Design and Safety Requirements
for
Liquefied Petroleum Gas Mounded Storage Facility

Prepared by

FUNCTIONAL COMMITTEE

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Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director
Oil Industry Safety Directorate
FOREWORD

The Oil Industry in India is 100 years old. Because of various collaboration agreements, a variety of international codes, standards and practices have been in vogue. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This, coupled with feed back from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by the Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safe operations. Accordingly, OISD constituted a number of functional committees of experts nominated from the industry to draw up standards and guidelines on various subjects.

The first edition of the document on “Design and Safety Requirements for Liquefied Petroleum Gas Mounded Storage Facility” was published in August 2000. The present document is the revised by functional committee based on the accumulated knowledge and experience of industry members and the various national, international codes and practices.

This document is meant to be used as supplement and not as a replacement for existing codes and practices. Suggestions are invited from the industry to improve the document further, and the same may be addressed to

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These documents are intended only to supplement and not to replace the prevailing statutory requirements.
**FUNCTIONAL COMMITTEE**  
(First Edition - August, 2000)

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In addition to the above, several experts from the industry contributed in the preparation, review and finalisation of this document.
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ANNEXURE

I. General Guidelines for Cathodic Protection System

DRAWINGS

I. Typical Mounded Storage Vessel
II. Typical Mounded Storage Construction Methodology
III. Bottom Outlet with Inspection Tunnel
IV. Typical Nozzle arrangement mounted on Top of Dome with Sprinklers System
V. Mounted Top Surface Construction
1.0 INTRODUCTION

Liquefied Petroleum Gas (LPG) handling has many challenges due to its inherent dangerous properties. Some of the major fires/explosions have underlined the need for total in depth review of design, procedures maintenance fire fighting and safety aspects in LPG handling. The conventional method of storage of LPG in India is in a pressurised vessel installed above ground.

The mounded storage of LPG has proved to be safer compared to above ground storage vessels since it provides intrinsically passive and safe environment and eliminates the possibility of Boiling Liquid Expanding Vapour Explosion (BLEVE). The cover of the mound protects the vessel from fire engulfment, radiation from a fire in close proximity and acts of sabotage or vandalism. The area of land required to locate a mounded system is minimal compared to conventional storage.

2.0 SCOPE

This standard lays down minimum requirements on safety, design, layout, installation, operation, maintenance and testing of aboveground fully mounded bulk vessels used for storage of Liquefied Petroleum Gas (LPG) installed in the refineries, gas processing plants, terminals, bottling plants and auto LPG dispensing stations otherwise falling under the scope of any of the OISD standards namely OISD-STD-144, OISD-STD-116, OISD-STD-118, OISD-GDN-169 and OISD-STD-210 as applicable. This standard only supplement to the requirements of above mentioned OISD standards as regards to mounded storage facility for LPG.

3.0 DEFINITIONS

Mounded Vessel(s)

A storage vessel(s) sited above ground and completely covered by a mound of earth or similar inert material except for nozzles, manhole covers, inspection covers fitted on vessel(s).

Bullet

A horizontal pressure vessel used for storage or transportation by rail/ road.

Compressed Gas

Any permanent gas, liquefiable gas or gas dissolved in liquid under pressure or gas mixture which in a closed container exercises a pressure either exceeding two atmosphere (gauge) at the maximum working temperature, which for vessels without insulation or refrigeration shall be considered as 55°C.

Explosive mixture

It is a mixture of combustion agent (oxidising substance-gaseous, liquid or solid) and a fuel (oxidisable substance- gaseous, liquid or solid) in such proportions that it could give rise to a very rapid and violent oxidation reaction liberating more energy than is dissipated through conduction and convection causing practical effect of explosion.

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Hazard Area Classification

It is the classification of hazardous area zone wise/group wise, based on the nature of the flammable substance and the extent of presence of the explosive vapour-air mixture likely to be present under operating conditions for the purpose of selection of the type of electrical equipment in the respective zone/area.

Bulk Vessels

A pressure vessel of more than 1000 liters water capacity used for storage or transportation of compressed gas.

Water Capacity

The volume of water in liters that the container can hold at 15 °C.

