps forming part of the escape routes shall be minimum 1.2 M with treads 30 centimetre (minimum) and maximum rise of 15 centimetre.

1.7 PROTECTION OF FACILITIES:

- 1.7.1 Properly laid out roads around various facilities shall be provided within the installation area for smooth access of fire tenders and like other tenders, in such a way that all facilities are accessed at least from two sides in case of emergency.
- 1.7.2 Proper industry type boundary wall at least 3 M high with 0.6 M barbed wire on top shall be provided around the installation unless the bottling plant is protected as a part of refinery complex.
- 1.7.3 Emergency exit with proper gate shall be provided in the earmarked zone.
- 1.7.4 In case provision for green belt is made, the same shall be segregated from hazardous area by 1 M high wall or chain link fencing, otherwise, it shall be treated as a part of hazardous area.

1.8 UTILITIES:

- 1.8.1 Utilities consisting of fire water pumps, administration Building, canteen, motor control centre, DG room, air compressors, dryers and like other apparatus shall be separated from other LPG facilities and located as per the separation as specified in Table-I in this Chapter.

TABLE - I

INTERDISTANCE FOR LPG FACILITIES

		1	2	3	4	5	6	7	8
1. LPG Storage vessels	*	#	30	30	50	30	15	60	
2. Boundary or property	#	**	30	30	50	30	30	**	

line or group of buildings
not associated with LPG
installation

3. Shed-LPG***	30	30	15	30	50	30	15	60
4. Tank truck gantry - LPG	30	30	30	30	50	50	30	60
5. Tank wagon gantry 60		50	50	50	50	50	50	30
6. LPG or other rail spurs	30	30	30	50	50	50	30	60
7. Pump house or Compressor house (LPG)	15	30	15	30	30	30	**	60
8. Fire Pump House or storage tank	60	**	60	60	60	60	60	-

Notes:

1. All distances are in metres. All distances shall be measured between the nearest points on the perimeter of each facility. except in case of tank vehicle loading/unloading area where the distance shall be measured from the centre of each bay and for storage vessels where the distance shall be measured from the nearest point on the vertical shadow of the vessel.
2. Notation:
 - # - Refer Table – II in this Chapter;
 - * 1/4 of sum of diameters of adjacent vessels or Half the diameter of the larger of the two adjacent vessels, whichever is greater.
 - ** Any distance for operational convenience.
 - *** Minimum 20 M inter distance shall be maintained between the loading/unloading fingers & boundary wall/property line / group of buildings in a collinear direction of the said fingers.
3. Distance of stabling line shall be as per minimum Railway Standards.
4. Distance of stabling line shall be as per Railway guidelines.

TABLE - II
DISTANCE BETWEEN LPG STORAGE VESSELS AND PLANT
BOUNDARY/GROUP OF BUILDINGS NOT ASSOCIATED WITH LPG
INSTALLATION

Capacity of each vessel (Cu. Mt. of water)	Distance (in metre)
10-20	15
> 20-40	20
>40-350	30
>350-450	40
>450-750	60
>750-3800	90
> 3800	120

2.0 GENERAL DESIGN CONSIDERATIONS:

2.1 GENERAL:

This section describes the design and safety features required in a typical LPG Storage, Handling and Bottling Facilities.

2.2 LPG STORAGE VESSELS:

The minimum requirements with reference to design considerations and various fitting to be provided. LPG storage vessels are specified in paragraph 2.2.1 to 2.2.4 as under, namely: -

2.2.1 Mechanical Design:

- (i) The storage vessel shall be designed in accordance with the codes i.e. ASME SEC.VIII or IS-2825 or PD - 5500 or equivalent duly approved by CCE. Design shall take into account the Static and Mobile Pressure Vessels (Unfired) Rules 1981 also

A single code shall be adopted for design, fabrication, inspection and testing of the same storage vessel;

- (ii) Material shall be in line with design code. ASTM A516 Gr. 60 shall be used for refinery service (BS-5500 shall not be used for the same) and for marketing installation where H₂S is not present ASTM A 516 Gr. 70 or A 537 CLASS 1 can be used. Micro-alloyed steel containing Ni, Mo, Va shall not be considered. Maximum specified tensile stress shall not be more than 80,000 psi;

- (iii) Design temperature: (-) 27°C to (+) 55 °C;
- (iv) Design Pressure: Minimum 14.5 Kg/ cm²g on top at 55 °C;
- (v) Marketable LPG conforming to IS: 4576 can have a maximum vapour pressure of 16.87 Kg/ Sq.cm.g at 65 °C temperature. LPG with higher vapour pressure are not expected to be stored in bottling installations;
- (vi) The recommended design pressure and temperature shall be treated as 'MINIMUM requirement' and other design consideration and statutory requirements shall also be considered.
- (vii) Other Design Considerations are as under, namely: -
 - (a) Corrosion Allowance: minimum 1.5 mm
 - (b) Radiography: Full
 - (c) Stress Relieving: 100% irrespective of thickness.
 - (d) Wind pressure: as per IS: 875
 - (e) Earthquake pressure: as per IS:1893
 - (f) Hydro test pressure: As per Design Code

Where ever extreme climatic conditions or security reasons warrants, suitable alterations in design can be made with approval from statutory bodies.

2.2.2 In case of mounded storage, following shall also be considered in designing of storage vessels, namely: -

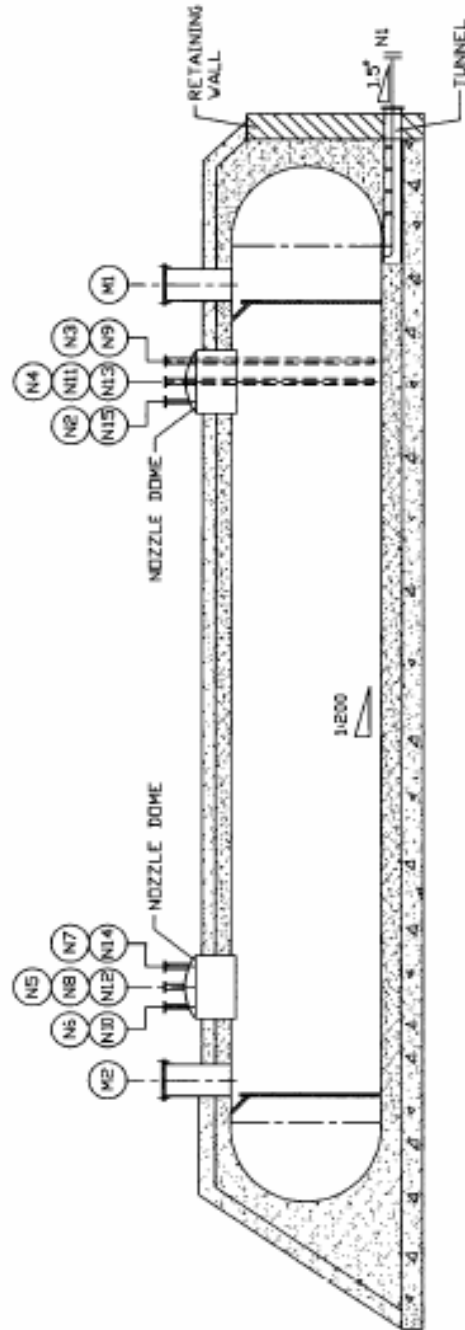
- (i) The specific consideration shall be given in design of vessel to-
 - (a) Internal vapour and hydraulic pressure;
 - (b) External loadings on the vessel; and
 - (c) Internal vacuum;
- (ii) The dimensions (diameter and length) of the vessel shall be decided based on site conditions, soil mechanics, type of fabrication facilities available and other design considerations;
- (iii) Mounded vessels shall be placed on a firm foundation and installed so as to prevent movement or floatation and the sub-soil water, rainwater or any other surface water should not be allowed to percolate in to the mound and the foundation should be constructed such that in the longitudinal direction of a vessel slope of at least 1:200 is maintained to facilitate draining of the vessel and for such purpose reference may be made to attached Drawing-1 and Drawing-2 to this chapter;
- (iv) Site conditions and soil mechanics shall be deciding factors for selection of the type of foundation in a given situation and the preferred type of foundation is a continuous sand bed, supporting the vessel over its full length;

- (v) The foundation shall have sufficient load bearing capacity and all the factors affecting the foundation shall be considered while designing the same and such factors should not be limited to the following, namely: -
 - (a) The load of the vessel during normal operations and also during hydro test when the specific gravity of liquid is 1 (one) instead of that of LPG;
 - (b) The earth or sand cover; and
 - (c) The settlement behavior of the foundation which include
 - (i) Overall settlement;
 - (ii) Differential settlement which causes bending of the vessel; and
 - (iii) Differential settlement which causes sloping of vessel;
- (vi) The sand bed beneath the vessel shall be of adequate elevation not less than 0.76 meter to facilitate drainage from liquid outlet pipe by gravity and in this case, bottom connection shall be permitted on mounded vessels with an access to connections by providing an opening or tunnel with 1.2 m minimum diameter and a 0.9 m minimum clear area and the bottom connections shall be considered as part of the vessel where these extend beyond the mound and shall be designed for the forces that can act on the connection;
- (vii) Proper provision shall be made for encountering the consequences of the settlement of the vessel and the surrounding of the bottom connection should be filled with such material that can absorb such settlement;
- (viii) Where submersible type of pumps is provided for individual vessel, conditions stated in sub clause (a) of clause (V) shall not apply and in such cases drainage of water shall be made by using dip pipe with top connected drain valves and the first valve on this pipeline shall be provided as close to vessel as possible and shall be kept close condition in normal operating conditions;
- (ix) The mound shall protect the vessel from the effects of thermal radiation and shall be sufficiently robust to remain in place in the event of jet flame impingement;
- (x) Mound shall be of earth, sand or other non-combustible, non-corrosive material such as Vermiculite or Perlite and shall provide at least 700 mm minimum thickness of cover for the vessel;
- (xi) The mound surface shall be protected against erosion by rain or wind by providing a suitable protective cover of prefabricated stone, open concrete tiles, and like other material;
- (xii) Water ingress into the mound shall be minimized by providing impervious layer of suitable material, but, a continuous impermeable cover shall not be installed, to prevent the possibility of gas accumulation inside the mound and the proper drainage and slope on top of the mound shall also be provided;
- (xiii) Longitudinal axis of vessels (any number) in a mound shall be parallel to each other with ends in line;
- (xiv) Where more than one row is installed, the adjacent ends of the vessel in each row shall be separated by not less than 3 meter;
- (xv) The valves and appurtenances of mounded vessels shall be accessible for operation or repair, without disturbing the mound;
- (xvi) Provision shall be made to monitor the settlement of the mound or vessel by providing

permanent reference points and a minimum of three reference points shall be provided to ascertain uniform/ differential settlement and also identify possible vessel bending (One each near the vessel ends and one in the middle);

- (xvii) Maximum permissible differential settlement shall be determined at the project design stage. Procedures shall be developed to regularly monitor the settlement throughout the lifetime of the vessel and records maintained thereof.
- (xviii) Provision shall be made for inserting portable CuSO₄ reference electrode on top of the mound for measurement of PSP at 12 - O Clock position of the vessel and shall be protected to prevent water ingress in the mound;
- (xix) The external surface of the vessels which are covered by mound should be suitably treated to protect it from corrosion and the Methods of protection shall include surface coatings (suitable for design conditions as specified in the preceding clauses) and cathodic protection (Impressed current system) and General guidelines given in Annexure - I, NACERP-0169, "Control of External Corrosion on Underground or Submerged Metallic Systems" and T-10D-17/T-6A-63 ON "Pipe Line Rehabilitation Coatings" may also be referred;
- (xx) Holiday detection of the coated surface shall be carried out to ensure defect free coated external surface using suitable Spark Holiday Detector;
- (xxi) The cathodically protected system shall be isolated from the unprotected structures or surfaces by installing monolithic joints i.e. one each on liquid and vapour lines and a suitable isolation shall also be provided on utility pipelines such as air line to ROV, metallic structures, instrument lines and like other joints; and.
- (xxii) Reference points on inner surface of the vessel shall be marked for NDT and subsequent inspections.

MOUNDED LPG STORAGE



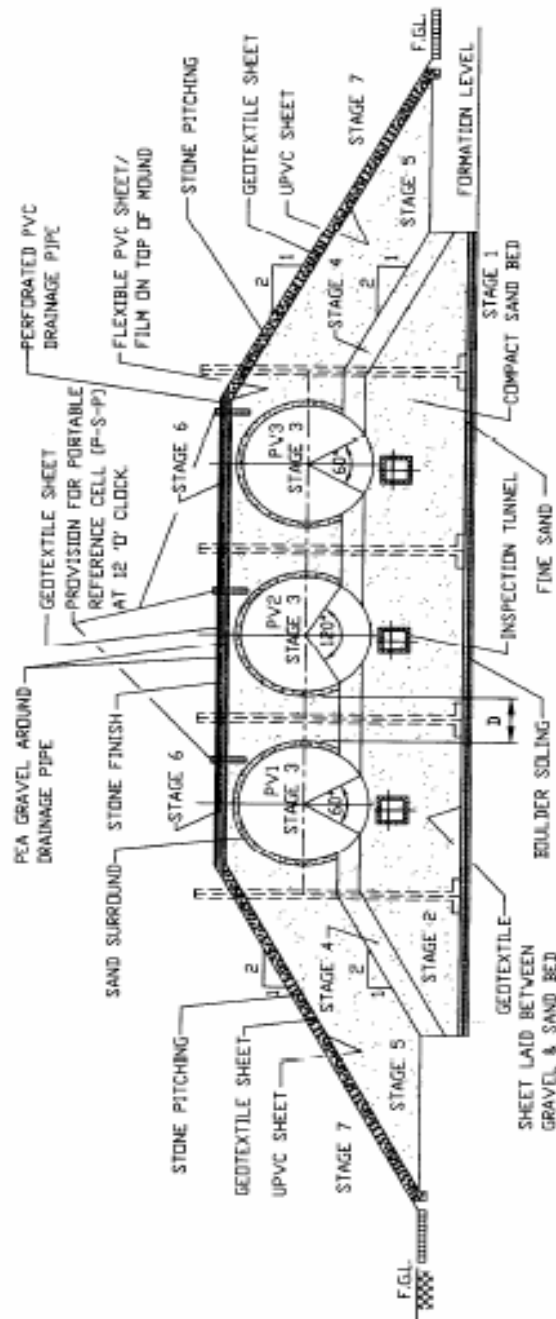
DETAILS OF NOZZLE

N1	LPG LIQUID OUTLET	N11,12	SERVO GAUGE
N2	LPG VAPOUR INLET	N13,14	TEMP. TRANSMITTER
N3	LPG VAPOUR OUTLET	N15	SPARE NOZZLE
N4	LPG LIQUID INLET	M1,2	HAN WAY
N5	HIGH LEVEL ALARM		
N6,7	SAFETY RELIEF VALVE		
N8	FIXED TUBE GAUGE		
N9	PRESSURE GAUGE		
N10	PRESSURE TRANSMITTER		

NOTE

THIS IS ONLY REPRESENTATIVE DRAWING AND MAY BE MODIFIED AS PER DESIGN CONSIDERATION KEEPING THE BASIC PRINCIPLE.

MOUNDED STORAGE CONSTRUCTION METHODOLOGY



- STAGE 1 - EXCAVATING, PREPARATION OF FORMATION LEVEL.
- STAGE 2 - INITIAL SAND BED TO 60° LEVEL.
- STAGE 3 - INSTALLATION OF TANKS.
- STAGE 4 - RAISING SAND BED TO 120° LEVEL FOR HYDROTESTING.
- STAGE 5 - GENERAL MOUND FILLING.
- STAGE 6 - CONSTRUCTION OF DRAINAGE LAYER.
- STAGE 7 - CONSTRUCTION OF SLOPE PROTECTION.

NOTE 1

THIS IS ONLY REPRESENTATIVE DRAWING AND MAY BE MODIFIED AS PER DESIGN CONSIDERATION KEEPING THE BASIC PRINCIPLE

D - 1.5 METER FOR VESSELS UP TO 1.5 METER DIA
 - 2.0 METER FOR ALL OTHER CASES

2.2.3 Fittings:

- (i) Spheres or bullets, other than underground, shall have a single nozzle at the bottom for liquid inlet as well as outlet and the nozzle shall be full welded pipe, stress relieved along with the vessel and shall extend minimum 3 meters from the vertical shadow of the sphere or bullet and a fire safe remote operated valve (ROV) shall be provided on this bottom nozzle at a distance of at least 3 meters from the vertical shadow of sphere or bullet and the nozzle pipe shall have a minimum slope of 1.5⁰ to horizontal;
- (ii) There shall not be any other flanges, manhole, and instrument tapping on this nozzle up to the ROV or on sphere or bullet bottom and in order to avoid stress on the nozzle due to relative settling of support and storage vessel, suitable supports for the bottom nozzle shall be provided;
- (iii) The top vapour zone of the vessel shall be provided with nozzles for vapour outlet, and recirculation wherever applicable and such lines shall be provided with fire safe ROV. ROVs for vapour and /or recirculation lines should be provided at the ground level with an isolation valve at top and in case, ROV is provided at top of the vessel, there is no need to provide an isolation valve;
- (iv) Fire safe ROVs shall also be provided on liquid line and vapour line of TLD, Tank wagon gantry and on the entry of liquid lines at LPG filling shed and such ROVs shall be provided with QB detector and sprinkler nozzles to cool the complete ROV uniformly in case ROV is provided within 15 metre from such facilities and provision for shutdown operation in local mode shall be made for ROVs from operating station located at a minimum distance of 15 metre from the facility and all ROVs shall have provision for electro-pneumatic actuation;
- (v) Nozzles for two independent level indicators, a high level switch, two safety relief valves, pressure gauge and a manhole shall be provided on top of the vessel;
- (vi) All the fittings shall be suitable for use at the design parameters of the storage vessels and for the temperatures appropriate to the worst operating conditions and the remote operated valves on the storage vessel connecting pipelines shall be fire-safe type conforming to API 607 or equivalent;
- (vii) The flange joints of these valves shall either have spiral wound metallic gaskets or ring joints and plain asbestos sheet or reinforced gaskets shall not be used and such gasket used shall conform to ASME B16.20 or IS: 7719 or equivalent and the studs used shall conform to ASTM A 194 Gr 2H / ASTM A 193 Gr B7 or equivalent;
- (viii) Flange connections shall be of minimum of 300 lb rating conforming to ANSI B16.5 class 300 or equivalent and all tapings or openings shall be of minimum 3/4 inch;
- (ix) Facility for water draining to be provided through a water draw off line from between the liquid ROV of vessel and the subsequent isolation valve and two valves, with suitable distance piece between them, shall be provided between ROV and the first isolation valve and the first drain valve from the vessel should be of quick shut-off type valve while the second valve should be throttle type (Globe Valve);

- (x) In case of mounded storage, the following shall also be provided, namely: -
- (a) The top vapour zone of the vessel shall be provided with nozzles for vapour outlet, recirculation wherever applicable and the lines shall be provided with fire safe ROV and the ROVs for vapour or recirculation lines should be provided at the ground level with an isolation valve at top and in case, ROV is provided at top of the vessel, there is no need to provide an isolation valve;
 - (b) In case of provision of liquid outlet from the top of the vessel, the line shall extend up to bottom;
 - (c) In case of liquid line from the bottom of the vessel, the minimum distance of 3 m from the vessel to ROV shall be maintained. The nozzle pipe shall have a slope of minimum 1.5° ; and
 - (d) Minimum two nos. of manhole shall be provided on top of the vessel.

2.2.4 Instruments:

- (i) Each storage vessel shall have at least two-level gauges, each working on different principles and in addition one independent high level switch shall also be provided and the high level alarms shall be set at not more than 85% level of the volumetric capacity of the vessel and audio alarm and visual indication shall be at local panel and control room and on actuation of high level alarm, the inlet ROVs of the affected vessel shall close;
- (ii) Differential pressure (DP) type gauge should not be used for level measurement;
- (iii) Each storage vessel shall have at least two safety relief valves with isolation arrangement set at different values and at not more than 110% of design pressure of the vessel and each having 100 % relieving capacity adequate for limiting the pressure build up in the vessel not more than 120% of design pressure and in case of mounded vessel, the full flow capacity of each SRV on mounded vessels shall be minimum 30 % of the capacity required for an equivalent size of above ground vessel;
- (iv) The relieving load for the safety valves shall be based on fire condition and no credit shall be taken for fire proofing on the vessel, if provided;
- (v) The discharge of safety valves shall be connected to flare system, wherever available and in such case, safety valves shall have lock open (or car seal open) type isolation valves on both sides of safety valves;
- (vi) In case of non-availability of flare system, the discharge from safety valve shall be vented vertically upwards to atmosphere at an elevation of 3 meter (minimum) from the platform for effective dispersion of hydrocarbons and in such case, isolation valve on downstream of safety valve is not required; and
- (vii) A weep hole with a nipple at low point shall be provided on the vent pipe of the safety release valve in order to drain the rain water which may get accumulated otherwise and weep hole nipples shall be so oriented that in case of safety valve lifting and consequent fire, the flame resulting from LPG coming out from weep-hole does not impinge on the sphere or structure and a loose fitting rain cap with a chain (non sparking) fitted to vent pipe shall be provided on top of safety valve.

2.3 LPG LOADING OR UNLOADING FACILITIES:

2.3.1 Each loading station shall consist of the following: -

- (i) Excess flow check valve and non return valve shall be provided in LPG loading lines;
- (ii) A vapour return line with an isolation valve connected back to the storage vessel or suction line with NRV.
- (iii) Properly designed loading arm shall be provided at the end of filling and vapour return lines for connecting to the tank truck vessel and the loading arm shall be provided with breakaway couplings and an isolation valve and loading arm shall be of approved type and be tested as per OEM recommendations and alternatively, hoses (hoses having integrated valve in each end fittings, which, if the hose assembly experience a catastrophic hose failure, shall instantaneously shutting down the flow in both directions) shall be used;
- (iv) The hose - coupling or flange joint shall be of Class 300 lb. rating with metallic gasket and the hose coupling shall be provided with a cap or blind flange by which the nozzle can be closed when not in use;
- (v) Weigh bridges of suitable capacity for road or rail movements and mass flow meters for pipeline transfers shall be provided and the mass flow meters shall be certified for its use with LPG;
- (vi) A check valve shall be provided in the vapour return line; and
- (vii) An isolation valve shall be provided before the break away coupling and the provision shall be made for cold flaring of this section before disconnecting the arm from the tank truck.

2.3.2 Unloading of LPG from tank truck is carried out with vapour compressors using pressure differential method of liquid transfer in the following manner, namely: -

- (i) Each unloading station shall consist of the following, namely: -
 - (a) Vapour line with isolation valves;
 - (b) Excess flow check valve and non return valve shall be provided in LPG unloading lines with isolation valves; and
 - (c) Weigh bridge of suitable capacity;
- (ii) Properly designed loading arm shall be provided at the end of filling and vapour return lines for connecting to the tank truck vessel and the loading arm shall be provided with breakaway couplings and an isolation valve and loading arm shall be of approved type and be tested as per OEM recommendations and alternatively, hoses (hoses having integrated valve in each end fittings, which, if the hose assembly experience a catastrophic hose failure, shall instantaneously shutting down the flow in both directions) shall be used.

2.3.3 Additionally following shall be ensured.:

- (i) Suitable provision shall be made for evacuation of LPG from bulk storage vessels to tank truck or another vessel to empty the vessel in case of emergency or for statutory testing;
- (ii) Tank truck shall be loaded or unloaded with suitable arrangement for cold flaring of hose content at the end of the operations and in case loading arms are used for loading operation, the section from tank truck valve to first isolation valve in the arm shall be depressurized by cold flaring before disconnection of the arms from the tank truck;
- (iii) In case, LPG hose are used, it shall conform to IS: 9573 for design and testing requirements for use with LPG; and
- (iv) The hose - coupling or flange joint shall be of 300 lb. rating with metallic gasket and the hose coupling shall be provided with a cap or blind flange by which the nozzle can be closed when not in use.

2.4 CYLINDER FILLING FACILITIES:

- (i) The cylinder filling area shall be completely open type and covered from top with roof designed to ensure good natural ventilation and RCC roofing shall not be used;
- (ii) The filling area shall not be on upper floors of building or in cellars unless specifically required on account of extreme weather conditions;
- (iii) As far as possible, the floor area shall not have any channels or pits and where these are necessary for conveyors or other equipment like weigh machine and like other machine, suitable gas detection system shall be provided and additionally, proper ventilation system through ducts fitted with blowers shall be provided to release LPG outside of the shed at safe location and the whole of the LPG filling shed flooring shall be provided with mastic flooring;
- (iv) All carousels including electronic carousels and leak detectors shall have type approval by PESO;
- (v) Adequate lighting shall be provided in the cylinder filling area and emergency lighting shall also be provided at critical places;
- (vi) Water drains from the cylinder filling area shall be provided with water seals wherever they interconnect with an outside drainage system and a drawing shall be kept readily available with complete plant drainage system and water seal locations displayed therein;
- (vii) Proper access shall be made available for other fire fighting equipment i.e. fire tender, and like other equipment.
- (viii) Cylinder storage area requirement shall be worked out based on the stacking pattern of filled and empty cylinders as per law in force;
- (ix) The filling machines shall be provided with auto cut-off system so that LPG supply is cut off when the desired quantity of product has been filled in the cylinders and the filling pressure shall not be more than the design pressure of the cylinders i.e. 16.9 kg/sq.cm.g;

- (x) Filling machines in a carousel or stationary filling machines shall meet the requirements as per law in force in respect of metrology;
- (xi) On-line check weighs scales with a maximum least count of 50 gms shall be provided;
- (xii) Electronic leak detectors shall be provided alternatively Compact Valve Tester to check valve and “O” ring shall be installed on line;
- (xiii) Water test bath or electronic leak detectors shall be provided to detect body and bung leak cylinders for all types/ capacities of cylinders; and
- (xiv) Vapour extraction system at strategic locations near carousel, cylinder evacuation unit, valve changing unit, degassing shed and at locations where leakage of LPG is expected to accumulate shall be provided and it shall be interlocked with filling machine so that filling does not start without vapour extraction unit being functional.

2.5 UTILITIES:

2.5.1 Compressed air:

- (i) The quality of instrument air shall conform to the requirements as recommended by the manufacturers of instruments or equipment;
- (ii) If one compressor is envisaged to run normally, another standby compressor of 100% capacity shall be provided and when more than one compressor running is envisaged, 50% standby capacity shall be provided.

2.5.2 Service Water:

- (i) Service water is required for the cylinder washing equipment and leak check bath, compressor cooling and in hose stations for washing and like other activity;
- (ii) Water may be provided at a pressure of about 3 Kg/sq.cm.g and if one pump is envisaged to run normally, another pump with 100% capacity shall be provided as a standby and where more than one pump running is envisaged, 50% capacity as standby shall be provided.

2.5.3 Emergency Power:

The installation shall be provided with battery or diesel generating set for operating the essential systems such as the instrumentation and safety systems (gas detectors, automatic fire water sprinkler system) and minimum lighting during the grid power failure.

2.6 LPG PUMPS:

- (i) LPG Pumps shall be designed for handling of LPG and safely withstand the maximum pressure which could be developed by the product and / or transfer equipment and the pumps shall conform to API 610 or equivalent;
- (ii) Check valves shall be installed on the delivery side of all centrifugal pumps;
- (iii) LPG Pumps shall be provided with suction and discharge pressure gauges, a high point vent to safe height or flare, and a suction strainer;
- (iv) Double Mechanical seal with seal failure alarms and trip shall be provided;
- (v) Anti-cavitation protection through a pressure switch taken from discharge end actuating a low pressure alarm both in control room as well as local annunciator shall be provided and actuation of low discharge pressure alarm shall trip the LPG Pump automatically;
- (vi) Pumps shall be designed to build a discharge pressure such that the pressure at the carousel filling machine is at least 5.0 kg/sq.cm.g. above the vapour pressure at the operating temperature;
- (vii) Pumps shall have a by-pass valve and other suitable protection against high discharge pressure on the delivery side;
- (viii) The electrical motor drive and switchgear shall conform to area classification as per IS -5572 and belt drives shall be of the anti-static type; and
- (ix) Provision shall be made for Audio Visual indications of various safety trips in the LPG pump house.

2.7 LPG VAPOUR COMPRESSOR:

- (i) Compressors shall be suitable for handling LPG and designed to safely withstand the maximum outlet pressure to which they will be subjected and compressors shall conform to API 618 or API 619 or equivalent;
- (ii) The belts used in shall be of antistatic type and fire resistant;
- (iii) Compressor shall be provided with the following features as a minimum, namely: -
 - (a) Pressure gauges in suction and discharge;
 - (b) Temperature gauge in discharge;
 - (c) Discharge safety valve and a vent valve, their outlets leading to flare/ safe height outside the shed;
 - (d) Low Suction Pressure Trip;
 - (e) Low Cooling water flow switch – Trip;
 - (f) Suction strainer;
 - (g) High Discharge Pressure Trip;
 - (h) High Temperature Trip;
 - (i) Low cooling water pressure trip;
 - (j) Check valve in discharge; and
 - (k) A discharge to suction recycle valve for achieving capacity turndown during startup;
- (iv) A suitable size scrubber or liquid knockout drum shall be installed upstream of the

vapour compressor and it shall be equipped with a gauge glass, safety relief valve, a drain and high liquid level shut down device;

- (v) Provision shall be made for Audio Visual indications of various safety trips in the LPG compressor house; and
- (vi) Provision for unloading shall be provided and compressor shall start in unloading condition only.

2.8 PIPING:

- (i) Piping shall be designed for handling of LPG;
- (ii) Piping shall conform to the provisions of ANSI B 31.3;
- (iii) The material shall conform to API 5L Gr. B / ASTM A106 Gr B or equivalent;
- (iv) Seamless pipes shall be used and furnace butt welded or spiral welded pipes shall not be used;
- (v) Pipe joints should be welded with full penetration weld and number of flanged or threaded joints should be kept to a minimum;
- (vi) Low point drains and high point vents shall be plugged or capped suitably;
- (vii) Buried piping shall be protected against physical damage and corrosion with suitable sleeves, properly sealed at both the ends, at road crossings; and
- (viii) Hydro test shall be carried out once every 5 years.

2.9 THERMAL PRESSURE RELIEF SYSTEM:

Any equipment or section of piping in which liquid LPG may be trapped e.g. between shut off valves, shall be protected against excessive pressure developed by thermal expansion of the LPG by providing suitable thermal pressure relief valves and if pressure relieving devices discharge to atmosphere, the discharge shall be done in a safe manner and the set pressure for hydrostatic thermal safety valve shall have settings not less than 110 % or more than 125 % of the system design pressure of piping.

2.10 VALVES:

Steel valves conforming to relevant API standards shall be used and cast-iron valves should not be used.

2.11 FITTINGS:

- (i) Steel flanges and flanged fittings conforming to API 105 Class 300 (forged) or equivalent shall be used and slip- on or weld neck flanges should be used and screwed flanges for sizes 50 mm or smaller may be used and steel flanges should conform to the applicable provisions of ANSI B 16.5;

- (ii) Steel screwed fittings and couplings shall conform to ANSI B 16.11 or equivalent and steel unions shall have ground metal to metal seats and gasket type unions shall not be used;
- (iii) Plugs shall be of steel and cast iron or brass plugs shall not be used;
- (iv) All flanges shall be connected for bonding for electrical continuity.

2.12 EVACUATION FACILITY FOR DEFECTIVE CYLINDERS:

- (i) The cylinder evacuation facility shall consist of -
 - (i) Cylinder emptying vessels;
 - (ii) Compressor;
 - (iii) Four-way valves or equivalent;
 - (iv) Cylinder rack, header to be provided with pressure gauge and a strainer with isolation valves;
 - (v) The LPG line exit cylinder evacuation area to be provided with a non-return valve before joining the main LPG return header; and
 - (vi) Independent earthing connections.
- (ii) Each of cylinder emptying vessels mentioned above shall be equipped with the following: -
 - (i) Pressure gauge;
 - (ii) Level gauge;
 - (iii) high level alarm switch set at 85 % with trip or switchover arrangement;
 - (iv) Pressure relief valves;
 - (v) Vent valves discharging to 1.5 m above the shed; and
 - (vi) Other trims like drain valve, utility connection.

2.13 PURGING OF NEW CYLINDERS OR TANKERS:

- (i) The new LPG cylinders containing air shall be evacuated with a vacuum pump. The evacuation facility shall consist of -
 - (a) Vacuum pump (water or oil or air-cooled type);
 - (b) Purging manifold;
 - (c) Vacuum receiver fitted with vacuum gauge, vent and drain;
 - (d) LPG vapour header;
 - (e) Purging adapters;
 - (f) Vacuum pump with suction strainer; and
 - (g) Pressure regulator, relief valves.
- (ii) Purging of tankers and vessels shall be done using either Nitrogen or by filling water

and displacing with LPG vapours.

2.14 EQUIPMENT FOR ETHYL MERCAPTAN SERVICE:

2.14.1 Material of Construction of Ethyl Mercaptan containers:

Stainless steel and copper free steel alloys are the preferred materials of construction of equipment for mercaptan service and aluminum of desired pressure rating can also be used and the use of Iron or carbon steel shall be avoided as there is the hazard of formation of iron-sulphur complexes which are pyrophoric and copper or copper bearing alloys shall not be used for mercaptan service as mercaptan readily attacks and contaminates them.

2.14.2 Pumps for Mercaptan service:

Only hermetically sealed pumps shall be used.

2.14.3 Piping and Fittings:

- (i) Seamless stainless-steel piping shall be used and threaded fittings can be used provided they meet the service requirement ratings and a fluoroplastic tape sealant should be used;
- (ii) Flexible connections shall be seamless stainless steel with pipe nipples welded to each end;
- (iii) Relief valves shall be full nozzle, disc type, closed bonnet carbon steel body with 304 stainless steel trim and stainless or aluminized steel spring;
- (iv) For transfer valves, stainless steel ball valves with fluoroplastic seats and stainless steel (SS316) trim or their equivalent are recommended;
- (v) Rigid connection should be welded or flanged joint type;
- (vi) Fluoro plastics shall be used for gasketing;
- (vii) For pressure gauges, stainless steel diaphragm type is recommended with stainless steel socket and tip; and
- (viii) Provision for analysis in line with IS:4576 or IS14861 as applicable shall be made.

2.15 Selection of Electrical Equipment:

- (i) Electrical equipment shall be selected, sized and installed so as to ensure adequacy of performance, safety and reliability and the equipment in general shall conform to relevant Indian standards and shall be suitable for installation and satisfactory operation in the service conditions envisaged;
- (ii) All electrical equipment shall be selected considering the system neutral earthing;
- (iii) Electrical equipment including for lighting system shall conform to hazardous area classification and be selected in accordance with IS:5571 and they shall be tested by agencies such as CIMFR, CMRI, ERTL, CPRI or independent test laboratory of country

of origin for such equipment and indigenous flameproof equipment shall comply with relevant BIS standard as per requirements of statutory authorities and all equipment used in hazardous area shall be approved by Chief Controller of Explosives shall have PESO approval; and

- (iv) For details on hazardous area classification, enclosure protection and like other protection, National Electric Code (SP 30) 5, IS/IEC 60079 Part 1 to Part 11, IS:5571, 5572,) Petroleum Rules, 2002 shall be applicable.

2.16 Installation Lighting:

- (i) Sufficient lighting shall be provided so as to enable plant operators to move safely within the accessible areas of installation and to perform routine operations and in the event of normal power failure, emergency lighting shall be provided;
- (ii) Normal lighting system shall be on 415/ 240V AC supply, whereas emergency lighting will be either on 220V or 110V DC;
- (iii) Lighting requirements provided during the failure of power supply for Normal lighting are intended broadly-
 - (a) to facilitate carrying out of specified operations for safe shutdown of the installation;
 - (b) to gain access and permit ready identification of firefighting facilities such as fire water pumps, fire alarm stations and like other facilities; and
 - (c) Escape route for safe evacuation of operating personnel;
- (iv) Under normal operation both emergency and normal lighting shall be fed by normal power source and on failure of normal supply, emergency lighting shall be transferred to emergency source until the start of D.G. set within 15 seconds and critical lighting (D.C. supply based) shall be normally kept 'ON' and during power failure, battery bank shall be used to provide power; and
- (v) Low pressure sodium vapour lamps shall not be installed in hazardous areas;
- (vi) The illumination levels in different areas shall be as per good engineering practice and depending on the nature of job activities to be carried out the suggested minimum illumination levels for various areas are as below: -

Area or Facility	Average Maintained Illumination
Operating areas (Filling, storage, repair sheds, control areas)	100 - 200
Compressor houses at or near equipment	200
Stairways, platforms and walkways	60
Outdoor operational areas (Process areas, pipe racks, heat exchanger, flare and like other operational areas)	60
Outdoor Non-operational areas (At grade)	10
Tank farms	20

Main roads and Tank Truck parking area		20
Secondary roads		10
Pump houses, Sheds, Switches		100
Switchgear Room and UPS Room		150-200
Cable cellar Room		70
Battery rooms and transformer bays		100-150
Toilets and locker rooms		150
Control Room	General lighting or laboratories	400
	Rear of instrument panels, aux. and panel	200-300
	Outside, near entrances	150

- (vii) The lighting fixtures on various circuits shall be suitably interlaced so that failure of any one circuit do not result in complete darkness;
- (viii) Switches controlling the lighting fixtures and exhaust fan shall be installed outside the battery room; and
- (ix) Switches of lighting panels installed in hazardous area, shall have a pole to break the neutral in addition to the poles for phases and when the means of isolation is located in a non-hazardous area, the switch shall break all poles including neutral or alternatively may break only live poles, the neutral being isolated by a removable link.

