PETROLEUM AND NATURAL GAS REGULATORY BOARD

NOTIFICATION

New Delhi, the ________

G.S.R.____. 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 Refineries and Gas Processing Plants) Regulations, 2020.
   (2) They shall come into force on the date of their publication in the Official Gazette.

2. Definitions.

   (1) In these regulations, unless the context otherwise requires:

      (a) "Act" means the Petroleum and Natural Gas Regulatory Board Act, 2006;
      (b) "Board" means the Petroleum and Natural Gas Regulatory Board established under sub-section (1) of section 3 of the Act;
      (c) "Block" means facilities operated / used in integrated way and surrounded by roads. For example, process unit, boiler house, group of tanks located in a dyke, group of pressurized storage tanks, loading gantries, flare etc.
      (d) "C4 and Lighter ends" means hydrocarbons or a mixture of Hydrocarbons containing four or less than four carbon atoms. Examples are Butane, Propane, Propylene etc. LPG, a mixture of propane and butane also fall under the same category.
      (e) "Compressed Gas" means any permanent gas, liquefiable gas, or cryogenic liquid under pressure or gas mixture which in a closed pressure vessel exercise a pressure exceeding one atmosphere (gauge) at the maximum working temperature and includes Hydrogen Fluoride. In case of vessel without insulation or refrigeration, the maximum working temperature shall be considered as 55 °C;
      (f) "Control of Work" process means a documented system to control hazardous work. It covers job planning, risk assessment, scheduling, isolation management and a formal PTW (Permit to Work) system.
         a. "Cold Work" means an activity which does not produce sufficient heat to ignite a flammable air-hydrocarbon mixture or a flammable substance.
         b. "Permit" means a formal and detailed agreed document that contains location, time, equipment to be worked on, hazard identification, mitigation / precaution measure(s) used and the names of those authorizing the work and performing the work.
         c. "Hot Work" means an activity that can produce a spark or flame or other source of ignition having sufficient energy to cause ignition, where the potential for flammable vapors, gases, or dust exists.
         d. "Approver" means designated Plant/ Area in-charge is to approve an activity based on the risk involved in executing the activity. Higher the risk, higher would be the approval level required for authorization.
         e. "Issuer" means designated person authorized to issue work permit.
         f. "Receiver" means designated person authorized to receive work permit.

Note: Where open flame jobs are involved, additional precautions/controls on top of those for regular Hot Work must be in place
(g) “Critical temperature” means the temperature above which gas cannot be liquefied by the application of pressure alone;
(h) “Crude Oil Gathering Station” means crude oil gathering station / Group gathering station is a production installation used for gathering, treating or storing crude oil and includes central tank farm, oil collecting station, gas compressor station and well head installation.
(i) “Design” includes drawings, calculations, specifications, codes and all other details necessary for complete description of the pressure vessel and its construction;
(j) “Design pressure” means the pressure used in the design of equipment, a container, or a vessel for the purpose of determining the minimum permissible thickness or physical characteristics of its different parts. Where applicable, static head shall be included in the design pressure to determine the thickness of any specific part;
(k) “Dyke” means a structure used to establish an impounding area;
(l) “Emergency Shutdown System” (ESD) means a system that safely and effectively stops whole plant or an individual unit during abnormal situation or in emergency;
(m) “Facility” means this refers to any building, structure, installation, equipment, pipeline, or other physical feature used in petroleum refining, storage, transportation and distribution.
(n) “Failsafe” means a design feature that provides for the maintenance of safe operating conditions in the event of a malfunction of control devices or an interruption of an energy source;
(o) “Flammability range” means the difference between the minimum and maximum percentage by volume of the gas in mixture with air that forms a flammable mixture at atmospheric pressure and ambient temperature;
(p) “Flash Point” means the lowest temperature at which the liquid yields vapour in sufficient concentration to form an ignitable mixture with air and gives a momentary flash on application of a small pilot flame under specified conditions of test as per IS: 1448 (Part-I).
(q) “Fired Equipment” means any equipment in which the combustion of fuels takes place and includes among others, fired boilers, fired heaters, internal combustion engines, certain integral heated vaporisers, the primary heat source for remote heated vaporisers, gas-fired oil foggers, fired regeneration heaters and flared vent stacks;
(r) “Fire station” means a building housing facilities of parking fire tenders and keeping other ready to use fire-fighting equipment for meeting plant emergencies, fire control room with required communication facilities/mimic panel.
(s) “Fire Water pump house” means a building housing fire water pumps, jockey pumps, communication and alarm system, instrumentation and the required operating & supporting personnel.
(t) “Gas free” means the concentration of flammable or toxic gases or both if it is within the safe limits specified for persons to enter and carry out hot work in such vessels;
(u) “Gas Processing Plant” means gas processing plant is a facility where natural gas is received and processed to separate gas, LPG, condensate etc.
(v) “General Classification of Petroleum Products” means petroleum products are classified according to their closed cup FLASH POINTS as given below:
   — **Class-A Petroleum:** Liquids which have flash point below 23°C.
   — **Class-B Petroleum:** Liquids which have flash point of 23 °C and above but below 65 °C.
   — **Class-C Petroleum:** Liquids which have flash point of 65 °C and above but below 93 °C.
   — **Excluded Petroleum:** Liquids which have flash point of 93 °C and above.
   Liquefied gases including LPG do not fall under this classification but form separate category.
   **Note:** In the following cases, above classification does not apply and special precautions should be taken as required:
   (i) Where ambient temperatures or the handling temperatures are higher than the flash point of the product.
   (ii) Where product handled is artificially heated to a temperature above its flash point.
(w) “Hazardous fluid” means LNG or liquid or gas that is flammable or toxic or corrosive;
(x) “Hazardous Area” means an area will be deemed to be hazardous where;
(i) Petroleum having flash point below 65 deg.C or any flammable gas or vapor in a concentration capable of ignition is likely to be present.

(ii) Petroleum or any flammable liquid having flash point above 65 deg.C is likely to be refined, blended or stored at above its flash point.

For classification and extent of hazardous area, refer “The Petroleum Rules - 2002”.

(y) “Ignition source” means any item or substance capable of an energy release of type and magnitude sufficient to ignite any flammable mixture of gases or vapours that could occur at the site;

(z) “Impounding area” means an area that may be defined through the use of dykes or the topography at the site for the purpose of containing any accidental spill of LNG or flammable refrigerants;

(aa) “LPG Facilities” means LPG facility is one where liquefied petroleum gas (LPG) is stored, received / dispatched by rail / road / pipeline and / or filled in cylinders.

(bb) “Lube Oil Installations” means the facilities for receipt, storage and blending of base oils & additives into finished Lube products. It includes lube-blending plants, grease manufacturing plants.

(cc) “May” means provisions that are optional.

(dd) “Maximum Allowable Working Pressure” means the maximum gauge pressure permissible at the top of equipment, a container or a pressure vessel while operating at design temperature;

(ee) “NDT” means Non-Destructive Testing methods like Dye Penetration Inspection, Wet Fluorescent Magnetic Particle Inspection, Ultrasonic thickness checks, Ultrasonic Flaw Detection, Radiography, Hardness Test and other relevant Inspection procedures carried out to detect the defects in the welds and parent metal of the pressure vessel;

(ff) “Petroleum Refinery” means a plant where crude oil is received and processed into intermediates and finished products.

(gg) “Pressure vessel” means any closed metal container of whatever shape, intended for the storage and transport of any compressed gas which is subjected to internal pressure (>= 15 psi) and whose water capacity exceeds one thousand liters and includes inter connecting parts and components thereof upto the first point of connection to the connected piping and fittings;

(hh) “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.

(ii) “Protection for exposure” means fire protection for structures on property adjacent to liquid storage.

(jj) “Refinery” means a group of one or more units or facilities i.e. unloading or loading, storage, processing, associated systems like utilities, blow down, flare system, fire water storage and fire water network, control room and administration service buildings like workshop, fire station, laboratory, canteen etc.;

(kk) “Safety relief device” means an automatic pressure relieving device actuated by the pressure upstream of the valve and characterized by fully opened pop action intended to prevent the rupture of a pressure vessel under certain conditions of exposure;

(ll) “Service building” means a building housing facility for inspection / maintenance / other supporting services which are directly required for operation of the plant e.g. warehouse, workshop etc.

(mm) “Shall” indicates a mandatory requirement;

(nn) “Should” indicates a recommendation or that which is advised but not mandatory;

(oo) “Source of ignition” means naked lights, fires, exposed incandescent materials, electric welding arcs, lamps, other than those specially approved for use in flammable atmosphere, or a spark or flame produced by any means;

(pp) “Vessel” means a pressure vessel used for more than 1000 liters water capacity for storage or transportation of LPG, gases etc.
“Tank height” means the height from tank bottom to top kerb angle for cone roof tanks. For floating roof tanks, it is the height from tank bottom to top of tank shell.

“Tank vehicle loading / unloading” means a facility for loading/ unloading of petroleum product to / from tank wagon or tank truck.

“Water capacity” means capacity in litres of the pressure vessel when completely filled with water at 150 C;

Words and expressions used and not defined in these regulations, but defined in the Act or in the rules or regulations made there under, shall have the meanings respectively assigned to them in the Act or in the rules or regulations, as the case may be;

3. **Application.**
Definitions of design, material selection, installation, commissioning, testing, corrosion control, operation, maintenance & safety of equipment and piping system components of Refineries and Gas Processing Plant shall be in accordance with the requirements of these regulations. The mandatory requirements of this regulation are not applicable to the common facilities constructed outside the ISBL (Inside Battery limit) of entity where no processing of hydrocarbon is carried out. e.g. Main Administrative Building, Material Stores, Raw water facility, Engineering workshops, Security watch towers.

4. **Scope.**
(1) Requirements of these regulations shall apply to all Refineries and Gas Processing Plants,
(2) These regulations lay down minimum requirements of layout within the plant boundary for unloading or loading, storage, processing, transfer and handling of hydrocarbons/ other hazardous substances / chemicals in Refineries and Gas Processing Plants.
(3) These regulations also cover engineering considerations in design, installation, operation, maintenance, inspection including fire protection and safety systems.
(4) The Liquefied Natural Gas facilities are covered in PNGRB (Technical Standards and Specifications including Safety Standards for LNG facilities) Regulations, 2018.
(5) These regulations shall not be applied to onshore/ offshore upstream facilities.

5. **Objective.**
These standards are intended to ensure uniform application of design principles in layout and to guide in selection and application of materials and components, equipment and systems and uniform operation and maintenance of the Refineries and Gas Processing Plants and shall primarily focus on safety aspects of the employees, public and facilities associated with Refineries and Gas Processing Plants.

6. **The standard.**
Technical standards and specifications including safety standards (hereinafter referred to as standards) for Refineries and Gas Processing Plants shall be as specified in Schedule - 1 which cover design and layout, electrical systems, process system, maintenance, inspection, competency assessment, fire prevention, leak detection, firefighting system and safety management system.

7. **Compliance to these regulations.**
(1) The Board shall monitor the compliance to these regulations either directly or through an accredited third party as per separate regulations on third party conformity assessment.
(2) The Board of the entity shall appoint one of its directors, within ninety days of these regulations coming into force, to be responsible for ensuring compliance to these regulations.
(3) Any entity intending to set up Refineries and Gas Processing Plants shall make available its detailed plan including design consideration conforming to these regulations to PESO for their approval prior to seeking registration with the Board.
(4) If an entity has laid, built, constructed, under construction or expanded the Refineries and Gas Processing Plants 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 (RA; HAZOP & HAZID) of its infrastructure. The entity shall thereafter take approval from its Board for non-conformities and mitigation measures. The entity’s Board approval along with the compliance report, mitigation measures and implementation schedule shall be submitted to the Board within six months from the date of notification of these regulations.
8. Default and Consequences.

(1) There shall be a system for ensuring compliance to the provision of these regulations through conduct of technical and safety audits during the construction, pre-commissioning and operation phase.

(2) In case of any deviation or shortfall including any of the following defaults, the entity shall be given time limit for rectification of such deviation, shortfall, default and in case of non-compliance, the entity shall be liable for any penal action under the provisions of the Act or termination of operation or termination of authorization.

9. Requirements under other statutes.

(1) It shall be necessary to comply with all statutory rules, regulations and Acts in force as applicable and requisite approvals shall be obtained from the relevant competent authorities for Refineries and Gas Processing Plants.

10. Miscellaneous.

(1) If any dispute arises with regard to the interpretation of any of the provisions of these Regulations, the decision of the Board shall be final.

(2) The Board may at any time effect appropriate modifications in these regulations.

(3) The Board may issue guidelines consistent with the Act to meet the objective of these regulations as deemed fit.
Draft PNGRB (Technical Standards and Specifications including Safety Standards for Refineries and Gas Processing Plant) – To be finalized after completion of all chapters

Schedule-1: Site selection & Layout
Schedule-2: Design of Equipment, and storage facilities
Schedule-3: Operations (Commissioning, Pre-commissioning, SOP)
Schedule-4: Asset Integrity Management System (AIMS)
Schedule-5: Electrical Systems
Schedule-6: Inspection
Schedule-7: Fire & Gas Detection and Protection Facilities
Schedule-8: Competence Assessment and Assurance
Schedule-9: Safety Audits
Schedule-10: Road Safety
Schedule-11: Occupational Health and Industrial Hygiene Monitoring
Schedule-12: Control of Work
Schedule-13: Safety Management System (SMS)
1.0 Site selection & Layout:

1.1. Introduction:

(i) Hydrocarbon processing and handling plants are inherently hazardous. Today’s trend of large and complex plants presents substantial risk potential. At times plants are modified to operate at higher capacities or efficiencies necessitating larger storage requirements than contemplated earlier. For these reasons, initial site analysis for the proposed new construction or addition should be done carefully while considering the space allocation to the various facilities.

(ii) The hydrocarbon industry over the years learnt lessons from fires, explosions, toxic releases etc. throughout the world and has been up-dating plant safety norms including inter-distances between facilities and their relative locations. The minimum distances recommended many years ago need review in the context of today’s environment in the industry.

1.2. Plant Layout Philosophy:

Following philosophy should be adopted in layout of an installation;

(a) Block layout should be adopted as far as possible. Plant layout arrangement should follow the general route of raw material to process unit(s) with tankages interposed as required followed by storage & dispatch facilities. The entire area should be sub-divided into blocks.

(b) All process units and dyked enclosures of storage tanks shall be planned in separate blocks with roads all around for access and safety.

(c) Primary traffic roads in the installation should be outside hazardous areas. Roads separating the blocks shall act as firebreaks.

(d) Pedestrian pathways should be provided / marked alongside the primary traffic roads.

(e) Alternative access shall be provided for each facility so that it can be approached by emergency responders.

at road junctions shall be designed to facilitate movement of the largest fire-fighting vehicle in the event of emergency.

(f) Rail spur shall be located close to the periphery of the plant to minimize road/pipe crossings and blockage of roads during shunting.

(g) Layout of the facilities should be made to minimize truck traffic ingress in the plant.

(h) Two road approaches from the highway / major road should be provided, one for employees and other for product / material movement. Both these approaches should be available for receipt of assistance in emergency.

(i) Presence of ignition source shall always be contemplated beyond the boundary wall of the installation.

(j) Orientation of flares, furnaces & heaters, dusty operations (e.g. Sulphur handling etc.) and cooling towers should be decided based on prevailing wind direction to avoid travel of hydrocarbon vapour over sources of ignition.

(k) Erection methods shall be studied for all types of equipment / structures. Towers, reactors, fired equipment etc. should be located in such an area so to facilitate erection.

(l) Maintenance requirements for each type of equipment shall be identified and considered.

(m) For construction activities, area should be earmarked.

(n) Future expansion should be assessed, and space provision be made accordingly.

(o) Location of emergency control center and alternate control center shall be identified and should be close to OHC, Fire control room and Security control center.

1.3. Layout of Blocks / Facilities

To prepare a layout, information should be collected on the following aspects, as applicable;
(a) Process units, utility requirements, storage tanks, LPG storage vessels and other pressurized storage vessels

(b) Product receipt / dispatch and mode of transport (rail, road and pipeline)

(c) Warehouses, storage areas for solid products such as petroleum coke, petroleum wax, sulfur, bitumen / asphalt etc. and other open storage areas like scrap yards and dumping ground

(d) Chemical / Toxic chemicals storage, hazardous waste storage / disposal.

(e) Flares

(f) Service buildings, fire station and fire training ground

(g) Site topography including elevation, slope, and drainage

(h) Meteorological data,

(i) Bathymetric data (high tide level, surge wave height etc.), highest flood level in the area, water table, natural streams/ canal for installations in coastal areas.

(j) Seismic data, Approach roads to main plant areas

(k) Aviation considerations

(l) Risk to and from adjacent facilities

(m) Environmental considerations

(n) Statutory obligations

1.3.1. General consideration for the layout of blocks / facilities, while locating the various facilities / blocks, the following should be considered:

(a) Layout of Blocks / facilities should be in sequential order of process flow.

(b) Process unit(s), tank farm, loading gantry, solid storage, utilities, Effluent Treatment Plant (ETP), Emergency DG sets and approach roads should be located on high ground to avoid flooding.

(c) In case process units are operated in an integrated way and shutdowns are taken simultaneously, then it may be considered as a single block. Control room should be located in a non-hazardous area upwind of process plants / hydrocarbon storage and handling facilities. It shall not be located on a lower level than surrounding plants and tank farms. There shall be no structure that would fall on the control room in case of a blast.

(d) Utility block(s) should preferably be located adjacent to unit blocks.

(e) Power generation facilities which also supply steam for process requirement should be located near the process unit block. When external power grid is interconnected with plant power generation facilities, either the power plant should be located at the side of the boundary wall or the external power transmission lines should be taken underground upto interconnection grid.

(f) Overhead power transmission lines shall not pass over the installation including the parking areas. Horizontal clearance shall be in line with the Indian Electricity Rules.

(g) High Tension (HT) sub-station(s) should be located close to major load centers.

(h) Low Tension (LT) sub-station should be located at load centers in such a way that the distance between distribution transformer and farthest motor is minimum.

(i) Cooling Towers should be located downwind of process equipment and substation so that fog developed will not cause corrosion or obstruct vision or short-circuiting.

(j) Storage tanks should be grouped according to product classification. In undulating areas, storage tanks should be located at lower elevations

(k) Truck loading / unloading facilities should be located close to product movement gate and should be oriented to provide one-way traffic pattern for entrance and exit.

Rail loading facilities should be located along the periphery of the installation.

(l) Sulphur recovery unit and Sulphur loading area should be located close to product movement gate and away from process units, hazardous and populated areas.

Equipment drawing air (e.g. air compressors, air blower, FD fan etc.) should be located away from Sulfur recovery unit / Sulfur handling facility.
Minimum separation distance of 50 meters is recommended between sulfur storage / handling and any facility or boundary wall.

(m) Petroleum coke storage and handling facilities should be located as far as possible away from process units, air separation plants, populated and hazardous areas.

(n) Separate collection system should be provided for different types of waste generated in the process plant such as oily water, caustic, acid effluents, fecal etc. Effluent Treatment Plant should be located minimum one block away from process unit area, downwind of process units and important areas considering odour & emission of volatile organic compound. This should be closer to disposal point by the side of the boundary and at lower grade to facilitate gravity flow of effluent.

(o) Flare should be located upwind of process units and the area around flare should be paved.

(p) Main pipe racks / pipe track shall not be routed through process units. Provide overhead clearance for vehicles over roadways and railroads.

(q) Roads should be provided in a symmetric manner to serve all process areas requiring access for the operation, maintenance and firefighting. These roads should encircle the process blocks/ process units.

(r) Smoking shall not be permitted in inside the installation.

(s) Fire station, firewater storage & firewater pump house shall be located at a safe place away from hazardous areas. Fire station should be upwind of process units and hydrocarbon storage area with straight approach to process units / other critical areas.

1.3.2. Location of firewater pumps shall not be less than 60 meters from other hazardous facilities

1.3.3. Separation distances:

Minimum separation distances between various blocks / facilities described above shall be as per Table-1. The table shall be read in conjunction with the notes specified with the table. Siting of manned buildings should be based on Consequence (Dispersion) Analysis. In order to promote Inherently Safer Design, various PHA studies should be used e.g. HAZID, HAZOP, SIL Assessment, CA, QRA etc. Hierarchy of Control shall be applied to minimize process hazards and the associated occupational health & safety hazard to personnel.

1.4. Layout of Process Units:

Equipment in process unit can be arranged in many ways. Safety, economy, operability, and ease of maintenance should be considered in locating each item within the unit. Adequate spacing between equipment will help in minimizing the spread of fire and domino effect. Consideration should be given to access for firefighting.

1.4.1. General Considerations for the layout of Process Equipment:

(a) Process flow sequence and operating procedures should be thoroughly understood so that equipment arrangement in the plot plan is functional. Equipment should be arranged in logistic process sequence for optimum piping runs and operational and maintenance ease. Spacing between equipment shall be adequate for undertaking maintenance jobs.

(b) The unit pipe rack should be kept in the centre, thereby splitting the unit into two or more areas of equipment. Pumps may be arranged in two rows close to and on either side of the pipe rack. Heat Exchangers and vessels should be grouped together forming outer rows on both sides of the rack.

(c) Heat exchangers should be located perpendicular to the pipe rack on the outer row to facilitate pulling of tube bundles with mobile crane or by other means. Shell and tube heat exchanger should have a longitudinal clearance of at least one-meter plus the length of removable bundles.

(d) Air fin coolers should be installed above the pipe rack / technological structures / independent structure. Pumps handling hydrocarbons above the temperature of 230°C or C₄ and Lighters should not be installed underneath the air fin coolers.

(e) Vessels having large liquid hold-up should be installed at lower heights and preferably at grade. Adequate drainage should be provided around such vessels. Where process requirement dictates their installation above grade, these should be located in open area.
(f) Towers/ columns should be located along the pipe rack towards open areas for unobstructed erection as well as maintenance of internals at grade. Tall towers requiring frequent operating attention at upper levels may be located at one place so that common connecting platform can be provided.

(g) Thermo-siphon re-boilers should preferably be placed close to their associated towers.

(h) Vessels, column, Reactors with internals and / or containing catalysts, chemicals etc should have a drop-out area for removing / installing the internals and / or for loading / unloading of catalysts and chemicals.

(i) Heaters should be located up wind at one corner of the unit. Space should be provided for removal and cleaning of heater tubes besides approach for crane. Areas around the heaters shall be graded for guiding spills away from process equipment. Forced Draft fans shall be located away from process equipment from where they are likely to suck hydrocarbon vapors.

(j) No trenches or pits which might hold flammables should extend under the furnace and connections with underground drain system should be sealed over an area 15 meters from the furnace walls.

(k) The local control panel for soot blower control and flue gas analyzer only should be located on and near the process heater. The rest of controls should be taken to control room.

(l) Gas compressors should be located downwind from heaters so that leaked gases will not drift towards the heater. Gas compressors should have roofing and open from sides to avoid accumulation of heavier vapours/gases on the floor of compressor house. Compressor house should be located near the battery limits to facilitate ease in maintenance and operation. Drop out area should be provided for maintenance.

(m) No other tankage except day tanks / process chemicals shall be provided within battery limits of any process unit.

(n) Process chemicals storage tanks should be provided with kerb wall of minimum 300-mm height. Hydrocarbons day tanks shall be provided with dyke in line section 7.0 of this standard.

(o) Cold boxes should be located on grade or on separate elevated structures. Adequate space should be provided around cold boxes for ease of operation and maintenance.

(p) Flare knock out drum for the process units should be located at battery limit of the unit.

(q) Blow down facilities / buried drum should be located at one corner of the plant / unit farthest from furnace or any fired equipment and on the lee-ward side of the unit.

Vent from Blow down facility shall be minimum 6m above the highest equipment falling with in radius of 15 m from the vent stack.

(r) Operators cabin may be provided in the process unit. The cabin should be located upwind side of the unit in non-hazardous area and away from draining / sampling facilities. The cabin should be for minimum occupancy of the shift operators of the respective facilities only.

(s) Stairways should be provided for the main access.

(t) Minimum headroom under pipes, cable racks, etc should be 2.1 meters.

(u) Equipment should be spaced to permit use of mobile equipment and power tools or servicing and maintaining equipment during turn around periods.

1.4.2. Equipment spacing with in process units:

a) Minimum separation distances between various equipment within process units are given in Table-2. The distances recommended should be followed to the extent feasible. Equipment spacing within the process unit may be varied to meet the requirements specified by Licensors or of the Engineering Consultants except the followings.

(i) Blow down facility (open pit type) / oil catcher shall be located at a distance not less than 30 m from fired heater / any fired equipment. If the blow down drum is located underground / oil catcher is cover with vent to safe location, the minimum separation distance shall be 15m.

(ii) Fuel Oil day tank shall be located at a distance of not less than 15m from equipment except those facilities such as heat exchanger, pump connected directly with the Fuel Oil system.

b) Firewater hydrant / monitors shall be minimum 15 m away from the equipment that is to be
protected.

c) Water spray deluge valve shall be minimum 15 m from equipment handling hydrocarbon.

d) Fuel gas knock out drum shall be located at a minimum separation distance of 15 m from the heater.

1.5. Layout of Storage Tanks:

1.5.1. General considerations:

1.5.1.1. Dyked Enclosures:

(a) Petroleum storage tanks shall be located in dyked enclosures with roads all around the enclosure. Aggregate capacity of tanks located in one dyked enclosure shall not exceed following values:

(i) 60,000 cum. for a group of fixed roof tanks.

(ii) 120,000 cum. for a group of floating roof tanks

Fixed cum floating roof tanks shall be treated as fixed roof tanks. However, in case these tanks are provided with windows opening on the shell and these windows will not get blocked in any case, then these may be considered as floating roof tanks.

If a group of tanks contains both fixed and floating roof tanks, then it shall be treated as a group of fixed roof tanks for the purpose of above limits.

(b) Dyked enclosure shall be able to contain the complete contents of the largest tank in the dyke in case of any emergency. Enclosure capacity shall be calculated after deducting the volume of tanks (other than the largest tank) and the tank pads within the dyke upto the height of the enclosure. A free board of 200 mm above the calculated liquid level shall be considered for fixing the height of the dyke.

(c) The height of tank enclosure dyke (including free board) shall be at least 1.0 m and shall not be more than 2.0 m above average inside grade level. The dyke wall made up of earth, concrete or solid masonry shall be designed to withstand the hydrostatic load. Earthen dyke wall shall have not less than 0.6-meter wide flat section on top for stability of the dyke wall.

(d) For excluded petroleum, the capacity of the dyked enclosure should be based on spill containment and not for containment on tank rupture. The minimum height of dyke wall in case of excluded petroleum shall be 600 mm.

(e) Separation distances between the nearest tanks located in separate dykes shall not be less than the diameter of the larger of the two tanks or 30 meters, whichever is more.

(f) Process equipment should not be located inside the dyke. Pump stations and piping manifold should be located outside dyke areas by the side of roads.

(g) Tanks located overhead shall meet safety distances and shall also have dyked enclosure of RCC construction and provided with efficient drainage system for the dyke enclosure.

1.5.1.2. Grouping:

(a) Grouping of petroleum products for storage shall be based on the product classification. Class-A and / or Class-B petroleum may be stored in the same-dyked enclosure. Class-C petroleum should preferably be stored in separate enclosure. However, where Class-C petroleum is stored in a common dyke along with Class-A and/or Class-B petroleum, all safety stipulations applicable for Class-A and/ or Class-B respectively shall apply.

(b) Excluded petroleum shall be stored in a separate dyked enclosure and shall not be stored along with Class-A, Class-B or Class-C petroleum.

(c) Tanks shall be arranged in maximum two rows so that each tank is approachable from the road surrounding the enclosure. This stipulation need not be applied to tanks storing excluded petroleum class.

(d) Tanks having 50,000 cum capacity and above shall be laid in single row.
1.5.1.3. **Fire walls:**

(a) In a dyked enclosure where more than one tank is located, firewalls of minimum height 600 mm shall be provided to prevent spills from one tank endangering any other tank in the same enclosure.

(b) A group of small tanks each not exceeding 9 meters in diameter and in all not exceeding 5,000 cum in capacity shall be treated as one tank for the provision of firewall.

(c) For excluded petroleum product storage, firewall of height not less than 300 mm shall be provided by limiting the number of tanks to 10 or the capacity of group of tanks to 5,000 cum whichever is lower.

(d) The tank height shall not exceed one and half times the diameter of the tank or 20 m whichever is less. For the installations covered under Oil Mines Regulation, the maximum height of the tank, dyke requirements etc. shall be as per Oil Mines Regulations.

(e) Piping from/to any tank located in a dyked enclosure should not pass through any other dyked enclosure. Piping connected to tanks should run directly to outside of dyke to the extent possible to minimise piping within the enclosures.

(f) The minimum distance between a tank shell and the inside toe of the dyke wall shall not be less than half the height of the tank.

(g) There shall be access on all four sides of each dyke area and roads should be linked to minimize the effect if one road is cut off during the fire.

1.5.2. **Separation Distances between tanks / offsites facilities:**

The following stipulations shall apply for the separation distances for above ground tanks storing petroleum:

(a) For larger installation, minimum separation distances shall be as specified in Table-3 and Table-4. The tables are applicable where total storage capacity for Class-A and Class-B petroleum products is more than 5000 cum or the diameter of Class-A or Class-B product tank is more than 9 meters.

(b) For smaller installation, minimum separation distances shall be as specified in Table-5. This table is applicable where total storage capacity of Class-A & Class-B is less than 5000 cum and diameter of any tank storing Class-A and Class-B petroleum product does not exceed 9 meters. Table-5 shall also be applicable for the installation storing only Class-C petroleum.

(c) Excluded petroleum should be treated as Class-C petroleum for the purpose of separation distances and Table – 5 shall be applicable for their separation distances.

1.6. **Layout of LPG Facilities:**

1.6.1 **General Considerations:**

1.6.1.1 **LPG Storage:**

The requirements given below are applicable to above ground LPG storage facilities. The detailed requirements for mounded, above ground, refrigerated, cavern LPG storage, handling and bottling facilities have been covered in the PNGRB (Technical Standards and Specifications including Safety Standards for LPG storage, handling and bottling facilities) Regulations, 2019.

Storage vessels shall be arranged into groups each having a maximum of six vessels. Capacity of each group shall be limited to 15000 cum. Each group shall be provided with a Kerb wall.

(a) Any storage vessel in one group shall be separated from a storage vessel in another group by a minimum distance of 30 meters.

(b) Spheres and bullets shall be treated as separate groups with 30 meters separation distance between two groups.
(c) Longitudinal axes of horizontal vessels (Bullets) should not point towards other vessels, vital process equipment and control room.

(d) Storage vessels should be located down wind of process units, important buildings and facilities.

(c) LPG storage vessels shall not be located within the same dykes where other liquid hydrocarbons are stored.

(f) Above Storage vessels shall be laid out in single row both in case of the spheres and bullets. Storage vessels shall not be stacked one above the other.

(g) Spillage collection shallow sump shall be located at a distance where the flames from sump fire will not impinge on the vessel. This distance shall not be less than the diameter of the nearest vessel or 15 meters whichever is higher.

(h) Kerb wall around the storage tank shall have a minimum height of 30 cm. However, it shall not exceed 60 cm at shallow sump position, as otherwise evaporation of spilled LPG may get affected.

1.6.1.2 LPG bottling facility:

(a) LPG bottling facilities should be located at a safe distance from other facilities with minimum ingress to trucking traffic and downwind to storage.

(b) There shall not be any deep ditches in the surrounding area to avoid LPG settling.

(c) Stacking areas for empty and filled cylinders should be located separately. Cylinders shall be stacked vertically. Filling machines and testing facilities shall be organized in sequential manner distinctly in a separate area.

(d) Filled LPG cylinders shall not be stored in the vicinity of cylinders containing other gases or hazardous substances.

(e) Trucking traffic shall be smooth to avoid blocking/obstruction for loading and unloading of cylinders.

1.6.1.3 Bulk handling facilities:

(a) LPG truck loading/unloading gantry shall be located in a separate block and shall not be grouped with other petroleum products.

(b) Maximum number of LPG tank truck bays shall be restricted to 8 in one group. The bay should be designed in such a way that the driver's cabin will be facing the exit direction and shall have no obstruction.

(c) LPG rail loading/unloading gantry shall be located on a separate rail spur and shall not be grouped with other petroleum products.

(d) Rail loading/unloading of LPG should be restricted to a maximum of half rake. Full rake loading/unloading is shall be done on two separate rail gantries having a minimum distance of 50m.

1.6.2 Separation distances for LPG facilities:

The distances for LPG facilities shall be as per the PNGRB (Technical Standards and Specifications including Safety Standards for T4S for LPG Installations) Regulations, 2019.
Schedule-2

2.0 Design of Equipment, and storage facilities

2.1 Process Equipment

2.1.1 Relief System:

(1) Pressure Relieving / Safety Devices:

There are basically following type of safety devices used for relieving pressure in a system.

(i) Reclosing type Safety/ Pressure Relief valves
   (a) Conventional
   (b) Balanced Pressure relief valves
   (c) Pilot-operated relief valves

(ii) Non-Reclosing type Safety/Pressure Relief Valves
   (a) Rupture disk Device
   (b) Pin-actuated device

(iii) Emergency depressurization Valves.

(A) Set Pressure of Relief Valves:

Relief valves shall be set at minimum 110% of the normal operating pressure to allow a reasonable margin so that the valves do not open frequently with minor process upsets. The difference between the set pressure and the normal operating pressure should not be less than 2 Kg/CM2. This aspect shall be considered for selecting the design pressure of the equipment. The set pressure of various Relief Valves shall be fixed based on criteria given below:

1. Pilot Operated Valves:

   Pilot operated valves shall be used:

   (i) Where the margin between set pressure and maximum operating pressure is less than 10% of the maximum operating pressure (as low as 5% is judged to be acceptable).
   (ii) When the built-up backpressure is expected to exceed 50 per cent of the set pressure.