Earthing & Bonding

Earthing is the provision of a safe path of electrical current to ground, in order to protect structures, plant and equipment from the effects of stray electrical current, and electrostatic discharge.

Bonding is the provision of connecting different parts of an equipment or system by way of bond wire/strip so as to maintain electrical continuity among all parts of the system.

Fire safe

As applied to valves, it is a provision of dual seating to control leakage to acceptable level even after damage due to fire.

Fire proof/proofing

It is a passive means of protection of a structure/equipment/vessel from exposure to direct fire or flame impingement or prolonged exposure to high intensity radiant heat flux, by the application of a coating of a specified rating.

Flammability Range/Limits

It is the range in percentage by volume of any flammable vapour which in admixture with air, forms an explosive mixture.

Flammable (or Inflammable)

Any substance which when tested in a specified manner will ignite when mixed with air on contact with a flame and will support combustion.

Gas-Free

It is a condition when the concentration of a flammable gas in equipment is well below the threshold limits (LEL) so that it is safe for a man to enter into the equipment or to carry hot work there, as the case may be.
Hot Work

It is an activity, which may produce enough heat to ignite a flammable air-hydrocarbon mixture or a flammable substance.

Kerb Wall

A wall of appropriate height and size constructed of suitable material and designed to contain the LPG spillage and to direct it to a safe location around the storage vessel.

Liquefied Petroleum Gas (LPG)

A mixture of certain light hydrocarbons derived from petroleum, which are gaseous at normal ambient temperature and atmospheric pressure but may be condensed to liquid state at normal ambient temperature by the application of moderate pressure, and which conforms to IS : 4576 or IS : 14861 (Auto LPG).

Purging

It is the act of replacing the atmosphere within a equipment by an inert gas / LPG vapour in such a manner as to prevent the formation of explosive mixture.

Reid Vapor Pressure

Reid Vapor Pressure is the vapor pressure in pounds per square inch (psi) at 100 Deg. F as determined by Reid apparatus.

Statutory Authority

It is an authority appointed under specific Act or regulation for administering specific function under the Act/regulation.

“Chief Controller of Explosives”, hereafter referred as CCOE, is the Statutory Authority for administering the SMPV (U) Rules 1981.

“Chief Inspector of Factories" in a State/UT is the Statutory Authority for enforcement of the Factories Act, 1948 and the Factories Rules made thereunder.*

Sources of Ignition.

Devices or equipment which, because of their mode, use or operation, are capable of providing required thermal energy to ignite flammable LPG-Air mixtures when introduced to such a mixture or when such a mixture comes into contact with them.

SMPV (Unfired) Rules.

The Static and Mobile Pressure Vessels (Unfired) Rules, 1981, (with latest amendments) abbreviated as “SMPV (U) Rules”. These are Rules governing the storage, transportation; handling etc. of compressed gas in vessels exceeding 1000 liters in volume. These rules are framed under the Indian Explosives Act, 1884 and administered by Chief Controller of Explosives.
Shall.

Indicates mandatory requirement.

**Competent Person**

Competent person means a person recognised by the applicable Statutory Authority for the job in respect of which the competency is required.

**4.0 LOCATION AND SEPARATION DISTANCES**

**4.1 LOCATION**

The location of mounded storage to be decided after careful consideration of all influencing factors, including the following aspects:

a) The area to be covered by mound and the area within the separation distances, as given in clause 4.2, shall be clear of any tree, stump, root, bush, combustible material and other objectionable matter.

b) Space requirement for movement of construction/fabrication equipment and materials, onsite fabrication and maintenance for each mounded vessel.

c) 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.

d) The manhole and safety relief valves of mounded vessels shall be in a well-ventilated position.

e) Fire hydrants/ monitors shall be positioned at a safe distance as given in item 8.0.

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

g) 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.

**4.2 SEPARATION DISTANCES**

Separation distances are intended to minimise both the potentials for small leak ignition and exposure risk presented to adjacent vessels, equipment or installations in case ignition occurs. Separation distances are not intended to provide protection from a major incident. Risk analysis and dispersion modeling are recommended tools to limit the exposure risk to adjacent facilities.