2.17 Installation Earthing:

- (i) Installation earthing design shall be carried out in accordance with the requirements of Indian Electricity Rules and IS: 3043 and all earth connections should be visible for inspection to the extent possible;
- (ii) All electrical equipment shall be suitably earthed and earthing system shall cover the following, namely; -
 - (a) Equipment earthing for personnel safety;
 - (b) System neutral earthing; and
 - (c) Protection against Static and Lightning discharges;
- (iii) The earthing system shall have an earthing network with required number of earth electrodes connected to it and the following shall be earthed, namely: -
 - (a) System neutral;
 - (b) Metallic non-current carrying parts of all electrical apparatus such as transformers, switchgears, motors, lighting or power panels, terminal boxes, control stations, lighting fixtures, receptacles and like other electrical apparatus;
 - (c) Steel structures, loading platform and like other equipments;
 - (d) Cable trays and racks, lighting mast and poles;
 - (e) Spheres, Bullets and like other equipments;
 - (f) Electrical equipment fencing (e.g. transformer, yard and like other equipments);
 - (g) Cable shields and armor; and
 - (h) Flexible earth provision for wagon, truck;

- (iv) Where installed, lightning protection shall be provided as per the requirements of IS:2309;
- (v) The resistance values of an earthing system to the general mass of earth should be as per Indian Electricity Rules as below, namely: -
 - (a) For the electrical system and equipment, a resistance value that ensures the operation of the protective device in the electrical circuit shall not be in excess of 4 Ohms;
 - (b) 10 Ohms in the case of all non-current carrying metallic parts of major electric apparatus or any metallic object;
 - (c) The resistance to earth shall not exceed 7 Ohms and the resistance to any part of the fitting to the earth plate or to any other part of fitting shall not exceed 2 Ohms, and
 - (d) All joints in pipelines, valves in installations, and associated facilities and equipment for LPG shall be made electrically continuous by bonding or otherwise; the resistance value between each joint shall not exceed 1 Ohm;
- (vi) The earth conductor shall be adequately sized to carry the applicable maximum earth fault current without undue temperature rise and all joints shall be protected against corrosion;
- (vii) All the electrical equipment operating above 250 volts shall have two separate and distinct connections to earth grid;
- (viii) The main earthing network shall be used for earthing of equipment to protect it against static electricity;
- (ix) An independent earthing network shall be provided for lightning protection and this shall be bonded with the main earthing network below ground, minimum at two points;
- (x) Every Sphere or bullet shall be electrically connected with the earth in an efficient manner by not less than two separate and distinct connections and the connections and the contacts required shall have as few joints as possible and all joints shall be riveted, welded or bolted and also soldered to ensure both mechanical and electrical soundness.

CHAPTER II

3.0 LPG TANK TRUCKS (REQUIREMENTS OF SAFETY ON DESIGN OR FABRICATION AND FITTINGS):

Transportation of LPG by road is regulated by Department of Explosives by applying the Petroleum Rules, 1976 and The Motor Vehicle Act 1988 (59 of 1988) and the transportation of LPG in bulk is regulated through the Static and Mobile Pressure Vessels (unfired) Rules, 1981 and The Motor Vehicle Act, 1988.

3.1 DESIGN CRITERIA:

Pressure vessels used for transportation of LPG shall be designed and fabricated in accordance with the Static and Mobile Pressure Vessels (Unfired) Rules 1981, IS: 2825 or equivalent codes.

3.1.1 MAXIMUM FILLING VOLUME:

Minimum vapour space or the maximum quantity of LPG filled in any vessel shall be limited to the filling density of LPG and shall be such that the vessel should not become liquid full due to expansion of the content with the rise in temperature to 55 deg. centigrade and such requirement shall be applicable irrespective of the ambient temperature of the product at the time of filling. (Generally, it is filled maximum up to 85% of the volume).

3.2 VESSEL DESIGN:

3.2.1 Design Pressure:

Vapour pressure of LPG conforming to IS:4576 at a maximum anticipated service temperature of 55 deg. C. to be considered and the minimum design pressure shall be 14.5 kg/sq.cm and in addition, 3g effect to take into account acceleration or deceleration shall be considered while designing of the vessel.

3.2.2 Design Temperature:

The design temperature of the vessel shall be in line with the specification of LPG and as per statutory requirement.

3.2.3 Vessel Design Code:

- (i) Vessel shall be designed, fabricated and tested in accordance with requirements of Class I pressure vessels conforming to IS:2825, PD-5500, ASME SEC. VIII or equivalent codes accepted by Statutory Authority and the vessel shall be designed to withstand shocks normally encountered during transport including those set up by the movement of the

contents of the vessel such as acceleration or deceleration of a minimum of 3g to be calculated considering that the vessel is full with LPG at 55 deg. C and saddle supports and other attachments shall also be designed according to the fabrication code;

- (ii) Joints shall be as required by the code with all under cuttings in shell and head material fabricated as specified therein;
- (iii) All longitudinal shell welds shall be located in upper half of the vessel and shall be staggered when assembling the cylindrical shell from two parts by means of a circumferential joint and the distance between two such staggered joints shall be at least 5 times the thickness of the thicker plate or as specified by code as adopted.

3.2.4 Material Specifications:

Material used in the manufacture of pressure parts of the vessel shall be in accordance with that specified in IS: 2825, PD-5500, ASME SEC. VIII or equivalent code as adopted and a single code shall be adopted for materials, fabrication, inspection and testing.

3.2.5 Vessel Plate Thickness:

The nominal thickness of the plate material used in fabrication shall not be less than the sum of minimum calculated thickness as per the fabrication Code and corrosion allowance (CA), if necessary and in addition, adequate thinning allowance in case of formed heads and for mobile vessels (for which CA may not be necessary) an allowance of at least 0.5 mm. shall be included in place of CA to safeguard against wear and tear and the nominal plate thickness shall also be not less than the minimum calculated thickness and the under-tolerance as allowed in material specification and in addition the thinning allowance as aforesaid and the minimum actual thickness of the finished formed head shall be physically verified by the Inspecting Authority to ensure that it is not less than the required thickness, as explained above and such minimum actual thickness shall be indicated in the final certificate issued.

3.2.6 Connecting Joints or Nozzles and Manhole:

Connecting joints or nozzles and manhole shall be constructed in accordance with the applicable design and fabrication code.

3.2.7 Baffle Plates:

Every vessel over 5 cu.m water capacity shall be fitted with baffle plates to minimize the surge, the design of which should facilitate complete internal inspection and the baffle plates shall be provided as follows, namely: -

- (i) Over 230 cms in length shall be provided with baffles, the number of which shall be such

that the linear distance between any two adjacent baffles or between any tank head and the baffle nearest it, shall in no case exceed 150 cms;

- (ii) Each baffle shall have adequate strength to sustain without undue stress or any permanent set a horizontal force equal to the weight of so much of the contents of the tank as may come between it and any adjacent baffle or tank head, applied as a uniformly distributed load on the surface of the baffle or tank head and the baffles shall be formed with a curvature of 200 to 300 cms radius;
- (iii) Each baffle shall have at least 2/3rd of the cross-sectional area of the tank and the baffles shall have suitable openings at top and bottom and the openings at bottom should allow access to the other side and the baffles shall be attached to the shell by means of suitably spaced cleats (min. 8 nos.) of minimum size 150 x 150 x 6 mm thick and the weld between baffle to cleat and cleat to the shell shall meet the applicable design code requirements And no vessel supports or baffle or baffle cleat shall be welded directly to the vessel and all such supports shall be attached by means of pad of the same material of which the vessel is made and the pad thickness shall not be less than 6 mm and shall not exceed the thickness of the shell material.
- (iv) Each pad shall extend at least 4 times its thickness in each direction beyond the weld attaching the support and each pad shall be formed to an inside radius not greater than the outside radius of the vessel at the place of attachment and each pad corner shall be rounded to a radius of at least 1/4th width of the pad and not greater than 1/2 the width of the pad and the weep holes and tell-tale holes if used shall be drilled or punched before the pads are attached to the tank and each pad shall be attached to the tank by filler material having the properties conforming to the similar filler material used for welding of the vessel and the baffle shall be located away from SRV to facilitate ease of access for fitment / removal and safety of SRV.

3.2.8 Safety Appurtenances:

LPG tank truck is provided with them following openings or nozzles, namely: -

- (i) Safety Relief valves;
- (ii) Excess flow check valves in the liquid and vapour lines and pressure gauge nozzle;
- (iii) Pressure gauge (Provided in the vapour space of the vessel);
- (iv) Temperature gauge (Provided in the liquid space);
- (v) Roto-gauge (to measure the percentage of liquid in the vessel);
- (vi) Manhole with cover;
- (vii) Fixed level gauge;
- (viii) Drain point at the bottom; and
- (ix) Liquid or Vapour manifold

3.2.8.1 Safety Relief Valve (SRV):

Each tank truck is provided with two or more SRVs for providing the relieving capacity under excess pressure and the SRVs are mounted on the top surface of the vessel either in

the recessed fittings or at the shell level with head projecting out and in the event of an accident causing the tank truck to fall off the road and topple, there is a possibility that Safety Relief Valves which projects out can hit against a hard surface and get damaged or even come out of the nozzles as adequate protection as envisaged in the rules has not been provided and to prevent this from happening, the following measures shall be adopted, namely: -

- (i) The SRV of an LPG tank truck shall be provided in a recessed cup formation and alternatively, it may be equally protected by providing a guard all rounds as per the CCE approved procedure for modification;
- (ii) SRV shall be replaced by a new SRV every ten years and if found defective during any of the earlier yearly inspections, it shall be replaced earlier;
- (iii) Unstamped (Uncertified) SRVs shall not be used;
- (iv) At the time of yearly inspection or each opening, the threads of the valve and coupling shall be checked by an Inspection Agency or Competent Person using “Go” or “No Go” gauges and SRV shall be tightened to the required torque specified for its size so as to obtain minimum engagement of 5-6 threads by hand tightening and another 1-2 threads by spanner tightening and LPG tank trucks shall carry SRV certificates issued by Inspection Agency or Competent Persons which apart from test date and set pressures shall also include the following information: -
 - (a) The number of threads engaged in its coupling;
 - (b) The number of threads outside its coupling;
 - (c) Torque applied for tightening; and
 - (d) Identification mark of SRVs

3.2.8.2 Internal Excess Flow Check Valves (IEFCVs.):

- (i) Each liquid or vapour pipeline and pressure gauge nozzle shall be provided with internal excess flow check valve duly type approved by PESO;
- (ii) IEFCVs before fitment, shall be checked using “Go” or “No Go”, gauges and shall be tightened to the required torque specified for the size to obtain minimum engagement of 5-6 threads through hand tightening and another 1-2 threads by spanner tightening;
- (iii) IEFCV shall be examined for its proper operation along with SRV, once a year by competent person;
- (iv) IEFCV shall be checked for its rated capacity every five years; and
- (v) Each IEFCV shall be replaced by a new IEFCV every ten years and if found defective during operation or any of the earlier inspection, it shall be replaced at that time itself i.e., earlier than ten years.

3.2.8.3 Pressure Gauge:

The functional parts of EFCV of pressure gauge shall remain within its coupling and in addition, the pressure gauge should be provided with isolation valve with lock open arrangement.

3.2.8.4 Fixed Level Gauge or Drain Nozzles:

The fittings have been found to be redundant and to minimize the openings in the tanker, these fittings shall be plugged (After necessary amendment to the SMPV Rules, 1981) and such plugging shall be approved by Competent Persons or Inspection Agency.

3.2.8.5 Roto Gauge:

These fittings shall be housed in a recessed cup formation, when fitted on longitudinal sides of vessel to avoid any accidental damage to bleed valve or seal and the roto gauge shall also be protected with a provision of hinged cover of 5 mm thick plate.

3.2.8.6 Liquid or Vapour Piping:

The pipes shall conform to the ASTM A-106B, schedule 80 standards and liquid or vapour piping shall be single piece and the end flanges shall be of ASA-300 rating and metal jacketed gasket shall be used for the piping system and in addition, sturdy guard shall be provided between the propeller shaft and the elbow of the piping and adequately strong arrangement shall be provided to fix the piping rigidly to the bullet or chassis to minimise the effect of vibrations.

3.2.8.7 Height Barrier:

Whenever cabin height is less than the height of the vessel and fittings on top of it, a height barrier shall be provided all along the width of the cabin in the form of a cage either 50mm diameter pipe or 50 X 50 X 3 MM angle frame on the top of vessel and within the height regulation of Road Transport Authority (with whatsoever name it is called).

3.2.8.8 Mounting:

U-Bolts used for mounting of the pressure vessel on the chassis shall conform to ASTM 193 B7 and the nuts to A194 Gr.2H and the number and size of bolts should be as per the design requirements for the particular chassis and load thereon.

3.2.9 Other Considerations:

- (i) Openings for liquid and vapour low and pressure gauge and like other purposes in the truck shall be protected by suitable excess flow check valves mounted in the openings of the vessel and openings of less than 1.5 mm need not have such a valve;
- (ii) Valves or accessories situated at the rear of a vehicle shall be protected by the rear cross

- member of the frame of the vehicle against damage;
- (iii) All piping, fittings, pumps and meters permanently mounted on the vehicle shall be designed to withstand the most severe combined stresses imposed by the following, namely:
 - (a) The maximum design pressure of the vessel;
 - (b) The superimposed pressure of the shock loading caused by road movements;
 - (iv) All piping, fittings and equipment shall be adequately protected to minimize accidental damage which may be caused by road accidents or overturning and all trucks should be provided with suitable height barriers on the drivers cabin if the height of the bullet exceeds the cabin height;
 - (v) The engine and exhaust system together with all electrical generators, motors, batteries, switch gears and circuit breakers shall be efficiently screened from the vessel or the body of the vehicle by a fire-resisting shield or by enclosure within an approved fire resisting compartment;
 - (vi) When any of the safety appurtenances referred to in paragraph 3.3.8 is mounted forward of the rear of the driving cabin the cabin can be considered to act as an acceptable shield, provided the back, the roof and the floor of the cabin are of fire resisting construction for the full width of the cabin, without any openings in the back or roof, and that the back extends downwards to the top of the chassis;
 - (vii) When the cabin construction does not conform to the requirements mentioned clause (vi), a separate fire resistant shield should be installed extending upwards without any openings from the top of the chassis to the top of the vessel;
 - (viii) In any case where windows are provided in the shield, they should be fitted in fire-resistant framing with wired glass or other heat resistant material and shall not be capable of being opened;
 - (ix) When any of the safety appurtenances referred to in paragraph 3.3.8 is mounted to the rear of the cabin, it shall be contained wholly within an approved fire-resistant compartment;
 - (x) In any case where the fuel used to propel a vehicle gives off a flammable vapour at a temperature less than 65-degree C, the fuel tank shall not be behind the shield unless the following requirements are complied with, namely-
 - (a) The fuel tank is protected from external blows by stout steel guards or by the under frames of the vehicle;
 - (b) The fill pipe of the fuel tank of the vehicle is provided with:
 - (i) an arrangement facilitating breathing of the fuel tank and preventing spillage of fuel in the event of overturning of vehicle; and
 - (ii) suitable locking arrangement;
 - (c) The fuel-feed apparatus placed in front of the fire resisting shield is used to lift the contents of the fuel tank;
 - (xi) The fuel tank is protected by stout steel guards or by the frames of the vehicle;
 - (xii) The fill pipe of the fuel tank of the vehicle is provided with a cover having locking arrangements;
 - (xiii) Fuel feed apparatus placed in front of the fire-resisting shield is used to lift the

- contents of the fuel tank;
- (xiv) The electrical systems shall have, as far as may be applicable, the same safety features as detailed in preceding clause;
 - (xv) Tyres shall be of the “anti-skid” type;
 - (xvi) There shall be a clear space of at least 15 cm. between the rear of the cabin and the front of the vessel;
 - (xvii) The rear of the vessel shall be protected by a robust steel bumper and such bumper shall be
 - (a) attached so that collision stresses will be transmitted to the frame work of the vehicle or, in the case of an articulated vehicle to the frame work carrying the wheels of the vessel;
 - (b) situated at least 7.5 cm to the rear of the rearmost part of the vessel providing complete cover to the body; and
 - (c) extended on each side of the vehicle to, at least, cover the maximum width of the vessel;
 - (xviii) The maximum weight of the liquefied gas for which the vehicle is designed should not exceed the difference in weight between the unladen weight of the vehicle and the maximum gross weight permitted for that class of vehicle under the applicable transport laws or CCOE licensed capacity; when such law is applicable;
 - (xix) The vessel shall be conspicuously marked to show the product which is being carried;
 - (xx) Two portable ISI marked 9 kg. DCP fire extinguishers shall be provided on each vehicle, one on each side and should be accessible from outside the cabin and another DCP extinguisher should be kept in the driver’s cabin and all extinguishers (minimum 3 nos) should have the marking indicating next due date for pressure testing;
 - (xxi) Pressure relief valves shall be tested every year by competent person and certificates or records maintained and the functioning of excess flow check valves should also be checked once a year;
 - (xxii) All pressure gauges, level gauges and temperature gauges should be calibrated once a year;
 - (xxiii) Tank or bullet mounted on the chassis shall be hydrostatically tested every 5 years through competent person and Certificates or records maintained In this regard and if the chassis is not suitable for taking the load the tank or bullet should be removed and tested separately;
 - (xxiv) After maintenance or repair job the LPG tank trucks are to be purged by water displacement by LPG or inert gas;
 - (xxv) Driver of the vehicle should carry TREM card and route-map with detail locations and contact agencies in case of an emergency;
 - (xxvi) Checklists for Bulk LPG tank trucks are given in Annexure - I To Chapter IV of this Schedule; and
 - (xxvii) The spark arrestor shall be welded to the exhaust pipe of the prime movers or horse and spark arrestor shall be of a type approved by the CCOE Any alternate spark elimination system duly approved by CCOE shall also be accepted e.g.in case exhaust of diesel engine is based on design having electronic fuel management with unit injectors and electronic control unit coupled with turbo charger and intercooler arrangement, no separate spark arrestor to be provided.

3.2.10 Painting:

Vessel external surface shall be sand blasted and painted with two coats of red-oxide primer (as per IS: 2074 Part I) and two coats of enamel paint (as per IS: 2932 Part I), of the colour stipulated by statutory authorities.

3.3 SAFETY OF TANK TRUCKS IN TRANSIT:

- (i) Except for driving crew and oil companies officials during emergencies or leaks or accidents, no other person shall be carried on the tank truck;
- (ii) Vehicle shall be constantly attended by the driver or his assistant;
- (iii) The vehicle shall be halted at a safe place;
- (iv) Vehicle shall be equipped with Anti-lock Braking System (ABS) as per Central Motor Vehicle Rules, 1989;
- (v) The vehicle should be parked with the consent of the occupier in an open yard or enclosed premises subject to the Factories Act, 1947 (.....of 1947);
- (vi) The driver should take all reasonable precaution to ensure that the vehicle is parked in safe environment;
- (vii) The driver of a vehicle carrying petroleum product shall be trained in the properties of the material carried, the handling method applicable to the grades being carried, in the use of the fire extinguishing equipment carried on the vehicle and in the emergency procedure to be followed and the training to drivers should be in line with syllabus under rule 9 of The Central Motor Vehicle Rules, 1989 and such training should be provided by any Government approved agencies for this purpose;
- (viii) All necessary steps shall be taken by the owner or loader of the vehicle to ensure that the driver is fully aware of, and understands, all instructions;
- (ix) As a precaution against any accident or emergency that may occur during carriage, the driver shall be supplied with instructions in writing in the form of a safety instruction booklet;
- (x) The nature of the danger presented by the dangerous substances carried safety precaution to avert such nature of the danger shall positively be ensured;
- (xi) The appropriate action shall be taken and medical treatment shall be given in the event of persons coming in contact with the dangerous substances being carried or with any substances which might escape there from;
- (xii) The measures to be taken in case of fire and in particular the extinguishing methods or agents or groups of extinguishing methods or agents not to be used shall be ensured;
- (xiii) The measures to be taken in case of breakage or deterioration of packaging or spillage of the dangerous substances, particularly on the road shall be ensured;
- (xiv) The instructions relating to this paragraph should be in local language, Hindi and English;
- (xv) The system of Transport Emergency Cards (TREM) shall meet the requirements; and
- (xvi) The emergency kit to be carried with tank truck shall contain wooden wedges of various sizes, Teflon tapes, non-sparking tool, sealant compound, low temperatures gloves, goggles, threaded brass caps, first aid box, flameproof torch, gaskets, studs, and such equipment;

3.4 LABELLING OF CONTAINERS OR VEHICLES CARRYING LPG:

- (i) To ensure that any package or truck carrying dangerous goods is recognized from a distance, the recommendations include a labelling system and the recommended labels are diamond shaped i.e. they are in the form of square (25 cm x 25 cm) set at an angle of 45 degrees and the upper half of the label is reserved for the pictorial symbol representing the nature of the risk, different symbols being provided for each of the classes and the number of the class or division should be shown in block in the bottom corner of the label unless the substance in question presents more than one risk and any other text inserted optionally in the lower half of the label should be printed in black and should be confined to particulars indicating the nature of the risk and precautions to be taken in handling;
- (ii) Every goods carriage carrying any dangerous or hazardous goods shall display the class label both in front and in the rear in a conspicuous place;
- (iii) Every goods carriage used for transporting any dangerous or hazardous goods shall be legibly and conspicuously marked with an emergency information panel;
- (iv) The display on vehicles of the descriptive names or prescribed "correct technical names" at national and international level of the chemicals or petroleum products in letters not less than 50 mm high;
- (v) The display on vehicle of special signs or plates denoting that dangerous goods are being conveyed or plates bearing special code numbers (HAZCHEM) which may identify the substances or reveal its hazardous property or indicate what action should be taken in emergencies;
- (vi) The name and telephone numbers of the emergency services to be contacted in the event of any fire or any other accident in letters and numerals that are not less than 50 mm high and the name and telephone number of the consignor of the dangerous or hazardous goods or of some other person from whom expert information and advice can be obtained concerning the measures that should be taken in the event of an emergency involving such goods; and
- (vii) Every class label and emergency information panel shall be marked on the goods, carriage as stipulated in the Motor Vehicle Rules, 1989 and shall be kept free and clean from instructions at all the times.

3.4.1 Marking:

Vessel Identification Plate:

Each vessel shall have a non-corrosive metal plate permanently affixed by brazing or welding on the rear dished end in a place readily accessible for inspection and maintained legibly and neither the plate itself nor the means of attachment to the vessel may be subjected to impingement by the tank contents and the plate shall be plainly marked by stamping or embossing or by other means of forming letters to the metal of the plate with the following information in addition to that as required by local regulations, namely:

- (1) Vessel Manufacturer;
- (2) Chief Controller of Explosives (CCOE) approval number

- (3) Vessel Manufacturer's Serial No.;
- (4) Design code;
- (5) Radiography;
- (6) PWHT;
- (7) Design Pressure;
- (8) Design Temperature;
- (9) Hydrostatic test pressure;
- (10) First test date and subsequent test dates;
- (11) Water capacity in liters;
- (12) Licensed Product capacity in tons and symbol or chemical name;
- (13) Name of the Inspection Agency with their stamp;
- (14) Certificate number of Inspecting Agency in respect of-
 - (a) Shell thickness; and
 - (b) Dish End Thickness; and
- (15) Next hydrotest date of the vessel shall be painted on the body of the vessel.

3.5 TRANSPORTATION BY RAIL:

Railway Administration, acting as a carrier of Petroleum Products, is exempted from taking any licence for transporting it under Petroleum Rules, 1976 and Railway Administration have elaborate rules for the carriage of petroleum by rail as provided in the,1989 (24 of 1989) Railways Act and Red Tariff No.19 of Indian Railways Conference Association.

3.5.1 Design Criterion:

All tank wagons used for the conveyance of petroleum products and LPG shall be of a design approved by RDSO and the design parameters for tank wagons used for transportation by rail are issued by the Wagon directorate, Research, Design, and Standards Organisation of Indian Railways.

3.5.2 Safety Appurtenances and other Safety Features:

- (i) Tank wagons for petroleum class A: These wagons are marked as "TP" as per Railway Code, except Hexane which is loaded in TH tank wagon;
- (ii) Each tank wagon is provided with an effective pressure valve as per approved design;
- (iii) All openings of fill pipe and dip pipe are provided with air tight caps;
- (iv) A master valve set at the bottom inside the body with control from the top of tank wagon;
- (v) A block valve at bottom of the wagon to which unloading hose is connected;
- (vi) The top fittings are protected by a dome cover;
- (vii) Tank wagons designed by RDSO are provided with safety valve with Discharge Capacity: 10.3 cum/sec;
- (viii) All other fittings such as liquid valves, vapour valves, magnetic gauging device, thermowell, sample valve, safety valves and pressure gauges are provided on top of the pressure vessel

- in a protective housing known as 'dome' with a cover; and
- (ix) After repair or maintenance tank wagons are required to be purged with LPG or inert gases.

CHAPTER III

4.0 SAFETY IN INSTALLATION AND MAINTENANCE OF LPG CYLINDERS MANIFOLD:

4.1 Design of Installation:

- (i) In order to meet the larger requirement of commercial customers, it may be necessary to connect a number of cylinders to a manifold so that the required quantity of gas at requisite pressure can be obtained and the multi cylinder installations shall be designed as per IS:6044 (part I); and
- (ii) A suitable site for cylinder storage room shall be selected as per the layout considerations.

4.2 Requirement of Cylinder Bank and Burners:

- (i) While deciding at the size of the manifold, it should preferably be designed for higher no. of cylinders to accommodate for increase in consumption in future; and
- (ii) Size of the cylinder storage room shall depend upon the number of installed cylinders designed for the layout of the manifold (parallel or linear) and the cylinder arrangement in the storage room (Standard or staggered) and enough room shall be provided for easy access to each and every cylinder.

4.3 Connections for LPG cylinder Manifold:

- (i) All the cylinders at the customer's premises shall always be connected to the manifold wherever the installed cylinders at the premises are more than four;
- (ii) The cylinders should not be left unconnected or stored elsewhere;
- (iii) Additional cylinders which are to be kept loose, can be stored as per stipulations in Gas Cylinders Rules, 1981 and but, such cylinders should not be stored in manifolded room;
- (iv) Each arm of the manifold shall have a control valve and to each arm of the cylinder manifold cylinders shall be connected through a pigtail;
- (v) For 'SC' type valve cylinders, it is necessary to use an adaptor to connect the cylinder pigtail and the distance between the nipples on the manifold to which pigtails are attached, depends upon the type of cylinder arrangement required i.e., standard or staggered and the staggered arrangement is to be used when availability of space is limited;
- (vi) The flexible hose or pigtail shall be in the same room and its length shall not exceed 2 M;
- (vii) Flexible hose or pigtail shall not pass through doors, windows, walls, ceiling (or) floors; and
- (viii) The pigtails shall be accessible for inspection.

4.4 Location for Manifold Installations:

- (i) Manifolded installations up to 40 kgs LPG can be installed on any floor. Minimum floor area required 5M²;
- (ii) Manifold installations not exceeding 40 kgs. of LPG may be installed in doors on any floor within the same workspace provided the minimum distance between two such installations is 3 M and the floor area for each installation should be at least 5M² and the aggregate quantity of LPG in all such installations does not exceed 200 kgs;
- (iii) Manifolded installations not exceeding 80 kgs. of LPG may be installed indoors on any floor provided the floor area is not less than 12 M² for such installation;
- (iv) Manifolded installation not exceeding 80 kgs. of LPG may be installed indoors on any floor area provided the minimum distance between the installations is 3 M, the proportion of such installations to floor area is one installation per 12 M² and the aggregate quantity of LPG in all such installations does not exceed 200 kgs;
- (v) Small manifold (i.e. Total capacity up to 320 kgs) can be accommodated within the building and for bigger manifold (i.e. capacity 321 to 1000 kgs), a separate shed away from the main building shall be provided keeping adequate safety distances as per IS:6044 (Part D).
- (vi) For manifold capacity requirement of more than 1000 kgs, separate installations each not exceeding 1000 kgs. shall be provided; and
- (vii) The manifold (header) pipeline shall not have any joints to extend its length.

CHAPTER IV

5.0 OPERATING PROCEDURES: BULK LOADING and UNLOADING:

5.1 Loading of Tank Trucks:

Check for following in a tank truck as per statutory regulations before accepting it for filling, namely: -

- (i) Provision of two safety valves, level gauge, Internal Valve with Excess flow check and control valve on liquid and vapour lines, pressure gauge, temperature gauge on the vessel or bullet and fire screen between cabin and vessel is provided and for this purpose, cabins with metallic back cover without any opening will be considered as fire screen (Provision of 2 nos. of 9 Kgs. DCP Fire Extinguishers).
- (ii) Fitment of Spark arrestors of approved quality and no leakage in exhaust silencer pipe exists and manufacturer's name plate with date of testing is fitted on the vessel. Valid Explosive License and RTO certificate is available. Approved drawings of vessel are available and blind flanges or caps are provided on vessel. Availability of Earthing cable. Bonding between vessel and chassis and between flanges is satisfactory. Earthing or bonding point is available. Third party inspection or test certificates for vessel or fittings are available. Liquid or vapour line valves are in good condition.
- (iii) Driver must be trained for hazardous goods transportation and their driving license or certificate must have RTO endorsement for hazardous goods transportation;
- (iv) In order to prevent accidental movement, the handbrake and wheel chocks shall be firmly on and the engine shall be stopped;
- (v) When discharge is in progress, the driver shall remain at his vehicle in such a position as to be able to stop the discharge immediately in an emergency;
- (vi) A visual check shall be made of the surroundings, the tank and connections for unusual or dangerous situations;
- (vii) Warning notices shall be displayed and suitable fire appliances shall be available for instant use;
- (viii) Bonding leads shall be connected before making the hose connections and shall remain connected till the hoses have been removed and perfect bonding contact should be ensured;
- (ix) When operations are commenced, a further examination for leakage at connections shall be carried out;
- (x) No person shall smoke while on or attending such a vehicle;
- (xi) No article or substance capable of causing fire or explosion shall be carried on such a vehicle;
- (xii) Move truck to the loading bay or weigh bridge and record the weight of the empty tank truck;
- (xiii) Place the truck on loading bay and place choke blocks at front and rear wheels and keep the truck in neutral mode with hand brakes "ON";
- (xiv) Stop the engine and switch off all electrical equipment. The master switch shall be put off immediately after parking the truck in position and no electrical switch on the truck shall be turned "on" or "off" during the loading operation;
- (xv) All persons should leave the driver's cabin;
- (xvi) Make earthing connections of the vehicle at specified point to the fixed grounding system;

- (xvii) Connect liquid and vapour lines suitably with the loading point and crack open valves on loading and vapour return lines and inspect hoses or arms and connections for leakage and loading shall start only when the system is leak free;
- (xviii) Start the loading pump;
- (xix) The quantity loaded into the truck can be determined by –
 - (a) Liquid level;
 - (b) Weighment;
 - (c) Positive displacement meter;
 - (d) Mass flow meter; and
 - (e) The quantity of LPG filled shall not exceed the RLW of the tank truck;
- (xx) Liquid level may be determined by roto-gauge or fixed liquid level gauge and percentage volume to be filled shall not exceed 85 % at ambient temperature or the allowable filling limit as per PESO whichever is lower;
- (xxi) Where weigh bridge is used, it is necessary to determine the density of the product being loaded to avoid excess filling in terms of volume and the weigh bridge shall be periodically calibrated and stamped by Weights and Measures Authorities;
- (xxii) When the filling operation is in progress, the pressure within the tank truck vessel shall be observed to ensure that it does not approach the start-to-discharge pressure of the relief valve. Filling rate may be regulated as required; and
- (xxiii) The couplings may then be removed and plugs or caps may be replaced on the tank truck valves and, then, Re-check tightness with soap solution.

5.2 Unloading of tank trucks:

Additional precautions to be taken during unloading are as under, namely: -

- (i) Liquid line and vapour line of the tank truck shall be connected to the respective unloading arm or hoses fixed to the designated unloading point;
- (ii) Test the connections for leaks by slightly opening the valves for pressurizing and when satisfied, valves on the tank truck and the receiving vessel shall be opened;
- (iii) Start the LPG compressor Then, Vapours will be sucked from the receiving vessel and will be discharged into the vapour space of the tank truck vessel creating pressure differential thereby pushing the liquid from the tank truck vessel to the receiving vessel;
- (iv) Care should be exercised to see that the pressure created within the delivering vessel does not reach or exceed the set pressure of the relief valve;
- (v) An authorized person of the company shall supervise the transfer operation and respond immediately in the event of an emergency;
- (vi) After the liquid has been taken out, the vapour recovery operation may be started and care should be taken not to bring down the pressure of the delivering vessel below 1.5 Kg/cm²g. Checklist for bulk LPG tank Trucks at unloading locations is given at Annexure I to Chapter IV of this Schedule, and
- (vii) Unloading by LPG Pump in the storage vessel can be undertaken after taking the safety precautions and SOPs.

5.3 BULK HANDLING FOR MOVEMENT BY RAIL:

LPG is moved in Tank Wagons by the Railways and such wagons are designed by RDSO and are fitted with various devices for safe transportation and operations and the loading facilities are similar as for tank truck loading while unloading of LPG from tank wagons shall be done with the help of compressor. The compressor is used to create a differential pressure between the receiving and discharging vessels by withdrawing vapors from the receiving vessel and forcing it at high pressure into the discharging vessel thereby establishing a smooth flow. The content of the tank wagons at loading locations can be ascertained by weighment on weigh bridge or alternatively by, mass flow meters. The content of the wagons at unloading locations can also be taken as per the stock transfer document or product dispatch note received from the loading locations or by weighment on weigh bridge and like other process.

5.3.1 Safety Precautions:

- (i) Do not allow the locomotive to come on the weigh bridge unless its capacity is designed to take the locomotive load;
- (ii) Sufficient number of dummy wagons shall be used to avoid hauling locos coming within 15 mtr and from first fill point during placement or withdrawal of rake;
- (iii) The first operation after positioning the wagon shall be to provide for proper earthing and earthing shall be disconnected just before the release of the wagon;
- (iv) For connecting and disconnecting hoses, only non-sparking tools shall be used;
- (v) After the wagons are placed on weigh bridge and before the loco is detached, the hand brakes on each and every wagon shall be applied;
- (vi) Like-wise, before the wagons are moved from the weigh bridge, release brakes on all the wagons;
- (vii) Do not use footwear with protruding nails;
- (viii) Ensure that the lower portion of flapper bridge at wagon side is fitted with rubber or wooden padding;
- (ix) Ensure that electrical continuity of the system is intact;
- (x) Ensure that all fittings on the wagons are checked physically;
- (xi) Hoses shall be tested as per statutory requirements and records maintained;
- (xii) The loading or unloading operation shall be carried out under close supervision of authorized person;
- (xiii) During unloading operation, after the liquid transfer is over, the wagon pressure shall not be reduced below 1.5 Kg/sq.cm.(g).

5.3.2 Filling Considerations:

- (i) Tank Wagons for Petroleum Class A Vapour space of not less than 4% of the capacity of tank wagon shall be kept and since tank wagons are loaded in accordance with the load carrying capacity by weight in relation to axle design, the above vapour space is allowed and in addition, the tank wagons are filled as per the calibration tables provided by railways

and which specifies the maximum dip to be loaded for various products; and

- (ii) The maximum quantity of LPG filled in any tank wagon shall be limited to the filling density of the LPG and shall be such that the tank wagon shall not be liquid full due to expansion of the contents with rise of the temperature to 55 °C. or limited to specified gross weight on the wagon, whichever is less.

5.3.3 Operating Procedures:

5.3.3.1 Loading Operations:

- (i) Place the wagon on weigh bridge taking care to see that all the four wheels are properly accommodated on the platform and engage hand brakes;
- (ii) Ask loco to move away and exhibit caution sign at suitable distance away from the wagons on both ends;
- (iii) Switch off loco engine, if parked nearby;
- (iv) Apply brakes on all wagons;
- (v) Ensure fire system, safety interlocks and communication system are permissible to function;
- (vi) Take loading advice;
- (vii) Connect earthing lugs to the wagons;
- (viii) Lower the flapper bridge slowly on the wagon;
- (ix) Open the lid of the wagon;
- (x) Take the tare weight reading and set the pointer of the scale to zero and compare such tare with the marked tare weight on the wagon, alternatively, use mass flow meter to fill the wagons;
- (xi) Connect the filling hose or loading arm and vapour return line hose or arm to the wagon and ensure that the flare connection valves are closed;
- (xii) Ensure that the header is charged with LPG and the bulk loading pump is running;
- (xiii) Open the tanker filling line valve and vapour return line valve;
- (xiv) Check the system for leaks;
- (xv) Open the valve on the vapour return line, therefore, slowly open the valve on the filling line and increase the valve opening and gradually open the valve fully and ensure that filling is up to safe filling level keeping in view temperature factors and take mass flow meter readings if used;
- (xvi) Once the filling is over, close the wagon filling and vapour return lines valves and also valves on filling and vapour return lines at the loading point;
- (xvii) Open the valve on flare line connection to both feed line and vapour return line slowly while depressurizing to avoid ice formation, then, close the flare line connection valves;
- (xviii) Disconnect the filling and vapour return line arm or hose connections from the wagon and replace and tighten the plugs on filling and vapour return lines.
- (xix) Close the top cover of the wagon and seal it properly and remove earthing connections;
- (xx) Release the hand brake of the wagon;
- (xxi) Release all the wagons on the loading points in the lot;

- (xxii) Check the gross and net weight at the weigh bridge; and
- (xxiii) Use loading arms for loading and unloading operations.

