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SANS 10087-3:2015

Edition 5

SOUTH AFRICAN NATIONAL STANDARD

The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations

Part 3: Liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500 L

WARNING
This document references other documents normatively.

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Table of changes

Change No.	Date	Scope

Foreword

This South African standard was approved by National Committee SABS/TC 1019, *Gas supply, handling and control (fuel, industrial and medical gases),* in accordance with procedures of the SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement.

This document was approved for publication in March 2015.

This document supersedes SANS 10087-3:2008 (edition 4).

This document is referenced in the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993), and the National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977).

This document was written in order to support a specific South African Regulation and, of necessity, includes references to South African legislation. It therefore might not be suitable for direct application in other jurisdictions where conflicting legislation exists.

SANS 10087 consists of the following parts, under the general title *The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations*:

Part 1: Liquefied petroleum gas installations involving gas storage containers of individual water capacity not exceeding 500 L and a combined water capacity not exceeding 3 000 L per installation.

Part 2: Installation of LPG systems in mobile units, including but not limited to caravans, motor homes, park homes and mobile kitchens.

Part 3: Liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500 L.

Part 4: The transportation of LP gas including the design, construction, inspection, fittings, filling, maintenance and repair of LP gas bulk vehicles and rail tank cars.

Part 6: The application of liquefied petroleum and compressed natural gases as engine fuels for internal combustion engines.

Part 7: Storage and filling premises for refillable liquefied petroleum gas (LPG) containers of gas capacity not exceeding 19 kg and the storage of individual gas containers not exceeding 48 kg.

Part 8: Filling containers for LP gas operated fork lift vehicles in-situ.

Part 10: Mobile filling stations for refillable liquefied petroleum gas (LPG) containers of capacity not exceeding 9 kg.

Annexes A, B and C form an integral part of this document.

Introduction

This document represents a minimum standard. Compliance with it does not confer immunity from relevant legal requirements. Where mandatory requirements are applicable, the authority that has jurisdiction, i.e. the approving authority (see 3.3), should be approached.

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Contents

Contents *(concluded)*

The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations

Part 3:
Liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500 L

1 Scope

1.1 This part of SANS 10087 specifies requirements for the layout, design and installation of butane, propane and liquefied petroleum gas equipment, and of storage vessels of individual water capacity exceeding 500 L and associated vaporizers, pipework and fittings up to the outlet of the first pressure reduction stage in the line.

It also specifies requirements for the fitting of automatic and other devices (operative in the event of physical damage to the installation) for the purpose of ensuring maximum security, for the storage of gas from a design point of view, and for limiting the escape of liquid through normal pressure relief fittings.

1.2 This part of SANS 10087 covers provisions for underground and above-ground liquefied petroleum gas (LPG) storage tanks and associated equipment, such as pumps, dispensers and pipework at service stations, container filling sites and consumer installations.

It also covers dedicated LPG dispensing stations.

1.3 This part of SANS 10087 does not cover refrigerated LPG storage.

NOTE For information in this regard refer to international standard and requirements such as NFPA 58.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

API Spec 5L, *Specification for line pipe*.

ASME BPVC Section VIII Division 1, *Boiler and pressure vessel code – Section VIII, Division 1: Rules for construction of pressure vessels.*

BS 1600, *Specification for dimensions of steel pipe for the petroleum industry.*

EN 1759-1, *Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, class designated – Part 1: Steel flanges, NPS ½ to 24.*

EN 1762, *Rubber hoses and hose assemblies for liquefied petroleum gas, LPG (liquid or gaseous phase), and natural gas up to 25 bar (2,5 MPa) – Specification.*

ISO 3183, *Petroleum and natural gas industries – Steel pipe for pipeline transportation systems.*

NFPA 58, *Liquefied petroleum gas code*.

PD 5500, *Specification for unfired fusion welded pressure vessels.*

SANS 347, *Categorization and conformity assessment criteria for all pressure equipment.*

SANS 460, *Plain-ended solid drawn copper tubes for potable water.*

SANS 1020, *Power-operated dispensing devices for flammable liquid fuels*.

SANS 1056-1, *Ballvalves – Part 1: Fire-safe valves.*

SANS 868-3-1, *Compression-ignition engine systems and machines powered by such engine systems, for use in mines and plants with explosive gas atmospheres or explosive dust atmospheres or both – Part 3-1: Hazardous locations on surface – Basic explosion-protected engines.*

SANS 868-3-2, *Compression-ignition engine systems and machines powered by such engine systems, for use in mines and plants with explosive gas atmospheres or explosive dust atmospheres or both – Part 3-2: Hazardous locations on surface – Explosion-protected engine systems.*

SANS 868-3-3, *Compression-ignition engine systems and machines powered by such engine systems, for use in mines and plants with explosive gas atmospheres or explosive dust atmospheres or both – Part 3-3: Hazardous locations on surface machines.*

SANS 1186-1, *Symbolic safety signs – Part 1: Standard signs and general requirements.*

SANS 1475-1, *The production of reconditioned fire-fighting equipment – Part 1: Portable and wheeled (mobile) rechargeable fire extinguishers.*

SANS 10086-1, *The installation, inspection and maintenance of equipment used in explosive atmospheres – Part 1: Installations including surface installations on mines*.

