MOUNDED BULLETS FOR LPG STORAGE

OIL INDIA LTD, DULIAJAN, ASSAM
Project Background

- Existing LPG storage at OIL, Duliajan includes 3 aboveground Bullets (each 360 m$^3$) and 2 Spheres (each 2000 m$^3$).

- OIL proposes to replace the above ground LPG storage facility with mounded storage facility.

- OIL engaged EIL to conduct a Pre-Feasibility Study to study alternatives for providing Mounded Storage.

- EIL conducted the study and issued the Pre-Feasibility Report during Feb. 2004 (price validity up to September 2003).
Why Mounded Bullets

Safety aspects

- Mounded bullets have a sand cover which can take impact of external missile bodies
- Scenario of BLEVE (boiling liquid expanding vapour explosion) is eliminated, since no fire possible below the bullets
- Reduced fire case PSV loads as compared to spheres
- Reduced firewater requirement for fire fighting.
- Difficult for external agencies to identify the mound as a storage facility
## Existing A/G Bullet Design vs OISD-150 Requirement

<table>
<thead>
<tr>
<th>Existing A/G Bullet Design</th>
<th>OISD-150 Requirement</th>
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<tbody>
<tr>
<td>MOC used:</td>
<td>Material used shall be SA 516 GR 60 (impact tested)</td>
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<tr>
<td>Shell – SA 612 GR B</td>
<td>Mounded Bullets shall be stress relieved irrespective of plate thickness</td>
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<tr>
<td>Head – A 445 GR B</td>
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<tr>
<td>Not Impact Tested</td>
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<td>Existing Bullets are not stress relieved</td>
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<td>Existing Bullets are designed for internal pressure only. Also already 20 years old.</td>
<td>Mounded Bullet shall be designed for internal pressure/mound load/differential settlement etc.</td>
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**Oil India Limited**
Design Aspects (contd.)

- 3 No. of new LPG Mounded Bullets will be provided
- Each bullet will have a stored capacity of 705 m$^3$
- Total stored capacity equal to 7 days production
- Existing LPG bullets will be dismantled
- Existing LPG spheres will become redundant
### Design details of new LPG Mounded Bullets:

- **Nominal capacity**: 830 m³
- **Liquid stored capacity**: 705 m³
- **Design pressure**: 14.0 kg/cm²(g)
- **Design temperature**: (+)55°C/(-)29°C
- **Dimensions**: ID 6.0 m, L 25.5 m
- **MOC**: CS (SA 516 Gr 60, impact tested)
- **Corr. All.**: 1.5 mm
Design Aspects (contd.)

Associated facilities:

- Odorant dozing system for batch and online dozing
- Utilities:
  - Instrument air and service water will be tapped from existing network
  - Manifold considered for nitrogen. During major requirement liquid N2 tanker will be mobilized
- Fire and gas detection system
  - Combustible gas detectors
  - Fusible plug loops for fire detection
- Fire protection system, security circuit
- Cathodic protection system for the mounded bullets
- Surveillance system for security purpose
Proposed Overall Execution Plan for Project

The proposed execution plan is based on following considerations

- Normal operation of the existing LPG unit and LPG dispatch facilities is not affected
- Safety is ensured during construction of new mounded bullets
The proposed plan includes following steps.

- Isolation of existing bullets from rest of the facilities.
  In this situation:
  - Existing spheres will be used for LPG storage
  - Set of pumps with sphere will be used for dispatch

- Decommissioning of the existing bullets. This includes:
  - Emptying out liquid LPG
  - Removal of LPG vapours (by N2 purging/ water filling)
  - Purging the bullets with air
Isolation of the operational area from the construction area. For this:
- Adequate barricade will be provided between operational and construction area
- Gas detectors shall be provided in the construction area

Dismantling of the existing bullets to create space for new mounded bullets

Construction of the new Mounded bullets and associated facilities
DESIGN, CONSTRUCTION & INSPECTION PHILOSOPHY FOR MOUNDED BULLETS
SALIENT FEATURES

- Used for storage of Liquefied gases (Mainly LPG and Propane) at ambient temperature
- Since the vessels are installed above the highest ground water table, the soil cover usually protrudes above grade as an earth mound, hence the term “MOUNDED STORAGE”
- Several vessels can be located side by side in one mound
- Vessels are completely covered with soil and only manhole/dome and other nozzles protrude outside.
- Vessels have a slope of 1:200 min. for drainage purpose
ADVANTAGES