5.3.3.2 Unloading Operations:

- (i) Ascertain that the liquid discharge valve and the vapour valve within the tank wagon cover are in the closed position;
- (ii) Open the port covers in the side of the dome shell, if exist, then, unscrew the plugs in the outlets of the vapour valve and the liquid valves using a box wrench and such operations must be done slowly;
- (iii) If there is any sound of escaping vapour or if there seems to be pressure behind the plugs, the pressure shall positively be allowed to relieve itself past the threads before the plugs are entirely disengaged;
- (iv) If the vapour discharge continues or if there is evidence of a liquid discharge, the valves should be re-tightened;
- (v) With the plugs removed, screw pipe nipples into the outlets of the valves after first having applied a modest quantity of sealant to the male threads, keeping the sealant away from the end of the thread and tighten nipples with a pipe wrench;
- (vi) Connect the two-liquid transfer unloading swing arms or hoses to the nipples attached to the liquid discharge valves and connect the vapour or equalizing swing arm or hose to the nipple attached to the vapour valve and in most of the cases, such connections will be made by means of either a ground joint union or a hose coupling;
- (vii) In the event, a ground joint union is used, no gasket will be required and if a hose coupling is employed, ensure that the appropriate gasket is in place and make sure that they are secured tightly by appropriate means;
- (viii) After the vapour and liquid hoses have been connected and before any valve are opened, the valves on the tank wagon are crack opened in order to apply pressure to the hoses or loading arms as a test for leaks;
- (ix) If any leak appears, the valve should be immediately closed and corrective measures applied;
- (x) Recheck the lines and connections to make sure that they are connected correctly;
- (xi) After the liquid and vapour lines have been secured and tested, both liquid education valves should be opened slowly and completely, then, open all other valves in the liquid line working from the tank wagon to the storage tank.
- (xii) If the tank wagon pressure is higher than that in the storage tank, do not open the valves in vapour line or operate the compressor and when the rate of liquid flow drops to an unsatisfactory level with the storage tank filling valve wide open, open the vapour valves between the tank wagon and the storage tank;
- (xiii) At this point, make sure that the control valves at the compressor are in a position which allow the compressor to draw vapours from the storage tank and force it into the tank wagon, then start the compressor;
- (xiv) When the tank wagon is held at a pressure of 2.0 to 2.5 Kg/sq.cm. above the storage tank pressure, the tank wagon should be emptied into the storage vessel;
- (xv) A flow of gas instead of liquid through the sight-flow glass in the unloading line indicates

that the wagon is empty of liquid, then, recheck it by opening the sample valve in the tank wagon dome;

- (xvi) When the tank wagon is emptied of all liquid, stop the compressor and close the liquid valves beginning at the storage tank and progressing to the tank wagon;
- (xvii) If the facilities are so arranged that vapours may be removed from the tank wagon, the pipeline at the compressor should be arranged so that the compressor will draw vapour from the tank wagon and force it into the storage tank;
- (xviii) In this operation, the vapour should be discharged below the surface of the liquid in the storage tank to hasten the liquefaction and, in turn, help prevent excessive pressure in the storage tank;
- (xix) Restart the compressor and when the tank wagon pressure is reduced to about 1.5 - 2.0 Kg/sq.cm., stop the compressor and close all the valves in the vapour line;
- (xx) After bleeding off the pressure in the unloading arm or hoses, disconnect both the liquid and vapour lines and replace all the plugs in the tank wagon valves and the unloading fittings;
- (xxi) Recheck sample valve, gauging device and thermometer well to determine that they have been returned to their original condition and are closed tight and lower the dome cover carefully and lock it in place with the locking pin or secure by appropriate means;
- (xxii) Remove bonding connections;
- (xxiii) Reverse or remove and replace the "Flammable" placard with "Dangerous - Empty" placard;
- (xxiv) Remove the "Stop – Tank Wagon Connected" sign and wheel blocks;
- (xxv) Any defect observed in the tank wagon should be noted on the appropriate forms and routed in accordance with acceptable procedure;
- (xxvi) Notify the railways in writing about release of wagon and ensure that it is removed from the siding promptly;
- (xxvii) Gauge the storage tanks, within the installation, which have received the LPG to determine that the liquid level is appropriate; and
- (xxviii) In the event of LPG received on weight basis, the tank wagon may require weighing following the completion of the unloading operation.

5.3.4 Procedure for Degassing of LPG tank Wagons:

The following sequence shall be followed, namely: -

- (i) During degassing operation on a spur, all loading or unloading operations on that spur shall be stopped and earthing to be ensured even on the degassing bay before commencing the degassing;
- (ii) Sampling valve should be opened and vapours allowed to escape fully;
- (iii) The plugs of liquid and vapour reduction valves should be unscrewed and then valve be opened;
- (iv) The method adopted to make the wagon free from LPG is to fill the wagon completely with water and allow to overflow for an hour and then pump out the water after 24 hours and alternatively, steam or inert gas can be used for degassing;
- (v) Remove the manhole cover and in no case the heating of studs/bolts shall be adopted to open

- them and if required, rust remover solution shall be used;
- (vi) Check thoroughly for presence of LPG vapours inside by explosive meter and repeat the procedure if explosive meter shows presence of vapour inside;
 - (vii) Ensure that the barrel is completely dry in case water filling or steam purging method of degassing is adopted;
 - (viii) A safety instruction checklist should be exhibited at the degassing station containing all relevant points in the degassing procedure;
 - (ix) Degassing operation should be discontinued at the approach of thunder storm and all valves manhole covers and hoses disconnected to make the wagon ready for removal; and
 - (x) Disposal of sludge from the LPG wagons should be transported away from the siding in wet condition and disposed of in safe manner.

ANNEXURE – I

CHECKLIST FOR UNLOADING OF BULK LPG TANK TRUCKS:

Checks required to be carried out before allowing entry of tank trucks inside licensed area:

- (i) TT has suitable spark arrestor of make and design approved by CCE, Nagpur, properly welded to exhaust;
- (ii) Carries 2 nos. 9 Kg. DCP extinguishers in easily accessible and removable position with if;
- (iii) Truck No. date of checking and charging painted on it;
- (iv) Quick closing manifold valve with lever indicating close and open status;
- (v) No visible dent on the bullet;
- (vi) Whether tyres fitted is in roadworthy condition;
- (vii) All junction boxes are properly sealed;
- (viii) Any loose electrical wiring or terminal, if found is remained;
- (ix) Electrical wiring is insulated and provided with suitable over current protection;
- (x) Truck is self-starting;
- (xi) Readily accessible master switch for switching off the engine is provided inside the cabin;
and
- (xii) Leakage from any fittings or joints is repaired.

Checks required to be carried out before issuing loading memo (During the course of unloading operations):

- (i) Height barrier provided as per specifications;
- (ii) Fuel tank is protected by means of stout guard and fuel tank cap is locked;
- (iii) Paint of bullet is not peeling off; and
- (iv) First aid kit is available.

Checks required to be carried out on random basis minimum one day, once in a month:

- (i) Internals of fire extinguishers in good condition;

- (ii) Carries TREM CARD, instructions booklet detailing instructions on handling emergencies enroute;
- (iii) Carries route map;
- (iv) Carries TERM card;
- (v) Has valid CCE licence and authenticated copy of drawing;
- (vi) Carries RTO permits;
- (vii) RLW-ULW Licensed capacity;
- (viii) Hazchem sign, name of contractor with address and telephone No. displayed prominently;
- (ix) Tank has no sign of external corrosion;
- (x) Excess flow check valves are functioning;
- (xi) Liquid or vapour lines are adequately anchored and are well protected by means of stout steel guard;
- (xii) Liquid or vapour pipe lines are in single piece from excess flow check valve to discharge valves;
- (xiii) Safety fitting viz. safety valve, roto-gauge, pressure gauge and temperature gauge are adequately protected; and
- (xiv) Operative fittings like roto-gauge, pressure gauge and temperature gauge are operational.

General :

Following shall be available in Tank Truck, namely: -

- (i) Tools for all fittings;
- (ii) 4 Nos. caution sign board with luminous paint for stopping traffic in case of any emergency;
- (iii) Based on the nature of defects either all the deficiencies should be got corrected; and
- (iv) unloading location itself or the tanker should be allowed to get the repairs done enroute and submit the details at loading location are available.

CHAPTER V

6.0 Bottling Operations:

6.1 Receipt and Segregation of LPG Cylinders:

- (i) Cylinders shall be received in capped condition and cylinder shall conform to IS:3196 Part I or IS:16646;
- (ii) All cylinders received should be verified against valid documents and the actual receipt should be tallied with the details on the relevant documents and the shortages or any other shortcomings should be endorsed and certified on the body of the document;
- (iii) All new cylinders received shall be supported by test certificates issued by BIS;
- (iv) The defective returns from the distributors or end users shall be supported by a certificate providing description of the defects and such cylinders shall be segregated for further corrective action; and
- (v) Purged cylinders shall be unloaded in upright condition and use of telescopic conveyors should be used for the purpose and purged cylinders should not be rolled on the belly.

6.2 VISUAL INSPECTION/SEGREGATION:

On line detailed visual inspection shall be carried out during receipt or unloading of cylinders at Plant in line with IS 15966.

6.2.1 Based on visual inspection, cylinders shall be segregated as under, namely: -

- (i) Cylinders due for statutory testing;
- (ii) Under-filled cylinders received from the distributors or end users, duly tagged and certified for further correction;
- (iii) Leaky or defective cylinders received from the distributors or consumer duly tagged;
- (iv) Spurious cylinders for investigation or scrapping;
- (v) Cylinders found unfit for filling (beyond repairs) on visual inspection (e.g. heavily rusted or heavily dented etc. (for degassing, de-shaping and disposal as scrap);
- (vi) Cylinders found defective, but repairable such as-
 - (a) Cylinders having defective valves; and
 - (b) Cylinders having broken or bent foot rings or valve protection rings (to be

segregated for cold or hot repairs depending upon the condition and those found unfit after close examination, are rejected as unserviceable);

- (vii) Cylinders owned by Other Marketing Companies (OMC), wrongly mixed with receiving company's cylinders (to be segregated for further action as per receiving Company's Policies);
- (viii) Empty cylinders fit for filling; and
- (ix) Cylinders to be checked physically for presence of O ring and new O ring to be provided, if O ring is missing in cylinders.

- 6.2.2 Rejection criteria for physical and material defects on the cylinder shall be per IS 15966.
- 6.2.3 Reasons for leaky or defective cylinders received from the distributors should be verified from the tag attached to the cylinder and such cylinders should be corrected.
- 6.2.4 New cylinders or cylinders received from statutory testing plants or hot repair plants or any cylinder which has undergone pneumatic test shall be purged as per Purging Procedure.
- 6.2.5 Cylinders due for statutory testing or hot repairs shall not be taken up for filling but sent to testing plant.
- 6.2.6 Cylinders without proper markings or without serial number shall not be taken up for filling and should be declared as spurious.

6.3 FILLING OF CYLINDERS:

- (i) The cylinders are passed through online washing and drying unit for external cleaning before filling;
- (ii) Safety cap of the cylinder shall be removed only after the cylinder passes through a washing and drying unit as the entry of the water inside may damage the internals of the valve;
- (iii) Cylinder shall be introduced to the filling machine only after removal of safety cap;
- (iv) 'O' Ring (joint packing) shall be present and there is no apparent damage to valve and the same shall be checked before cylinder introduction into the filling machine;
- (v) It shall be ensured that all earthing and bonding connections of filling head, filling machine frame and like other connections are proper and there is no LPG leakage from filling machine or filling head;
- (vi) It shall be ensured that vapour extraction system is switched on before start of filling operation. where cylinders are to be filled at carousel, vapour extraction blowers should be interlocked with the carousel rotation to ensure that carousel cannot be rotated without switching on of the vapour extraction blowers; and
- (vii) Bypassing of safety interlocks, fire water system, gas detection system, vapour extraction system and heat detection system shall not be permitted unless authorised by Location In-Charge having jurisdiction in writing and alternate mitigation measures are in place.

6.4 TARE WEIGHT MARKING:

- (i) Tare weight stenciling shall be legible and prominent on the cylinder; and
- (ii) Tare weight the new cylinders received at the plant shall be checked for their tare weights marked or stenciled on the cylinder and in case discrepancies are observed in a particular

lot, the lot should be kept segregated for further corrective action.

6.5 FILLING OPERATION:

Filling of cylinders are under taken either on Carousel or on Unit Filling Machine (UFM) and all cylinders shall be filled on gross weight basis on filling machine in the following manner, namely: -

- (i) Cylinder shall be introduced in the carousel or unit filling machine;
- (ii) Filling head is fixed either manually or automatically on the valve;
- (iii) Tare weight of the cylinder shall be set or transferred to filling machine where the cylinder is to be filled;
- (iv) After introduction of cylinder on filling machine LPG shall be filled into the cylinder through a filling head connected to LPG supply source;
- (v) The filling pressure should not exceed maximum working pressure of cylinder i.e. 16.9 kg/cm² at 65-degree C;
- (vi) When the gross weight (Tare weight + Net weight of LPG) reaches the targeted weight, the filling shall stop and filling head shall be disconnected from the cylinder; and
- (vii) After filling, the cylinder shall be removed from the filling machine.

6.6 CHECK WEIGHING-POST FILLING OPERATION or INSPECTION:

- (i) All filled cylinders coming out of the carousel shall be weighed for ensuring 100% check weighing;
- (ii) Accuracy of the check scale shall be verified by using standard weights at the beginning of the shift and subsequently at suitable intervals;
- (iii) Maximum permissible errors on net quantity declared by weight shall be in accordance with the Legal Metrology (Packaged Commodities) Rules, 2011 and as amended time to time.
- (iv) On check weighing, the cylinders that do not meet the norms under Legal Metrology Rules referred to in Clause (iii) shall be segregated for correction of the net weight quantity of LPG in the cylinder;
- (v) Cylinders meeting the net weight specifications of Legal Metrology Rules referred to in Clause (iii) shall be proceeded for further checks for valve defect; and
- (vi) Daily record for underweight and overweight cylinders generated shall be maintained.

6.7 LEAK TEST-VALVE, O-RING, BUNG AND BODY DEFECTS:

Checks shall be carried out for the following categories of leaks, namely: -

- (i) Leak detecting equipment for valve or “O” ring shall be calibrated to detect leakage beyond 0.5 gm/hr;
- (ii) Defective ‘O’ rings identified, shall be replaced with new “O” ring and again checked with O-Ring leak detector before dispatch;
- (iii) Valve Leak cylinders shall be sent for replacement with new valves which shall be re-

- checked for valve leak before dispatch;
- (iv) Cylinders having leaks through valve-bung threads shall be segregated and sent for valve replacement and if bung is damaged and leak re-surfaces after valve replacement, such cylinders shall be segregated, valves shall be retrieved after product evacuation and cylinder shall be degassed and scrapped;
 - (v) Cylinders without valve or O-Ring leaks shall be proceeded for further checks for body and bung leak at water bath and such cylinder shall be capped prior to dipping in test bath water;
 - (vi) Leakage from the cylinder body, either from the parent metal or from the weld joints is identified at water bath and such cylinders are sent for evacuation, valve removal and reshaped for scapping;
 - (vii) Daily record of leaky cylinders generated should be maintained at the plant;
 - (viii) Suitable tags or markers should be used to identify different categories of leaky cylinders;
 - (ix) Valve defective cylinders shall be capped with safety caps until they are evacuated;
 - (x) Body leak and bung leak cylinders shall be evacuated on priority immediately; and
 - (xi) Only those cylinders found passing all above weight and leak test checks shall be processed further for sealing.

6.8 SEALING AND DESPATCH OF CYLINDERS:

- (i) Cylinders shall be sealed with PVC seal or Aluminum seal and such seal shall have identification mark of oil company and preferably name of plant;
- (ii) The sound filled cylinders that pass through all quality control checks, are then sealed at the sealing unit and all sealed cylinders ready for dispatch shall meet the various marking norms as laid down in Legal Metrology (Packaged Commodity) Rules, 2011 as amended time to time; and
- (iii) The cylinders can be directly loaded to the stack trucks and dispatched or can be sent to filled cylinder storage shed for loading into stack trucks at a later stage.

6.9 AUXILLARY OPERATIONS:

6.9.1 Purging:

Cylinders received from manufactures or after statutory testing or hot repairs shall be purged before filling to purge air from the cylinders and introduce LPG in cylinders and in purging, the air is sucked from the cylinder by means of a vacuum pump and the pressure inside the cylinder comes down below the atmospheric pressure $0.35 \text{ kg /cm}^2 \text{ absolute} = (-)0.65 \text{ kg/cm}^2(\text{g})$ and such cylinder then immediately filled with LPG vapour to bring it back to at least atmospheric pressure (i.e. a pressure of 1.035 kg / cm^2) but not above working pressure of cylinder i.e. 16.9 kgf/cm^2 at 65 degree C and in such process, the entire cylinder space is occupied with LPG vapour.

6.9.2 Evacuation:

- (i) Before evacuation it must be ensured that bonding and earthing connections of the filling gun and equipment are proper to dissipate any static charge that may develop due to flow of LPG;
- (ii) Evacuation procedure will depend on the type of equipment provided and due to such dependency, the Manufacturer's manual should be referred for operating instructions;
- (iii)Cylinders profusely leaking and over-filled cylinders shall be evacuated first and all cylinders with valve leak shall remain capped till evacuation and valve change;
- (iv)After product evacuation, the cylinder shall be depressurized to pressure near atmospheric pressure by cold flaring the residual pressure through a flare line extending 1.5 m above eve of the shed;
- (v) Provision for evacuation of all type of cylinders being handled shall be available at the Plant;
- (vi)Provision shall also be made for evacuation of valve pin stuck or broken LPG Cylinders through use of suitable adapter; and
- (vii) All LPG has to be evacuated into the LPG vessel in closed loop and there shall not be any vented out of LPG at the Plant floor.

6.9.3 Cold Repair of Cylinders:

Cylinder having defective valve and with bung leak shall have to undergo valve removal and valve re-fixing operation and the valve leak and bung leak cylinders are repaired as under, namely: -

- (i) on-line valve changing machine shall be used to change the valve without evacuation as per the procedure laid down in the operating manual of the manufacturer and alternatively, cylinder shall be evacuated of its product and thereafter depressurized to near atmospheric pressure through cold flare before opening the defective valve;
- (ii) Before fixing the valve, suitable jointing compound shall be used and the jointing compound shall be compatible with LPG, water and metallurgy of cylinders and valves;
- (iii)The valve shall be tightened to a torque of 20 Kgf-m +/- 2 Kgf-m by the valve screw or unscrew machine where the specified torque level is pre-set;
- (iv)The torque limit (20 Kg-M. +/- 2Kg-M.) set on screw or unscrew machine shall be verified by using a torque wrench for the machine's correct setting;
- (v) The cylinders identified for the bung thread defects shall be segregated, recorded and further declared as scrap; and
- (vi)Cylinders marked for valve replacement and valve removal alone shall have suitable identification mark to prevent mix up and ensure proper segregation.

6.9.4 De-gassing of Cylinders:

If the cylinders are identified as unserviceable during the operation, the same shall be degassed after evacuation and the unserviceable cylinders shall be evacuated and depressurised to atmospheric pressure and the valves are removed from the cylinders after depressurizing and the cylinders shall be filled fully with water and allowed to overflow and

thereafter shall be emptied out by inverting.

6.9.5 Defective Cylinders:

Cylinders with defects like, foot-ring (bent or broken), valve protection ring (bent or broken), body damage (dent or cut or pitting) and like other defects, should be segregated for cold or hot repairs depending upon the condition.

6.9.6 De-shaping or Disposal of Cylinders:

Any cylinder which fails to pass examination as per IS: 16054 or IS: 15966 or test or which loses in its tare weight by over 5 per cent or which for any other defect is found to be unsafe for use, shall not be filled with any compressed gas and shall be destroyed by flattening it as a whole or after being cut into pieces in such a manner that the pieces cannot again be joined together by welding or otherwise to form a cylinder and the concerned plant must maintain record of cylinders which are scrapped for disposal with details line manufacturer's name, Serial No., Original test date, age profile and like other particulars.

6.10 Handling and Storage of Cylinders:

- (i) Handling and storage of LPG cylinders, whether empty or full, shall in compliance with the provisions of the Gas Cylinder Rules, 2004;
- (ii) The owner of a cylinder shall keep for the life of each cylinder, a record containing the following information regarding each cylinder, namely: -
 - (a) Cylinder manufacturer's name and the rotation number;
 - (b) The specification number to which the cylinder is manufactured;
 - (c) The original hydrostatic test or hydrostatic stretch;
 - (d) Cylinder manufacturer's test and inspection certificates; and
 - (e) Number and date of letter of approval granted by the Chief Controller;
- (iii) Purged cylinders shall be handled in the vertical position at all stages of operations and handling;
- (iv) LPG cylinders shall not be dropped, rolled on body and shall not be subjected to any violent contact with any other cylinder or object cylinder shall be moved by rolling on its foot ring or on conveyors or hand trolleys and the telescopic conveyors shall be provided for loading or unloading of cylinders from or to the trucks at loading or unloading point;
- (v) Belly rolling of purged cylinders either filled or empty is strictly prohibited;
- (vi) No attempt shall be made to heat the cylinders for normal operation;
- (vii) The safety cap shall not be removed from the cylinder valve until the cylinder is taken up for filling or any other operation and such cylinder should be refitted as soon as the operation is over and safety cap shall be fitted while the cylinders are passed through the washing unit and water bath;

- (viii) Cylinders shall never be thrown from a height even though sufficient padding on the floor is available;
- (ix) Any cylinder having body leak, bung leak, bulge, fire ravaged or spurious shall be evacuated immediately;
- (x) Cylinders requiring repairs other than valve leak shall be degassed for repairs; and
- (xi) All cylinders referred to in Clause (i) to (x) shall be clearly identified, with markers, to their nature of defects and shall be kept capped during storage.

6.10.1 Handling during Loading and Unloading Operations:

- (i) Cylinders shall be loaded or unloaded without dropping them or subjecting them to any excessive impact;
- (ii) Telescopic conveyors shall be used for this purpose to extent possible;
- (iii) While loading operations, the Filled cylinders or empty cylinders in use shall be stacked in vertical position in stake trucks up to a maximum height of 2m; that the maximum height and overall gross weight of the truck does not exceed the Registered Laden Weight (RLW) fixed by Regional Transport Officer (RTO) or any other local road restrictions enroute;
- (iv) While unloading operations of filled or empty cylinders, the cylinders should be handled in such a way, that the dropping or subjecting them to shocks or rolling inside the truck or on the ground shall not occur.

6.10.2 Storage of Cylinders:

- (i) Valves of all cylinders stored in the plant shall be kept capped with safety caps;
- (ii) LPG cylinders should be stored in a covered shed or a godown, duly licensed by PESO in earmarked cylinder stacks;
- (iii) The storage area should be cool, dry, well ventilated, covered and away from any potential source of heat and the area should also be easily accessible;
- (iv) The quantity of empty serviceable cylinders and filled cylinders stored in the sheds at any point of time should not exceed the designed capacity of the area of the shed. Inventory of the filled cylinders shall not exceed the licensed capacity mentioned in the PESO license and there should be different storage areas (stack marks) earmarked for different categories of cylinders to prevent mix up;
- (v) All the filled cylinders shall be stacked vertically with the exception of body leak cylinders which may be temporarily laid horizontally and but such stacking, this should not be done in the case of cylinders having leakage through bungs or valves which shall be kept vertically and the cylinders, shall be evacuated on priority;
- (vi) In case of the cylinders segregated as scrap, the valves should be removed after de-pressurizing and then degassed;
- (vii) Cylinders either filled or empty should be stacked only two highs;
- (viii) In case removal of valve without immediate replacement, the bung hole must be covered with a suitable plug taking all precautions to ensure that the internal threads of the bung are not damaged, due to corrosion;
- (ix) The cylinders shall be stored in such a way that each cylinder is easily accessible at all times

so that any leaky cylinder can be detected easily and speedily removed from the stack for corrective action and-

- (a) To achieve such store, the stack should comprise of small lots of 4 rows with 25 cylinders in each row in two high and minimum access pathway of one metre wide must be maintained on both sides of the 4 rows and 2 meters after every 5 such lots;
- (b) After each length of 25 cylinders there must be a passage of 2 meters;
- (c) The stack areas must be properly marked or painted on the flooring and in addition, two metres clear distance should be maintained from edges of the shed, edges of conveyer and from the equipment; and
- (d) Each stack should be clearly marked with sign boards indicating the type of cylinders in the stack;
- (x) All leaky cylinders shall be corrected or evacuated before the end of the working hours;
- (xi) Minimum distance of 15 metres from cylinder loading area and minimum distance of 10 metres from filling point shall be observed for all filled cylinders stack; and
- (xii) Different type of cylinders shall not be mixed in single stack and defective cylinders of different types shall be stacked separately.

6.10.3 Handling of Ethyl mercaptan:

Leaks and spills of mercaptan can be treated with commercially available masking agents (e.g. Aldor and Neutroleum Alpha and like other agents) to make them odourless and large mercaptan spills shall be covered with sand or activated carbon or any other absorbing material which are then buried or incinerated and the area over the spill should then be washed with ordinary household bleach solution and then thoroughly with water. Dry bleaching powder should never be used in treating mercaptan spills, otherwise a violent reaction could occur.

The empty containers of ethyl mercaptan shall be disposed as per MSIHC Rules, 1989.

CHAPTER VI

7.0 OPERATION, MAINTENANCE AND INSPECTION:

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

7.1 Basic Requirements:

Each facility shall meet the following requirements, namely: -

- (i) To have written procedures covering operation, maintenance, and training;
- (ii) To keep up-to-date drawings of plant equipment, showing all revisions made after installation;
- (iii) To revise the plans and procedures as operating conditions or facility equipments require;
- (iv) To establish a written emergency plan;
- (v) To 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) To analyse and document all safety-related malfunctions and incidents for the purpose of determining their causes and preventing the possibility of recurrence;
- (vii) To follow the maintenance philosophy that, the activities should be identified that would be contracted to third party contractors for maintenance and support;
- (viii) That the activity supervisors shall be identified according to the level of supervision required;
- (ix) That the referred to in clause (viii) supervisors are given Safe supervisor training by designated staff and then they are put on the job;
- (x) That the contractors staff shall be engaged in toolbox talk given on relevant topics, which are held with the Contract holders and owners; and
- (xi) That the OEM service engineers are involved in critical overhauls for better quality assurance and for first time activities.

7.2 The operating manual for LPG storage, handling and bottling facilities shall include standard operating procedures shall include procedures for the following, namely: -

- (i) Bulk handling, bottling operations, maintenance, inspection and fire protection facilities;
- (ii) Determining the existence of any abnormal conditions, and the response to these conditions in the plant;

- (iii) The safe transfer of LPG and hazardous fluids, including prevention of overfilling of vessels for the proper startup and shutdown of all components to ensure that each control system is adjusted to operate within its design limits;
- (iv) The monitoring operations; and
- (v) The emergency preparedness and handling.

7.3 The operating procedures manual shall be accessible to all plant personnel and shall be kept readily available in the operating control room and the operating manual shall be updated when there are changes in equipment or procedures and all LPG plant components shall be operated in accordance with the standard operating procedures as per operating manual.

7.4 The periodic inspections and tests shall be carried out in accordance with generally accepted engineering practice or recommendations of Original Equipment Manufacturer to ensure that each component is in good operating condition;

7.5 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;

7.6 It shall ensure that where the operation of a component is taken out of service, which 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 and wherever possible, the component shall be locked out; and

7.7 Stop valves for isolating pressure shall be locked or sealed open. These shall not be operated except by an authorized person.

8.0 Maintenance Manual:

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

8.2 The maintenance manual for facility components shall include the following, namely: -

- (a) The manner of carrying out and the frequency of the inspections and tests should be specified in respect of the component;
- (b) 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;
- (c) That each entity shall conduct its maintenance program in accordance with its written manual for facility components; and
- (d) That in addition to as specified in clauses (a) to (b), the history card of all critical equipment, instruments and systems shall be maintained.

8.3 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 and the

maintenance execution begins with the receipt of a work request and concludes with the close out of the work order;

- (ii) The 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 and such stable work environment 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; and
 - (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 and 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 and if the work is not completed, it should continue the next working day after taking requisite permission and approval from work permit issuing personnel; and
- (xi) The work permits 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 and after completing like other formalities.

8.4 Maintenance Strategy:

- (i) The facilities should be designed for minimum maintenance intervention;
- (ii) The maintenance requirements should be clearly defined in writing 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 and online data acquisition to support planning and analysis;
- (vi) Special Critical Equipment shall have OEM defined performance standards which shall be periodically tested and verified; and
- (vii) Structural and pipeline survey and painting shall be done on a regular basis.

8.5 The entity shall prepare a written plan for preventive maintenance covering the scope, resources, periodicity and like other requirements and the corrective measures should include the preventive maintenance, scheduling, execution and closure;

8.6 Each facility should have well defined system in writing for identification of spare part, rationalization and optimization to minimize any supply chain or logistics constraints and risks;

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

9.0 INSPECTION;

- (i) Each facility shall have written inspection, testing and commissioning program in place. Inspection shall be done before commissioning during installation as well as during regular operation of the LPG 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 and like other system shall be properly maintained and followed;
- (iii) Inspection shall cover the review of test protocols and acceptance criteria that such protocol and criteria 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 there from be documented and approved;
- (v) All safety systems are installed inspected and tested as per design or OEM requirement;
- (vi) Inspection shall cover that all safety devices are installed and are in working condition as per the design or OEM requirements;
- (vii) Inspection shall cover the verification of various safety interlocks and ESD provided in the design;
- (viii) Inspection shall cover the adequacy of sealing systems;
- (ix) Inspection shall cover the electrical systems, check its integrity, earthing resistance, bonding and like other technical requirements;
- (x) Inspection shall cover the integrity of mechanical and rotating equipment;
- (xi) The integrity and efficacy of gas detection, fire protection and fighting system, and connected equipment shall be covered in the inspection;
- (xii) Inspection shall cover the efficacy of corrosion system;
- (xiii) Inspection shall cover and review the mechanical completion records that the PSVs are of the correct type and sizing as per the P&IDs or data sheets;

- (xiv) Inspection shall cover location of inlet pipe-work to relieving devices in relation to potential restrictions (e.g. above liquid levels, vessel internals, and like other restrictions);
- (xv) Inspection shall cover and review P&IDs to check the position of isolation valves for relieving devices, their capacities and the inspection has 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;
- (xvi) 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 in writing;
- (xvii) Inspection shall cover that all ESD devices move to their safe condition on loss of system output, hydraulic power or instrument air and all ESD Valves and actuators shall remain functional following an explosion or under fire conditions for a sufficient time period to perform their intended function;
- (xviii) The maximum allowable back pressure and minimum design temperature of the relief system shall be checked for suitability for the highest identified flow rate;
- (xix) Control System shall include all status monitoring and actions to and from the control rooms;
- (xx) Inspection to cover the escape and evacuation passages;
- (xxi) Inspection shall cover the emergency communication system for its effectiveness during emergency situations; and
- (xxii) The inspection frequency table shall be developed for all safety interlocks, alarms, trips, firefighting equipment and system, detectors and like other safety equipments in line with OEM guidelines or specifications, checked and records maintained thereof and the typical inspection frequency for various safety systems, interlocks is provided below -

Typical Inspection Frequency

Item	Minimum Frequency	Remarks
(1) Excess Flow Check Valve of TT loading gantry	Once in six months	
(2) Jockey pump start or stop pressures	Once a week	
(3) Main fire pump set pressure	Once a month	
(4) Earthing interlock test in TT loading/unloading gantry	Once a week	
(5) ESD system in control room	Once a month	
(6) Alarms and trips in pipeline transfer system	Once a month	

(7)	Leak detection system of pipeline transfer	Once a quarter	
(8)	Pipeline transfer high pressure or low pressure alarms	Once a month	
(9)	Low pressure alarm in fire hydrant in control room	Once a week	
(10)	ESD in pipeline transfer system	Once a month	
(11)	Emergency Push button or Break Glass in the field	Once in two months	
(12)	Heat detector functionality test at each facility	Once in a quarter	
(13)	Electric siren interlock test	Once in a month	
(14)	GMS alarm	Once a month	
(15)	Sprinkler system check for blockage or effectiveness	Once a quarter	
(16)	ROV emergency shut off tests	Once a month	
(17)	Jetty ROV closure tests	Once in a month	
(18)	ERC or Breakaway Couplings	Once in six months	
(19)	Manual Call points	Once a month	
(20)	High level alarms in Control room	Once in a month	
(21)	High level switch (85 %)	Once in three months	
(22)	Radar Gauge calibration	Once in five years	
(23)	Servo Gauge calibration	Once in five years	
(24)	Mass flow meter calibration	Once a year	
(25)	CP system potential check by reference electrode	Once in quarter	
(26)	Interlock Carousel and vapour extraction blower	Once a month	

CHAPTER VII

10.0 Safety Management System:

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

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

10.2 Elements of Safety Management system:

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

- (i) **Safety Organization**, - which denotes that leadership and management commitment should be clearly visible in the SMS and 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 program. Management should review the safety and environmental management program 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 program in light of program audit results, changing circumstances and the commitment to continual improvement. Observations, conclusions and recommendations of management review should be documented;
- (ii) **Safety Information**, - which denotes that 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**, - which denotes that 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 or minimize the consequences of

uncontrolled releases and other safety or environmental incidents and human factors should also be considered in this analysis and

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 and recommendations resulting from the process hazard analysis (PHA) should be completed before start-up for a new process or facility, or modification in existing facility;

- (iv) **Operating Procedures**, - which denotes that 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 and operating procedures should be based on process safety information so that all known hazards are taken care of and 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 and training shall be imparted to the operators on operating procedures and they should be certified as competent. When changes are made in facilities, operating procedures should be reviewed as part of the management of change procedure and 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 and competent person every year;

- (v) **Safe Work Practices**, - which denotes that 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 and such safe work practices may apply to multiple locations and will normally be in written form (safety manual, safety standards, work rules, and like written form) but site-specific work practices shall be prepared and followed and 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 and such deviation should be documented for future analysis.

- (vi) **Training**, - which denotes that the training program shall establish and implement programs 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 and any change in facilities that requires new or modification of existing operating procedures may require training for the safe implementation of those procedures and the 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 programs; and operator observation of contractor work performance;

- (vii) **Management of Change (MOC)**, - which denotes that there should be procedures to identify and control hazards associated with change and to maintain the accuracy of safety information and for each such MOC, the operator shall identify the potential risks associated with the change and any required approvals prior to the introduction of such changes and the types of changes that such a MOC procedure addresses shall include:
- (a) technical;
 - (b) physical;
 - (c) procedural; and
 - (d) organizational.

and changes in such procedure shall be considered permanent or temporary changes and the process shall incorporate planning for the effects of the change for each of these situations and such procedures should cover the following, namely: -

- (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 program;
- (d) Communication of the proposed change and the consequences of that change to appropriate personnel and the necessary revisions of the safety and environmental information;
- (e) The duration of the change, if temporary; and
- (f) Required authorizations to effect the change;

- (viii) **Contractors**, - which denotes that when selecting contractors, operators should obtain and evaluate information regarding a contractor's safety and environmental management policies and practices, and performance there under, and the contractor's procedures for selecting subcontractors and 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 or 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**, - which denotes that procedures should in place and 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 and entity shall maintain inspection and testing procedures for safety-related equipment and human factors should be considered, particularly regarding equipment accessibility for operation, maintenance and testing;

- (x) **Pre-startup Safety Review**, - which denotes that 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 and it should be ensured that programs to address management of change are in place;

- (xi) **Permit to Work (PTW) System**, - which denotes that PTW system is a formal written system used to control certain types of work which are identified as potentially hazardous and essential features of permit-to-work systems are the following, namely: -
 - (a) Clear identification of the person, 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; and
 - (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**, - which denotes that 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 and the copies of the ERDMP for the LPG storage, handling and bottling facilities shall be maintained at each installation. The emergency response planning shall have clear written procedures for expected actions during anticipated emergencies and the 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 of any component of the LPG storage, handling and bottling facilities, personnel error, forces of nature, and activities carried on adjacent to the facilities and also the emergency procedures shall include-
 - (i) but not be limited to procedures for responding to controllable emergencies, including the following, namely: -
 - (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; and
 - (d) Other steps to ensure that the escape of gas or liquid is promptly cut off or reduced as much as possible;

- (ii) procedures for recognizing an uncontrollable emergency and for taking action to achieve the following, namely: -
 - (a) Minimize harm to the personnel at the LPG storage, handling and bottling facilities and to the public; and
 - (b) Provide prompt notification of the emergency to the appropriate local officials, including the possible need to evacuate persons from the vicinity of the LPG storage, handling and bottling facilities;

- (iii) 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, namely: -
 - (a) Quantity and location of fire equipment throughout the LPG storage, handling and bottling facilities;
 - (b) Potential hazards at the LPG storage, handling and bottling facilities; and
 - (c) Communication and emergency-control capabilities at the LPG storage, handling and bottling facilities;

- (xiii) **Incident Investigation and Analysis,-** which denotes that 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 and incident investigations should be initiated as promptly as possible, considering the necessity of securing the incident scene and protecting people and the environment and the intent of the investigation should be to learn from the incident and help prevent similar incidents and a corrective action program should be established based on the findings of the investigation to prevent recurrence; and

- (xiv) **Compliance Audit, -** which denotes that safety Audits are the periodic examination of the functioning of safety system and it gives an idea about how effectively the safety system is implemented and how they are being accomplished and it is the feedback 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 program and procedures should cover the following, namely: -
 - (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; and
 - (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.

CHAPTER VIII

11.0 FIRE PROTECTION FACILITIES:

11.1 GENERAL:

LPG Installations shall have well defined in-built fire prevention and protection system to mitigate any exigency and the requirements of fire prevention and protection system shall be as specified in the succeeding paragraph of this Chapter.

11.2 DESIGN CRITERIA:

- (i) The single largest fire risk shall be considered;
- (ii) All LPG storage Vessels, Cylinder Storage or Filling or Repair Sheds, LPG Pump or compressor Houses, remote operating valves or motor operating valves on LPG lines Bulk Lorry and Tank Wagon Gantries shall be fully covered by medium velocity water spray system;
- (iii) Fire Protection Facilities shall have fire fighting access, means of escape in case of fire and also segregation of facilities so that the adjacent facilities are not endangered during the fire; and
- (iv) Heat Detectors for detection of fire for automatic actuation of medium velocity water sprinkler system shall be provided and the QB or EP detectors shall be placed directly overhead or inside the hazard and in areas without specific hazard, detectors shall be placed evenly across the ceiling or with maximum spacing of 3 meters inside the shed and any other detectors if provided shall comply with the design requirements.

11.3 FLOW RATE DESIGN:

The Fire Water pumping requirement for medium velocity spray system shall be calculated based on minimum spray density as 10.2 LPM/Sq.M of the exposed surface or area to be cooled, in case of LPG Pump or compressor it shall be 20.4 LPM/Sq.M.

11.3.1 Storage Vessels:

MV sprinkler system with automatic heat detection having remote or local operated deluge valve with spray density of Minimum 10.2 LPM/ Sq.M shall be provided on all above ground storage vessels. For water flow calculations aggregate surface area of all vessels within distance of 30 Mts. from the periphery of the affected LPG vessel shall also be considered as single risk.

11.3.2 Sheds:

MV sprinkler system with automatic heat detection having remote or local operated deluge valve with spray density of minimum 10.2 LPM/Sq.M shall be provided in the

entire shed including the loading or unloading fingers. For spray water calculations, the shed can be divided into suitable number of zones, each served by independent deluge system and the adjacent zones shall be operative around the zone under fire and the same shall be considered as a single risk and the width of a zone shall not be less than 10 meter except of the zone on either end of the shed and as there is no storage of cylinders in the loading or unloading fingers, spray system can be taken as separate zone within dependent deluge valve to optimize the fire water requirement.

11.3.3 LPG Pump or Compressor House:

MV sprinkler system with automatic heat detection having remote or local operated deluge valve with spray density of Minimum 20.4 LPM/Sq.M shall be provided and the entire pump or compressor house shall either be considered as single risk area. alternatively, it can be divided in to suitable number of zones, each of which shall have width not less than 10 mtr. each zone shall be served by an independent deluge system.

11.3.4 Tank Lorry Gantry:

In case of Tank Lorry Gantry, automatic detection of heat for automatic actuation of MV sprinkler system having remote and local operated deluge valve with spray density 10.2 LPM/Sq.M of surface area shall be provided and a maximum of 8 bays shall be considered as single risk area and in addition to the tank lorry surface, MV spray system shall effectively cover the tyres, manifold and dish ends of various size of tank lorries and there shall be at least 3 tiers of MV sprinkler system to uniformly cool the top, middle and the bottom of the tank lorry. Each zone shall be served by an independent deluge system.

