

DEP SPECIFICATION

PRESSURISED BULK STORAGE INSTALLATIONS FOR LPG

DEP 30.06.10.12-Gen.

February 2011
(DEP Circular 58/11 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the layout, location, safety and operability aspects of above-ground and mounded storage of LPG in pressure vessels. LPG includes commercial propane, commercial butane and mixtures thereof.

Excluded from the scope of this DEP is the storage of pressurised pentane; for this the Principal should be consulted.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual DEM 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated January 2010; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (6).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated January 2010. The following are the main, non-editorial changes:

Old section	New section	Change
Various		Content regarding layout of plant and equipment has been removed and incorporated into DEP 80.00.10.11-Gen.
3.10		Removed and placed in DEP Informative

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

**Amended per
Circular 58/11**

Dual units have been incorporated throughout this DEP.

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

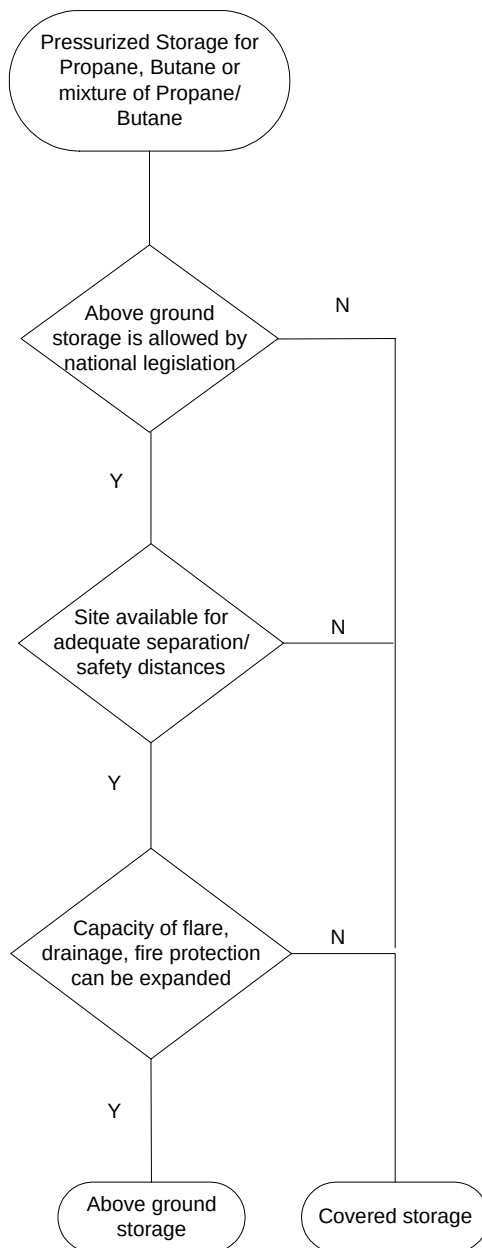
2. TYPES OF STORAGE VESSEL

LPG under pressure and ambient temperatures can be stored in two different types of vessels:

- i. Above ground storage vessels (spheres, bullets)
- ii. Covered storage vessels (mounded or submerged storage)

Mounded storage may provide additional safety compared with above ground storage. For instance, the occurrence of a BLEVE (boiling liquid expanding vapour explosion) is virtually impossible. However, the design aspects of mounded storage projects are in general more complicated than those for above ground spheres or bullets. Particular attention should be given on settlement issues as well as the corrosion protection. Reference is made to EEMUA190 chapter 3. Furthermore, as indicated in the flow chart of storage vessel selection, above ground storage installations require adequate flare capacity, sufficient drainage systems, and extended fire protection systems.

A flow chart for storage vessel selection is provided below:



3. ABOVE-GROUND BULK STORAGE OF LPG IN PRESSURE VESSELS

3.1 LAYOUT AND LOCATION

3.1.1 General

Layout and selection of location shall be in accordance with DEP 80.00.10.11-Gen. section 5.16.

3.1.2 Safety Distances

Recommended distances for initial layout studies should be verified by a fire safety/risk assessment on a case-by-case basis taking for the credible accident scenarios. The principle of the safety/risk assessment with respect to the determination of distances is related to the maximum allowable heat radiation flux levels, which can be estimated within the assessment.