SANS 10087-1, *The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations – Part 1: Liquefied petroleum gas installations involving gas storage containers of individual water capacity not exceeding 500 L and a combined water capacity not exceeding 3 000 L per installation*.

SANS 10087-6, *The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations – Part 6: The application of liquefied petroleum and compressed natural gases as engine fuels for internal combustion engines*.

SANS 10087-7, *The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations – Part 7: Storage and filling premises for refillable liquefied petroleum gas (LPG) containers of gas capacity not exceeding 19 kg and the storage of individual gas containers not exceeding 48 kg*.

SANS 10087-8, *The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial and industrial installations – Part 8: Filling containers for LP gas operated fork lift vehicles in-situ.*

SANS 10089-1, *The petroleum industry – Part 1: Storage and distribution of petroleum products in above-ground bulk installations.*

SANS 10089-2, *The petroleum industry – Part 2: Electrical and other installations in the distribution and marketing sector*.

SANS 10089-3, *The petroleum industry – Part 3: The installation, modification, and decommissioning of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations.*

SANS 10108, *The classification of hazardous locations and the selection of apparatus for use in such locations.*

SANS 10131*, Above-ground storage tanks for petroleum products.*

SANS 10142-1, *The wiring of premises – Part 1: Low-voltage installations*.

SANS 10232-3, *Transport of dangerous goods – Emergency information systems – Part 3: Emergency response guides.*

SANS 10400 (all parts), *The application of the National Building Regulations.*

SANS 15589-1/ISO 15589-1, *Petroleum and natural gas industries – Cathodic protection of pipeline transportation systems – Part 1: On-land pipelines.*

SANS 61779-6/IEC 61779-6, *Electrical apparatus for the detection and measurement of flammable gases – Part 6: Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of flammable gases.*

3 Definitions

For the purposes of this document, the following definitions apply.

3.1
acceptable
acceptable to the approving authority

3.2
approved
approved by the approving authority

3.3
approving authority
appropriate of the following:

a) within the scope of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993): the Chief Inspector;

b) within the scope of SANS 10400 (all parts): the local authority concerned, generally the fire department;

c) in terms of the Trade Metrology Act, 1973 (Act No. 77 of 1973): the Director of Trade Metrology;

d) within the scope of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996), and in respect of the control of general safety: the Chief Inspector

3.4
buried storage vessel
storage vessel that is installed below ground level with access to the tank fittings from the top only

3.5
capacity
total water capacity of the storage vessel

3.6
competent person
any person that has the knowledge, training and experience specific to the work or task being performed

3.7
critical location
area that is not ventilated for the dispersal of LPG

3.8
design pressure
pressure that is used for calculating the minimum shell thickness of the storage vessel and pressure equipment

3.9
dispenser
device or system that is designed to measure and transfer LPG into permanently mounted fuel containers on vehicles

NOTE This serves the same purpose as the petrol dispenser in service stations.

3.10
diversion wall
solid non-combustible wall that is erected with the specific purpose of ensuring and maintaining the appropriate safety distances between the point of gas release and any drains, doors and windows in buildings, and possible sources of ignition, for example electrical apparatus

3.11
emergency route
that part of an escape route which provides fire protection to the occupants of any building and which leads to an escape door

3.12
escape route
entire path of travel for all persons, including persons with disabilities, from the furthest point in any room in a building to the nearest escape door and may include an emergency route

3.13
filling ratio
ratio of the mass of LPG introduced into a storage vessel to the mass of water (determined at, or corrected to, 20 °C) that would fill the storage vessel

NOTE The term 'filling ratio' applies when the filling of a liquefied gas into a storage vessel is controlled by the mass of the gas introduced.

3.14
firewall
solid non-combustible wall with a fire rating of 240 min and height of at least 1,8 m, constructed and placed with the specific purpose of preventing the spread of fire as a result of the radiation of heat or direct flame impingement in accordance with the relevant parts of SANS 10400, or a double brick wall of minimum 190 mm width, or a reinforced concrete wall of 150 mm width, or any other barrier with a fire rating of at least 240 min

3.15
hazard (in relation to 14.2.3)
threat of rupture or other failure of a storage vessel to surroundings within a radius of (nominally) 0,5 km of the storage vessel (see emergency response guide as given in SANS 10232-3)

NOTE Hazards will normally vary proportionately with the concentration of property or people within this radius, as well as with the capacity of the storage vessel expressed as a factor of risk in relation to the probability of the hazard.