11.3.5 Tank Wagon Gantry:

MV sprinkler system with automatic heat detection having remote and local operated deluge valve with effective spray density of 10.2 LPM/Sq.M shall be provided and the gantry can be divided into suitable number of zones with minimum zone length of 30 meters and adjacent zones shall operate around zone under fire and same shall be considered as single risk and each zone shall be served by an independent deluge system and there shall be at least 3 tiers of MV sprinkler system to uniformly cool the top, middle and bottom of the tank wagons the spray system shall also cover the associated LPG pipelines in the gantry. The fire water system in the plant shall be designed to meet the highest firewater flow requirement of a single largest risk of any of the above cases at a time plus 288 Cu.M/Hr. for operating 2Nos. Fire water Monitors or Supplementary Hose requirements.

11.4 FIRE WATER SYSTEM DESIGN:

- (i) The Fire Water system pressure shall be designed for a minimum residual pressure of 7.0 kg/ cm² g of water at any point of application in the extant flow configuration of the plant;
- (ii) A fire water ring main shall be provided all around perimeter of the LPG Plant facilities with hydrants or monitors spaced at intervals not exceeding 30 M when measured aerially and fire hydrants and monitors shall not be installed within 15 Meters from the facilities or equipment to be protected;
- (iii) Fire hydrant network shall be in closed loops to ensure multidirectional flow in the system and isolation valves shall be provided to enable isolation of any section of the network without affecting the flow in the rest and the isolation valves shall be located normally near the loop junction and the additional isolation valves shall be provided in the segments where, the length of the segment exceeds 300 Mts.

11.5 FIRE WATER STORAGE:

- (i) Water for the hydrant service shall be stored in any easily accessible surface or underground lined reservoir or above ground tanks of steel, concrete or masonry and the effective capacity of the reservoir above the level of suction point shall be minimum 4 hours aggregate working capacity of pumps and where make up water supply system is 50% or more this storage capacity may be reduced to 3 hours aggregate rated capacity of pumps;
- (ii) Large natural reservoirs having water capacity exceeding 10 times the aggregate water requirement of fire pumps may be left unlined;
- (iii) Storage tank or reservoir shall be in two inter connected compartments to facilitate cleaning and repairs and in case of steel tanks there shall be a minimum of two tanks;
- (iv) Isolation valves shall have visible indication for open and close condition;
- (v) Suitable over pressure relief mechanism shall be provided in the hydrant line against thermal expansion or sudden closure of valves so as to ensure the pressure in the line never exceeds its design pressure, even in transient condition; and
- (vi) Fire engines shall have provision for high coolant temperature and low lube oil pressure alarms.

11.6 FIRE WATER PUMPS:

- (i) Centrifugal type fire water pumps having flooded suction shall be installed to meet the

designed fire water flow rate and head and if the fire water is stored in underground tanks, an overhead water tank of sufficient capacity shall be provided for flooded suction after accounting for leakage in the network, if any. Pumps shall be provided with suitable size strainers and NRVs on suction and discharge lines respectively;

- (ii) The system pressure has to be maintained at 7 kg/cm²g at the hydraulically farthest end of the hydrant system with the help of Jockey Pump operating automatically;
- (iii) The Jockey Pump shall start-stop automatically actuated by pressure switches;
- (iv) A standby jockey pump shall be provided if the number of hydrant points is more than 100. One monitor shall be considered as equivalent to 4 hydrant points;
- (v) The fire water pump including the stand by pump shall be diesel engine driven and the pumps shall be capable of discharging 150% of its rated discharge at a minimum of 65% of the rated head and the shutoff head shall not exceed 120 % of rated head for horizontal centrifugal pumps and each engine shall have an independent fuel tank of suitable size for 6 Hrs. continuous running at the desired head and discharge of the fire pump concerned and fuel tanks should be installed outside the fire pumps house and shall have provision for venting and if tanks are located inside the fire pump house the vent shall have a provision for venting outside the pump house;
- (vi) Where power supply is through adjoining captive power generation facility, electrically driven centrifugal pumps can be used up to a maximum of 50 % of total number of pumps installed Power supply to the pump motors should be from two separate feeders;
- (vii) At least one standby fire water pump shall be provided when the number of main pumps does not exceed 2 nos. When the said requirements exceed 2 pumps, at least 2 standby pumps of the same capacity, head and characteristics shall be provided and all the fire water pumps shall be of same rated capacity, head and similar characteristics;
- (viii) Fire water pumps shall be used exclusively for Fire protection and prevention purpose only;
- (ix) Suction and discharge valves of fire water pump shall be kept open all the time;
- (x) The fire water pumps shall be provided with auto start facility and the auto starting logic shall ensure that if the pump designated to start first fails to build up the required pressure in the fire water ring main system within 20 sec(max) or fails to start at all the next designated pump shall start and continue the same cycle;
- (xi) All the Fire Engines shall be set at the rated RPM of the fire pump and as all the fire engines are to start in auto mode, throttling of the fire engines governors for setting the engine speed below the rated RPM shall not be permitted; and
- (xii) The OEM drawing of the cooling system of the fire engines clearly marking the minimum and maximum inlet and out pressures permitted in the line, location of the pressure regulator and its settings and like other locations shall be available and manual opening of the valves of cooling line after engine starts in auto mode shall not be permitted.

11.7 FIRE HYDRANT NETWORK:

- (i) Fire hydrant ring main shall be laid above ground ensuring that -

- (a) Pipe line shall be laid at a height of 300 mm to 400mm above finished ground level;
 - (b) The mains shall be supported at regular intervals not exceeding 6 meters or as per design approved; and
 - (c) The system for above ground portion shall be analysed for flexibility against thermal expansion and necessary expansion loops where called for shall be provided;
- (ii) However, the ring main may be laid underground at the following places, namely: -
- (a) Road crossings;
 - (b) Places where above ground piping is likely to cause obstruction to operation and vehicle movement;
 - (c) Places where above ground piping is likely to get damaged mechanically, particularly in the LPG storage area where water supply lines are laid for feeding sprinkler deluge system; and
 - (d) Where Frost conditions warrant and ambient temperature is likely to fall below zero deg. Centigrade, underground piping at least 1 meter below the ground level should be provided, alternatively, for above ground pipelines, water circulation to be carried out.
- (iii) For Fire water ring main laid underground, the following shall be ensured, namely: -
- (a) The Ring main shall have at least one-meter earth cushion in open ground, 1.2 meters cushion under the road crossings and in case of rail crossing, provisions stipulated by Indian Railways shall be complied;
 - (b) The Ring main shall be suitably protected against soil corrosion;
 - (c) In case of poor soil conditions; it may be necessary to provide concrete or masonry supports under the pipe line;
 - (d) Ring main made of composite material can be used and shall be laid underground only.
- (iv) Fire water ring main shall be sized for 120% of the design water flow rate and the velocity of water shall not exceed 5 meter per second in fire water ring main. Design flow rates shall be distributed at nodal points to give the most realistic way of water requirements in an emergency;
- (v) In case of sea water service, the fire water main pipes shall be concrete mortar lined internally or other suitable coating material shall be used;

- (vi) Hydrants or monitors shall be located considering various fire scenario at different sections of the premises to be protected and to give most effective service and at least one hydrant post shall be provided at every 30 mtrs of external wall measurement or perimeter of battery limit in case of high hazard areas and for non-hazardous area, they shall be spaced at 45 mtrs. intervals and the horizontal range and coverage of hydrants with hose connections shall not be considered beyond 45 mtrs;
- (vii) Hydrants shall be located at a minimum distance of 15 mtrs. from the periphery of storage tank or equipment under protection and in case of buildings this distance shall not be less than 2 mtrs. and not more than 15 mtrs. from the face of building. Provision of hydrants within the building shall be provided in accordance with IS: 3844. Hydrant or Monitors shall be located along road side berms for easy accessibility;
- (viii) Double headed hydrants with two separate landing valves on 3"/ 4" stand post shall be used and all hydrant outlets shall be 1.2 mtrs. above ground level;
- (ix) Monitors shall be located to direct water on the object as well as to provide water shield to firemen approaching a fire And-
 - (a) the requirement of monitors shall be established based on hazards involved and layout considerations; and
 - (b) the location of the monitors shall not exceed 45 mtrs from the hazard to be protected;
- (x) Hydrants and monitors shall not be installed inside the dyked areas;
- (xi) LPG tank wagon Loading or unloading facility and Tank Truck gantry area should be provided hydrants having multipurpose combination nozzles for jet spray and fog arrangement and fire hydrants located at a spacing of 30 mtrs. on both sides of the gantry. The hydrants and monitors shall be located at a minimum distance of 15 mtrs. from the Tank Wagon or Tank Trucks measured from edge of the facilities;
- (xii) Fire water monitors shall be provided with independent isolation valves;
- (xiii) Hose box with 2 nos. hoses and a nozzle shall be provided at each hydrant points;
- (xiv) The deluge valves shall be located outside the kerb wall at a safe distance in case of LPG spheres or bullets and 15 meters away from the limits of LPG cylinder sheds and a fire wall shall be provided for the protection of deluge valve and for operating personnel;
- (xv) The fire water deluge valves shall be kept outside the kerb wall at a safe distance in case of sphere or bullet and located 15 M away from limits of other sheds or vertical shadows of spheres and a fire wall shall be provided for the protection of the deluge valve and

- for personal protection of the operator; and
(xvi) Pipes made of composite material shall be laid underground.

11.8 MATERIAL SPECIFICATIONS:

All the materials used in fire water system using fresh water shall be of type as indicated below, namely: -

- (i) Pipes: Carbon Steel (CS) per IS:3589/IS: 1239:1978 or composite material or its equivalent for fresh water service. in case saline, brackish or treated effluent water is used, the fire water ring main of steel pipes, internally cement mortar line or glass reinforced epoxy coated or pipes made of material suitable for the quality of water able to withstand the temperature and pressure shall be used and alternatively, pipes made of composite material to be used may be as per API 15 LR/ API 15 HR/IS 12709 and in case composite pipes are used they shall be used underground.
- (ii) Isolation Valve: Gate valve or quick shut off type isolation valve made of carbon steel having open or close indicator shall be used. Other material such as cupro-nickel for saline or brackish water can be used and the material of the valve shall be suitable for the service.
- (iii) Deluge valve : Carbon Steel
- (iv) Hydrant Stand post : CS Outlet valves Gunmetal/ Aluminum
- (v) Monitors : CS

Explanation: - for the purposes of Clauses (i) to (v), Equivalent or superior materials meeting the design requirements can also be used;

- (vi) In case of underground mains, the isolation valves shall be located in RCC or brick masonry chamber;
- (vii) The above ground fire water main and the fire hydrant stand post shall be painted with corrosion resistant "Fire Red" paint as per IS: 5; and
- (viii) Water monitor, hydrant point and hose box shall be painted "Luminous Yellow' IS: 5.

11.9 MEDIUM VELOCITY SPRINKLER SYSTEM:

- (i) The medium velocity spray system shall be provided in all critical areas like LPG Storage Area, LPG Sheds having cylinder filling, cylinder storage, cylinder loading or unloading fingers (including packed trucks covering including cylinders thereon), LPG

Pump or Compressor House, bulk Tank truck or wagon loading or unloading areas, piping manifolds, cold repair sheds and like other areas;

- (ii) Spray nozzles shall be directed radially to the vessel at a distance not exceeding 0.6 m from the equipment surface and only one type and size of spray nozzle shall be used in a particular facility. The horizontal extremities of water flow from spray nozzles shall at least meet;
- (iii) Where projections (manhole flanges, pipe flanges, staircase, supports brackets) obstruct the water spray coverage, including rundown or slippages on vertical surface, additional nozzles shall be installed around the projections to maintain the wetting pattern and the valve of the vessel shall be adequately covered with sprinklers, and
- (iv) Horizontal dry piping downstream of the block valve, and after deluge, valve, shall have adequate drain facilities at selected locations.

11.10 AUTOMATIC FIRE PROTECTION SYSTEM:

11.10.1

- (i) Automatic fire protection (Fixed) system based on heat detection through thermal fuses or quartz bulbs or EP detectors shall be employed and sensors shall be installed at all critical places wherever medium velocity spray system has been installed as described below, namely: -
 - (a) For LPG Storage vessels, such detectors shall be provided in multiple rings (at least two rings for bullets and three rings for spheres) encircling each vessel, equi-spaced with a maximum horizontal spacing of 1 meter, the lowest ring starting at an elevation of within 1.5 meter from bottom of vessel and also minimum 2 nos. detectors shall be provided at the top of the vessel at each flange or flange cluster as the case may be and at least 1 no. near the liquid line ROV to take care of failure of flanges and in case of an automatic thermal fuse-based fire protection system the instrument air supply pressure to thermal fuses shall be maintained through a pressure control valve and a restriction orifice and /or solenoid valves, and
 - (b) Detectors shall be placed at critical locations in LPG sheds (filling, cylinder storage, testing, evacuation, degassing, cylinder loading or unloading fingers including packed trucks (covering at least cylinder thereon), excluding trucks carrying unpurged cylinders, which are under cylinder loading or unloading operations and like other operations) bulk tank truck and tank wagon loading or unloading gantries, LPG pump or compressor house, piping manifold, repair sheds and like other locations at bulk tank truck and tank wagon loading or unloading gantries detectors shall be provided at least in 2 tiers. Upon actuation there shall be alarm in control panel, LPG pumps and compressors would trip, ROVs (wherever provided) on LPG supply and return lines shall close and the deluge valves on fire water sprinkler system will get actuated;

- (ii) In case, Quartzoid Bulbs are used for detection, the same shall be designed to blow at 79 deg. centigrade (max.) and Quartzoid Bulb network shall be maintained with plant air at a pressure not more than 3.5 kg/sq.cm.g and shall be such that the discharge of air through one Quartzoid Bulb will depressurise the system to actuate the deluge valves;
- (iii) In case of Electro pneumatic (E.P) heat detectors, it shall actuate the deluge valve in any of the following conditions, namely: -
 - (a) Rate of rise - 10 °C/min of temp.
 - (b) At 79 deg. C (max.)

Explanation- for the purpose of this clause, the EP detectors shall be divided in groups and alternate detectors shall be connected in one circuit. Two detectors from two different groups shall function/ operate for actuation of sprinkler system.

- (iv) Water spray nozzles and heat detection system shall be of approved type and duly certified for the performance;
- (v) The actuation of detectors shall initiate the following, namely: -
 - (a) Opening of deluge valve of the affected zone as well as adjacent zones;
 - (b) Audio-visual alarm indicating the affected zone at the fire pump house and manned control panel. The control panel shall also have status indications for deluge valves with facility for actuation;
 - (c) Fire siren of 1km range;
 - (d) Closure of all Remote Operated Valves in affected facility;
 - (e) Tripping of main power supply barring the emergency power;
 - (f) The water spray from all nozzles within 30 seconds; and
 - (g) The fire water pump shall start based on their set pressure to supplement or to maintain the fire water pressure in the ring main.

11.10.2 Additionally for each deluge valve suitable systems like push buttons and like other systems for initiating all the above actions shall be provided on remote operating panel and further similar system like push buttons and /or air release valves and like other system shall also be provided for each deluge valve locally in the field at easily accessible position placed at a minimum distance of 15 mtr. from the protected facility and in case, the zoning

concept is used for MV sprinkler system, the concerned zone shall be marked on each of the push buttons and in the field, manual bypass valves of fire water deluge valves shall also be provided.

11.10.3 The performance test certificates, after installation in respect of spray density, flow rate, response time for each facility to be protected, provided by manufacturer shall be maintained at the LPG Installations and verified once in 6 months and records maintained thereof and further, all spray nozzles shall be inspected for proper positioning, corrosion and cleaned, if necessary, at intervals of not more than 12 months or earlier based on actual experience.

11.10.4 Care shall be taken in positioning nozzles so that water spray does not miss the targeted surface and reduce the efficiency or calculated discharge rate.

11.11 FIRST AID FIRE FIGHTING EQUIPMENT:

11.11.1 PORTABLE FIRE EXTINGUISHERS:

- (i) Portable fire extinguishers shall be located at convenient locations and shall at all times be readily accessible and clearly visible;
- (ii) The maximum running distance to locate an extinguisher in working areas shall not exceed 15 meters;
- (iii) The top surface of the extinguisher shall not be more than 1.5 meter high;
- (iv) The fire extinguishers shall be provided at various locations as under, namely: -
 - (a) LPG Storage : Vessel (Each) 2 Nos. 9 kg DCP extinguisher;
 - (b) LPG cylinder : 2 Nos. 9 kg DCP extinguisher per 200 Sq.M. Area of sheds;
 - (c) LPG Pump houses : 2 Nos.9 kg. DCP extinguisher per 50 Sq.m. Area;
 - (d) Tank Truck loading or unloading gantries : 1 No. 9 kg. DCP Extinguisher in each bay;
 - (e) Tank Wagon loading or unloading gantries : 1 No. 9 kg unloading gantries DCP Extinguisher for every 15/20 meters of gantry;
 - (f) Other Pump Houses : 2 Nos. 9 kg DCP extinguisher;
 - (g) Office or Canteen or stores : 2 X 9 kg DCP extinguishers in each building
 - (h) MCC or DG Room or HT Room : 2 X 4.5 kgCO2 extinguisher in each room or for floor

area of about 100 Sq.m. and 4 sand buckets and a stand shall be provided in MCC or DG Room.

- (v) 100% spare CO2 cartridges and 50% (Min) spare DCP bags (as per Fire Extinguisher Capacities) shall be stored in the LPG plant.

11.11.2 WHEELED MOBILE FIREFIGHTING EQUIPMENT:

- (i) One No. Mobile 75 Kg DCP fire extinguisher shall be provided in filling shed, LPG storage vessels or LPG Pump House area, Tank truck loading or unloading gantry area and tank wagon loading or unloading gantry area;
- (ii) The Dry chemical powder used in the extinguishers shall be Potassium or Urea based or Sodium Bicarbonate as per IS:4308. Nitrogen or Carbon Dioxide shall be used as expelling gas;
- (iii) A trolley containing first aid fire protective accessories shall be readily available in the LPG plant.

11.11.3 HOSES, NOZZLES AND ACCESSORIES:

- (i) Reinforced rubber lined hoses (63mm) conforming to IS: 636 (type A or B) shall be provided;
- (ii) The hoses shall be of 15 Meters standard length and shall be provided with Gun metal or aluminum alloy male and female couplings of instantaneous pattern;
- (iii) Minimum of two or 25% spare Hoses shall be stored in the LPG plant;
- (iv) In addition to the nozzles provided in the hose boxes, there shall be at least 2 Nos. spare nozzles in each category viz. Jet Nozzles with branch pipes, Fog Nozzles, universal Nozzles, water curtain Nozzles, Spray Nozzles and Triple purpose nozzles in the plant, and
- (v) The following accessories or first aid items shall be provided in the plant namely: -

- | | |
|-------------------------|---|
| (1) Fire hoses | Two nos. for each Hose Box; |
| (2) Safety helmets | 1 no. for each person. (min. 10 nos.); |
| (3) Hose Box | At each hydrant point; |
| (4) Stretcher with | Min. 2 Nos. blankets; |
| (5) First aid Box | Min. 2 nos; |
| (6) Rubber hand gloves | Min. 2 pairs for electrical (BIS approved) purpose; |
| (7) Low temperature | 4 pairs rubber hand gloves for LPG emergency; |
| (8) Low tem. Protective | Min. 2 sets clothing for LPG emergency; |
| (9) Fire proximity suit | Min. 1 No.; |

- | | |
|-----------------------------|---|
| (10) Resuscitator | Min. 2 No.; |
| (11) Red or Green Flags | As reqd. |
| (12) Self-contained | Min. 1 No. breathing apparatus with one spare cylinder. (Cap. 30 minutes) |
| (13) Water gel blankets | Min. 2 nos. |
| (14) Portable Gas detectors | min. 2 nos. or Explosimeter |

Note: - The accessories and first aid specified in this clause are guidelines and minimum requirements of each item and can be increased depending upon the scale of operations, statutory or mandatory requirement of local bodies or State Governments or any other expert body.

11.12 EMERGENCY CONTROL OR ALARM SYSTEM:

11.12.1 FIRE ALARM SYSTEM:

- (i) Manual call points near to filling shed, storage area, tank truck or tank wagon gantry, pump house, and like other places shall be provided in the installation with marking of the concerned facility on the said call points and the operation of such points shall raise audio visual alarm in control room;
- (ii) Electricity operated Fire Siren shall be audible to the farthest distance in the plant (1 K.M. from the periphery of the plant);
- (iii) Manually operated fire sirens shall be provided at strategic places;
- (iv) For fire condition the siren shall be wailing sound for minimum 2 minutes and for all clear signal it shall be straight run siren for 2 minutes; and
- (v) For Disaster condition the wailing sound given shall be repeated thrice with 60 seconds gap in line with PNGRB (Codes of Practices for Emergency Response and Disaster Management Plan (ERDMP)) Regulations, 2010.

11.12.2 COMMUNICATION SYSTEM:

- (i) Communication system like telephone or PA or paging or walkie-talkie shall be provided;
- (ii) In the hazardous areas, flame-proof or intrinsically safe telephones shall be provided;
- (iii) Wherever possible Hot line connection between City Fire Brigade or nearby major Industries shall be provided; and
- (iv) Plant shall have a 'Mutual Aid' arrangement with nearby industries.

11.13 SPECIAL FIRE PROTECTION:

11.13.1 The most hazardous situation in LPG vessel is the possibility of BLEEVE and such situation usually takes place when the vessel is subjected to external fire.

11.13.2 The unwetted (vapour space) portion of the shell gets overheated and fails even at the operating pressure, as such, it is important that metal temperature in the vapour space is protected from overheating by some measures and a passive measure like fire proofing or insulation or fire retardant coating will provide protection in the initial period of fire which is very crucial and such measures will give some breathing time for activating other fire fighting measures like starting of pumps, organizing people, opening of valves like other measures and such measures will also take care of automation failure wherever it is provided.

11.13.3 The fireproofing of LPG storage vessel should be decided based on the risk analysis keeping in view local considerations, availability of water and societal risk.

11.13.4 The fireproofing of LPG storage vessel shall be decided based on the fire safety analysis, keeping in view local considerations, population density, availability of water, societal risk and fire protection measures provided.

11.13.5 Fire proofing provided on the vessel and supporting legs shall be adequate to protect the shell material from overheating and consequent failure. The minimum rating for fire proofing shall be as under, namely: -

(a) LPG storage vessel & connected lines upto the fire safe ROVs: 1 hrs;

(b) Supporting legs of all above: 2 hr.

Note: - Fire proofing is not required for diagonal bracing, including tie rods, or redundant members that are not necessary for supporting the static loads.

11.13.6 Before fire-proofing application, protected metal surfaces shall be prepared through such means as sand-blasting and corrosion-protective primers. Particular attention shall be given to the top junction of the fire- proofing with the protected metal to prevent water ingress. Fire water line to each sphere should be so routed that it is not exposed to direct fire. Such fire water line is to protect it from failure in the initial period when water flow has not commenced. It is recommended that riser should be located away from bottom ROV. The horizontal run of the Fire Water line may be buried if fire engulfment cannot be avoided otherwise. Fire proofing shall include connected LPG lines and pipe supports within 15 M of a storage vessel or in the drainage paths.

11.14 INSPECTION AND TESTING:

11.14.1 The fire protection equipment shall be kept in good operating condition all the time.

11.14.2 The fire fighting system shall be periodically tested for proper functioning and logged for record and corrective actions. In addition to routine daily checks or maintenance the following periodic inspection or testing shall be ensured.

11.14.3 Fire siren shall be tested atleast once in a week.

11.14.4 FIRE WATER PUMPS:

- (i) Every Pump shall be in test run for atleast 30 minutes twice in a week at the rated conditions as per OEM Guidelines. Suitable provision should be made in fire water pump house to ensure that during test run of any individual fire pump fire fighting system of entire plant continues to be in auto mode.
- (ii) Once in a month each pump shall be checked and tested and the shut-off pressure observed and logged, in addition the pump performance shall be ascertained;
- (iii) Each pump shall be run continuously for 4 hours at its rated head and flow using circulation line of fire water storage tanks at least once a year and observation logged;
- (iv) The cooling line of fire engines shall not require manual intervention and the line pressure inlet-outlet shall be as per OEM to avoid bursting of water jackets;
- (v) Fire engine and fire pump rpm should match to get rated performance and fire pumps should be operated as rated rpm to get desired /rated head and flow; and
- (vi) The Jockey pump operation shall be checked periodically and frequent start or stop condition of Jockey pump indicates that there are water leaks in the system which should be attended promptly.

11.14.5 FIRE WATER RING MAIN:

- (i) The ring main shall be kept pressurised at 7 kg/sq.cm.g with the help of one or more jockey pumps;
- (ii) The ring main shall be inspected for any visual leaks, detects, damage and corrosion at least once in week and relevant records shall be maintained; and

- (iii) All valves on the ring main or hydrant or monitor valves shall be checked for leaks or operation and lubricated once in a month.

11.14.6 FIRE WATER SPRINKLER SYSTEM:

- (i) All deluge valves and sprinkler system shall be operated and checked once in a quarter for correct remote operation performance of each nozzle and effectiveness of system in total;
- (ii) Testing of sprinkler system in the sheds shall be carried out by closing the outlet of the deluge valve for correct remote operation once in a quarter; and
- (iii) The strainers provided in the Fire water sprinkler system shall be cleaned once in a quarter and records maintained.

11.14.7 FIRE WATER RESERVOIR:

In case of a Reservoir the same shall be cleaned once in 6 months or earlier as and when needed so that there shall not be any foreign particles or fungus or vegetation in the reservoir.

11.15 MAKE UP WATER:

Facilities to make up water during fire fighting shall be provided and if borewell is or are available within the Plant, yield from there should be recorded on quarterly basis for each borewell.

CHAPTER IX

12.0 GAS MONITORING SYSTEM:

The gas monitoring system shall be designed considering small leaks (leaks which have secondary closures) such as mechanical seals failure and like other thickness sampling point left open, gasket leaks, hose pinholes, valves gland leakage, drain point left partially open, TSV's relief discharge in manifold area, filling and evacuation hoses leakage and the Gas Monitoring system shall provide early warning on buildup of dispersed gas concentration below the LEL limits.

12.1 APPLICATION:

- (i) The detectors for the gas monitoring system shall be strategically located in LPG Bottling Plant at all facilities close to the potential source of leakage; and
- (ii) The detection control equipment should be provided in the control room for continuous monitoring even during power failure.

12.2 DETECTORS:

The control equipment is not required to have automatic corrective action capabilities on sensing leakages as this is basically a warning device, but, in case of any specific recommendations made in the risk analysis or HAZOP studies, the same should be implemented.

12.3 ANNUNCIATION SYSTEMS:

Appropriate field and remote annunciation system shall be available to ensure that all the alarms generated, both, audio and visual are reported to the plant personnel, who are authorized to take corrective action and depending on the deployment pattern of the plant, the alarms both, audio and visual can be repeated at additional location to ensure corrective action is taken.

12.4 LOCATION OF DETECTORS:

- (i) The behavior of the gas leakage governs the positioning of the gas detector, and as LPG is heavier than air, the height of the detector should not be more than 0.3 M from the mounting level,
- (ii) The pre-dominant wind direction should be considered with respect to the potential source of leakage to ensure positioning of the detector on the downstream side of the wind direction;

- (iii) The detectors especially the catalytic type should not be positioned very close to the potential source of leakage to avoid poisoning of the detectors (temporary malfunctioning) and the detectors should be located at least 0.3 meters away from the potential source of leakage;
- (iv) In case of infra-red detectors, the same shall be installed on the downwind side ensuring the path is free from obstructions and in case any additional expansion or construction if undertaken, the detectors will have to be pre-positioned.
- (v) The minimum detectors facilities- wise are as given below, namely: -
 - (a) Storage vessels (above ground) – 1 No. top and 1 No. near bottom ROV. one each near water draining or sampling points;
 - (b) LPG pump house 1 No. in pump house and 1 No. in manifold;
 - (c) Filled cylinder shed - 2 No., Valve change shed – 1 No.;
 - (d) Empty-cum-filling shed – 2 Nos. near carousel, 1 No. near evacuation unit tank, 1 No. weight correction unit, 1 No. at Valve changing machine without evacuation; TLD – one at each manifold and at ends;
 - (e) Tank wagon gantry – 1 no. for every two bays or 30 m whichever is less at bottom, and additionally, some detectors at selected locations shall be provided at the top of platform.

Note: -The number and location of the detectors required over and above the minimum requirements specified in clause (a) to (f) shall be as per the specific requirements identified in the risk analysis or HAZOP study report and the location can be decided by assessing the behavior of gas drift and consequential safety risk;

- (vi) The inspection and testing shall be as below, namely: -
 - (a) The gas monitoring system shall be kept in good operating condition all the time;
 - (b) The inspection of the system shall be done at an interval of 1 month in which the gas shall be released at all the detectors and the performance of the systems shall be established;
 - (c) The calibration of the equipment shall coincide with the monthly inspection schedule every three months for calibration of the gas detectors and the calibrated gas with known and certified level of concentration shall be used;
 - (d) The drift in the sensitivity of the individual detectors shall be recorded in maintenance history log book during calibration and the detectors with abnormal or wide drift in sensitivity; and

- (e) The plants should have at least 2 Nos. spare detectors for each system maintained at all times to facilitate immediate replacement of defective detectors.

CHAPTER X

13.0 COMPETENCE ASSURANCE AND ASSESSMENT:

13.1

- (i) Every operating company shall develop, implement, and maintain a written training plan to instruct all LPG plant personnel with respect to the Carrying out the emergency procedures that relate to their duties at the LPG plant as set out in the procedure manual and providing first aid
- (ii) Permanent maintenance, operating, and supervisory personnel with respect to the following, namely:
 - (a) The basic operations carried out at the LPG plant;
 - (b) The characteristics and potential hazards of LPG and other hazardous fluids involved in operating and maintaining the LPG plant, including the serious danger from frostbite that can result upon contact with LPG or cold refrigerants;
 - (c) The methods of carrying out their duties of maintaining and operating the LPG 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 LPG plant; fire fighting; the potential causes of fire in an LPG plant; the types, sizes, and likely consequences of a fire at an LPG plant; and
 - (e) Recognizing situations when it is necessary for the person to obtain assistance in order to maintain the security of the LPG plant

13.2 Each operating company shall develop, implement, and maintain a written plan to keep personnel of its LPG plant up-to-date on the function of the systems, fire prevention, and security at the LPG plant.

13.3 The Refresher programs for training of all personnel shall be conducted at an interval not exceeding 2 years to keep personnel current on the knowledge and skills.

13.4 Every operating company shall maintain a record for each employee of its LPG plant that sets out the training given to the employee under this section.

13.5 Each operating company shall ensure that LPG plant personnel receive applicable training and have experience related to their assigned duties and any person who has not completed the training or received experience shall be under the control of trained personnel.

13.6 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.

13.7 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 and further their capability shall be assessed periodically.

13.8 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.

13.9 Corrosion control procedures including those for the design, installation, operation, and maintenance of cathodic protection systems, shall positively be carried out by, or under the direction of, a person qualified by experience and training in corrosion control technology.

13.10 Personnel having security duties must be qualified to perform their assigned duties by successful completion of the training as specified.

13.11 Each operator shall follow a written plan to verify that personnel assigned operating, maintenance, security, or fire protection duties at the LPG plant do not have any physical condition that would impair performance of their assigned duties.

13.12

- (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 LPG and other flammable fluids used or handled at the facility, including, with regard to LPG, low temperatures and flammability of mixtures with air;
 - 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 LPG installation shall be trained to carry out the emergency procedures that relate to their assigned functions; and
- (iii) All operating and appropriate supervisory personnel of an LPG installation shall be trained to understand detailed instructions on the facility operations, including controls, functions, and operating procedures; and to understand the LPG transfer procedures.

13.13 Personnel responsible for security at an LPG plant shall positively 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.

13.14 All personnel involved in maintenance and operations of an LPG plant, including their immediate supervisors, shall positively 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;
- (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; and
- (vi) TT Crew.

13.15 Each entity shall maintain a system of records which —

- (i) provide evidence that the training programs required by this subpart have been implemented;
- (ii) provide evidence that personnel have undergone and satisfactorily completed the required training programs; and
- (iii) records shall positively be maintained for one year after personnel are no longer assigned duties at the LPG plant.

13.16 Each TT crew of a vehicle carrying LPG shall undergo training which shall include but not limited to the following, namely: -

- (i) In line with syllabus under rule 9 of The Central Motor Vehicle Rules 1989 and should be by any approved Govt. agencies for this purpose;
- (ii) The emergency handling as per as per PNGRB ERDMP Regulations;
- (iii) The characteristics and potential hazards of LPG including the serious danger from frostbite that can result upon contact with LPG or cold refrigerants;
- (iv) The use of fire extinguishing equipment carried on the vehicle and the emergency procedure to be followed;
- (v) For hazardous goods transportation and their driving license or certificate must have RTO endorsement for hazardous goods transportation; and
- (vi) Use of emergency kit and First aid box.

SCHEDULE – 2 [see regulation 6(2)]

**STANDARDS FOR SMALL LPG BOTTLING PLANTS
(LAYOUT, DESIGN AND FIRE PROTECTION FACILITIES)**

Contents of the Schedule:

This Schedule contains details regarding Layout, Design and Fire Protection Facilities.

1.0 SCOPE:

Technical standards and specifications including safety standards (hereinafter in this Schedule referred to as standards) for capacity up-to 100 MT and maximum bottling of 20 MT per day on design, layout, storage, loading or unloading, operation LPG storage, handling and bottling are specified in this Schedule. Further, paragraph 4.0 of this Schedule also specifies the additional minimum safety requirements on design, layout, storage, loading or unloading, operation at LPG installations having minimum three Bulk Storage vessels (a) exceeding 100 MT but limited to 300 MT for aboveground storage and also for (b) 450 MT in mounded or in combination of aboveground and mounded storage of LPG with total bottling quantity not exceeding 50 MT per shift. of 8 hrs. For LPG Storage, Handling and Bottling Facilities exceeding either of the above limits, Schedule – 1 shall be applicable.

1.1 SEPARATION DISTANCES:

The various facilities within LPG storage, handling and bottling premises shall be located based on Table-I and Table-II. The separation distances as given are the distances in plane between the nearest point on a vessel other than the filling/discharge line and a specified feature, e.g. adjacent vessel, site boundary etc.

TABLE – I - INTERDISTANCES FOR LPG FACILITIES

(All distances are in metre)

	1	2	3	4	5
1. LPG STORAGE VESSEL II	2	T-II	T-II	15	T-II
2. BOUNDARY OR PROPERTY LINE OR GROUP OF BUILDINGS NOT ASSOCIATED WITH LPG PLANTS.	T-II	-	15	15	-
3. LPG SHED	T-II	15	15	15	30
4. TANK TRUCK GANTRY	15	15	15	NA	30

5. FIRE WATER PUMP HOUSE	T-II	*	30	30	-
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- NOTES: 1. T-II: Refer Table II
2. * : Any Distance for operational convenience

TABLE – II

INTERDISTANCES BETWEEN LPG STORAGE VESSELS, FILLING SHED, STORAGE SHED AND BOUNDARY/PROPERTY LINE/GROUP OF BUILDINGS.

CAPACITY OF EACH VESSEL (CU. MTS. OF WATER)	DISTANCES (MTS.)
10 – 20	15
20 – 40	20
41 – 235 ^{Note}	30

Note: MAXIMUM PACKED STORAGE LIMITED TO 20000 KGS. Horizontal bullets with the total volumetric capacity up to 235 Cu. M. shall be used for storing LPG.

1.2 LOCATION:

While assessing the suitability of any site for location of LPG storage facilities, the following aspects shall be considered, namely: -

- (i) In addition to the requirements for safety, the plant should be located in such a manner so as not to be contiguous to any industry having open flame. Property line of the plant shall be away from the central line of the road or railways as per statutory requirements and overhead high-tension wire shall not traverse through the battery limit of the plant;
- (ii) Adequate availability of water from a nearby reliable source should be ensured;
- (iii) The topographical nature of the site with special reference to its effect on the disposal of LPG, in the event of its escape, if any, shall be considered;
- (iv) The access for mobile fire fighting equipment to the storage vessels under all foreseen circumstances, preferably from two sides and upward prevailing wind direction is an important parameter;
- (v) For any expansion beyond the specified limit, the provisions of Schedule - 1 shall be applicable;

- (vi) Predominant direction of wind and velocity shall be considered;
- (vii) Longitudinal axis of horizontal vessels (Bullets) shall not point towards other vessels, vital process equipment and other facilities;
- (viii) Storage vessels shall be located downward of processing units, important building and facilities;
- (ix) Storage vessels shall be laid out in single row within a group; and
- (x) Storage vessels shall not be located one above the other.

1.3 LAYOUT:

The following aspects shall be considered while establishing layout of LPG storage vessels, namely:

1.3.1 LPG STORAGE FACILITIES:

1.3.1.1 GRADING:

Area below the storage vessels (Bullets) shall be free from vegetation and the property shall be graded with the slope of 1:100 (towards one side) away from the pipeline manifold.

1.3.1.2 PIPING:

Piping manifold shall be away from the vertical shadow of the vessel. Spring loaded quick closing valve with fusible link or Rov to facilitate immediate closure in the event of emergency, if any, shall be provided in the LPG liquid line of each vessel between excess flow check valve (EFCV) and pipeline manifold.

1.3.1.3 SURFACE DRAINAGE

In order to prevent the escape of spillage into the main drainage system, surface water from the storage area and from the manifold area shall be directed to the main drainage through a water seal designed to avoid the spread of hydrocarbon.

1.3.1.4 GROUPING:

Vessels shall be arranged in a group and total volumetric capacity of the group shall be limited to 235 Cu. M. Inter-distances as specified in Table-I and Table-II in paragraph 1.1

shall be maintained. Top surfaces of all the vessels installed in a group shall be on the same plane so that the safety blowout from them do not affect each other.

1.4 LPG BULK HANDLING FACILITIES:

- 1.4.1 LPG tank lorry loading or unloading gantry shall be located in a separate block and shall not be grouped with other petroleum products.
- 1.4.2 Space for turning with a minimum radius of 20 meters for tank lorries shall be provided commensurate with the capacities of the tank trucks.
- 1.4.3 LPG tank lorries up to the maximum of 2 Nos, at a time should only be taken for unloading.
- 1.4.4 Adequate permanent protection for TLD pipeline island shall be provided and the minimum width of such pipeline island shall be 1 metre.