- Additional safety compared to above ground storage of gases in spheres or bullets
- ‘BLEVE’, Boiling Liquid Expanding Vapor Explosion is virtually impossible
- Mound cover protects the vessels against:
  1) Heat radiation from nearby fire
  2) Pressure wave originating from an explosion
  3) Impact by flying objects
  4) Sabotage
- Results in reduced site area due to less stringent inter spacing requirements
A) SIZING CONSIDERATIONS

- Maximum diameter is usually determined by factors such as design pressure, fabrication, PWHT requirements, transport limitations, subsoil conditions and economy of design (8 m may be regarded as a practical upper limit).
- The maximum allowable length is usually determined by the subsoil conditions (especially if differential settlements are expected), size of available site and economy of design.
B) DESIGN PARAMETERS

Vessels are designed for :-

i) INTERNAL PRESSURE

ii) MOUND PRESSURE : The weight of mound above the vessel is transmitted by the vessel to the foundation and will result in radial loads on the vessel

iii) UNEVEN SUPPORT BY FOUNDATION : Results due to variation in Sub-soil characteristics along the length of vessel and construction tolerances

iv) VARIATION IN TEMPERATURE & INTERNAL PRESSURE : Variations in vessel temperature & internal pressure will cause variations in the length and radius of the vessel
V) EARTHQUAKE LOADS: Earthquake loads are calculated as per site data, if available or as per local building codes.

VI) EXTERNAL EXPLOSION: An explosion of a gas cloud in the vicinity would result in a pressure increase on the soil cover. This is taken into account for analysis as an increase of the weight of the soil cover.

VII) VESSEL TO SOIL INTERACTION: Soil underneath the vessel exerts a reaction which shall be taken into account for determining max. bending moment and shear load.

VIII) CORROSION PROTECTION OF VESSELS: The foundation & mound shall be regarded as a potentially corrosive environment, therefore, a heavy corrosion protection system (e.g. Cathodic Protection System) shall be installed.

IX) EXTERNAL COATING OF VESSELS: Anti corrosive paint system as per project specification.
DESIGN CODE AND MATERIAL SELECTION  
(As per OISD-150)

- **CODES:** PD 5500 or ASME Sec. VIII Div. 2 or equivalent duly approved by CCE
- **MATERIALS:** PD 5500 material, SA 516 Gr. 60 (Impact Tested), SA 516 Gr. 70 (Impact Tested) or SA 537 Cl. II (Impact tested)
- Post Weld Heat Treatment & Full radiography is mandatory irrespective of thickness
- Recommended maximum tensile stress shall be below 80,000 PSI
LOCATION AND SEPARATION DISTANCES *  
(As per OISD-STD-150)  
(* Distances to be measured from the edge of the mound at FGL and also from the first valve on the vessel i.e. ROV)  

- Min. Separation distance between mounded LPG storage and boundary, property line, group of buildings not associated with LPG plant  
- Min. Separation distance between mounded LPG storage vessel and LPG pump house/compressor house  
- 15 mtrs.  
- As per operational needs
LOCATION AND SEPARATION DISTANCES*  
(As per OISD-STD-150)

- Min. Separation distance between mounded LPG storage vessel and any other facility (other than LPG pump/compressor house) associated with LPG plant (e.g. Decantation shed)
  - 15 mtrs.

- Min. Separation distance between mounded LPG storage vessel and firewater pump house and/or firewater tank
  - 30 mtrs.
LOCATION AND SEPARATION DISTANCES*
(As per OISD-STD-150)

- Min. inter-distance between the edge of the vessel(s) in a mound
- Min. inter-distance between the edge of the mounds on FGL

- A) Shall not be less than 1.5 mtrs. (for vessel dia. up to 2 mtrs.)
- B) 2.0 mtrs. for all other cases
- Shall not be less than 3.5 mtrs.
Vessel shall be placed on a firm foundation & installed so as to prevent movement or flotation.

Sub soil water, rain water or any other surface water percolation should not be allowed into the mound.

1:200 longitudinal slope to be provided to facilitate drainage.

Adequate elevation of sand bed (Min. 760 mm) required to facilitate drainage from LPG liquid outlet pipe by gravity.