3.16
liquefied petroleum gas
LPG
commercial butane, commercial propane, or a mixture of light hydrocarbons (predominantly propane, propene, butane and butene) that is gaseous under conditions of ambient temperatures and pressure, and that is liquefied by an increase of pressure or a lowering of temperature

3.17
LPG dispensing station
service station (forecourt)
fixed equipment where LPG is stored and dispensed into non-cargo containers that are mounted on vehicles

NOTE The public may be permitted access to the dispensing station.

3.18
point of transfer
location where connections and disconnections are made and where LPG is vented to the atmosphere in the course of transfer operations

3.19
registered installer
person that has the ability, appropriate training, knowledge and experience to carry out the necessary work in a safe and proper manner, and who is registered in accordance with the requirements of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993)

3.20
risk
likelihood of a storage vessel being exposed to damage, gas escape, radiant heat and similar dangers

NOTE Risk is independent of the capacity of a storage vessel and represents an evaluation of the effect that external circumstances could have upon the storage vessel.

3.21
safe working pressure
maximum gauge pressure, at the coincident metal temperature, that is permitted for a storage vessel when in operation

3.22
storage vessel
bulk tank
horizontal or vertical storage vessel of capacity exceeding 500 L and that is of the above-ground, buried or mounded type

3.23
vapour barrier
wall or other barrier or diversion wall of height at least 500 mm, constructed and placed with the object of preventing the passage of vapour from any one place to another

4 Properties of LPG and precautions to be observed for storage vessels

The location of LPG vessels shall be planned and put into effect with full regard for the properties of the gas and the construction of installations for conveying this gas in domestic dwellings and commercial buildings. All persons concerned with the installation of vessels and appliances shall be registered installers in this respect and shall be familiar with the following characteristics of the gas and the precautions to be observed:

a) The gas is stored as liquid under pressure.

b) Leakage, especially of liquid, will release large volumes of highly flammable gas.

c) A gas-air mixture that contains approximately 2 % to 10 % of LPG is flammable. If a large enough volume of gas is so dispersed in the atmosphere as to reach flammable proportions, ignition of the mixture will result in the combustion of a near-explosive force.

d) LPG is denser than air and will flow along the ground or through drains. It can be ignited at a considerable distance from the source of leakage, therefore low-level ventilation shall be provided.

e) LPG is non-toxic, but since it can induce headaches and dizziness when inhaled, inhalation of LPG should be avoided whenever possible.

f) LPG liquid, by its rapid vaporization and consequent lowering of the temperature, can cause severe cold burns when it comes into contact with the skin. Appropriate protective clothing, such as gloves, goggles, aprons and gumboots, shall be worn when there is any possibility of such contact. Because of the hazard of the generation of static electricity, the soles of gumboots shall be made of leather or conductive rubber, and clothing shall not be made of fabrics that contain artificial fibres.

g) A storage vessel that has held LPG and is presumed to be “empty” can still be hazardous. In this state, the internal pressure is approximately atmospheric and, if the valve leaks or is left open, air can diffuse into the storage vessel and form a flammable or explosive mixture. Furthermore, even an “empty” storage vessel that does not yield gas when the valve is opened, might in fact not be quite empty. In cold weather, the heavier fractions of the liquid might not vaporize and will therefore remain in the storage vessel. All vessels that are (or appear to be) empty shall be handled with the same care as a full storage vessel.

h) Valves shall be kept fully closed at all times when storage vessels are not in use.

i) Because of the hazards involved with the filling of storage vessels, no one shall fill a storage vessel with gas unless such a person

   1) is fully conversant with the relevant requirements of this part of SANS 10087,

   2) is satisfied that the storage vessel complies with the requirements of an approved manufacturing standard (if necessary, this may be ascertained from the relevant storage vessel documents),

   3) employs staff trained and experienced in the pre-filling inspection and actual filling of storage vessels with those gases that are handled,

   4) ensures that the storage vessel is not due for periodic inspection or testing, and

   5) is aware of the emergency procedures in the event of spillage and fires.

j) Permission to fill the storage vessel has been granted by the owner of the storage vessel.

5 Construction and design

5.1 General

Storage vessels shall be designed and constructed in accordance with PD 5500 and ASME BPVC Section VIII Division 1, or an equivalent approved standard. The approved standards shall be as given in SANS 347. Typical above-ground LPG storage vessels are shown in figure 1(a) and (b).