(B) Rupture Disc:

When rupture disc is used, the bursting pressure of the rupture disc and safety valve set pressure shall be kept at same nominal value A pressure gauge/bleeder between rupture disc and relief valve helps to indicate the health of the rupture disc.

(C) Emergency Depressurizing Valves:

For sizing of Emergency Depressurizing Valves, generally involves reducing the equipment pressure from initial conditions to a level equivalent to 50% of vessel design pressure within approximately 15 minutes. This criterion is based on the vessel wall temperature versus stress to rupture and applied generally to vessels with wall thickness of approximately 1 inch or more. Vessels with thinner walls generally require a higher depressurizing rate.

2.1.1.1 Installation of Safety Devices

(a) Inlet piping shall be adequately sized so as to limit pressure drop between vessel and safety valve to 3% of the set pressure on the inlet side.
(b) The discharge side including the header shall be sized so as to contain total back pressure within permissible limits depending upon the type of safety valve.

(c) Inlet and outlet of a safety valve shall not be less than the nominal sizes of inlet/outlet flanges respectively of the safety valve.

(d) Inlet and outlet (if pressure relieving device is discharging to a closed system) piping shall be free draining away from the safety valve.

(e) The discharge line shall join the header from top and preferably at an angle of 45° to avoid high pressure drop.

(f) In vessels where there are chances of liquid carryover along with vapour in the form of froth, mist, etc., the inlet line to safety valve and the outlet line from safety valve to the unit knock-out/Blowdown drum shall be sized based on two-phase flow.

2.1.1.2 No hydrocarbon and other toxic releases shall be discharged to atmosphere directly. However, in certain situation like marketing installations, LPG bottling plants and other remotely located installations where hydrocarbons are stored and handled and no flare or other closed disposal systems are feasible, the relieved vapours can be discharged to atmosphere. In such case following key points shall be considered while routing PSV discharge to atmosphere:

(a) The individual relief valve vent shall discharge to atmosphere in upward direction, so sized that minimum exit velocity of 150 meter/sec would be obtained. The maximum velocity shall not exceed 0.5 mach. If feasible, snuffing steam or Nitrogen Shall be connected to the vents. Under these conditions, the air entrainment rate is very high and the released gases will then be diluted to below their lower flammable limit.

(b) A single common vent shall not be used for several relief valves because this results in a discharge velocity much less than the designed discharge velocity when only one safety valve is operating.

(c) The vent of relief valve shall discharge at a minimum elevation of 3 meters above grade or the tallest structure, within a radius of 15 meters, whichever is higher.

(d) Individual vents shall have a drain hole of 1/2” at the low point in the vent line. The drain connection shall be piped to a safe location.

(e) If the relieved vapours produce excessive noise at the nearest operating structure, the vent line shall be provided with acoustic insulation. Silencers shall not be used as they are likely to block the outlet due to fouling, etc.

2.1.1.3 Main Flare Header

The flare header shall not have any pocket and shall be free draining towards the nearest K.O. drum. A slope of 1 in 500 is normally recommended. No check valves shall be permitted in the flare header system.

If the liquids to be handled include oil with a relatively high pour point, provision shall be made to avoid solidification in the system. Likewise, the introduction of high viscosity oils shall require protection against low ambient temperatures, particularly on instrument leads. Use of heat tracing is recommended under such situations. H2S is corrosive and if handled together with the main flare header, it will lead to corrosion of the header. It shall have a separate flare header of material suitable to handle acid gases.

2.1.1.4 Main Flare Knock-out Drum
Horizontal and vertical drums are both acceptable. The drums shall be sized to separate out liquid droplets of 300-600 microns size. The K.O. drums should be sized to provide liquid hold up of 20-30 minutes, which shall be recycled with the provision of pumps.

2.1.1.5 Seal drum

The seal drum shall have a cross sectional area at least equal to 4 times the inlet pipe cross sectional area and be designed for 3.5 Kg/CM2g as minimum. The inlet pipe shall drop vertically down for at least 3 meters above the water level to avoid ingress of air in to the system due to vacuum created when hot vapours cool off.

Maximum allowable back pressure in the header will decide the maximum submergence of inlet pipe under the seal. A minimum seal of 100 mm is recommended. As a standard design practice, maximum seal height shall not exceed 300 mm.

Water shall be continuously added to the seal drum and the overflow shall be automatic through a liquid seal leg. As a minimum, the leg height shall be equal to 1.75 times the maximum expected operating pressure (not design pressure). The vertical down flow section of the water outlet line from the drum is sized for maximum velocity of 0.12 m/s to allow entrained gases to disengage. The seal loop shall be sized for the normal water flow of 6.0 m3/hr. All lines connecting K.O. drums, seal drums and the flare stack shall be free of pockets. The seal leg shall be provided with a 1½” siphon breaker. Provision shall be made to skim off any oil that get accumulated in water seal drum.

2.1.2 Pump:

2.1.2.1 Pressure & Temperature:

(a) The casing shall be designed to withstand simultaneously MAWP (Max. Allowable Working Pressure) at corresponding temperature and the worst-case combination of twice the allowable nozzle loads as per applicable standard.

(b) In case of Centrifugal Pumps, radial split casings shall be used for any of the following operating conditions:

   (i) Pumping temperature of 200 deg. C or higher (a lower temperature limit should be considered if thermal shock is probable).
   (ii) Flammable or hazardous pumped liquid with a relative density of less than 0.7 at the specified pumping temperature.
   (iii) Flammable or hazardous pumped liquid at a rated discharge pressure above 100 bar.

   For applications like pipeline products transfer, feed water etc. pumps designed as per proven vendor standards shall also be acceptable for MAWP of higher than 100 bars.

(c) Pulsation suppression shall be provided at the discharge of all metering pumps.

2.1.2.2 Hydraulics:

(a) Pumps shall be designed for continuous operation at a minimum of 28 deg. C higher than specified maximum operating temperature.

(b) Flow dampener and pressure relief valves shall be provided in positive displacement pumps.

2.1.2.3 Process Control and Protection Systems:
The lower and upper limits for critical process parameters like suction pressure, discharge pressure, differential pressure, suction and discharge temperatures, should be identified and necessary alarms and trips to prevent failures as applicable should be provided.

2.1.3 **Compressors:**

(i) In case of centrifugal compressors, radial split (barrel) type design should be considered for Hydrogen/ Hydrogen-rich service, while axial split for other services.

(ii) Rotational speeds of reciprocating compressors in Hydrogen service should be limited to a maximum of 350 RPM.

(iii) Where the process fluid contains contaminants like H2S, manufacturing process shall require materials and special heat treatment in conformity with NACE MR-103/ NACE MR0175 Standard.

2.1.3.1 **Temperature:**

(i) The basic compressor design, materials, seals and sealing arrangements shall be suitable for the lowest and highest operating temperatures in the system.

(ii) In case of reciprocating compressor in utility services, the discharge temperature should not exceed 170 degree centigrade.

2.1.3.2 **Auxiliary Assemblies:**

(i) Pulsation suppressor connections shall be flanged in positive displacement compressors.

(ii) Vents and drains shall be routed to safe location, and double block valves shall be provided for compressors in Hydrocarbon service.

2.1.3.3 **Process Control & Protection System:**

The safety of equipment from abnormal process conditions shall be ensured by incorporating system that provides adequate protection to the equipment. Following considerations shall be given:

(i) For centrifugal / axial compressors, to prevent failures due to surge or minimum flow conditions, systems shall be equipped either with surge control systems, discharge vent or with minimum opening inlet valves in case of closed loop operations as applicable.

(ii) The lower and upper limits for critical process parameters like suction & discharge pressures and suction & discharge temperatures shall be identified and necessary alarms and trips to detect failures, as applicable shall be provided.

(iii) For rotary and centrifugal compressors, systems shall have necessary provisions like NRVs to prevent the reverse rotation of the equipment. NRVs should be suitably located to prevent reverse rotation in case of abrupt stoppage or tripping of the machine.

2.1.3.4 **Guidelines for Compressor Design and Manufacture:** should we go into such details? The equipment are designed referring to API standards, why should we repeat the requirements and make the document bulky?

(i) Overall Sound level, around complete package, at one-meter distance should preferably be less than or equal to 90 dBA. Provision of noise enclosures should be considered above 90 dBA.

(ii) Process Gas connections shall be flanged or machined and studded. Threaded flange holes are not accepted.

(iii) External lube oil coolers shall be supplied. For Shell and Tube type coolers, lube oil pressure shall be higher than water pressure.
(iv) Coupling guards shall be of Non-Sparking metallic and of rigid construction. Coupling guard should be designed to withstand 900 N static point load in any direction without the guard contacting moving parts.

(1) **Centrifugal Compressors:**

For services where partial pressure of hydrogen exceeds 13.8 bar (200 psig), Radial Split (barrel) type casing design shall be provided.

(2) **Reciprocating Compressors:**

Piston Speed shall be preferably below 4 m/s for the reciprocating compressors. Wherever higher speeds are offered, references with successful applications shall be made available.

The maximum predicted discharge temperature shall not exceed 135°C for hydrogen rich (MW less than 12) service and 150°C for other services for all specified operating and load conditions.

(3) Cylinder coolant inlet temperature shall be higher by 6°C than suction temperature.

2.1.4 **Steam Turbine:**

2.1.4.1 **Lubrication Systems:**

Rundown tanks should be provided for the safe coast-down of the steam turbines with high coast down periods. Emergency power shall be provided in absence of run-down tanks.

2.1.4.2 **Steam Purity:**

<table>
<thead>
<tr>
<th>Conductivity</th>
<th>Continuous</th>
<th>Start-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micromhos / cm at 25Deg C</td>
<td>Drum</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Once Through</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Sio, ppb, max</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Fe, ppb, max</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Cu, ppb, max</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Na+ k, ppb, max</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Up to 800 Psi [55616 kpa (gauge)]</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>801 to 1450 psi [5517 to 9998 kpa (gauge)]</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>1451 to 2400 psi [9999 to 16548 kpa (gauge)]</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Over 2400 psi [over 16548 kpa (gauge)]</td>
<td>3</td>
</tr>
</tbody>
</table>

2.1.4.3 **Process Control and Protection Systems:**

(a) A manual trip device/button shall be provided near the turbine.

(b) On extraction turbines, the extraction lines shall be provided with a non-return valve (combined check/ trip valve).

2.1.5 **Gas Turbine:**

2.1.5.1 **Inlet and Exhaust Conditions:**

(a) Gas turbine shall be provided with suitable air filtration system based on the condition of the ambient air.
(b) Flue gas exhaust system ducting shall be provided with suitable silencer to limit the sound as per applicable standard/ statutory requirement.

### 2.1.5.2 Fuel Systems:

(a) Facilities with dual fuel firing capability shall have provision for continuously purging the liquid fuel lines when the turbine is running on gaseous fuel.

(b) Both the fuel systems Fuel Oil/Fuel Gas shall have separate provision of fuel shutoff valves in the circuit. This shutoff valve shall completely stop the fuel supply to the turbine in case of any shutdown/ trip condition. Valve shall only be opened when all firing permissive are met.

(c) Total sulphur content in the fuel oil shall be considered for designing the metallurgy of downstream HRSG’s and Auxiliary boiler coil, stack etc.

### 2.1.5.3 Lubrication Systems:

(a) Lubricating oil pumps with separate emergency source of power supply shall be made available for safe cool down of the gas turbines.

(b) Rundown tanks should be provided for the safe coast-down of the steam turbines with high coast down periods. Emergency power shall be provided in absence of run-down tanks.

### 2.1.5.4 Noise and Environment Control:

(a) Suitable acoustic enclosures shall be provided to meet the applicable statutory requirements with respect to noise and ambient temperature.

(b) Enclosures shall have provisions to open the access doors from inside also.

(c) Access doors shall be designed so as to prevent accidental closure.

(d) Exhaust systems shall be provided in the enclosure to vent out oil/ fuel vapours.

(e) Exhaust from the gas turbine shall meet the applicable statutory emission norms for environment.

### 2.1.5.5 Process Control and Protection Systems:

(a) Separate pick-ups for speed control and over speed trip shall be provided. Triple redundancy for speed control and redundancy for over speed should be considered.

(b) Over speed system separate from the turbine control system shall be provided. This over speed protection system shall be mechanical, hydraulic, electronic or combined.

(c) A manual trip device/ button shall be provided near the turbine.

### 2.1.5.6 Forced draft fans shall be provided with suction screen to protect the fan from any external object. The screen material shall be corrosion resistant material as required by the environmental condition. Casing of Fans & Blowers shall be suitably insulated or lined for hot fluid service. Fans and Blowers handling hot gases shall be provided with a deflector plate between shaft seal & bearing housing to prevent impingement of hot gases on bearing housing. FD fan suction point location to be from safe area.

### 2.1.6 Agitators & Mixers:

(i) Shaft seals installed in Hydrocarbon service and for low lubricity liquids and gaseous applications, double mechanical seal with pressurized external fluid shall be provided.

(ii) The equipment and sealing systems shall be designed for the minimum and maximum specified pressures, temperatures, and other parameters, like liquid level, specific gravity, viscosity, etc.

### 2.2 Storage and Handling:
2.2.1 Storage Tank:

2.2.1.1 Level:

Tanks shall be provided with at least two numbers of level instruments of which one may be local and the other remote, located in control room or office. In addition, high/low level alarms with independent primary sensing device are recommended.

2.2.1.2 Steam Heating:

(i) Manway heaters consist of a tube bundle, usually of hairpin type, fixed through a manhole of the tank. Man-way heater shall be designed so that its removal can be done without the requirement of person entering in the tank.

(ii) Steam coils should have no flange connections inside the tank. Provision should exist in condensate outlet lines to check for oil leak. Gradient of the coil bundle inside the tank should be such that condensate accumulation is avoided.

2.2.1.3 No cast iron valve shall be used in oil service. Only cast steel valves shall be considered.

2.2.1.4 Wagon & Truck Loading Gantry:

(i) Loading points shall have quick shut-off valves viz. Plug or Ball Valves.

(ii) Vacuum release valves shall be provided with chain lever arrangement for release in case of stuck up vacuum release valves.

(iii) As there would be variations in number of trucks/wagons being loaded at a time, the flow rate through each point would also vary. Hence, restriction orifices or flow control valves shall be provided to restrict velocity upto 6 m/sec, particularly for motor spirit, kerosene, ATF and diesel.

2.2.2 Liquefied Petroleum Gas Mounded Storage Facility:

(a) A detailed soil testing shall be carried out, analysed to ascertain the suitability of the location and as a support document for selection and design of the foundation.

(b) Each mound shall have accessibility to Fire Tender from at least two sides.

(c) Vessel(s) shall be located such that these do not affect or are affected by other underground structures e.g. foundations, pipelines, sewers, electrical cables and are also not subjected to loads from vehicular traffic or affected by other hazards like power cables, cathodically protected pipelines etc.

2.2.2.1 Separation Distances

The minimum separation distances for mounded storage shall be as follows:

(a) Between mounded LPG storage and boundary, property line, group of buildings not associated with LPG plant shall be 15 meters. Further, between edge of the mound and boundary, property line, group of buildings not associated with LPG plant shall be 5 meters.

(b) Between mounded LPG storage and any other (other than LPG pump/compressor house) facility associated with LPG plant (e.g. decantation shed) shall be 15 meters.

(c) Between mounded LPG storage vessel and firewater pump house and / or Firewater tank shall be 30 meters.

All the separation distances shall be measured from the nearest point of the periphery of the vessel and also from the first exposed flange on the vessel i.e. ROV.
Further separation distance between mounded LPG storage vessel and LPG pump house/ compressor house shall be kept based on operational needs. In case of the liquid outlet from top of the mounded vessel, submersible pump may be installed from the top of the vessel.

A road of minimum 3.5 m width shall be provided around the mound for movement of earth moving / firefighting equipment.

2.2.2.2 The minimum inter-distance between the edge of the vessel(s) in a mound shall be determined by the site conditions and the need for safe installation, testing, maintenance and removal of vessels. However, in any case this distance shall not be less than 1.5 m between the vessels having diameter of 2 m and 2 m for all other cases.

2.2.2.3 The minimum inter-distance between the edge of the mounds on finished ground level shall be determined by the site conditions, the need for safe installation, testing, maintenance and removal of vessels and the requirement for the passage for emergency equipment e.g. Fire Tender, hydrant system. In any case this distance shall not be less than 3.5 meter.

2.2.2.4 Design Code:

ASME SEC. VIII or PD - 5500 or equivalent duly approved by CCE. A single code shall be adopted for design, fabrication, inspection and testing. The specific consideration shall be given to-

(a) Internal vapour and hydraulic pressure
(b) External loadings on the vessel
(c) Internal vacuum

2.2.2.5 Material:

(1) For Refinery Service:

Since H2S presence cannot be completely ruled out in the Refinery LPG storage, high strength material shall not be used for vessels as it is prone to Sulfide stress corrosion cracking. The material shall be selected as per design code as illustrated below:

(a) Material shall be in line with design code. ASTM A516 Gr. 60 or eqv. shall be used.
(b) Micro-alloyed steel containing Ni, Mo, Va shall not be considered.
(c) Maximum specified tensile stress shall not be more than 80,000 psi.

(2) For Marketing Installation:

Where H2S is not present, ASTM A 516 Gr.70 (IT) or SA 537 C II (IT) or PD: 5500 or eqv. material shall be used.

2.2.2.6 Design Temperature:

– minus 29 deg. C to + 55 °C.

2.2.2.7 Design Pressure:

14.5 Kg/cm2 g (1.42 Mpa) vapour pressure of LPG at top of the vessel (as per IS: 4576 or IS :14861) at 55 °C.

2.2.2.8 Other Considerations:

(a) Internal Corrosion Allowance: 1.5 mm (minimum)
(b) Radiography: Full
(c) Stress Relieving:100% irrespective of thickness.
(d) Earthquake pressure: as per IS: 1893
(e) Hydro test pressure: As per Design Code
2.2.2.9 Fittings and Instruments on A Vessel:

(a) The fire safe Remote Operated Valve (s) (ROV) shall be provided on first flange on liquid line (s) from each vessel either from bottom or top as per the design considerations. There shall not be any other flanges, or any other tapping up-to the ROV.

(i) In case of provision of liquid outlet from the top of the vessel, the line shall extend up to bottom. 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°.

(ii) The top of the vessel shall be provided with nozzles for vapour outlet and re-circulation, which shall also be provided with fire-safe ROVs. ROVs for vapour / recirculation lines should be provided at the ground level with an isolation valve at top. In case, ROV is provided at top of the vessel, there is no need to provide an isolation valve”.

(b) Minimum two nos. of manhole shall be provided on top of the vessel.

(c) Each vessel shall have at-least two Safety Relief Valves (SRV). The full flow capacity of each SRV on mounded vessel(s) shall be minimum 30 % of the capacity required for an equivalent size of above ground vessel.

(d) The flange joints of valves shall either have spiral wound metallic gaskets or ring joints. Plain asbestos sheet / reinforced gaskets shall not be used. Flange connections shall be a minimum of ANSI-300 lb flange class.

(e) Each storage vessel shall have minimum two different types of level indicators and one independent high-level switch. High level alarm shall be set at not more than 85% level of the volumetric capacity of the vessel. Audio visual indication shall be provided at local panel & control room.

(f) Each vessel shall also be provided with one pressure and temperature measuring instrument. The pressure gauge shall be provided with two isolation valves and an excess flow check valve.

2.2.2.10 Fire Detection / Protection System:

The fire detection / protection system for the mounded storage area shall be as follows;

1) Auto Fire Detection / Protection System:

(i) Automatic fire detection and /or protection (Fixed) system based on heat detection through thermal fuses/ quartz bulbs/ EP detectors shall be provided. Sensors shall be installed at all critical places as below:

(a) Minimum One detector shall be provided on each exposed portion of the vessel. However, if the nozzles are covered in a dome, each group shall have at least two detectors.
(b) At least one detector shall be provided near ROV on all liquid line (s).

(ii) The actuation of any one of above said detector on or around the mound shall initiate the following:

(a) An audio visual alarm at the local/ main control panel and fire water station, indicating the fire.
(b) All ROVs on the affected vessel shall close.
(c) LPG pumps and compressors in LPG storage area shall trip.
(d) Fire water /Spray system, if provided, shall operate.

(iii) In addition, devices for initiating all the above actions shall be provided on remote operating panel and also in field at safe location to enable manual actuation. Suitable arrangement for routine testing of security system shall be provided.

2.2.2.11 The fire proofing (2 Hours rating) of all exposed portion of the vessel shall be done including piping up to the first ROV, appurtenances etc. Alternatively, auto actuated fixed water spray system shall be provided and this system should be actuated through heat detection device.

2.2.2.12 Hydrant(s)/monitor(s) shall be located at a safe place and shall not be installed within 15 meters from the exposed portion facilities/equipment to be protected.

2.2.2.13 Cathodic Protection System:

(a) In this specification only the structure to soil potential is used as a criterion for effective cathodic protection.

(b) For the vessels to be considered fully cathodically protected, the “OFF” potential on all parts of the vessels shall be equal to or more negative than -850 mV vs Cu/CuSO4 (+250 mV vs Zinc) reference.

(c) If anaerobic conditions and activity of sulphate - reducing bacteria are present or likely, the “OFF” potential shall be equal or more negative than –950 mV vs Cu/CuSO4 (+150 mV vs Zinc) reference.

(d) To avoid detrimental effects on the applied coating or on the metal due to overprotection, “OFF” potentials shall not be more negative than –1150 mV vs Cu/CuSO4 (-100 mV vs Zinc) reference.

For further details and compliance for LPG installations, the Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for LPG Storage, Handling and Bottling Facilities) Regulations, 2019.
3.0 Commissioning and Pre-commissioning

3.1 Mechanical Completion of the Refinery projects

A plant, unit, or facility, or any part thereof, is considered Mechanically Complete (MC) when it has been erected in accordance with applicable drawings and specifications. The definition of MC varies from project to project depending on contractual requirements.

Mechanical Completion activities consist of all non-operating activities. A typical list might be as follows:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Mechanical Completion Items</th>
<th>Constructors</th>
<th>Operations</th>
<th>PMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installation of piping and equipment</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Integrity (hydrostatic/ pneumatic) testing</td>
<td>Perform</td>
<td>Witness</td>
<td>Witness</td>
</tr>
<tr>
<td>3</td>
<td>Equipment Inspection (Towers, Reactors, etc.) and Boxup</td>
<td>Perform</td>
<td>Witness</td>
<td>Witness</td>
</tr>
<tr>
<td>4</td>
<td>Develop Punch List</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cold alignment checks</td>
<td>Perform</td>
<td>Witness</td>
<td>Witness</td>
</tr>
<tr>
<td>6</td>
<td>Point to Point continuity checks</td>
<td>Perform</td>
<td>Witness</td>
<td>Witness</td>
</tr>
<tr>
<td>7</td>
<td>Removal of free water from systems</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Preservation and maintenance</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Development of Systems (small packages):

(a) To enable a smooth transition from construction to com-missioning it is required to complete construction work in small packages, generally known as systems. This enables Pre-Commissioning work to progress from an earlier point in the schedule, thus reducing the final pre-commissioning peak workload substantially. Defining the systems becomes more important due to:

(i) Increase in boundaries between the construction and commissioning groups.
(ii) Increase in parallel activities during the final stages of construction.

(b) The size and content of a system changes for each project, however it is essential to take the following points into consideration when defining system size and content:

(i) Not relevant to regulation Systems should be defined by color coding of P&IDs. System boundaries should be “flagged” in RED and system numbers should be clearly marked at regular intervals on the respective line-work and equipment.
(ii) System summary sheets should be prepared which list the system content by line and equipment numbers.
3.3 Development of Pre-Commissioning Plan:

(1) A plan is developed that identifies all of the major pre-commissioning activities by system. The plan will be developed in reverse and will clearly identify “system ready for pre-commissioning” milestones.

(2) Commencement of system turnover from construction to commissioning should ideally commence at approximately 70% erection completion. From this point handover of systems should be made on a regular basis. Safety is impaired when there is a period of low activity followed by a period of high activity to achieve target-pre-commissioning progress.

(3) A method of pre-commissioning progress monitoring should be developed to allow progress to be monitored by:

(a) Overall pre-commissioning completion for the complex
(b) Pre-commissioning completion by individual Process Unit
(c) Pre-commissioning completion by system
(d) Discipline completion by system

(4) Commissioning input to the Design Process: Input of commissioning experience to the design process will ensure that:

a. Commissioning and operating safety is addressed in the design
b. All phases of the initial start-up (Including one-off special procedures) are adequately covered in the design specifically including definition of systems and system turnover sequence.
c. Consideration has been given to the pre-commissioning of the process units.

(5) To achieve this commissioning group representatives will attend and provide input at P&ID reviews, HAZOP Reviews and Model Reviews: They will also review cause and effect diagrams and spare parts orders.

(6) The main lists of the procedures to be carried out are:

i. Mechanical Preparation
ii. Flushing of equipment and piping
iii. Chemical Cleaning Instructions
iv. Physical Cleaning Instructions Mechanical Restoration Machinery
v. Run in Tightness test
vi. Electrical testing/functional tests/energizing
vii. Instruments calibration and functional test
viii. Loading of chemicals
ix. Loading of catalyst
x. Heaters drying
xi. Chemicals boil out of steam generation facilities Verification of Mechanical Completion

3.4 Punch-Listing:

Punch-Listing will be undertaken on a systems basis. An integrated team will be formed to participate in Punch-Listing. An initial Punch-List will be undertaken immediately prior to system handover for Pre-Commissioning purpose. This will probably occur at around the hydrotest time. Punch-List items generated at this stage will be incorporated into the Project master Punch-List system.

A PSSR shall be undertaken by the entity immediately prior to the commencement of commissioning activities aimed at checking the system over before introducing hydrocarbons. Utilization of the Pre-
Commissioning check sheets shall assist in completing a full range of required checks. Punch-Listing progress will be recorded on P&IDs.

The category of a punch list item determines if a system is ready to move into the next phase of commissioning. Punch list items are prioritized into one of three categories; type A, B, or C. Pre-commissioning Check is carried out after the MC, therefore, Category definition below need to be reviewed.

(i) Category type A

Type A punch list items are deficiencies or pending work that shall be repaired or completed prior to issuance of a Mechanical Completion.

(ii) Category type B

Type B punch list items are deficiencies or pending work that may be cleared after declaration of Mechanical Completion but shall be closed out in pre-commissioning.

(iii) Category type C

Type C punch list items are deficiencies that shall be cleared prior to commissioning. These are items that are required to be corrected prior to proceeding with a safe start-up and continuing operations.

3.5 Pressure Testing of Equipment/ piping

3.5.1 Hydrostatic Testing of process equipment / lines

(i) Hydrostatic pressure testing of the Unit shall be performed to prove strength of the materials and weld integrity after completion of the construction. The tests shall be made on new piping or repaired equipment and piping. The initial testing is ordinarily done by the Contractor in the course of erection.

(ii) Detail procedure for testing the equipment and lines shall be prepared by the Contractor and submitted to the Company for approval.

(iii) Water having quality which meets the Company’s approval shall be used for hydrostatic test purpose. In systems where residual moisture can’t be tolerated, e.g., in SO2, acid, ammonia and LPG service, and where certain catalysts are used, oil is the preferred test medium. If the water has to be used, the system should afterwards be dried out with hot air. Special attention should be given to the points where water may be trapped, such as in valve bodies or low points.

(iv) If for any reason it is not practical to carry out a hydraulic test, a pneumatic or partially pneumatic test may be substituted subject to prior agreement with the Company. Full details, including proposed safety precautions, will be required. The following are usually excluded from hydrostatic testing, and are usually tested with compressed air and soap solutions:

(a) Instrument air lines (test with dry air only, if possible).
(b) Air lines to air-operated valves (test with dry air only).
(c) Pressure parts of instruments in gas or vapor service.
(d) Piping in which supports are not designed for hydraulic test load.
(e) Refractory lined piping.

(v) When austenitic or austenitic stainless steel clad or Ni Alloy clad or lined equipment and piping are tested, the test fluid chloride ion content shall meet the following condition:

(a) If the piping and equipment metal temperature never exceeds 50°C during commissioning, operation or nonoperation, water containing up to 30 ppm (by mass) chlorides ion shall be used. The chlorides ion content might be increased up to 150 ppm (by mass) if the equipment or piping can be thoroughly washed out using water containing less than 30 ppm (by mass) chlorides ion as soon as testing is complete if allowed by the Company. In any case, the water shall be drained and the equipment thoroughly dried immediately thereafter. If the piping and equipment metal
temperature exceeds 50°C during commissioning, operation or nonoperation, the piping shall be tested using condensate water, demineralized water or oil with minimum flash point of 50°C.

(vi) The testing medium should not adversely affect the material of the equipment or any process fluid for which the system has been designed. Reference should be made to the applicable codes in the case of pressure vessels to determine the minimum ambient and fluid temperatures at which testing may be carried out. If it is desired to test vessels, tanks or piping at temperatures below 16°C, attention shall be made to the danger of brittle fracture occurring in carbon steels and ferritic alloy steels unless the materials have adequate notch ductility properties. For any equipment or piping, water should not be used for testing, when either the water temperature or the ambient temperature is below 5°C. Hydrostatic testing at temperatures below this value may be carried out using gas oil, kerosene or antifreeze solution at appropriate strength, provided that, the fluid used to be agreed with the Company. When flammable liquids including gas oil or kerosene are to be used, appropriate safety measures shall be observed and a work permit shall be required in line with organization's safety requirements.

(vii) Sea water shall not be used for the testing of equipment and lines on process Units and steam generating plants. Proposals for the use of sea water for the testing of storage tanks and offsite lines shall receive Company’s approval.

(viii) Hydrostatic test pressure shall be calculated in accordance with the code of construction.

(ix) Pressure gauge (s) used for monitoring the hydrostatic test pressure shall have a range of 1.5 to 4 times of the calculated test pressure.

(xi) During the hydrostatic test pressure with water the system loss should not exceed 2% of the test pressure per hour unless otherwise specified (no leak permitted during hydrostatic testing; Indicate the reference for 2% loss). Evidence of water at valves, flanges, etc. will indicate the leaking areas to be repaired if the system fails the test. All welds and piping shall be inspected for defects by looking for wet spots, therefore they should be tested before they are painted and/or insulated.

(xii) Vents or other connections shall be opened to eliminate air from lines which are to receive hydrostatic test. Lines shall be thoroughly purged of air before hydrostatic test pressure is applied. Vents shall be open when systems are drained so not to create buckling from a vacuum effect.

(xiii) Relief valves shall be removed or blinded prior to hydrostatic testing.

(xiv) After completion of hydrostatic testing, all temporary blanks and blinds shall be removed and all lines completely drained. Valves, orifice plates, expansion joints and short pieces of piping which have been removed shall be reinstalled with proper and undamaged gaskets in place. Valves which were closed solely for hydrostatic testing shall be opened. After lines have been drained with vents open, temporary piping supports shall be removed so that insulation and painting may be completed.

(xv) Extreme care shall be taken in field testing of heater and furnace tubes, which are normally field fabricated and shall be hydrostatically tested. Heaters which are not designed for hydrostatic testing or liquid draining shall be pneumatically tested, after erection as per OEM guidelines. Where possible, piping and heater tubes shall be tested together.

Heater tubes shall be tested to manufacturer’s recommended test pressure. Test shall be coordinated with heater erection Contractor.
(xvi) Vessels constructed in accordance with ASME Code Section VIII will not require individual pressure tests at site except in the following cases:
   
   (a) Vessels whose condition, resulting from transport, storage, handling, or for any other cause is suspect in the opinion of the Company.
   
   (b) Vessels which have had any site modification which in the opinion of the Company necessitate a site pressure test.

(xvii) With the exception of the relief valves, all valves and fittings should be installed on the vessels and included in the test. Relief valves shall be removed or otherwise isolated.

On satisfactory completion of a pressure test the vessel should be drained completely, any blinds inserted for test purposes removed and these joints remade to the satisfaction of the Company.

(xviii) At the conclusion of the test, the system shall be drained. If pumps have been included, they shall each be drained and refilled with oil to prevent rust forming in the seals. If fractionating columns are included, the water shall be displaced with sweet gas, nitrogen, or an inert atmosphere rather than air to avoid corrosion and sticking of the valves on the fractionating trays.

(xix) Provided manufacturers test certificates are available, only the following pressure tests should be carried out on heat exchangers except as required below:

   (a) On floating head shell and tube type exchangers, on tube side with bolted bonnets removed.
   
   (b) On tube-in-tube types, on both sides in conjunction with associated pipework.
   
   (c) On air-cooled types, the bundles are to be isolated and tested separately from associated pipework.

(xx) In the case of tubular exchangers whose condition, resulting from transport or other causes is suspect in the opinion of the Company, a pressure test on the shell side at least equal to the maximum allowable pressure should be carried out. Tests may be carried out individually or on groups of exchangers having similar operating conditions. Test pressure for shell and tube and air-cooled types should be not less than the maximum operating pressure in the tubes. For tube in tube types, the test pressure should be as for the associated pipework.

After completion of test all equipment shall be thoroughly drained and dried out to prevent scaling of tubes before commissioning.

After completion of test all bonnets and covers should be reinstated, temporary blanks removed and all joints remade to the satisfaction of the Company.

(xxi) All tanks shall have bottoms, shells and roofs tested in accordance with API 650 or API 620, latest edition, as applicable.

(xxii) The blow off (set) and blow down (re-seat) pressure of all relief valves should be set to the satisfaction of the Company. After approval of the Company, a seal to be fixed to each valve. The Company's inspector shall check each valve after it has been re-installed to ensure that its seal is intact.

Inlet lines to relief valves should be cleared before the valves are finally installed.

(xxiii) In case where the valve exhausts to a pressure system, the downstream side should be tested to a pressure equal to the test pressure rating of the outlet system.