1.5 LPG BOTTLING FACILITIES:

- 1.5.1 LPG Bottling facilities should be located at a safe distance from other facilities with minimum ingress of trucking traffic and upward wind direction with respect to bulk storage. There shall not be any deep ditches in the surrounding area to avoid settling of LPG.
- 1.5.2 Bottling section shed shall be of single story having asbestos roofing and open from all sides for adequate ventilation to ensure quick dissipation of LPG Vapour in the event of leakage, if any and, RCC roofing shall not be used. Anti-static mastic flooring conforming to IS-8374 shall be provided in the LPG filling shed or cylinder storage shed to avoid frictional sparks. Anti-static mastic coating up to 1.5 meters height from bottom of the supporting columns in the shed shall be provided.
- 1.5.3 Stacking area for empty and filled cylinders shall be marked specifically and the cylinders shall always be stacked vertically in two lines. Plant should have one shed each for filling and storing of filled or empty cylinders.
- 1.5.4 Valve changing operation should be carried out in a demarcated place within the filling shed itself.
- 1.5.5 Cylinder storage shall be kept on or above grade and never below grade in cellar or basement.
- 1.5.6 Filled cylinders shall not be stored in the vicinity of cylinders containing other gasses or hazardous substances.
- 1.5.7 Escape routes shall be specified in LPG sheds for evacuation of employees in emergency.

- 1.5.8 There shall not be any trapping of personnel in LPG sheds by conveyors, cylinders and other facilities and If such trapping cannot be eliminated, it should be kept to the minimum and in such place sufficient arrangements for escape routes to be provided.
- 1.5.9 Minimum illumination of 100 lux shall be provided in the cylinder filling area or other operating area.
- 1.5.10 Water drains from cylinder filling areas to outside drainage system shall be provided with water seals (near the plant boundary).

1.6 PROTECTION OF FACILITIES:

- 1.6.1 There shall be road, all around the various facilities within LPG storage, handling and bottling facilities, for accessibility of fire fighting operations.
- 1.6.2 There shall be proper industry type boundary wall all around the Bottling Plant.

1.7 UTILITIES:

Utilities consisting of Fire Water Pumps, Admin. Building, Motor Control Center, DG Room, Air Compressors, Dryers etc. shall be separated from other LPG facilities and to be located as per the area classification as specified in Table-I.

2.0 DESIGN CRITERIA:

2.1 GENERAL:

The design of storage vessels, facilities, safety features and process design shall be as per Schedule 1 except for requirements as specified in succeeding paragraph:

2.2 DESIGN BASIS:

- 2.2.1 For safety reasons, the operation of facilities should be restricted to maximum two shifts operation and facilities shall include the following, namely: -
- (i) Stationary Filling Machines: For filling Cylinders;
 - (ii) Check Scale: To countercheck the quantity of LPG filled;
 - (iii) Compact Valve Tester: To check valve or “O” Ring leakage;
 - (iv) Test Bath: To check the body or bung leak cylinders;
 - (v) Evacuation Rack: For evacuation of cylinders;
 - (vi) Purging Manifold: For purging of cylinders; and
 - (vii) Vapour extraction system at strategic locations near carousel or manual filling machines, cylinder evacuation unit valve changing unit and at locations where

leaking LPG is expected to accumulate shall be provided and further it shall be interlocked with carousel if provided so that filling do not start without vapour extraction unit being functional.

2.2.2 STORAGE CAPACITY:

The maximum bulk storage (of all vessels) shall be restricted to 100 MT.

2.2.3 LPG LOADING OR UNLOADING FACILITIES:

LPG loading or unloading facilities through tank truck should be provided.

2.2.4 CYLINDER FILLING FACILITIES:

2.2.4.1 FILLING MACHINES:

- (i) The filling machines should preferably be provided with auto cut-off system and shall be ensure that LPG supply is cut-off after filling the desired quantity of product and the filling pressure shall not exceed the design pressure of the cylinders.
- (ii) Filling machines shall not have weight error more than +/-1% of the net LPG filled in the cylinder; and
- (iii) It is recommended that in-line check weigh scales with a minimum graduation of 50 gms be installed and all cylinders after filling should be counterchecked for correct weight.

2.2.5 CYLINDER STORAGE:

Maximum cylinder storage of filled cylinders shall be restricted to a total of 20,000 Kgs.

2.3 LPG STORAGE VESSELS:

2.3.1 FITTINGS:

- (i) Bullets shall have a single nozzle at the bottom for inlet as well as outlet and the nozzle shall be fully welded, stress relieved along with the vessel and shall extend minimum 3 metres from the vertical shadow of the bullet and Excess Flow Check Valve (EFCV) shall be provided on the bottom nozzles to ensure immediate stoppage of the flow of LPG in the event of downstream leakage rupture, if any and

- There shall not be any other manhole, instrument tapping on this nozzle upto the EFCV;
- (ii) High level gauge should be provided to ensure safe filling of vessels and slip tube or Roto or Gauge or Rochester gauge should be provided for gauging of the vessels; and
 - (iii) All the fittings shall be suitable for use at not less than the design pressure and temperature appropriate to the worst operating conditions of the vessel.

2.3.2 INSTRUMENTS:

- (i) The storage vessel shall have minimum 2 different type of level indicators as stated below, namely: -
 - (a) High Level Gauge.
 - (b) Slip Tube Gauge or Roto Gauge or Rochester Gauge.
- (ii) Each vessel shall have atleast two safety valves, each set at not more than 110% of design pressure of the vessel and having the relieving capacity adequate for limiting the pressure build-up in the vessel not more than 120% of design pressure and the relieving capacity shall be based on fire condition.

2.4 SAFETY OR SECURITY SYSTEM:

The features of safety or security system for the different areas in the LPG Bottling Plants shall be as follows, namely: -

- (i) The hand operating or electrical siren should be provided to sound the alarm in case of fire or emergency, if any; and
- (ii) Manual push button should be provided at 2-3 strategic locations to bring to halt all the operational activities in the event of any emergency.

2.5 OTHER EQUIPMENT OR SYSTEM:

2.5.1 BOTTLING PUMPS:

Two pumps including one stand-by shall be provided with suction and discharge pressure gauge, a high point vent to safe height or flare, suction strainer and mechanical seal shall be provided. Pumps shall be designed to build a discharge pressure to ensure 5 Kg/CM² pressure above the vapour pressure at the operating temperature at the filling machines.

2.5.2 LPG COMPRESSOR:

- (i) Gear driven compressor shall preferably be used, but when, belt driven compressors are be used provided the belts used are antistatic type and fire resistant;
- (ii) There shall be minimum of two compressors including one as a standby.
- (iii) The operating parameters shall be decided on a case to case basis; but, typical operating conditions may be as follows, namely: -
 - (a) Suction Pressure: 10.0Kg/cm² abs (max). during unloading;
 - (b) 2-11.8kg/cm² abs. During vapour recovery; and
 - (c) Discharge Pressure: 13.0 kg/cm² abs. During unloading 11.5 kg/cm² abs. During vapour recovery;
- (iv) Compressor shall be provided with the following features, namely: -
 - (a) Pressure gauges in suction and discharge;
 - (b) Temperature gauge in discharge;
 - (c) Discharge safety valve and a vent valve, their outlets leading to cold flare or vent at a safe height outside the shed;
 - (d) Suction and discharge block valves (lock open type);
 - (e) Suction strainer;
 - (f) Check valve in discharge; and
 - (g) A discharge to suction recycle valve for achieving capacity turndown during startup.
- (v) Besides as specified in clauses (i) to (vi), other indications or protections can also be provided along with those recommended by compressor vendor.

2.5.3 EVACUATION FACILITIES FOR DEFECTIVE CYLINDERS:

- (i) Proper cylinder evacuation facility with cold flaring arrangement shall be provided to evacuate the defective cylinder before undertaking cold repairing job; and
- (ii) Cylinders shall be evacuated and depressurised to near atmospheric pressure and the residual LPG in the cylinder shall be cold flared in the atmosphere at a vent outside the shed at 1.0 M height above the roof of the shed.

2.5.4 PURGING OF NEW CYLINDERS:

Proper facility shall be provided to disperse the air from newly or hydrotested cylinders before commissioning.

2.5.5 ELECTRICAL AREA CLASSIFICATION:

For electrical area classification refer to IS-5571 and IS-5572 (Part-I)

3.0 FIRE PROTECTION FACILITIES:

3.1 DESIGN CRITERIA:

Following should be considered while designing the Fire Protection Facilities:

- (i) City fire water supply or facilities not available for these LPG storage, handling and Bottling facilities;
- (ii) One single largest fire risk situation shall be considered;
- (iii) All LPG storage vessels, cylinder filling or storage shed, tank lorry loading gantry, LPG pump or compressor shall be covered by fixed water spray sprinkler system;
- (iv) Fire protection facilities shall have fire fighting access, means of escape in the event of fire and whole area should be segregated depending upon the risk involved and each segregated area should have independent system; and
- (v) Layout shall permit access from at least two directions.

3.2 FIRE WATER SYSTEM:

Water to be used for fire extinguishment/ fire control or cooling of vessels or equipment and protection of equipment and personnel from heat radiation.

3.2.1 COMPONENTS OF FIRE WATER SYSTEM:

The main components of the system are-

- (i) Fire water storage;
- (ii) Fire water pumps;
- (iii) Fire Hydrant or distribution piping network; and
- (iv) Water Sprinkler.

3.2.2 FLOW RATE DESIGN:

3.2.2.1 The fire water pumping requirement shall be calculated based on spray density as given below, namely: -

- (a) LPG Storage Vessels 10.2 LPM/Sq M.;
(R + 15)
- (b) LPG Shed 10.2 LPM/Sq. M.;
- (c) LPG Unloading Gantry 10.2 LPM/Sq. M.; and
- (d) LPG Pump and compressor facility: 20.4 LPM/sq.m. Fixed water spray system with isolation valve to be operated manually and placed at a safe distance of 15 mtr. from LPG Pump house facility shall be provided.

3.2.2.2 LPG STORAGE VESSELS:

Fixed water system shall be provided with manually operated isolation valve located at a safe distance of 15 meters and for water flow calculations adjoining vessels within distance of $R + 15$ Mts. (Where R is the radius of the LPG Vessels) shall be considered.

3.2.2.3 SHED:

Fixed water spray system with isolation valve to be operated manually and placed at a safe distance of 15 meters from the shed shall be provided.

3.2.2.4 TANK LORRY GANTRY:

For tank lorry unloading gantry, fixed spray system with manual operating valve located at 15 meters distance from the gantry shall be provided.

3.2.2.5 WATER REQUIREMENT:

The fire water system in the plant shall be designed to meet the highest fire water flow requirement of a single largest risk of any of the cases covered under paragraphs 3.4.2.1 to 3.4.2.4, at a time plus 72 Cu. M per hour for operating 2 hydrant points.

3.2.3 FIRE WATER SYSTEM DESIGN:

- (i) Fire water ring main always charged with water (atmospheric pressure at a normal condition) shall be provided all around perimeter of the LPG plant facilities, with hydrants or monitors conveniently placed to combat the fire protection system;
- (ii) Fire water ring main shall be designed for a minimum residual pressure of 7 Kg/cm² quake at the farthest point of application in the plant; and
- (iii) Fire hydrant network shall be in closed loops to ensure multidirectional flow in the system and isolation of any section on the network shall be without affecting the flow in the rest. The isolation valves shall be conveniently located near the loop junction for ease of operation.

3.2.4 FIRE WATER STORAGE:

- (i) Water for the hydrant service shall be stored preferably in above ground tanks for availing the advantage of flooded suction to enable easy start of fire water pump and the effective storage capacity shall be for two hours aggregate working capacity of fire water pumps; and
- (ii) Storage tank or reservoir shall be 2 in Nos. and interconnected with suitable valve to facilitate cleaning or repairs.

3.2.5 FIRE WATER PUMPS:

- (i) Centrifugal type fire water pumps shall be installed to meet the designed fire water flow rate and head;

- (ii) At least one fire water pump shall be of diesel engine driven type;
- (iii) Pumps shall be capable of discharging 150% of its rated discharge at a minimum of 65% of the rated head; and
- (iv) Fire water pumps shall be exclusively used for fire fighting purposes only and No. of fire water pumps of appropriate capacity shall be provided as per the following criteria, namely: -
 - (a) Normal operation - 1 No.; and
 - (b) Stand –By - 1 No.

3.2.6 FIRE HYDRANT NETWORK:

- (i) Fire hydrant ring main should normally be laid above ground. Following precautions should be taken, namely:
 - (a) Pipe line should be laid at a height of 300 mm to 400 mm above finished ground level;
 - (b) The mains shall be supported at regular intervals not exceeding 6 meters;
 - (c) The system for above ground portion shall be analysed for flexibility against thermal expansion and necessary expansion loops where called for, shall be provided;
 - (d) The portion of fire water hydrant above ground and within 15 M of the LPG storage vessels shall be fire proofed; and
- (ii) The ring main shall be laid underground at the following places, namely: -
 - (a) Road crossings;
 - (b) Place where above ground piping is likely to cause obstruction to operation and vehicle movement; and
 - (c) Place where above ground piping is likely to get damaged mechanically particularly in the LPG storage area where water supply lines are laid for feeding sprinkler deluge system;
- (iii) Fire water ring main laid underground and the following precautions shall be taken, namely: -
 - (a) The ring main shall have at least one-meter earth cushion in open ground and 1.2 meters cushion under the road crossings;
 - (b) The ring main shall be provided with protection against soil corrosion by suitable coatings or wrappings; and
 - (c) In case of poor soil conditions, it may be necessary to provide concrete or masonry supports under the pipeline;
- (iv) Fire water ring main shall be sized for 120% of the design water rate and design flow rates shall be distributed at nodal flow rates and shall be distributed at nodal points to give the most realistic way of water requirements in an emergency;

- (v) Hydrants or monitors shall be located bearing in mind the fire hazards at different sections of the premises to be protected and to give most effective service;
- (vi) Connections for fire water monitors shall be provided with independent isolation valves;
- (vii) Hose boxes with 2 Nos, hoses and a nozzle shall be provided by the side of each hydrant points; and
- (viii) Consid
 ering radiation levels in the event of a fire, Hydrant or Monitors or Control valves shall be located at a safe distance from hazardous equipment or buildings.

3.2.7 FIXED WATER SPRAY OR SPRINKLER SYSTEM:

Fixed water spray or sprinkler system shall be installed in LPG storage area. Tank lorry unloading area, LPG shed and in the pump or compressor shed, if any.

3.2.8 FIRE AID FIRE FIGHTING EQUIPMENTS:

3.2.8.1 PORTABLE FIRE EXTINGUISHERS:

- (i) Portable fire extinguishers (only ISI approved) shall be located at convenient locations and shall at all times be readily accessible and clearly visible;
- (ii) The maximum running distance to locate an extinguisher in working areas shall not exceed 15 meters;
- (iii) The top surface of the extinguishers shall not be more than 1.5 meter high; and
- (iv) The fire extinguishers shall be provided at various as under, namely: -
 - (a) LPG storage Vessels 2 Nos. 9 Kg. DCP;
 (each)
 - (b) LPG Cylinder Filling or 2 Nos. 9 Kg. DCP per 200 sq. M area;
 storage shed
 - (c) Tank Truck loading or 1 No. 9 Kg. DCP Fire Extinguisher in each Bay and 1 No
 unloading gantries 50 Kg, Mobile DCP Unit per gantry;
 - (d) Office or Canteen or At least 2 Nos. 9 Kg, DCP Extinguishers in each Bldg.;;
 Stores
 - (e) MCC or DG Room or Min 2 Nos, 4,5 kg. CO2 Extinguishers in each room or 100
 HT Room Sq. M area and 4 sand buckets with a stand; and
 - (f) 100% spare CO2 cartridges and 50% spare Dry Chemical Powder i.e. DCP shall always be stored in the plant.

3.2.8.2 MOBILE FIRE FIGHTING EQUIPMENT:

The Dry Chemical powder used in the extinguishers shall be potassium or Urea based or Sodium Bicarbonate as per IS:4308 and the expellant gas i.e. CO₂ should be of food quality.

3.2.8.3 HOSES, NOZZLES AND ACCESSORIES:

- (i) Reinforced rubber lined hoses confirming to IS:636 (Type A or B) shall be provided;
- (ii) The hoses of 15 meters standard length shall be provided with gun metal or Aluminum alloy male and female couplings of instantaneous pattern;
- (iii) 50% spare hoses shall be stored in the LPG Plant;
- (iv) In addition to the nozzles provided in the hose boxes, 4 Nos. triple purpose nozzles shall be provided;
- (v) Fire Hoses: 50% of no. of Hydrant points;
- (vi) Sand drums with scoops: 20 Nos.;
- (vii) Hose boxes: 1 No. for each hydrant point;
- (viii) First aid box: 2 Nos. each;
- (ix) Explosimeter: 2 Nos.;
- (x) Siren: 1 No.;
- (xi) Red or Green Flag: 1 No. each; and
- (xii) Hand gloves:
 - (a) Leather lined asbestos hand gloves for cold working: 2 pairs.; and
 - (b) Rubber hand gloves: 2 pairs for MCC room.

3.3 FIRE/ALARM OR COMMUNICATION SYSTEM:

- (i) Electricity operated Fire Siren shall be audible to the farthest distance in the plant; and
- (ii) Manually operated fire sirens shall also be provided at strategic places.

3.4 INSPECTION AND TESTING:

- (i) The fire protection equipment shall be kept in good operating condition all the time; and
- (ii) The fire fighting system shall be periodically tested for proper functioning and logged for record and corrective actions and in addition to routine daily checks or maintenance periodic inspection or testing shall be ensured.

3.5 FIRE WATER PUMPS:

- (i) Every pump shall be subjected to test run for atleast 10 minutes minimum twice a week; and
- (ii) Once in a month each pump shall be checked and tested and the shut-off pressure observed should be logged and the pump performance shall be ascertained also.

3.6 FIRE WATER RING MAIN:

- (i) The ring main shall be inspected for any visual leaks, defects, damages and corrosion; and

- (ii) All valves on the ring main or hydrant or monitor valves shall be checked for leaks or operation and lubricated once in a month.

3.7 FIRE WATER SPRINKLER SYSTEM:

- (i) The sprinkler system in the sheds shall be tested once in a month; and
- (ii) The strainer provided in the fire water sprinkler records maintained and the system shall be cleaned once in a quarter and record maintained.

3.8 FIRE WATER RESERVOIR:

In case of a reservoir the same shall be cleaned once in 6 months or whenever needed so that there shall not be any Foreign particles or fungus or vegetation in the reservoir.

3.9 Make up water:

Facilities, to receive make up water during fire fighting, shall be provided.

4.0 Additional minimum safety requirements on design, layout, storage, loading or unloading, operation at LPG storage, handling and bottling facilities:

- (i) For all Aboveground Horizontal bullets with the total volumetric capacity up to 705 Cu. M. shall be used for storing LPG and in case of mounded storage (all vessels) the total capacity shall be increased up to 1058 cu M;
- (ii) For combination of mounded and aboveground vessels, the total capacity of 450 MT shall be permitted with maximum aboveground storage capacity 100 MT; and
- (iii) The maximum filling in single shift shall not exceed 50 MT.

4.1 GENERAL:

The requirements under this section are minimum additional safety requirements for the LPG storage, handling and bottling facilities meeting the requirements as per 4.0 and the all other provisions of Schedules 1.0 and this Schedule shall be applicable.

4.1.1 There shall be minimum 3 nos. of vessels in each case 4.1.2 Confinement or Grading shall be as per Schedule 1

4.1.3 The operation of facilities should be restricted to maximum two shifts operation.

4.1.4 Filing Facility shall meet the following requirements, namely: -

- (a) Filling Machines (Stationary or Carousel): With not more than 10 filling units;
- (b) Check Scale: To countercheck the quantity of LPG filled;
- (c) Correction scale with Auto cut off facility;
- (d) Compact Valve Tester or any other proven device: To check valve or "O" Ring leakage;
- (e) Test Bath: To check the body or bung leak cylinders;
- (f) Evacuation Rack: For evacuation of cylinders; and

(g) Purging Manifold: For purging of cylinders.

4.2 **Filling Machine:**

The filling machines shall be provided with auto cut-off system to ensure that LPG supply is cut-off after filling the desired quantity of product and the filling pressure shall not exceed the design pressure of the cylinders.

4.3 **Instrumentation:**

The storage vessel shall have minimum 2 different type of level indicators, one of them shall be High Level switch with alarm interlocked to close ROV of liquid line and the other may be - Slip Tube Gauge or Roto Gauge or Rochester Gauge or Servo Gauge or Radar Gauge or any other proven gauge developed through advancement in technology.

4.4 **Safety and Fire Protection:**

All LPG storage vessels shall be provided heat detection based auto operated sprinkler system with deluge valve.

4.5 **Hydrant Main:**

Fire water ring main shall always be charged with water maintain residual pressure of 7 Kg /sq cm at farthest point with the help of Jockey Pump.

SCHEDULE – 3
[See regulation 6 (3)]

**STANDARDS FOR DESIGN, LAYOUT, OPERATION AND MAINTENANCE OF
REFRIGERATED LPG STORAGE**

1.0 GENERAL:

Safety in Refrigerated LPG Storage facilities need specific attention considering the fact that large volumes of LPG are stored at near atmospheric pressure well below the ambient atmospheric temperatures. Any change in the ambient conditions of the product would result in boiling of large volume of liquid at a very high rate which may lead to rise in tank pressure and failure of storage tanks. These tanks are prone to collapse under vacuum in case of high rate of evacuation of product. The product stored in the tanks is without any odour. Before the commencement of these regulations, there was no specific standard in the country for standardizing the design, Layout, Operation and Maintenance of the refrigerated LPG Storage Facilities. The standards provided in this schedule are intended to serve as guidelines to the Design, Layout, Operation and Maintenance of Refrigerated LPG Storage facilities. The primary objective of standard, in this Schedule is to ensure safety in Refrigerated LPG Storage facilities by following the basic safety requirements and practices in the design, construction and Operation of Refrigerated Storage Facilities And the provision of this Schedule shall be construed keeping such objective in views.

2.0 SCOPE:

This standards in this Schedule lay down the minimum safety requirements for Design, Layout, Operation and Maintenance of Refrigerated LPG Storage facilities including the offsite storage facilities at refineries and gas processing plants which are not part of process requirements. The facilities at port and the associated cross-country pipelines are not part of the scope of the standard, in this Schedule and such standards do not cover the buried or semi buried refrigerated LPG storage facilities. The requirements under the provision of Schedule -1 shall be applicable after the point LPG is no longer in Refrigerated State.

3.0 DEFINITIONS:

In this Schedule, under the context otherwise requires-

- (a) “Aboveground Tank or Aboveground Vessel” means a tank or vessel as a whole or any part of it is exposed above grade;
- (b) “Annular Space” means the space between the primary cylindrical liquid container and the primary cylindrical product vapor container or cylindrical purge gas container of a double wall tank;
- (c) “Auto-refrigeration” means the chilling effect of vaporization of LPG when it is released or vented to a lower pressure;
- (d) “Base Heating System” means a heating system provided in the base slab or soil below the tank system to prevent freezing of the soil and frost heave;
- (e) “Base Slab” means a continuous concrete base supporting the tank system and such

- base may be either at grade or elevated and may be either supported by soil or piles;
- (f) “Deriming synonymous with defrosting or de-icing” means the removal, by heating and evaporation, sublimation, or solution, of accumulated constituents that form solids, such as water, carbon dioxide, and like other constituents from the low-temperature process equipment;
 - (g) “Design Liquid Level” means maximum liquid level that will be experienced during operation of the tank and such liquid level is used for the static shell thickness determination.
 - (h) “Dyke” means a structure remote from the tank system used to establish an impounding area for the purpose of containing any accidental spill of stored liquid and sometimes such structure is referred to as a bund wall;
 - (i) “Elevated Foundation” means a foundation with base slab, supported by either piles or piers located at an elevation above grade, leaving an air gap between the grade and the bottom of the base slab;
 - (j) “Flameproof Enclosure” means type of protection in which the parts which can ignite an explosive atmosphere are placed in an enclosure which can withstand the pressure developed during an internal explosion of an explosive mixture and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure;
 - (k) “Hazardous Atmosphere” means an atmosphere containing any flammable gas or vapour in a concentration capable of ignition;
 - (l) “Load Bearing Insulation” means insulation with special compressive strength properties used for thermal insulation and for transferring the load to the load bearing structure;
 - (m) “Maximum Liquid Capacity” means the total volume between the design liquid level and the tank bottom and such liquid capacity is also referred to as total liquid capacity in API 620;
 - (n) “Maximum Normal Operating Level” means maximum liquid level that will be experienced during normal operation of the tank;
 - (o) “Minimum Normal Operating Level” means minimum liquid level that will be maintained during normal operation of the tank and the unusable volume of liquid below the minimum normal operating level is known as Heel;
 - (p) “Net Working Capacity” means the volume between the maximum normal operating level and minimum normal operating level;
 - (q) “Overfill Protection Margin” means capacity (tank height or volume) between the maximum normal operating level and the design liquid level;
 - (r) “Pump Column” means a pipe column to house a combined vertical pump and close coupled electric motor and such column itself protrudes through the outer tank roof;
 - (s) “Primary Liquid Container” means parts of a tank system that contain the liquid during normal operation.
 - (t) “Primary Vapour Container” means parts of a tank system that contain the product vapour during normal operation;
 - (u) Process means any or any combination of the following, namely: -
 - (i) “Boil-Off” which means the process of vaporization of refrigerated product by heat conducted through the insulation surrounding the tank;

- (ii) “Design Pressure” which means the maximum gauge pressure permissible in the vapour space above the product of a tank system in its design condition;
 - (iii) “Rollover” which means the spontaneous and sudden uncontrolled movement of a large mass of liquid from the bottom to the top surface of a refrigerated storage vessel due to an instability caused by an adverse density gradient due to presence of stratified liquids of different densities and rollover can cause a sudden pressure increase and can affect vessel integrity;
 - (iv) “Set Pressure” which means the gauge pressure at which the pressure relief device first opens;
 - (v) “Set Vacuum” which means the gauge pressure at which the vacuum relief device first opens;
 - (vi) “Sweetening” which means the introduction of LPG vapour into the tank; and
 - (vii) “Purging” which means the replacement of one gas or vapour by another in an enclosed tank system by displacement, by dilution, by diffusion or by combinations of these actions.
- (v) “Secondary Liquid Container” means parts of a tank system that contain the liquid in the event of leakage from the primary liquid container;
- (w) “Seismic Freeboard” means the design height above the maximum normal operating level to minimize or prevent overflow or damage to the roof due to sloshing of the liquid contents during a seismic event;
- (x) “Stratification” means the possibility of the creation of layers with a less dense liquid overlying a heavier one, when liquids of different densities are received in the same tank and, unstable stratification may also occur when the liquid in the lower layer becomes less dense due to heat input, while the liquid in the upper layer becomes heavier due to the evaporation at the surface and such unstable situation can relieve itself with a sudden or spontaneous rapid mixing process (Roll over) which occurs in tanks as a result of a density inversion;
- (y)
- (z) “Refrigerated Tank System” means storage in a vessel or tank artificially maintained at a temperature below the nominal ambient temperature and such vessel or tank includes the combination of a primary liquid container, together with secondary liquid container (if any), insulation, vapor container, appurtenances, instrumentation and all other associated elements and the product is stored at their respective boiling point depending upon the constitution at near atmospheric pressure;

4.0 REFRIGERATED LPG STORAGE AND HANDLING FACILITIES – PROCESS:

4.1 Refrigerated LPG:

The product shall be stored either in pure propane and pure butane form or in premixed LPG (i.e. mix of propane and butane conforming to IS: 4576) at their respective boiling point at near atmospheric pressure.

4.2 Receipt of refrigerated LPG, butane or propane:

The refrigerated propane, butane or LPG shall be discharged by the pumps of the ocean tanker through the unloading arms at the port to the cross-country pipelines and shall be transferred to the designated storage vessels at the terminal through insulated pipelines.

4.3 Storage of Refrigerated LPG:

The primary function of storage vessel is to receive, hold and stock refrigerated product and the above ground dome roof tanks are used to store the liquefied gas at or below its boiling point and the tank is designed to ensure the functions specified in the succeeding paragraphs 4.3.1 to 4.3.4.

4.3.1 Liquid Retention:

The storage tank shall be capable of withstanding the hydrostatic load of the liquid and low temperature of the propane, Butane or LPG.

4.3.2 Gas Tightness:

Tanks should be tight enough to prevent any evaporation losses and also to avoid ingress of air and moisture.

4.3.3 Thermal Insulation:

Thermal insulation shall be provided to limit boil-off rates and to avoid cold spots on the outer shell.

4.3.4 Thermal Stresses:

Under normal operating conditions, the tank is subjected to variation in the temperatures and also during start up, tank temperature is required to be brought down from ambient to refrigerated temperatures and sometimes the tank may require deriming for various reasons like repair of internals, modifications and like other reasons, as such, the tanks shall be capable of withstanding the heat variation. The detailed requirements of Refrigerated Storage Tanks has been specified in paragraph 6.0 to 6.16.3.

4.4 REFRIGERATION SYSTEM: BOIL OFF COMPRESSORS, FLASH COMPRESSORS, CHILLERS OR CONDENSERS:

- (i) A vapour recovery system comprising of positive displacement compressors, LPG condenser and liquid receiver is provided to maintain refrigerated LPG tank pressure and the auto-refrigeration system compensates for heat gain in the tank, headers and in-tank pump heat;
- (ii) Large capacity refrigeration compressors called Flash Compressors are operated to handle large-scale refrigeration requirement during ocean tanker receipts and smaller capacity refrigeration compressors called Boil-Off Compressors are used during normal course of operations to maintain tank temperatures at required levels;

- (iii) The vapor extracted during the operation specified in Clause (ii) is compressed and then re-liquefied by condensing in condensers or chillers and the condensate, intermediately stored in condensate receivers, is then pumped to separate buffer storage tanks thereby completing an open-cycle auto-refrigeration process and the liquid returned to the either refrigerated storage tank or above ground tank as per the designed process flow; and
- (iv) Refrigerated storage tanks and refrigeration systems are designed to maintain normal process operations during routine maintenance of equipment, and to assure plant safety under emergency conditions and sufficient sparing of equipment is provided so that any single piece of equipment can be removed from service while maintaining normal operations.

4.5 Flare System:

- (i) The terminal shall be provided with flare system to enhance the plant safety and the flaring is done only as a final solution when the normal Boil or Flash compressor are not available to meet the requirement and the flare is connected to the tank pressure vent valve to provide sufficient time for operator intervention in case of pressure rise and hot flare shall be provided in view of LPG vapour being heavier than air and no mercaptan is added in the refrigerated product;
- (ii) Flare System is very important considering the following, namely: -
 - (a) Automatic release in the event pressure develops beyond the design pressure;
 - (b) Manual venting through ROV and Control Valve during vapour purging operation while commissioning the terminal; and
 - (c) Since there would be two types of release, one low temperature and other higher temperature the flare system shall have properly designed knock-out drum.

4.6 Product withdrawal:

The product stored in the tanks is pumped out using in tank Pumps (duty and standby) installed inside each tank.

4.7 Heating or Blending:

- (i) The refrigerated product (LPG or propane or butane) is brought to ambient condition from its sub-zero temperature by various method of heating the product by either through steam or heat exchangers or air preheaters and like other heating methods and it is very important to ensure that the product LPG or propane or butane at downstream of heating arrangement shall be at temperature above 15°C and the failure of the heating arrangement to increase the temperature of the product up to 15°C should immediately trip the in-tank pump and prevent flow of refrigerated product from heating arrangement;

- (ii) The product (propane and butane) above 15°C is blended in a blending unit in the correct ratio to make commercial LPG and the final product is dozed with dozing facilities for odorizing ethyl mercaptan from the LPG in the correct proportion; and the
- (iii) The product piping or equipment at the downstream of the heating arrangement up to the blending section shall be of LTCS material only and other process or utility pipelines shall be as per design requirements as per ASME B 31.3.

5.0 Terminal Layout:

5.1 General:

- (i) Terminal lay out arrangement shall consider location of the facilities at a site of suitable size, topography and configuration with a view to minimise the hazards to persons and property due to leaks and spills of LPG and before selecting a site, all site related characteristics which could affect the integrity and security of the facility shall be determined and a site shall provide ease of access so that personnel, equipment, materials from offsite locations can reach the site for fire fighting or controlling spill associated hazards or for the evacuation of the personnel; and
- (ii) The safety distances among various facilities shall be maintained as given in Schedule – 1 and the minimum distance of 60 m shall be maintained between LPG Storage Tank and Sub-station and specific points related to Refrigerated LPG should be brought out for the purpose of safety distances to be maintained.

5.2 Basic Information:

Information on following items should be collected before proceeding with the development of overall plot plan, namely: -

A:

- (i) Site location map;
- (ii) Site Geotechnical and Seismic data;
- (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) Storm water disposal point and effluent disposal point;

- (ix) Source of water supply and likely entry or exit point;
- (x) Electric supply source and direction of entry point;
- (xi) LPG entry point or Gas exit point;
- (xii) Approach roads to main Terminal areas;
- (xiii) Surrounding risks;
- (xiv) Air routes and the proximity of the Airports;
- (xv) Fire station; and
- (xvi) The Proximity to the unloading jetty.

B:

- (i) Terminal capacity;
- (ii) Process flow diagram indicating flow sequence;
- (iii) Process units and capacities;
- (iv) Refrigerated LPG storage tanks, sizes and type of storage tanks;
- (v) Other LPG storage tanks;
- (vi) LPG transfer;
- (vii) No. of flares;
- (viii) Provision for spill containment and leak control;
- (ix) Minimum inter distances between facilities as well as between facilities and boundaries;
- (x) Operating and maintenance philosophy for grouping of utilities;
- (xi) Plant and non-plant buildings;
- (xii) Space for future Expansion;
- (xiii) Chemical storage; and
- (xiv) Ware house and open storage areas.

5.3 Grouping:

The Refrigerated LPG Terminal may consist of the following basic facilities, namely: -

- (i) Refrigerated LPG receipt line to shore terminal;
- (ii) Refrigerated LPG Storage;
- (iii) Pressurized LPG storage facilities;
- (iv) Boil Off or Flash Compressor, condensers, chillers;
- (v) Process Area;
- (vi) Heating or Blending or dozing facilities;
- (vii) Flare system;
- (viii) Utility Block (Air Compressors, De-mineralization plant, Boiler Room and like other utility blocks);
- (ix) Fire water Storage and fire water Pump House;
- (x) LPG loading or transfer facilities Road or Rail or Pipeline;
- (xi) Control Room;
- (xii) Administrative Block;
- (xiii) Workshop;
- (xiv) Warehouse;
- (xv) Electrical Substation; and
- (xvi) Laboratory.

5.4 General Considerations:

- (i) Future expansion requirement shall be assessed and provision of space for the same should be made;
- (ii) The Erection and Maintenance requirements shall be considered;
- (iii) The layout of the 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 effected by fire rapidly and effectively;
- (iv) The layout shall permit access from at least two directions;
- (v) Each group shall be separated by roads on all four sides for easy access and emergency handling; and
- (vi) Classification of areas for Electrical Installations in LPG Terminal shall be as per IS 5571 as applicable.

5.5 Processing Equipment Spacing:

It shall meet the requirements as specified in design standards and licensors guidelines.

5.6 Aboveground Refrigerated LP-Gas Containers:

- (i) The minimum horizontal distance between the shell of a refrigerated LPG tank and the line of adjoining property, that may be developed, shall be 60 m and where residences, public buildings, places of assembly, or industrial sites are located on adjacent property, greater distances or other supplemental protection shall be evaluated;
- (ii) Non-refrigerated LP-Gas containers or flammable liquid tanks shall not be located within dykes or impoundments enclosing refrigerated LP-Gas containers;
- (iii) Refrigerated LP-Gas containers shall not be installed one above the other;
- (iv) The minimum distance between aboveground refrigerated LP-Gas containers shall be one-half the diameter of the larger container;
- (v) The minimum horizontal distance between the shell of a refrigerated LPG tank and the shell of another non-refrigerated hydrocarbon storage facility shall be the largest of the following distances subject to a maximum requirement of 60 m. namely: -
 - (a) If the other storage is pressurized, three quarters of the larger tank diameter. or 30 m whichever is more;
 - (b) If the other storage is in atmospheric tanks and is designed to contain material with a flash point of 55 or less, one diameter of the larger tank or 30 m whichever is more; and
 - (c) If the other storage is in atmospheric tanks and is designed to-contain material with a flash-point greater than 55 C, half the diameter of the larger tank or 30 m whichever is more.
- (vi) Refrigerated LPG tanks shall not be located within buildings, within the spill containment areas of other flammable or combustible liquid storage tanks or within the spill containment areas of pressurized storage tanks;
- (vii) The inter-distance requirements among various process facilities such as flash or boil off compressor area heat exchanger or condensers or blending or dosing facilities shall be governed by process or design or hazop considerations;

- (viii) There shall not be any process facility such as condenser or compressor house or dosing or blenders within 30 m of tank shell; and
- (ix) The inter-distance for the facilities handling non-refrigerated LPG shall be as per Schedule – 1 for respective facilities.

5.7 Spill Containment:

- (i) Single containment Refrigerated LPG tanks shall be provided with spill containment facilities and spill containment shall be provided by the dyking of the area surrounding the vessel;
- (ii) For double and full containment tanks, only kerb wall of atleast 0.6 m height shall be provided. The distance of kerb wall from tank shell shall not be less than 15 m and such case, double wall tanks shall be designed to hold the entire quantity in the outer shell as well as suitable to handle hydrostatic pressure and low temperature requirements;
- (iii) To prevent the accumulation of flammable material under or near a refrigerated LPG tank, the ground under and surrounding the tank shall be graded to drain any spills to a safe area away from the tank;
- (iv) In respect of Dyking (Dyke wall), the following shall be taken into account, namely: -:
 - (a) If Dyking around the vessel is to be used for spill containment, the dyked area shall be designed to meet the capacity of single largest tank in the dyke. Effective containment capacity shall be after considering 0.2 m of free board;
 - (b) The grading of the area under and surrounding the vessel shall direct any leaks or spills to the edge of the dyked area and the grading shall be a minimum of 1% slope and within the dyked area, the grading shall cause spills to accumulate away from the vessel and any piping located within the dyked area;
 - (c) Each refrigerated LPG tank shall be provided with its own dyked area and the holdup of the dyked area shall be at least 100% of the volume of the tank;
 - (d) More than one tank may be enclosed within the same dyked area provided provisions are made to prevent low temperature exposure resulting from leakage from any one tank from causing subsequent leakage from any other tank and when dykes are used as part of the spill containment system, the minimum height shall be 0.5 m, measured from the inside of the dyked area and where dykes are higher than 1.8 m, then, provisions shall be made for normal and emergency access into and out of the dyked enclosure and the height of dyke shall not exceed 2.0 m excluding free board of 0.2 m;
- (v) The edge of a dyke or kerb wall, impoundment, or drainage system that is intended for a refrigerated LP-Gas container shall be 30 m or more from a property line that can be built upon, a public way, or a navigable waterway; and
- (vi) The ground within 7.5 m of any aboveground refrigerated LP-Gas container and all ground within a dyke, impoundment, or drainage area shall be kept clear of readily ignitable materials such as weeds and long dry grass.