The following factors shall be reviewed for determination of a safe distance

3.1.2.1 Vessel capacity

Refer to DEP 80.00.10.11-Gen. section 5.16.

3.1.2.2 Radiation flux levels

Refer to DEP 80.00.10.11-Gen. section 5.16.

3.1.2.3 Leakage

Refer to DEP 80.00.10.11-Gen. section 5.16.

3.1.2.4 Natural Phenomena

Local rules shall be applied to safeguard against natural phenomena, such as, lightning, earthquakes, flooding, hurricane.

3.1.2.5 Safety distances for above-ground pressurised LPG storage facilities vessels

Refer to DEP 80.00.10.11-Gen. section 5.16.

3.1.2.6 Relief valve fire

Refer to DEP 80.00.10.11-Gen. section 5.16.

3.1.3 Piping

Only piping directly associated with the storage vessels shall be located within the storage area (refer to 3.2.4, Figure 3 and Figure 4).

Active and passive fire protection for piping shall be in accordance with DEP 80.47.10.30-Gen. Refer to section 3.3.10.

For the purpose of deflecting solar radiation, shields may be considered to prevent vapour locks.

3.1.4 Grading and ground finish

Spills shall be drained away from equipment as quickly as possible, to ensure that escaped product cannot collect under vessels or remain in their immediate vicinity. To facilitate the flow of escaped product and prevent its penetration into the soil, the ground shall be finished with concrete paving sloping towards the perimeter drain channels.

For further information, refer to DEP 34.14.20.31-Gen. section 10.

For storage vessels in dedicated LPG service always having an adiabatic flash fraction larger than 0.1 (the fraction on a mole base going to vapour when flashed from process conditions to 1 bara (15 psia) together with a resulting adiabatic flash temperature 20 °C (70 °F) or more below the lowest ambient temperature, the concrete paving together with the perimeter drain channels can be omitted. The content of the vessel will vaporise sufficiently without a danger of a pool fire. Omission of the sloping floor and the liquid collecting trench should therefore be considered shall (refer to DEP 80.47.10.30-Gen.).

3.1.5 Separation between the vessel and the pipe manifold

There shall be a positive separation/deflection, e.g. a wall of 0.6 m (2 ft) maximum height, between the storage vessels and the pipe manifold/track to prevent the flow of any leakage from one to the other. Deflection walls may be considered between vessels to prevent product escape from one vessel from flowing under another (see Figure 1).

3.1.6 Confinement

Bund walls interfere with the ventilation of the site and impede the vaporisation/dispersion of escaped products and shall not be used.

3.1.7 Surface drainage

Surface drainage shall be in accordance with DEP 34.14.20.31-Gen.

3.2 VESSELS

3.2.1 Types of vessels

Pressure vessels for above ground storage of LPG shall be one of the following types:

- Horizontal cylindrical vessels
- Vertical cylindrical vessels
- Spherical vessels

3.2.2 Applicable codes

LPG storage vessels shall comply with one of the following DEP Specifications:

- DEP 31.22.10.32-Gen. Pressure Vessels (amendments/supplements to PD 5500:2009)
- DEP 31.22.11.32-Gen. Unfired Pressure Vessels (amendments/supplements to EN 13445:2009)
- DEP 31.22.20.31-Gen. Pressure Vessels (based on ASME Section VIII)
- DEP 31.22.31.31-Gen. Pressure Vessels (based on Chinese Code GB150)

Unless otherwise specified by the Principal, the Manufacturer shall be responsible for obtaining the required certificates of acceptance for the storage vessels from the appropriate authorities.

3.2.3 Design temperature and pressure

3.2.3.1 Maximum Operating Temperature (MOT)

The MOT is the highest temperature attained by the commercial product in the storage vessel under normal operating conditions. The MOT is therefore the maximum temperature on receipt into storage or the assessed temperature for the relevant climate, whichever is the higher.

The assessed temperatures are 35 °C (95 °F), 40 °C (105 °F) and 45 °C (113 °F) for temperate, tropical and desert climates respectively. If assessed temperatures have been established by local regulations or by the design code specified by the Principal, then these shall be used for design purposes.