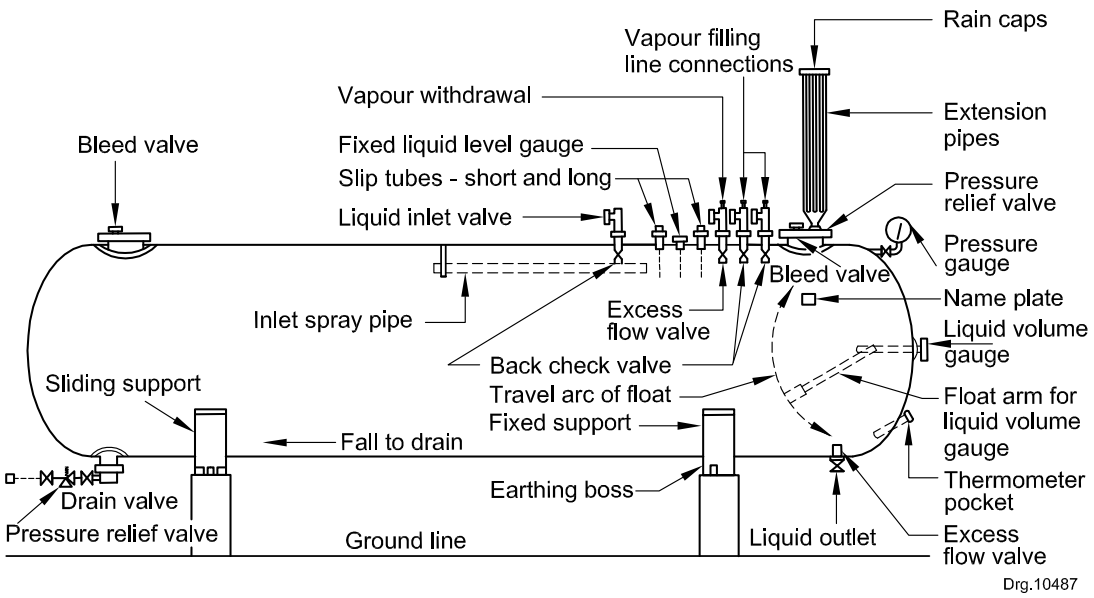
5.2 Design temperature for storage vessels (above ground, buried or mounded)

5.2.1 Maximum design temperature

The lowest maximum design temperature for a storage vessel shall be the maximum product filling temperature or 38 °C, whichever is the greater.

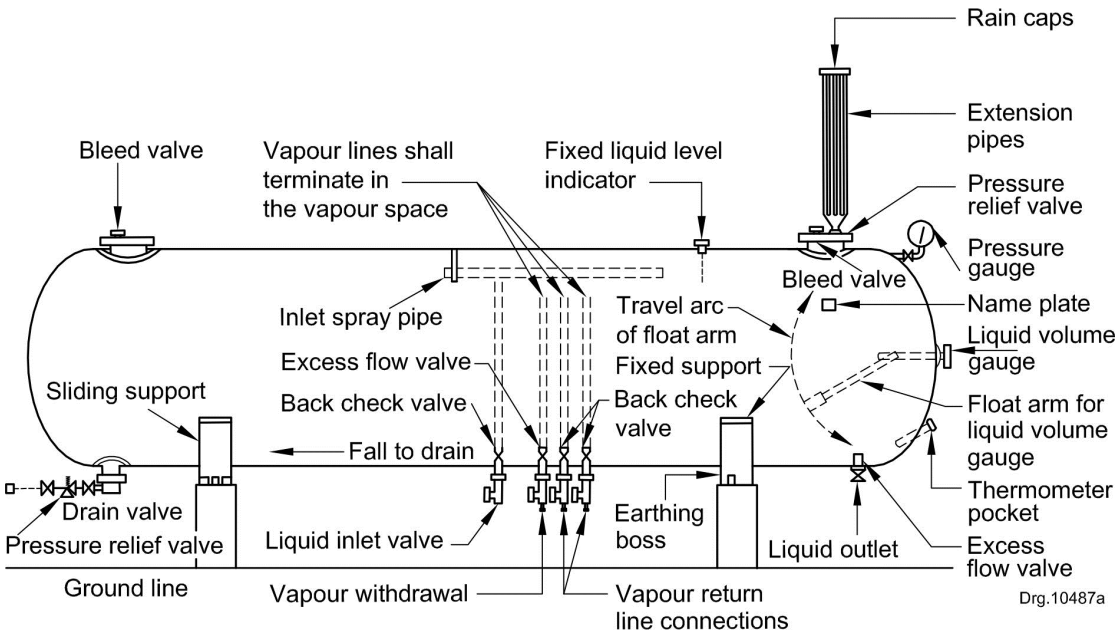
5.2.2 Minimum design temperature

The minimum design temperature for a storage vessel shall be at least −20 °C. For a buried or mounded storage vessel, the minimum design temperature shall be the minimum expected temperature of the surrounding ground or −20 °C, whichever is the lower.