(xxiv) Flame arrestors and other miscellaneous equipment that does not have test pressure indicated shall be isolated from the test.
Hydrostatic Testing of Instrument lines / connections:

(1) Certain types of instruments with their connecting process lead pipelines shall be tested at the same pressure as the main pipelines or the equipment to which they are connected. Such instruments normally include the following types:

(a) Displacer type level instruments.
(b) Gauge glasses.
(c) Rotameters.
(d) Control valves.
(e) Flow meter pots.

(2) Other types of instruments shall not be tested at line pressure, but shall have process lead lines tested to the first block valve or valves nearest the instrument. Care shall be taken that this equipment is protected by removal, or by blocking the instrument lead line and disconnecting or venting the instruments. These types will normally include the following:

(a) Analyzers.
(b) Diaphragm Type Level Instruments.
(c) Differential Pressure Type Flow Instruments.
(d) In-Line Type Flow Switches.
(e) Direct Connected Regulators.
(f) Open-FLOAT Type Level Indicators and Alarm Switches.
(g) Positive Displacement Type Flow Meters.
(h) Pressure Indicators Recorders and Transmitters.
(i) Pressure Switches.
(j) Pressure-Balanced Control Valves.
(k) Pressure Gauges.
(l) Turbine Type Flow Sensors.
(m) Lifting manways of storage tanks.

(3) Special precautions shall be taken to ensure that instruments and instrument lead lines to be tested are vented and completely filled before testing, and are thoroughly drained after test.

3.5.2 Flushing, Blowing and Shock Blowing: Responsibility should be with Entity and Contractor reference shall be removed

(a) Process lines shall be flushed after hydrotesting was done and supervised by commissioning personnel. The Contractor shall avoid over-pressuring lines, equipment or vessels and also avoid creating negative pressures.
(b) Where process compressors are intended to be used for air blowing of lines, the specification shall be checked to ensure that the compressor design will allow for this.
(c) Process lines if service for air, gas and steam shall be blown with air or steam. During this operation, all instruments shall be isolated, all orifice plates, flow meter elements, control valves and safety valves shall be removed. The flushing and blowing shall be carried out through both block valves and bypasses. Hydrostatic test water shall be drained thoroughly before air or steam blowing is carried out.
(d) The Contractor shall select the section of the systems for the flushing, blowing or shock blowing such that the lines in the selected section shall be thoroughly cleaned. The manual cleaning for the line shall not be allowed for the project. Where pipelines are made of stainless steel, duplex stainless steel or carbon steel with internal stainless-steel cladding, the requirements concerning chloride content in water shall be followed.

3.5.3 Precautions in processes using air

(Clarify the applicability of this paragraph with respect to pressure testing requirements)
In processes, like regenerative type Catalytic Cracking, Reforming, Bitumen Blowing and other processes requiring air, the addition of air should be carefully controlled such that the off gases form the process does not contain oxygen more than 0.5% volume.

Adequate safeguards should be provided to ensure that there is no undesirable run away reactions, explosions and other unsafe conditions.

Protective measures shall include a careful tie-in between hydrocarbon feed and oxygen supply rate to prevent the formation of explosive mixture. Also, the physical arrangement of vessel and piping should be designed to eliminate pockets where vapor can collect.

3.5.4 **Drying of the system / lines:**

Natural gas handling piping, vessels and equipment shall be dried to a water dew point of -22 °F (-30 °C) and inerted with nitrogen. The Contractor shall submit his procedure for this drying and inerting to approve with the mechanical completion plan document.

3.5.5 **Reinstallation after hydro-test / flushing:**

(a) All flushing loops shall be normalized as per the P&ID.
(b) Where specified by process conditions or process specifications, all lines and equipment within the process Units shall be dried and preserved under an inert gas.

3.5.6 **Records:**

The records for flushing and blowing to approve standards of cleanliness and restoration of plant condition to P7ID requirement shall be retained in each Systems Completion Manual.

3.5.7 **Cleaning Requirements:**

Carry out cleaning of the piping systems and equipment which calls for additional “Internal Surface Cleanliness Class” and “Special cleaning Methods” as per specific Inspection guideline/ standards, for example- Oxygen service piping & equipment.

3.6 **Development of Commissioning Plan:**

Commissioning is a verification process used to confirm that a facility has been designed, procured, fabricated, installed, tested and prepared for operation in accordance with design, drawing and specifications. In practice, the commissioning process comprises the integrated application of a set of engineering techniques and procedures to check, inspect and test every operational components of the project.

3.6.1 **Activities in commissioning:** First three activities below falls under pre-commissioning

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Activities</th>
<th>Constructors</th>
<th>Operations</th>
<th>PMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operational Tightness testing</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Flushing of Utility systems</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Loading of Desiccants and Catalysts</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Start-up/commissioning of major equipment</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Drying out and inerting</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument and electrical function testing</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Function testing of safety systems</td>
<td>Perform</td>
<td>Witness</td>
<td></td>
</tr>
</tbody>
</table>

3.6.1.1 Operational Tightness Testing / system integrity testing: these are the procedures included in regulations, we need to keep only critical requirements which shall be followed to avoid confusion.

3.6.1.2 Flushing of Utility systems / lines:

3.6.1.3 Commissioning of Major Equipment:

3.6.1.4 Instrument and electrical function testing:

This part shall be performed jointly by Operations, maintenance, inspection and the vendors in line with the standard guidelines or specified by the vendors.

3.6.1.5 Function testing of safety systems:

This part shall be performed jointly by Operations, maintenance, F&S and the vendors in line with the standard guidelines or specified by the vendors.

3.6.2 General commissioning activities before commissioning of main process systems:

Following Auxiliary systems shall be commissioned and in operation prior to the commissioning of the main process unit.

(a) Flare system  
(b) Cooling Water system  
(c) Steam Network / system  
(d) Instrument Air system  
(e) Electrical system  
(f) Fuel Gas system  
(g) Fuel Oil System  
(h) Flushing Oil system.  
(i) Plant Air system  
(j) N2 system  
(k) CBD/SWS System  
(l) Fire water system and fire-fighting system  
(m) Communication system

3.7 Standard Operating Procedures (SOP):

(i) The most important part of any facility’s technical documentation shall come in the form of Standard Operating Procedures (SOPs). Operator error is the most common type of mishap at industrial facilities, as well as many other technical industries. Operators who use the SOPs will know exactly what is expected of them to properly conduct their job duties.

(ii) Standard Operating Procedures should be formatted similarly so that each SOP maintains consistency throughout the facility. Each SOP should be designed with input from experienced Operators that have performed the associated task or operation successfully in the past. It is
important to ensure that the SOPs that are used are accurate and easy to follow. Frequently used SOPs should be given formal reviews periodically to ensure that any changes to how the plant is being operated, is properly reflected and incorporated into the SOP.

(iii) Effective SOPs that are diligently used by operators may be the driver for the next step change in process safety in the industry.

(iv) A SOP shall cover following aspects:

(a) SOP shall be prepared by the experienced personnel in line with the design, standards and vendors specifications.
(b) SOP shall be checked and approved by the higher management before being followed.
(c) Description of the system being handled
(d) Detailed Operating procedural steps along with precautions
(e) Handling in case of emergency situation
(f) Additional precautions whenever required
(g) SOP shall be updated regularly incorporating the previous experiences and recommendations
4.1 Asset Integrity Management System (AIMS)

Asset integrity management (AIM) is a management system for ensuring the integrity of assets throughout the life cycle of the assets. In this context, an asset is a process or facility that is involved in the use, storage, manufacturing, handling or transport of chemicals, or the equipment comprising such a process or facility.

AIM is a product of many activities, usually performed by many people. When these activities are done well, AIM can provide the foundation for a safe, reliable facility that minimizes threats to the workforce, the public and the environment.

4.2 Introduction

AIM programs vary according to geography and plant culture in addition to industry, regulatory requirements. However, entity shall include following minimum characteristics in AIM programs. Entity asset Integrity program should ensure that assets are designed, procured, fabricated, installed, operated, inspected, tested and maintained in a manner appropriate for its intended application. Entity Asset Integrity program should,

- Clearly designate assets to be included in the program based on defined criteria.
- Encourage plant staff perform planned maintenance and reduce the need for unplanned maintenance.
- Support plant staff recognize when equipment deficiencies occur and include controls to help ensure that equipment deficiencies do not lead to serious incidents.
- Applicable codes, standards and other recognized and generally accepted good engineering practice (RAGAGEP).
- Help ensure that personnel assigned to perform AIM activities are competent and have access to appropriate procedures for these activities.
- Maintain service documentation and other records to enable consistent performance of AIM activities and to provide accurate asset information to other users, including other process safety and risk management elements.

4.3 Management Responsibility

In successful AIM programs, supervisors and managers emphasize how each person contributes to preventing incidents and improving process reliability.

AIM shall be best directed and controlled at the corporate level to ensure consistent implementation and to help establish a positive process safety culture, whereas execution should be the operating facility’s responsibility. A good practice is to establish an AIM corporate center of excellence. Corporate AIM center should establish corporate AIM standards and drive efforts to continuously improve the safety and reliability of facility assets. Corporate AIM program should include Roles and responsibility matrix.

4.4 AIM life cycle

Although the primary activities associated with managing asset integrity are during a facility’s operating phase, decisions affecting AIM should start at the earliest design stages and AIM should not end until the final decommissioning of facility assets. The activities related to AIM should be commensurate with different stages of facility’s life cycle. Entity Asset lifecycle management should,

1. Define the requirements to be achieved by the assets.
2. Design and build integrity into new and modified assets.
3. Maintain the integrity of the assets throughout the facility lifetime.
4. Detect and correct deficiencies and failures that occur during operation.
Asset Integrity Management life cycle stages should include,

**Facility Life Cycle Stages**

1. **Research**
2. **Concept Design**
3. **Process Development**
4. **Process Design**
5. **Operations**
6. **Decommissioning**

**Research through Process Design**

### 4.4.1 Research through Process Development

Although managing asset integrity is centered on the operating phase of a facility’s life cycle, decisions should be made at the earliest life cycle stages that should have a profound effect on an AIM program. Opportunities are best taken at the research; development and design stages to choose options that will make the need less demanding for ongoing containment and control of hazardous materials and energies. As the developmental phases progress, AIM philosophies and then technical specifications that address integrity (such as materials of construction, code selection, etc.) should be established before detailed engineering can progress.

**Inherently Safer Design.** Inherent safety reviews, should be performed early in a facility’s life cycle as well as at later stages. The primary decisions related to inherent safety at these early stages are associated with selection of process materials and chemistry.

**Establishment of AIM Program Requirements.** The best time to define requirements to be achieved by the new or updated facility’s assets is before the start of the process design. Activities at this point include developing the organization’s AIM philosophies and top-level program documentation, followed by technical specifications such as selection of applicable codes and standards and materials of construction. AIM program requirements should be established before the start of the detailed engineering.

### 4.4.2 Process Design

Inherent safety reviews and consideration of inherent safety principles should continue during process design. The primary decisions related to inherent safety during process design are associated with reducing hazardous material inventories, simplifying the process equipment and designing to operate closer to ambient conditions.

**Reliability in Design.** The process design can have a profound effect on the reliability of facility assets. The design stage is the primary opportunity a facility has to “build in” reliability to assets. After startup, during the operating phase, AIM shall be focused on preserving this fundamental designed-in reliability. Building reliability into facility assets at the design stage can have additional benefits besides improved reliability once the facility is in operation.

**Process Safety in Design.** Many of these design elements related to process safety shall be identified and managed within the AIM program as safety-critical equipment. They shall not only be relied upon to prevent or mitigate a major incident, but also to survive an initial fire or explosion and still perform its critical function.

**Design Documentation.** Entities shall develop and maintain accurate and complete design documentation. This knowledge base should be used for performing process hazard analyses, for developing standard operating and maintenance procedures, for upgrading facilities and managing
change, and for supporting ongoing AIM activities such as generating baseline test data, performing preventive maintenance, and correcting deficiencies and failures.

4.4.2.1 Procurement and Construction

During the engineering, procurement and construction life cycle stages AIM should,

- Ensure the process and its associated assets are properly designed to ensure a safe and reliable operating facility,
- Construct facility in a manner that is consistent with the design specifications and readies the facility for managing asset integrity when started up and operating.

Entity shall ensure that, final as built plant, including instrumentation, controls and supporting facilities, fully meets appropriate design specifications and has the asset information documented in such a way as it can be effectively used for ongoing AIM. Entity shall maintain the design documentation provided by the manufacturer. The Documentation should cover:

i. Manufacturer’s recommendations for periodic inspection/ testing/ maintenance of equipment supplied by them.
ii. Deviation from the inspection procedure as recommended by manufacturers with proper justification.

4.4.2.2 Commissioning

The commissioning stage of a facility’s life cycle involves the final preparation activities involving newly constructed or modified assets in making the transition to an operating facility. Commissioning involves not only the physical assets (including auxiliary equipment and functions) but also the operating and maintenance personnel and the facility documentation and written procedures.

Commissioning is a planned, deliberate sequence of steps that may have certain “hold points” to ensure everything is prepared, documented, consistent with the intended design, and working properly (such as the functionality of instrumented protective systems) before proceeding. Entity shall develop checklists for Pre start up Safety Review (PSSR) to ensure all planned commissioning steps relevant to assets or group of assets are completed.

Operational Readiness Review. One of the final opportunities to identify integrity issues before introducing hazardous materials into a process is during an operational readiness review, also known as a pre-startup safety review (PSSR).

Entity should consider requiring a QA review as part of operational readiness activities. During the QA review, the installed equipment should be compared to the design documentation, and any project-specified installation requirements should be verified. Upon completion of the QA review entity should,

1. Document any discrepancies between design and installation
2. Evaluate whether each discrepancy is tolerable (this evaluation can be similar to a change review process)
3. Make necessary corrections prior to equipment startup
4. Document the as-built condition and closure of any identified items.

4.4.2.3 Selecting and Applying RAGAGEP at each stage

RAGAGEP is an acronym for “recognized and generally accepted good engineering practice,” RAGAGEP stems from the selection and application of appropriate engineering, operating, and maintenance knowledge when designing, operating and maintaining chemical facilities with the purpose of ensuring safety and preventing process safety incidents. RAGAGEP can be derived from singular or multiple sources and will vary based upon individual facility processes, materials, service, and other engineering considerations.
All repairs and changes shall preserve the integrity of the equipment and should comply with the original equipment specification/RAGAGEP. Changes, which do not preserve the original specification (even if conforming to RAGAGEP), shall be approved under MOC procedures.

4.4.2.4 Asset Performance Management

Entity must develop program for Asset Performance management. The program should consist of four stages which defines the complete life cycle of assets in manufacturing. The four stages should include the develop stage, manage stage, execute stage and evaluate stage of an asset. Implementation of these stages forms a continuous improvement loop, which consequently ensures that optimal strategies are always in place.

**Develop stage:** In this stage, the asset strategies are defined with an emphasis on risk mitigation. Focusses on how asset fail, the risk and impact of the failures and what is to be done on the asset to mitigate these failures. The typical methodologies are based on industry standards that includes Reliability Centered Maintenance (RCM), Failure Modes and Effects Analysis (FMEA), Risk Based Inspection (RBI), Safety Instrumented System Life Cycle Management (SLCM) and Strategy Analysis.

**Manage Stage:** The output of the develop stage are utilized in this stage to develop best practices to be applied on large population of asset class as well as management of updates and revisions to best practices overtime. The Manage Stage also includes key functions to implement the asset strategy within one or many strategy execution systems such as Condition Monitoring (CM), Condition Assessment, Process Historians and Engineering systems (for re-design recommendations).

**Execute stage:** In this stage, the implementation strategies are built for business benefit of an asset. The strategies should include time as well as condition based activities to be performed on the asset. This stage should also captures the documentation of the activities resulting into event recording for future references.

**Evaluate stage:** Entity should put in place the process for evaluation of asset performance and strategies overtime. The evaluation outcomes should act as feedback and recommendations for develop and manage stages so that optimal strategies are in place through continuous improvement.

4.4.3 Operations and Maintenance

Managing asset integrity during the operational phase of a facility’s life cycle shall include following aspects:

- Safe starting up of facility to the authorized procedures to protect the integrity of assets.
- Operating the facility within its intended design parameters.
- Recognizing deviations from the intended integrity operating window and properly responding to these deviations.
- Performing regular preventive/predictive maintenance tasks on schedule and tracking/trending results.
- Monitoring the condition of assets by inspections, tests, condition monitoring and performance monitoring as required.
- Executing transient operations such as shutdowns and restarts in a manner such that asset integrity is not compromised or weakened.
- Successfully managing changes to the facility, including not only changes to equipment but also to utilities and support facilities, personnel, technology, procedures, chemicals and feedstock.
- Detecting latent safeguard deficiencies and failures by inspections and functional tests.
- Detecting primary containment system deterioration by inspections and tests.
- Correcting deficiencies and failures as they arise using proper spare and replacement parts and restoring the system to its fully functional state.

Mechanical integrity program should assure continued integrity of process equipment. The appropriate working procedures, methods and techniques should be used, which are considered
most fit for the purpose and in line with the codes and practices. Elements of mechanical integrity program should include:

(a) Identification and categorization of equipment and instrumentation, inspection and tests, training of inspection personnel, testing and inspection frequencies, development of maintenance procedures, the establishment of criteria for acceptable test results, documentation of test and maintenance results, and documentation of manufacturer recommendations as to meantime to failure for equipment and instrumentation.

(b) The information pertaining to process equipment design should be documented so as to identify the codes and standards relied on for establishing good engineering practices.

(c) Documented system to confirm that equipment complies with recognized and generally accepted good engineering practices.

(d) Equipment designed and constructed in accordance with codes, standards or practices that are no longer in general use, it should be determined and documented that the equipment is designed, maintained, inspected, tested and operating in a safe manner.

4.4.3.1 Inspection, Testing and Preventive Maintenance

Entity shall develop and implement an inspection, testing and preventive maintenance (ITPM) program. ITPM program activities might cut across more than one part of an organization. For example, an Inspection Department may perform inspections and tests while the Maintenance Department carries out preventive maintenance tasks.

Entity ITPM program should address the situations during the operating and maintenance life cycle stage because of potential for degradation of assets over time due to age-related mechanisms such as corrosion, erosion, fatigue and embrittlement.

Each entity shall,

- Develop and implement an inspection, maintenance and turnaround strategy to manage identified risks and deliver availability in line with the entity business strategy. Include inspection, maintenance and turnaround actions in the annual plan.
- Implement and maintain an inspection program to determine the condition of safety and production critical equipment and systems, and verify and document they are fit for service. Verify that deficiencies identified from the inspection program are investigated and corrected on a timely basis.
- Implement and maintain a maintenance management system to plan, schedule, and resource and record the results of inspection and maintenance work.
- Evaluate inspection program results and maintenance regimes, and modify the programs to take account of the risk of equipment and system failure.
- Implement and maintain a process to verify that equipment replacement or modification maintains operating integrity.
- Verify equipment that has been out of service is fit-for-service prior to use.

4.4.3.2 Maintenance Procedures:

The maintenance programs and schedules should be reviewed and analyzed to see if there are areas where break down maintenance is used rather than an ongoing mechanical integrity program consisting predominantly of preventive & predictive maintenance.

(i) The maintenance procedure should address to the safety aspects with regard to organization of maintenance (system of work permit and non-routine work), determining whether execution should be on line/off-line, regulations to be followed, harmonizing with operation, incident reporting system, maintenance analysis, do it oneself or contract out.
(ii) Use of personal protective equipment should be laid down for specific maintenance activities.
(iii) The task, role and responsibilities should be defined.
(iv) Records of trend analysis of machine and equipment should be taken into consideration.
(v) All maintenance procedures should be duly authorized.

4.4.3.3 Inspection and Test Results: (Please refer Schedule VII for additional requirements)
Inspection programme should cover the following:

(a) Each inspection and test performed on the process equipment shall be documented.
(b) The list of process equipment, components, instruments should be made for inclusion in the mechanical integrity/ maintenance program.
(c) The documentation should identify the date of inspection or test, the name of the person who performed the inspection and test, the serial number or other identifier of the equipment on which the inspection and test was performed, a description of the inspection or test performed and the results of the inspection or test.

4.4.3.4 Criteria for Accepting Equipment after Maintenance:

Following considerations should be taken into account while accepting equipment after maintenance:

(i) Equipment that has been out of service for maintenance should be taken over after due testing and documentation.
(ii) Criteria for acceptance of test results should be well defined taking into consideration RAGAGEP, manufacturer's recommendation, anticipated life and operating conditions.
(iii) Any deviation accepted should be approved by competent person.
(iv) Equipment deficiencies which are outside acceptable limits shall be corrected before further use or corrected in safe and timely manner with alternate measures to assure safe operation.
(v) Proper records for handing / taking over of equipment to be maintained.

4.4.3.5 Quality Assurance:

Entity Quality assurance program should follow a life-cycle approach encompassing quality from the time the asset is designed until the time it is taken out of service. The program shall ensure that,

i. The equipment fabricated is suitable for the process application for which they will be used.
ii. The equipment is installed properly and consistent with design specifications and the manufacturer's recommendations.
iii. The quality assurance system is defined to help that the proper materials of construction are used,
iv. The maintenance materials, spare parts and components are suitable for the equipment for which they will be used.
v. 'As built' drawings, together with certifications of coded vessels and other equipment and materials of construction are verified and retained in the quality assurance documentation.
vi. Use of appropriate gaskets, packing, bolts, valves, lubricants and welding rods are verified in the field and documented.
vii. The procedures for installation of safety devices are verified such as torque on the bolts on rupture disc installations, uniform torque on flange bolts, proper installation of pump seals etc.
viii. Any change in equipment that may become necessary will need to go through the management of change procedures.
ix. Calibration / standardization of all equipment required for fabrication.

4.4.3.6 Management of change:

i. Risks associated with any planned change, permanent or temporary that can have an impact on achieving the asset management objectives, shall be assessed before the change is implemented.
ii. The entity shall ensure that such risks are managed in accordance With established risk management processes.
iii. The organization shall control planned changes and review the unintended consequences of changes, taking action to mitigate any adverse effects, as necessary.

4.4.3.7 AIM Training and Performance Assurance

An important ingredient of an effective asset integrity management program is personnel competency, achieved in part by training and performance assurance. Entity shall develop and
implement a program for training to ensure that only qualified personnel develop and perform AIM tasks and that AIM tasks are performed appropriately and consistently; i.e. with fewer opportunities for human errors. Reducing human errors can greatly reduce the overall rate of asset failures. Following aspects of training should be considered for ensuring competent workforce is deployed:

- Management awareness training
- Skills/knowledge assessment
- Training for new and current workers
- Verification and documentation of training effectiveness
- Certification, where applicable
- Ongoing and refresher training
- Training for maintenance technicians and for operators performing maintenance tasks
- Training for technical personnel
- Roles and responsibilities.

4.4.4 Decommissioning

Entity should define process of decommissioning during late-life operation and maintenance. Entity should develop the procedures for decommissioning of the facility. This should include a review of all critical assets, along with their reliability and associated maintenance requirements. Entity should define a risk-based approach to review of both preventive and corrective maintenance associated with each asset and system that has strategic input to decommissioning planning. This should involve an assessment of the reliability of critical assets that are required to be functional during decommissioning.

Potential for Re-use of Assets. Any equipment that is not removed and disposed of upon decommissioning might potentially be re-used. “Mothballed” units and “boneyards” present opportunities for saving money. However, they also present significant AIM challenges. Entity shall establish decommissioning and recommissioning procedures specific to the assets. A decommissioning procedure should consider depressurization and cleaning of equipment, additional measures for equipment preservation, and any ongoing inspections and/or preventive maintenance (PM) activities that need to be performed to maintain assets in a state of readiness or near-readiness. Equipment on its way to the warehouse shall be labeled or tagged. Units that are mothballed for re-use at a later date (e.g., seasonally operated equipment) should have procedures to ensure that liquids are drained, systems are purged and other measures are taken to help preserve equipment life (e.g., maintaining a proper atmosphere to prevent corrosion) and protect the safety of personnel and contractors from hazardous materials and energies and unsafe atmospheres inside equipment.

Definition of ITPM Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection</td>
<td>Assessing the current condition and/or rate of degradation of assets</td>
</tr>
<tr>
<td>Testing</td>
<td>Checking the operation/functionality of assets. Includes proof tests, which are the exercising of passive (standby) systems.</td>
</tr>
<tr>
<td>Preventive maintenance</td>
<td>Maintenance that seeks to reduce the frequency and severity of unplanned shutdowns by establishing a fixed schedule of routine inspection and repairs</td>
</tr>
<tr>
<td>Inspection, testing and preventive maintenance (ITPM)</td>
<td>Scheduled proactive maintenance activities intended to (1) assess the current condition and/or rate of degradation of assets, (2) test the operation/functionality of assets, and/or (3) prevent asset failure by restoring asset condition</td>
</tr>
</tbody>
</table>
5.0 Electrical Systems

5.1 Design Philosophy

i. The selection of electrical equipment and systems shall be governed by fitness for purpose, safety, reliability, maintainability, during service life and compatibility with specified future expansion, design margins, suitability for environment, economic considerations and past service history.

ii. The design and engineering of the electrical installation shall be in accordance with established codes, specifications, sound engineering practices and shall meet the statutory requirements and local regulations.

iii. Electrical equipment and materials shall comply with their relevant specification, Data sheet and Project Specification and the latest edition of the codes and standards (including any amendments) applicable shall be followed.

iv. All Electrical equipment, systems and their installation shall be designed for operation under site conditions as required.

v. All equipment and materials shall be suitable for operation in service conditions typical of refineries and Gas processing plants within a coastal environment in the tropics.

vi. VFD & UPS Room shall be air-conditioned to increase reliability of heat sensitive electronic component like semi-conductor devices, Transducers, Cards for inter electronic equipment communication etc. Switchgear Room shall be force ventilated or airconditioned.

vii. Battery Room shall be ventilated with minimum two nos. Exhaust Fans. However, failure of cooling or ventilation shall not affect the operation of the equipment.

viii. VRLA battery room shall be air conditioned to maintain specified temperature.

ix. For the purpose of electrical earthing calculations (soil electrical resistivity) and cable rating calculations (soil thermal resistivity) the data of the area shall be used.

x. There shall be classified for the degree extent of hazard from flammable materials. Classification of hazardous areas for all areas shall be done as per guidelines indicated in latest IS 5572 and equipment selection for hazardous area shall be as per IS 16724/IEC 60079-14. All electrical equipment in hazardous area shall be minimum suitable for Zone-2 Gas Group IIA/IIB, Temperature class T3.

5.2 System Design

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

i. The design of electrical system for refineries and Gas processing plants facility shall include the following:

   a. Site Conditions
   b. Details of Power source
   c. Planning and basic power distribution system and single line diagram
   d. Protection / metering / control
   e. Electrical Substation design for New Substation
   f. Electrical equipment design
   g. Illumination System
   h. Earthing system
   i. Lightning protection system
   j. Electrical equipment for hazardous area
   k. Statutory approvals
   l. Cable sizing
   m. Emergency power sizing
   n. Power system studies
   a. Heat tracing system as applicable
b. 24V,230V,415V power output system

d. Underground and above ground including cable tray support and routing through pipe racks / sleepers.

iii. The designed electrical system shall facilitate and provide:

- a. Standard products applications
- b. Safety to personnel and equipment
- c. Reliability of services
- d. Constructability access
- e. Cabling access
- f. Minimum fire risk
- g. Cost effectiveness
- h. Ease of maintenance and convenience of operation

iv. Adequate provision of changes during design development and for future expansion and modification (as appropriate engineering margins or space provisions)

v. Automatic protection of all electrical equipment and isolation of faulty system through selective relaying systems or intelligent control devices.

vi. Remote control and monitoring facilities & interfacing for selected devices with other discipline systems.

vii. Lock out Tag out (LOTO) provisions for all LT & HT Feeders.

viii. Maximum interchangeability of equipment.

5.3 Power System Studies

Power system study/calculation shall be carried out to substantiate the selection and sizing of all electrical facilities and equipment in the refineries and Gas processing plants facilities. Study should include minimum but not limited the following as applicable:

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

5.4 Power Supply

5.4.1 Main Power Sources and Systems:

The main power source shall be captive power generation or grid power supply or combination of both. The voltage level of proposed primary distribution system shall be decided based on plant generation, respective grid supply level and total load envisaged on the plant. The number and schemes of indoor switchboards shall be governed both from considerations of power distribution capacity and also from considerations of process loading under abnormal plant operating conditions.
5.4.2 Plant Emergency Power Sources and Systems

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

Critical / Emergency / Normal loads shall be determined based on hazard analysis and/or safety reviews during the process design. DC lighting or AC lighting having DC battery back-up fed through lighting inverter for control room, substation, escape routes shall be provided. DG sets shall be provided for feeding emergency power supply.

5.5 Power Distribution

5.5.1 General

a. A load summary shall be prepared for recording and calculating the electrical loads of the refineries and Gas processing plants facilities. The load summary shall indicate continuous, intermittent and stand by loads.
b. This shall be used to verify the rating and numbers of transformers, switchgears etc. The current rating of switchboard bus bars shall also be determined accordingly.
c. Where secondary selective systems are provided, each transformer/incomer shall be rated in accordance with the above.

5.5.2 Main Power Distribution

a. A substation shall be built at the site to cater all load ( e.g. the storage tank and plant) requirement.
b. It should be provided with dual redundant power supply from, in its each Bus sections "A" & "B". Two incomers and one bus-coupler system with 100% redundant capacity for incomers shall be considered for all HT switchboards and PCCs.

5.6 Sub-Station Design

5.6.1 General

a. The substation shall be located in a safe area and outside the risk zone. Consideration shall be given to vehicular traffic or any other factor that might affect the operation of the substation.
b. Substation buildings switchgear room should be Airconditioned and shall comprise elevated structures permitting the use of bottom entry switchgear with cable cellar for cable racking and trays below. MCC room building should be single floortype without cellar with pressurized switchgear room. The floor level of the MCC room shall be 1500mm above surrounding grade level.
c. Sub-station can also be provided without cable cellar with battery trenches similar to MCC room.
d. In large plants, the main sub-station floor shall be raised above grade level and the space below the sub-station floor shall be utilised for installation of cable trays. The substation cellar shall preferably have a clear minimum height of 3 meters. The cable cellar floor shall be at least 300 mm above the approach road level. The switchgear rooms should be Airconditioned/ pressurised to prevent ingress of dust & to prevent or to make more reliable heat sensitive electrical Equipment & Panels . Large substation (length greater than 60 meters) shall have three entries, one for equipment entry, second for normal entry and the third emergency exit. Whereas required normal and equipment entries can be combined. The substation shall also have an emergency door opening outward.
e. Push button shall be provided in each transformer bay for tripping of the transformer feeder breaker.
f. HVAC or Air Conditioning System of substation shall trip on activation of fire and gas detection signal. Flooring to the Battery room and walls up to 1.0 m height shall have acid / alkaline resistant protective material coating/ tiling.
g. Luminaire, receptacles, exhaust fan etc. in Battery Room shall be Ex-d, IIIC, T3 Type of protection.
h. Substation shall have firefighting equipment, first aid boxes and other safety equipment as per statutory requirements. Mats of required voltage rating shall be provided around all indoor switchgears and panels and suitable voltage rated overshoes should be used for outdoor switchgears and panels wherever insulation mats cannot be provided.
i. The substation building shall be sized for housing all equipment like transformers, switchgears, capacitors etc. The substation shall be sized to maintain adequate clearances between equipment as per CEA guidelines.

5.6.2 Transformer Bay Layout

Oil filled transformers shall be located at grade level in fenced enclosures adjacent to the substation building and shall be provided with oil containment pits which shall be connected to the Common Oil soak pit if envisaged as per IS. This shall be located outside transformer bay. Firewalls shall be provided where required by codes and standards.

5.7 Hazardous Area

5.7.1 Electrical Equipment Selection in Hazardous Area

a. Electrical equipment shall meet the selection requirements of the Indian Standard :16724/IEC 60079 part 14- Guide for selection of electrical equipment for hazardous areas All the electrical equipment installed in hazardous area shall meet the requirements of relevant IS or IEC or CENELEC standards, whichever is followed for design for electrical systems.

b. All electrical equipment for hazardous area shall be certified by CIMFR, PTB, BASEEFA, UL, ATEX or FM or equivalent independent testing agency for the service and the area in which it is to be used. All indigenous flameproof equipment shall have BIS license. PESO approval shall be obtained for equipment installed in hazardous areas for both indigenous and imported equipment.

5.8 Equipment

5.8.1 Switchgear/Motor Control Centres/ LV Distribution Boards

a. These shall be designed to ensure maximum safety during operation, inspection, connection of cables and maintenance with Switchboards energized.

b. The switchboard shall be totally enclosed, dust and vermin proof.

c. Lighting and small power distribution boards shall be suitable for indoor or outdoor use and the hazardous area classification in which these are to be installed.

d. Automatic motor re-acceleration/restarting following voltage dips shall not be provided unless specifically warranted by process requirements.

e. Power system monitoring, control and protection philosophy shall be in accordance with project specifications Emergency Shut Down (ESD) systems and emergency stops shall be hard wired back to the switchgear/MCC.

f. Transformer incomer shall be rated at least equal to forced cooled rating of transformer or 110% of ONA N rating as applicable.

g. Interlocks and protection as per CEA guidelines shall be provided.

5.8.2 Protective Relays

a. Protective relays for all types of feeders i.e. incoming feeders, buss ties and motors power feeders, capacitors etc. shall be provided.

b. Meters. Protection relays and other components shall be as per relevant metering and protection diagrams and designed and procured as per project specification.

c. The protection relaying philosophy for 132KV and above systems shall also include suitable main and backup schemes.

