

DEP SPECIFICATION

LPG BULK TRANSFER AND TRANSPORTATION

DEP 30.06.10.13-Gen.

February 2011

(DEP Circular 34/11 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 transfer methods and systems for pressurised LPG. It also specifies requirements for the layout, location and safety and operability aspects of loading/discharging facilities used for the bulk transportation of LPG by pipeline, road, rail and water.

LPG includes commercial propane, commercial butane and mixtures thereof.

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.

1.3.2 Specific definitions

Term	Definition
ADR	Act on the European Agreement on the transportation of Dangerous Goods by Road

Term	Definition
DoT	Department of transport (US)
ESD	Emergency Shut Down
EFV	Excess Flow Valve
ERC	Emergency Release Coupling
ERS	Emergency Release System
GVW	Gross Vehicle Weight
IMDG	International Maritime Dangerous Goods Code
IMO	International Maritime Organisation
ISO	International Organization for Standardization
ISV	Internal Safety Valve
LPGITA	Liquefied Petroleum Gas Industries Technical Association UK
NFPA	National Fire Protection Association
NRV	Non-Return Valve
OCIMF	Oil Companies International Marine Forum
PRV	Pressure Relief Valve
QCDC	Quick Connect/Disconnect Coupling
RID	Regulations on the International Transport of Dangerous Goods by Rail
ROV	Remotely Operated Valve
RTW	Rail Tank Wagon
SIGTTO	Society of International Gas Tanker and Terminal Operators Limited

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 (7).

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.

The "SHALL [PS]" elements in this DEP were critically reviewed and updated as required. Sections 2.5.2 and 4.3.5a relating to plant layout and safety distances were removed from this DEP and included in DEP 80.00.10.11-Gen. Cross references to this DEP were included under the original sections.

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://sww.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

**Amended per
Circular 34/11**

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. BULK TRANSFER AND TRANSPORTATION

2.1 PUMPS AND COMPRESSORS

DEP 30.06.10.11-Gen. shall apply.

2.2 METERS

DEP 30.06.10.11-Gen. shall apply.

2.3 LOADING/DISCHARGING FACILITIES

2.3.1 General

The design layout and type of equipment for loading/discharging facilities is dependent on a number of factors such as:

- whether the facility is for loading or discharging, or both;
- the number of grades (mixtures of C3 and C4) to be handled. Separate systems should be used for each grade, although multi-product lines may be used. If multi-product piping is used up to the loading/discharging facility, the design shall ensure that inter-grade mixing does not result in off-specification product. Interlocks shall be provided to prevent the flow of more than a single grade through the loading/discharging facility. A product sampling system for monitoring product quality shall be provided at these facilities.
- The initial loading velocity and bonding requirements of API RP 2003, Section 4 shall be met to guard against hazards of static electricity.

2.3.2 Safety distances

The requirements of DEP 80.00.10.11-Gen. shall be applied.

2.3.3 Hoses

All hoses and hose assemblies used in LPG service/operations shall be manufactured, tested, approved and maintained in accordance with EN 1762, EN 13766, ISO 2928 or equivalent national standards..

2.3.4 Loading arms

Although hoses operated in the correct manner, with breakaway couplings and excess flow valves, are safe and are low-maintenance components, the longer term preference is to move to loading arms as a safe and long term reliable mode of operation.

The term "loading arm" refers to all metal self-supported loading and unloading arms with articulated swivel joints and also, if required by the operation, quick connect/disconnect couplings (QCDCs), power system (for large marine arms), control system, operational controls, range control system, purge system, emergency release system (ERS) and jacks (supports).

To improve safety, loading arms should be used to transfer LPG into and from tankers, bulk vehicles and rail tank wagons. In such cases, hoses should be replaced by flexible arms.

Compared to hoses, flexible arms:

- are often economically advantageous over the longer term, i.e. life of the arm,
- are potentially less prone to damage,
- require less maintenance and less manpower for handling, particularly in the larger sizes,
- require less frequent testing.

All loading arms and loading arm assemblies used in LPG service/operations shall be approved, manufactured, tested and maintained in accordance with DEP 31.06.15.10-Gen.