a) Typical above-ground tank and fittings

Figure 1 — Bulk tank and fittings



b) Typical new generation above-ground tank and fittings

Figure 1 — Bulk tank and fittings *(concluded)*

5.3 Branches and manholes

5.3.1 Couplings, branches and manholes shall comply with the requirements of this part of SANS 10087.

5.3.2 Branches shall be flanged but the couplings of any screwed connections shall comply with an approved standard in respect of design and pressure rating.

5.4 Fittings

5.4.1 General

5.4.1.1 All fittings for LPG service shall be acceptable for use at the safe working pressure of the storage vessel concerned.

5.4.1.2 All equipment, such as storage equipment, vaporizers, pumps and pipelines, shall be electrically bonded and earthed (see 14.6).

As soon as any LPG installation (or any extension to it) has been completed, all parts of the system shall be tested for electrical continuity and resistance to earth, which shall not exceed 10 Ω, and a certificate of compliance shall be issued by a competent person as defined in the Electrical Installation Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

5.4.2 Connections for filling, withdrawal and equalizing

5.4.2.1 Manually operated primary shut-off valves (see clause 9) shall be fitted on all liquid and vapour connections with the following exceptions:

a) openings to which safety relief valves are fitted;

b) openings protected by a controlling orifice of diameter not exceeding 1,4 mm;

c) plugged openings;

d) openings fitted with approved gauging devices;

e) filling connections mounted directly on storage vessels of capacity not exceeding 9 000 L, provided that the opening is fitted with a non-return/excess-flow valve combination or one double non-return valve or two single non-return valves; and

f) openings fitted with quick-closing internal shut-off valves (see 5.4.2.5).

5.4.2.2 The shut-off valve shall be fitted as close to the storage vessel as is practicable except that where there is no mechanical joint between the shut-off valve and the storage vessel, and the inter-connecting piping is designed, constructed and tested in accordance with the design standard used for the storage vessel, the valve can be located at the downstream end of that length of piping.

5.4.2.3 All liquid and vapour connections, with the exception of those listed in 5.4.2.1(a) to (e) inclusive, and drain openings (see 5.4.2.7), shall be fitted with an emergency shut-off valve (for example an excess-flow valve, an automatically operated valve, a remote-controlled valve or a non-return valve). Emergency shut-off valves and non-return valves are not considered necessary if the bore of the connection to the storage vessel does not exceed 3 mm in the case of liquid and 8 mm in the case of vapour.

5.4.2.4 If the emergency shut-off valve (see 5.4.2.3) is of the excess-flow type, its closing flow rate should be below that likely to result from a complete fracture of the line it is protecting (calculated under the most adverse conditions likely to be experienced), but in no case shall it exceed 1,5 times the design flow rate for the line.

Excess-flow valves shall have a rated closing capacity sufficiently higher than the normal flow requirements so as to prevent valve chatter.

5.4.2.5 A quick-closing internal shut-off valve (see 5.4.2.1(f)) can be used to give more positive protection in a storage vessel opening than is afforded by an excess-flow valve alone. Quick-closing internal valves shall be so arranged as to give at least one point for thermal closure (by actuation of the heat-sensing device) and at least one point for manual closure from a safe remote position. Such valves shall be kept closed when the line they serve is not in actual use.

5.4.2.6 If the filling connection is remote from the storage vessel, the following shall apply:

a) a non-return valve shall be fitted in the liquid line at a distance not exceeding 500 mm from the filling connection;

b) an excess-flow valve (similarly located) shall be fitted in the vapour return line, if relevant;

c) in addition to (a) and (b) above, emergency shut-off valves, bleeder valves and terminal caps shall be placed within 500 mm of the vapour connections and liquid filling point; and

d) flow indicators can be included, if desired.

5.4.2.7 Each drain connection (see figure 1) shall, in accordance with 5.4.2.1, have a ball-type, fire-safe shut-off valve of nominal size preferably limited to a maximum of 50 mm and that complies with SANS 1056-1. This shut-off valve shall be connected direct to a length of piping that terminates in a second shut-off valve of nominal size not exceeding 18 mm.