5.8.3 Power and Distribution Transformers, Lighting Transformers

a. The cooling arrangement of all power transformers shall be ONAN/ONAF with the possible exception of the main generator step-up transformers which will have cooling requirements as specified on the relevant data sheets.

b. The distribution transformers shall be ONAN type.
c. Automatic on-load tap changer (OLTC) shall be provided on the main power transformers as required. Lighting transformers shall be Dry type, Air cooled mounted indoor.
d. For harmonic mitigation, use of transformers with special vector groups may be considered for supplying large non-linear loads as VSD’s and process heaters.
e. All transformers with oil capacity more than 2000 liters shall be provided with firefighting as per IS/IE rules or with nitrogen injection fire protection system.

5.8.4 Emergency Diesel Generators:
i) The emergency generating sets shall form a complete package and shall be designed to start automatically on power failure and feed the selected loads. It shall be capable of taking care of the load variations (e.g. the starting of largest rated motors on a preloaded system). The unit shall be complete with necessary starting equipment, associated control panel.

ii) Emergency DG set shall have Auto starting arrangement but only with manual switching off features. The rating (Ampere Hours) of battery, for cranking the engine shall be adequate to make three attempts with an interval of 5 to 10 seconds, if required.

iii) The generator set shall be provided with complete protection against overloads, short circuits, ground faults, excitation failure, prime-mover failure and shall include other connected instrumentation interlocks.

iv) Diesel Engine installation, does not call for Area Classification, provided the DG room is properly ventilated. Normally the ventilation provided to remove heat from the radiator is adequate to take care of the hazard aspect. DG sets shall comply with the latest guidelines of environment ministry with regard to noise levels and stack height requirements.

5.8.5 Neutral Earthing

(1) Earthed System

i) Power system neutral shall be earthed:
   a) To limit the difference of electric potential between all uninsulated conducting objects in a local area.
   b) To provide for isolation of faulty equipment and circuits when a fault occurs.
   c) To limit over voltages appearing on the system under various conditions.

ii) The neutral earthing system employs one of the following methods:
   a) Solid earthing for low, medium voltage system (upto 650V) and for high voltage above 11 kV.
   b) Resistance / Impedance earthing for 3.3 kV to 11 kV system.
   c) Resistance/Neutral Grounding Transformer earthing for Generators.

iii) The values of neutral earthing resistors normally applied in industrial power system are selected to meet the governing criteria for limiting transient over-voltages, i.e. earth fault current should not be less than the system charging current. Besides, the value of neutral earthing resistor selected shall limit the earth fault current to a value, which shall be sufficient for selective and reliable operation of earth fault protection system.

   iv) The neutral earthing resistor shall be able to carry at least 10% of its rated current continuously, unless otherwise required, and full rated current (100%) for a minimum duration of 10 seconds.

(2) Unearthed System

i) Use of unearthed system should be avoided since arcing ground faults can result in severe over voltages.

ii) Where unavoidable (such as expansion projects where existing systems have unearthed system) unearthed system shall have provision for detecting earth fault and for isolation of faulty section through the use of core balance current transformers. The current transformers (CTs) shall be sized in relation to the system capacitive currents arising due to distributed capacitance of the entire network.
The system shall also include alarm/tripping provision using unbalance voltage sensing through open delta voltage transformers (VTs) under earth fault conditions. Provision of 'on line insulation monitoring facilities' may be considered.

5.8.6 DC Supply Units

i) Each DC power supply system shall include redundant charger-cum-rectifier, battery and DC distribution board. DC link in the UPS system shall not be tapped for DC instrumentation power supply except in rare circumstances.

ii) A 2 x 50% battery bank configuration should be provided.

iii) Fire alarm system shall have a dedicated DC battery backup system.

**Battery Sizing for DC systems**

a. Electrical Switchgear and Controls

i) Battery shall normally be sized for a load cycle having a minimum duration of two hour. While deciding the load cycle, consideration shall be given to the specific operating/safety requirements of plant & equipment e.g. lube oil pump of STG for bearing oil flushing. The duration for battery sizing hence shall vary accordingly as per specific operational requirements.

b. DC Instrumentation Shutdown System

This shall in general be sized for 30 minutes, unless otherwise required.

c. Critical Lighting This should be sized for two hours unless specified otherwise.

d. Battery shall be Nickel Cadmium/flooded electrolyte Lead Acid/VRLA type designed as per design specifications.

5.8.7 Equipment for Uninterrupted Power Supply System

i) UPS panel shall be of free-standing, floor mounted, metal enclosed and vermin proof type having hinged door for front access and suitable for indoor use.

ii) Under normal conditions, the rectifier-cum-charger shall feed the inverter and charge the battery set. In case of mains failure, the battery shall supply the necessary power to the inverter. The inverter in turn feeds the load through the static switch. If the inverter malfunctions or is overloaded, the load shall be instantaneously transferred to the by-pass line through the static switch. The inverter shall be operated in synchronised mode with the by-pass line, and manual forward transfer or manual reverse transfer shall be effected without any break. Battery for UPS system shall be sized for 30 minutes unless otherwise specified.

5.8.8 Alarm Annuciations

All electrical fault, tripped, alarm and equipment malfunction signals from the communicable relays should be accessible via a computer connected to the communication port in each switchgear/PMCC. In addition, certain signals shall bring up alarms/indications in a Central Control Room (CCR) or in the DCS as specified.

5.8.9 Variable Frequency Drives

i. Low & high voltage variable frequency drive (VFD) equipment shall be in accordance with design project specifications.

ii. The requirement of variable frequency drives shall be considered based on an economic and technical basis subject to process requirements.
iii. Converter and rectifier equipment controlling plant motors shall be located inside the substation, except the associated transformers and reactors, which shall be located within the substation building next to VFD panels. For very large rated VFD, the transformer and/or reactor should be located in outdoor transformer bay.

5.8.10 Motors

i. LV motors shall be selected to have ratings in accordance with the preferred rated output values of the primary series as listed in IEC 60072 and IS 325. The enclosure of motors and motor control station shall be in accordance with the hazardous area classification and equipment selection in hazardous area.

ii. All LV motors shall comply to IE2 Class of efficiency unless otherwise specified in Motor Datasheet.

iii. Motor operated valves and electric cranes shall be fully equipped with integral motor control gear.

5.8.11 EARTHING SYSTEM

i) Earthing system shall provide low impedance earth paths for earth faults, static discharge and lightning protection. Earthing design shall generally be carried out in accordance with the requirements of CEA Regulations 2010 and code of practice for earthing IS 3043.

i. Power system earthing, lightning protection and equipment bonding shall be achieved by overall common earthing system. All units shall be bonded together to form a single continuous earthing system. All equipment in refineries and Gas processing plants shall be connected with Plant earthing system as per CEA guidelines.

ii. The metallic enclosure of all electrical equipment shall be bonded and earthed to the common earthing grid.

iii. In hazardous areas or where the equipment contains a hazardous liquid, the metallic enclosures of non-electrical equipment, vessels, tanks, structures, pipeline, etc shall be bonded and earthed to the common plant earthing grid. Maximum values of resistance of equipment earthing system to the general body of earth shall be as under:

   (a) General Earthing Grid: 1 ohm
   (b) Earthing for Lightning Protection & Static Bonding: 10 ohms

iv. Earthing of lighting and small power systems shall be by means of an earth conductor integral with the cable.

5.8.12 Instrument earthing

Separate earth bars above ground shall be provided for Instrument earthing.

5.8.13 Lightning Protection

Lightning protection shall be provided as per IEC 62305 or IE rules.

5.9 Lighting System

5.9.1 General Lighting

This can be broadly classified as under:

i) Normal lighting
   ii) Emergency lighting
iii) Critical lighting

i) Normal and emergency lighting system shall be on AC supply, whereas critical lighting shall be on DC.

ii) Sufficient lighting shall be provided so as to enable plant operators to move safely within the accessible areas of plant and to perform routine operations. In the event of normal power failure, emergency lighting should be provided. Desired lux level shall be achieved considering that both the lighting fixtures, normal as well as emergency one are energised. In the event of normal power failure, emergency lighting shall remain energised through emergency power source.

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 plant.
   b) To gain access and permit ready identification of fire fighting facilities such as fire water pumps, fire alarm stations etc.
   c) Escape route for safe evacuation of operating personnel.

iv) The recommended areas for critical lighting (DC) include:

   Control rooms (Process & utility)
   Main substations
   DG Shed
   Central Fire Station
   Fire water pump house (for start-up of Diesel driven F.W. pump)
   First Aid Centre
   Emergency escape route
   Instrument/Process control & central control buildings.

v) The recommended areas for AC emergency lighting include:

   Control rooms (Process & utility)
   Fire water pump house, Fire stations
   Main sub stations
   Foot of stairs and ladder
   Platforms with ladders changing direction
   Other changes of floor level that may constitute a hazard.

   Strategic locations in Process, utility areas where specific safety operations are to be carried out such as:

   - Areas near heat exchangers, condensers
   - Barring gears of steam turbine
   - Some portions of roads interconnecting substations and process plants.

vi) the AC emergency lightening shall be considered as 20-25% of Normal Lighting load. However for small plants, where AC emergency load is not substantial/ where there is no separate standby DG set, DC critical lighting system should take care of entire emergency lighting.
vii) Critical lighting (DC supply based) will be normally kept ‘ON’ and during Normal/emergency power failure, battery will provide power.

viii) Besides, adequate number of self contained portable hand lamps and Battery emergency lighting units shall be provided for personnel safety for immediate use in emergency at remote substations and at other strategic places (safe areas), where there is no provision of DC lighting.

ix) LED lamps shall generally be used for outdoor plant lighting. LED lamps can be considered for emergency lighting to achieve this objective. Fluorescent lamps/LED may be used for indoor lighting in non-process buildings and control rooms. Safe area street lighting and yard lighting may use sodium vapour/LED lamps. Sodium vapour lamps shall not be installed in hazardous areas.

x) The illumination levels in different areas shall be as per good engineering practice. Depending on the nature of job activities to be carried out the suggested minimum illumination levels for various areas are as under:

<table>
<thead>
<tr>
<th>Areas</th>
<th>Illumination in Lux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main roads (along process units, power houses, Workshops, etc.)</td>
<td>7 - 10</td>
</tr>
<tr>
<td>Secondary roads (along storage tanks settling basins etc.)</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Tank farm</td>
<td>10</td>
</tr>
<tr>
<td>Pump houses, sheds</td>
<td>100</td>
</tr>
<tr>
<td>Main operation platforms &amp; access stairs</td>
<td>60</td>
</tr>
<tr>
<td>Ordinary platforms</td>
<td>20</td>
</tr>
<tr>
<td>Process areas, pipe racks, heat exchanger, heater, separators, cooling tower, columns, pig launching/ receiving loading area, flare etc.</td>
<td>60</td>
</tr>
<tr>
<td>Switchgear building</td>
<td>150-200</td>
</tr>
<tr>
<td>Transformer bay</td>
<td>100</td>
</tr>
<tr>
<td>Battery room</td>
<td>150</td>
</tr>
<tr>
<td>Control room bldg./laboratory</td>
<td>400</td>
</tr>
<tr>
<td>Boiler house</td>
<td>150</td>
</tr>
<tr>
<td>Charger/UPS rooms</td>
<td>150-200</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>60</td>
</tr>
<tr>
<td>Switchyard</td>
<td></td>
</tr>
<tr>
<td>(i) operating area</td>
<td>100</td>
</tr>
<tr>
<td>(ii) other areas</td>
<td>50</td>
</tr>
<tr>
<td>Warehouse</td>
<td>100</td>
</tr>
<tr>
<td>Office</td>
<td>300</td>
</tr>
<tr>
<td>Area</td>
<td>Lighting Level</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Compressor operating area</td>
<td>200</td>
</tr>
<tr>
<td>Watch room</td>
<td>100</td>
</tr>
<tr>
<td>Stairs</td>
<td>50</td>
</tr>
<tr>
<td>Corridors/ lifts</td>
<td>70</td>
</tr>
<tr>
<td>Tube well, gate &amp; watchman booth</td>
<td>100</td>
</tr>
<tr>
<td>Fire house, garage</td>
<td>100-150</td>
</tr>
<tr>
<td>Escape Lighting</td>
<td></td>
</tr>
<tr>
<td>Escape way (interior)</td>
<td>5</td>
</tr>
<tr>
<td>Areas at exit door and at points where it is necessary to emphasise the position of potential hazard if any.</td>
<td>30</td>
</tr>
</tbody>
</table>

However, lighting levels in all areas shall take into consideration the requirements from point of view of safety, ease of operation and maintenance.

5.9.2 Aircraft Warning Lighting

The type of Aircraft warning lights shall be provided in accordance to latest International Civil Aviation Organization and local regulations. The aircraft warning lights shall be steady glowing with red colour and shall be fitted at the highest points of the platform obstacles.

5.9.3 Power and Convenience Outlets

i. Adequate no of 415 V 63 A, TP&N+E power outlets of switched socket type shall be provided at suitable locations to ensure accessibility.

240 V, 16 A, SP+N+E convenience outlets at suitable locations.

5.9.4 Cables and Cable Installation

5.9.4.1 Cable Types

i. In order to avoid spread of fire due to cables, it is recommended that the outer PVC sheath of all cables used in industry shall be flame retardant type low smoke (FRLS) conforming to category AF as per IS: 10810.

ii. High voltage cables may be Aluminium/Copper Conductor XLPE insulated FRLS PVC sheathed, armoured type.

iii. The selection of voltage rating of HV cables shall take into account the system voltage, system earthing arrangements and type of earth fault protection schemes. (Guidelines on this can be had from IEC 60183 & IS:7098). For resistance earthed systems, unearthed grade cable shall be used.

v. All power and control cables shall preferably have extruded inner and outer sheaths.

vi. Where single core cables are armoured and are meant for use on AC circuits, armouring with non-magnetic material (e.g. Aluminium) shall be employed.

vii. All cables used shall have non hygroscopic fillers, wire armoring and PVC overall sheath. Unarmored cables and wires may be used where proper mechanical protection (e.g. metallic
conduit) is provided or where sheathed cables are installed above ceilings or below floors in non-industrial locations. Concealed metallic conduits shall be used for buildings where appropriate.

viii. The control cables shall be twisted pair type with overall shielding in case of longer lengths.

5.9.4.2 Cable Installation

i. The Cable installation shall be installed above ground or laid on dedicated cable racks/ trays within dedicated levels of overhead pipe racks and on the sleepers of low level pipe ways.

In certain instances cables may be routed underground either in concrete lines cable trenches or directly buried cable trenches, these include:

a) High voltage distribution cables and associated control cables
b) Cables entering or leaving buildings
c) Cables in areas where ground contamination is unlikely and economic consideration precludes the erection of special cables supports.
d) Cabling within the power generation area
e) Feeder cables to satellite substations.
f) Cables within process areas or offsite areas.
g) Any other area where overhead cabling is not feasible.

iii) While designing layout with single core cable installations following factors shall be considered:

a. Cables are laid as a general practice in trefoil formation touching each other. If trefoil arrangement is not possible, flat formation with spacing as per requirement may be followed.

- When cables are laid in a flat formation, the individual cable fixing clamps and spacers shall be of non-magnetic material.

iv) All cable trenches shall be sized depending upon the number of cables, and their voltage grade. High voltage, medium voltage and other control cables shall be separated from each other by required spacing or running through independent pipes, trenches or cable trays as applicable. Cable trenches inside substations shall be filled with sand, pebbles or similar non-flammable, materials or covered with incombustible slabs. If a significant number of cables are taken on racks, adequate supports should be provided on the side wall of trench.

v) RCC covers of cable trenches should be sealed to avoid ingress of chemicals and oils.

vi) In unpaved areas, cables should be directly buried in ground. Where underground cables cross roadways or pipe sleepers at grade etc., they shall be protected by being drawn through sleeves/ducts to provide a permanent crossing. Sleeve/duct ends shall be effectively sealed thereafter.

vii) Concrete lined cable trenches should be sealed against ingress of liquid and gases wherever the trenches leave a hazardous area or enter control room or substation.

viii) Above ground cable trays shall be well supported suitably at every 3metres interval and protected against mechanical damage. Routing shall be decided to avoid proximity to high temperature sources (steam drains, furnaces etc.), places subject to undue fire risk. Cable trays, racks and trenches shall
be sized to allow for 10 to 20% future cables reserve. Each cable tray tier shall accommodate the cables preferably in single layer.

ix) Instrument and communication cables shall not be laid in the same trench/tray along with electrical power cables. Electrical cables shall be where practical separated by at least 600 mm from instrumentation and telecommunication cables. The overall cable layouts shall be designed for minimum interference between signal and power cables. Where ever there is a possibility of electromagnetic interference, shielded twisted pair and/or screened and overall shielded cables should be used for control cables/signal cables.

x) Cable cellars shall be provided with fire detection and monitoring devices.

xi) Cable straight through joints in power and control cables shall be avoided as far as possible inside unit battery limits. Cables shall be in one length where practical but cable joints may be installed when necessary. Above ground cable joints shall not be installed in hazardous areas.

xii) Cable installations shall provide for minimum cable bending radii as recommended by manufacturer.

xiii) Cable trenches in hazardous area should be filled with sand and covered with RCC slabs to prevent accumulation of flammable gas/vapour inside the trench.

xiv) All Cable glands for Equipment located in hazardous area shall be flame proof type.

No underground power cables exceeding 33kV shall be laid without minimum depth of 1200 mm. Top most cable trays & vertical cable trays shall be provided with GI covers. Further bottom tray covers shall be provided wherever cable tray are routed through process pipes or equipment.

5.10 Electrical Heat Tracing

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

6.1 Each facility shall have written inspection and testing programme in place. Inspection shall include during installation, before commissioning as well as during regular operation of the Refineries and Gas Processing Plants.

6.2 The pre-commissioning inspection of equipment and piping systems shall include the scrutiny of all the related records to ensure that all examinations and tests during fabrication and erection have been carried out.

6.3 Inspection shall cover the integrity of static and rotary equipment including vessels, columns, heaters, heat exchangers, boilers, storage tanks, relief valves, piping, pumps, compressors, turbines, drives. through regular in-service external and out of service comprehensive inspection.

6.4 External in-service inspection shall include visual inspection including instrument aided non-destructive testing like ultrasonic, radiographic, thermographic etc.

6.5 Out of service inspection shall be carried out to assess the integrity of the equipment, condition of internals and to determine the degradation rate through thickness measurement to estimate the remaining life.

6.6 The inspection strategy / program shall be designed based on the likelihood and consequence of damages because of the prevailing or expected internal service / environment conditions. Inspection shall include preparation and implementation of schedules to meet requisite standards, OEM, process licensor and quality requirements. Inspection frequency shall be decided based on corrosion rate calculations.

6.7 Inspection shall cover the integrity of rotating equipment through regular monitoring and preventive maintenance. Periodic Overhauling shall be done as specified by OEM.

6.8 The authorised persons performing the inspection shall be qualified and experienced. The requisite criteria for deciding the qualification and experience shall be decided by entity.

6.9 Inspection shall include identification of likely locations of material deterioration and adoption of suitable inspection technique to identify the degradation mechanism.

6.10 Inspection shall include evaluation of current physical condition of the equipment and piping for fitness for continued service.

6.11 The thickness reduction, damages etc. shall be ascertained to determine fitness for continued service in line with the design codes/standards. In case equipment and pipe components fail to qualify the minimum requirements, the same shall be replaced or repaired in line with the design code alternatively advanced fitness for service assessment maybe carried out for acceptance.

6.12 All repairs and alteration work shall be authorised and approved.

6.13 Micro structure examination and remaining life assessment (RLA) of equipment operating in creep range shall be carried out as they are subjected to metallurgical degradation due to high temperature exposure.

6.14 Performance of stage wise inspection and documentation of inspection records and equipment history shall be done.

6.15 Inspection program should evaluate the effectiveness of corrosion control systems, where applicable.
6.16 Inspection shall cover that all new equipment and piping systems are installed in accordance with design, and any deviations documented and approved.

6.17 All documents like as built drawings, manufacturers inspection and testing certificates of the respective vendors shall be properly retained and followed.

6.18 Inspection program shall include the review of quality assurance plan and acceptance criteria in line with the approved technical specification requirements.

6.19 Inspection shall cover the electrical systems, check its integrity, earthing resistance, bonding, cable joint integrity, reliability of cathodic protection systems etc.

6.20 Inspection shall cover the verification of various safety interlocks, Emergency Shutdown (ESD) provided in the design.

6.21 Inspection shall cover that all ESD devices move to their safe condition on loss of system output, hydraulic power or instrument air. All Emergency Shutdown Valves (ESDVs) and actuators shall remain functional following an explosion or under fire conditions for a sufficient time period to perform their intended function as per design.

6.22 The integrity and efficacy of gas detection, fire protection and fighting system, connected equipment shall be covered in the inspection.

6.23 Inspection shall cover the emergency communication system for its effectiveness during emergency situations.

6.24 Inspection of structures like RCC technological structures, Buildings, Steel structures etc. shall be carried out at predefined intervals to assess general conditions of the structure, identification of distresses & subsequent preventive repairs measures/rehabilitation to ensure integrity, stability & durability of the structure. Inspection methodologies should include visual Inspection, NDT’s like Rebound Hammer Test for assessing strength of concrete, USPV for assessing integrity of concrete, Carbonation test to assess depth of carbonation in the concrete, Cover meter test to assess thickness of cover concrete, Half Cell potentiometer test to identify probability of active corrosion of reinforcement steel, concrete core test for assessing in-situ concrete strength, laboratories test like PH value, sulphate content, chloride content and RCPT test to assess permeability of concrete. Also, for structural steel members ultrasonic thickness test and vibration test to measure vibration in the structure to ensure structural integrity should be carried out.
7.0 FIRE & GAS DETECTION AND PROTECTION FACILITIES

The Fire Protection Philosophy should be based on Loss Prevention and Control considering that a hydrocarbon processing plant carries inherent potential hazard. A fire in one part/section of the plant can endanger other sections of plant as well. If fire breaks out, it must be controlled / extinguished as quickly as possible to minimise the loss to life and property and to prevent further spread of fire.

7.1 GENERAL CONSIDERATIONS

The size of process plant, pressure and temperature conditions, size of storage, plant location and terrain determine the basic fire protection need.

The following fire protection facilities shall be provided depending upon the nature of the installation and risk involved.

- Fire Water System
- Foam System
- Clean Agent Fire Protection system
- Carbon Dioxide System
- Dry Chemical Extinguishing System
- Detection and Alarm system
- Communication System
- Portable fire fighting equipment
- Mobile fire fighting equipment
- First Aid Fire Fighting Equipment.

7.2 DESIGN CRITERIA

The following shall be the basic design criteria for a fire protection system.

(i) Facilities shall be designed on the basis that city fire water supply is not available close to the installation.
(ii) Fire protection facilities shall be designed to fight two major fires simultaneously anywhere in the installation. Fire water requirements shall be as per guidelines given in Annexure-I.
(iii) All the tank farms and other areas of installation where hydrocarbons are handled shall be fully covered by fire water network system.

7.2.1 Fixed Water Spray on storage Tanks

(i) Class ‘A’ Petroleum storage in above ground tanks shall have fixed water spray system, whether floating roof or fixed roof.
(ii) Class ‘B’ Petroleum storage tanks of following dimensions shall be provided with fixed water spray.
   - Floating roof tanks of diameter larger than 30 M.
   - Fixed roof tanks of diameter larger than 20 M.

7.2.2 Semi-fixed Foam system for Storage

(i) Semi-fixed Foam system shall be provided for the following tanks:
   - Floating roof tanks storing Class ‘A’ and Class ‘B’ petroleum products.
- Fixed roof tanks storing Class ‘A’ and class ‘B’ petroleum products.
- Fixed roof tanks storing class ‘C’ petroleum products, of diameter larger than 40 M.

7.2.3 **Automatic Actuated Rim Seal Protection System for External Floating roof tanks:**

Automatic actuated Rim Seal fire detection and foam flooding type extinguishing system shall be provided on all external floating roof tanks storing Class A Petroleum products. The components of the system shall be listed or approved by any of the national or international agencies like BIS, UL, FM, VdS, LPC etc. to ensure that those systems are used which meet with highest standards of safety.

The minimum requirement for design of the system is given in Annexure VII. This shall be in addition to the water spray and semi-fixed foam system on all the floating roof tanks storing class-A products.

7.2.4 **Automatic Water Spray for Pressurised storages including LPG / Hydrogen**

(i) LPG and hydrogen Pressure storage vessels shall be provided with automatic water spray system.
(ii) Automatic water spray system shall be provided in LPG bottling stations, LPG loading/unloading gantries and LPG pump and LPG / Hydrogen compressor areas.

7.2.5 **Water Spray System in Process Unit**

(i) Water spray system shall be provided for hazardous locations and equipment in process unit areas. Some of these areas are:
   - Un-insulated vessels having capacity larger than 50 m³ and containing class A or B flammable liquid.
   - Pumps handling petroleum products class ‘A’ under pipe racks.
   - Pumps handling products above auto-ignition temperature under pipe racks
   - Air fin coolers in hydrocarbon service located above pipe racks / elevated location.
   - Water spray rings for columns of height more than 45 M shall be provided

7.2.6 **Water Spray for Electrical Installation**

Water spray requirement with mode of operation to be considered as per CEA regulations.

7.2.7 **Clean Agent for Control rooms & Satellite Rack Room (SRR)**

Clean agent based automatic fire detection and extinguishing system shall be provided for all control rooms and satellite rack rooms (SRR). Selection of Clean Agent and design of Fire protection system for process control rooms and SRR shall follow the Standard on “Clean Agent Extinguishing systems NFPA Standard 2001 (latest edition) including its safety guidelines with respect to “Hazards to Personnel”, electrical clearance and environmental factors in line with environmental considerations of Kyoto & Montreal Protocols and latest MoEF regulations.

7.2.8 **Loading / unloading Gantry**

Oil loading/unloading Tank Truck & Tank Wagon Gantries shall be provided with water spray and/or foam system.

In case automatic fixed water spray system is provided in TW gantry, the gantry may be divided into suitable number of segments (each segment having min. length of 15 m length & width of 12 m) and three largest segments operating at a time shall be considered as single risk for calculating the water requirement. Accordingly, a provision shall be made to actuate the water spray system from a safe approachable central location i.e. affected zone and adjoining zones.
7.3 **Fire Water System**

Based on the site requirement, water shall be used for fire extinguishment, fire control, cooling of equipment and protection of equipment as well as personnel from heat radiation. Fire water system shall comprise of fire water storage, fire water pumps and distribution piping network along with hydrants and monitors, as the main components.

7.3.1 **Basis**

In line with the design criteria given at 7.2, the fire water system in an installation shall be designed to meet the fire water flow requirement for fighting two fires simultaneously anywhere in the facility or single fire for largest floating roof tank roof sinking case, whichever requiring largest water demand.

7.3.2 **Fire Water Flow Rate**

Two of the largest flow rates calculated for different sections as shown below shall be added and that shall be taken as design flow rate. An example for calculating design *major* fire water flow rate is given in Annexure-1.

(i) Fire Water flow rate for tank farm shall be aggregate of the following:

- Water flow calculated for cooling a tank-on-fire at a rate of 3 lpm/m² of tank shell area.
- Water flow calculated for all other tanks falling within a radius of (R+30) M from centre of the tank on fire at a rate of 3 lpm/m² of tank shell area.
- Water flow calculated for all other tanks falling outside a radius of (R+30) M from centre of the tank on fire and situated in the same dyke area at a rate of 1 lpm/m² of tank shell area.
- Water flow required for applying foam into a single largest cone roof or floating roof tank (after the roof has sunk) burning surface area of oil, by way of fixed foam system, where provided or by use of water/foam monitors. (Refer section 7.8 for foam rates).
- Fire water flow rate for supplementary stream, shall be based on using 4 single hydrant outlets and 1 HVLR monitor (1000 GPM) simultaneously. Capacity of each hydrant outlet as 36 m³/hr and of each HVLR monitor as 228 m³/hr shall be considered at a pressure of 7 kg/cm²g.

(ii) Fire water flow rate for LPG sphere storage area shall be aggregate of the following:

- Water flow calculated for cooling LPG sphere on fire at a rate of 10.2 lpm/ m² of sphere surface area.
- Water flow calculated for all other spheres falling within a radius of (R+30) metre from centre of the sphere on fire at the rate of 10.2 lpm/ m² of surface area.
- Water flow for supplementary stream shall be considered as 372 m³/hr as indicated under item (i).

(iii) Water flow required for applying foam into a single largest cone roof or floating roof tank (after the roof has sunk) burning surface area of oil, by way of fixed foam system, where provided or by use of water/foam monitors. (Refer section 7.8 for foam rates).

(iv) Water flow rate requirements for fire fighting in other major areas shall be calculated based on criteria *in terms of lpm/ m² given in section 5.9*.

7.3.3 **Header Pressure**

The fire water system shall be designed for a minimum residual pressure of 7.0 kg/cm²g at the farthest point of application at the designed flow rate at that point.

The fire water network shall be kept pressurised at minimum 7.0 kg/cm²g at all the time.
7.3.4 Storage & Make-up Water

7.3.4.1 Firewater Storage

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. The fire water storage should be located not less than 60 M from hazardous areas. The effective capacity of the reservoir above the level of suction point shall be minimum 4 hours aggregate working capacity of main pumps (excluding standby pumps).

Where rate of make up water supply is 50% or more, this storage capacity can be reduced to 3 hours aggregate working capacity of main pumps. Storage reservoir shall be in two equal interconnected compartments to facilitate cleaning and repairs. In case of aboveground steel tanks there shall be minimum two tanks each having 50 % of required capacity.

Large natural reservoirs having water capacity exceeding 10 times the aggregate fire water requirement can be left unlined.

In addition to fire water storage envisaged as above, emergency water supply in the event of depletion of water storage shall be considered. Fire water supply shall be from fresh water source such as river, tube well or lake. Where fresh water source is not easily available, fire water supply can be sea water or other acceptable source like treated effluent water. In case sea water or treated effluent water is used for fire fighting purposes, the material of the pipe selected shall be suitable for the service.

7.3.4.2 Make up Water

Suitable provisions shall be kept for make up firewater during fire fighting time. Provision should be made to divert water from various sources like ETP, Process Cooling Water, river, ponds etc. to the fire water system.

7.4 Firewater Pumps

Firewater pumps shall be used exclusively for fire fighting purposes.

7.4.1 Type of Pumps

Fire water pumps shall be of the following type:

- Electric motor driven centrifugal pumps
- Diesel engine driven centrifugal pumps

The pumps shall be horizontal centrifugal type or vertical submersible centrifugal pumps. Each pump shall be capable of discharging 150% of its rated capacity at a minimum of 65% of the rated head. The shut-off head shall not exceed 120% of rated head, for horizontal pumps and 140% in case of vertical submersible type pumps.

Number of diesel driven pumps shall be minimum 50% of the total number of pumps (inclusive of standby pumps). Minimum 50% of total flow requirement should be available through diesel driven pumps all the time. Power supply to the electric driven pumps should be from two separate feeders.

7.4.2 Capacity of main Pumps

The capacity and number of main fire water pumps shall be fixed based on design fire water rate, worked out on the basis of design criteria as per section 5.2. The capacity of each pump shall not
be less than 400 m³/hr or more than 1000 m³/hr. All pumps should be identical with respect to
capacity and head characteristics.

7.4.3 Standby pumps

- When total number of Working pumps work out to be one or two, 100% standby pumps shall be provided.
- When total numbers of working pumps are more than two, 50% standby pumps shall be provided.
- In cases where two sets of firewater storage and pumps are provided, the number of pumps at each location shall be according to hydraulic analysis of piping network.

7.4.4 Jockey Pumps

The fire water network shall be kept pressurised at minimum 7.0 kg/cm² g by jockey pumps. Minimum 2 Jockey pumps (1 working plus 1 standby) shall be provided. The capacity of the pump shall be sufficient to maintain system pressure in the event of leakages from valves etc. Its head shall be higher than the main fire water pumps. Auto cut-in / cut-off facility should be provided for jockey pumps

7.4.5 Power Supply for Fire Water Pumps

i. A direct feeder dedicated only to fire water pumps shall be laid from the sub-station to ensure reliable power supply. The direct feeder line shall not run along with other HT cables.

ii. The diesel engines shall be quick starting type with the help of push buttons located near the pumps, or at remote location.

iii. Each diesel engine shall have an independent fuel tank adequately sized for 6 hours continuous running of the pump.

iv. Main fire water pumps shall start automatically and sequentially with pressure switches/PLC on fire water mains. The system shall ensure auto start of the standby pump in case a pump in sequence failed to take start.

7.4.6 Location of pumps

Firewater pumps shall be located as far away as possible (not less than 60 M) from hazardous areas to avoid any damage in case of fire/explosion.

7.5 Distribution Network

7.5.1 Looping & Maintainability

The fire water network shall be laid in closed loops as far as possible to ensure multidirectional flow in the system. Isolation valves shall be provided in the network to enable isolation of any section of the network without affecting the flow in the rest. The isolation valves shall be located near the loop junctions. Additional valves shall be provided in the segments where the length of the segment exceeds 300 M. For ease of maintenance, Firewater pumps should be segregated in two groups by providing an isolation valve on common discharge header of pumps. Flushing connections with isolation valves should be provided at suitable locations in the firewater ring main.

For branch piping, an isolation valve shall be provided at the take-off point.

Permanent connection shall not be taken from fire water line / system for purposes other than fire protection/ fire prevention.

7.5.2 Criteria for above / underground network
The firewater network piping should normally be laid above ground at a height of at least 300 mm above finished ground level. However, the fire water network piping shall be laid below ground level at the following places. Pipes made of composite material should be laid underground.

i. Road crossings.
ii. Places where the above ground piping is likely to cause obstruction to operation and vehicle movement, and get damaged mechanically.
iii. Where frost condition warrants, the ring main system shall be laid underground beneath the frost layer.