2.4 PORTABLE TANKS

IMO/ISO freight container tanks are specifically designed for multi-modal transportation of products, i.e. by road, rail or sea. LPG tanks are designed and constructed to comply with IMO Type 5 (IMDG code, Section 13) plus the requirements of other relevant codes, e.g. ISO standard for container tanks, ADR, RID and the US Government Department of Transport (DoT) specification. These tanks, if used for LPG, are usually equipped with pressure relief valves (PRVs), a maximum ullage gauge and liquid and vapour valves fitted with remotely operated internal safety valves (ISVs). Road containers operated internationally in and from ADR signatory countries shall conform to ADR. Rail containers operated internationally shall conform to RID specifications. Containers used in areas subject to US Coast Guard regulations also conform to DoT requirements. Most containers in international operation are owned by leasing companies who should ensure that tanks on hire meet all current regulations.

Only vessels designed to an appropriate transport pressure vessel safety standard SHALL [PS] be used for the transport of LPG.

ISO/IMO containers (Portable tanks) SHALL [PS] not be used for providing permanently installed storage facilities, as they do not always fulfil requirements with respect to piping, ESD and fire fighting provisions (they are normally used in small sizes to provide customer storage).

Figure 1 shows a typical layout of an IMO Type 5 container tank.

ISO/IMO containers (Portable tanks) shall comply with The United Nations Recommendations on the transport of Dangerous Goods Model Regulations

2.5 ODORISATION FACILITIES

The requirements of DEP 30.06.10.11-Gen section 8. shall be applied.

2.6 SAFEGUARDING SYSTEMS - EMERGENCY SHUTDOWN

In view of the potential consequences of an LPG liquid/vapour spill, systems for safeguarding the integrity of the plant and equipment SHALL [PS] be incorporated in the design to limit the quantity of released product.

The requirements of DEP 30.06.10.20-Gen. shall be applied.

2.7 FIRE SAFETY REQUIREMENTS

**Amended per
Circular 34/11**

The requirements for fire protection facilities SHALL [PS] be based on a fire safety assessment.

Fire safety requirements shall be according to DEP 80.47.10.30-Gen. and DEP 80.47.10.31-Gen.

3. TRANSPORT BY PIPELINES

3.1 GENERAL

A pipeline is a system of pipes and other components used for the transportation of fluids, between (but excluding) plants. A pipeline extends from pig trap to pig trap (including both pig traps) or, if no pig traps are fitted, to the first isolation valve within the plant boundaries or a more inward valve if so nominated.

3.2 PIPELINES

3.2.1 Pipeline engineering

Pipeline engineering shall be in accordance with DEP 31.40.00.10-Gen.

3.2.2 Product segregation

LPG grades should be segregated by providing each grade with its own dedicated facilities. Non-odorised grades shall be segregated in systems designed to prevent contamination.

The requirements of DEP 30.06.10.12-Gen. shall be applied.

3.2.3 Multi-product pipelines

LPG can be handled in appropriately rated multi-product white oil pipelines. The parcel size shall be both economical and practical, taking into account the requirements and costs of adequate storage at each end of the system as well as those of handling the interface at the receiving end.

- The ancillary fittings and equipment of a multi-product pipeline system shall be suitable for operation at the maximum foreseen pressure in the system.
- The pipeline system SHALL [PS] be equipped with pressure control valves to ensure that the product is under sufficient pressure to prevent LPG vaporisation in the pipeline.
- Mechanical separation of the different products in long pipelines will reduce the interface volume.
- Interface signalling equipment, e.g. gravitometer, will enable accurate interface cuts to be made thereby minimising the cuts to slops.
- A suitable pressure vessel (slops tank) and associated compressor to handle the interface cut are required.

For information on a method of calculating interface volumes in multi-product pipeline operations contact the Principal. Refer to (3.2.8) for details on the use of mechanical separators.

3.2.4 Corrosion protection

Pipelines above ground shall be painted in accordance with DEP 30.48.00.31-Gen. to prevent corrosion. Buried and submerged pipelines SHALL [PS] be protected by a suitable coating and by cathodic protection. Polyethylene and polypropylene coating shall be in accordance with DEP 31.40.30.31-Gen. and fusion-bonded epoxy powder coating shall be in accordance with DEP 31.40.30.32-Gen.

Cathodic protection shall be in accordance with DEP 30.10.73.31-Gen. for buried pipelines and DEP 30.10.73.32-Gen. for offshore pipelines.