5.8 Marking of Tanks:

Each refrigerated storage system shall be identified by the attachment of name plates readily visible and accessible which shall contain the following details, namely: -

- (a) Manufacturers name and serial number;
- (b) Design standard;
- (c) Maximum LPG filling level;
- (d) Liquid volume of the tank when filled with LPG to the maximum safe level;
- (e) Maximum and minimum design pressure;
- (f) Maximum and minimum design temperature;
- (g) Density of the LPG for which the tank is designed; and
- (h) Year of construction and test.

5.9 Piping, Valves and Equipment:

- (i) Piping, valves and equipment for handling refrigerated LPG shall conform to the low temperature requirements and to be suitable for use at the temperature of the application and shall be designed for not less than the maximum pressure and for minimum temperature to which they may be subjected;
- (ii) Cast iron shall not be used for piping systems handling refrigerated LPG;
- (iii) Screwed joints and compression fittings shall not be used in piping for low temperature Propane, Butane or LPG service except for the instrument lines downstream of an isolation valve;
- (iv) All the welds of Propane, Butane or LPG service line shall be tested as per ASME B31.3 Chapter VI and records maintained for future references; and
- (v) Piping systems and their supports shall be suitably insulated or protected for fire exposure conditions.

6.0 DESIGN CONSIDERATIONS REFRIGERATED STORAGE TANKS:

6.1 Design Information:

Following information shall be collected at the design stage, namely: -

- (a) Natural environmental loads (such as earthquake, wind);
- (b) Spillage handling requirements;
- (c) Corrosion allowances;
- (d) Hazard Protection System requirements (such as water spray, gas detection, if any);
- (e) Accidental loads determined by assessment of risk (such as fire, pressure wave, projectile impact, if any);
- (f) Settlement prediction and inspection method;
- (g) Ambient temperature;
- (h) Properties of the stored product, including density at the design temperature;
- (i) Minimum design temperature of primary containment;
- (j) Tank maximum liquid capacity;
- (k) Design liquid level;
- (l) Internal diameter and height of inner tank;
- (m) Normal maximum or minimum operating liquid level;

- (n) Design pressure or vacuum, maximum or minimum operating pressure;
- (o) Pressure relief and vacuum set points (High- or low-pressure alarm set point);
- (p) High- or low-level alarm;
- (q) Minimum normal operating level basis;
- (r) Overfill protection margin;
- (s) Capacity to receive the interface turbulence of two products at different temperature and density;
- (t) Product filling or emptying rates;
- (u) Rollover applicability and rollover prevention provisions;
- (v) Design boil-off rate;
- (w) Condensation of vapours in annular space;
- (x) Risk assessment;
- (y) Applicable codes and standards;
- (z) Materials of tank construction;
- (aa) Emergency relief valve discharge flow rate;
- (bb) Piping and instrumentation requirements;
- (cc) NDE applied to non-hydrostatically tested components;
- (dd) Tank type;
- (ee) Networking capacity;
- (ff) Tank location on plot plan;
- (gg) Process flow diagrams, piping and instrumentation diagrams (P and IDS); and
- (hh) Pre-commissioning and commissioning procedures, including purging, drying, and cool down.

6.2 DESIGN REQUIREMENTS:

6.2.1 Tank Systems for Refrigerated Storage:

The tank system for Refrigerated Storage covers low pressure, aboveground, vertical, and cylindrical tank systems storing liquefied gases requiring refrigeration and such requirements are general requirements on selection of storage concept, performance criteria, accessories or appurtenances, quality assurance, insulation, and commissioning of tank systems and the Refrigerated storage tank system consist of a primary liquid and vapor containment constructed of metal, concrete, or a metal and concrete combination and, when required, a secondary liquid containment.

6.2.2 Metallic Containers:

Metallic container materials, design, fabrication, inspection, examination, and testing shall be in accordance with API 620 including Appendix R.

6.2.3 Concrete Containers:

Concrete container materials, design, construction, inspection, examination, and testing shall be in accordance with ACI 376.

6.2.4 General Requirements:

For all containment systems, liquid-tightness of the primary liquid container is required and the liquid is not permitted to accumulate outside the primary liquid container during normal operation. Tank system where it is not assured would require consideration of issues such as liquid collection and disposal, potential cold spots, effect on tank venting and like other issues.

6.2.5 Type:

Three main different storage concepts are Single containment, Double Containment Tank System and Full Containment Tank System.

6.2.6 Single containment:

A single containment system is one having either a single tank or a tank comprising an inner tank and an outer container designed and constructed so that only the inner tank is required to meet the low temperature ductility requirements for storage of that product and the outer container of a single containment storage tank would primarily be for retention and protection of insulating material and to contain the vapour gas pressure and would not be designed to contain liquid in the event of leakage from the inner tank.

6.2.7 Double Containment (double integrity) Tank System:

A double containment system is one having a double tank designed so that both the inner tank and the outer tank are capable of independently containing the refrigerated liquid stored and the inner tank contains the refrigerated liquid under normal operating conditions and the outer tank is intended to contain the refrigerated liquid product leakage from the inner tank and is not designed to contain product vapour in the event of liquid leakage from the inner tank.

6.2.8 Full Containment Tank System:

- (i) A full containment storage tank is one meeting all the requirements of double containment storage plus the additional requirement that it shall avoid the uncontrolled release of product vapour in the event of liquid leakage from the inner tank; and
- (ii) The full containment concept evolved from double containment and has the following advantages, namely: -
 - (a) That it controls or prevents the release of product vapors following primary liquid container leakage or failure; and
 - (b) That it possess greater ability to resist external threats such as blast, fire and impact compared to single and double containment tanks.

6.2.9 Guidance on selection of storage concept:

The selection is to be based on a risk assessment. The risk is a function of not only the

storage concept itself but also the way the tank system relates to many other aspects of the overall facility. Therefore, other aspects of the facility and its surroundings shall be considered.

Plans for the proposed facility should specifically address the impact of vapour clouds and radiant heat flux on plant facilities and adjacent properties and the intrinsic within this approach is the selection of storage concept; separation distances and proximity to property lines; site topography; soil conditions; and ground water conditions and a review of the site may identify constraints or provide opportunities to utilize specific features of site to the benefit of the facility. The rate of heat generation from a large pool of burning liquefied gas is significantly higher than that of a similar pool of another oil product and in order to limit the radiant heat flux on the surroundings to acceptable levels it may be necessary to reduce as much as possible the area of the pool of spilled liquefied gas through the selection of containment concept.

6.3 External hazards include the following:

- (a) Environmental hazards including earthquake, lightning, wind loading including hurricane typhoons or flooding;
- (b) Snow and ice loading and tsunamis;
- (c) Ground conditions, weak strata, liquefiable layers, lateral spreading, and presence of caverns, voids and defects;
- (d) Flying objects, and equipment following a process incident;
- (e) Pressure waves due to vapor cloud ignitions from the process plant, adjacent plant, process equipment, and Carriers including facilities located outside the boundary limits;
- (f) Operational and upset conditions including spillage and leakage of product;
- (g) Maintenance hazards;
- (h) Fire hazards from adjacent tanks, dykes, relief valves, sumps, jet fires, and plant areas; and
- (i) Proximity of tanks to external uncontrolled sources of ignition such as ground flares and other flares.

6.4 Internal hazards include the following:

- (a) Leakage of product from the inner tank;
- (b) Overfilling of the tank;
- (c) Over or under pressurization of the tank due to process upset;
- (d) Rollover leading to over pressurization of the tank;
- (e) Major leak (i.e. The complete failure of the inner tank);
- (f) Minor leak (i.e. Partial leakage from the inner tank due to a postulated defect);
- (g) Fatigue and cyclic loading of key components (e.g., annular plates);
- (h) Corrosion;
- (i) Failure of pipe work attached to the tank bottom or sides;
- (j) Instrumentation failures.

6.5 Safety Improvement:

If the assessment of risk identifies risks that exceed acceptable limits, then, positive

measures (action) should be taken to reduce the level of risk to an acceptable level and the typical mitigation measures may be as follows, namely: -

- (a) Selection of alternative containment concepts (i.e. Migration from single containment to double or full containment);
- (b) Improvements to process equipment selection;
- (c) Substitution of a metal roof on a full containment tank with a concrete roof;
- (d) Increase in safety distances (separation distances) to limit impact in respect of vapor dispersion and radiant heat flux;
- (e) Elimination of ignition sources;
- (f) Selection of alternate layouts and site locations; and
- (g) Inclusion of protection systems to shield or protect critical equipment from hazard.

6.6 General Design Considerations:

- (i) All pipe connections shall be through the top of the tank to avoid siphoning effect and all isolation valves shall be pneumatically operated and interlocked to prevent accidental movement of tank contents from one tank to another;
- (ii) Each tank shall be provided with at least two independent means of determining the liquid level and such tank shall be provided with isolation arrangement so that they can be replaced or repaired without taking the tank out of service;
- (iii) Each tank shall be provided with high level alarm and a high-level trip system which shall be designed to stop all liquid flows into the tank to prevent over-filling;
- (iv) The high-level trip system shall be independent of both high level alarm and of liquid level gauges;
- (v) Double and full containment system shall be provided with means for detecting and removing the liquid leakage or buildup of condensation in the annular space and the provision made for injecting nitrogen for purging is considered meeting the requirement and vapor at higher temperatures may be pushed for vaporizing the condensate through such provision;
- (vi) All the primary containers shall be tested to the maximum filling level with water;
- (vii) Outer tanks of double and full containment system shall be tested in manner as specified in clause (vi) and to prevent damage to the inner shell, the level in the inner tank shall be maintained above the level in the outer shell during the hydrostatic test;
- (viii) The tank has a spray-ring for cool-down with product and skin mounted temperature elements at Tank Shell to monitor the cool-down during commissioning and the temperature element is also required to be provided at Tank bottom at different radii in uniformly distributed manner to avoid temperature stratification during commissioning;
- (ix) If the tank is resting for a longer period, a potential for temperature stratification could exist and the warmer liquid from the tank bottom is moved upwards during restarting which could lead to excessive evaporation and higher tank pressure and the mean, such as the recirculation should be provided to break the stratification;
- (x) Tank shall be provided with pressure or vacuum relief valves as per API standard 2000 independent of the pressure or vacuum control and trip systems;
- (xi) Sections of LPG pipe-work that could be blocked are provided with thermal relief valves;

- (xii) 100% capacity In-tank pumps (duty and standby) shall be provided for delivery of product from the refrigerated storage tank and an additional separate pump well and foot valve shall be provided in each refrigerated tank;
- (xiii) Roof manholes shall be provided as per requirement; and
- (xiv) Walkways or platforms shall be provided to access all roof appurtenances requiring periodic maintenance such as vents and level gauges and for access to the roof manholes.

6.7 Design Pressure:

- (i) The design pressure of a refrigerated LPG tank is determined by the product's vapor pressure at the storage temperature and the set pressure or sizing of the pressure-relieving devices shall be such so as not to allow pressure buildup of more than 105% of the design pressure in the container; and
- (ii) The tank section above the maximum liquid level shall be designed for a pressure of at least that at which the pressure relief valves are to be set and for the maximum partial vacuum that can be developed and all portions of the tank below the maximum liquid level shall be designed for at least the most severe combination of gas pressure (or partial vacuum) and static liquid head affecting each element of the tank.

6.8 Design Temperature:

The design temperature for a refrigerated-LPG tank shall be the lowest of the following, namely: -

- (i) The lowest temperature to which the tank contents will be refrigerated;
- (ii) The lowest shell temperature resulting from cold ambient conditions, if that temperature is below the refrigerated product temperature; and
- (iii) The auto refrigeration temperature of the contents.

6.9 Pressure or Vacuum Control and Relief Systems:

- (i) The purpose of the pressure relief system is to prevent the Tanks from excess pressure beyond design by way of controlled release of hydrocarbon vapour to the atmosphere;
- (ii) The purpose of the vacuum control system is to prevent the Tanks from implosion under vacuum beyond design by way of controlled breathing of air from atmosphere into the tank;
- (iii) All the tanks shall be provided with a pressure or vacuum control and relief system to maintain the Tank pressure within the design pressure range in all conditions;
- (iv) The pressure relief system shall be sized to relieve the flow capacity determined for the combination of the following scenarios responsible for Vapour generation, namely: -
 - (a) Liquid entering the tank;
 - (b) System heat in-leak;
 - (c) Energy input from in tank Pumps;
 - (d) Decrease in atmospheric pressure;
 - (e) Mixing of Product of different constituents;

- (f) Fire Exposure;
 - (g) Operational Upset, such as failure of a control device; and
 - (h) Rollover scenario;
- (v) In normal operation such vapours shall be collected by the Boil Off or Flash compressors and the same is re-liquefied thus preventing their loss to the atmosphere;
 - (vi) The terminal shall be provided with flare system to relieve the excess pressure, when the normal Boil or Flash compressor are not available or able to meet the requirement and flare is connected to the tank pressure vent valve to provide sufficient time for operator intervention in case of pressure rise;
 - (vii) The venting rate to be calculated for arriving at the following, namely: -
 - (a) Size of Control Valve;
 - (b) Size of Flare Header; and
 - (c) Capacity of Flare Stack;
 - (viii) Low pressures shall be limited by the use of the following systems, namely: -
 - (a) Tripping of Boil off or Flash compressors and product transfer pumps;
 - (b) The supply of hot gas or liquid or inert gas into the tank; and
 - (c) The relief system shall be such that it is able to function even at time when the control system is failed;
 - (ix) The mixing of air with flammable LPG vapours is undesirable and only acceptable when an alternate (implosion leading to potential tank failure) would constitute a greater hazard.

6.10 Pressure or Vacuum-Relieving Devices:

- (i) Relief Valves shall be provided for tanks designed to conform to API Std 620 R in accordance with API Std 2000;
- (ii) The pressure relief valves should be adequate to relieve the worst case emergency flow, assuming all other outlets from the tanks including that of flare are closed;
- (iii) When a closed inner-tank design is used with an outer vapor-tight shell, the outer shell shall be equipped with one or more pressure or vacuum-relieving devices;
- (iv) Each refrigerated LPG tank shall be provided with a sufficient number of pressure-relieving device set to discharge at no more than the maximum allowable design pressure of the tank;
- (v) Tanks that may be damaged by internal vacuum shall be provided with a sufficient number of vacuum-relieving device set to open at not less than the vacuum design pressure;
- (vi) A sufficient number of pressure and vacuum relief valves shall be installed on the LP-Gas container to allow each relief valve to be isolated individually while maintaining the full relieving capacities required;
- (vii) Factors for consideration for sizing of pressure relief valves are as following, namely: -
 - (a) Liquid entering the tank at maximum rate;
 - (b) Maximum possible boil off assuming failure of boil off compressor;

- (c) Effect of radiation from an adjacent fire (tank);
 - (d) Effect of possible hot product intake in the tank;
 - (e) Flow of hot liquid or vapour in the tank assuming failure of vacuum protection system;
 - (f) Effect of possible mixing of products; and
 - (g) Operational Upset, such as failure of a control device; and
- (viii) As a minimum, the pressure relief valves shall be sized to discharge vapor in case of refrigeration system failure to maintain the refrigerated storage tank pressure within the design limits for at least 24 hrs.

6.10.1 Product Mixing:

- (i) Loading LPG into a partially full refrigerated LPG tank where LPG being loaded has a different composition than the existing tank content can cause generation of huge quantities of vapor and if this condition can exist, the vaporization rate can be calculated and included in the sizing of the tank pressure relief valves;
- (ii) The vacuum relief devices shall be sized to relieve the flow capacity determined from the combinations of the following factors, namely: -
 - (a) Maximum possible liquid withdrawal rate;
 - (b) Maximum possible vapour withdrawal rate (assuming the compressors fail to trip);
 - (c) Rise in barometric pressure; and
 - (d) Reduction in vapor pressure as a result of filling with sub-cooled liquid;
- (iii) No vacuum relief capacity credit shall be allowed for gas-repressuring or vapour make-up systems;
- (iv) Reduction in the vacuum relief capacity to allow for the rate of vaporization resulting from minimum normal heat gain to the contents of the container shall be allowed;
- (v) The pressure and vacuum relief valves must be provided with stop valves with spare positions and interlocks so that inspection or maintenance can be done without opening the tank to atmosphere and without reducing the relief capacity below the design requirements;
- (vi) Inlet and outlet piping connections to relief devices shall be included in the selection and sizing of relief devices;
- (vii) A manually operated full opening stop valve shall be installed between each pressure and vacuum safety relief valve and the LP-Gas container;
- (viii) All stop valves installed between a relief valve and a container shall be lockable or sealable in the fully open position;
- (ix) Emergency Pressure relief valves shall discharge directly to the atmosphere;
- (x) Precautions must be taken to prevent icing on relief valves and care must be taken to ensure prevention of possibility of freezing up of vent or flare system; and
- (xi) Care must be taken to ensure prevention of possibility of blockage due to liquid in lines of vent or flare system, therefore, such lines should be free of pockets and slope towards a knock out drum.

6.11 THERMAL CONSIDERATIONS:

The tank foundation shall be designed to prevent 0°C (32°F) or lower temperatures from penetrating the pad and soil and such limitation shall be accomplished by ventilation, insulation, heating systems, or any combination thereof and heating elements, controls, and temperature sensors shall be designed for easy access and replacement while the tank is in service. Foundation heating systems shall be provided with temperature monitoring and controls. The design of the supporting structure shall consider loads resulting from the thermal gradient across the supporting structure, foundation, and piling due to the temperature of the contents of the vessel and the thermal shock from accidental spills.

6.11.1 Insulation:

- (i) The tanks external insulation and cladding shall: -
 - (a) be weatherproof and capable of withstanding direct impingement of the cooling water from any fixed deluge system; and
 - (b) be impervious to the ingress of moisture and the insulation shall comprise or contain a vapor barrier shall be weatherproofed;
- (ii) Insulation and weatherproofing to be fire retardant and steel surfaces covered by insulation to be properly coated to prevent corrosion.

6.12 TANK ACCESSORIES:

6.12.1 Temperature Indicators or Level Indicators or Pressure Indicators:

- (i) Each tank shall be fitted with thermocouples or equivalent temperature indicating devices for use during cooldown and operations and temperature Element shall be provided in skin at uniform interval of the tank shell at different heights for correct representation of temperature of product inside;
- (ii) Temperature element is also required to be provided at Tank bottom at different radii in uniformly distributed manner to avoid temperature stratification during commissioning.

6.12.2 Level Indicators:

- (i) Each tank shall be provided with at least two independent means of determining the liquid level and the same shall be provided with isolation arrangement so that they can be replaced or repaired without taking the tank out of service;
- (ii) Such tank shall also be provided with high level alarm and a high-level trip system which shall be designed to stop all liquid flows into the tank to prevent over-filling. The high-level trip system shall be independent of both high-level alarm and of liquid level gauges; and
- (iii) Double containment and full containment system shall be provided with means for detecting and removing the liquid leakage in the annular space.

6.12.3 Pressure Indicators:

Each tank shall be provided with at least two Pressure Gauges or Transmitters and the same shall be provided with isolation arrangement so that they can be replaced or repaired without taking the tank out of service and the pressure indicators shall also be provided with local display.

6.12.4 Sampling Connections:

If sampling connections are required, they shall be installed on the tank piping rather than on the tank.

6.12.5 Tank Accessory Materials:

- (i) All materials including non-metallic parts of valves, seals, gaskets, and like other materials shall be resistant to LPG under the service conditions of pressure and temperature to which they will be subjected;
- (ii) Low-ductility materials such as cast iron shall not be used; and
- (iii) Except for instrument lines downstream of an isolation valve, screwed joints and compression fittings shall not be used in piping for low temperature service.

6.13 PIPING REQUIREMENTS:

- (i) Piping for refrigerated product shall conform to the low temperature requirements of ASME B31.3 or equivalent;
- (ii) All the piping welds shall be 100 % radiographed and the same shall be preserved for future reference;
- (iii) When cold piping is routed below grade, trenches, casing, other means shall be used to permit expansion and contract of the piping; and
- (iv) When a storage facility handles more than one type of product, dedicated loading and unloading lines between tanks and racks shall be considered for each type of product.

6.14 Thermal pressure relief:

- (i) Any sections of pipelines in which product may get trapped e.g. between shut off valves, shall be protected against excessive pressure caused by thermal expansion of the liquid contents by thermal pressure relief valves;
- (ii) The settings shall of thermal pressure relief valves and shall not be less than the maximum working pressure of the line and shall not be more than the design pressure of the pipe line; and
- (iii) If the relief valves discharge to atmosphere, the discharge shall positively be arranged in a safe manner.

6.15 Valves:

Shutoff valves and accessory equipment shall be of material suitable for the operating pressure and temperature extremes to which they may be subjected.

6.16 REFRIGERATION SYSTEM:

6.16.1 LPG Temperature:

The refrigeration system shall maintain the product (Commercial Propane, butane or LPG) at a temperature at which the LPG's vapor pressure does not exceed the tank's design pressure.

6.16.2 Sizing:

The sizing of the refrigeration system shall consider the following factors, namely: -

- (a) The difference between the design ambient temperature and the design storage temperature;
- (b) Maximum solar radiation;
- (c) Receipt of product that is warmer than the design temperature, if such an operation is expected;
- (d) Foundation heaters, connected piping; and
- (e) Vapor displacement during filling and vapor return during product transfer.

6.16.3 Pressure-Relieving Devices:

- (i) The system shall be in line with the design code of the refrigerated storage; and
- (ii) Reference shall be made to API 2000 and API RP 520, Parts I and II, for the proper design of pressure-relieving devices and systems for process equipment used in liquefaction and vaporization facilities.

7.0 FIRE PROTECTION, SAFETY AND EMERGENCY SYSTEMS:

7.1 GENERAL:

- (i) The concept of loss control shall be based on the principle that an incident of loss of containment of LPG should not escalate to the extent that facilities are endangered and the public at large is subjected to an unacceptable risk. Reasonable and reliable safeguards for the protection of properties, personnel and surroundings from damages resulting from fires, explosions and other unsafe conditions in a Refrigerated LPG Storage Facility shall be provided so as to accomplish the following objectives considering both normal and abnormal conditions, namely: -
 - (a) Limit or prevent escalation of a fire by providing spacing that adequately separates the storage, transfer, loading and unloading equipment, buildings, utility like other things;
 - (b) Minimize or avoid serious injury to personnel by providing adequate means of escape to evacuate safely, access for emergency responders and safe access for personnel to isolate plant and equipment;
 - (c) Contain and prevent the spread of fire by having early detection and warning devices that enable emergency isolation, shutdown and depressurization of vessels or equipment remotely to limit the volume of flammable material released in the event of

a fire;

- (ii) Refrigerated tanks and their associated dykes and impounding basin should be such that in the event of either a tank fire or a spill fire, thermal radiation levels do not exceed the maximum limits as specified in the table below (IP 1987) and in any case, minimum Inter-distances as per design standard or licensors requirements shall be maintained.

S. No.	Site	Maximum Thermal Flux (kW/m ²)
1.	Outer surfaces of adjacent refrigerated tanks	
	-Thermally protected (1)	32
	-Unprotected (2)	8
2	Outer surfaces of adjacent tanks having flammable products	
	-Thermally protected (1)	32
	-Unprotected (2)	8
3.	Outer surfaces of adjacent LPG pressure vessels or process equipment (3)	8
4.	Personnel inside boundary	
	-Process Area (4)	8
	-Protected work area (5)	8
	-Work area (6)	5
5.	Plant Boundary	
	-Critical area (7)	1.5
	-Urban Area (8)	5
	-Remote area (9)	13
Notes	<p>(1) Protection by water sprays, insulation, radiation screens</p> <p>(2) Protection by spacing alone</p> <p>(3) Allowable radiation flux restricted due to longer duration of exposure resulting from a refrigerated tank or bund fire.</p> <p>(4) Trained plant personnel familiar with escape routes and temporary shelter locations in plant.</p> <p>(5) Permanent building where personnel are shielded</p> <p>(6) Temporary building without shielded means of escape</p> <p>(7) Unshielded area with people present during emergencies</p> <p>(8) Neither a remote or critical area</p> <p>(9) Infrequently occupied by people</p>	

- (iii) The extent of Fire Protection shall be determined by an evaluation based upon sound fire protection engineering principles, analysis of local conditions and hazards within the facility and exposure to, or from, other property and include, as a minimum-

- (a) the type, quantity and location of equipment necessary for the detection and control of fires, leaks and spills of LPG, flammable refrigerants or flammable gases, all potential

- fires non-process and electrical fires;
 - (b) the methods necessary for protection of the equipment and structures from the effects of the fire exposure;
 - (c) fire protection water system;
 - (d) fire extinguishing and other fire control equipments;
 - (e) the equipments and process systems to be operated with the emergency shutdown (ESD) system;
 - (f) the type and location of sensors necessary for automatic operation of the emergency shutdown (ESD) systems or its subsystems;
 - (g) hazard area identification and communication system (Walkie Talkie or Paging Units).
 - (h) the availability and duties of individual plant personnel and the availability of external response personnel operating an emergency; and
 - (i) the protective equipment and special training necessary by the individual plant personnel for their respective emergency duties;
- (iv) Procedures developed for handling emergencies shall include-
- (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;
 - (e) Duties of personnel; and
 - (f) Communication procedure in case of emergency;
- (v) Pre-incident planning which forms part of site emergency plans should be prepared addressing likely and realistic scenarios to define personnel responsible for addressing an emergency, communication, determine operational actions required for isolating plant and equipment, quantify the fire or vapour cloud dispersion, set priorities for fire fighting and quantify extent of fire fighting capacity required (equipment and resources) to control the incident effectively and the updated emergency response plan shall be available in the operating control room.
- (vi) All personnel shall be trained in handling flammable products, use of portable, mobile and fixed fire protection equipment, first aid and breathing apparatus and training should expand to cover Emergency response to the use of fire protection equipment and the refresher training of personnel shall be conducted periodically.
- (vii) The planning of effective fire control measures shall be coordinated with the authority having jurisdiction and emergency handling agencies such as Fire and Mutual Aid arrangements that are expected to respond to such emergencies.

7.2 IGNITION SOURCE CONTROL:

- (i) Sources of ignition should be effectively controlled in all hazardous areas by a combination of design measures, and systems of work by-
 - (a) using electrical equipment and instrumentation classified for the zone in which it is located;
 - (b) continuity of Earthing or Bonding of all plant or equipment to avoid static electrical charges

- build up;
 - (c) elimination of surfaces above auto-ignition temperatures of flammable materials being handled or stored;
 - (d) provision of lightning protection including installation of a surge protection device between each non-earth bonded core of the cable and the local structure;
 - (e) control and restricted entry of vehicles in the zoned areas and site rules should be clear where normal road vehicles may be taken and areas where they must be excluded;
 - (f) prohibition of smoking or use of matches or lighters;
 - (g) controls to be needed to prevent or minimize the release of gas or vapor during the transfer operation;
 - (h) control of maintenance activities that may cause sparks or hot surfaces or naked flames through a permit to Work System.
 - (i) furnaces or Heaters with open flames which shall be located up wind of the LPG storage or sources of potential leaks;
 - (j) precautions to control the risk from pyrophoric scale, in process equipment; and
 - (k) flare which shall be located in predominant upwind area at a safe distance arrived as per consequences modeling and cold flaring or venting should be avoided.
- (ii) Road and Rail rakes shall be permitted to enter hazardous areas and shall have their engines switched off and locomotives removed prior to commencement of loading or unloading operations. No vehicles shall be permitted within impounding areas or within 15 m of containers or equipment containing LPG, flammable liquids or flammable refrigerants, except when specifically, authorised and under constant supervision.

7.3 EMERGENCY SHUTDOWN SYSTEMS:

- (i) The emergency shutdown system shall consider process safety as well as leakage of gas, fire, smoke detection and depending on seriousness, the level of shut down is required to be graded and considered and such grading could be by way of section isolation or total complex shut down;
- (ii) The emergency shutdown system (ESD) or systems shall be of failsafe design and it should be installed, located or protected so as it is easily operated in the event of an emergency or failure of the normal control system;
- (iii) Emergency shutdown systems shall have all components that are located within 15 m of the equipment to be controlled; -
 - (a) either installed or located where they will not be exposed to a fire; or
 - (b) be protected against failure due to fire exposure of at least 15 minutes duration;
- (iv) Emergency shutdown (ESD) system that when operated; -
 - (a) isolates or shutoff a source of LPG, flammable refrigerant or flammable gases;
 - (b) shuts down equipment which on continued operation may add to an emergency; and
 - (c) audio-visual alarms at control room with identification of the hazard or emergency area;

- (v) When equipment shutdown results in an additional hazard or substantial mechanical damage to the equipment, the shutdown of such equipment or its auxiliaries shall be omitted from the ESD system, provided that continuous release of flammable or combustible fluid are controlled;
- (vi) Vessel containing liquids that are subjected to metal overheating and catastrophic failure from fire exposure and not otherwise protected shall be depressurized by the ESD system;
- (vii) Initiation of ESD system shall be either manual, automatic, or both manual and automatic, depending upon result of evaluation performed in accordance with fire protection facilities. Manual actuator shall be located in an area accessible in an emergency and shall be located at least 15 meters away from the equipment and marked distinctly and conspicuously with their design function; and
- (viii) Communication shall be provided between ship and terminal control room and interlock shall be provided between the ship and the Jetty control Room and the provision shall be given in the jetty for the such interlock facility. During unloading operation, the terminal operator shall take control of the unloading and in addition to automatic shutdown system (ESD), the terminal operator shall be in a position to initiate shut down of unloading.

7.4 FIRE AND HYDROCARBON LEAK DETECTION SYSTEM:

- (i) Hydrocarbon detectors shall be installed near all potential leak source of LPG vapors e.g. on the top of the vessel, tank dykes, manifolds, pump house manifold and like other leak sources Hydrocarbon detector of proper type shall be selected and also shall be proof tested and shall be maintained in good condition. The Hydro Carbon Detection System shall provide early warning on buildup of Vapour concentration below the LEL limits. Such detectors shall be placed in a way that entire possible source of leaks and collection of products is continuously detected and alarm is set at 20% of lower explosive limit;
- (ii) The areas including enclosed buildings that have a potential for flammable gas concentrations of LPG or spill of flammable refrigerant and fire shall be monitored;
- (iii) Continuously monitored low temperature sensors or flammable gas detection systems shall sound an alarm at the plant site and at a constantly attended location and flammable gas detection systems shall initiate such alarm at 20 % LEL of the gas or vapour being monitored; and
- (iv) The Fire detectors shall initiate an audio and visual alarm at the plant site and at a constantly attended location.

7.4.1 Power Supply:

The supply to the system (control system such as DCS, PLC, control valves, TxS) shall be through a reliable online uninterrupted power supply. (online UPS).

7.4.2 Architecture Components:

- (i) The main architecture components shall be-
 - (a) Hydro Carbon Detectors;
 - (b) Field Transmission units or Signal scanners;

- (c) Control system or PC with printing option for alarms;
 - (d) Display;
 - (e) Annunciation System and like other system;
 - (f) Cables, hooters, repeater, Power Supplies and like other devices; and
- (ii) All the components installed in the hazardous area shall conform to the Hazard Area Classification applicable and shall be certified by PESO or Authorized lab by the country of the origin.

7.4.3 Annunciation System:

Appropriate annunciation system shall be available to ensure that all the alarms generated, both, audio and visual are reported to the installation personnel at local and remote-control panel. The alarms both, audio and visual can be repeated at additional location to ensure that the corrective action is taken.

7.4.4 Hydro Carbon Detectors:

- (i) The detectors shall be able to detect the presence of Hydro Carbon Vapours well below the LEL level and any one or more in combination from the following types can be provided, namely: -
 - (a) Catalytic detectors;
 - (b) Infra-red detectors; and
 - (c) Line or Path detectors.
- (ii) The system shall be available at all times and the control equipment should have data logging facilities to provide print outs of the history of the events with date and time of leakages. The control equipment should be able to generate at least two alarms at different levels of LEL concentration of Hydro Carbons.

7.4.5 Inspection and Testing:

- (i) The system health status shall be checked by the safety officer on a daily basis;
- (ii) The system shall be thoroughly inspected once in each quarter by releasing Hydro Carbon Mixture at each detector; and
- (iii) Calibration of every detector shall be done once in every three months by releasing known concentration of Hydro Carbon mixture and the record of such calibration maintained. The drift in the sensitivity of the individual detector shall be recorded in maintenance history log book during calibration and the detector with abnormal or wide drift in sensitivity shall be rectified or replaced.

7.5 FIRE PROTECTION SYSTEM FOR LPG TERMINAL:

The primary source of fire and explosion hazard is from a leak or spill from the LPG storage or transfer systems.

7.5.1 FIRE WATER SYSTEM:

- (i) The main components of the fire water system are-
 - (a) Fire Water Storage;
 - (b) Fire Water Pumps;
 - (c) Fire Hydrant or Monitor distribution piping network; and
 - (d) Water Sprinkler or Deluge system;
- (ii) The fire protection scheme shall be designed on the assumption that only one major fire shall occur at a time in the terminal;
- (iii) For the storage tanks, water sprays shall be provided on the tank shell including the roof and the appurtenances on the tank and-
 - (a) Water application rate for the tank roof and walls shall be minimum 3 lpm/m²;
 - (b) The water application rate on the appurtenances shall be 10.2 lpm / m² as per this code;
 - (c) Water spray is not applicable for the concrete outer tank; and
 - (d) The water densities applicable to other equipment shall be as follows, namely: -
 - (A) Vessels, structural members Piping and valves manifolds 10.2 lpm / m²; and
 - (B) Pumps and Compressors: 20.4 lpm/ m²;
- (iv) The roof section shall be provided with duplicate 100% risers;
- (v) The deluge valves on the water spray systems on the tanks as well as the pumps, compressors, vessels and like other devices 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;
- (vi) For single containment tanks having metallic outer tank which are having a dyke, high expansion foam systems shall be provided as per NFPA 11. High expansion foam generators shall be located on the impounding area around the storage tanks. Foam units comprising storage facilities and pumps shall be provided in a safe area removed from the protected risk and shall be accessible in an emergency;
- (vii) Portable high expansion foam generators suitable for coupling to hydrant hose lines for isolated LPG spills, may also be provided;
- (viii) Fire hydrants shall be provided along the main fire header at suitable intervals in the process and storage areas and fixed foam or water monitors may be provided around the process areas based on requirement;
- (ix) Water Spray System shall be provided for process area housing condensers heat exchangers, evaporators and blender with spray density @ 10.2 lpm / Sq. M;
- (x) Refer Annexure A1 to this Schedule for typical water Calculations in Refrigerated LPG terminal.

7.6 FIRE EXTINGUISHING AND OTHER FIRE CONTROL EQUIPMENT:

- (i) Portable wheeled fire extinguishers suitable for gas fires, preferably of the dry chemical

- type shall be made available at strategic locations;
- (ii) Fixed fire extinguishing and other fire control systems that may be appropriate for the protection of specific hazards, are to be provided;
 - (iii) Vessels, equipment, structures, cables, safety critical instruments and like other devices, that are likely to be exposed to LPG fire radiation shall be provided with a passive fire protection in the form of fire proofing insulation or water deluge for the duration of the hazard. Fire proofing shall be executed as per appropriate standards. The extent and duration of passive Fire protection shall be based on the HAZOP study;
 - (iv) For Embrittlement Protection, Equipment and structures shall be protected by insulation or appropriate metallurgy selection against cold shock and failure due to a spill of LPG; and
 - (v) CCTV cameras shall be provided at the critical points for continuous monitoring such as Flash and Boil off Compressor house, heaters, condenser, refrigerated tank dyke, Top of refrigerated tanks, LPG storage Vessels, LPG pump house and blender area, Flare, process area, cross country pipeline transfer area and like other critical points.

7.7 PERSONNEL SAFETY:

- (i) Personnel shall be advised of the serious danger from frostbite that can result upon contact with LPG or cold refrigerant. Suitable protective clothing and equipment shall be made available. Low temperature suits or hand gloves shall be worn when carrying out emergency repairs or maintenance and the provisions of this clause shall also apply in case of exposure to flash fires as well;
- (ii) Those employees who will be involved in emergency activities shall be equipped with the necessary clothing and equipment;
- (iii) Self-contained breathing apparatus shall be provided for those employees who may be required to enter an atmosphere that could be injurious to health during an emergency; and
- (iv) A portable flammable gas indicator shall be readily available, for the reasons that LPG and hydrocarbon refrigerants within the process equipment are usually not odorized and the sense of smell cannot be relied upon to detect their presence.

8.0 OPERATIONS OF REFRIGERATED LPG STORAGE INSTALLATION:

In refrigerated LPG installation the product is stored either in pure propane and pure butane form or in premixed LPG (i.e. mix of propane and butane conforming to IS: 4576) at their respective boiling point (i.e. - 42 deg C for Pure Propane, - 5 deg C for Pure Butane and – 25 to – 28 deg C for LPG depending upon the constitution) at ambient pressure. The area wise operations are as specified in paragraphs 8.1 to 8.13.5.

8.1 Storage Tank Operation:

8.1.1 Receipt and Storage:

- (i) Before receipt of any parcel in the refrigerated storage tanks, it is required to be ensured that the receipt lines to be maintained at the temperature of the receiving product and such maintenance is normally done by re-circulating the product of the same specification already available in the storage tank;
- (ii) Receipt operation should be carried out in a way so that storage tank pressure and

temperature can be maintained within the limit and the same may be accomplished by operating the refrigeration compressors. The storage tank pressure and temperature are the key parameters for this kind of installation, which should be rigorously monitored by operational personnel to avert product loss due to auto-flaring or pop-up of SRVs on excess pressure; and

- (iii) After completion of receipt, the receipt lines need to be evacuated by pushing compressed vapor from the refrigeration compressor discharge.

8.1.2 Dispatch:

- (i) Specially designed submersible In-tank pumps are used for dispatching of product because of very low NPSH availability. The levels of product to be monitored while starting and during the dispatch operation. The Tank pressure and temperature to be continuously monitored during the dispatch operation as there may be pressure rise due to re-circulation of product or pressure decrease due to faster evacuation of product; and
- (ii) Before start-up of pumps, it is to be ensured that all the discharge valves are in closed condition. The recirculation valve to be put mandatorily on auto mode.