3.2.3.2 Maximum Operating Pressure (MOP)

The MOP is the vapour pressure of the commercial product concerned (refer to Table 1) corresponding to the MOT.

3.2.3.3 Design Pressure (DP)

The DP shall be as per DEP 01.00.01.30-Gen. The DP is defined for the top of the vessel, hence the maximum liquid static head shall be taken into account to determine sizing/strength of the lower parts of the vessel.

The use of a vapour return line and/or top spray filling (refer to 3.2.4.6) is recommended as a means of limiting excessive back-pressure build-up in vessels during the filling operation. Vapour return systems also prevent vacuum from developing during discharge. If such systems are not used, then the DP should be checked to ensure that the back-pressures generated when filling are adequately covered, in order to avoid product loss through spurious relief.

The relationship between temperature and vapour pressure of commercial propane, commercial butane and propane/butane mixtures is shown in Figure 2.

3.2.3.4 Upper Design Temperature (UDT)

The UDT is the temperature corresponding to the DP. More information on the definition is given in DEP 01.00.01.30-Gen.

3.2.3.5 Lower Design Temperature (LDT)

Lower Design Temperature (LDT) is the lowest temperature at which equipment may be subject to its design pressure. DEP 30.10.02.31-Gen. Sections 1.3.2 and 4.2 and DEP 01.00.01.30 shall apply. These DEPs shall also be referred to with respect to the allowable maximum pressure at low temperatures.

3.2.3.6 Minimum Metal Temperature (MMT)

Minimum Metal Temperature (MMT) is the lowest temperature that equipment may possibly attain; MMT is further described in DEP 30.10.02.31-Gen. section 4.1. This temperature is not related to its design pressure conditions (as LDT does).

3.2.3.7 Vacuum conditions (external pressure)

Provisions to cope with vacuum conditions are required where ambient temperatures can be expected to fall below the Atmospheric Boiling Point (ABP) of the commercial product stored, or where very high liquid withdrawal rates are applied without an adequate vapour return system. In these cases, which normally only apply to butane storage, vessels SHALL [PS] be designed for full vacuum.

Table 2 provides details of the pressure in a vessel containing pure n-butane at low temperatures, which shall be considered in the design.

3.2.4 Connections

3.2.4.1 General

The number of nozzles on vessels, particularly below the liquid level, shall be minimised.

Nozzle flanges shall be in accordance with ASME B16.5.

Nozzles to which product transfer piping, product drains and pressure relief systems are connected shall be at least DN 50 (NPS 2).

Flanges in piping under vessels shall be avoided for safety reasons (flame impingement in the event of fire).

3.2.4.2 Bottom connections

For details, see Figure 3.

There shall be only one bottom connection, which may be used for filling, withdrawal and draining. The connecting pipe SHALL [PS] be welded and not flanged to this nozzle. The vessel nozzle shall include this pipe and shall terminate at the weld between the nozzle and the first valve. All joints in this bottom pipe up to and including the first valve (ESD valve) SHALL [PS] be welded and fully radiographed. The minimum size of the bottom pipe shall be DN 100 (NPS 4). The pipe thickness shall be as determined by the pressure vessel code but shall be not less than Schedule 80 or, for pipes larger than DN 100 (NPS 4), Schedule 40. Due to the fact that the pipeline is welded, it may be more vulnerable to mechanical damage during engineering work.

The product line shall be:

- as short as possible and sloping downwards from the vessel to the pump suction;
- provided with a water drain system upstream of the operational valve(s) (but downstream of the ESD valve, see Figure 3) at the manifold (refer to (3.2.4.3));
- SHALL [PS] provided with an ESD valve (refer to (3.4.2)).

This ESD valve SHALL [PS] be welded to the product line and located downstream of the separation/deflection wall.

Where the pump's net positive suction head (NPSH) requirements are critical, consideration shall be given to using a full bore ball valve.