3.2.5 Access

Above ground pipelines (including pig trap installations) should be readily accessible for operation, maintenance and inspection purposes. Protection SHALL [PS] be provided against possible impact/collision damage where vehicle movements may occur in the vicinity of the pipeline. Buried pipelines SHALL [PS] be protected against the effects of superimposed loads.

3.2.6 Overpressure protection

The design and engineering of the overpressure protection systems shall comply with DEP 31.40.10.14-Gen.

3.2.7 Leak detection

Pipelines shall be provided with a suitable leak detection system in accordance with DEP 31.40.60.11-Gen.

3.2.8 Mechanical separation

Mechanical separators, such as pigs or spheres, may be used to physically separate different products in a pipeline if the line has been designed and constructed for their use.

Pigs and spheres utilise synthetic rubbers or plastic materials to make contact with the pipeline walls and provide the seal between the products. The materials shall be compatible with and resistant to the products being handled.

3.2.9 Pig trap systems

The requirements of DEP 31.40.10.13-Gen. shall be applied.

3.2.10 Bi-directional pipeline operation

Some LPG pipeline clearing operations require a pig or a sphere to travel in the reverse direction to normal. These operations could entail:

- replacing water with LPG vapour;
- replacing air or inert gas with LPG vapour;
- replacing LPG liquid with LPG vapour.

In these cases, the pipeline shall be designed and constructed to include pig/sphere launchers/traps capable of both launching and receiving.

3.3 PIPING

3.3.1 General

Piping is the assembly, within designated plant boundaries, of pipes, elbows, flanges, gaskets, fittings, valves and other components (e.g. expansion joints, strainers, devices for mixing, separating, distributing, metering and flow control). It also includes pipe supports and insulation. The requirements of DEP 31.38.01.11-Gen. shall be applied.

3.3.2 Bonding/Earthing

To prevent the accumulation of static electricity, piping should be electrically continuous. Normal pipefittings, bolted flanges, etc., are generally sufficient to ensure this.

DEP 33.64.10.10-Gen. or DEP 33.64.20.10-Gen. shall apply as applicable.

3.3.3 Thermal expansion and flexibility

Provisions shall be made to prevent excessive pressure developing in sections of piping, which are isolated by valves or other equipment. DEP 30.06.10.12-Gen. shall apply.

4. TRANSPORT BY BULK ROAD VEHICLES

4.1 GENERAL

LPG vehicles shall comply with local design and construction regulations for the transport of flammable gases. If local regulations do not exist, or are not sufficiently comprehensive, then a recognised standard shall be followed, e.g. ADR, US Department of Transport MC 331, UN Model Regulations, UKLPG (formerly LPGITA) Code No. 2. The more stringent requirements of the local regulations (or the selected code) and this DEP shall be applied.

4.2 VEHICLE DESIGN

4.2.1 Vessel capacity

The maximum carrying capacity of the vessel is determined by the Gross Vehicle Weight (GVW) and axle load limitations set by local regulations, by the chassis Manufacturer's maximum recommended GVW and axle loadings and by the minimum safe ullage requirements of the product grades transported.

4.2.2 Safe filling capacity

LPGs have high volumetric coefficients of expansion compared to other liquid hydrocarbons and water. For example, at 15 °C (59 °F) the volumetric expansion of butane is 0.210 % per °C (0.117% per °F) and the volumetric expansion of propane 0.273 % per °C (0.152% per °F).

The maximum quantity of LPG filled into a vessel used in road transport operations SHALL [PS] be such that the vessel will not become more than 97 % liquid full (3 % ullage) due to expansion of the product at the Assessed Temperature. In areas with temperate climates the highest temperature the product may reach in normal operation shall only be used with the approval of the Principal.

The assessed temperatures given in Table 2 shall be used unless local regulations dictate otherwise. Some authorities recognise that if sunshades are used assessed temperatures may be lowered. In Table 2 it is assumed that the vessel shell is not protected against solar radiation.

- NOTES:
1. In some publications, e.g. BS 5355, the Assessed Temperature for Safe Filling is referred to as the "reference temperature".
 2. The term assessed temperature is also used to define the developed vapour pressure for vessel design purposes (see (4.2.5)). As stated in a number of codes and standards, e.g. NFPA 58 and BS 5355, there is a difference between the Assessed Temperature for Safe Filling and the Assessed Temperature for Developed Pressure, the latter being set several degrees higher.
 3. Some codes dictate that the maximum filling level should be set such that the vessel does not become liquid full at temperatures of up to 5 °C (9 °F) above the Assessed Temperature for Safe Filling. The 3% ullage safety factor referred to above always meets this requirement.