8.2 Compressor House Operation:

- (i) The refrigeration compressors play very important role in keeping the pressure and temperature in the refrigerated storage tanks under control and the compressors to be run on need basis as per the requirement during receipt, dispatch and even when there is no operation to maintain the pressure;
- (ii) The compressors referred to in clause (i) are very big compressors normally run by HT motors with lot of safety interlocks and normally the capacity of the compressors may also be varied seamlessly as per the requirement; and
- (iii) The compressors referred to in clause (i) are positive displacement types, hence the discharge valves should mandatorily be in open condition while starting the compressors. The cooling water supply and control air supply as per the specification must be ensured. The lubricant supply should be ensured before starting.

8.3 Process Unit Operation:

The process unit consists of following operations, namely: -

- (a) Condensation of the Refrigeration Compressor Discharge;
- (b) LPG Condensate Transfer unit;
- (c) Heating Section for heating the refrigerated product to ambient temperature;
- (d) Steam Condensate Transfer Unit;
- (e) Blending of Pure Propane and Pure Butane for manufacturing LPG;
- (f) Odourisation; and
- (g) Vapour Pressure Analyser.

8.4 Condensation of the refrigeration compressor discharge:

- (i) Compressed gas from the discharge of the refrigeration compressor is being fed to the

condensation unit where the liquefaction process is taking place through heat exchangers using Cooling Water as the cooling medium and the condensate is received in transit tanks (known as product condensate receiver). Subsequently the condensate is pumped to buffer storage bullets where the product is stored under pressurized conditions; and

- (ii) The whole system of condensation and condensate pumping is being associated with safety interlocks and alarms for safe operation.

8.5 Heating Section for heating the refrigerated product to ambient temperature:

- (i) The refrigerated product pumped from the storage tanks is heated through Heat exchangers using LP Steam as the heating medium or by any suitable alternate heating mechanism such as hot air, ambient air, water and like other mechanism. The steam or air or water heating process is normally a multistage process where product is passed through more than one heat exchanger. The hot product is routed to blending section for further processing and the steam condensate in case of steam heating arrangement (i.e. LP Steam converts into water by releasing latent heat to the refrigerated product) is collected in a Steam Condensate receiver. The Steam condensate is subsequently pumped from the receiver to the Demineralised Water plant polishing unit for further processing; and
- (ii) The whole system of heating of product is associated with safety interlocks and alarms to ensure desired temperature of product at the heating section outlet for safe operation.

8.6 Air Preheater System:

Tube bundle shall be provided for increasing the surface area of the product during travel and all tubes shall be covered with fins and subjected to forced draft air from the fans operating at fixed or variable RPM to maintain the required temperature at the outlet.

8.7 Steam Condensate Transfer Unit:

The unit consists of a Steam Condensate receiver and Condensate transfer pumps and the steam condensate is transferred by the pumps at regular interval preferably in auto mode interlocked with the level of receiver to DM plant condensate receiver tank for further processing.

8.8 Blending of Pure Propane and Pure Butane for manufacturing LPG:

The heated product (i.e. Pure Propane and Pure Butane) is blended at specified ratio in blender with the help of automatic flow control valves for making LPG conforming to IS:4576 and the property of the blended product is checked through online analyzer for meeting IS:4576 and subsequent feedback control mechanism. Blending conforming to IS: 4576 is compulsory & hence necessary measure should be always in place to check the composition meeting IS: 4576.

8.9 Odourisation Unit:

The LPG is extremely inflammable and it has no odour, as such the detection of any leakage

of LPG is very difficult and for this reason, the LPG is subsequently passed through odourisation section where Ethyl Mercaptan is dosed @ 15 to 20 PPM immediately after blending for identification of any leakage at the downstream in line with IS: 4576. Proper deodorizing agent i.e. Sodium hypo chloride or sand or mask or any other deodorizing agent to be provided at Dozing unit.

8.10 Buffer Storage Operation:

The product transferred from Product condensate receiver is stored at buffer storage in pressurized condition at ambient temperature and subsequently the product is evacuated by pumps and sent to blending area for further processing.

8.11 Flaring Operation:

Normally the of installations like flaring operations are equipped with hot flaring facility And the flaring is usually avoided as it leads to loss of product and whenever required flaring shall be resorted to control the pressure inside the refrigerated tanks. Flaring can be done through flow control valves by operator or it may be done in auto-mode as per the system presets. The flaring is of extreme importance as this is the last resort to maintain the pressure inside the tank and it avoids any untoward event due to pressure rise.

8.12 Control Room Operation:

There is lot of operations to be handled simultaneously for running the of installations Like control room operations, for this reason, a central control room is provided to facilitate all the operations from remote and from a single location. Control Room houses DCS based or equivalent automation system shall be provided where from all the commands can be initiated, controlled and all the parameters can be monitored through single window system and the system shall be backed-up with UPS of suitable capacity.

8.13 Utility Section:

The utility section mainly consists of following facilities, namely: -

- (a) Boiler;
- (b) Instrument Air;
- (c) Cooling Tower; and
- (d) Electrical Sub-station.

8.13.1 Boiler:

If Low Pressure Steam heating is envisaged, Boiler of suitable capacity is used to produce LP Steam for using in heating of refrigerated product. Boiler system houses DM Water Generation Plant, Effluent Treatment Plant and Boilers.

8.13.2 Instrument Air:

Instrument Air is used for operating ROVs and other control systems of the entire plant.

8.13.3 Cooling Tower:

Cooling Tower is used for supplying Cooling Water for mainly using in condensation of refrigeration compressor discharge, for cooling of refrigeration compressors and other cooling requirements. Maintaining schedule for chemical treatment of cooling water or cooling tower

8.13.4 Electrical Sub-station:

- (i) For catering the electrical requirement of all HT and LT Motors and other electrical loads; and
- (ii) DG sets for HT supply and LT supply.

8.13.5 Raw Water Tank:

Raw Water Tank and associated pumping system on auto mode to top up cooling water reservoir shall be considered.

9.0 INSPECTION AND MAINTENANCE OF REFRIGERATED LPG STORAGE INSTALLATION:

9.1 INSPECTION –TANK:

- (i) Routine internal inspection of Refrigerated LPG tanks are not required to be carried out since Refrigerated LPG tanks are not subjected to corrosion under service condition because of the low temperature involved and Refrigerated LPG tanks can be taken up for internal inspection when the tanks are taken out of service for other operational or repair reasons;
- (ii) Inspections to be carried out under the supervision of technically qualified experienced person;
- (iii) For Tank Settlement, Tanks levels and settlements shall be checked at intervals and records shall be maintained at a frequency of at least once in a year;
- (iv) In respect of Roof, Outer roofs shall be checked visually for external corrosion at intervals of every Quarter;
- (v) Regular monitoring of LPG leakage is required, in between area of tank and dyke wall using GMS sensors;
- (vi) Checking for leakage of liquid LPG from inner tank to outer tank is required, in case of double containment and full containment tanks on continuous basis;
- (vii) Visual checking to ascertain the condition of external insulation cladding, insulating material and load bearing insulation is required every year;
- (viii) Checking foundation bolts and anchor straps for deterioration and tightness every year;
- (ix) Checking of filling and off take pipes, supports for movements is required yearly;
- (x) Pressure and Vacuum Relief Valves shall be inspected for corrosion, blockage and like other inspection and tested annually and records maintained. In-situ tests shall be

- permissible;
- (xi) In respect of Refrigerated LPG lines inside the terminal, NDT shall be carried out once in three years at selected windows and records thereof shall be maintained and Hydro test of the concerned section shall be done after any hot work; and
 - (xii) In respect of Process Unit, Equipment and fittings shall be inspected and tested as per the OEM Standards.

9.2 Storage Tank:

Such atmospheric above ground refrigerated tanks are designed for life time without any appreciable maintenance in respect of regular maintenance is required regarding external painting, insulation, external cladding, calibration of valves, transmitters, gauges and like other purposes and for any other maintenance in this type of tank, requires complete de-commissioning of the tank.

9.3 Compressor House:

The regular maintenance requirement of the compressors is as following, namely: -

- (a) Checking of lubricant level in the gear box;
- (b) Checking of lubricant level in the oil separator drum;
- (c) Checking and cleaning of the vapour suction filter;
- (d) Checking and cleaning of the Oil Filters;
- (e) Cleaning of Intercooler, after-cooler heat exchangers;
- (f) Calibration of Safety Valves;
- (g) Insulation Resistance Checking of Motors;
- (h) Greasing of Motor Bearings;
- (i) Checking of Alignment between Motor, Gear Box, Compressor as applicable;
- (j) Checking functioning of solenoid valves and control valves;
- (k) Maintenance Painting of the equipment; and
- (l) Major overhauling of the compressor as per the period specified by OEM.

9.4 Process Unit:

In respect of Process Unit, the following are required, namely: -

- (a) Periodical cleaning of Condensers;
- (b) Periodical cleaning of Pump Filters;
- (c) Periodical cleaning of Heat Exchangers and Vaporisers;
- (d) Periodical testing and calibration of safety valves;
- (e) Periodical maintenance or overhauling of mechanical valves;
- (f) Periodical calibration of gauges and transmitters;
- (g) Statutory testing of Heat Exchangers and Condensate Receiver Vessels;
- (h) Periodical Calibration of Vapor Analysers;
- (i) Maintenance Painting of Structures and equipments;
- (j) Periodical calibration of metering pump of odourisation unit;
- (k) Periodic testing of redundancy of the Digital Control System (DCS) and

Programmable Logic Controller (PLC) system;

- (l) Periodic checking of various parameters of software programs and
- (m) Periodic checking of all interlocks and logic for effective functionality.

9.5 Buffer Storage:

In respect of Buffer Storage, the following are required, namely: -

- (a) Periodic Testing of Buffer Vessels;
- (b) Periodic cleaning of Pump Filters;
- (c) Periodic maintenance or overhauling of pumps;
- (d) Periodical testing and calibration of safety valves and Periodical maintenance and overhauling of mechanical valves;
- (e) Periodical calibration of gauges and transmitters;
- (f) Daily monitoring of CP system and rectification, if required; and
- (g) Statutory testing.

9.6 Utility Section:

In respect of Utility Section, the following are required, namely: -

- (a) Periodical testing of DM water quality;
- (b) Health Checking of the Refractory of Boiler;
- (c) Statutory inspection by IBR;
- (d) Periodical testing and calibration of safety valves;
- (e) Periodical maintenance or overhauling of mechanical valves;
- (f) Periodical calibration of gauges and transmitters;
- (g) Maintenance Painting of Structures and equipments;
- (h) Periodical maintenance of IA Compressor;
- (i) Periodical cleaning of Cooling Tower;
- (j) Periodic chemical treatment of cooling water;
- (k) Periodical testing of CW Water quality;
- (l) Periodical checking and filling of lubricant in CW Fan Gear Box; and
- (m) Periodical health checking of CW Fan Motors.

9.7 Electrical Sub-station:

Carrying out all electrical maintenance periodically as per requirements.

9.8 Inspection of Refrigerated LPG Storage Installation:

Besides routine and statutory inspections like other plants, the following specific inspection may be undertaken, namely: -

- (a) Checking the condition of Insulation of the storage tanks;
- (b) Checking the condition of Insulation of receipt lines;

- (c) Checking the health of Refractory Lining of Boilers;
- (d) SQC of DM Water;
- (e) SQC of Cooling Water; and
- (f) Periodical Checking or the quality of all lubricants.

9.9 Ethyl Mercaptan Dosing unit:

In respect of 9.9 Ethyl Mercaptan Dosing unit, the following are required, namely: -

- (a) Periodic testing of ethyl mercaptan storage tank;
- (b) Periodic testing of ethyl mercaptan pumps; and
- (c) Periodic testing of SRV on mercaptan tank.

9.10 EQUIPMENTS MAINT AND INSPECTION:

Relevant OEM recommendations shall be followed.

10.0 COMMISSIONING AND DECOMMISSIONING:

10.1 COMMISSIONING:

- (i) After hydro testing Tanks to be dried to desired level considering storage of the refrigerated product;
- (ii) Purging of the Tank to be done by inert gas to drive away ambient air and moistures
- (iii) Cool down shall be performed after the tank purge has been completed. A cool down procedure shall be developed to provide a controlled process. During the initial introduction of liquid product, it is important to ensure that the storage tank cools as uniformly as possible. Sharp thermal gradients can cause permanent local distortions and potential crack growth. The cool down rate for a steel primary liquid container shall be as per the design in line with the standard used for design;
- (iv) Sweetening of Tanks to be done very slowly by taking refrigerated product vapor through bottom ring so that temperature stratification at the tank bottom and tank wall can be avoided. The temperature gradient to be closely monitored. The pressure inside the tank is also to be closely monitored so that it lies within the designed pressure range of the Tank and for controlling pressure inside the tank controlled flaring to be resorted till the Tank is completely filled up with the refrigerated product vapour;
- (v) For sweetening of tank and maintaining uniform temperature gradient the bottom sprayer rings installed inside the tanks to be used;
- (vi) When the final temperature is achieved inside tank using refrigerated product vapour, refrigerated liquid product to be introduced very slowly through bottom sprayer rings for avoiding any cold spot and to be filled up to minimum 6 inches, thereafter the rate may be slowly increased up to designed level; and
- (vii) The Compressors, Process Unit Equipment, product pipings and Buffer Storage to be purged and sweetened before commissioning of Tank and after so sweetening of the Tanks is completed, immediately compressor shall be used for maintaining pressure and temperature inside tanks for avoiding flaring loss.

10.2 DECOMMISSIONING:

- (i) Refrigerated LPG tanks are constructed for life time and not envisaged for decommissioning. Maintenance of the tank internals should not be attempted on routine basis and, if any operational reasons or any tank internal failure is envisaged, then, decommissioning may be planned.
- (ii) Following minimum procedures to be adopted, namely: -
 - (a) Removal of pumpable liquid using In-tank pumps;
 - (b) Removal of liquid dead-stock using Compressors by means of vaporization as advised by the licensor. Close monitoring to be done to maintain the Tank Pressure within design pressure range and for maintaining a slow temperature gradient suitable as per design; and
 - (c) Degassing the Tanks using dry inert-gas introducing from the top and evacuating the hydrocarbon from bottom dip-pipe and such procedure to be continued till the entire tanks become gas free which may be ascertained by sampling.

11.0 REFERENCES:

The following codes, standards and publications specified in the Table have either been referred

to or used in the preparation of the document and the same shall be read in conjunction with such document, namely: -

S.No.	Ref Code No	Title
1	EEMUA: Pub 147	Recommendations for the Design and Construction of Refrigerated Liquefied Gas Storage Tanks.
2	IP 9	Institute of Petroleum Liquefied Petroleum Gas Volume 1 Large Bulk Pressure Storage and Refrigerated LPG.
3	API 2510	Design and Construction of LPG Installations.
4	API 620	Design and Construction of Large, Welded, Low-pressure Storage Tanks.
5	API 2350	Overfill Protection for Storage Tanks in Petroleum Facilities, Third Edition.
6	API 2000	Venting Atmospheric and Low-pressure Storage Tanks.
7	NFPA 58	Liquefied Petroleum gas Code.
8	NFPA 59	Utility LP-Gas Plant Code.
9	NFPA 59A,	Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG).
10	API 625	Tank Systems for Refrigerated Liquefied Gas Storage.
11	ACI 376	Code Requirements for Design and Construction of Concrete Structures for the Containment of Refrigerated Liquefied Gases and Commentary.
12	AGA XK 0101	Purging Principles and Practice
13	EN 14620:1-4	Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gasses with operating temperatures between 0 °C and –165 °C Part 1 to Part 4.
14	ASTM C165	Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
15	ASTM C177	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
16	ASTM C240	Standard Test Methods of Testing Cellular Glass Insulation Block.
17	ASTM C552	Standard Specification for Cellular Glass Insulation.

18	ASTM C549	Standard Specification for Perlite Loose Fill Insulation.
19	ASTM C764	Standard Specification for Mineral Fiber Loose-Fill Thermal Insulation.
20	ASME B31.3	Process Piping.
21	IS 15652	Insulating mats for Electrical purposes.
22	IS:875	Code of Practice for Design loads (Other than Earthquakes) for buildings and other structures.
23	IS:1893 (Part 1)- 2002	IS 1893 (Part 1) (2002, Reaffirmed 2007): Criteria for Earthquake Resistant Design of Structures.
24	IS 3043	Code of Practice for Earthing.
25	IS 5571	Guide for selection of electrical equipment for hazardous areas.
26	IS 5572	Classification of Hazardous area having area having flammable gases and vapours for electrical installation.

ANNEXURE A1

Fire Water or Pump Requirement Calculation

A. Medium Velocity Water Spray System (MVWSS):							
Sl. No.	Location	Area or size	Area or size	Area of Single largest zone	Area of adjacent zones	Spray Density (LPM)	Hour Cu Mtr per hr
1	Tank Truck Loading or Unloading Facility	30	15	450	0	10.2	275
2	(a) Refrigerated Tank Surface area	35	20	2198	2198	3	791
	(b) Refrigerated Tank Roof area	35		961.6	961.63	3	346
	(c) Refrigerated Tank Total area						1137
3	LPG Pump House	20	10	200	0	20.4	245
4	Compressor House	30	20	600	0	20.4	734
5	Rail Loading Facility	30	15	450	900	10.2	826
6	Process Area	20	15	300	0	10.2	184
7	Horton Sphere	18		1017.4	2034.7	10.2	1868
8	Shed	40	12	480	960	10.2	881

Note:

- (i) Single largest area covered by Medium Velocity Water Sprinkler System is Horton Sphere: 1868;
- (ii) Water Requirement for operating 2 nos. Monitors @ 144 Cum/Hr: 288;
- (iii) Total Water requirement (as specified in clauses (i) and (ii)): 2156 Cum/Hr;
- (iv) No. of Fire Water Pumps Required (410 Cum/Hr capacity): $2156/410=5.3$ Say 6;
- (v) No. of standby pumps required: 2.

Explanation: At least one standby fire water pump shall be provided upto 2 nos of main pumps. For main pumps 3 and more, minimum two standby pumps of the same capacity as the main pumps shall be provided;

- (vi) Total number of Fire Water Pumps Required $(6 + 2) = 8$;
- (vii) Total No. of main Fire Water Pumps Available: 6;
- (viii) Fire water storage tanks capacity required for 4 Hrs fire fighting $(6 \times 4 \times 410)$: 9840 Kl; and
- (ix) Minimum two nos of tanks shall be provided.

SCHEDULE – 4

[See regulations 6(4)]

DESIGN, LAYOUT, OPERATION AND MAINTENANCE OF UNLINED UNDERGROUND ROCK CAVERN STORAGE FOR PETROLEUM AND LIQUEFIED PETROLEUM GAS

1.0 GENERAL:

A cavern for storage of petroleum and LPG is a large cavity either existing or created underground. The caverns are considered the safest means of storage and beyond certain volumes, caverns are cost effective, compared to surface storages. In view of their inherent advantages, the underground caverns are being used by a number of countries for storage of hydrocarbons viz. crude oil, petroleum products both for commercial and strategic purposes. Based on the experience from Scandinavian and other countries, underground cavern storage of crude oil, LPG and like other substances is much safer than the above ground storage such as steel tanks, pressurised spheres or bullets or refrigerated tanks and like other devices. Some of the major advantages of underground cavern storage are listed below, namely: -

- (a) Underground storage is safe from warfare, sabotage, terrorist attacks, earthquakes, storms, and like other deviations;
- (b) There is no risk of leakage;
- (c) The project is environment friendly;
- (d) Caverns require less land area than surface storage facilities;
- (e) The natural landscape and scenic beauty of the project area is not affected as the major installations are located underground as compared to above ground storage facilities;
- (f) They can be used as buffer or strategic storage for the country; and
- (g) For large quantity storage, underground cavern storage is cheaper as compared to above ground storage. Underground storage also needs little maintenance and the underground storage have long life as compared to surface tanks.

1.1 A number of methods exist for storing petroleum/ petroleum products underground and a few have been enumerated in the succeeding paragraphs 1.1.1 to 1.1.4.

1.1.1 Underground Rock Cavern Storage:

A cavern is an underground facility consisting of one or more galleries excavated in rock either through a vertical shaft or by an access tunnel. Location and geometry of such facilities are selected based on availability of favourable geological setting and geo-mechanical properties of the rock. The stored product is prevented from escaping by the principle of hydro-geological containment. The cavern is located at a depth where the water in the surrounding rock creates a counter pressure exceeding that of the stored product, thus preventing its migration outwards. Underground rock caverns are used for storing petroleum and liquefied petroleum gas (LPG).

1.1.2 Salt Leached Cavern Storage:

Rock Salt usually occurs either as extensive bedded salt formations or as salt domes. In such favourable salt formations, huge artificial underground caverns are created. Such caverns are solution mined. Water is injected to the required depth below ground through a bore hole and controlled leaching is carried out by progressive dissolution of the salt formation. The resulting brine is removed and disposed either through surface evaporation or by injecting back into deep sub surface formations. The caverns are usually cylindrical in shape (several hundred metres in height and several tens of metres in diameter) and may have a volume of several hundred thousand cubic metres. The cavern shape and volume are determined by deployment of sonar survey. Cavern stability is monitored by periodic sonar surveys of its geometry and continuous surveillance of acoustic emissions (seismic monitoring techniques).

1.1.3 Aquifers and Depleted Fields:

A porous and permeable geological formation (the reservoir) can be used to store natural gas provided it fulfils conditions by virtue of the geological setting such as the following, namely:

-
- (a) The reservoir should be overlain by an impermeable stratum (the cover) to prevent any upward migration of the gas;
- (b) The formation with structural or stratigraphic control should ensure lateral containment, for example in the form of an anticline;
- (c) The formation should be situated, at such depth (between 500 and 2000 m) so that the range of pressures attainable in the reservoir is compatible with that of the transport system; and
- (d) The formation may be a depleted oil or gas field or an aquifer, which has never held hydrocarbons. For storage, the gas being compressed and injected in gaseous state into the reservoir, it displaces the water and occupies the pores in the rock.

1.1.4 Abandoned Mines:

Disused mines can be converted to underground storage as long as these comply with the strict stability and leak-tightness criteria and the necessary rehabilitation work is done. Large quantities of liquid hydrocarbons can be stored at reasonable cost using such method and it can also provide an attractive method for storing natural gas.

1.2 Cavern Containment Principle:

The underground storage of liquid and gaseous hydrocarbons in unlined underground rock caverns is based on a principle of hydrogeological containment. For the cavern to be leak tight (to ensure containment of the stored product), the pressure in the cavern (due to the product stored) at any point of the cavern has to be lower than the pressure of water in the rock mass at the corresponding point and, for design purpose, in addition to the product vapour pressure, two other factors are also considered i.e., Safety factor and Shape factor when determining the maximum possible pressure in the cavern. Shape factor is the additional pressure required depending on the cavern dimension, cavern shape and storage arrangements, and like other factors. Safety factor refers to a designed safety margin. The Cavern Containment Principle is shown in the Figure below, namely: -

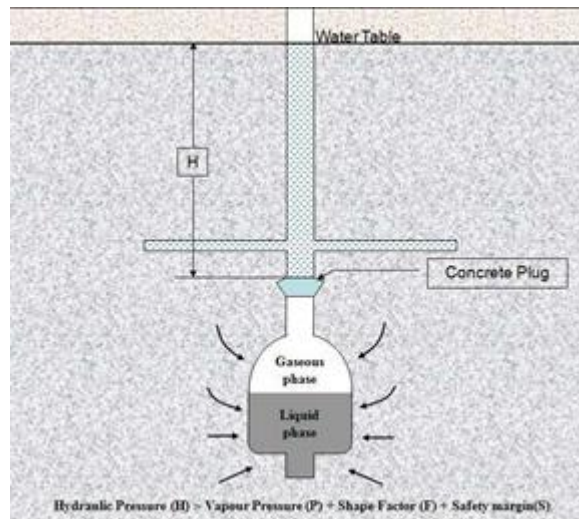


Figure 1 Cavern Containment Principle

For the purpose of this standard, only unlined underground rock cavern storage for petroleum based on hydrogeological containment principle has been considered.

2.0 SCOPE:

The standard under this Schedule lays down the minimum requirements on location, design, layout, operation and like other descriptions of Unlined Underground Rock Caverns for Storage of Liquid Petroleum and Liquefied Petroleum Gas. Such standard covers the requirements for various aspects of the mined cavern and includes items like site selection, design criteria, construction methodology, construction safety, operation, inspection, maintenance and emergency plan.

3.0 DEFINITIONS:

In this Schedule, unless the context otherwise requires, -

- (a) **“Casing (for a rock cavern)”** means a pipe or set of pipes that can be screwed or welded together to form a string surrounding the tubing connecting the cavern to the surface;
- (b) **“Cementing”** means operation whereby a cement slurry is pumped and circulated down a well, through the casing and then upwards into the annular space between the casing and the open or cased hole;
- (c) **“Containment”** means capability of a cavern to prevent migration of stored hydrocarbons;
- (d) **“Exploration”** means all technical activities connected with the investigation of a geological site;
- (e) **“Inadmissible”** means which is not permissible under the laws or regulations in force.
- (f) **“Liquefied petroleum Gas”** means a mixture of certain light hydrocarbon predominately C3 and C4, derived from petroleum and natural gas which are gaseous at ambient temperature and pressure and which may be condensed to a liquid state at normal ambient temperature by the application of moderate pressure and conforming to IS: 4576 or IS: 14861;
- (g) **“Logging”** means measurement of any physical parameter versus depth in a well;

- (h) **“Maximum Operating Pressure (MOP) (for a rock cavern)”** means maximum value of the pressure of any fluid contained in a cavern which can be accepted in normal operation and maintenance;
- (i) **“Modeling”** means generating the image of a structure from the information gathered;
- (j) **“Numerical Simulation”** means computer simulation of a system;
- (k) **“Permeability”** means capacity of a rock to allow fluids to flow through its pores;
- (l) **“Petroleum”** means any liquid hydrocarbon or mixture of hydrocarbons and any inflammable mixture (liquid, viscous or solid) containing any liquid hydrocarbon;

- (m) **“Porosity”** means volume of the pore space (voids) within a formation expressed as a percentage of the total volume of the material containing the pores;
- (n) **“Saturation”** means percentage of pore space occupied by fluid in the material;
- (o) **“Subsurface Safety Valve”** means valve installed in tubing or casing beneath the wellhead for the purpose of stopping the flow of gas in an emergency; and
- (p) **“Tubing”** means a pipe or set of pipes that can be screwed, welded or flanged together to form a string, through which fluids are injected or withdrawn.

4.0 STATUTORY ACTS AND REGULATIONS:

Construction of cavern, storage of petroleum in cavern and all associated facilities require specific approval from concerned authorities and the enactment, regulations and other laws inter alia applicable in this respect are as under, namely: -

- (a) The Environment Protection Act, 1986 (29 of 1986);
- (b) The Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);
- (c) The Air (Prevention and Control of Pollution) Act, 1981 (14 of 1981);
- (d) The laws relating to Coastal Regulation Zone (CRZ) as applicable for the time being;
- (e) The Factory Act, 1948 (63 of 1948);
- (f) The Petroleum Act, 1934 (30 of 1934);
- (g) The Explosives Act, 1884;
- (h) The Indian electricity Act, 1910 (9 of 1910);
- (i) The Manufacture Storage and Import of Hazardous Chemicals Rules, 1989
- (j) The Hazardous Waste management and Handling Rules, 2003
- (k) The relating to Municipal corporation or Town planner or Panchayat as applicable for the time being.

5.0 GENERAL REQUIREMENT:

5.1 Long-term containment of stored products:

The storage facility shall be designed to ensure the long-term containment of the stored products and

if pre supposes, -

- (a) adequate prior knowledge of the geological formation in which the storage is to be developed and of its geological environment;
- (b) acquisition of all relevant information needed for specifying parameter limits for construction and operation;
- (c) demonstration that the storage is capable of ensuring long-term containment of the stored products through its hydraulic and mechanical integrity; and
- (d) That no other installation or activity shall affect the integrity of the containment and vice versa.

5.2 Environmental and Safety considerations:

5.2.1 Underground:

The storage facility shall be designed, constructed and operated so as to prevent any inadmissible impact on the environment including ground water table, contamination and like other in admissible impacts; and such design, construction and operation presupposes that the surrounding formations have been identified and their relevant characteristics determined, and that they are adequately protected.

5.2.2 Aboveground:

The storage facility shall be designed, constructed and operated so that it shall not cause any inadmissible ground movement at the surface and impact on the environment.

5.2.3 Safety:

The storage facility shall be designed, constructed, operated and maintained so as to present no inadmissible risk to the safety of the personnel and property and Suitable measures shall be taken to reduce the risk and consequences of blow-out and leakages.

5.2.4 Monitoring:

In order to verify that the standards specified in paragraphs 5.2.1 to 5.2.3 are met, monitoring systems and procedures shall be implemented.

6.0 SITE SELECTION:

A pre-feasibility study for selection of the site shall be carried out which shall include collection and reviewing of all available geological and hydro-geological data in addition to proximity to transportation infrastructure, dumping areas, population density and environmental concerns and it shall also include availability of land or Right of way for approaching the storage site and pipeline route. The detailed feasibility of the selected area shall be carried out once the site has been identified based on pre-feasibility studies. The detailed feasibility studies shall encompass extensive field investigation campaign, followed by analysis of on-site information both laboratory and numerical modeling so as to establish suitability of site and based on the collected information and results thereof, design of the proposed facilities shall be undertaken. A list of BIS codes for underground civil works including investigations, laboratory and field testing, design and construction and like other work is enclosed as Annexure B2 to this

Schedule. Such standards or eqv. International standards or code of practices shall be followed. Various elements of site selection are specified in succeeding paragraphs 6.1 to 6.6.2.

6.1 Geological Site Characterisation:

Site characterization shall include geological, geophysical, geotechnical and hydro-geological investigations and studies, so as to establish the geological and hydro-geological conditions, rock mass characteristics and in-situ stresses of the proposed site.

6.2 Geological Investigations:

- (i) The geological investigations shall include review of available reports and maps followed by geological field mapping and the following minimum geological site characterizations shall be considered, namely: -
 - (a) The type and nature of rocks and soils, including the litho-stratigraphy;
 - (b) Presence and extent of weathering of rocks;
 - (c) Structural disposition of the litho types;
 - (d) Spacing and Orientation of discontinuities;
 - (e) Condition of discontinuities including roughness, separation, weathering and infilling;
 - (f) Major and minor faults;
 - (g) Intact rock and Rock Mass condition;
 - (h) Surface and ground water conditions;
 - (i) Quality of ground water;
 - (j) Geological hazards;
 - (k) Presence of hazardous gases viz. CH₄, H₂S, SO₂, CO, CO₂ and like other gasses; and
 - (l) Presence of radioactive minerals;
- (ii) Representative samples shall be collected for the purpose of correlation to mapped formations and for subsequent laboratory analysis which shall include but not limited to, petrography, sonic test, geo-chemical analysis, rock-product compatibility test and radioactivity analysis; and
- (iii) Engineering geological investigation shall be supplemented by geophysical and geotechnical investigations. Information collected during the field campaign shall be represented on engineering geological maps.

6.3 Geotechnical Investigations:

Geotechnical investigation includes vertical and inclined core holes located suitably to detect geological profile and the depth of investigation shall extend at least 10m below the anticipated invert of the cavern. The Core Recovery, Rock Quality Designation (RQD), discontinuities spacing, joint condition, orientation, dip of strata, cavities, fissures, the occurrence of seams,

gouge material and like other disruptions shall be duly recorded. The engineering geological map shall be prepared with the interpretation of the geotechnical findings and such information shall be used to establish the layout of the rock caverns. For orientation of the cavern, hydro-fracture stress tests shall be carried out to measure the maximum and minimum horizontal in-situ stresses. The spacing and depth of the measurement shall be kept so as to properly assess the stress profile at and around the cavern depth. Laboratory tests shall be carried out on intact rock samples as listed in Annexure-B1 to this Schedule.

6.4 Hydro-Geological Investigations:

To establish the permeability profile and seepage water quantity assessment in the caverns, water pressure tests and pumping interference test shall be carried out. Water pressure tests shall be conducted in selected sections of the borehole using either inflatable or mechanical packers. The kind of water pressure test depends on the ground water and rock mass conditions. The water table fluctuation shall be recorded during investigation campaign. Meteorological statistics such as average rainfall and its impact on water table during pre and post monsoon in the area shall be considered to assess the ground water recharge conditions.

6.5 Geophysical Investigations:

After preliminary site selection based on geological and hydro-geological conditions, detailed geophysical investigations shall be carried out for the selected sites. Geophysical investigations include Seismic refraction, electrical resistivity and geophysical well-logging i.e. sonic, temperature and like other factors as applicable. The investigation method shall be finalized based on the geological frame work of the site.

6.6 Site Selection Criteria:

Based on the data obtained from the investigation campaign and desk top studies, the following criteria specified in paragraph 6.6.1 to 6.6.2 shall determine the selection of the site.

6.6.1 Rock Mass:

The cavern host rock shall be of low permeability and substantially free of fractures to minimize leakage. The rock shall be competent enough requiring limited artificial support to the cavern. The rock shall be uniform and shall have little or no jointing, faults and other discontinuities.

6.6.2 Hydro-geological consideration:

Availability of sufficient water table to maintain a positive hydrostatic head above the storage cavern shall be ensured.

6.7 Disposal Plan:

Identify safe and environment friendly site for temporary storage and final disposal of large volumes of rock to be excavated.

7.0 DESIGN CRITERIA:

7.1 Basic Information:

For any storage cavern project, the following information shall be taken as pre-requisite, namely: -

- (a) Knowledge of geological formation and geological environment;
- (b) Information about the various parameters pertinent for construction and operation;
- (c) Knowledge of geological formation and geological environment;
- (d) Information about the various parameters pertinent for construction and operation;
- (e) Type and properties of the product to be stored;
- (f) Geographical constraints of the area;
- (g) Environmental consideration and restrictions within the area;
- (h) Various natural resources or facilities available at the location or the region;
- (i) Risk Assessment, Environment Impact Assessment and HAZOP studies; and
- (j) Emergency procedures.

7.2 Design Principles:

- (i) The facility shall be designed to handle the product stored and to control the entire process from receipt to evacuation of the product from the cavern. The design shall take into consideration the complete range of operating conditions (Pressure, temperature, corrosion, water seepage and like other conditions,) that the facility could encounter. Each individual part of the facility shall conform to the applicable standards;
- (ii) The design shall only use established methods for analysis and calculations;
- (iii) The design shall also incorporate emergency procedures;
- (iv) All design shall be properly documented and shall be based on written procedures and shall be carried out by competent personnel or companies. The design shall comply with the safety and environmental requirements of the location;
- (v) The cavern volume shall also include the design volume of hydrocarbon and the vapour phase volume, which shall be at least 3% of the volume of the hydrocarbon and an additional volume equivalent to at least three days seepage water volume shall also be provided;
- (vi) In addition to as specified in clauses (i) to (iv), the shafts shall also be designed to ensure minimum seepage into the underground works during the entire excavation phase;
- (vii) All pipelines and fittings shall be adequately protected against corrosion by anti-corrosion coatings or cathodic protection system;

(viii) Provision shall be made to ensure that seepage water, prior to disposal, does not exceed the specified permissible limits as per Water (Prevention and Control of Pollution) Act 1974 (6 of 1974); and

(ix) Risk Assessment studies covering the underground and above ground facilities shall be carried out.

7.3 Depth:

(i) The cavern shall be located adequately below the groundwater table to ensure that sufficient hydraulic potential is available around the storage to confine the product within the cavern. The conditions created around the cavern shall be such that in spite of the seepage of ground water into the cavern the hydro static head will never get depleted and it shall be necessary to enhance the natural hydro-geological flow pattern around the cavern by providing specially designed water curtains; and

(ii) The cavern shall be located at a depth below the ground water table, corresponding to the maximum operating pressure of the stored product and an additional minimum hydraulic margin (safety margin + shape factor) of 20m of water head and for LPG, minimum hydraulic margin shall be kept as 30 m.

7.4 Shape or Stability:

(i) The shape of the cavern shall be decided on the geological setting in which it is to be located. The geo-mechanical characteristics and the in-situ stress of the rock mass are the most important inputs for the determining the cavern shape. The shape of the cavern could be subject to change because of the actual rock conditions encountered during excavation;

(ii) The layout, cross-sections, pillar widths, intersections shall be designed in a manner that would ensure the stability of the cavern for its entire life; and

(iii) The designer shall theoretically demonstrate the stability of the cavern through numerical simulations for both static and dynamic cases and address the impact of seismic activity in the design.

7.5 Inter distance:

(i) New cavern storage facilities shall not be located less than 50 m from other active, inactive or abandoned storages or excavations and alternatively, approval shall be taken from the concerned authorities after ensuring structural stability, non-migration of products and establishing the same through proven modelling or risk assessment; and

(ii) Inter distance of all above ground facilities shall conform to applicable OISD standards.

7.6 Operating Parameters:

7.6.1 Temperature:

For LPG storage, the geothermal temperature of the rock and the temperature gradient shall be considered for determining the depth of the cavern.

7.6.2 Maximum Pressure:

- (i) The Operating Pressure is a consequence of the following, namely: -
 - (a) Characteristics of the product to be stored;
 - (b) Geothermal temperature of the rock at the depth of the cavern; and
 - (c) Hydro geological conditions around the cavern;

- (ii) The range of vapour pressures for products like LPG could vary considerably with the product blend and care shall be taken in determining the operating pressures as the conditions could vary over a period of time. The possible change in operating philosophy shall also be assessed;

- (iii) The Maximum Operating Pressure shall be based on the most severe conditions; and

- (iv) For the selected Maximum Operating Pressure, the hydraulic containment shall be established theoretically by numerical modelling and simulation.

7.6.3 Lines and Fittings:

- (i) All connections to the cavern shall be defined during the design stage and shall include at least the following, namely: -
 - (a) Product inlet lines;
 - (b) Product outlet lines;
 - (c) Instrumentation and monitoring lines and cables;
 - (d) Seepage water removal lines; and
 - (e) Vent lines.

- (ii) The location of the pipelines and cables shall be spelt out (Operation shaft, access shaft or boreholes) and all casing carrying the pipelines into the cavern shall be tightly embedded in a concrete plug built near the exit of the cavern;

- (iii) Secondary seal or expandable packers to be provided;

- (iv) The casings carrying the pipelines shall be protected against corrosion in case of casings installed in the shafts. The material selected for the casings shall withstand the highest pressures that could be encountered during worst case scenarios; and
- (v) In case of pipelines installed in boreholes, the methodology of avoiding leakages from behind the casings shall be clearly spelt out by the designer.