The piping between the valves shall be of length at least 1 m and such that the risk of simultaneous obstruction of both valves is minimized. On the downstream side, the second valve shall be connected to piping that is long enough to ensure that discharge will not take place beneath the storage vessel. The end of the pipe shall be closed by means of a screw plug. The second valve and all the piping shall be so supported and secured as to prevent failure. The means of actuation of both drain valves shall be such that they cannot be removed (or moved from the closed position) except by intentional operation.

5.4.3 Pressure relief valves

5.4.3.1 Each storage vessel shall be equipped with at least two pressure relief valves. Each pressure relief valve shall have direct communication with the vapour space of the storage vessel. This can be accomplished by the use of a multi-port device. A number of pressure relief valves can be combined to constitute one multi-port device.

If any valve is inoperative, the number and size of the remaining pressure relief valves shall be sufficient to provide the full relief flow capacity required for the storage vessel in accordance with annex A (see also 5.4.3.2).

5.4.3.2 The maximum start-to-discharge pressure of the relief valve shall not be higher than 110 % of the design pressure of the storage vessel. Each pressure relief valve shall be of such design that it reseats (closes) at a pressure not less than 90 % of the start-to-discharge pressure.

5.4.3.3 On storage vessels of capacity exceeding 9 000 L, vent pipes shall be fitted to the relief valve outlets. These pipes shall project vertically upwards (terminating not less than 2 m above the storage vessel) and shall discharge, without obstruction, to the open air. Each vent pipe shall be equipped with a loose-fitting rain cap that is held in place by a length of light chain or flexible wire. If liquid drain holes are required in vent pipes, such holes shall be so positioned that jets of fluid cannot impinge on the shell or on any fitting to the storage vessel.

5.4.3.4 Pressure relief devices shall be such that it is not possible to tamper with the relief valve settings.

5.4.3.5 Shut-off valves shall not be installed between a storage vessel and any pressure relief device or valve.

5.4.3.6 Provision can be made to isolate any relief valve for testing or servicing, provided that the remaining relief valves provide the full relief capacity (see annex A).

5.4.3.7 Each pressure relief valve shall be clearly and permanently marked with the following:

a) the pressure at which the valve is designed to start to discharge;

b) the actual air discharge rate of the valve, in cubic metres of air per minute at normal temperatures and pressure, at 120 % of the set pressure; and

c) a serial number.

5.4.3.8 Each pressure relief valve on a storage vessel shall be re-certified within a period of three years, and shall be sealed and stamped with the date of testing and the identification mark of the testing station.

5.4.4 Contents gauges

5.4.4.1 Each storage vessel shall have a contents gauging device (mechanical or electrical) and a device for indicating the maximum liquid level.

5.4.4.2 Each liquid level indicator shall be appropriate for operation at the maximum allowable operating pressure of the storage vessel that it serves.

5.4.4.3 Each gauging device (such as a rotary tube, a fixed tube or a slip tube) that relies on bleeding to the atmosphere shall be so designed that

a) unless it is protected by an emergency shut-off valve, the maximum diameter of the bleed hole does not exceed 1,4 mm,

b) it cannot be completely withdrawn in normal gauging operations, and

c) the gland is capable of being repacked while the storage vessel is in service.

5.4.4.4 Each maximum liquid level indicating device shall be appropriate for use with the LPG being stored and shall indicate the maximum liquid level of the storage vessel, based on the filling ratio.

5.4.5 Temperature-measuring instruments

Storage vessels can be fitted with a temperature-measuring instrument of acceptable design and operation. Electronic temperature-measuring devices may also be used.

Bulbs or sensing heads of temperature-measuring instruments shall not be mounted in direct contact with the contents of a storage vessel.

5.4.6 Pressure gauges

Storage vessels shall be equipped with an acceptable pressure gauge that has a face diameter that is not less than 50 mm and that is connected to the vapour phase of the storage vessel. Electronic gauging may also be used.

Pressure gauge mounting connections shall be protected internally by means of an excess-flow valve, or by pressure tapping reduced internally to a bleed hole of diameter not exceeding 1,4 mm.

5.5 Mountings and supports

Mountings and supports shall be so designed that they comply with the requirements of the standard in accordance with which the storage vessel was constructed.

5.6 Finish and marking

5.6.1 Finish

The outside of storage vessels shall have an approved corrosion-protection finish which shall be appropriate to the manner of installation (see also 7.3.5).

NOTE LPG is not corrosive to steel and consequently the inside of the storage vessel need not have a corrosion-resistant coating.