7.5.3 Protection for underground pipelines

Where the pipes are laid underground the following protections shall be provided:

i. The main shall have at least one meter earth cushion in open ground and 1.5 metre earth cushion under the roads. In case of crane movement areas, pipes should be protected with concrete/steel encasement.
ii. The mains shall be provided with protection against soil corrosion by suitable coating/wrapping.
iii. Pipe supports under the pipe line shall be suitable for soil conditions.

7.5.4 Protection for above ground pipelines

Where the pipes are laid above ground, the following protection shall be provided:

i. The firewater mains shall be laid on independent sleepers by the side of road. These shall not be laid along with process piping on common sleepers.
ii. The mains shall be supported at regular intervals not exceeding 6 metre. It should be supported at every 3 M for pipes less than 150 mm diameter.
iii. The system for above ground portion shall be analysed for flexibility against thermal expansion and necessary expansion loops shall be provided wherever called for.

7.5.5 Hydraulic Analysis & Sizing of Firewater Network

i. The hydraulic analysis of network shall be done. Also whenever fire water demand increases due to addition of plant & facilities or extensive extension of network, fresh hydraulic analysis shall be carried out.
ii. Fire water distribution ring main shall be sized for 120% of the design water rate. Design flow rates shall be distributed at nodal points to give the most realistic way of water requirements in an emergency. Several combinations of flow requirements shall be assumed for design of network. For large water requirement for floating roof tank (Annexure-VI), the network around tank farm shall be suitably designed.

7.5.6 Fire hydrants

Fire water hydrants shall be provided on the fire water network. Each of these connections shall be provided with independent isolation valves.

7.5.7 Fixed water monitors

Fixed water monitors shall be provided on the fire water network. Each of these connections shall be provided with independent isolation valves.

7.5.8 Layout

i. Fire water mains shall not pass through buildings or dyke areas.
ii. Hydrants / monitors shall not be located inside the dyke area.
7.6 Hydrants & Monitors - Details

7.6.1 Hydrants

i. Hydrants shall be located keeping in view the fire hazards at different sections of the premises to be protected and to give most effective service. At least one hydrant post shall be provided for every 30 M of external wall measurement or perimeter of unit battery limit in case of hazardous areas. Hydrants protecting utilities and non plant buildings should be spaced at 45 M intervals. The horizontal range and coverage of hydrants with hose connections shall not be considered more than 45 M.

ii. The hydrants shall be located at a minimum distance of 15 M from the periphery of storage tank or hazardous equipment under protection. For process plants location of hydrants shall be decided based on coverage of all areas. In the case of buildings, this distance shall not be less than 5 M and more than 15 M from the face of building.

iii. Hydrants / Monitors shall be located along road side berms for easy accessibility as far as possible.

iv. Double headed hydrants with two separate landing valves on 4” stand post shall be used. All hydrant outlets shall be situated at a workable height of about 1.2 metre above ground level.

v. Hydrants / Monitors shall be located with branch connections and not directly over main header for easy accessibility.

7.6.2 Monitors

i. Monitors shall be located at strategic locations for protection of cluster of columns, heaters, gassifiers, etc., and where it is not possible to approach the higher levels. A minimum of 2 monitors shall be provided for the protection of each such area. Water monitors for protection of heaters shall be installed so that the heater can be isolated from the rest of the plant in an emergency.

ii. Monitors shall be located to direct water on the object as well as to provide water shield to firemen approaching a fire. The monitors should not be installed less than 15 M from hazardous equipment.

iii. Field adjustable variable flow monitors shall be installed at critical locations. These shall be listed or approved by national/ international standards like BIS/UL/FM etc.

iv. The requirement of monitors shall be established based on hazard involved and layout considerations.

v. The location of fixed HVLR monitors to be planned in such a way that the very purpose of these monitors is served and throw of the monitors is safely delivered at the aimed object. The location of monitors shall not exceed 45 M from the hazard to be protected.

vi. Monitors should be painted with luminous color for ease of identification during emergency.

7.6.3 Dry/Wet Risers with hydrants should be provided on each floor of technological structures.

7.6.4 Fixed or Mobile High Volume Long Range Water cum Foam Monitors.

Fixed or Mobile high volume long range water cum foam monitors (Capacity 1000 GPM & above) shall be provided. This can be a mobile system or a fixed system operated either manually or in remote mode.

The mobile HVLR monitors, if used, shall be of variable flow type. The mobile fire fighting system shall be designed to fight full surface fire of the largest floating roof tank in the installation. The foam logistic, water supply etc. shall be designed and available accordingly. Trained manpower to operate the mobile HVLR effectively shall be available round the clock.
Number and capacity of mobile monitor shall be such that the foam application rate from the monitors meet requirement of foam application rate (8.1 LPM/m²) for full surface tank fire of the largest floating roof tank in the installation as per NFPA-11.

Following criteria shall be followed for providing fixed HVLR monitors for tank farm area:

a) Fixed or mobile type variable flow monitors shall be provided in such ways that all the tanks in the installation are within the horizontal range of foam throw.

b) Number and capacity of monitor shall be provided in such a way that foam application rate from the monitors meet requirement of foam application rate (minimum 8.1 LPM/m²) for full surface tank fire as per NFPA-11.

For determining the total foam solution requirement, potential foam loss from wind and other factors shall be considered.

7.6.4.1 Fixed or Mobile High Volume Long Range Water Monitors

Fixed or Mobile high volume long range water monitors (Capacity 1000 GPM & above) with variable flow shall be provided in

i. In accessible areas such as column, reactor, compressor house etc.

ii. In critical units like CCRU, DHDS, HCU, Hydrogen, FCCU, DCU, CDU etc.

iii. Critical equipment at higher locations (above 45 mtrs.)

This shall be operated either in remote or manual mode. HVLR monitors shall be listed/approved by national/ international certification like BIS/UL/ FM etc. The electrical or hydraulic remote control mechanism shall be in line with Hazardous Area Classification.

7.6.5 Hose Boxes/ stations

Provision of hose boxes / stations should be given at critical locations for housing hoses and nozzles.

7.6.6 Water cum Foam monitors for Gantry area

Tank Wagon & Tank Lorry loading/ unloading gantry area shall be provided with alternate water cum foam monitors having multipurpose combination nozzles for jet, spray & fog arrangement and fire hydrants located at a spacing of 30 M on either sides of the gantry. These monitors shall be listed/approved by national/ international certification like BIS/UL/ FM etc. (This is in addition to water spray requirement given in 7.8.2)

7.7 Material Specifications

All the materials required for firewater system using fresh water shall be of approved type as indicated below.

i. Pipes: Carbon Steel as per IS: 3589/ IS: 1239/IS:1978 or Composite materials as per API 15LR/API 15 HR or its equivalent shall be used.

In case saline water is used, the fire water main of steel pipes shall be, internally cement mortar lined or glass reinforced epoxy coated or made of pipe material suitable for the quality of water. Alternatively, pipes made of composite materials shall be used. The material selection for fire main line shall consider the quality / impurities in the water.

Cast iron pipes shall not be used for fire water services.
ii. **Isolation Valves:** Cast Steel valves shall be used in all areas including unit areas, offsite and fire water pump stations.

  Isolation valves having open/close indication shall be Gate valves more than 16” should be provided with gear mechanism.

iii. **Hydrant:**

  Standpost: Carbon Steel

  Outlet valves: Gunmetal / Aluminium Landing valves: Stainless Steel / Al-Zn Alloy/gun metal.

iv. **Monitors:**

  Water Monitors: Carbon Steel/ Gun Metal ; Staineless Steel / Anodised Aluminum

  Nozzle: Stainless steel/ brass/ Anodised Aluminum

v. **Fire Hose:** Reinforced Rubber Lined Hose as per IS 636 (Type A)/Non-percolating Synthetic Hose (Type B).

vi. In case of underground mains the isolation valves shall be located in RCC/brick masonry chamber.

vii. The above ground fire water mains and the fire hydrant standpost shall be painted with corrosion resistant "Fire Red" paint shade 536 of IS: 5.

viii. Water monitor and hose box shall also be painted in "Fire Red" shade 536 of IS: 5.

ix. Corrosion resistant paint shall be used in corrosion prone areas.

7.8 **Fixed Water Spray System**

7.8.1 **General**

It is a fixed pipe system connected to a reliable source of water supply and equipped with water spray nozzles for specific water discharge and distribution over the surface of area to be protected. The piping system is connected to the hydrant system water supply through an automatically or manually actuated valve which initiates the flow of water.

i. Fixed water spray system should be provided in high hazard areas where immediate application of water is required.

ii. Water supply patterns and their densities shall be selected according to need. Fire water spray system for exposure protection shall be designed to operate before the possible failures of any containers of flammable liquids or gases due to temperature rise. The system shall, therefore, be designed to discharge effective water spray within shortest possible time.

7.8.2 **Water Spray Application Rates**

The following water spray application rates are recommended for general guidance. These rates should be reviewed on case to case basis and increased, if required. While calculating the water rates for spray application for cases other than tanks/vessels, the area should be divided into suitable segments so that maximum water requirement for spray application should not exceed 1200 m3/hr.

**Application Area Water application rate**

Atmospheric storage : 3 lpm/m2 of tank shell area for tank on fire  Tanks 3 lpm/m2 of tank shell area for exposure protection for tanks located within (R+30) M from centre of tank-onfire within the same dyke area.
1 lpm/m² of tank shell area for exposure protection for tanks located outside (R+30) metre from centre of tank-on-fire within the same dyke area.

Pressure Storage Vessels: 10.2 lpm/m² of shell area

Process Unit Area
- Pumps (Volatile product service 20.4 lpm/m² located under Pipe rack)
- Columns, other Extremely hazardous area: 10.2 lpm/m²

LPG pump house: 20.4 lpm/m²

LPG Tank Truck & Tank Wagon loading/ Unloading gantries: 10.2 lpm/m²

LPG Bottling plants:
- Carousel machine 10.2 lpm/m²
- Filled cylinder storage 10.2 lpm/m²
- Empty cylinder storage 10.2 lpm/m²
- LPG cylinder cold repair Shed: 10.2 lpm/m²

Oil Tank Truck & Tank Wagon loading/unloading gantries: 10.2 lpm/m²

Cable Trays and Transformers: 10.2 lpm/m²

7.9 Fixed Water Sprinkler System

i. Fixed water sprinkler system is a fixed pipe tailor made system to which sprinklers with fusible bulbs are attached. Each sprinkler riser/system includes a controlling valve and a device for actuating an alarm for the operation of the system. The system is usually activated by heat from a fire and discharges water over the fire area automatically.

ii. Sprinkler systems are used for fire extinguishment when the hazards located inside buildings.

Some of the examples being:
- Car parking in basement
- Building/sheds storing combustible and flammable materials.

iii. The water for sprinkler system shall be tapped from plant fire hydrant system, the design of which should include the flow requirement of the largest sprinkler installation.

iv. The design flow for sprinkler installation would depend on the type of hazard and height of piled storage. The water flow rate for automatic sprinkler system for car parking area shall be taken as 5.1 lpm/m² of the area protected by sprinkler installation. The design water flow shall be restricted to a minimum 100 m³/hr and to a maximum 200 m³/hr. The design flow rate for other areas shall be taken as 10.2 lpm/m² of the area protected by sprinkler installation, subject to a minimum of 150 m³/hr. and a maximum of 400 m³/hr. Higher water application rates should be used if called for depending on risk involved. Minimum Design density and assumed area of operation of fixed water sprinkler system shall be in accordance with hazard area occupancies classification given in BIS 15105 or NFPA 13.

7.10 Foam Systems

Efficient and effective foam delivery system is a vital tool for its usefulness in controlling the fire.

7.10.1 Floating Roof Tank Protection Using Foam
7.10.1.1 Protection using Semi-Fixed Foam System:

For floating roof tank, foam shall be poured at the foam dam to blanket the roof’s rim seal.

Features of foam system for floating roof tank protection shall be as follows:

i. System shall be designed to create foam blanket on the burning surface in a reasonably short period.

ii. Foam shall be applied to the burning hazard continuously at a rate high enough to overcome the destructive effects of radiant heat.

iii. Foam makers/foam pourers shall be located not more than 24 M apart on the shell perimeter based on 600 mm foam dam height. The height of foam dam shall be at least 51 mm above the top of metallic secondary seal.

iv. A minimum of two foam pourers shall be provided.

7.10.2 Protection using Automatic Actuated Foam Flooding system:

Provision of an automatic rim-seal protection system of foam flooding type shall be in line with the details mentioned at 4.2.3 and at Annexure-VII.

7.10.3 Foam solution landing valve at wind girder of floating roof tank top should be provided.

7.10.4 Fixed Roof Tank Protection Using Foam

Foam conveying system shall have same features as of floating roof tank excepting that a vapour seal chamber is required before the foam discharge outlet.

Features of the foam system for fixed roof protection shall be as follows:

i. The vapour seal chamber shall be provided with an effective and durable seal, fragile under low pressure, to prevent entrance of vapour into the foam conveying piping system.

ii. Where two or more vapour seal chambers are required these shall be equally spaced at the periphery of the tank and each discharge outlet shall be sized to deliver foam at approximately the same rate.

iii. Tanks should be provided with foam discharge outlets/ vapour seal chambers as indicated below:

<table>
<thead>
<tr>
<th>Tank Diameter in M.</th>
<th>Minimum number of foam discharge outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>upto 20</td>
<td>2</td>
</tr>
<tr>
<td>&gt;20 upto 25</td>
<td>3</td>
</tr>
<tr>
<td>&gt;25 upto 30</td>
<td>4</td>
</tr>
<tr>
<td>&gt;30 upto 35</td>
<td>5</td>
</tr>
<tr>
<td>&gt;35 upto 40</td>
<td>6</td>
</tr>
<tr>
<td>&gt;40 upto 45</td>
<td>8</td>
</tr>
<tr>
<td>&gt;45 upto 50</td>
<td>10</td>
</tr>
</tbody>
</table>
The estimation of number of foam discharge outlet is based on pourer capacity of 1000 lpm at a pressure of 7 kg/cm²g upstream of eductor. This can be suitably adjusted for different vapour seal chamber capacity in accordance with para 6.4 (iii).

7.10.5 Floating Cum Fixed Roof Tank Protection Using Foam

Protection facilities shall be provided as required for fixed roof tank.

7.10.6 Dyke Area/ Spills/ Oil Separator Protection Using Foam

Portable monitors / Medium Expansion foam generator / foam hose streams shall be considered for fighting fires in dyke area, spills and oil separator.

7.10.7 Foam Application Rate

The minimum delivery rate for primary protection based on the assumption that all the foam reaches the area being protected shall be as indicated below. In determining total solution flow requirements, potential foam losses from wind and other factors shall be considered.

For cone roof tanks containing liquid hydrocarbons, the foam solution delivery rate shall be at least 5 lpm/m² of liquid surface area of the tank to be protected. For floating roof tanks containing liquid hydrocarbons foam solution delivery rate shall be at least 12 lpm/m² of seal area with foam dam height of 600 mm of the tank to be protected. In case of floating roof sinking, the rate considered should be 8.1 lpm/m² of liquid surface areas.

7.10.8 Duration of Foam Discharge

The equipment shall be capable of providing primary protection at the specified delivery rates for the following minimum period of time.

i. Tanks containing liquid hydrocarbons - Class 'C' Petroleum - 30 minutes.

ii. Tanks containing Class 'A' & 'B' Petroleum or liquids heated above their flash points - 65 minutes.

iii. Where the system’s primary purpose is for spill fire protection - 30 minutes.

7.10.9 Foam Quantity Requirement

Calculation of foam compound storage should be based on the design criteria and as given below.

The aggregate quantity of foam solution for a single largest tank fire should be calculated as sum total indicated below under items (i), (ii) and (iii) for a minimum period of 65 minutes. The quantity of foam compound required should be calculated based on 1%, 3% or 6% concentrate.

i. Foam solution application at the rate of 5 lpm/m² for the liquid surface of the single largest cone roof tank or at the rate of 12 lpm/m² of rim seal area of the single largest floating roof tank or at the rate of 8.1 lpm/m² of the liquid surface of the largest floating roof tank for a roof sinking case, whichever is higher. (Refer Annexure- for sample calculation)

ii. One portable foam monitor of 4500 lpm foam solution capacity.

iii. Two hose streams of foam each with a capacity of 1140 lpm of foam solution. A typical example showing calculation of foam compound requirement is given at Annexure - II.

7.10.10 Foam Compound Storage

- Foam compound should be stored in containers of 200 / 210 litre capacity barrels or 1000 litre tote in case of protein, fluoroprotein or AFFF or AR-AFFF. Foam compound can also be stored in overhead storage tank of suitable capacity for quick filling of foam tender / nurser during emergency.
- Type of foam compound used can be protein or fluoro-protein or AFFF or AR- AFFF. Minimum shelf life of foam compound shall be taken as per manufacturer’s data.
- Foam compound should be tested periodically for ensuring its quality and the deteriorated quantity replaced. The deteriorated foam compound can be used for fire training purposes.
- Quantity of foam compound equal to 100% of requirement as calculated in 7.10.9 shall be stored in the installation, subjected to a minimum of 60,000 litres. However, for installations having tankages larger than 60 M diameter, minimum of 77000 liters foam should be stored or foam sufficient to fight two major fires whichever is more.

7.11 **Clean Agent based Protection System for Control Room, SRR and Computer Room Protection**


**Quantity and Storage of Clean Agent**

Each hazard area to be protected by the protection system shall have an independent system.

The time needed to obtain the gas for replacement to restore the systems shall be considered as a governing factor in determining the reserve supply needed. 100% standby charge of clean agent containers shall be considered based on the largest cylinder bank of similar type of gas in similar type of cylinders available in the complex.

Storage containers shall be located as near as possible to hazard area but shall not be exposed to fire.

Storage containers shall be carefully located so that they are not subjected to mechanical, chemical or other damage.

All the components of the system shall be capable of withstanding heat of fire and severe weather conditions.

7.12 **Carbon Dioxide Systems**

Fixed CO2 systems shall be provided in Turbo generator enclosure, Gas turbine enclosure etc. Fixed CO2 system should be designed and installed in accordance with NFPA-12. Before the CO2 flooding system is operated; persons in the confined area should be evacuated.

7.13 **Dry Chemical Extinguishing System**

The extinguishing system comprises of supplying the Dry Chemical agent, manually or automatically, through a distribution system onto or into the protected hazard.

7.13.1 **Recommended use:**

Dry chemical powder extinguishing system can effectively be used on following hazards.

- Electrical hazard such as transformers or oil circuit breakers.
- Combustible solids having burning characteristic like naphthalene or pit which melts while on fire.
- Class ‘A’, ‘B’, ‘C’ & ‘D’ fire using multipurpose dry chemical. Requirement for each item should be finalised while deciding design basis.
7.13.2 System Design:

Basic requirement of designing the dry chemical extinguishing system is to provide for sufficient quantity and rate of discharge depending upon the hazard.

System consists of dry chemical powder and expellant gas container assemblies of capacity sufficient for given hazard with distribution piping and discharge nozzles. System can be actuated manually or automatically on visual or automatic means of detection. Alarm and indication shall be provided to show that the system has operated and personnel response is needed.

Personnel safety shall include training, warning signs, discharge alarm, respiratory protection and prompt evacuation of personnel.

Following types of systems can be provided to protect a hazard:

a. Total flooding system
b. Local application system
c. Hand hose line system, and
d. Pre-engineered system

(Refer NFPA-17 for limitations & precautions for use of dry chemical and for system design)

7.14 First Aid Fire Fighting Equipment
7.14.1 Criteria to determine the quantity needed:

Portable fire fighting equipment shall be provided in Refinery/Process plant as indicated in the following table:

<table>
<thead>
<tr>
<th>Description</th>
<th>Norms/criteria to determine the quantity needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Dry chemical powder (DCP)* fire extinguishers - 9 kg capacity: IS:15683/UL299</td>
<td>While selecting the Extinguisher, due consideration should be given on the factors like flow rate, discharge time and throw in line with IS: 2190 / UL711. Extinguisher to be located in process units, pump houses, pump area, LPG storage area, LPG bottling plant, Oil separator, tank truck/ tank wagon loading areas, substations, Workshops, laboratory, power station buildings etc. The number should be determined based on the max. Traveling distance of 15 M in above areas. At least one fire extinguisher shall be provided for every 250 m2 of hazardous operating area. There shall be not less than two extinguishers at one designated location e.g. pump house.</td>
</tr>
<tr>
<td>ii) Dry chemical powder fire extinguishers 25/50/75 kg capacity: IS:10658/UL299</td>
<td>The extinguishers with the selection criteria viz. flow rate, discharge time and throw mentioned as above, to be located in critical operating areas. At least one fire extinguisher should be provided for every 750 m2 of hazardous operating area.</td>
</tr>
<tr>
<td>iii) CO2 extinguishers 4.5/6.5/9.0/22.5 kg capacity (IS: 16018/UL154)</td>
<td>To be located in substations, power stations, office building and control room. The number should be determined based on the maximum traveling distance of 15 metre.</td>
</tr>
</tbody>
</table>
At least one fire extinguisher shall be provided for every 250 m² of hazardous operating area. There shall not be less than 2 nos. extinguishers at one designated location e.g. control room.

iv) Portable clean agent extinguishers
   This should be as an alternate to CO2 extinguisher.
   To be located in control rooms, computer rooms, laboratories and office buildings.

v) Portable water-cum-foam monitor.
   Minimum 2 no. for Petroleum refinery and 1 no. for Gas Processing Plant

vi) Steam lancers (as a part of utility station)
   For fighting incipient fires at flange leakages & hot pumps.

vii) Rubber hose reel (25mm)
   To be located in Process unit battery limits and other process areas for quenching of incipient fires.

7.14.2 Other firefighting Equipment:

Additionally, following items should also be provided. The number of units required for these shall be decided by local management, on case-to-case basis.

i) Thermal imaging Camera: As an aid to the fireman during fire fighting operation to locate the seat of the fire and to facilitate search and rescue operation in smoky area e.g. during cable gallery.

ii) Personal Protective Equipment required during Fire Fighting like Water gel based blanket, Fire Proximity Suit, Self contained breathing apparatus, Air line breathing apparatus, Safety Helmets, Fire Helmets, Stretcher, First Aid box, Rubber hand gloves, canister mask etc.

iii) Other Equipment like Portable Gas detectors, Explosive meter, Oxygen meter, Hand operated siren, Red/Green Flag for fire drill, Safe walk roof top ladder, emergency lighting, portable mega phone, various leak plugging gadgets, oil dispersants and oil adsorbents, lifting jacks (for rescue of trapped workers), etc.

Note: The number of unit required for these should be decided by local management, on case to case basis.

7.15 Mobile Fire Fighting Equipment

7.15.1 Fire Tenders:

The exact number of fire tenders shall be higher of the items (a) or (b):

(a) The quantities firmed up in each case based on two simultaneous major fires taking into consideration the size, location of the plant and statutory requirements.

(b) The quantities indicated below.

(i) nos. of foam tenders out of which two are for fire fighting and one for spill/ standby. The foam tender should have foam tank capacity of minimum 3000 litre and the pump capacity of minimum 4000 lpm at 10 kg/cm².

(ii) One DCP tender having 2000 kg capacity each with Nitrogen as expellant gas. These are required for fighting LPG/Gas fires. DCP monitor should have a variable throw. The throw of the monitor shall be 40 to 50 M for the DCP charge.

7.15.2 Other Mobile Equipment
In addition to fixed monitors provided in the tank farm, following additional mobile equipment shall be provided:

(i) Minimum 2 nos. of foam tank trailers with field adjustable variable flow water cum foam monitors having foam tank capacity of 500-1000 liters and monitors capacity of minimum 1000 GPM which are listed / approved by national / international standards like BIS, UL, FM etc.

(ii) Minimum 2 nos. of Trolley mounted water cum foam monitors of capacity of minimum 2000 GPM with field adjustable variable flow which are listed / approved by national / international standards like BIS, UL, FM etc. Foam induction to the monitor shall be possible from minimum 60M distance from the monitor.

(iii) 1 to 2 numbers of Foam Nurser (i.e. Trailer mounted foam compound supply tank) with foam compound tank of 7000 – 16000 litre capacity with suitable pump for foam transfer.

(iv) 1 to 2 nos. of portable/ trailer fire pumps of capacity ranging from 1800 to 2250 lpm at discharge pressure of 7 kg/cm2 g.

7.15.3 Other Fire Fighting Equipment

Following other fire fighting equipment shall be provided:

(i) Emergency rescue equipment like cutters, expanders, inflatable lifting bags, leak pads, protective clothing, breathing apparatus, trolley mounted BA set

(ii) Fire Hoses: IS 636: Type A or Synthetic hose of Type B.

The hose length shall be calculated as follows:

(i) For installation with hydrants upto 100 Nos: - One 15 mtrs hose length/hydrant.

(ii) For installation with more than 100 hydrants:
    - One 15 metre hose length/hydrant, for the first 100 hydrants; and,
    - One 15 M hose length for every 10 hydrants above 100.

The hose length so calculated shall be suitably divided into hose lengths of 15 M, 22.5 M or 30 M. Of the total requirement of the hoses, minimum 50% of hoses shall be of type B.

(iii) Fire jeep (s) with two way radio communication facility and towing facility.

(iv) One ambulance fitted with medical aid and suitable arrangements.

(v) Other accessories, foam making branch pipes, nozzles, etc. as per requirements.

(vi) Higher size hoses of suitable length for feeding large capacity mobile monitors wherever provided.

In addition to above, provision of following equipment should also be considered:

(i) Suitable equipment for fighting high level fires.

(ii) Multipurpose fire fighting skid should be used as a single self sufficient unit of having capacity of discharging foam, water/ water mist & DCP and thus performing multiple functions effectively, individually or together, saving power and time in combating a fire. Such a Multipurpose fire fighting skid should be used in lieu of one foam tender/ DCP tender.

7.16 Storage of Fire Fighting Agents

The following quantities of fire fighting agents shall be stored in the Refinery as given below in the table.

| Sr. No | Description | Quantity to be stored |
i) Dry chemical powder: Reaction product of urea and Potassium bicarbonate based DCP powder or Potassium bicarbonate DCP powder or Mono-ammonium phosphate based DCP powder. The DCP product shall be approved / listed by national / international standards like BIS, UL, EN etc. The DCP powder shall have compatibility with fire fighting foams.

| Amount | 4000 kg for the DCP tender plus 500 kg for additional requirement. This is in addition to the charge loaded on tender. |

| ii) Potassium bicarbonate DCP powder or Mono-ammonium phosphate based DCP powder for recharging of fire extinguishers. The DCP product shall be approved / listed by national / international standards like BIS, UL, EN etc. | As required based on shelf life. However, minimum 10% of the total charge in the extinguishers should be maintained. |

| iii) Foam compound | The minimum foam compound storage shall be the quantity as calculated by Clause 7.11.9. |

### 7.17 Detection System and Alarm

#### 7.17.1 Areas to be covered with detectors

7.17.1.1 The following areas shall be provided with hydrocarbon gas detectors:

- Light hydrocarbon pumps in process units.
- Process cooling tower top platform in the units having pressurised cooling water return.
- Fuel gas knock out drum
- Suction side of forced draft air blowers if located where hydrocarbon vapours can be present.
- Light hydrocarbon pump stations if located below grade level.
- LPG Horton spheres
- LPG pump house
- LPG bulk truck loading area
- LPG bulk wagon loading area
- LPG bottling, storage, repair sheds.
- Gas compressor
- Air-intake point for control room.

The exact location and number of points should be decided on need basis.

7.17.1.2 Following areas shall be provided with Smoke/ Flame / Heat detectors with alarm and/or system to actuate relevant fire suppression system:

- LPG spheres
- LPG filling sheds
- LPG pumps/compressors
- LPG loading/unloading, both in tank truck and tank wagon gantry

7.17.1.3 Hydrocarbon detectors shall be installed near all potential leak source of class-A petroleum products. e.g. tank dykes, tank manifolds, pump house manifold etc.

Hydrocarbon detector of proper type shall be selected and also shall be proof tested and shall be maintained in good condition.

7.17.1.4 Additionally, following areas should also be provided with suitable detectors:
- Extremely hazardous area in process units
- Computer room, Server room, Process control rooms, Record room
- Unmanned electric substations / MCC rooms
- Cable galleries
- Chemical Storage

7.18 Communication System

Effective communication is an essential element in the fire protection system of any plant. The following communication systems should be provided in the Refinery/Process plants.

(i) Telephone

Fire Station Control Room shall be provided with 2 nos. of internal telephones which are exclusively meant for receiving fire/emergency calls only. These phones should have facilities for incoming calls only. For general communication a separate telephone should be provided. Fire Station should also have a direct P&T telephone. Hot line, telephone for contacting mutual aid parties shall be provided wherever possible.

(ii) Public Address System

Public address system should be connected to all control rooms, administration building (all floors), all departmental heads, security etc. Telephone exchange should control and take care of this system.

(iii) A.R.P. (Air Raid Protection) System / Paging

Air raid communication system (with civil defence) should be provided. The details of such a system should be worked out in association with civil defence authorities of the area. Alternatively, group communication system (all call system)/ alpha numerical pager system should be considered for group emergency communication.

(iv) Fire Sirens

The Fire siren/s should be located suitably to cover the whole area with the operational control in the Fire station control room. These should be tested at least once in a week to keep them in working condition.

Fire siren code should be as follows:

1. Small Fire: No siren
2. Major Fire: A wailing siren for two minutes.
3. Disaster: Same type of siren as in case of Major Fire but the same will be sounded for three times at the interval of one minutes i.e. (wailing siren 2min + gap 1 min + wailing siren 2min + gap 1min + wailing siren 2min) total duration of Disaster siren to be eight minutes.
4. All Clear (For fire): Straight run siren for two minutes.
5. Test: Straight run siren for two minutes at frequency atleast once a week.

(v) Walkie-Talkie / Wireless

All the Fire Tenders shall be provided with a walkie-talkie/ wireless system which will help in communicating with the people in case the other system fails. Besides, key personnel coordinating emergency operations should also be provided with walkie-talkie.

(vi) Fire Alarm System
The fire alarm systems includes manual call points (break glass), automatic gas/smoke/heat detectors, release & inhibit switches for fire suppressing clean agent and conventional or microprocessor based data gathering panels viz. central fire & gas alarm panel, CCTV mimic panels & associated equipment.

Manual Call Points shall be provided at suitable locations like access point, approach roads, walkways etc. to cover the critical areas. These manual call points activate the audio-visual alarm in the Central fire alarm panel installed in fire station and in the repeater panel installed in the respective area control room(s). The location of these points shall be conspicuously marked on the annunciation panel for proper identification.

7.19 Inspection & Testing of Fire Protection System:

The fire protection equipment shall be kept in good operating condition all the time and the fire fighting system shall be periodically tested for proper functioning and logged for record and corrective actions. In addition to routine daily checks/maintenance, the following periodic inspection/testing shall be ensured.

7.19.1 Fire Water Tank/ Reservoir / Foam Tanks

(i) Above ground fire water tanks should be inspected externally once in 5 years & internally once in 15 years.
(ii) The water reservoir shall be emptied out & cleaned once in 3 years. However, floating leaves, material or algae, if any shall be removed once in 6 months or as & when required.
(iii) The foam tanks shall be inspected every 3 years externally and shall undergo internal inspection every 10 years.

7.19.2 Fire Water Pumps

(i) Every pump should be tested by running it minimum two times a week, minimum 30 minutes for diesel driven and 10 minutes for electrical driven pumps.
(ii) Once a month each pump should be checked for the shut off pressure and auto start operation. Observations should be logged.
(iii) Once in six months each pump shall be checked for performance i.e rated flow and rated head.

7.19.3 Fire Water Ring Main

The ring main should be checked once a year for leaks etc. by operating one or more pumps with the hydrant points kept closed as required to get the maximum operating pressure.

The ring main, hydrants, monitors, valves should be visually inspected every month for any pilferage, defects and damage.

All fire main valves should be checked for operation and lubricated once in six months for fresh water and once in three months for saline/ETP water.

Thickness survey & inspection of Firewater header should be done once in three years.

Segment - wise flushing of main header should be done once a year.

7.19.4 Fire Water Spray System

Fixed water cooling spray systems on storage tanks should be tested at least once in six months.

Deluge systems on LPG spheres and bullets should be tested at least once in every three months, for proper performance.
Spray system in LPG bottling plant and should be tested at least once in every quarter. Operation of ROVs should be checked once in three months.

**7.19.5 Fixed / Semi-Fixed Foam System**

Foam system on storage tanks should be tested once in 12 months. This shall include the testing of foam maker/ chamber.

The foam chamber should be designed suitably to facilitate testing of foam discharge outside the cone roof tank.

Piping should be flushed with water after testing foam system.

**7.19.6 Clean Agent (Halon Substitute) Based Extinguishing System**

The systems should be checked as given below:

a) Agent quantity and pressure of refillable containers should be checked, six monthly.

b) The complete System should be inspected for proper operation once every year (Refer latest NFPA Standard 2001 (latest edition) for details of inspection of various systems).

**7.19.7 Mobile Fire Fighting Equipment and Accessories**

Foam tenders should be tested at least once a week. This should include running of pump and foam generation equipment.

All other mobile equipment should be checked, serviced and periodically tested under operating conditions, at least once a month.

Trailer mounted pumps should be test run at least once a week.

All the fire hoses should be hydraulically tested at least once in six months.

DCP tender should be visually inspected every week. This should include checking of pressure of expellant gas.

Records shall be maintained of all maintenance, testing and remedial/ corrective actions taken wherever necessary.

**7.19.8 DCP/ CO2/ Foam Type Fire Extinguishers:**

Inspection and testing frequency and procedure should be in line with IS 2190.

**7.19.9 Communication System**

Fire sirens should be tested at least once a week. Testing of Manual call points once in a month.

**7.20 Fire Protection Training**

All the plant personnel shall be trained on fire prevention and fire fighting aspects. Fire fighting skill upgradation / refresher training shall be given periodically. The fire crew belonging to the fire fighting department shall be given intensive training for the use of all equipment and in various fire fighting methods for handling different types of fires.