**4.2.1** 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 meter.
Further between edge of the mound and boundary, property line, group of buildings not associated with LPG plant shall be 5 meter.

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 meter.

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

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 / fire fighting equipment.

4.2.2 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. (Refer attached drawing - 2)

4.2.3 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.

5.0 MOUNDED LPG STORAGE FACILITIES

5.1 STORAGE VESSEL(s)

Horizontally placed cylindrical vessel(s) shall be used for mounded storage. The mechanical design of storage vessel shall be based on following considerations:

i) 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

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ii) MATERIAL

Material of construction shall conform to design code. However, for any reasons, these codes differ (i.e. Design code and selection of material code), the selected material should confirm to equivalence of design code.

a) FOR REFINERY SERVICE

Since H₂S presence cannot be completely ruled out in the Refinery LPG storage, high stress material shall not be used for vessels as it is prone to Hydrogen induced stress corrosion cracking. The material shall be selected as given below:

i. Material shall be in line with design code. ASTM A516 Gr. 60 or eqv. shall be used.

ii. Micro-alloyed steel containing Ni, Mo, Va shall not be considered.

iii. Maximum specified tensile stress shall not be more than 80,000 psi.

b) 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.

iii) DESIGN TEMPERATURE

- 27 °C to + 55 °C.

iv) 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.

v) OTHER CONSIDERATIONS

Internal Corrosion Allowance: 1.5 mm (minimum)

Radiography: Full

Stress Relieving:100% irrespective of thickness.

Earthquake pressure: as per IS: 1893

Hydrotest pressure: As per Design Code

The recommended design pressure and temperature shall be treated as MINIMUM requirement and other design consideration and Statutory requirements shall also be considered.

5.1.1 The dimensions (diameter and length) of the vessel shall be decided based on site conditions, soil mechanics, type of fabrication facilities available and other design considerations.

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5.1.2 The external surface of the vessels which is covered by mound should be suitably treated to protect it from corrosion. Methods of protection shall include surface coatings (suitable for design conditions as specified above) and cathodic protection (impressed current system). General guidelines are given in Annexure - I. NACERP-0169, “Control of External Corrosion on Underground or Submerged Metallic Systems” and T-10D-17/T-6A-63 ON “Pipe Line Rehabilitation Coatings” may also be referred.

5.1.3 Holiday detection of the coated surface shall be carried out to ensure defect free coated external surface using suitable Spark Holiday Detector.

5.1.4 The cathodically protected system shall be isolated from the unprotected structures /surfaces by installing monolithic joints i.e. one each on liquid and vapour lines. A suitable isolation shall also be provided on utility pipelines such as air line to ROV, metallic structures, instrument lines etc.

5.1.5 Reference points on inner surface of the vessel shall be marked for NDT, for subsequent inspections.

5.2 MOUND

5.2.1 Mounded vessel(s) shall be placed on a firm foundation and installed so as to prevent movement or floatation. The sub-soil water, rainwater or any other surface water should not be allowed to percolate in to the mound. The foundation should be constructed such that in the longitudinal direction of a vessel slope of at least 1:200 is maintained to facilitate draining of the vessel. Reference may be made to attached Drawing-1 and Drawing-2.

5.2.2 Site conditions and soil mechanics shall be deciding factors for selection of the type of foundation in a given situation. The preferred type of foundation is a continuous sand bed, supporting the vessel over its full length.

5.2.3 The foundation shall have sufficient load bearing capacity and all the factors affecting the foundation shall be considered while designing the same. The factors should not be limited to the following:

a) The load of the vessel during normal operations and also during hydro test when the specific gravity of liquid is 1 (one) instead of that of LPG.
b) The earth/sand cover
c) The settlement behavior of the foundation which include

   i) Overall settlement
   ii) Differential settlement which causes bending of the vessel
   iii) Differential settlement which causes sloping of vessel

5.2.4a) The sand bed beneath the vessel shall be of adequate elevation not less than 0.76 meter to facilitate drainage from liquid outlet pipe by gravity. In this case, bottom connection shall be permitted on mounded vessel(s) with an access to connections by providing an opening or tunnel with 1.2 m minimum diameter and a 0.9 m minimum clear area. Bottom connections shall be considered as part of the vessel where these extend beyond the mound and shall be designed for the forces that can act on the connection.
Proper provision shall be made for encountering the consequences of the settlement of the vessel. The surrounding of the bottom connection should be filled with such material that can absorb such settlement.