5.6.2 Permanent marking of storage vessels

A plate, securely attached in a conspicuous place on the shell of the storage vessel, shall be permanently marked (by the manufacturer) with at least the following information:

a) the manufacturer's name;

b) the country of origin;

c) the year of manufacture;

d) the vessel’s serial number;

e) reference number, date and addition of the Health and Safety Standard;

f) the design pressure, in pascals;

g) the minimum and maximum design temperature, in degrees Celsius;

h) the water capacity, in cubic metres;

i) a mark of an approved inspection authority or symbol of the manufacturer, as applicable, in accordance with the Pressure Equipment Regulations (PER) of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993);

j) the hazard category in accordance with the requirements of SANS 347; and

k) the date of initial pressure testing.

5.7 Initial inspection, testing and certification

The initial inspection, testing and certification of storage vessels shall be under the supervision of an approved inspection authority who shall furnish each storage vessel with a certificate providing, in addition to the information required in terms of 5.6.2, the following information:

a) the date of the test;

b) the pressure at which the storage vessel was tested;

c) any other data considered necessary; and

d) the stamp of the approving authority.

NOTE See also SANS 10227.

6 Location of storage vessels

6.1 Above-ground storage vessels

6.1.1 Storage vessels shall not be placed beneath any building or in the basement of a building (see also annex B).

6.1.2 The surface area beneath and around a storage vessel (equal to the footprint of the vessel) shall be made of a non-porous material (concrete or other material). The area from the footprint edge shall slope away from the storage vessel to the edge of the appropriate safety distance limit (see table 1) or a minimum of 5 m. A 3 m area outside of the footprint, around the vessel, shall be clear of any combustible material (see 14.1). A typical commercial LPG installation is shown in figure 2.

6.2 Buried and mounded storage vessels

The load imposed by any storage vessel shall not affect other underground structures (for example, foundations, pipelines or sewers). A storage vessel shall not be subjected to loads from vehicular traffic or other surface loading, unless it has been designed and installed to withstand such conditions.

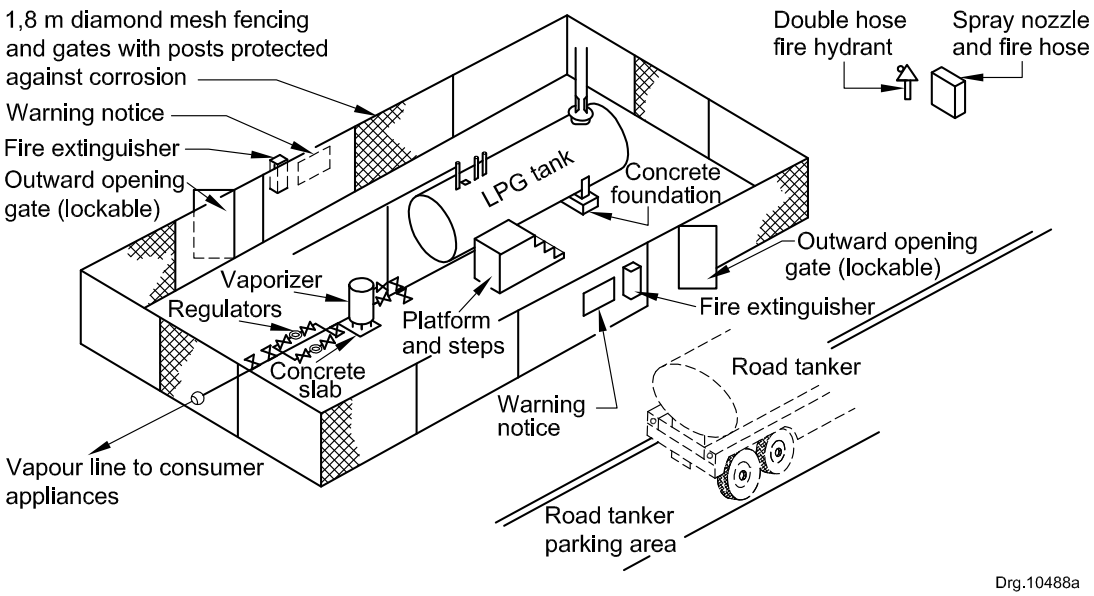


Figure 2 — Typical above-ground LPG bulk storage vessel and vaporizer

6.3 Safety distances

6.3.1 General

6.3.1.1 One of the major requirements for an effective and hazard-free fuel installation is that the various components comprising the total installation shall be installed at specific and predetermined minimum distances in relation to each other. These distances are generally known as safety distances.

6.3.1.2 The appropriate safety distances applicable to

a) LPG installations, are given in figures 3, 4 and 5,

b) combined fuel and gas facilities, including rail tank cars, are given in figure 7, and

c) service station (forecourts) installations, shall be as given in B.2.3.

6.3.2 Installations involving above-ground storage vessels

6.3.2.1 The safety distances applicable to the installation of above-ground storage vessels, shall be in accordance with the appropriate values given in table 1.