Only in locations subjected to moderate/severe earthquake conditions (refer to DEP 34.00.01.30-Gen. section 3.13) or where local regulations dictate, shall the ESD valve be internally mounted. In this case (refer to Figure 4), the product line SHALL [PS] be:

- provided with a shut-off valve directly downstream of the ESD valve. This shut-off valve may be fitted with an actuator and be remotely controlled, but should also be capable of being manually operated.
- provided with a flanged tee, to accommodate an elbow between it and a DN 50 (NPS 2) valve to provide a bypass in case of malfunction of the internal ESD valve.

NOTE It is recommended to have the by-pass installed fully welded with the by-pass valve in the locked closed position (to be approved by local authorities).

- fire-insulated at all flanges immediately beneath the vessel. It is however recommended to install the bypass permanently by using a welded connection with a locked valve (to be approved by Authorities) see Figure 4.

3.2.4.3 Drain system

A drain connection shall be provided for each storage vessel and shall consist of a nozzle not larger than DN 50 (NPS 2) (schedule 80) welded to the bottom line (see Figures 3 and 5), to which a fire-safe ball valve not larger than DN 50 (NPS 2) (upstream drain valve), shall be connected.

The drain system SHALL [PS] meet the following requirements:

- Having two manual shut-off ball valves separated by at least 600 mm (24 in) of adequately supported piping with a slope towards the drainage direction to ensure that both valves are never simultaneously blocked open by ice. In fact, the separation is so that if flashing of LPG at the second valve freezes, the valve in the open position is far enough away that it is still operable and can operate the drain.
- The two drain valves shall be positioned so that a single operator can operate both valves simultaneously.
- The downstream drain valve shall be a DN 20 (NPS $\frac{3}{4}$), quick-acting, spring-loaded type (spring-to-close) valve, which will operate as a dead man's handle.
- The discharge point shall be lined up to flare or a vent in a safe location via a knock out vessel. The size of the knock out vessel is to be determined by the rate of draining and the volume of the piping contents between the bottom of the storage vessel and the drain connection.

Knockout drums and associated equipment shall be designed in accordance with DEP 80.45.10.10-Gen. refer to section 4. Additional details on separation equipment, may be found in DEP 31.22.05.11-Gen.

A vent to atmosphere may be considered only if there are no flare facilities or if a connection to flare would be impractical due to long distances. A risk assessment and dispersion analysis must be carried out in order to determine if the use of a vent to atmosphere is acceptable. In this case, a DN 20 (NPS $\frac{3}{4}$) pipe shall follow the downstream drain valve into a small separator vessel with discharge to atmosphere at a safe location

(more information is given at DEP 80.45.10.10-Gen. section 3.6.2. The discharge point shall always be in a freely ventilated area outside the periphery of the vessel. The equipment shall in accordance with DEP 80.45.10.10-Gen. DEP 31.22.05.11-Gen. shall be reviewed for sizing requirements as well.

The water drained from the vessel shall be routed/collected at a safe location.

At locations where freezing can occur, the drain valves, separator/knockout vessel and lines SHALL [PS] be adequately protected against freezing. The tracing shall not be welded to the product drain line.

3.2.4.4 Top connections

The nozzles of all top connections shall be above the maximum liquid level.

(i) Pipe connections

Liquid and vapour lines terminating in the vapour space should be flange connected to a nozzle at the top of the vessel. Liquid fill connections shall be provided with a non-return valve directly connected to the vessel nozzle and a close coupled fire-safe shut-off valve preferably of the remotely operated type. If flow may be bi-directional, the vapour connection shall be fitted with a remotely operated fire-safe shut-off valve. Back flow protection shall be in accordance with 80.45.10.11-Gen.

To prevent the release of liquid in the event of a pipe leak, the internal pipe shall not extend below the maximum liquid level. For ergonomic purposes, it may also be investigated whether it is possible to have all connections and valves at operator level and to have welded internal pipes extending into the vapour space.

(ii) Manhole

There should be only one (topmounted) manhole (minimum size DN 600 (NPS 24) for above-ground vessels. For mounded vessels the manhole (top mounted) should be in accordance with DEP 34.51.11.30-Gen. except in very long horizontal vessels where two manholes may be required to facilitate access/escape for maintenance/ inspection personnel and improve gas freeing. The manhole cover should be used to its maximum extent for the location of connections/fittings, e.g. instruments.