Reference may be made to attached Drawing-2 and Drawing -3.

b) Where submersible type of pumps is provided for individual vessel, conditions stated at “a)” above shall not apply. In such cases drainage of water shall be made by using dip pipe with top connected drain valves. The first valve on this pipeline shall be provided as close to vessel as possible and shall be kept close condition in normal operating conditions.

5.2.5 The mound shall protect the vessel from the effects of thermal radiation and shall be sufficiently robust to remain in place in the event of jet flame impingement.

5.2.6 Mound shall be of earth, sand or other non-combustible, non-corrosive material such as Vermiculate or Perlite and shall provide at least 700 mm minimum thickness of cover for the vessel.

Reference may be made to attached Drawing-4

5.2.7 The mound surface shall be protected against erosion by rain or wind by providing a suitable protective cover of prefabricated stone, open concrete tiles, etc..

5.2.8 Water ingress into the mound shall be minimised by providing impervious layer of suitable material. However, a continuous impermeable cover shall not be installed, to prevent the possibility of gas accumulation inside the mound. Proper drainage and slope on top of the mound shall also be provided.

5.2.9 Longitudinal axis of vessels (any number) in a mound shall be parallel to each other with ends in line.

Where more than one row is installed the adjacent ends of the vessel in each row shall be separated by not less than 3 meter.

5.2.10 The valves and appurtenances of mounded vessel(s) shall be accessible for operation or repair, without disturbing the mound.

5.2.11 Provision shall be made to monitor the settlement of the mound/ vessel by providing permanent reference points. A minimum of three reference points shall be provided to ascertain uniform/ differential settlement and also identify possible vessel bending (One near each the vessel ends and one in the middle.)

Maximum permissible differential settlement shall be determined at the project design stage. Procedures shall be developed to regularly monitor the settlement throughout the lifetime of the vessel and records maintained thereof.

5.2.12 Provision shall be made for inserting portable CuSO₄ reference electrode on top of the mound for measurement of PSP at 12 - O Clock position of the vessel. This shall be protected to prevent water ingress in the mound.

Reference may be made to attached Drawing-2.
6.0 FITTINGS AND INSTRUMENTS ON A VESSEL

All the fittings / instruments shall be suitable for use at not less than the design pressure of the vessel and for the temperatures appropriate to the worst operating conditions. Various fittings and instruments to be provided on the vessel are as under:

6.1 The fire safe Remote Operated Valve (s) (ROV) shall be provided on first flange on liquid line (s) from the 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, structures.

In case of provision of liquid outlet from the top of the vessel, the line shall extend upto 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°. Reference may be made to attached Drawing-3.

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”.

6.2 Minimum two nos. of manhole shall be provided on top of the vessel.

6.3 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.

The discharge of SRVs shall be connected to flare system wherever available. SRVs shall have lock open (or car seal open) type isolation valves on both sides of SRV.

In case of non availability of flare system, the discharge from safety valve shall be vented vertically upwards to atmosphere without any intermediate valve on downstream side at an elevation of 3-meter (minimum) from the top of the mound or exposed nozzle whichever is higher for effective dispersion of hydrocarbons. A weep hole with a nipple at low point shall be provided on the vent pipe in order to drain the rainwater. Weep hole nipples shall be so oriented that in case of safety valve lifting and consequent fire, the flame resulting from LPG coming out from weephole does not impinge on the vessel or structure. A loose fitting rain cap with a chain (non-sparking) fitted to vent pipe shall be provided on top of SRV.

6.4 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.

6.5 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.

Audiovisual indication shall be provided at local panel & control room.
6.6 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.

In case, temperature gauge provided on the vessel is in thermo well, it shall be welded to vessel.

6.7 In areas where heavy snowfall can be expected, piping, regulators, meters, and other equipment installed in the piping system shall be protected from the forces anticipated as a result of accumulated snow.