Bulk vehicles are loaded by measuring either the mass (weighbridge or mass meter) or the volume (volumetric meter or internally mounted ullage gauge). Whichever method is applied, a weighbridge SHALL [PS] be used both before loading (to assess the ullage available in the vessel) and after loading (to ensure that the maximum GVW is not exceeded).

4.2.3 Vessel construction

The maximum overall width of any vessel and its service equipment shall not project beyond the overall width of the chassis/cab or the ISO frame in the case of a tank container.

Unless otherwise specified by local regulations, vessels shall comply with one of the following:

- DEP 31.22.10.32-Gen.
- DEP 31.22.20.31-Gen.

- DEP 31.22.11.32-Gen.
- DEP 31.22.31.31-Gen.
- ASME Section XII Rules for Construction and Continued Service of Transport Tanks
- EN12493 LPG equipment and accessories – Welded steel tanks for Liquefied petroleum gas (LPG) – Road tankers design and manufacture

To limit the effect of product surge on the braking efficiency of vehicles, vessels may require baffle plates to be fitted. If local regulations covering this requirement do not exist, advice should be sought from the chassis supplier. Baffles should be fitted at intervals of not more than 7 500 litres water capacity.

The design of the baffle shall ensure unrestricted drainage of liquid and the interconnection of vapour spaces, and include a manway not less than 410 mm (16 in) x 360 mm (14 in). The position of the drainage cut-outs in the baffle SHALL [PS] allow the flow of liquid and vapour across the baffle when the vehicle is on its side or upside down.

Baffle plate thickness should be at least 2 mm (0.079 in). If double plates or sealing rings are used to support baffles the enclosed spaces so formed shall be provided with plugged sockets for monitoring the atmosphere prior to carrying out hot work.

4.2.4 Vessel nozzles and manhole pads

Vessel nozzles and manhole pads SHALL [PS] be manufactured from forged pads with studs for flanged fittings or internal threads as appropriate. The use of pipe nozzles is prohibited.

Threaded connections, if unavoidable, shall be kept to a minimum and should not be used on piping greater than DN 50 (NPS 2) (refer to (4.2.14) for size limitations on threaded connections on proprietary equipment, e.g. pumps, meters).

4.2.5 Design pressure, temperature, load and stress

The vessel design pressure SHALL [PS] be the vapour pressure of LPG at the Assessed Temperature for Developed Pressure plus the effects of the dynamic loads defined hereunder. If assessed temperatures for the design of LPG transport vessels are not covered by local regulations, the temperatures given in Table 1 should be used. Refer to (4.2.2) regarding the use of sunshades.

If vessels may be subjected to a vacuum, e.g. transport of butane in sub-zero temperatures, then vessels SHALL [PS] be designed to withstand full vacuum conditions.

The upper design temperature SHALL [PS] be not less than the Assessed Temperature for Developed Pressure.

The requirements for the prevention of brittle fracture and for lower design temperature shall be in accordance with DEP 30.10.02.31-Gen.

The design load and stress shall be according to EN 12493 section 5.4 and 5.5.

4.2.6 Mountings

Mountings used to support and anchor the vessel to the transport vehicle

- shall comply with the chassis and vessel Manufacturers' recommendations;
- shall account for the additional stress referred to in 4.2.5;
- SHALL [PS] be fabricated in steel that is compatible with the vessel:
 - o be designed as an integral attachment;
 - o be designed with continuous welds with adequate reinforcement to resist high stress concentrations at the attachment point;
- SHALL [PS] have electrical continuity between the vessel and fittings and the vehicle chassis.

4.2.7 Vessel connections - Primary shut-off systems

Valves which are directly connected to the vessel shell to control the flow of product into or out of the vessel and provide the means of stopping flow in emergency situations are referred to as primary shut-off systems.

Typical piping and equipment layouts for bulk delivery and bridging vehicles are shown in Figures 2 and 3.

The number of vessel connections, particularly those into the liquid phase, shall be minimised.