7.6.4 Instrumentation:

- (i) Following instruments or fittings shall be provided, namely: -
 - (a) Two water level measurement gauges of independent operating mechanism with inter-lock with water pump for starting and stopping. The audio-visual alarm of the gauges shall be provided in control panel. Interlock with product pump, in case, water level going beyond maximum permissible level, the product pump shall trip; and
 - (b) Two product level measurement gauges with independent operating mechanism with High Level Alarm set at 95 %. The audio-visual indication shall be provided on control panel. Further, High High-Level alarm shall not be set at more than 97 %, with interlock with incoming LPG pumps. On actuation of High High-Level alarm, the pumping in cavern shall stop and all incoming shut down valves shall close;
- (ii) The capacity of seepage water pump shall be commensurate with maximum seepage rate envisaged in the design and 100 % identical stand by water pump shall also be provided. In case more than one pump is used, 50 % standby pumps shall be provided;
- (iii) Temperature and pressure gauges representing the entire cavern (as envisaged in design) shall be provided; and
- (iv) Minimum 2 nos. of Safety valves of adequate capacity shall act as impulse to initiate shut down of cavern.

7.6.5 Shut Down Valves:

- (i) Each emergency shutdown valve shall be capable of activation from the on-site control center as well as from control room and in addition, from field location which shall be easily accessible during emergency;
- (ii) Each emergency shutdown valve shall be an automatic fail-safe device that automatically closes for pre-set conditions;
- (iii) Each emergency shutdown valve shall be closed and opened at least monthly;
- (iv) Each emergency shutdown valve system shall be tested at least twice each calendar year at intervals not exceeding six months. The test shall consist of activating the actuation devices, checking the warning system and observing valve closure; and

- (v) If an emergency shutdown valve system fails to operate as required, the cavern operation shall be immediately suspended.

8.0 CONSTRUCTION:

- (i) The construction plan shall be defined at the design stage and shall include the following, namely: -
 - (a) Method of access (whether shaft or inclined access);
 - (b) Method of ensuring rock remains saturated with water during construction;
 - (c) Method of excavation (drill and blast, road runners and like other methods)
 - (d) Type of rock support, structural reinforcement and grouting works required; and
 - (e) Method of isolating the cavern (location of concrete plugs);
- (ii) Water curtain bore holes shall be charged at least 20 Metres ahead of the main cavern excavation face;
- (iii) The excavation method shall be designed to handle or accommodate the following, namely:-
 - (a) Access of men and material into the cavern during construction;
 - (b) Movement of all equipment required for the underground works; and
 - (c) Removal of muck;
- (iv) In case of the depth of access shaft (vertical) exceeds 40 m, a properly guided` hoisting mechanism with safety contrivance shall be provided; and
- (v) The construction activities shall comply with best engineering practices and also OISD-GDN-192 as applicable.

9.0 MONITORING PLAN:

Cavern monitoring can be classified as follows, namely:

- (i) Hydro Geological Monitoring.
- (ii) Seismic Monitoring.
- (iii) Operation Monitoring

9.1 Hydro Geological Monitoring:

- (i) Hydro geological monitoring shall be carried out during pre-construction, construction and operation of rock caverns to ensure that there is no impact on the hydraulic safety of the

caverns at any point of time. Equipments for monitoring during construction shall include piezometers, pressure cells, underground pressure gauge holes, flow meters, and equipment for monitoring seepage water and piezometers and pressure cells shall also form part of the permanent monitoring system to be used during operations of the storage facility and additionally, temperature monitoring shall be carried out during commissioning;

- (ii) The hydro-geological boundary shall be defined in advance to monitor the ground water table and the land use in hydro geological boundary shall not adversely affect the cavern containment principle;
- (iii) A buffer zone of at least 200 m shall be considered. No heavy blasting shall be allowed in buffer zone which can develop any fissures and cracks which propagates to the storage area;
- (iv) Hydro geological monitoring of the rock caverns during construction shall include the following, namely: -
 - (a) Water levels in piezometers, monitoring wells and shafts;
 - (b) Hydraulic potentials by pressure readings from pressure cells;
 - (c) Pressure on underground pressure gauge holes;
 - (d) The flow rate of water injected and pressure in individual water curtain bore holes;
 - (e) Seepage for individual sections of the underground works;
 - (f) Inventory of seepage occurrences;
 - (g) Chemical and bacteriological analysis of water samples from piezometers, water curtain and seepage water; and
 - (h) Rainfall, tide levels, and like other natural incidents.

9.1.1 Piezometers:

Piezometers shall consist of boreholes drilled from surface and equipped for water level measurements and sampling. The piezometers shall have either single or double completion equipment and every piezometer shall be equipped with galvanized tube slotted at the level of the piezometric window and the inside diameter of borehole shall be at least 50mm.

9.1.2 Pressure Cells:

- (i) Pressure cells shall be installed in especially drilled holes in order to measure the pore pressure around the cavern and the pressure cells boreholes can be vertical or inclined. The range of pressure measurement shall be suited to the depth below water level; and
- (ii) Underground pressure gauge holes shall be drilled from the access tunnel, water curtain tunnel and the main storage galleries and such drilling should be either vertical or inclined.

The equipment for the pressure gauge hole shall include mechanical packer, isolation valve, main valve and a pressure gauge.

9.1.3 Analysis of Water Samples:

Analysis of water samples shall consist of physical analysis, chemical analysis, bacteriological analysis and dissolved gas analysis in line with prevalent regulations.

9.1.4 Other Requirements:

All water pumped out from the underground works shall be measured on a daily basis.

9.2 Seismic Monitoring:

- (i) As part of operational requirements permanent seismic monitoring system shall be put in place to record all the disturbance in the ground round the clock and for the long-term stability of the facility. The ground disturbances could be due to various reasons, viz., movements due to proximity to faulted zones, structural discontinuities, weak zones developed during blasting, movements due to displacement of rock bolts and like other reasons and such movements may lead to major hazards and require continuous monitoring;
- (ii) Seismic monitoring system includes planting of geophones, installation of seismographs, preamplifiers, filters, analog and digital recorders compatible to computers and acquisition or processing software. The software shall be equipped with a built-in alarm system that is always on the job and shall alert personnel to changes in pressure or stress, within the cavern and to prevent the loss of product;
- (iii) The entire monitoring shall be through a network of transducers and each location of transducer shall give the magnitude and direction of disturbance, so that the movements in different directions can be computed. The transducers shall be cemented into the borehole and shall be installed from the water curtain gallery through the instrumentation well; and
- (iv) The system shall be designed to detect and record seismic events equivalent to a rock fall of 0.5m³ from the top of any gallery to an accuracy of location better than half the diameter of the main storage gallery.

9.3 Operation Monitoring:

- (i) The operating pressure of cavern shall be measured continuously at the shaft and within the cavern;
- (ii) The pressure differential between the shaft pressure and the pressure in the cavern shall be calculated;
- (iii) The MOP shall not be exceeded; and
- (iv) Wellhead pressure, product level, water level, and operating status of each cavern shall be monitored.

9.3.1 Inventory:

- (i) Product injected into or withdrawn from the storage facility shall be metered and the measurements shall be counterchecked by means of the product level measurement in the cavern; and
- (ii) The operator of the storage facility shall investigate any variation in inventory and the reasons for the variations. In case of variations of stock due to migration of the stored hydrocarbon or seepage, the operator shall undertake a study to review the integrity of the storage system.

10.0 TESTING AND COMMISSIONING:

10.1 General:

- (i) Testing and commissioning shall be based on written procedures and performed by skilled personnel;
- (ii) Casings shall be pressure tested before commissioning; and
- (iii) Safety devices shall be functionally tested prior to operation.

10.2 Air pressure test:

- (i) After construction, the cavern shall be filled with compressed air to a test pressure at least equal to the MOP to demonstrate gas tightness and the test pressure shall not jeopardize the ability of the groundwater level to maintain the hydraulic containment;
- (ii) The rate of depressurization shall be such that it should not jeopardize the hydraulic containment principle;
- (iii) During air test, all piezometers around the cavern facilities shall be monitored and any abnormal fluctuation shall be analyzed;
- (iv) When several caverns are involved, each cavern shall be pressurized in turn, the other caverns being kept at atmospheric pressure;
- (v) A test report shall be generated; and
- (vi) All relevant data concerning the tests (such as test records or quality assurance documentation) should be made available before acceptance.

10.3 First hydrocarbon filling:

- (i) The first product filling shall take place only after successful completion of the air pressure test;
- (ii) Purging with inert gas before first filling; and
- (iii) During the first product filling, the part of the caverns where the product is in the vapour phase shall not lead to any explosive mixture with air.

Note: - Typical testing and commissioning procedure for LPG caverns is attached as Annexure – B3 to this Schedule.

11.0 OPERATION AND MAINTENANCE:

11.1 Operating principles:

- (i) The Operating manual shall be prepared based on approved operating instructions, safety procedures, best practices and experiences of operating similar facilities and such manual shall cover start-up, normal operations, emergency conditions, shutdown and maintenance operations;
- (ii) The management should employ operating staff of suitable ability and experience and the management shall ensure that such staff are trained to carry out their duties in a safe manner;
- (iii) Safety training shall be given and updated as necessary; and
- (iv) Safety audits shall be conducted on a regular basis.

11.2 Maintenance:

11.2.1 Maintenance procedures:

The operator of the storage facility shall: -

- (a) Possess approved maintenance procedures, including procedures for cavern maintenance;
- (b) Maintain the gas storage facilities in compliance with such procedures;
- (c) Keep records necessary to administer such procedures;
- (d) Update such procedures as experience dictates and as changes in operating conditions require;
- (e) Execute routine inspection and maintenance schedule for surface and subsurface safety equipment shall be prepared by him;
- (f) Periodically check every safety device to ensure reliability of functioning properly; and
- (g) carry out periodic instrumentation calibration checks, at a frequency depending upon the required accuracy and special attention should be paid by him to gas detectors, legal metrology equipment and cavern level instruments, which can be used to cross-check each other.

12.0 EMERGENCY PROCEDURES:

The operator of the storage facility shall: -

- (a) possess established emergency procedures, including procedures for the safe operation or the shut-down of the storage facility or parts thereof, in the event of a failure or other emergency, and safety procedures for personnel at emergency site;
- (b) possess documented emergency procedures to deal with product releases, including mitigation of the release, notification and protection of operating personnel, notification and protection of the public, and communications with community and regulatory bodies;
- (c) test the procedures for operating personnel at frequencies determined by such factors such as the condition of the system and the population density;

(d) document the test results and recommendations; and

(e) possess a programme in place to demonstrate so that the personnel are familiar with the emergency procedures.

13.0 INTEGRITY MANAGEMENT:

13.1 A comprehensive manual containing program and practices shall be developed for existing cavern to manage cavern integrity taking into consideration of various consequence due to operations or failures.

13.2 The integrity management program framework shall take into consideration continual or periodic assessment and an evaluation process as to its effectiveness of the current health of the cavern and associated facilities to prevent any failure in future.

13.3 To maintain safe operating conditions in case of an adverse condition detected, cavern should be shut down until the required repairs are completed and clearance for operation is given.

13.4 Corrosion monitoring shall be periodically carried out and in case, the values are beyond acceptable limits as given in design, necessary corrective action be taken.

13.5 The integrity assessment during the lifetime shall consist of an initial (base line) and continual assessment.

14.0 CAVERN CLOSURE AND ABANDONMENT:

A rock cavern, which has been inactive for three years or longer shall be considered to have been abandoned and shall be plugged unless otherwise authorized by environmental authority and plan for plugging the cavern shall be prepared for submission to appropriate authority in this regard.

ANNEXURE-B1

LIST OF LABORATORY TESTS:

The laboratory tests on intact rock samples shall include, but not limited to the following, namely:

1. Index Tests:

- (i) Specific Gravity;
- (ii) Bulk Density (Wet or Dry);
- (iii) Water Absorption;
- (iv) Water Content;
- (v) Porosity;
- (vi) Slake Durability;
- (vii) Swelling Index; and
- (viii) Hardness and Abrasivity.

2. Strength Tests:

- (i) Point Load Test;
- (ii) Unconfined Compressive Strength;
- (iii) Tri-axial Compression Test; and
- (iv) Tensile Strength.

3. Compressibility Tests:

- (i) Elastic Modulus and Poisson's Ratio;
- (ii) Uniaxial Compression; and
- (iii) Dynamic Modulus.

4. Petrography-Thin Section Study and Rock Composition.

5. Chemical Tests.

6. Geochemical Analysis.

7. Water Quality.

8. Permeability.

9. Joint Roughness Coefficients-Kn and Ks.

10. Sonic Velocity.

ANNEXURE B2

BIS Codes

(Underground Structures in Rock-for reference)

S.No	Code No.	Part or Section	Year	Reaffirmed	Description
1.	7422	Part 1	1974		Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs: Part 1: Abbreviation.
2.		Part 2	1974		Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs: Part 2: Igneous Rock
3.		Part 3	1974		Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs: Part 3: Sedimentary Rocks
4.		Part 4	1985		Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs: Part 4: Metamorphic Rocks.
5.		Part 5	1992		Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs: Part 5: Line symbols for formation contacts and structural features
6.	11358		1987		Glossary of terms and symbols relating to rock mechanics.
7.	1892		1979	2002	Code of Practice for subsurface investigation for foundation.
8.	4453		1980		Code of Practice for subsurface exploration by pits, Trenches, drifts and shafts.
9.	6926		1996	2001	Diamond core drilling-site investigation for river valley projects-Code of Practice.
10.	10060		1981	1999	Code of Practice for subsurface investigation for power house sites.
11.	11358		1987		Glossary of terms and symbols relating to rock mechanics.
12.	14396	Part 1 to 4	1996		Argillaceous swelling rocks-Methods for laboratory testing.
13.	10782		1983	2001	Method for laboratory determination of dynamic modulus of rock core specimen.
14.	8764		1998	-	Method of determination of point load strength index of rocks.
15.	7746		1991	2000	Code of Practice for in-situ shear test on rock.
16.	10082		1981	2001	Method of test for determination of tensile strength by indirect tests on rock specimen.
17.	13047		1991	2001	Method for determination of strength of rock materials in triaxial compression.

S.No	Code No.	Part or Section	Year	Reaffirmed	Description
18.	12955	Part 1	1990		Code of Practice for insitu determination of rock mass deformability using a flexible dilatometer:
19.	12955	Part 2	1990		Code of Practice for insitu determination of rock mass deformability using a flexible dilatometer: Part 2 : Radial displacement.
20.	9179		1979	2001	Method for the preparation of rock specimen for laboratory testing.
21.	14395		1996	2002	Guidelines for monitoring rock movement using probe inclinometer.
22.	9143		1979	2001	Method for the determination of unconfined compressive strength of rock material.
23.	9221		1979	2001	Method for the determination of modulus of elasticity and poisons ratio of rock materials in uniaxial compression.
24.	10050		1981	2001	Method for determination of slake durability index of rocks.
25.	11209		1985		Specification for mould assembly for determination of permeability of soils.
26.	5529	Part 1	1985		Code of Practice for In-situ Permeability Test: Part1: Tests in Overburden.
27.	5529	Part 2	1985		Code of Practice for In-situ Permeability Test: Part2: Tests in bed rocks.
28.	13946	Part 1	1994		Code of Practice for Determination of rock stress: Part 1: Using Hydraulic Fracturing technique.
29.	13946	Part 2	1994		Code of Practice for Determination of rock stress: Part 2- Using USBM type drill hole deformation gauge.
30.	13946	Part 3	1994		Code of Practice for Determination of rock stress: Part 3: Using CSIR or CSIRO type cell with 9 or 12 strain gauges
31.	13946	Part 4	1994		Code of Practice for Determination of rock stress: Part 4: Using flat jack technique.
32.	12608		1979		Method of test for hardness of rock.
33.	7317		1993		Code of Practice for Uniaxial Jacking Test for deformation modulus of rock.
34.	12634		1989		Method of determination of for direct shear strength of rock joints.
35.	13030		1991		Method of test for laboratory determination of water content, porosity, density and related properties of rock materials.
36.	14436		1997		Method of test for laboratory determination of resistivity on rock specimen.
37.	12634		1989		Method of determination for direct shear strength of rock joints.
38.	13372	Part 1	1992		Code of practice for seismic testing of rock mass Part 1: within a borehole.
39.	13372	Part 2	1992		Code of practice for seismic testing of rock mass Part 1: within a borehole.

S.No	Code No.	Part or Section	Year	Reaffirmed	Description
40.	10785		1983		Method for determination of compressive and tensile strengths from point load test on rock lumps.
41.	7292		1974		Code of practice for in situ determination of rock properties by flat jack.
42.	10060		1981		Code of practice for sub-surface investigation of powerhouse sites.
Design or Construction					
43.	10270		1982	2003	Guidelines for design and construction of pre-stressed rock anchors.
44.	11105		2004		Design and construction of Tunnel plugs- Code of Practice.
45.	11309		1985	2001	Method of conducting pull out test on anchor bars and rock bolts.
46.	13414		1992		Guidelines for monitoring of rock movements using multi point borehole extensometer.
47.	12070		1987		Code of practice for design and construction of shallow foundations on Rocks.
48.	13063		1991		Code of practice for structural safety of building on shallow foundations on rocks.
49.	4756		1978	2002	Safety Code for tunneling work.
50.	4081		1986	2000	Safety Code of blasting and related drilling operations.
51.	7456		1994		Rock drill shanks and chuck bushings- Dimensions.
52.	6066		1994	-	Recommendation for pressure grouting of rock foundation in river valley projects.
53.	9012		1998		Recommended Practice for Shotcrete.
54.	13365	Part 1	1998	-	Quantitative classification of rock mass guidelines: Part 1: RMR for predicting of engineering properties.
55.		Part 2	1992	2001	Quantitative classification of rock mass guidelines: Part 2: Rock mass Quality for prediction of support pressure in underground openings.
56.		Part 3	1997	2003	Quantitative classification of rock mass guidelines: Part 3: Determination of slope mass rating (SMR).
57.	11315	Part 1	1987	2001	Method for the quantitative description of discontinuities in rock mass: Part 1: Orientation.
58.		Part 2	1987	2001	Method for the quantitative description of discontinuities in rock mass: Part 2: Spacing.
59.		Part 3	1987	2000	Method for the quantitative description of discontinuities in rock mass: Part 3: Persistence.
60.		Part 4	1987	2000	Method for the quantitative description of discontinuities in rock mass: Part 4: Roughness.
61.		Part 5	1987	2001	Method for the quantitative description of discontinuities in rock mass: Part 5: Wall Strength.
62.		Part 6	1987	2001	Method for the quantitative description of discontinuities in rock mass: Part 6: Aperture.

S.No	Code No.	Part/Section	Year	Reaffir	Description
63.		Part 7	1987	2000	Method for the quantitative description of discontinuities in rock mass: <u>Part 7: Filling.</u>
64.		Part 8	1987	2000	Method for the quantitative description of discontinuities in rock mass: <u>Part 8: Seepage.</u>
65.		Part 9	1987	2001	Method for the quantitative description of discontinuities in rock mass: <u>Part 9: Number of Sets.</u>
66.		Part 10	1987	2001	Method for the quantitative description of discontinuities in rock mass: <u>Part 10: Block Size</u>
67.		Part 11	1985	2001	Method for the quantitative description of discontinuities in rock mass: <u>Part 11: Core Recovery and Rock quality.</u>
68.		Part 12	1992	2001	Method for the quantitative description of discontinuities in rock mass: <u>Part 12: Drill core study.</u>
69.	14448		1997		Code of Practice for reinforcement of rock slopes with plane edge failure.
70.	11973		1986		Code of Practice for treatment of rock foundations, core and abutment, contacts with rock for embankment dams.
71.	6922		1973	2003	Criteria for safety and design of structures subject to underground blasts.
72.	4999		1991		Recommendation for grouting of pervious soils.
73.	5878	Part I	1971	2000	Code of Practice for Construction of Tunnels: <u>Part I: Precision Survey and setting out.</u>
74.		Part II, Section 1	1970	2000	Code of Practice for Construction of Tunnels: <u>Part II: Underground Excavation in Rock; Section 1: Drilling and Blasting.</u>
75.		Part II, Section 2	1971	2000	Code of Practice for Construction of Tunnels, <u>Part II: Underground Excavation in Rock; Section 2: Ventilation, Lighting, Mucking and Dewatering.</u>
76.		Part II, Section 3	1971	2000	Code of Practice for Construction of Tunnels: <u>Part II: Underground Excavation in Rock; Section 3: Tunneling Method for Steeply inclined tunnels, shafts and underground power houses</u>
77.		Part III	1972	2000	Code of Practice for Construction of Tunnels; <u>Part III: Underground excavation in soft strata.</u>
78.		Part 4	1971	2000	Code of Practice for construction of tunnels conveying water: <u>Part 4: Tunnel Supports.</u>
79.		Part 5	1976	2000	Code of Practice for construction of tunnels conveying water: <u>Part 5: Concrete lining.</u>
80.		Part 6	1975		Code of Practice for construction of tunnels conveying water: <u>Part 6: Steel Lining.</u>
81.		Part 7	1972	2000	Code of Practice for construction of tunnels conveying water: <u>Part 7: Grouting.</u>
82.	15026		2002		Tunneling methods in Rock Masses- Guidelines.

ANNEXURE B₃

TYPICAL ACCEPTANCE TEST FOR LPG CAVERNS

1. GENERAL:

- (i) Before commissioning the storage facility, the gas-tightness of the storage galleries must be tested with compressed air according to a procedure developed for underground rock caverns to meet the same requirements as aboveground pressure storage vessels;
- (ii) The test consists of recording pressure changes over time which must coincide (to within the experimental error) with the pressures calculated for a non-leaking cavern. Pressure changes must be caused solely by air temperature variations in the cavern, air dissolved into the seepage water and, if applicable, water level changes in the pit and
- (iii) The test is performed before filling the cavern with LPG for the first time.

2. DESCRIPTION:

- (i) The test consists of injecting compressed air. In the case of two caverns, injection of compressed air into the second cavern can be done, totally or partially, from the first compressed cavern;
- (ii) Once the test pressure is reached in the cavern, temperatures are allowed to stabilize. This waiting period is minimized by using water coolers to bring the injected air as close as possible to the initial cavern temperature. The test can start after a period of stabilisation. The cavern is considered to be stable when no temperature recorded by any cavern transducer is changing by more than 0.1°C per day. This activity typically requires four days;
- (iii) The cavern test pressure is set with reference to-
 - (a) hydrogeological parameters; that is to say-
 - (A) hydraulic potential at the cavern roof,
 - (B) shape factor; and
 - (C) hydraulic safety margin;
 - (b) operating conditions that is to say-
 - (A) maximum working pressure; and
 - (B) safety valve settings.

3. ACCEPTANCE TEST PROCEDURE:

3.1 instrumentation:

- (i) Pressures and temperatures are recorded every hour during the test;
- (ii) The specific test instrumentation required is as follows, namely: -
 - (1) Three-wire platinum Resistance Temperature Detectors (RTD), resistance 100 ohms at 0 °C, tolerance 1/3 of IEC Standard 751 class B, Le. +0.1 °C at 0 °C (installed according to attachment);
 - (2) Pressure Standard with digital display for measuring pressure at top of vent, repeatability 50 Pa at test pressure, with calibration certificate;
 - (3) Digital barometer with an accuracy on measured values of 20 Pa, with calibration certificate;
 - (4) Real time acquisition and recording system (Programmable Logic Controller);
 - (5) Microcomputer for test control, data storage and data reduction;
 - (6) One instrument measuring temperature in test shed, accuracy ± 0.1 °C;
 - (7) One RTD in the vent line at wellhead to measure the air temperature during compression, accuracy ± 1 °C; and
 - (8) Dial pressure gage, scale 1.5 MPa, accuracy 5 kPa (1), at wellhead.
- (iii) The temperature transducers are installed after final cleaning of the galleries, just before closure of the access works;
- (iv) Each instrument cable is brought out to the surface in a single length without splices or junction boxes, through dedicated casing provided in the operation shaft. The 3 wires of each RTD (item #1) shall have the same impedance, lower than 10 ohms. Each RTD cable is shielded and the 3 wires of each cable are twisted;
- (v) A shed sited as near as possible to the shaft is used as the control centre for the test. The shed will have a solid floor and the temperature inside will be controlled around 20°C. Stability of the shed against vibrations must be ensured and circulation of heavy vehicles around the shed shall be restricted;
- (vi) The instrument cables are connected to the acquisition and recording system in the shed. All the cables shall be clearly labeled and
- (vii) For cavern pressure measurements, temporary piping is installed from the equilibrium casing to the control centre.

3.2 Test Procedure:

The steps in the pressure test are to-

- (a) prepare the caverns and fill access tunnel with water;
- (b) pressurize the caverns with air;
- (c) allow temperatures to stabilize; and

(d)run the test.

3.2.1 Preparation of Caverns:

- (i) When all construction works in the caverns are finished (including final plugs), a designed volume of water is injected in each cavern and then pumped out in order to-
 - (a) Fill the geometric traps to get an accurate value of water seepage flowrate during the acceptance tests;
 - (b) Check water level measurement equipment;
 - (c) Check that the water seepage pumps work properly; and
 - (d) Check that the product pumps work properly;
- (ii) Alternatively, the pumping of the water seepage can be stopped during a sufficient period of time in order to have 3000 m³ of water in the cavern;
- (iii) Before starting the cavern compression, some information is required, such as the following, namely: -
 - (a) The geothermal temperature inside the cavern (from the RTDs);
 - (b) The water seepage flowrate, and
 - (c) The cavern volume vs depth curve (from the galleries photo profiles), including the sump and the pit.

3.2.2 Access tunnel or Access shaft water filling:

- (i) After the storage, caverns are closed and all the access (operation shaft, access shaft, access tunnel) begin to be filled with bacteria free fresh water before the compression of the caverns. The water shall be injected at a flowrate sufficient to assure that the rise in level is not less than 10 m/day (i.e. 75 m along the access tunnel). When the water reaches a level of 25 m above the crown of the cavern, the compression of this cavern can begin, provided hydrogeological parameters are satisfactory;
- (ii) During the simultaneous access tunnel or access shaft water filling and cavern compression, the height of water above the crown of the cavern will be set at 102 % of cavern pressure + 25 m,

3.2.3 Cavern Compression:

- (i) Air is supplied by a bank of compressors, for 24 hours continuously until the cavern pressure test;

- (ii) The compressed air is injected through the vent line, and the number of compressors shall be adapted to produce a pressure increase in the cavern around 1 kg/ cm² per day. A backup compressor is mandatory;
- (iii) The compression rate may be reduced in the event of abnormal evolution of the pore pressure in the rockmass, or the piezometric behaviour;
- (iv) Air is supplied from a bank of compressors. Wellhead air temperature is kept close to the geothermal temperature with variation no more than 2 oC, using temporary air-cooling system;
- (v) The cooling system may be required to start or stop several compressors at different times, in order to meet the above requirements specified in preceding clauses and to minimize the stabilization time;
- (vi) During such stage, the following readings are taken every hour, namely; -
 - (a) cavern pressure, from the pressure standard;
 - (b) atmospheric pressure, on digital barometer;
 - (c) compressed air inlet temperature;
 - (d) temperatures from cavern RTD's;
 - (e) test room temperature; and
 - (f) volume of water pumped out of the cavern using the meter at the wellhead, and at the same time, water level in the pit, pressure cells (*with an automatic system, the readings of the pressure cells are taken every hour*);
- (vii) The control of the air inlet temperature shall be performed by a thermometer just after the air-cooling system, and by an RTD on the vent line just before the wellhead;
- (viii) Once daily, piezometer levels and water levels in access works (shaft or tunnel) are recorded (The frequency of the piezometer level records can be adjusted during the compression phase);
- (ix) For cavern pressure measurement, the connection shall be made to the pressure measurement (equilibrium) line of the cavern and not to the vent line;
- (x) During the test, it is necessary to have the following information, namely: -
 - (a) Status of the seepage water pumps: in function or not in function (signal ON or OFF); and
 - (b) Level switch E+H information (signal ON or OFF),

3.2.4 Stabilization Stage:

- (i) The temperature stabilization stage lasts about four days, and is considered complete when no transducer records a temperature change in excess of 0.1 oC per day and per RTD;
- (ii) The following are recorded every hour, namely: -
 - (a) Cavern pressure, from pressure standard;
 - (b) Atmospheric pressure, from digital barometer;
 - (c) Cavern temperatures from RTDs;
 - (d) Test room temperature; and
 - (e) Water volume pumped out of the cavern and water level in the pit;
- (iii) Daily readings are taken from the piezometers and water level in the access works (shaft or tunnel). The frequency of the piezometric readings can be adjusted during such phase. Readings are taken hourly from the pressure cells in case of automatic system;
- (iv) In case of transient phenomena in relation with the hydrogeology, it will be necessary to increase the duration of the stabilization phase; and
- (v) If cavern pressure measured at shaft head goes below the test pressure, it will be necessary to restart compression and to repeat the stabilization stage.

3.2.5 Testing time:

- (i) The test is run continuously for not less than 100 hours. Its duration is long enough to detect any pressure drop in excess of 5 mm of Water Column in the cavern;
- (ii) The following parameters are recorded hourly at constant water level in the sump, namely: -
 - (a) Cavern pressure, atmospheric pressure, cavern temperatures (RTDs), test room temperature, test shed temperature to correct cavern temperature recordings, and if required sump water level (nominally the level at which the seepage water pump stops) volume of water pumped out of the cavern; and
 - (b) All piezometer levels and water level in access works are recorded daily and the pressure cells are recorded twice a day. The frequency of these readings can be adjusted on the site.

4. PRELIMINARY OPERATIONS BEFORE START UP:

- (i) At the end of the gas-tightness test, the caverns contain pressurized air;
- (ii) It is necessary, before the first LPG filling in the caverns, to inert the caverns to avoid creation of an explosive mixture;
- (iii) As soon as the calculations from test measurements have proved the gas-tightness of the cavern, preliminary operations before start -up can commence;

(iv) The procedure of such preliminary operations is as follows, namely: -

- (a) Fill the cavern with water to a level to be defined according to actual cavern geometry given by profile scanning;
- (b) Inject nitrogen in the remaining air space with simultaneous removal of water;
- (c) Fill with water up to the same level to flush out the air -nitrogen mixture; and

(v) After the procedure specified in clause (V) is successfully completed, the cavern will be ready to receive liquid propane or butane (with simultaneous withdrawal of water).

4.1 Water Filling:

4.1.1 Water Quality:

(i) During the water filling operation, the cavern can be filled either with water from the natural environment (river, lake, sea and like other natural environment) or with fresh water from a specific network (city water, fire system). For example, a mixture of seawater with fresh water can be used;

(ii) With natural environment source, the injected water must satisfy the following criteria, namely: -

(a) Quantity of suspended material < 20 mg/l and such figure corresponds to maximum suspended material fixed by the LPG and seepage water pumps supplier (to be confirmed at Detail Design stage);

(b) maximum bacteria content specified as below, namely: -

(A) total aerobic bacteria: < 1000 bacteria per ml;

(B) total anaerobic bacteria : < 1000 bacteria per ml;

(C) sulphur reducing bacteria : = 0 " " ; and

(D) slime forming bacteria : = 0 " " ;

(iii) In case of water with silt content greater than 20 mg/l, a filtering system is required and in case of water containing bacteria, a sodium hypochlorite treatment is required.

4.2 Procedure:

4.2.1 Single cavern:

(i) The water is injected into the cavern through a metering system (accuracy < 1 %) via the filling line and the water flowrate does not exceed 1000 m³/h;

- (ii) The upper water level in the storage is defined according to the cavern crown geometry. Ultimately a small volume of air remains under the crown. Such small volume, called free air volume shall be determined by a specific operation just before the end of the water filling;
- (iii) A known volume of water (installation and supply of a flowmeter, accuracy 0.1 %) is injected in the cavern for about two hours at a rate not exceeding 50 m%;
- (iv) The pressure inside the cavern is the test pressure at the beginning of the water filling and such pressure is lowered to the minimum operating pressure at a pressure drop around 1 kg/cm² per day; and
- (v) The air is evacuated through the vent line (the air flow is controlled by a valve fitted on the vent line) down to minimum operating pressure at a maximum rate of 1 kg/cm² per day. Silencer to be used to bring down noise below permissible levels.

4.2.2 Two Caverns:

- (i) Identical procedure but for optimisation is possible;
- (ii) During injection of water in cavern A, the air removed can be injected in cavern B until the test pressure is reached in cavern B;
- (iii) During such phase, cavern B acceptance test can be completed and if the test and calculation show that cavern B is gas-tight, depressurization can commence at the rate mentioned above; and
- (iv) Cavern B can be filled with water coming from cavern A, during the dewatering and first LPG filling of cavern A.

4.3 Measurements and controls:

- (i) The water filling provides an opportunity to cross-check the volume or level calibration curve drawn from the profiles scanning;
- (ii) During the water filling phase, the following measurements will be performed every two hours, namely: -
 - (a) The volume of water entering the cavern using the meter on the water filling pipe;
 - (b) The water temperature near the filling point at wellhead;
 - (c) The temperature in the cavern using the temperature probes installed in the cavern;
 - (d) The water level in the cavern with equipment used for measuring the LPG level during operation;
 - (e) The cavern pressure with pressure standard; and
 - (f) The atmospheric pressure with digital barometer;

- (iii) At the end of this phase, the exact free air volume of the cavern, corresponding to the upper water level in relation with the cavern crown geometry, is performed according to a specific operation; and
- (iv) All piezometer levels, pressure cell readings and water level in access works are recorded daily.

4.4 Injection of Nitrogen:

Before the initial filling with LPG, the volume of air remaining in the cavern will be inerted by injecting gaseous nitrogen at ambient temperature.

4.4.1 Procedure:

- (i) Nitrogen or other inert gases like CO₂ is injected through the vent line, with simultaneous removal of water at a maximum rate permitted by the water pumping and such maximum pressure variation in the cavern is lower than 1 kg per day;
- (ii) The quantity of nitrogen to be injected shall be 1.5 times the free volume of air in the cavern, in order to reduce oxygen content to 8 %;
- (iii) The required equipment for the nitrogen injection shall be:
 - (a) vaporiser, to transform the liquid nitrogen into gaseous nitrogen; and
 - (b) flowmeter and thermometer, to follow the quantity and the temperature of the injected nitrogen;

4.4.2 Measurements and Controls:

Record every two hours, the following namely: -

- (a) Cavern pressure shown on pressure standard;
- (b) Atmospheric pressure on the digital barometer;
- (c) Water level in the cavern;
- (d) Water volume evacuated during the procedure;
- (e) Injected nitrogen volume; and
- (f) once a day all piezometer levels and water level in access works, and twice a day for the pressure cells.

4.5 Removal of the air-nitrogen mixture:

4.5.1 Procedure:

- (i) After inerting, the cavern will contain a large quantity of gas and to avoid the mixing of gas with LPG, which could induce difficulties during possible recompression, the gas mixture is vented through the vent line, controlling the pressure variation to a rate lower than 1 kg per day. The cavern is filled with water to the upper water level according to the cavern crown geometry; and
- (ii) Before discharging the air-nitrogen mixture through the vent line to the atmosphere, a stabilization period is necessary to allow the air -nitrogen mixture to mix (usually around one day).

4.5.2 Measurements and controls:

Record every two hours, the following namely: -

- (a) Cavern pressure on pressure standard;
- (b) Atmospheric pressure on digital barometer;
- (c) Injected water volume shown on water meter;
- (d) Water level;
- (e) Oxygen content of gaseous mixture; and
- (f) once a day all piezometer levels, pressure cell readings and water level in access works.

5 FIRST FILLING WITH LIQUID LPG:

5.1 Procedure:

- (i) The procedure for the first filling with liquid LPG will be as follows, namely: -
 - (a) Injection of liquid LPG via the vent line; and
 - (b) Removal of water at the flowrate of LPG pumps;
- (ii) At the beginning, the cavern pressure is low and LPG will first vaporize until the vapour pressure in the cavern (assumed at water temperature) is reached, then, LPG will stay in a thermodynamic and two-phase equilibrium, the condensation rate is related LPG and water flowrates; and
- (iii) Injection of product will be done in two steps as specified in succeeding paragraph 5.1.1 and 5.1.2.

5.1.1 First step:

- (i) Liquid or gaseous LPG will be injected slowly (from trucks, coastal tanker, and like other means.) into the cavern to gradually increase its partial pressure to its vapour pressure; and

- (ii) Operating pressure shall not exceed the maximum operating pressure of the caverns by controlling the filling parameters.

5.1.2 Second step:

- (i) When the change of the pressure rate becomes small, there remains liquid LPG in the cavern and the product will be injected according to the maximum dewatering flowrate. Water or product rates will be controlled in order not to exceed the maximum operating pressure; and
- (ii) If it appears that LPG delivery is not possible at a sufficient flow, it will be necessary to adjust the water flow according to LPG flow, in order to maintain the cavern pressures above atmospheric pressure;
- (iii) Before starting such operations, all safety equipment, detection and monitoring instruments shall be ready to use; and
- (iv) Operational safety procedures shall be applied at this stage.

5.2 Measurements and Controls:

- (i) The following parameters will be monitored every two hours namely: -
 - (a) Cavern pressure on pressure standard;
 - (b) Mass of LPG injected in the cavern;
 - (c) Water volume pumped out from the cavern; and
 - (d) LPG and water levels in caverns (water level being also given by plotted curve from water filling).
- (ii) The water evacuated from the cavern with the LPG pumps is sent to the sea, via a drainage system (water pond) equipped with gas detector to detect the first traces of LPG in the discharged water;
- (iii) Before the water has reached normal operation levels, and before traces of LPG are detected in water (more than 25 ppm), the LPG pumps will be replaced by the seepage water pumps and the water shall be sent to the stripper prior to being discharged;
- (iv) The storage will be operational when the water level reaches the normal operation level; and
- (v) During such operations, a control valve and a flow totaliser are necessary on the dewatering line.

6 TEMPORARY WORKS:

All temporary works and equipment required for performing the test shall be checked and certified by authorized person in this behalf before initiating the cavern acceptance test and such drawings shall include the following, namely: -

- (a) The temporary connection for air pressurization of the cavern;
- (b) The temporary works for air depressurization of the cavern;
- (c) The temporary lines for water injection in the cavern including the metering unit;
- (d) In case of two caverns, the temporary works for cavern B water filling from cavern A including metering unit,
- (e) The temporary connections for nitrogen injection; and
- (f) The temporary connections for first LPG filling through the vent line.

Vandana Sharma, Secy.

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