7.0 HAZARDOUS AREA CLASSIFICATION

The hazardous area shall be classified as per IS : 5572 and OISD-STD-113. The electrical fittings/ equipment in the respective classified area/ zone shall be of a type suitable for the particular area/zone as per classification in line with IS : 5571.

8.0 FIRE DETECTION / PROTECTION SYSTEM

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

8.1 AUTO FIRE DETECTION / PROTECTION SYSTEM

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).

The actuation of pressure switch on any one of above said detector on or around the mound shall initiate the following:

- An audiovisual alarm at the local/ main control panel and fire water station, indicating the fire.
- All ROVs on the affected vessel shall close.
- LPG pumps and compressors in LPG storage area shall trip.
- Sprinklers. If provided, shall operate.

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.

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8.2 GAS DETECTION SYSTEM

Suitable gas detectors shall be placed at critical locations in the LPG storage area such as near the ROVs, in inspection tunnel, inside the nozzle box enclosure (if provided) or dome connection, near water draining/ sampling points.

Audio-visual alarms showing the location of gas leakage shall be provided on the control panel. First level alarm shall be set at 20% of Lower Explosive Limit (LEL) and second level alarm at 60 % of LEL.

8.3 WATER REQUIREMENT / STORAGE

The mound of vessel(s) provides protection against direct flame impingement and minimises heat absorption from nearby fires. Therefore, for water requirement / storage in mounded storage area, the clauses of OISD - STD –144 w.r.t. medium velocity water sprinklers shall not be applicable.

8.4 The fire proofing (2 Hours rating) of all exposed portion of the vessel shall be done including piping upto 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 installed as per above clause 8.1.

Reference may be made to attached Drawing-4, and Drawing-5.

8.5 Hydrant(s) / monitor(s) coverage shall be provided for adequate coverage of unprotected portions exposed to thermal radiation including the top of the mound and product pipelines.

8.6 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.

8.7 Measures to prevent the freezing of cooling water supplies and frost damage to supply lines, etc. shall be provided in the areas where heavy snowfall can be expected.

9.0 OPERATION, MAINTENANCE AND INSPECTION

The following provisions specific to mounded storage facility shall be followed and records to be maintained:

9.1 Safety Relief valves shall be tested and calibrated every year by a competent person.

9.2 Cathodic protection system, shall be maintained, tested as below:

a) Pipe to Soil Potential (PSP) Readings

i) PSP readings at feeding points shall be monitored fortnightly.

ii) The PSP reading at the test lead points for entire vessel shall be taken once in a quarter. The PSP survey results shall be plotted graphically to identify and locate cathodic holidays. The minimum PSP shall be more negative than - 0.85 volts with respect to copper/copper sulphate half-cell. In areas where anaerobic bacteria are active minimum PSP shall be more negative than - 0.95 volts instead of - 0.85 volts. Over protection of coated vessel shall be avoided by ensuring that polarisation potential is below - 1.2 volts with respect to copper/copper sulphate half cells. Polarisation

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potential shall be measured at a given location on a coated vessel by measuring PSP immediately (within the first second or two) after simultaneously interrupting the current output from all cathodic protection sources affecting that portion of the vessel.

iii) The PSP readings shall also be recorded on weekly basis with respect to permanent Zinc reference cell.

iv) The polarisation cell shall be checked regularly for replenishing the liquid levels (KOH).

v) The protective current shall be monitored quarterly.

b) Insulating Joint/Coupling Inspection

Insulating joints and couplings shall be inspected once in a year.

9.3 The settlement of the vessel shall be monitored at least on half yearly basis.

9.4 Vessel(s) shall be subjected to hydro test once every 10 years or at every welding to the vessel (repairs or new connections) whichever is earlier, by a competent person.

9.5 Vessel(s) shall be tested every 5 years internally using visual and other techniques for the following:

a) All the weld joints of the vessel shall be examined through Non-Destructive Testing (NDT) techniques e.g., radiography, Wet Magnetic Particle Test (WPT), Dye Penetration Test (DPT), ultrasonic flaw detection to ensure the integrity of the joints.

b) The wall thickness of the vessel shall be measured ultrasonically.

For (a) and (b) above other established NDT techniques may be used for example acoustic emission testing.