Mounding material:-

* Compacted earth
* Compacted sand of minimum thickness of 700 mm
* Non combustible material like vermiculate or perlite
FOUNDATION FOR MOUNTED STORAGE

- Impervious layers like geo-textile layers on top & bottom of vessels to minimize ingress of moisture into the mound and in turn to check corrosion of vessel

- Protective covering with prefabricated stone tiles or open concrete tiles to protect earth cover from rain or wind

- Top sand cover on the vessels shall be min. 700 mm

- Mound surface shall be protected by providing protective cover or prefabricated stone, open concrete tiles etc.
INSPECTION, TESTING AND QUALITY ASSURANCE

- MP testing for all welding edges
- 100% radiography for all weld joints
- All C-welds in lower 120 Deg. of sand bed are ultrasonically tested after hydrotest since approach is not available from the bottom side
- 100% MP/DP test of all pressure part welds including nozzle connections
- 100% MP test from inside and outside for all welds including in-situ welds after hydrotest
- Simultaneous Hydrostatic test of all vessels in a single mound
SAFETY/SECURITY SYSTEM

- AUTOMATIC FIRE DETECTION/PROTECTION SYSTEM
  - Heat detectors through Thermal fuses/Quartz Bulbs Detectors
  - Sensors at critical places

- THE ACTUATION OF DETECTORS SHALL INITIATE:
  - Audio/Visual alarm at 1) Local/Main control panel
    2) Fire water station
  - ROV on liquid inlet/outlet line closing the affected vessel
  - ROV on vapor balance line & liquid return line of affected vessel closing the same
  - Tripping of LPG pumps in LPG storage area
FIRE PROTECTION FOR MOUNDED VESSELS

- Auto Actuated fixed spray system shall be provided for the following:
  - All exposed portion of the vessel including piping upto 1st ROV
  - LPG pump station & RCC inspection tunnel (Likely source of vapour leakages)
    (This system shall be actuated through heat detector devices installed as per OISD-150)

- Fire water network with hydrants & monitors shall be installed all around mounded vessels
MOUNDED BULLETS

FIELD JOINTS OF SHOP - PREFABRICATED SECTIONS
(SUGGESTED METHOD)

LOCATION OF STIFFENERS
Construction Methodology

Pre-construction activities / Preparatory works:

- Isolation of the operational area from the construction area by providing -
  - Adequate barricade between operational and construction area
  - Gas detectors shall be provided in the construction area
  - Fencing in other areas (fabrication yard, storage, etc)
  - Separate entry / exit gate for labour and construction equipment / materials

- Dismantling of the existing bullets to create space for new mounded bullets

- Development of fabrication yard at identified location, preferably nearer to the erection site

- Arranging Construction Water, Construction Power, Drinking water, access roads, etc

- Identification of source of Sand and earth of required quality near to the site
Mound Construction

- Grade the site & buildup the site upto FGL.
- Simultaneously excavate below the Mound area upto required depth & compact the natural ground to 95% standard proctor density as per IS 2720 Part XIV.
- Construct Retaining Walls, Tunnels, Drains, Concrete Blocks & Concrete Supports for Vessel Piping network in phases for compatibility with construction.
- Proceed with sand filling and compaction in layers of 150 mm thickness. Compact each layer to 85% of Relative Density upto FGL.
- Spread geotextile membrane (Terrum 1000 / Netlon or equivalent) over the sand fill.
Mound Construction (contd.)

- Fill stone metal soling of 500 mm thickness in layers of 200 mm (Maximum) with stone metal of sizes 80 to 40 mm. Voids shall be filled up by sand & compacted by road rollers.
- Spread geotextile membrane over the stone metal soling.
- Spread & compact sand as per specification. This filling is to be done upto 60° from the bullet center line.
- During the above construction of the mound the bullet is constructed in required sub-assemblies as described in vessel construction procedure.
Mound Construction & Bullet Erection (contd.)

- The sub-assemblies are installed on the mound on saddles & circ-seam joints welded.
- "A" frame / crane is used for the vessel erection on the mound.
- Bullet will be supported on jacks to remove the saddles and then it will be lowered into final position onto mound bed.
- Fill and compact sand as per specifications in layers for achieving mound construction up to 120 degree from the bullet center line.
- The bullets are now resting on the completed sand bed upto 120 degree.
- All the bullets in a mound are subject to hydro-test simultaneously as per code.
Mound Construction & Bullet Erection (contd.)