A fire training ground with the following minimum training facilities should be set up:

a) Trench fire simulation facilities
b) A small open top tank fire simulation facility  
c) Pan fire simulation facility.  
d) Pipeline flange leak fire simulation facility  
e) Fire suits and breathing apparatus.

A mock fire drill should be conducted once in a month to rehearse the fire emergency procedure and to keep the fire fighting team trained and alert and facilities in top order.

7.21 Fire Station / Control Room

The location and construction of control room should be suitable for following activities.

7.21.1 Location

Fire station should be located at minimum risk area. It should be spaced at a safe distance from any process plant and other hazardous areas.

When planning for new fire station, adequate land should be provided for parking and maneuvering of fire appliances. Also, access and exits of the building should not be obstructed by other vehicles.

Fire station control room should be close to parking bay for fire appliances and should have good view of vehicles parked.

7.21.2 Communication:

Reliable communication system is must for supporting effective fire service dept. operations.

Following equipment should be available in the Control Room, (i) Telephones (2) Wireless sets/walkie-talkie (with a dedicated frequency) (3) Hotlines to neighbouring industries/civil Fire Brigade (4) Fire Alarm system with central control in fire station.

7.21.3 General:

a) Fire Station should have 2 overhead storage tanks for foam compound storage, so that during emergency refilling is not delayed.  
b) Control room should have portable emergency lights.  
c) Fire Station should have prominently located pressure gauge showing fire water network pressure.  
d) Emergency power supply shall be ensured for Fire Station & Fire water Pump House.

7.22 Passive Fire Protection Measures / Other Safety Measures

Although adequate fire protection is provided in an installation, Passive fire protection measures as indicated below should be adopted wherever required.

a) Fire Proofing of structural members  
b) Spark Arresters and Flame Arresters  
c) Fire Separation Walls in concealed space/Electrical Substation/transformer yard/bays/cable galleries.  
d) Fire Seals in underground sewer system/Flare Knock out Drums  
e) Impounding Basins/Dyke Walls  
f) Lightning Arresters  
g) Pressurisation of Enclosure  
h) Venting Facilities of process equipment  
i) Electrical Relays and Fuses, earth leakage circuit breakers, neutral current circuit breaker  
j) Fire retardant coatings and tapes for cables
k) Fire resistant low smoke insulation cable.
l) Flame proof and flame resistant electrical enclosure.
m) Insulation of hot surfaces.

7.23 Fire Alarm & Gas Detection

7.23.1 Scope:

This regulation covers the requirements of fire and gas detection system for refineries and gas processing plants.

A Fire and Gas (F&G) system shall detect and alert the occurrence of any of below incident at an early stage:

- Fire.
- Flammable gas leakage.
- Toxic gas leakage.
- Presence of smoke.

The Fire & Gas detection system and Alarm system will be designed as national / international standards like NFPA 72 / IS 2189.

A F&G detection system should be used to initiate the following functions either automatically or manually:

- Audible and visual alarms/messages in the control room and/or in the plant.
- Starting of firefighting or mitigation equipment, e.g. fire water pumps, water spray, gas suppression systems and fog systems, etc.
- Automatic closure of air ventilation inlets, shutdown of HVAC systems etc.
- Personnel evacuation systems (barriers, howlers, etc.)

The quantity, type and location of FGS detectors shall be determined by an assessment of the following:

- Hazardous area zoning, Gas mapping study Report, QRA (Quantified Risk Assessment) results;
- Limits of equipment congestion
- Potential leak sources and areas where accumulation of gas may be likely or particularly hazardous;
- Properties of process fluids (composition, volatility, phase, temperature, pressure, toxicity);
- Characteristics of potential releases
- Forced or natural draft ventilation patterns, wind speed and wind direction.

The location of gas detectors should depend on the type of gas generated by the fluid being handled. For gases which are lighter than air, gas detectors shall be mounted at a suitable height accordance with manufactures recommendations and for gases heavier than air detectors shall be located at low elevations.

7.23.2 Fire Alarm and Detection Systems:

Fire alarm and gas detection systems are to be provided in plants for early detection of fires so that immediate actions can be taken to mitigate the emergency situation. A control panel indicating location of fire alarms shall be provided in fire station with audio-visual alarm.

The fire alarm system shall be initiated by:

- Manual push button stations located strategically throughout the plant area and buildings.
- Automatic switches such as: sprinkler systems; heat, flame, gas or smoke detectors.
There are different type of fire detectors which can be used for this purpose as per IS: 2189 - standard on Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System or as per any International Standard.

The areas covered should include but not limited to the following:

- Buildings
- Substations including cable cellars
- Control rooms
- Satellite Rack Rooms etc

7.23.3 Gas Detection Systems:

A suitable gas detection system depending on the potential leak source of hydrocarbon, hydrogen and toxic gas shall be installed in refinery and gas processing plants. The location of gas detectors with audio-visual alarm shall be provided in respective plant/area control rooms.

Flammable Gas Detection

Fixed flammable gas detectors shall be provided where possibilities of release of hydrocarbons are expected in process and utility units and storage area.

The areas covered should include but not limited to the following:

- Light hydrocarbon pumps in process unit
- Process cooling tower top platform in the units having pressurized cooling water return
- Furl Gas knockout drum
- Suction side of forced draft air blowers if located where hydrocarbon vapours can be present
- Light hydrocarbon pump stations if located below grade level
- LPG pump house
- LPG mounded bullet
- LPG bulk truck loading area
- LPG wagon loading area
- LPG bottling, storage, repair sheds
- Gas compressor area
- Air intake for control room
- Potential leak source of class A tank dykes etc

The exact numbers and locations should be decided on need basis. Detectors of proper type shall be selected and maintained in good working condition.

Toxic Gas Detection

Toxic gas detectors shall be installed if the risk is applicable. Toxic gas detectors shall be mounted taking into account the prevailing wind direction and wind speed.

Additionally, Toxic gas sensors shall be installed to monitor HVAC air intakes to buildings that could be affected in the event of flammable or toxic release in the surrounding area.

Calibration of Detectors

The calibration using the appropriate test gas should be carried out once in six months or as per manufacturer’s specification whichever is earlier.

Functional Operability of Detectors:

The operability of all type of detectors should be tested once in three months.

7.23.4 Portable Gas Detectors:
Portable gas detectors in sufficient number should be available to monitor gas presence as and when required which are very useful in determining gas presence before issuing work permits.

7.23.5 Approvals: The detector should be ‘intrinsically safe’ suitable for use in hazardous area with certification from any National or International standard.

ANNEXURE-1

EXAMPLE FOR CALCULATION OF FIRE WATER FLOW RATE

1. Design Basis

   The fire water system in an installation shall be designed to meet the fire water flow requirement to fight two major fires simultaneously.

2. Fire Water Demand

   Various areas which can be under fire shall be considered and fire water demand for each area shall be calculated based on design basis, as indicated below:

2.1 Floating Roof Tanks Protection

   a) Data:

      Total storage capacity in one dyke area = 1,20,000 m³
      No. of tanks = 2
      Capacity of each tank = 60,000 m³
      Diameter of each tank = 79 m
      Height of each tank = 14.4 m

   b) Cooling water requirement:

      Cooling water rate @ 3 lpm/ m² of tank shell area for tank on fire,
      Cooling water required = ($π \times 79 \times 14.4 \times 3$) lpm = 10,726 lpm = 644 m³/hr
      Assuming that second tank is located within the tank dyke at a distance more than 30 meters from the tank shell.
      Therefore, in such case cooling water required at the rate of 1 lpm/ m² of tank shell area shall be 215 m³/hr.
      Total cooling water = 859 m³/hr

   c) Foam water requirement for rim seal area:

      Water flow required for applying foam on a largest tank burning surface area.
      For floating roof tank of 79 m diameter,
      Diameter of the tank (D1) = 79 m
      Distance of foam dam from shell = 0.8 m
      Diameter of roof up to foam dam (D2) = 79 - (2 \times 0.8) = 77.4 m
the rim seal area = \((\pi /4) \times (792 - 77.42)\) m²

= 197 m²

Foam solution rate @ 12 lpm/ m² = 2,364 lpm

(For 3% foam concentrate) = (0.97 x 2364) lpm

= 2293 lpm.

= 2293 x 60 m³/hr

1000

= 138 m³/hr.

**Note-1:** These are sample calculations only. Calculations on the basis of actual site conditions and dimensions need to be carried out for each installation as per guidelines provided in clause 5.2.

d) Fire water for supplementary hose stream based on 4 hydrant streams + 1 High Volume Long Range water monitor.

\(4 \times 36 \text{ m}^3/\text{hr} + 1 \times 228 \text{ m}^3/\text{hr} = 372 \text{ m}^3/\text{hr}\)

e) **Total water required:**

- Tank cooling 859 m³/hr
- Foam application 138 m³/hr
- Supplementary stream 372 m³/hr

Total **1369 m³/hr**

2.2 Cone Roof Tanks Protection

a) Data:

Total storage capacity = 50,000 m³

No. of tanks = 4 with 12,500 m³ capacity each.

Diameter of each tank = 37.5 m

Height of each tank = 12 m

b) **Cooling water requirement:**

Cooling water rate = 3 lpm/ m² of tank shell area for tank-on-fire

Cooling water required = \(\pi \times 37.5 \times 12 \times 3\)

= 4243 lpm

= 255 m³/hr

Cooling water required for other tanks at the rate of 3 lpm/ m² of shell area for tanks falling within (R+30) metre from centre of tank on fire,
Total cooling water rate = (255 + 765) m3/hr
= 1020 m3/hr

c) **Foam water requirement** (for 1 tank only) @ 5 lpm/ m2,
Foam solution rate = (π x (37.5)² x 5) lpm
4
= 5525 lpm
For 3% foam concentration = (5525 x 0.97) lpm
= 5359 lpm
= 322 m3/hr

d) Fire water for **supplementary hose** stream = 372 m3/hr

e) **Total water required:**
Tank cooling 1020 m3/hr
Foam application 322 m3/hr
Supplementary stream (including 2 HVLR) 372 m3/hr

**Total 1,714 m3/hr**

2.3 **LPG SPHERES AREA PROTECTION**

a) **Data:**
No. of sphere in one area = 3
Diameter of each sphere = 17 m

b) **Cooling water requirement:**
water rate for cooling = (π x 17² x 10.2) lpm
= 9,265 lpm
= 556 m3/hr
Considering other 2 spheres located within = (3 x 556) m3/hr
(R+30) M from centre of sphere and fire
cooling water rate for 3 spheres
= 1668 m3/hr

c) Hose stream requirement (including 1 HVLR) = 372 m3/hr
d) Total water requirement = 2040 m³/hr

2.4 LPG RAIL WAGON LOADING GANTRY PROTECTION

a) Data:

Total No. of loading points = Conventional or BTPN.

Width of Tank wagon gantry = 12 m

b) Cooling water requirement:

Divide total area of gantry into equal segments such that each segment measuring 15 m X 12 m and consider 3 segments operating at a time.

Water rate required = (3 x 15 x 12 x 10.2) lpm

= 5508 lpm

= 330 m³/hr

Water Requirement for supplementary Hose:

Water for 4 single hydrant streams = 4 x 36 = 144 m³/hr.

Water for 1 monitor stream (HVLR) = 1 x 228 = 228 m³/hr.

Total water requirement = 372 m³/hr.

Total water flow rate for gantry protection

(a) Gantry cooling = 330 m³/hr.

(b) Supplementary hose requirement = 372 m³/hr.

Total = 702 m³/hr.

2.5 PROCESS UNIT PROTECTION

For process unit protection in case of fire, water is to be applied using fixed water monitors and hose lines. Unit blocks separation is by 30 metre. Three following alternatives are considered for fire water rate.

Alternate-I

Total unit area = 120 x 80 m²

Consider water rate @ 1 lpm/ m² on area basis,

Water rate = (9600 x 1) lpm

= 576 m³/hr

Water for supplementary hose stream (including 1 HVLR) = 372 m³/hr

Total water rate = 948 m³/hr
Alternative - II
Consider a 10m x 10m portion of process unit area on fire. Provide water cover over an area of 30m x 30m at the rate of 10.2 lpm/ m²,
Water rate = (900x10.2) lpm
= 9180 lpm
= 551 m³/hr
Water for supplementary hose steam (including 1 HVLR) = 372 m³/hr
Total water rate = 923 m³/hr

Alternate – III
Water required for portion of unit area provided with fixed spray system (Extreme Hazardous Area)
Area assumed = 1000 m²
Water rate = 10.2 lpm/ m²
Cooling water required = 10200 lpm
= 612 m³/hr
Water for supplementary hose steam (including 1 HVLR) = 372 m³/hr
Total cooling water required = 984 m³/hr
Considering the maximum water under alternative I, II & III
Design flow rate = 984 m³/hr

2.6 Fire water calculation for full surface fire on largest floating roof tank (roof sinking case) – Treated as a single contingency
a) Data:
Total storage capacity in one dyke area = 120,000 m³
No. of tanks = 2
Capacity of each tank = 60,000 m³
Diameter of each tank = 79 m
Height of each tank = 14.4 m
b) Cooling water requirement:
Cooling water rate @ 3 lpm/ m² of tank shell area for tank-on-fire
Cooling water required = \pi \times 79 \times 14.4 \times 3
= 10726 lpm
= 644 m3/hr

Assuming that second tank is located within the tank dyke at a distance more than 30M from the tank shell.

Then, cooling water requirement @ 1 lpm/ m2 of tank shell area shall be 215 m3/hr.

**Total cooling water** = (644 + 215) m3/hr
= 859 m3/hr

c) Water requirement in foam application

Foam Application Rate : 8.1 lpm

Foam Solution Requirement = \((\pi \times 79 \times 79) / 4 \times 8.1\) lpm
= 39720 lpm
= 2383 m3/hr

Water required for the foam solution = 97% x 2383 m3/hr
= 2312 m3/hr ...... refer Note-2

d) Fire water for supplementary hose stream based on 4 hydrant streams + 1 High Volume Long Range water monitor.

4x36 m3/hr + 1X228 m3/hr = 372 m3/hr

e) **Total water required:**

Tank cooling 859 m3/hr

Foam application 2312 m3/hr (*Plus requirement for foam losses as per Note-2*)

Supplementary stream 372 m3/hr

**Total 3543 m3/hr**

Say **Total water requirement = 3550 m3/hr** (*Plus requirement for foam losses as per Note-2*)

3.0 **TOTAL DESIGN FIRE WATER RATE**

For two major fire fought simultaneously

Fire water rates for 5 cases are given below:

i) Floating roof tank protection = 1369 m3/hr

ii) Cone roof tank protection = 1714 m3/hr

iii) LPG sphere protection = 2040 m3/hr

iv) LPG rail wagon loading gantry = 702 m3/hr
Protection

v) Process unit protection = 984 m³/hr

**Note-2:** Potential foam losses from wind and other sources to be added to this value as per design requirements. These losses are not considered in this typical calculation sheet.

3.1 For fighting the above two major fires simultaneously, the design firewater rate is the sum of the two highest water rates i.e.

Design fire water rate = 2040 m³/hr + 1714 m³/hr
= 3754 m³/hr
Say = 3750 m³/hr

3.2 For full surface fire of largest floating roof tank (Roof sinking case):

Total firewater flow rate required as per typical calculations shown at 2.6 is 3550 m³/hr. (Plus requirement for foam losses as per Note-2)

The design Firewater rate shall be highest of above 3.1 or 3.2.

**NOTE:**

Full surface fire of a floating roof tank roof sinking case being a remote possibility, it is considered as a single largest contingency for the purpose of arriving at design fire water requirement.

**Note-2:** Potential foam losses from wind and other sources to be added to this value as per design requirements. These losses are not considered in this typical calculation sheet.

ANNEXURE - II

EXAMPLE FOR CALCULATION OF FOAM COMPOUND REQUIREMENT

1. CONE ROOF TANK PROTECTION:

i) Data:

Total Storage capacity in one dyke area = 50000 m³

Number of tanks = 4

Diameter of each tank = 37.5 m

Height of each tank = 12 m

ii) The quantity of foam compound shall be calculated as follows:

Consider foam solution application @ 5 lpm/ m² for the liquid surface of the single largest cone roof tank in the dyke area.
Foam solution rate \(\pi \times (37.5)^2\)

\[\frac{\pi \times (37.5)^2}{5} = 5525 \text{ lpm}\]

Foam compound required (3\%) = (5525 \times 3 / 100) lpm

\[= 166 \text{ lpm}\]

Foam compound quantity for 65 minutes = 166 \times 65

\[= 10,790 \text{ litre}\]

iii) Consider one portable foam monitor of 4500 lpm foam solution capacity:

3\% Foam compound required = 135 lpm

Foam compound required for 65 minutes = 8,775 litre

iv) Consider 2 hose streams of foam with a capacity of 1140 lpm of foam solution capacity

3\% Foam compound required = 68.4 lpm

Foam compound required for 65 minutes = 4,446 litre

v) **Total foam compound required for cone roof tank area Protection:**

Foam compound required for Cone Roof Tank = 10,790 litre

Foam Compound required for 1 Foam Monitor = 8,775 litre

Foam Compound required for 2 hose streams = 4,446 litre

Total = 24,011 litre

Say = 24,000 litres

**2. FLOATING ROOF TANK PROTECTION**

i) Data:

Total Storage Capacity in one dyke = 1,20,000 m3

No. of Tanks = 2

Capacity of Each Tank = 60,000 m3

Diameter of each tank = 79 m

Height of each tank = 14.4 m

iii) Consider foam solution application rate of 12 lpm/ m2 of seal area of the single largest floating roof tank in the dyke area:

For floating roof tank of 79 m diameter,
Diameter of the tank (D1) = 79 m
Distance of foam dam from shell = 0.8 m
Diameter of roof up to foam dam (D2) = (79 - (2X0.8)) m = 77.4 m
Rim seal area = ((π /4) x (79²-77.4²)) m²
= 197 m²
Foam solution rate @ 12 lpm/ m² = 2364 lpm
3% Foam Compound required = 70.9 lpm

**Foam Compound required for 65 mins. = 4,609 liter**

iii) Foam Compound required for 1 foam monitor and 2 hose streams as calculated for cone roof protection
   1 Foam monitor 8,775 liter
   2 Hose streams 4,446 litre

iv) Total foam compound required for floating roof tank area Protection:
    Foam Compound required for Floating Roof Tank 4,609 liter
    Foam compound required for 1 foam monitor 8,775 liter
    Foam compound required for 2 hose streams 4,446 litre
    Total required 17,830 liter

**Say, 18,000 liter**

3. On the lines of the above example foam compound requirement should be calculated for various dyke areas. Requirements to fight major fires in two dyke areas (with maximum foam compound rates requirements) should be added, to arrive at the total requirement of the installation.

For example, for 2 cone roof tank dyke areas with largest tank diameter of 37.5 metres in each area, foam compound required works out as 2x24000 liters i.e. 48,000 liters.

Similarly for 2 floating roof tank dyke areas with largest tank diameter of 79 M. in each area, foam compound required works out as 2 X 18000 liters i.e. 36,000 liters.

4. Foam Requirement for Full surface fire of the largest floating roof tank (roof sinking Case): considered as a single largest contingency & detailed at Annexure-VI
Example of Fire Case in a large Floating Roof Tank after sinking of floating roof

Example for calculation of Foam Requirement for Floating Roof tank with Portable Monitors:

**DATA:**

1. Diameter of Tank = 79 m
2. Type of Roof = Floating Roof
3. Foam Application Rate = 8.1 lpm

Foam Solution Requirement = \( \pi \times 79 \times 79 \)

\[ \frac{\pi \times 79 \times 79}{8.1} \]

\[ 4 \]

\[ = 39,720 \text{ lpm} \]

\[ = 2,383 \text{ m}^3/\text{hr} \]

Say, \[ = 2,400 \text{ m}^3/\text{hr} \]

Foam Compound Requirement = \( 39720 \times 3 /100 \)

\[ = 1192 \text{ lpm} \]

Foam Compound Requirement = \( (1192 \times 65) \) litre

for 65 minutes with 3% concentration

\[ = 77,480 \text{ litres} \]

**SYSTEM OF AUTOMATIC ACTUATED RIM SEAL FIRE DETECTION AND EXTINGUISHING SYSTEM FOR EXTERNAL FLOATING ROOF TANKS STORING CLASS-A PETROLEUM**

The automatic actuated flooding system is designed to automatically detect and extinguish the floating roof tank rim seal fire at its incipient stage. The system is mounted on the roof of the tank. The minimum requirement for the design of the system is given below:

**1.0 Foam Flooding system:**

Film Forming Fluoroprotein Foam (FFFP) / Aqueous Film Forming Foam (AFFF) type concentrate is used in the system.

**1.1 Foam Application system :**

A large storage tank requires one or more than one modular units for foam application in the entire rim seal. Each such unit consists of a foam distribution pipe, laid along the tank perimeter over the rim seal area.
The spray nozzles for foam application are mounted on the distribution pipe at suitable intervals. Distribution pipe is permanently connected to a storage vessel containing pre-mix foam and both are placed on the roof. The foam is kept pressurised with nitrogen. The premix foam solution is contained in a vessel which is kept charged with nitrogen. The system is designed for minimum foam application rate of @ 18 lpm/ m2 of rim seal area. For effective control, foam is to be discharged in approximately 40 seconds.

1.2 Alarm & Auto-actuation system:

In case of fire on the rim seal, it is automatically detected by a device capable to sense the same. The device then actuates the spray system for application of foam in the complete area of rim seal to quickly extinguish the fire in its incipient stage. An audio-visual alarm is also coupled with the detection & extinguishing system for necessary fire alert.

The system includes a fire detector network which senses fire and actuates the automatic release of the extinguishing medium on the rim seal area. Each tank shall have independent detection & extinguishing system.

The design considerations should include the impact of the weight of the modules placed on the floating roof.

The detection system needs to be highly reliable and shall work at varied site ambient temperatures for protection of rim seal fire. The detection systems shall be listed and/or approved by any of the national/international agencies like BIS, UL, FM, VdS, LPC etc. to ensure that those systems are used which meet the highest standards of safety.

1.3 Calculations for modular Foam application system for 79 mtr dia tank:

- Rim seal area of Tank : \( \pi \times 79 \times 0.3 = 74.5 \text{ m}^2 \) (Considering a flexible seal area of typically 300 mm)
- Rate of Foam application @ 18 LPM/ m2 = 1341 LPM
- Total Foam solution required in 40 sec = 894 litre
- Total nos. of Modular unit required for the tank = 7 *

* (considering a vessel of 150 litre capacity containing 135 litre of Foam)
Schedule-8

8.0 Competence Assessment and Assurance

Every entity shall develop, implement, and maintain a written Competency Assessment and Assurance plan. The plan should include relevant functional competencies required for personnel to ensure safe, reliable and compliant operations at Refineries and Gas Processing Plant. These competencies shall include following but not limited to,

(a) The basic operations and maintenance procedures carried out in Refineries and Gas Processing Plant;
(b) The characteristics and potential hazards of materials, chemicals, etc. involved including emergency arising out of toxic releases etc.;
(c) Carrying out their assigned roles and responsibilities;
(d) Fire prevention, including familiarization with the fire control plan firefighting; the potential causes of fire; the types, sizes, and likely consequences of a fire; and
(e) Carrying out the emergency procedures that relate to their duties at the Refineries and Gas Processing Plant and providing first aid.

8.1 Each entity shall develop, implement, and maintain a written plan to keep personnel of its Refineries and Gas Processing Plant up-to-date on the function of the systems, safety and security at the Refineries and Gas Processing Plant.

8.2 The Refresher programs for training of all personnel shall be conducted at an interval not exceeding 3 years to keep personnel current on the knowledge and skills.

8.3 Every operating company shall maintain a record for each employee of its Refineries and Gas Processing Plant that sets out the training given to the employee.

8.4 Each operating company shall ensure that Refineries and Gas Processing 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.

8.5 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.

8.6 Supervisors and other personnel utilized for construction, installation, inspection, or testing shall 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.

8.7 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.

8.8 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.
8.9 Personnel having security duties shall be qualified to perform their assigned duties by successful completion of the training as specified.

8.10 Each operator shall follow a written plan to verify that personnel assigned operating, maintenance, security, or fire protection duties at the Refineries and Gas Processing Plant do not have any physical condition that would impair performance of their assigned duties.

8.11 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 Refineries and Gas Processing Plant and other flammable materials/ fluids/ chemicals used or handled at the facility;
(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;

8.12 All personnel of Refineries and Gas Processing Plant shall be trained to carry out the emergency procedures that relate to their assigned functions; and

8.13 All operating and appropriate supervisory personnel of Refineries and Gas Processing Plant shall be trained to understand detailed instructions on the facility operations, including controls, functions, and operating procedures.

8.14 Personnel responsible for security at Refineries and Gas Processing Plant shall positively be trained in accordance with a written plan of initial instruction to-

(i) security risk assessment;
(ii) recognize breaches of security;
(iii) carry out the security procedures that relate to their assigned duties;
(iv) be familiar with basic plant operations and emergency procedures, as necessary to effectively perform their assigned duties; and
(v) recognize conditions where security assistance is needed.

8.15 Each entity shall maintain training and competency assessment and assurance records -

(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 be maintained.
9.0 Safety Audits

9.1 Objectives of Safety Audits:

While the basic aim of safety audits is to identify the areas of weaknesses and strengths, safety audits are undertaken to meet different specific objectives viz.-

(i) To identify any operating and design deficiencies that could impact safety of people, environment and asset.
(ii) To ensure that mitigative safeguards and safety systems are well maintained.
(iii) To ensure that operation, maintenance and emergency procedures are updated.
(iv) To verify the compliance of statutory regulations, standards, codes, etc.
(v) As a social objective to cater to public opinion and concern for safe environment. This also improves public relation of the organization.
(vi) To share best practices adopted with peers.

9.2 Scope of Safety Audits:

The scope includes all the components of the system viz. management policy, leadership and organization training, and competency, design (Process, Mechanical, Electrical, etc.) aspect, layout and construction of the plant, operating procedures, asset integrity plan, emergency response plans, personal protection standards, incident records.

9.2.1 Types of Safety Audits:

Two types of Safety Audits are proposed to be carried out as below:

(i) Internal Safety Audit:

9.3 Methodology of Internal Safety Audits:

9.3.1 Frequency of Audits:

The internal safety audit should be conducted minimum once a year.

9.3.2 Formation of Multi-Disciplinary Audit Teams:

The Internal Audits should be carried out through multidisciplinary audits teams. The composition of the Internal Safety Audit may vary depending on the Group and areas to be audited, however, person(s) concerned should have necessary experience and background to undertake in-depth audit in a particular discipline. A team of 4 to 5 experienced officers from various disciplines viz. Process / Production, Maintenance/ Inspection, Electrical, Instrumentation, Fire & Safety and with the activity involvement of concerned Plant/ Area Manager is suggested. In multi-unit organizations, the team members could also be drawn from the Head Office / Corporate Office and other operating Units under its control.

9.3.3 Duration of Audit:

Depending on the nature of audit and type / complexity of the installations in the selected group, the duration of internal safety Audit can be fixed. This may vary from 3 to 5 working days for facilities under each group.

9.3.4 Use of Safety Audit Check Lists:
Check lists are the most useful tool for undertaking systematic Safety Audit. Even for a skilled and well qualified engineer a good check list would be necessary as a guide. Like a code of practice, a Check List is a means of pooling the knowledge and hard-won experience and ensures that no important aspect is overlooked or forgotten. Such check lists help maintaining uniformity and speeding up the audits.

In Section-II of this document, detailed model Checklist covering important areas are given. It is suggested that oil industry members should adopt these model check lists for carrying out Internal Safety Audits.

9.3.5 Preparation Before Site Visits for Internal Safety Audits:

Before the safety Audit team visits any particular facility for carrying out Safety Audit, it would be essential to study all relevant documents as below to get complete picture:

(i) Layouts  
(ii) P & IDs  
(iii) Operating Manuals  
(iv) Maintenance / Inspection Manuals  
(v) Fire and Safety Manuals, etc.

Depending upon the nature of audit more emphasis can be given to study specific documents. All the audit team members should study these documents in advance to know the details of the installation.

9.3.6 Briefing:

Before beginning of each audit, all concerned persons of the area/installation be briefed by the team leader about the purpose of the audit. No impression should be left that audit will throw bad light on them.

9.3.7 Site Inspections:

Most of the information could be gathered through site inspection using ready-made check lists. The auditors should enter their observations under the remarks column and not simply state "yes" / "no". Wherever necessary, observations should be recorded in separate sheet. Inspection should be carried out accompanied by Installation / Plant Manager or the assigned officials.

9.3.8 Discussions:

Further information can also be gathered through discussions (formal & informal), with site personnel and Installation / Plant Manager, who is in-charge of the area or other site officers. The audit team should interact with persons from various disciplines such as Production, Maintenance, Electrical, Instrumentation, etc. Formal discussions could be in the form of brief periodical sessions while informal discussions could be over a cup of tea with personnel working in the area.

9.3.9 Study of Documents:

In addition to the documents which are already studied before inspection of the facilities, other documents, such as Operating Instructions, Standing Orders, Log Books, Log sheets, Accident Records, Minutes of Safety Committee Meetings etc. may also be studied as required.

9.3.10 Preparation of Audit Reports:

The work of the Internal Safety Audit item should be presented in the form of a Safety Audit Report for each group which should contain observations & recommendations and also in brief the modalities adopted in conducting audit and the names of the audit team members.
Before finalizing the report, the Safety Audit Team can give a presentation as feedback to the Operating / Management personnel of the Area / Installation. Additions or deletions could be made in the draft report based on the discussions and comments received during the presentation. This approach is always constructive and does not undermine the technical competence of the audit team.

9.4 Follow Up of Audit Reports:

Generally, the Internal Safety Audit Reports are submitted to the concerned authority who appoints the audit team for undertaking needful follow up actions. Only the appointing authority should exercise judgement in rejecting any of the recommendations. The appointing authority shall be of senior management level (General Manager and above).

The crux of the safety audits lies in removing the weakness identified during the audit. Sometimes audit reports identify only the problem / weakness, but not the solution.

In such cases, it would be necessary to undertake a detailed study of the specific area and to identify the rectification measures. Wherever the necessary in-house expertise is not available for detailed studies, help of consultants / professional bodies should be sought for.

9.5 Implementation of Recommendations

The final and most important phase is the implementation of recommendations. A senior person should be nominated for coordinating implementation of all accepted recommendation under a time bound program. Senior management should review the progress of implementation of recommendations periodically through Management Safety Committee meetings and other review meetings.
10.0 **Road Safety:**

10.1 Vehicles are always a probable source of ignition. At the same time unsafe driving is a potential hazard – the vehicle may collide with others, may hit someone working or may overturn. All these may lead to events that might turn out to be catastrophic. Hence movement of vehicles inside Refineries and Gas processing plants (thereafter referred to as “Installations”) needs to be controlled. However, some vehicles/ mobile equipment such as Maintenance vehicles, Cranes, Hydra etc. are required for carrying out operation, maintenance and project activities are required to be allowed to ply inside the hazardous area.

Accordingly, following aspects are broadly should be followed,

(a) Movement of vehicles inside these installations should only be strictly on NEED basis.

(b) There should be proper demarcation of battery limit with signage / barricades from where entry of vehicles are restricted / prohibited without proper authorization.

(c) A suitable procedure for Vehicle Entry inside installations shall be developed. Vehicles should be allowed to enter the hazardous area after issuance of suitable permit by the authorized person.

(d) Vehicles with Spark Ignition Engines shall not be allowed to be driven inside the hazardous area.

(e) PESO approved Spark arrester shall be fitted on vehicles entering into hazardous area

(f) There will be limitation of driving speed inside the installations.

10.2 **Parking of Vehicle:**

All vehicles shall be parked in approved parking areas.

10.3 **Vehicle Entry Permit System:**

i. Each installation shall develop a suitable Vehicle Entry Permit System for allowing entry of vehicles inside the restricted areas of installation.

ii. The Installation may classify the areas as Process, Storage, Utility etc. and accordingly issue permit for that areas where it is intended to go.

iii. The vehicle shall be checked by authorized personnel before entry in line with approved checklist.

iv. The physical condition and integrity of the spark arrester should be checked including trial running to ensure that no spark is coming out.

**Driver and Helper:**

i. All the Drivers and Helpers required to operate inside the hazardous area shall understand Safety Rules pertaining to the Refinery and Gas Processing plant.

ii. Refinery and Gas Processing plant should impart such training to these persons and the records may be maintained.

iii. In case of new persons, they shall be imparted the training on Safety Rules before allowing them to assign the work.

iv. The drivers attend refresher courses on safe driving practices at regular intervals.

v. Each driver should undergo periodic medical examination at regular interval with special reference to vision, night and colour blindness.
Signage:

In order to improve defensive driving culture, display boards showing precautions are installed at various locations and these traffic signals are to be strictly followed while driving inside these installations.

Speed limits shall be defined and followed inside refineries and gas processing plants for various locations.

Mirrors should be installed at blind spots on the road.

10.4 General Points:

Overtaking of the vehicle should not be allowed.
11.0 Occupational Health and Industrial Hygiene Monitoring:

(i) Occupational Health monitoring shall be applicable to Workers (Which include all regular employees, tenure/ term-based employees and Casual/ contingent workers).

(ii) Occupational Health Centre (OHC) with occupational health trained physician and adequate trained staff with necessary facilities shall be set up.

(iii) Organisation shall establish an efficient computerized Health Information System for storing and processing information on Occupational Hygiene, medical records, exposure hazards of chemicals and locations of potential chemicals exposures.

(iv) Occupational health considerations shall be taken into account in risk management studies, formal incident investigation system, unscheduled maintenance work, as contract requirements, contractors’ prequalification, in training and selection of PPEs.