(iii) PRV connection

PRVs shall be connected to the vapour space of the vessel. For further details refer to (3.4.8).

3.2.4.5 Instrument connections

Connections for instruments shall, where practicable, be above the maximum liquid level of the vessel to prevent the release of liquid in the event of a tubing leak. Instrument connections should be located where impact damage and shearing off of the fittings are unlikely to occur. A shut-off valve shall be installed for all instruments in open connection with the vessel. Normal industry requirement is for all instrument connections to be no more than 1.5mm (1/16 in) bore.

3.2.4.6 Top spray filling system

Top spray filling is recommended as a means of limiting excessive back-pressure build-up during the filling operation. Top spray filling will cause an intimate mixing of the incoming liquid with the vapour present in the storage vessel resulting in an accelerated condensation of the vapours.

The top spray filling system normally consists of a spray ring (for spheres) or straight pipe (for cylindrical vessels) with a sizing which is normally one size less than the inlet piping to the storage vessel e.g. if the line to the storage vessel is 100 mm (4 in) diameter then the spray ring would be 80 mm (3 in) diameter.

The pressure drop across the ring should be 1 bar (15 psi) maximum and 8 (5/16) to 10 mm (3/8 in) diameter holes should be used to give a reasonable liquid distribution with minimal risk of blocking due to rust. The pressure drop of 1 bar (15 psi) should be at the maximum

liquid flow rate. This would normally occur when LPG is being transferred from one storage vessel to another by means of the loading pumps. As the LPG rundown rate is normally lower than this transfer rate, the pressure drop will normally be correspondingly lower.

The top spray ring/pipe should be located as close to the top of the storage vessel as possible to avoid a significant reduction in vessel ullage. The holes should be angled upwards in an arc of 120 degrees. The top spray ring/pipe shall be provided with sufficient drain holes (6 mm (1/4 in) ID) to allow easy drainage of the LPG from the spray ring/pipe.

Care should be taken to ensure that the spray does not foul the level or temperature gauges.

The top spray ring/pipe should be installed so that the need to weld onto the shell of the storage vessel is avoided. However, significant stresses might be placed on the inlet nozzle of the storage vessel, and these should be calculated to confirm that they are within the acceptable limits. It may be necessary to reinforce the nozzle.

The top spray ring/pipe will have to be fabricated in sections to allow it to enter the vessel via the top manhole.

3.2.5 Supports and foundations

3.2.5.1 Supports

Supports shall be capable of carrying the vessel full of water.

The vessels shall be properly anchored to the foundation.

Horizontal vessels shall have two steel saddle supports for mounting on concrete pedestals. One saddle shall be a fixed support and the other a sliding support to permit expansion and contraction of the vessel. The fixed support shall be welded to the shell, the sliding support shall have a wear plate welded to the outside of the vessel at the location of its support. It may also be possible that the sliding takes place between the end of the support and the concrete plinth. The sliding support shall not permit the vessel to move in the transverse and vertical directions. The fixed support shall be at the same end of the vessel as the bottom nozzle.

The supports shall incline the vessel at a minimum slope of 0.5% for complete draining.

The concrete pedestals shall be high enough to protect the vessel from flotation in the event of flooding and to give adequate NPSH for pump suction.

3.2.5.2 Design of foundations

The Manufacturer shall submit a loading diagram for the foundation design. This shall include loads on the foundations, dimensions and location of base plates and holding-down bolts. Loading data and load combinations shall be in accordance with DEP 34.00.01.30-Gen.

3.2.5.3 Structural steel

Structural steel for platforms, stairs and railings shall be in accordance with DEP 34.28.00.31-Gen. Galvanised grating shall be used for stair treads and platforms (refer to DEP 34.28.00.31-Gen. and Standard Drawing S 28.022).

3.2.5.4 Fire proofing

Fireproofing of structures and vessel supports shall be in accordance with DEP 34.19.20.11-Gen. and DEP 80.47.10.30-Gen.

3.2.6 Identification

Storage vessels should be identified with a serial number (e.g. 1, 2, 3, etc.) painted prominently on the shell. Vessel markings shall also comply with any local regulations.

In addition, product identification marking shall be prominently located next to receipt and discharge connections.