9.6 In case of any indication of defect or doubts about any defect, the mound cover of the vessel shall be removed to expose the outer surface for necessary examination from outside.

9.7 If internal access to mounded vessel is not possible, the external surface of the vessel shall be exposed to enable examination.

9.8 Any repairs or modifications shall be carried out only after taking approval from applicable authority.

9.9 A manual for operation and maintenance procedure with necessary details for both normal and emergency operation shall be developed.

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10.0 REFERENCES

(b) NFPA 58 – Liquefied Petroleum Gas Code, U.S.

(c) Technical Paper on “Developments in the storage of dangerous gases and liquids in large capacity tanks” by Dr. F. Mang, University of Karlsruhe.


(e) NACERP-0169, “Control of External Corrosion on Underground or Submerged Metallic Systems” and T-10D-17/T-6A-63 on “Pipe Line Rehabilitation Coatings”, Nace International, U.S.

(f) Other Standards/specifications as referred in the different clauses of this standard.

Note: The attached drawing 1 & 2 are typical and are being modified.
GENERAL GUIDELINES FOR CATHODIC PROTECTION SYSTEM

1.0 General

The cathodic protection system shall be designed by and installed under the supervision of a specialised cathodic protection personnel.

The design of the cathodic protection system shall be an integral part of the total vessel design. Electrical isolation of piping and a suitable coating system shall be provided for in the vessel design.

2.0 Protection Criteria

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

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.

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.

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.

3.0 Design

The following data shall be considered for cathodic protection design:

- number of vessels with dimensions and locations
- design life of the installation
- external coating specifications
- plot plans, location of vessels, piping etc.
- piping diagrams and electrical diagrams showing electrical isolation and earthing systems
- relevant construction drawings of the vessels and foundation
- soil and groundwater conditions including resistivities
- adjacent buried metal and reinforced concrete structures
- existing and planned cathodic protection systems
- possible sources of interference
- availability of electrical supply
- hazardous areas classification
- further requirements by the company on potential control, monitoring facilities.
4.0 Electrical Separation

Each vessel shall be electrically isolated from other vessels, pipelines, plant, buried metal structures and electrical and instrument earthing systems.

Monolithic isolating joints shall be installed above ground in all piping attached to each individual vessel. These joints shall be suitable for the expected temperature range as given in the design data.

The resistance across isolating joints shall be measured immediately before welding into the pipeline. The minimum resistance shall be 1 mega ohm ($10^6$ ohm).

Isolating joints shall be painted in a contrast colour for easy identification.

Safety and instrument earthing installed on the vessels shall be provided with polarization cells to avoid loss of cathodic protection current while maintaining a low resistance to earth.

If more than one vessel is installed, polarization cells shall be installed in the earthing of each individual vessel to ensure electrical insulation between the vessels.

The polarization cells shall be suitably rated for the expected voltages and currents.

5.0 Transformer / Rectifiers

Transformer/rectifiers shall be of a special design for cathodic protection service.

The output voltage shall be adjustable from, zero to the rated maximum voltage. A stepless (continuous) adjustment shall be used, without adjustment by tapping switches.

Electronic voltage and/or current control is recommended in combination with automatic potential control.

The rectifier shall be constructed using high current density selenium cells or silicon diodes so arranged to provide full wave rectification. The AC-component of the secondary voltage under the most unfavorable load conditions shall not exceed 10% of the DC-output.

The transformer/rectifier shall be provided with a moulded case circuit breaker on its incoming circuit and suitably sized fuses shall be installed in the incoming AC and negative DC output circuit.

The transformer/rectifier shall be provided with meters to read the output voltage and current. The measuring accuracy shall be 2% of full scale or finer.

The polarity of the DC terminals and AC supply cables shall be clearly marked. AC and DC cables shall be physically separated by an insulating panel.

Transformer/rectifiers should be installed in a non-hazardous area.

When installed outdoors, the enclosure shall be weather-proofed.
6.0 Automatic Potential Control

The cathodic protection system shall be provided with automatic potential control. A switch shall be provided to switch the system between automatic and manual operation.