(v) Scope of activities involved are:

(a) Workplace Surveillance (Monitoring of all workplaces for Hazards, Ergonomic Assessment of the Workplace, Sanitation Evaluation – including potability of drinking Water)
(b) Personnel Surveillance (Periodic Medical Examination, Pre-Employment Medical Examination and Pre-Placement Medical Examination).
(c) Compliance to Statutory provisions
(d) Training

11.1 Occupational Health Monitoring:

(i) Occupational Health surveillance shall be implemented to evaluate employees’ health conditions, to evaluate the effectiveness of control measures and for early recognition of occupational diseases.

(ii) Occupational Health Monitoring shall either be carried out by creating facilities within the installations or through outside agency and records of all such examinations shall be kept, analyzed and action taken in a bid to obtain early recognition of any disease.

(iii) Occupational health hazard & Industrial health survey of all facilities shall be conducted to assess the occupational health hazards like physical (noise, heat, radiation, illumination), chemical, toxic exposures, ergonomics, biological and psychological. It shall require Job Analysis and Job observations by the survey team.

(iv) On basis of this survey, the hazardous areas shall be classified as high risk, medium and low risk areas. The main focus shall be on hazard elimination/ reduction. There shall be periodical monitoring.

(v) The results from the exposure monitoring and health surveillance shall be collected, recorded, validated and analysed. Specialist interpretation shall be necessary to obtain reliable conclusions and to make meaningful recommendations.

(vi) Periodic Medical Examination shall be conducted.

11.1.1 First-Aid:

(i) First-aid shall be provided by certified trained persons.
(ii) First aid personnel shall be readily available during working hours.
(iii) First Aid Kits should be placed in the workplace, at strategic locations.
11.2  Work-environment Monitoring & Industrial hygiene:

(i) Industrial Hygiene survey shall be done to map all the occupational health hazards in a work area and should cover all installations.
(ii) The Industrial Hygiene survey shall be done once every 5 years. However, a major change in the process will warrant a fresh survey.
(iii) Occupational health risk assessment shall be done based on the results of the survey.

11.2.1  Control Strategies:

After identifying the occupational health risks arising out of handling of hazardous substances, the strategy to prevent or minimise the health risk shall be based on hierarchy of control measures, namely elimination, substitution, Engineering Controls, Segregation, Procedural Controls, use of Personal Protective Equipment (PPE) and Personal Hygiene.

11.3  Pre-employment / Pre-placement Medical Examination:

(i) The organization shall develop and issue guidelines for determining the medical fitness of a Candidate considered for Pre-employment / placement in the services of the Company.
(ii) The medical examination shall be conducted for all regular employees using in-house facilities or through outsourcing. Medical examination of Contract employees shall also be ensured.

11.4  Periodic Medical Examination:

(i) The periodic examination should be carried out at regular intervals after the initial pre-placement examination.

The scope and periodicity of the health examination shall depend on the nature and extent of the risk involved. Biological monitoring (an assessment of exposures through measurements of some ‘index chemical’ in a body fluid) shall be used to further evaluate a potential health hazard in the workplace.

11.5  Contract Requirements:

Contractors shall be required to undertake the health risk assessment of their employees and shall implement suitable and adequate control measures to eliminate or minimize the risk. Contractors shall also undertake training of contract employees in health risk on jobs and their protection measures.

11.6  Auditing & Review:

(i) Each facility shall undergo a formal audit of occupation heath and industrial hygiene aspects periodically.
(ii) The findings and recommendations of the auditors shall be implemented in a time-bound manner.
(iii) An annual review of the status of various activities in the field of Occupation health and industrial hygiene shall be undertaken and corrective action, as necessary, be taken.
12.0 Control of Work (CoW):

This is one of the key processes the refining and Gas processing facilities shall develop and maintain at their respective facilities to ensure safe execution of the tasks. The process includes following key elements, Defining a Cow scope, Planning & Scheduling Risk assessment, Competency of permit roles, Task risk assessment, Preparation of PTW, Authorization of Hazards and controls, communication, Monitoring of all work requiring a permit and leaving worksite in safe condition on interruption, Permit Closure, Regular auditing of PTW, capturing and sharing lessons learned and authority to stop work.

12.1 Elements of Control of Work:

12.1.1 Plan the work:

(a) Procedures should exist describing the Control of Work process.
(b) All identified roles within the Control of Work procedure shall have defined responsibilities.
(c) All persons involved in the Control of Work process shall be appropriately trained and competent to carry out their roles.
(d) Planning and scheduling of work should identify individual tasks and their interaction.

12.1.2 Assess and manage the risk:

(a) Tasks shall not be conducted without being risk assessed.
(b) Before conducting non-routine work that involves confined space entry, work on energy systems, ground disturbance, hot work in or other potentially hazardous activities, a work permit (or work clearance) shall be obtained.
(c) The scope, hazards, controls and mitigations shall be communicated in writing and signed off by all involved in the task.

Note: PTW should finally and formally be handed over at site after joint site visit by Issuing and Performing Parties for verification of implementation of controls for pre-identified hazards and mitigation of the last moment hazards.

12.1.3 Training and Competency:

Employees who are involved in the CoW process shall be trained and competent in the tasks they are performing and meet the competency requirements for their assigned CoW roles.

Training should focus on use of the permit-to-work system but shall also ensure that the individual understands the working environment, the hazards associated with it, and more importantly, the controls required to appropriately manage the risks presented by those hazards.

12.2 Planning and Scheduling:

Irrespective of whether the work is routine or non-routine, or whether it requires a work permit or work clearance, the person responsible for planning the work shall allow time for the following actions for the safe execution of the work

(a) Define the scope of work;
(b) Identification of personnel and equipment required.
(c) Identification of dependent and linked work
(d) Identification of simultaneous operations and their compatibility with the work
(e) Review associated Procedures / Risk Assessments/ Isolation Plans / Blinding diagrams / LOTO requirements.
(f) Define any Regulatory requirements;
(g) Inspection of the work site.
(h) Conduct a risk assessment of the task.
(i) Implementation of control measures including isolations.
(j) Arrange resources for the work including the provision of the approval issuing authority if work is required to be undertaken under a work permit
(k) Coordinate and priorities work to reduce conflict between tasks.

Subject Matter Experts (SMEs) may be included in the planning stages, as required by the technical complexity of the task(s).

12.3 Risk Assessment of Tasks:

As there is potential hazard involved in the activities being performed, tasks shall not be conducted without being risk assessed.

12.3.1 Risk Assessment Process

Risk assessment is a systematic process of:

(i) Identifying hazards
(ii) Controlling risk by applying controls in the following hierarchy of controls:

(a) Elimination
(b) Substitution
(c) Engineering
(d) Isolation
(e) Administrative
(f) Personal protective equipment.

(iii) Evaluating acceptability of residual risk (As Low as Reasonably Practical- ALARP),
(iv) Documenting the hazards and controls.
(v) Record Approvals.
(vi) Communicate to those potentially affected.

12.3.2 Risk Assessment Process/ JSA Requirements

The risk assessment process requires:

(a) The risk assessment should be carried out by a team of persons having the competency and the required knowledge of the hazards involved in the task as well the job site and process hazards.
(b) A member of the work crew performing the task shall participate in the Risk Assessment, which shall be communicated in writing and signed off by all involved in the task.
(c) Hazard identification from the task along with job site and process should be considered.
(d) Possible interactions during simultaneous operations between different activities in the same task or other task should be considered.
(e) The identified hazards and associated controls will be agreed upon and will be documented on the risk assessment.
(f) Review the hazards identified during permit development, and ensure all identified controls are in place prior to starting work.
(g) Monitoring shall be done while execution of job to record any changes to the work site and should revisit the risk assessment in case any new hazards have been introduced during the job execution.

Alternatively, Job Safety Analysis (JSA) of the work/ task shall be carried out and communicated to all personnel involved.

12.4 Permit to Work System:
12.4.1 Control of work management: Entity shall define boundaries of applicability of the requirements of CoW at various stages of Projects, e.g. Green fields projects, Brown field projects, Turnaround, Normal Operations and routine maintenance by competent persons.

12.4.2 Type of Work Permits

Based on the nature of work to be performed, the following minimum type of work permits shall be used.

(a) Cold Work
(b) Hot Work
(c) Confined Space Entry
(d) Electrical isolation and Energization
(e) Work at height
(f) Critical lifts (To be defined)
(g) Composite permit as applicable
(h) Radiography
(i) Excavation

Specific precaution/ control measures should be taken w.r.t. the hazards associated with lifts/ rigging, line breaks, work in sub-station and transformers yards, road closure etc.

12.4.3 Permit to Work (PTW) System:

PTW system is a formal written system used to control certain types of work which are identified as potentially hazardous. Essential features of permit-to-work systems are:

(a) clear identification of who may authorize particular jobs (and any limits to their authority) and who is responsible for specifying the necessary precautions;
(b) training and instruction in the issue, use and closure of permits;
(c) monitoring and auditing to ensure that the system works as intended;
(d) clear identification of the types of work considered hazardous;
(e) clear and standardized identification of tasks, risk assessments, permitted task duration and supplemental or simultaneous activity and control measures.

(1) Cold Work Permit:

Work falling under the category of cold work such as opening process machinery, blinding & de-blinding, tightening of flanges, hot bolting, inspection, painting etc. shall be performed through Cold Work Permit. This Permit shall be in minimum two copies. The original should be in yellow colour and the copy should have the word “COPY” printed in large yellow letters. Original shall be issued to the receiver, retaining the duplicate in the book.

(2) Hot work Permit:

All hot work such as welding, grinding, gas cutting, burning, shot blasting, soldering, chipping, excavation, open fire, use of certain non-explosion proof equipment etc. shall be carried out through Hot Work Permit. Entry and operation of petrol or diesel driven vehicles or equipment in hazardous area also falls in the category of hot work and shall be performed under the hot work permit.

(3) Confined Space Entry Permit:

This permit is required for the protection of personnel entering a confined space such as Vessels, boilers, storage tanks, large diameter piping etc against hazards such as oxygen deficiency, toxic and flammable materials, falling objects, power driven equipment etc. Excavation more than 1.2-
meter-deep, entry on floating roof tanks when the roof is more than 3 meter down from the top, space located below ground level such as pits, drain channels etc. also fall under the confined space.

(4) **Electrical isolation and Energization permit:**

Before issuing any work permit, it is essential that the equipment/ facility to be worked on is electrically safe and electrical power is isolated to the extent necessary for the safe conduct of the authorized work.

Permit for electrical isolation and energization shall be in triplicate and in two sections with tear off facility. Section-A shall be used for electrical isolation and Section-B for energization.

The original should be in color different than the other permits and copies should have the word "COPY" printed in large letters. Original along with a copy shall be issued to the electrical section for electrical isolation / energization. Electrical section authorized person on isolation / energization of the equipment / circuit shall return the original to the issuer keeping copy for record. **Specimen format for the Electrical isolation / energization is enclosed at Annexure-III.**

12.4.4 **Lessons Learned:**

As part of the continuous improvement of the processes, the findings of the Lessons Learned shall be incorporated into the following if necessary:

(a) Procedures and Documentation; and
(b) Control of Work communications.

All persons involved in the CoW process should take a proactive approach to the lessons learned process.

12.4.5 **Communication of the Hazards and controls:** Entity shall establish the process for documenting hazards communication and controls to the work crew before and during the execution of the task.

12.4.6 **Permit authorization:** Entity shall develop and maintain the system for authorization of the work based on the level of risk or the type of the job involved

12.4.7 **PTW audits:** Entity should establish the process for regular inspection of the PTW process to ensure that, the process is followed to the intent. The inspections shall be carried out by the team external to the plant,

12.4.8 **Lessons learned:** Entity should establish the process of capturing the lessons learned through routine PTW process for the input to the major annual improvement process

12.4.9 **Stop work authority:** Entity shall empower everyone at site to stop the unsafe work

All persons involved in the CoW process should take a proactive approach to the lessons learned process.
13.0 Safety Management System (SMS)

Process safety management is widely credited for reduction in major accident risk and improved process industry performance. Process Safety management is a disciplined framework for managing the integrity of operating systems and processes handling hazardous substances by applying good design principles, engineering, and operating practices. It deals with the prevention and control of incidents that have the potential to release hazardous materials or energy. Such incidents can cause toxic effects, fire, or explosion and could ultimately result in serious injuries, property damage, lost production, and environmental impact.

An effective process safety management program requires a systematic approach to evaluating the whole chemical process. Using this approach, the process design, process technology, process changes, operational and maintenance activities and procedures, non-routine activities and procedures, emergency preparedness plans and procedures, training programs, and other elements that affect the process are all considered in the evaluation.

Entities should establish safety management system, which shall be an integral part of the overall management framework of an entity, which comprises following five major elements. Safety Management System (SMS) should be based on PDCA (Plan, Do, Check and Act) cycle. PDCA typically involves addressing following aspects to deliver an effective Safety performance:

(a) Leadership and commitment: includes top management, company operating model, accountability, defining policy, objectives, requirements, & strategies; setting standards
(b) Planning and execution – includes Line and Safety Organisation responsible for preparing and implementing operational standards and procedures for managing risks.
(c) Operational controls: includes basic expectations of the management to manage the risk of the business/ entity.
(d) Measuring and evaluating – includes defining KPIs, active monitoring, recording and handling of non-conformities;
(e) Continuous improvement – includes management review, visibility of commitment and its reflection of the importance of accountability for safety

13.1 Elements of Safety Management system (SMS)

Safety management system should include at least the following basic elements, which should help entities to meet the requirements of Process safety:

13.1.1 Leadership and Management commitment-

   a. General: Leadership and Management Commitment should be clearly visible in the SMS. Management should develop and endorse a written description of the company’s safety and environmental policies and organizational structure that define responsibilities, authorities, and lines of communication required to implement the management 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.
b. **Planning:**
Management shall ensure that:

a) Processes and procedures are defined to support execution of each SMS element;

b) Process is defined to address regulatory and legislative requirements for refinery safety and the impact on the SMS;

c) Plans, processes, and procedures are integrated to ensure that data, results, and findings are shared across relevant elements, processes, teams, employees and contractors; and

d) Budgets and resource planning, including for personnel and supporting technology requirements, are developed to design, implement and improve the PSMS.

c. **Top management shall lead and demonstrate its commitment to the its SMS by:**

i. promoting a positive safety culture and assessing how this culture is changing over time;

ii. ensuring that the operational elements set forth in this regulation are in place, with clear accountability for implementation and with a clear connection between objectives and day-to-day activities;

iii. fostering risk management processes that reveal and mitigate risk, making compliance and risk reduction routine;

iv. leading a resource allocation process;

v. establishing high-level performance measures;

vi. communicating commitment to the SMS with internal and external stakeholders;

vii. promoting engagement and leadership at all levels of the organization.

d. **Execution:** Entity management supported by top management shall establish, implement, evaluate, and improve processes, procedures, systems, and training to meet policies and objectives. They should be responsible for developing the annual plan with line organization, which is aligned to the policy and goals of the organization. Entity shall issue an annual HSE program addressing the entire site, including contracted staff, on relevant Health, Safety and Environment subjects including,

i. Previous year HSE performance.

ii. HSE targets for the coming year.

iii. Significant incidents & learnings.

iv. Specific initiatives within process safety, workplace safety, occupational health and environment.

v. Emergency response.

vi. Contractor involvement

vii. Audits and management review.

Entity leadership should identify, seek, and allocate resources sufficient for safe, environmentally sound, reliable, and efficient operations and share learnings and establish performance measures that address each element of the SMS.

2. **Risk Management:** The entity shall maintain procedure(s) for the performance of risk management. The entity shall maintain a description of the assets comprising the refining and Gas processing operations, including the surrounding environment, to identify threats to refining safety. The entity shall analyze risk considering the threat occurrence likelihood and consequence. The entity shall evaluate safety risk and make decisions on how to manage it through preventive controls, monitoring, and mitigation measures. Safety assurance sub-elements, including audits, data analysis, and performance evaluation are used to monitor the effectiveness of risk management. The entity shall maintain a process to identify threats that are posed by operations and the operating environment, including changes in conditions that could occur between assessments.

3. **Operational Controls:** Each entity shall be responsible to identify, understand, and control the hazards inherent in its process to prevent serious process-related incidents, which might affect plant...
personnel, off-site communities, the environment, or result in significant property loss or loss of business. The operational elements or operational controls should be an effective tool for increasing not only the safety of an operation, but its efficiency, cost-effectiveness, and quality, it is an instrument for developing, implementing, and maintaining not only a safe, but efficient process as well. It involves the application of systems and controls to chemical and manufacturing processes. Following operational controls should form the part of SMS. These are the basic expectation to manage the risk of the relevant business / entity. These expectations provide the framework for SMS. Based on levels of Risk and complexity of the operation the depth of the implementation of these elements should be established by the entity.

(i) **Process Safety Information** - Comprehensive safety and environmental information for the facility, which include documentation on process, mechanical and facility design, should be developed and maintained throughout the life of the facility.

Entity shall complete a compilation of written process safety information before conducting any process hazard analysis required by this document. The compilation of written process safety information should help the entity and the employees involved in operating the process to identify and understand the hazards posed by processes involving highly hazardous chemicals. Process safety information shall include information on the hazards of the highly hazardous chemicals used or produced by the process, information on the technology of the process, information on the equipment in the process and information on quantities handled at plant / facilities.

(A) Information on the hazards of the highly hazardous chemicals in the process shall consist of at least the following.

(i) Toxicity,
(ii) Permissible exposure limits,
(iii) Physical data,
(iv) Reactivity data,
(v) Corrosivity data, and
(vi) Thermal and chemical stability data, and hazardous effects of inadvertent mixing of different materials.
(vii) Minimum inventories handled

(B) Information on the technology of the process shall include at least the following:

(i) A block flow diagram or simplified process flow diagram,
(ii) Process chemistry,
(iii) Maximum intended inventory,
(iv) Safe upper and lower limits for such items as temperatures, pressures, flows or compositions, and
(v) An evaluation of the consequences of deviations, including those affecting the safety and health of employees.

(C) Where the original technical information no longer exists, such information may be developed in conjunction with the process hazard analysis in sufficient detail to support the analysis. Information on the equipment in the process shall include the following:

(i) Materials of construction,
(ii) Piping and instrument diagrams (P&IDs),
(iii) Electrical classification,
(iv) Relief system design and design basis,
(v) Ventilation system design,
(vi) Design codes and standards employed,
(vii) Material and energy balances for processes
(viii) Safety systems (e.g., interlocks, detection, or suppression systems).

For existing equipment designed and constructed in accordance with codes, standards, or practices that are no longer in general use, the entity should determine and document that the equipment is designed, maintained, inspected, tested, and operated in a safe manner.

(ii) **Process Hazard Analysis**- The purpose of Process Hazard Analysis (PHA) is to minimise the likelihood of the occurrence and the consequences of a dangerous substance release by identifying, evaluating and controlling the events that could lead to the release. Process hazards analysis should be performed for any facility to identify, evaluate, and reduce the likelihood and/or minimize the consequences of uncontrolled releases and other safety or environmental incidents. Systematic evaluation of process hazards through PHA involves steps like Hazard Identification, Hazard evaluation, Consequence analysis, Facility Siting, Inherently Safer Process and Human factors. These studies should encompass process hazards in various phases of the unit operations – steady state, start-up and shutdown phases. Recommendations resulting from the PHA should be completed before start-up for a new process or facility, or modification in existing facility.

The process hazard analysis should be updated and revalidated by a team, having requisite background, at least every 5 years after the completion of initial process hazard analysis. PHA revalidation is recommended earlier, in case of major incident occurrence or any major modifications in the unit that may deem the earlier PHA invalid.

Entity should maintain record of performance of process hazard analyses and updates or revalidation for each process covered by PSM, as well as the documented resolution of recommendations, for the life of the process.

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

The procedures shall address at least the following elements:

(a) Steps for each operating phase:
(b) Initial start-up;
(c) Normal operations;
(d) Temporary operations;
(e) Emergency shutdown, including the conditions under which emergency shutdown is required, and the assignment of shutdown responsibility to qualified operators to ensure that emergency shutdown is executed in a safe and timely manner;
(f) Emergency operations;
(g) Normal shutdown; and
(h) Start-up following a turnaround, or after an emergency shutdown.

**Safe Operating limits:**

(a) Consequences of deviation, and Steps required to correct or avoid deviation.

**Safety and health considerations:**
(a) Properties, and hazards of the chemicals used in the process;
(b) Precautions necessary to prevent exposure, including engineering controls, administrative controls, and personal protective equipment;
(c) Control measures to be taken if physical contact or airborne exposure occurs;
(d) Quality control for raw materials and control of hazardous chemical inventory levels;
(e) Any special or unique hazards.
(f) Safety systems (e.g., interlocks, detection or suppression systems) and their functions.

(iv) **Safe Work Practices** - The entity shall maintain procedures that address safe work practices to ensure the safe conduct of operating, maintenance, and emergency response activities and the control of materials that impact safety. These safe work practices may apply to multiple locations and will normally be in written form (safety manual, safety standards, work rules, etc.) but site-specific work practices shall be prepared and followed. In cases where an employee believes that following a procedure will cause an unsafe condition, one shall have authority to stop work and get permission to deviate. Deviations should be documented for future analysis. Safe work practices should be supporting entities Control of Work Process, as stipulated in Schedule 12 of this document.

(v) **Training** - The training program shall establish and implement programs so that all personnel including contractors are trained to work safely and are aware of environmental considerations, in accordance with their duties and responsibilities. Training shall address the operating procedures, the safe work practices, and the emergency response and control measures. Any change in facilities that requires new or modification of existing operating procedures may require training for the safe implementation of those procedures. Training should be provided by qualified instructors, documented and a robust validation process established.

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

   (b) technical,
   (c) physical,
   (d) procedural, and
   (e) organizational.

This procedure shall consider permanent or temporary changes. These procedures should cover the following:

(a) The process and mechanical design basis for the proposed change.
(b) Risk analysis based on 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. e. The necessary revisions of the safety and environmental information.
(e) The duration of the change, if temporary.
(f) Required authorizations to effect the change.

(vii) **Contractor Safety** - When selecting contractors, operators should obtain and evaluate information regarding a contractor’s safety and environmental management policies and practices, and performance, and the contractor’s procedures for selecting subcontractors. The entity shall communicate their safety and environmental management system expectations to contractors and
identify any specific safety or environmental management requirements they have for contractors. Interfacing of SMS of various entities (operator, contractor / service provider, subcontractor and third-party) should be ensured through a well written bridging document. Entity shall document the clear roles and responsibilities with its contractors.

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

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

Entity should develop the checklists based on the size of the project and risk involved. The check list shall include review of Implementation of PHA recommendations, up-to-date documentation including P&IDs, SOPs, Start-up procedures, Regulatory compliances, training of operating personal responsible for executing the change / project, risk reviews of modifications done during the MoC, Emergency response plans, Communication of new hazards to stakeholders, etc.

(x) **Permit to Work (PTW) System**- PTW system is a formal written system used to control certain types of work which are identified as potentially hazardous. Essential features of permit-to-work systems are:

(a) clear identification of who may authorize particular jobs (and any limits to their authority) and who is responsible for specifying the necessary precautions;
(b) training and instruction in the issue, use and closure of permits;
(c) monitoring and auditing to ensure that the system works as intended;
(d) clear identification of the types of work considered hazardous;
(e) clear and standardized identification of tasks, risk assessments, permitted task duration and supplemental or simultaneous activity and control measures.

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

(A) The emergency procedures shall include, at a minimum, emergencies that are anticipated from an operating malfunction of any component of the petroleum storage, handling and transportation facilities, personnel error, forces of nature, and activities carried on adjacent to the facilities. Key inputs to emergency planning scenarios should be taken from PHA studies and incident history.

(B) The emergency procedures shall include but not be limited to procedures for responding to controllable emergencies, including the following:

(i) The notifying of personnel
(ii) The use of equipment that is appropriate for handling of the emergency
(iii) The shutdown or isolation of various portions of the equipment
(iv) Other steps to ensure that the escape of gas or liquid is promptly cut off or reduced as much as possible

(C) The emergency procedures shall include procedures for recognizing an uncontrollable emergency and for taking action to achieve the following:

(i) Minimize harm to the personnel at the petroleum storage, handling and loading or unloading facilities and to the public.
(ii) Provide prompt notification of the emergency to the appropriate local officials, including the possible need to evacuate persons from the vicinity of petroleum installation.
(iii) The emergency procedures shall include procedures for coordinating with local officials in the preparation of an emergency evacuation plan that sets forth the steps necessary to protect the public in the event of an emergency, including the following:
   
   (a) Quantity and location of fire equipment throughout the petroleum installation.
   (b) Potential hazards at the petroleum installation.
   (c) Communication and emergency-control capabilities at the petroleum installation.

(xii) **Incident Investigation and Analysis**- Procedures for investigation of incidents as per the Petroleum and Natural Gas Regulatory Board (Codes of Practices for Emergency Response and Disaster Management Plan (ERDMP)) Regulations, 2010 shall be developed. Incident investigations should be initiated as promptly as possible, considering the necessity of securing the incident scene and protecting people and the environment. The intent of the investigation should be to learn from the incident and help prevent similar incidents. A corrective action program should be established based on the findings of the investigation to prevent recurrence.

(xiii) **Compliance Audit**- The entity shall perform audits to examine its conformity with this regulation and the implementation of its SMS. The audits shall verify that the entity's SMS is implemented, maintained, and conforms to the requirements of this document. It is critical that the entity discerns that the SMS elements and processes are in place and effective. *Entity* shall identify the audit criteria, scope, frequency, and methods used to assess the application of and compliance with the requirements of the SMS. Risk and complexity of operations are key drivers in the prioritization and frequency of audits.

(xiv) The entity shall conduct a comprehensive internal audit at least once every year. Internal audits shall be performed by the multidisciplinary team who are not reporting into the function / department being audited. Examples may include personnel of a separate operating unit, an organization's compliance unit, an organization's internal audit group.

(xv) External audit shall be performed by external professionals not involved in the work of the SMS or the operations being audited. The auditors could be external parties such as professional auditors, subject matter experts, or peer operators. *External audits shall be conducted at least every three years.*

(xvi) The audit program and procedures should cover:
- The activities and areas to be considered in audits
- The frequency of audits
- The audit team
- How audits will be conducted
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.

The management responsible for the area being audited or evaluated shall ensure that findings are addressed within the defined response times. The results of internal audits and the status of corrective actions shall be reported in the management review. Records of internal audits shall be maintained.

In addition to Internal and External Safety audits, entity shall define the program of inspection. This program shall be conducted by the respective plants for the plants. The objective of this field inspection program is to identify the deficiencies ahead of incidents or non compliance. Plant line management ensures that they are in control by running day to day risk controls and tools.

(xvii) Deviation Management Process: Entity shall establish the process for risk based Deviation management process for reported deviation in implementation from the plan.

4. Measuring and evaluating: The entity shall establish and maintain a procedure to identify key performance indicators (KPIs) to measure the effectiveness of risk management and to improve safety performance. KPIs shall also be developed to track the effectiveness and adequacy of the SMS. The entity shall maintain and monitor, at a minimum, fatalities, injuries, and property damage resulting from planned as well as unplanned releases; these are referred to as lagging KPIs. The entity shall establish leading KPIs, which are those, measures demonstrating risk reduction. The entity shall establish process KPIs, i.e., those measures that demonstrate completion or improvement of elements and their supporting processes and procedures.

Entity should develop, implement, maintain, and periodically update an integrated set of leading and lagging performance indicators at individual facilities for effectively monitoring its process safety performance on continuous basis. For further detailed information, organization can refer API Recommended Practice, API-RP-754 (Process Safety Performance Indicators for the Refining and Petrochemical Industries).

The entity should establish methods to evaluate the safety culture of its organization. Entity should assess the health of their safety culture using methods that assess employee perception of the safety culture. Methods to assess the perception of the culture include but are not limited to questionnaires, interviews, and focus groups.

5. Continuous improvement: Management shall ensure risk management effectiveness and improvement in safety performance are continually enhanced by using a SMS. Management shall continually improve the effectiveness of the SMS by using the safety policies and objectives, audit and assessment results, data analysis, and management review to identify corrective and preventive actions. Top management shall, at least annually, review and approve the output of management reviews. Management reviews shall be documented.
References

2. The Static and Mobile Pressure Vessels (Unfired) Rules, 1981
3. Oil Mines Safety Regulations - 1984
5. OISD-STD-116 on Fire protection Facilities for Petroleum Refineries / Process Plants
6. OISD-STD –117 on Fire protection facilities for Petroleum depots and terminals
7. OISD-STD- 144 on LPG bottling plant and layouts.
10. Loss Prevention in process Industries by Frank P Lees.
13. IS: 11360: on Specifications for smoke detectors for use in automatic electrical fire alarm system
14. IS: 2175: on Specifications for heat sensitive fire detectors for use in automatic fire alarm system
15. IS: 2189: A standard on Selection, Installation and Maintenance of Automatic Fire Detection and Alarm
16. OISD-GDN-166
21. BP, MS&L Procedure, PRO-4.5-0001-0-01, Control of Work
22. BP Wind Energy, Control of Work, Policies and Procedure Doc. No. HSSE 13.10.01
24. HPCL, MR Safety Manual-2018
26. ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS): ASME Code Section VIII
27. OISD-STD-105: Work Permit System
28. OISD-STD-109: Process Design and Operating philosophies on blow down and sewer system
29. OISD-STD-111: Process design and operating philosophies on fired process furnace
30. OISD-STD-112: Safe handling of air hydrocarbon mixtures and pyrophoric substances
31. OISD-STD-113: Classification of Area for electrical installations at Hydrocarbon processing and handling facilities
32. BP & BP Lubricant: work permit practice guidelines
33. Guidelines of department of HSE, UK: work permit practice guidelines
34. Linde Gas Corp, Germany: work permit practice guidelines
35. IOCL standard practices for Pre-commissioning and commissioning activities
36. KLM Technology Group, Malaysia: Standard practices for Pre-commissioning and Commissioning

ISS International: Integrated Service Solutions, Italy: Standard practices for Pre-commissioning and Commissioning.
<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
<th>Action Plan</th>
<th>Target Date</th>
<th>Review Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 (Status)</td>
</tr>
</tbody>
</table>

**A. MAIN GATE / TRUCK PARKING AREA**

- **A-01** Door Frame Metal Detector in working condition
- **A-02** Access to the Terminal is controlled and records for entry of all persons available
- **A-03** Persons entering the plant premises properly frisked by security.
- **A-04** Persons entering the plant premises briefed about safety precautions, Do's /Don’ts by security.
- **A-05** Mobilies are not allowed in the operating areas inside the battery limit.
- **A-06** Material In-Out documents maintained and entries made in the registers
- **A-07** Vehicles entering the plant premises properly checked.
- **A-08** Proper gates passes issued to contract workmen while entering the plant premises.
- **A-09** CCTV cameras are being monitored by security supervisor.
- **A-10** Vehicles parked properly in the allotted parking area
- **A-11** Entry exit gates in TT parking area in locked condition during non operating hours.
- **A-12** Driver rest room clean and hygienic
- **A-13** No driver found cooking in the parking area/outside the rest room.
- **A-14** Speed limit board visible at TT entry.

**B. SAFETY / FIRE PROTECTION SYSTEM**

- **B-01** Water Level in static water tank is satisfactory
- **B-02** Hydrant pressure maintained with jockey pump. Record Pressure
- **B-03** Fire Water Pumps / Engines
- **B-04** Are the batteries in good condition
- **B-05** Are the diesel tanks full
- **B-06** Start one pump, record pressure developed
- **B-07** Whether auto start system working
- **B-08** Fire alarm / communication system in working order
- **B-09** Automatic Gas Detection system operating
- **B-10** Any unsafe condition of S&EP system observed (specify in brief under remarks column)
- **B-11** Regular surprise checks / testing being done at gate / at the plant
- **B-12** Checking for presence of security personnel in designated areas.
- **B-13** Checking of duty roster, attendance of security.
<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
<th>Action Plan</th>
<th>Target Date</th>
<th>Review Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-14</td>
<td>Direction of wind (specify in remarks column by observing wind stock)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-15</td>
<td>Caution signs displayed at appropriate places</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-16</td>
<td>Security air compressor in working condition in auto-mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-17</td>
<td>Last fire drill in this area done on</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-18</td>
<td>Jockey pumps in working condition in auto-mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-19</td>
<td>Housekeeping properly maintained and in order.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. SUBSTATION
- C-01 Adequate CO2 Fire Extinguishers in the designated places.
- C-02 ALL panels in lock-close condition
- C-03 Adequate lighting in the substation
- C-04 Panel indication lamps working.
- C-05 Housekeeping properly maintained and in order.