All connections in the vessel greater than 1.4 mm (0.055 in) diameter (other than those for pressure relief valves), and bolted covers/blank flanges or screwed plugs which are permanently installed, should have a primary shut-off valve or series of valves installed as described below:

- Nozzles above 3 mm (0.12 in) diameter in the liquid phase and 8 mm (0.31) diameter in the vapour phase SHALL [PS] be fitted with:
 - o either an internally mounted excess flow valve (EFV) or non-return valve (NRV) in combination with a fire-safe ball valve externally fitted as close as possible to the EFV/NRV,
 - o or an internal safety valve (ISV) as described in the notes to Table 3.
- Smaller connections SHALL [PS] be fitted with fire-safe ball valves as the primary shut-off system except that equipment attached to a vessel nozzle and incorporating a controlling orifice not exceeding 1.4 mm (0.055in) diameter may rely upon the closing device provided, e.g. the bleed valve of a fixed liquid level gauge.

Table 3 indicates the type and the required characteristics of primary shut-off systems fitted to the main vessel connections.

Fire-safe ball valves shall meet ISO 10497, API 6FA or equivalent standard.

If the emergency uplift/drain is connected into the pump bypass as shown in Figure 2 then a type B valve should be fitted.

The closing rate of EFVs SHALL [PS] not be greater than the rate of flow, which would result from failure of the piping or hose immediately downstream of the EFV or 150% of the nominal operating flow rate.

The ISV SHALL [PS] be provided with at least two remote actuation points, one located at the front of the vessel and the other at the rear. On long vehicles consideration should be given to providing an additional actuation point at the front end of the vessel to enable closure of the ISV from both the offside and nearside. The actuator system SHALL [PS] include fusible links set to close the ISV in case of fire at or adjacent to the vehicle. Fusible links should have melting points not in excess of 120 °C (248 °F). Each closing device should be clearly identified to show its purpose and means of operation.

A drain/emergency offtake connection, SHALL [PS] not be greater than DN 50 (NPS 2). It shall be fitted into the bottom of the vessel or a suitable liquid connection, e.g. pump bypass (refer to Figure 2). Connections not exceeding DN 32 (NPS 1-1/4) diameter may be fitted with an internally mounted EFV and a fire-safe ball valve. Larger nozzles SHALL [PS] be fitted with an ISV capable of remote actuation that is fitted with a blank flanged or plug. Consideration shall be given to the effective use of this connection particularly if rust and other fine-grained deposits may build up in the vessel and collect in the outlet, possibly causing malfunction of the valves. To overcome this problem the drain/emergency offtake connection may be located in the pump bypass as shown in Figure 2. When draining to atmosphere, an extension pipe/hose at least 0.6 m (2 ft) long with a dead-man type valve at its free end should be connected to the fire-safe valve.

All piping, valves and vessel connections SHALL [PS] be protected from possible collision damage by one or both of the following methods:

- location design, e.g. between the wheels of the running gear of a semi-trailer outfit (where it is protected by the subframe);
- mechanical devices, e.g. under-run bumper, that has sufficient impact resistance to ensure protection of the pressurised equipment (see (4.2.3)).

Primary shut-off systems SHALL [PS] be protected against collision and impact damage by their location and if necessary by additional mechanical means. The objective is to ensure that in an accident the primary shut-off system remains operable and in any collision, which damages the piping system, at least the internal valve, i.e. the NRV, EFV or the internal part of the ISV, will continue to operate safely.

All valves and fittings shall be manufactured to a recognised standard and approved for handling LPG over the range of service pressures and temperatures. Equipment be installed in accordance with the Manufacturer's instructions.

Joining materials, thread sealants and gaskets shall be suitable for use with LPG and maintain satisfactory performance over the range of service conditions.

4.2.8 Manual shut-off valves

Manual valves which are fitted in the piping system for operational and maintenance purposes are referred to as secondary shut-off valves. It is not a general requirement for secondary shut-off valves to be fire-safe.

Shut-off valves should be located in the liquid offtake piping immediately upstream of hose reels and hose couplings. Manual shut-off valves in drain/emergency uplift and other connections SHALL [PS] be fitted with plugs or blank flanges.

All shut-off valves SHALL [PS] provide positive closure and shall be suitable for use in LPG operations over the design range of pressures and temperatures. If fire-safe ball valves are used, they shall meet ISO 10497, API 6FA or equivalent.