- Construction of retaining wall, tunnel, concrete block, RCC column, stone/RCC drains to be completed along with hydro-test. It is to facilitate final mound build-up.
- Apply corrosion resistant lining on the residual surface of the vessels after Hydrotest and NDT.
- Commence filling of sand for the general mound in layers upto the required levels.
- Mound area over the vessel shall be compacted by hand or plate compactors only. Top of mound shall have slope @ 1:100 from the center outwards across the width of the mound.
- Geotextile layer is to be spread on top of sand layer.
Mound Construction & Bullet Erection (contd.)

- The top and sides of the mound shall be sloped as per drawings & shall have a final layer of Brick lining / cement tiles.
- The four edges of mound shall be provided with a concrete lining.
- CP System shall be installed in stages along with the development of the mound. The first set of reference cells shall be installed prior to erection of vessels.
- Storm water drain shall be constructed around the mound.
- Piping, Structural support & electrical works shall be carried out along with the development of the mound.
- After completion of construction, but prior to the hydro-test, the mound formation shall be repaired/ re-compacted, as required.
Vessel Construction Procedure

PRINCIPLE OF CONSTRUCTION
To minimize the weight of the individual sections for easy erection the vessels shall be constructed in approximately 45 to 50 MT segments for LPG bullets. These segments are mounted on saddles on the mound to facilitate field welding on the mound.
Vessel Construction Procedure

PROVISIONS FOR CONSTRUCTION

“A” FRAMES / Cranes / Hydraulic Jacks shall be used for vessel erection on the mound and lowering into final position.

Saddles shall be used for fit up & welding of sub-assemblies on the mound.
Vessel Construction Procedure

STEP 1: Fabrication of Sub Assemblies

- The vessels shall be fabricated in appx. 45-50 MT segments in fabrication yard near to the site.
- A gantry crane shall be installed to handle shell & stiffener fabrication in the Fab. Yard.
- Blast cleaning and Surface prepared shall be done.
- Hemispherical dished ends are fabricated simultaneously. The hydraulic press is used for pressing the petals.
- Shell course fabrication and assembly of two shell courses shall be done in vertical on a hard stand in fabrication yard.
- Further joining of two sub-assemblies shall be done in horizontal on rollers in order to complete the segment.
- The circ-seams shall be welded by SAW/SMAW process.
- Sub-assemblies heat treatment shall be done in yard.
Vessel Construction Procedure

STEP 2 – Segment assembly on mound

- Install the "A" frame on the mound.
- Alternately, segments can also be handled by crane.
- The segment from fabrication to erection site shall be transported on trailers.
- The vessel assembly on the mound shall commence from the retaining wall end in set sequence.
- The segments shall be first mounted on saddles.
- Fit-up and welding of field joints shall be completed.
- All NDT/ Stress Relieving, surface preparation clearances for the field joints shall be completed.
STEP 3 – Erection and Hydrotest

- Prior to bullet lowering the under side of vessels shall have surface preparation & painting to at least the bottom 140° portion.
- External surface preparation & coating of weld seams on balance top 220° of vessel located above sand bed shall be carried out after hydrotest.
- Lower the vessel on the mound using hydraulic jacks.
- Ultrasonic testing of all cir-seam welds in the lower 120° shall be carried out before the hydro test.
- Also UT of all Circ-seam welds located in the lower 120° of sand bed shall be carried out after hydro test of vessels.
**Vessel Construction Procedure**

**STEP 3 – Erection and Hydrotest (Contd.)**

- Complete the lowering of all the three vessels on the mound.
- Complete sand filling & compaction of the mound to cover the vessel up to 120 degree from center line along the entire length of the bullets.
- Hydro-test all the vessels on the mound simultaneously. This ensures maximum loading of the mound for its settlement.
- Weld areas resting on the mound will be checked by ultrasonic testing & MPT from inside the vessel for leakage. Wet fluorescent MP Examination of all welds shall be done after hydro test (100 % on inside & excepting lower 120° of C-seam welds from outside).
Vessel Construction Procedure

SETP 4- Completion of mound

- Further stages of mound construction shall be carried out as described in the Methodology of mound construction.

QA PLAN

ERECTION SEQUENCE
THANK YOU