D. BUFFER TANK AREA
- D-01 Whether water draining sampling done under constant supervision
- D-02 Earthing connection apparently sound
- D-03 Cathodic Protection healthy
- D-04 Whether level instruments are working
- D-05 High level alarm in working condition (test check)
- D-06 Portable fire extinguishers in position
- D-07 Water spray / sprinkler system apparently OK
- D-08 Housekeeping is in order
- D-09 Gas Detection system working
- D-10 Any sign of LNG leakage
- D-11 Any settlement of vessel observed
- D-12 Condition of Water Seal
- D-13 ROVs on remote mode
- D-14 Bonding across flanges visible
- D-15 Pump tripping working condition.
- D-16 Last fire drill in this area done on

E. LNG TANK AREA
- E-01 Earthing connection apparently sound
- E-02 Whether level instruments are working
- E-03 High level alarm in working condition (test check)
- E-04 Portable fire extinguishers in position
- E-05 Water spray / sprinkler system apparently OK
- E-06 Housekeeping is in order
- E-07 Gas Detection system working
- E-08 Any sign of LNG leakage
- E-09 Any settlement of tank observed
- E-10 Condition of Water Seal in dyke area
- E-11 ROVs on remote mode
- E-12 Bonding across flanges visible
- E-13 High Pressure tripping-interlock with import valves.
- E-14 Auto Flare of tanks in working condition.
- E-15 Portable fire extinguishers in position
- E-16 The insulation cover and cladding of cryogenic tanks is in good
- E-17 Last fire drill in this area done on
- E-18 vapor trap is provided as per design.
<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-19</td>
<td>The upstream and downstream valves of TSV on in-tank pump</td>
<td></td>
</tr>
<tr>
<td>E-20</td>
<td>The pressure gauges on in-tank pump discharge line on tank top are</td>
<td></td>
</tr>
<tr>
<td>E-21</td>
<td>The upstream valve of SRV and VRV should be in open locked</td>
<td></td>
</tr>
<tr>
<td><strong>F. BOILER HOUSE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-01</td>
<td>No leakages observed in the Diesel/HSD lines.</td>
<td></td>
</tr>
<tr>
<td>F-02</td>
<td>No leakages observed in LPG lines.</td>
<td></td>
</tr>
<tr>
<td>F-03</td>
<td>No leakages observed in LPG cylinder.</td>
<td></td>
</tr>
<tr>
<td>F-04</td>
<td>No flue gas leakage observed from the Chimney.</td>
<td></td>
</tr>
<tr>
<td>F-05</td>
<td>No flue gas leakage observed from the combustion chamber/</td>
<td></td>
</tr>
<tr>
<td>F-06</td>
<td>No steam leakage from valve glands.</td>
<td></td>
</tr>
<tr>
<td>F-07</td>
<td>Explosion door properly placed.</td>
<td></td>
</tr>
<tr>
<td>F-08</td>
<td>No lagging damage found in steam lines</td>
<td></td>
</tr>
<tr>
<td>F-09</td>
<td>Portable fire extinguishers in position</td>
<td></td>
</tr>
<tr>
<td>F-10</td>
<td>Abnormal sound / vibration</td>
<td></td>
</tr>
<tr>
<td>F-11</td>
<td>Electrical connections apparently sound</td>
<td></td>
</tr>
<tr>
<td>F-12</td>
<td>Earthing apparently proper</td>
<td></td>
</tr>
<tr>
<td>F-13</td>
<td>House Keeping in order</td>
<td></td>
</tr>
<tr>
<td><strong>G. PRE HEATER SYSTEM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G-01</td>
<td>No leakages observed from the pre-heater tubes</td>
<td></td>
</tr>
<tr>
<td>G-02</td>
<td>All temperature gauges and transmitters at inlet and outlet are in working condition</td>
<td></td>
</tr>
<tr>
<td>G-03</td>
<td>All pressure gauges and transmitters at inlet and outlet are in working condition</td>
<td></td>
</tr>
<tr>
<td>G-04</td>
<td>Fan belt are aligned and are in good condition.</td>
<td></td>
</tr>
<tr>
<td>G-05</td>
<td>Earthing is provided and effective</td>
<td></td>
</tr>
<tr>
<td>G-06</td>
<td>ROV at inlet is working on OK mode</td>
<td></td>
</tr>
<tr>
<td>G-07</td>
<td>Pre heater fan motor alignment is OK</td>
<td></td>
</tr>
<tr>
<td><strong>H. DM WATER PLANT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-01</td>
<td>No leakages observed in the Acid and Alkali pipelines.</td>
<td></td>
</tr>
<tr>
<td>H-02</td>
<td>No leakages observed in the Acid and Alkali over head tanks.</td>
<td></td>
</tr>
<tr>
<td>H-03</td>
<td>All motor coupling guards in position.</td>
<td></td>
</tr>
<tr>
<td>H-04</td>
<td>Emergency Water Shower in working condition.</td>
<td></td>
</tr>
<tr>
<td>H-05</td>
<td>DM water tank level more than 3 mts.</td>
<td></td>
</tr>
<tr>
<td>H-06</td>
<td>Deaeration of effluent treatment plant in working condition.</td>
<td></td>
</tr>
<tr>
<td>H-07</td>
<td>No leakage in primary effluent tanks</td>
<td></td>
</tr>
<tr>
<td>H-08</td>
<td>No air leakage observed.</td>
<td></td>
</tr>
<tr>
<td>H-09</td>
<td>Electrical connections apparently sound</td>
<td></td>
</tr>
<tr>
<td>H-10</td>
<td>Earthing apparently proper</td>
<td></td>
</tr>
<tr>
<td>H-11</td>
<td>House Keeping in order</td>
<td></td>
</tr>
<tr>
<td>H-12</td>
<td>Acid Corrosion / Rusting visible</td>
<td></td>
</tr>
<tr>
<td><strong>I - AIR COMPRESSOR HOUSE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-01</td>
<td>No air / water leakage observed,</td>
<td></td>
</tr>
<tr>
<td>I-02</td>
<td>House Keeping in order</td>
<td></td>
</tr>
<tr>
<td>I-03</td>
<td>Equipment properly painted.</td>
<td></td>
</tr>
<tr>
<td>I-04</td>
<td>No abnormal vibration observed.</td>
<td></td>
</tr>
<tr>
<td>I-05</td>
<td>Electrical connections apparently sound</td>
<td></td>
</tr>
<tr>
<td>I-06</td>
<td>Earthing apparently proper</td>
<td></td>
</tr>
<tr>
<td>Sr. No</td>
<td>Item</td>
<td>Observation</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>I-07</td>
<td>Portable fire extinguishers in position</td>
<td></td>
</tr>
<tr>
<td>I-08</td>
<td>All the V-Belts available and properly tightened.</td>
<td></td>
</tr>
</tbody>
</table>

**J - DIESEL YARD**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-01</td>
<td>House Keeping in order</td>
<td></td>
</tr>
<tr>
<td>J-02</td>
<td>Equipment properly painted.</td>
<td></td>
</tr>
<tr>
<td>J-03</td>
<td>Electrical connections apparently sound</td>
<td></td>
</tr>
<tr>
<td>J-04</td>
<td>Earthing apparently proper</td>
<td></td>
</tr>
<tr>
<td>J-05</td>
<td>Portable fire extinguishers in position</td>
<td></td>
</tr>
<tr>
<td>J-06</td>
<td>Sand buckets filled with dry sand and in position.</td>
<td></td>
</tr>
<tr>
<td>J-07</td>
<td>No HSD leakage / accumulation observed.</td>
<td></td>
</tr>
<tr>
<td>J-08</td>
<td>No open electrical wire / connection available.</td>
<td></td>
</tr>
</tbody>
</table>

**K - SCRAP YARD**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-01</td>
<td>Designated scrap yard available.</td>
<td></td>
</tr>
<tr>
<td>K-02</td>
<td>No scrap material kept outside designated area.</td>
<td></td>
</tr>
<tr>
<td>K-03</td>
<td>Scrap yard separated by barbed wire fencing and gate kept closed.</td>
<td></td>
</tr>
</tbody>
</table>

**L - ADMINISTRATIVE BUILDING**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-01</td>
<td>House Keeping in order</td>
<td></td>
</tr>
<tr>
<td>L-02</td>
<td>No temporary electrical connections visible.</td>
<td></td>
</tr>
<tr>
<td>L-03</td>
<td>Electrical connections apparently sound</td>
<td></td>
</tr>
<tr>
<td>L-04</td>
<td>Portable fire extinguishers in position</td>
<td></td>
</tr>
<tr>
<td>L-05</td>
<td>ELCB for Water Cooler and Refrigerator in working condition. (Admin building)</td>
<td></td>
</tr>
<tr>
<td>L-06</td>
<td>Earthing system proper.</td>
<td></td>
</tr>
</tbody>
</table>

**M - AMINITIES BLOCK**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-01</td>
<td>House Keeping in order</td>
<td></td>
</tr>
<tr>
<td>M-02</td>
<td>No temporary electrical connections visible.</td>
<td></td>
</tr>
<tr>
<td>M-03</td>
<td>Electrical connections apparently sound</td>
<td></td>
</tr>
<tr>
<td>M-04</td>
<td>ELCB for Water Cooler and Refrigerator in working condition.</td>
<td></td>
</tr>
<tr>
<td>M-05</td>
<td>Fly catcher in working condition.</td>
<td></td>
</tr>
<tr>
<td>M-06</td>
<td>LNG storage having double wire mesh enclosure with DCP placed.</td>
<td></td>
</tr>
<tr>
<td>M-08</td>
<td>Earthing system proper.</td>
<td></td>
</tr>
<tr>
<td>M-09</td>
<td>Portable fire extinguishers in position</td>
<td></td>
</tr>
</tbody>
</table>

**N - JETTY FACILITIES**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-01</td>
<td>Any visible sign of LNG leakage/icing in dockline</td>
<td></td>
</tr>
<tr>
<td>N-02</td>
<td>Gas Detection Functional</td>
<td></td>
</tr>
<tr>
<td>N-03</td>
<td>ROVs on remote mode</td>
<td></td>
</tr>
<tr>
<td>N-04</td>
<td>Bonding across flanges visible</td>
<td></td>
</tr>
<tr>
<td>N-05</td>
<td>High Pressure tripping-interlock with import valves.</td>
<td></td>
</tr>
</tbody>
</table>

**O - ADDITIONAL POINTS**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Item</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-01</td>
<td>Emergency shut down system is working and effective</td>
<td></td>
</tr>
<tr>
<td>O-02</td>
<td>Cooling Tower in working condition</td>
<td></td>
</tr>
<tr>
<td>O-03</td>
<td>CCTV OPERATIONAL</td>
<td></td>
</tr>
</tbody>
</table>

Signature of inspecting officer  

Signature of Location I/C
## Monthly Checks

### Typical Monthly Check list

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>License / Test Certificate No.</th>
<th>validity</th>
<th>Remarks/ Renewal Application No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>PESO Licenses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Weights &amp; Measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Factory Related</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Pollution Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Labour Related</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Test Certificates</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PESO Licenses
- License to Store Compressed Gas in Pressure Vessels
- Storage of HSD inside premises for Own Use
- Updated Plant & equipment Layout duly approved.

### Weights & Measures
- Stamping of Weigh Bridge
- Stamping of Standard Weights
- Stamping of MFM

### Factory Related
- Copy of Notification of Occupier issued by MOPNG available

### Pollution Control
- Consent under Air (Prevention and Control of Pollution) Act.
- Consent under Water (Prevention and Control of Pollution)

### Labour Related
- PF no. & ESI Registration no. of Location, if applicable
- Registration under Contract labour (Regulation and Abolition) Act 1970
- License details of Contractors under Contract Labour (Reg. & Abo.) Act.

### Test Certificates
- Valid test certificates available for
- Hydrotest of LNG STORAGE VESSELS
- NDT and Hydrotest records for Underground / aboveground LNG pipelines
- NDT and Hydrotest records for Jetty LNG pipelines
- NDT & Hydrotest for other Pressure vessels as per Factory Act
- SRVs & TSVs
- Lifting tools & Tackles, chain pulley block
- Fire Water Line NDT
- Fire Water Tanks cleaning details
- LNG Hose Testing
- Pr gauge / Temp gauge testing records
| 2.1.11 | Relay Test record                                      |
| 2.1.12 | Earth Pit Testing                                      |
| 2.1.13 | Motor & LT/HT Cable IR testing                        |
| 2.1.14 | Electrical Hand Gloves                                |
| 2.1.15 | Insulating mats/Rubber Mats for Electrical purpose    |
| 2.1.16 | Transformer Oil Test                                   |

3 **SAFETY**

3.1 **Audit Compliance Status**

<table>
<thead>
<tr>
<th>Name of Audit</th>
<th>Total Points</th>
<th>Complied Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.1 OISD- ESA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.2 OISD- surprise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.3 MDT Audit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.4 Electrical Audit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.5 Security Audit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.6 Internal Audit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Remarks</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2</td>
<td>Emergency lighting system provided in strategic locations &amp; system working satisfactorily</td>
</tr>
<tr>
<td>3.3</td>
<td>Records of 'Daily Safety Audit' reviewed by Loc.In-Charge</td>
</tr>
<tr>
<td>3.4</td>
<td>Work Permit system viz Hot, Cold, Electrical and Working at height (issue and closure) checked</td>
</tr>
<tr>
<td>3.5</td>
<td>First-Aid facilities maintained</td>
</tr>
<tr>
<td>3.6</td>
<td>Safety Circle / Committee meeting are conducted. Record last meeting dates</td>
</tr>
<tr>
<td>3.7</td>
<td>Fire alarm (electrical &amp; hand sirens) working satisfactorily</td>
</tr>
<tr>
<td>3.8</td>
<td>Communication system (PA Paging / VHF) working satisfactorily</td>
</tr>
<tr>
<td>3.9</td>
<td>Flame proof Torches in working condition</td>
</tr>
<tr>
<td>3.10</td>
<td>Automatic Gas Detection system : Working &amp; Calibration records available</td>
</tr>
<tr>
<td>3.11</td>
<td>Record Pressure at farthest end of hydrant network</td>
</tr>
<tr>
<td>3.12</td>
<td>Interlock shutdown system as per Guidelines checked and found ok</td>
</tr>
<tr>
<td>3.13</td>
<td>Fire Protection System on auto. Test check atleast one DV through QB.</td>
</tr>
<tr>
<td>3.14</td>
<td>Fire engine - Sequence logic tested and found OK.</td>
</tr>
<tr>
<td>3.15</td>
<td>Fuel gauge of HSD tanks (DG &amp; fire engines) working and levels OK</td>
</tr>
<tr>
<td>3.16</td>
<td>Fire Water storage tank: Indicate Requirement in KL and availability in KL</td>
</tr>
<tr>
<td>3.17</td>
<td>Fire Extinguishers / Fire Hoses kept at nominated places</td>
</tr>
<tr>
<td>3.18</td>
<td>No temporary electrical connection existing</td>
</tr>
<tr>
<td>3.19</td>
<td>Safety Equipment inventory reviewed for shortfall and action taken</td>
</tr>
<tr>
<td>3.20</td>
<td>Any unsafe conditions observed in TTs Parking area</td>
</tr>
<tr>
<td>3.21</td>
<td>Important DO's &amp; Don't's, Operating Instructions, displayed prominently in respective places</td>
</tr>
<tr>
<td>3.22</td>
<td>SOP displayed at operating locations</td>
</tr>
<tr>
<td>3.23</td>
<td>Trainings being conducted and records available as per OISD 154</td>
</tr>
</tbody>
</table>

4 **SECURITY**

4.1 Fencing around plant is in proper condition

4.2 Tower lights illumination checked and found ok.
4.3 All records at the gates are maintained and reviewed as per norms
4.4 Material In-Out Register (Corporation / Contractor)
4.5 Returnable material register
4.6 Visitor’s register
4.7 Gatepass systems
4.8 CCTV functional
4.9 ACS functional
4.10 DFMD & HHMD in use
4.11 Under vehicle search mirror in use
4.12 Updated list of authorised signatory available.
5 Operations
5.1 One panel in PMCC checked for following
   a Cleanliness
   b Fuse/rating
   c Relay setting
5.2 ROVs working Satisfactorily
5.3 Cooling water flow adequate and cooling fans in working condition.
5.4 Whether on line analyser working satisfactorily.
5.5 DM water level in DM tank above 3 mtrs.
5.6 No acid / alkali leak visible
5.7 No HSD / LNG leak at boiler.
5.8 No Flue / Steam leak observed.
5.9 Whether logsheets/records are maintained for daily
5.10 No portion of pipe length found buried with soil or
5.11 SRVs are locked in open position
5.12 Vent pipes of Safety Relief valves on LNG storage
5.13 No LNG leakages observed in operating areas.
6 Maintenance
6.1 Double independent earthing connection for all motors/structures/vessels/ pipelines provided
6.2 FLP condition of electrical equipments intact
6.3 Push button earthed properly
6.4 All LNG Vent lines provided with double mesh and properly earthed
6.6 No leakage from mechanical seals of LNG pumps
6.7 Pipeline colour code system maintained
6.8 Bonding connections maintained for pipelines, Vessels, conveyors, gantry.
6.9 Two independent level instruments provided in storage vessels & are in working condition
6.10 HLA interlock with ROV on storage vessels working
6.11 Stores Module (SAP-MM module) implemented for equipment and consumable stores
6.12 Whether functional locations in PM module created and tasklists for these implemented
6.13 Whether all continuous monitoring devices are periodically checked & calibrated
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENERAL</strong></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>System for monitoring work done by the handling contractor, exists.</td>
</tr>
<tr>
<td>7.2</td>
<td>Canteen cleanliness adequate</td>
</tr>
<tr>
<td>7.3</td>
<td>Cylinder bank for canteen kitchen properly constructed/maintained</td>
</tr>
<tr>
<td>7.4</td>
<td>General Housekeeping standards</td>
</tr>
<tr>
<td>7.5</td>
<td>Maintenance of Buffer Zone, Peripheral Road motorable.</td>
</tr>
<tr>
<td>7.6</td>
<td>Condition of Painting of buildings, structures and facility</td>
</tr>
<tr>
<td>7.7</td>
<td>Monitoring of turn around time of packed and Bulk trucks ensured</td>
</tr>
<tr>
<td><strong>FINANCE</strong></td>
<td></td>
</tr>
<tr>
<td>8.1</td>
<td>Physical Inventory of LNG bulk and HSD tallying with Book Balance as per SAP</td>
</tr>
</tbody>
</table>

Note: -

1. The above audit is to be carried out by Location In-Charges on monthly basis within the 1st week of the Audit month.
2. In case of expiry of validity of statutory certificates/licenses, application date for renewal is to be mentioned in Remarks Column.
3. Sample test checks carried out should be different from the previous sample tests carried out.
4. Self M\&I Indexing to be carried out by Plant Maintenance Officer on bi-monthly basis.
5. Compliance to terms and conditions of various statutory licenses and certificates to be ensured.

Signature of Location In-charge
## SEPARATION DISTANCES BETWEEN BLOCKS/FACILITIES

### TABLE – 1

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>From / To</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Process Units</td>
<td>Note-1</td>
<td>Note-3</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>45</td>
<td>45</td>
<td>60</td>
<td>45</td>
<td>30</td>
<td>60</td>
<td>60</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>Process Control Room (Note –2)</td>
<td>Note-3</td>
<td>x</td>
<td>Note-4</td>
<td>Note-5</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>45</td>
<td>45</td>
<td>30</td>
<td>Note-3</td>
<td>x</td>
<td>30</td>
<td>15</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Storage Tanks Class-A</td>
<td>30</td>
<td>Note-6</td>
<td>Note-6</td>
<td>Note-6</td>
<td>30</td>
<td>90</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td>(90)</td>
<td>30</td>
<td>T3</td>
<td>60</td>
<td>30</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Storage Tank Class-B</td>
<td>30</td>
<td>Note-6</td>
<td>Note-6</td>
<td>Note-6</td>
<td>30</td>
<td>90</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td>(90)</td>
<td>30</td>
<td>T3</td>
<td>30</td>
<td>30</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Storage Tank Class-C</td>
<td>30</td>
<td>30</td>
<td>Note-6</td>
<td>Note-6</td>
<td>Note-6</td>
<td>30</td>
<td>90</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td>(90)</td>
<td>30</td>
<td>T3</td>
<td>30</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>Pressurised Storage: LPG/ C4 &amp; Lighter / H2</td>
<td>60</td>
<td>60</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>T7</td>
<td>90</td>
<td>30</td>
<td>T6</td>
<td>90</td>
<td>(90)</td>
<td>30</td>
<td>T7</td>
<td>45</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>Flare (Note-7)</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Bulk Loading POL (Rail /Road)</td>
<td>45</td>
<td>45</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>90</td>
<td>Note-8</td>
<td>Note-9</td>
<td>60</td>
<td>30</td>
<td>Note-10</td>
<td>T3</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>9</td>
<td>Bulk Loading LPG (Rail /Road)</td>
<td>45</td>
<td>45</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>T6</td>
<td>90</td>
<td>Note-9</td>
<td>T6</td>
<td>90</td>
<td>(90)</td>
<td>T6</td>
<td>T6</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>Fire Station / First Aid Center</td>
<td>60</td>
<td>30</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>90</td>
<td>90</td>
<td>60</td>
<td>90</td>
<td>x</td>
<td>30</td>
<td>30</td>
<td>12</td>
<td>12</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>11</td>
<td>Boiler house / Process Unit Heaters (Note-11)</td>
<td>45</td>
<td>Note-3</td>
<td>(90)</td>
<td>(90)</td>
<td>(90)</td>
<td>(90)</td>
<td>90</td>
<td>30</td>
<td>(90)</td>
<td>30</td>
<td>x</td>
<td>15</td>
<td>50</td>
<td>30</td>
<td>30</td>
<td>Note-12</td>
</tr>
<tr>
<td>12</td>
<td>Rail Spur</td>
<td>30</td>
<td>x</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>90</td>
<td>Note-10</td>
<td>T6</td>
<td>30</td>
<td>15</td>
<td>x</td>
<td>30</td>
<td>6</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>13</td>
<td>Boundary wall around installation</td>
<td>60</td>
<td>30</td>
<td>T3</td>
<td>T3</td>
<td>T3</td>
<td>T7</td>
<td>90</td>
<td>T3</td>
<td>T6</td>
<td>12</td>
<td>50</td>
<td>30</td>
<td>x</td>
<td>6</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>14</td>
<td>Service buildings</td>
<td>60</td>
<td>15</td>
<td>60</td>
<td>30</td>
<td>30</td>
<td>45</td>
<td>90</td>
<td>60</td>
<td>60</td>
<td>12</td>
<td>30</td>
<td>6</td>
<td>6</td>
<td>x</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>Cooling tower,</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>90</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>15</td>
<td>30</td>
<td>30</td>
<td>x</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>API Separators / Oil sludge pit</td>
<td>90</td>
<td>30</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>90</td>
<td>50</td>
<td>50</td>
<td>90</td>
<td>Note-12</td>
<td>50</td>
<td>50</td>
<td>15</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

**General Notes to Table-1:**

a) All distances are in meters. “T” indicates the table number to be referred. “x” means any distance suitable for constructional or operational convenience.
b) All distances shall be measured between the nearest points on the perimeter of each facility except (i) In case of tank vehicle loading / unloading area where the distance shall be from the center of nearest bay. (ii) The distances given in the brackets ( ) are from the shell of the Heater / Boiler / Furnace / Still.

Specific notes to Table-1:

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

Note-2: Type of construction shall be as per OISD-STD-163.

Note-3: Process control room to Process units / boiler house / heaters the minimum separation distance shall be 30 m. For a control room attached to single process unit or a boiler or a heater, the minimum separation distance shall be 16 m. For Gas processing plants, it shall be minimum 30 meters irrespective of whether it is for one or more units.

Note-4: Shall be 60 m for non-blast construction and 30 m for blast resistant construction.

Note-5: Shall be 45 m for non-blast construction and 30 m for blast resistant construction.

Note-6: Separation distances between the nearest tanks located in two dykes shall be equivalent to the diameter of the larger tank or 30 m, whichever is more. For distances within a dyke, it shall be as per Table-3 and Table-4.

Note-7: The distances specified are for the elevated flare. For ground flare, these distances shall be 150 m. For Exploration & Production installations, this shall be in line with Oil Mines Regulations.

Note-8: Separation distance between Tank truck gantry and wagon gantry shall be 50m.

Note-9: The separation distance shall be 50 m. However for LPG tank truck bulk loading to POL tank truck bulk loading it shall be 30 m.

Note-10: Separation distance between tank truck gantry and rail spur shall be 50 m.

Note-11: Boiler house or heater of a process unit is to be treated as a separate identity only for the consideration of surrounding blocks / facilities. However, heater of a process unit remains an integral part of the process unit to which it is attached and in that case the inter equipment distances should be inline with Table –2.

Note-12: Centralized / common API separators, Corrugated Plate Interceptor (CPI), open oil separators shall be categorized under the same risk and shall be located at a distance of 90 meters from heaters / boilers. However, if these are covered from the top and provided with adequate venting to safe location, the minimum separation distance shall be 30 meter.
### SEPARATION DISTANCES BETWEEN EQUIPMENT WITHIN PROCESS UNIT

#### TABLE-2

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>From / To</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fired Heater / Any fired equipment</td>
<td>x</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>22</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>x</td>
<td>18</td>
<td>6</td>
<td>30</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Reactors</td>
<td>15</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>15</td>
<td>7</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>15</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Distillation column</td>
<td>15</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Accumulators – Hydrocarbons</td>
<td>15</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>15</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Compressors - Hydrocarbons</td>
<td>22</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>15</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>15</td>
<td>4</td>
<td>3</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>Hot oil pump</td>
<td>15</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>3</td>
<td>x</td>
<td>15</td>
<td>x</td>
</tr>
<tr>
<td>7</td>
<td>Fuel Oil / HCs day tank</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>7</td>
<td>T-5</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>x</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Pumps for class- A &amp; all above Auto-ignition temp</td>
<td>20</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>3</td>
<td>x</td>
<td>15</td>
<td>x</td>
</tr>
<tr>
<td>9</td>
<td>Pumps - for all other Hydrocarbons</td>
<td>15</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>3</td>
<td>x</td>
<td>15</td>
<td>x</td>
</tr>
<tr>
<td>10</td>
<td>Heat Exchangers</td>
<td>15</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>x</td>
</tr>
<tr>
<td>11</td>
<td>Air fin coolers for Hydrocarbons</td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>x</td>
<td>15</td>
<td>2</td>
<td>x</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Fired heater Local control panel</td>
<td>x</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>x</td>
<td>10</td>
<td>x</td>
<td>15</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Pressure vessels / Drums of Hydrocarbons</td>
<td>18</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>Main Pipe rack</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td>3</td>
<td>x</td>
<td>15</td>
<td>x</td>
</tr>
<tr>
<td>15</td>
<td>Blow down facility – Drum, pump, vent stack</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>x</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Structural main – Technological platforms</td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>x</td>
<td>15</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>x</td>
<td>15</td>
<td>x</td>
</tr>
</tbody>
</table>

#### General notes to Table –2:

a) All distances are face-to-face clear minimum distances in meters.

b) “x” indicates suitable distance as per good engineering practices to meet construction, operational and maintenance requirements.

c) Distances specified in Table-2 are the minimum recommended distances that the industry should adhere. These could be suitably modified as required to suit space constraints and relevant engineering practices except the followings.

(i) Blow down facility (open pit type) / oil catcher shall be located at a distance not less than 30 m from fired heater / any fired equipment. If the blow down drum is located underground / oil catcher is cover with vent to safe location, the minimum separation distance shall be 15m.
(ii) Fuel Oil day tank shall be located at a distance of not less than 15m from equipment except those facilities such as heat exchanger, pump connected directly with the Fuel Oil system.

d) Firewater hydrant / monitors shall be minimum 15 m away from the equipment that is to be protected.

e) Water spray deluge valve shall be minimum 15 m from equipment handling hydrocarbon.

f) Fuel gas knock out drum shall be located at a minimum separation distance of 15 m from the heater.

**SEPARATION DISTANCES BETWEEN TANK / OFFSITE FACILITIES - (For large installations)**

**TABLE - 3**

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Tanks / Facility</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Storage Tank for Petroleum Class A / Class B.</td>
<td>T4</td>
<td>T4</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>0.5 D</td>
</tr>
<tr>
<td>2</td>
<td>Storage Tank for Petroleum Class C</td>
<td>T4</td>
<td>x</td>
<td>15</td>
<td>x</td>
<td>8</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>0.5 D</td>
</tr>
<tr>
<td>3</td>
<td>Storage / Filling Shed for petroleum Class A or class B</td>
<td>15</td>
<td>15</td>
<td>x</td>
<td>8</td>
<td>15</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Storage / Filling Shed for Petroleum Class C</td>
<td>15</td>
<td>x</td>
<td>8</td>
<td>x</td>
<td>8</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Tank vehicle loading / Unloading for petroleum class A</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>8</td>
<td>x</td>
<td>x</td>
<td>8</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Tank Vehicle loading / unloading for Class C</td>
<td>15</td>
<td>x</td>
<td>15</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Flame proof Electric Motor</td>
<td>8</td>
<td>x</td>
<td>8</td>
<td>x</td>
<td>8</td>
<td>x</td>
<td>x</td>
<td>8</td>
<td>x</td>
</tr>
<tr>
<td>8</td>
<td>Non flame proof electric Motor</td>
<td>15</td>
<td>x</td>
<td>15</td>
<td>x</td>
<td>15</td>
<td>x</td>
<td>8</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>9</td>
<td>Boundary wall</td>
<td>0.5 D</td>
<td>0.5 D</td>
<td>15</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

**SEPARATION DISTANCES BETWEEN STORAGE TANKS WITHIN A DYKE**

**TABLE - 4**

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Item</th>
<th>Between floating Roof Tanks Class A &amp; B</th>
<th>Between fixed Roof Tanks Class A &amp; B</th>
<th>Between Class C Petroleum Storage tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All tanks with Diameter upto 50 meters</td>
<td>(D+d) / 4 Min 10 m</td>
<td>(D+d) / 4 Min 10 m</td>
<td>(D+d) / 6 Min 6 m</td>
</tr>
<tr>
<td>2</td>
<td>Tanks with Diameter exceeding 50 meters.</td>
<td>(D+d) / 4</td>
<td>(D+d) / 3</td>
<td>(D+d) / 4</td>
</tr>
</tbody>
</table>
General notes to Table – 3 & 4

a) All distances are in meters.
b) "x" indicates suitable distance as per good engineering practices to meet construction, operational and maintenance requirements
c) D & d stands for diameter of larger and smaller tanks.
d) In Table – 3 all distances shall be measured between the nearest points on the perimeter of each facility except in the case of tank vehicle loading/unloading area where the distance shall be measured from the center of each bay.
e) In Table –4, Distances given are shell to shell in the same dyke.
f) For different combination of storage tanks, the stringent of the applicable formulae shall be considered for minimum separation distance.
g) The distance of storage tanks from boundary wall is applicable for;
   (i) Floating roof tanks having protection for exposure
   (ii) Tanks with weak roof-to-shell joint having approved foam or inerting system and the tank diameter not exceeding 50 meters
h) For the facilities not covered in Table- 3, refer Table-1.

SEPARATION DISTANCES BETWEEN TANKS/OFFSITE FACILITIES - (For small installations)

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Tanks/ Facility</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Storage Tank Class A</td>
<td>0.5D</td>
<td>0.5D</td>
<td>0.5D</td>
<td>6.0</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>15</td>
<td>15</td>
<td>3</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Storage Tank Class B</td>
<td>0.5D</td>
<td>0.5D</td>
<td>0.5D</td>
<td>6.0</td>
<td>9</td>
<td>0.5D</td>
<td>0.5D</td>
<td>9</td>
<td>4.5</td>
<td>4.5</td>
<td>3</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Storage Tank Class C</td>
<td>0.5D</td>
<td>0.5D</td>
<td>0.5D</td>
<td>6.0</td>
<td>9</td>
<td>0.5D</td>
<td>x</td>
<td>9</td>
<td>4.5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>0.5D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Min 3.0</td>
</tr>
<tr>
<td>4</td>
<td>Storage / Filling shed for petroleum Class -A</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>x</td>
<td>4.5</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Storage / Filling shed for petroleum Class -B</td>
<td>9</td>
<td>0.5D</td>
<td>0.5D</td>
<td>4.5</td>
<td>x</td>
<td>1.5</td>
<td>9</td>
<td>4.5</td>
<td>4.5</td>
<td>1.5</td>
<td>4.5</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Storage / Filling shed for petroleum Class -C</td>
<td>9</td>
<td>0.5D</td>
<td>x</td>
<td>6</td>
<td>1.5</td>
<td>x</td>
<td>9</td>
<td>4.5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Column 1</td>
<td>Column 2</td>
<td>Column 3</td>
<td>Column 4</td>
<td>Column 5</td>
<td>Column 6</td>
<td>Column 7</td>
<td>Column 8</td>
<td>Column 9</td>
<td>Column 10</td>
<td>Column 11</td>
<td>Column 12</td>
<td>Column 13</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>7</td>
<td>Tank vehicle Loading / unloading Class - A</td>
<td>15</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>x</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Tank vehicle Loading / unloading Class - B</td>
<td>15</td>
<td>4.5</td>
<td>4.5</td>
<td>9</td>
<td>4.5</td>
<td>9</td>
<td>x</td>
<td>4.5</td>
<td>1.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Tank vehicle Loading / unloading Class - C</td>
<td>15</td>
<td>4.5</td>
<td>x</td>
<td>9</td>
<td>4.5</td>
<td>x</td>
<td>9</td>
<td>4.5</td>
<td>x</td>
<td>x</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Flame proof Electric motors</td>
<td>3</td>
<td>3</td>
<td>x</td>
<td>3</td>
<td>1.5</td>
<td>x</td>
<td>3</td>
<td>1.5</td>
<td>x</td>
<td>x</td>
<td>3</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>11</td>
<td>Non Flame proof Electric motors</td>
<td>15</td>
<td>4.5</td>
<td>x</td>
<td>9</td>
<td>4.5</td>
<td>x</td>
<td>9</td>
<td>4.5</td>
<td>x</td>
<td>3</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>12</td>
<td>Office building, stores, amenities</td>
<td>15</td>
<td>d min 4.5</td>
<td>0.5 d min 3.0</td>
<td>9</td>
<td>4.5</td>
<td>3</td>
<td>9</td>
<td>4.5</td>
<td>3</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>13</td>
<td>Boundary wall</td>
<td>15</td>
<td>d min 4.5</td>
<td>0.5 d min 3.0</td>
<td>9</td>
<td>4.5</td>
<td>3</td>
<td>9</td>
<td>4.5</td>
<td>3</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

**General notes to Table –5:**

a) All distances are in meter and the table specifies the minimum requirement.

b) “x” indicates suitable distance as per good engineering practices to meet construction, operational and maintenance requirements.

c) “D” indicates the diameter of the larger tank.

d) Distances given for the tanks are shell to shell in the same dyke.

e) Where alternate distances are specified (like 0.5 D / 6.0), the minimum thereof shall be used.

f) 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 from the center of each bay.

g) Pig launcher/receiver at liquid hydrocarbon handling pipeline installations should be located at least 5 m from boundary.