Vessel nozzles with fittings/equipment which have controlling orifices not exceeding 1.4 mm (0.055 in) diameter SHALL [PS] be fitted with a suitable positive shut-off device, e.g. the proprietary equipment supplied with rotogauges, fixed ullage gauges, etc., is considered suitable because of the size of the controlling orifice.

4.2.9 Couplings

Couplings should be standardised throughout the distribution system to eliminate the use of adapters. Delivery vehicles and customer facilities should have standard types of couplings for liquid and vapour connections using differing sizes for the two phases. Odorised and non-odorised systems shall have totally incompatible couplings, e.g. by the selective use of right-hand and left-hand couplings.

If screw couplings are used they should have ACME threads to ASME B1.5 Class 2G. If self-sealing couplings are used they shall be compatible with mating couplings on fixed storage installations, in order to preclude the need for adapters.

For safe disconnection, a depressuring/bleed valve should be fitted close to, or in the connecting flange/coupling.

4.2.10 Gauges

4.2.10.1 Pressure gauge

Each vessel SHALL [PS] have a suitable pressure gauge connected to the vapour space as follows:

- The orifice size at the connection shall not exceed 1.4 mm (0.055 in); otherwise an EFV shall be fitted.
- A shut-off valve shall be fitted.

4.2.10.2 Contents gauge

All bulk vehicles SHALL [PS] be fitted with a suitable contents gauge, which may be of the rotating dip tube type or the capacitance type. Sliptubes SHALL [PS] not be used.

One or more fixed maximum liquid level gauges SHALL [PS] be fitted and set in accordance with (4.2.2). Fixed ullage gauges bleeding LPG to atmosphere may be employed provided that the maximum orifice size at the connection to the vessel does not exceed 1.4 mm (0.055 in) diameter and the operational bleed screw remains captive. Gauges in which it is possible to replace the sealing gland without withdrawing the vessel from service are recommended.

4.2.10.3 Thermometer

Thermometers shall be located so that they record the liquid temperature and SHALL [PS] be fitted in a sealed pocket in the form of a blind tube constructed to the vessel design code.

4.2.11 Pressure relief valves (PRVs)

Unless prohibited by local legislation all vessels SHALL [PS] be fitted with PRVs.

Vessels shall be fitted with one or more PRVs connected directly to the vapour space. The set pressure SHALL [PS] be not greater than the design pressure of the vessel. The total relief capacity SHALL [PS] be sufficient to protect the vessel against overpressure in the event of liquid filling and fire engulfment, but should not be less than that specified in NFPA 58, Appendix E, E-2.2.

Valves SHALL [PS] be of the internal spring-loaded type, with the operating mechanism being within the vessel and specifically designed for transport vessels. Weather caps should be provided to prevent water and solid particles from collecting in the outlet of the PRV.

The discharge from the PRV SHALL [PS] not impinge on the vessel.

The design of the PRV connections SHALL [PS] ensure that the valve is protected in the event of collision or rollover of the vehicle. Counter-sunk housings may be constructed in the vessel shell to provide such protection.

4.2.12 Pumps

Pumps on typical rigid chassis delivery vehicles are usually driven direct from the engine power take off (PTO) which should be of the constant speed type. Alternatively, the PTO may be used to drive a hydraulic pump, which powers a close-coupled hydraulic motor on the product pump. The latter system gives designers greater latitude in positioning the pump on the chassis.

Materials used in pump construction SHALL [PS] be suitable for use with LPG at the service conditions required. Cast iron SHALL [PS] not be used unless the grade is known to have adequate ductility and resistance to brittle fracture over the full range of temperatures and pressures likely to be encountered in service.

A system of controlling the pump rotational speed and a means to prevent overspeeding should be provided.

In addition to any integral pump bypass the piping system downstream of the pump SHALL [PS] include a separate, suitably sized bypass with spring loaded differential pressure valve, to return product to the vessel when the delivery valve is closed. The bypass valve should be adjusted so that it opens before the integral pump bypass operates and that the difference in the pressure settings of the two valves is sufficient to hold the integral pump bypass closed under full flow conditions.

A strainer should be fitted immediately upstream of the pump inlet and should be effective for both normal discharge and uplifts using the vehicle's pump.

The piping arrangement should allow the vehicle to uplift product using its own pump.