In automatic operation mode, the control circuit shall be capable of controlling the current output such that the structure to soil potential at the connected reference cell is maintained within 10 mV of the set value at the prevailing current demands during any period in the design life.

The potential measuring circuit shall have an input resistance of more than 100 mega-ohms and be capable of working with both Cu/CuSO₄ and Zinc reference cells.

The control system shall be provided with adjustable voltage and current limiting circuits and/or alarms to avoid overprotection of the vessel in case of failure of a reference cell.

A panel mounted meter to read the structure-to-soil potential at the selected control reference cell shall be provided.

7.0 Cables and Distribution Boxes

The connections of electrical cables to the vessel shall be designed to ensure adequate mechanical strength and electrical continuity and to prevent damage to the vessels.

The cable connections may be made by, welding, pin brazing or by mechanical means. Thermit welding or brazing to the vessel wall shall not be used.

Mechanical connections shall be made above ground only using cable lugs, nuts and serrated washers.

All below-ground electrical connections to the vessel shall be fully encapsulated to comply with the original vessel coating standards and shall be holiday tested before backfilling.

All cables shall be sized such that no excessive voltage drops occur which reduce the capacity of the system.

All cables shall be insulated and sheathed to withstand the prevailing soil conditions. Drain cables and grounded feeder cables shall be armoured. All cables shall be buried in soft sand at a depth of at least 0.5 m, provided with cable protection tiles or warning tape as considered suitable for the area.

All cables shall be identified by cable tags where they come above ground.

8.0 Design Documents

These design documents shall contain the following:

- results of site surveys carried out for the design.
- Calculation of current requirements and resistance and current capacity of groundbeds.
- A schematic diagram of the proposed cathodic protection system.
9.0 Commissioning

The commissioning of the cathodic protection system shall be carried out by competent person under supervision.

The commissioning shall comprise of following:

- visual examination of all system components, checking of all cable connections and polarity.
- Checking of all permanent reference cells with respect to a portable reference cell before energizing the system.
- Measurements of groundbed resistance to remote earth.
- Measurements of natural potentials at each permanent monitoring location.
- Energizing the system and current adjustment to obtain approx. protection potentials.
- Checking of the electrical insulation of each vessel.
- “OFF” potential measurements after at least 48 hours of polarization.
- Any other monitoring and readjustments required to meet the protection criteria.

A commissioning report shall be written containing the following:

- a brief description of the system.
- All information on the deep-well ground beds (depth, resistivity/depth profiles, active depth and length, anode arrangements).
- Results of all commissioning test procedures.

10.0 Operation and Maintenance

Operation and maintenance manual for the cathodic protection system shall cover the following:

- description of the system and system components, controls and connections
- as – built drawings.
- Manufacturer documentation
- A schedule of all monitoring facilities.
- Potential criteria for the system.
- Monitoring schedules and requirements for monitoring equipment.
- Monitoring procedures for regular (ON/OFF) measurements.
- Test procedures for electrical isolation integrity.
- Methods for readjustment of the system.
- Guidelines for the safe operation of the system.

11.0 Additional Design Considerations

Mounded storage designs other than those using sandbed foundations require additional buried metal or reinforced concrete structures to support the vessel. Those buried structures are sources for shielding and interaction with the vessel’s cathodic protection system. Because of this, such
designs are not optimal from a corrosion protection point of view, however, conditions may exist which prohibit the use of sand bed foundations.

When those foundation designs are used, the following points shall be considered in the cathodic protection design.

- Foundation piles, rafts and supports shall be electrically isolated from the vessel using suitable isolating sheets where metallic contact might occur.
- In locations where the vessel’s surface is covered by insulating materials, e.g. resilient material, or where settlement of soil may prevent intimate soil contact, effective cathodic protection may be inhibited. Where such a situation is expected, additional measures shall be proposed to ensure adequate corrosion protection. Such measures may consist of e.g. additional coating or corrosion allowance and shall always be proposed together with inspection methods to prove the effectiveness of these measures.
- Shielding effects by foundations and access tunnels may require special groundbed designs, e.g. anodes inside the mound. Such designs shall be accompanied by full justification and design calculations.
BOTTOM OUTLET WITH INSPECTION TUNNEL

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

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