6.3.2.2 Vapour barriers or diversion walls or firewalls, as appropriate, can be used to reduce the distances given in table 1. However, the presence of vapour barriers or diversion walls and firewalls can create significant hazards, for example, pocketing of escaping gas, interference with application of cooling water by the Fire Department, redirection of flames against storage vessels, and impeding ingress of personnel in an emergency.

Table 1 — Safety distances

1	2	3	4	5	6	7
Water capacity of storage vessel L	**Minimum safety distances** m					
	From above-ground storage vessel to points of transfer[a]	**From above-ground storage vessel to buildings and property boundaries**	**From points of gas release on buried and mounded storage vessel to buildings and property boundaries**	**From sealed surface equipment to building and property boundaries**	**From open flame equipment to building and property boundaries**	**Between above-ground LPG storage vessels**
500 to 2 250	5,0	5,0	3,0			¼ of sum of diameters of adjacent storage vessels
2 251 to 9 000	7,5	7,5	5,0			
9 001 to 67 500	9,5	9,5	7,0			
67 to 135 000	15,0	15,0	15,0	3,0	5,0	
501 to 265 000	15,0	22,5	15,0			
135 001 > 265 000	15,0	30,0	15,0			

[a] For points of transfer or filling points see clause 18 and figure 6.

6.3.2.3 Special care shall be taken to ensure that where two walls are joined to form an enclosing corner, the angle shall be not less than 90°.

6.3.2.4 Safety distances shall be measured horizontally from storage vessels where vapour barriers are used. The distance shall be measured in a horizontal line around such barriers. Safety distances shall be measured horizontally and radially from storage vessels where firewalls are used. The firewall shall be at least the height of the storage vessel (see also 14.4). Storage vessels shall not be installed one above the other.

6.3.2.5 Where a firewall is used to reduce the safety distances (see columns 2 and 3 of table 1) with respect to protection of adjacent buildings or, for example, property boundaries from the effect of radiant heat in the event of fire, the standard safety distances may be reduced to 50 % of the values given in table 1, provided the guidelines in figures 3 and 4 are followed.

6.3.2.6 The number of storage vessels in any one group shall not exceed six placed parallel to each other (see figure 3). Unless a firewall is erected between the groups, each storage vessel in one group shall be at least 7,5 m from the nearest storage vessel in another group. When firewalls are used to separate groups of storage vessels, the direct distance from each storage vessel in one group to the nearest storage vessel in another group shall be at least 4 m (see also figure 4 and figure 5).

The maximum number of groups is subject to site approval by the local authority.

6.3.2.7 The minimum horizontal separation distance between above-ground LPG storage vessels and above-ground storage vessels that contain liquids or gases that have flash points below 93,4 °C, shall be 6 m.

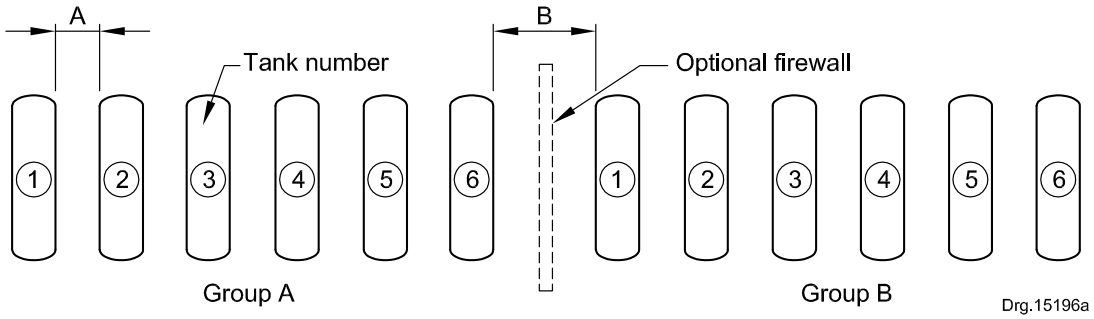
6.3.2.8 The minimum horizontal separation distance between an underground storage vessel and a second storage vessel, above or below ground, shall be at least 0,5 m.

6.3.2.9 The minimum horizontal separation distance between LPG storage vessels and above-ground storage vessels that contain liquid oxygen or hydrogen shall be as given in table 2. Where a firewall with a minimum fire resistance rating of at least 4 h interrupts the line of sight between un-insulated portions of the oxygen or hydrogen containers and the LPG containers, the minimum distance may be reduced by half.

6.3.3 Installations involving buried and mounded storage vessels

6.3.3.1 The safety distances applicable to the installation of buried or mounded storage vessels shall be in accordance with the appropriate values given in table 1. Other parts of the storage vessel shall be no closer than 1 m to a building, boundary or other equipment (see figure 6).

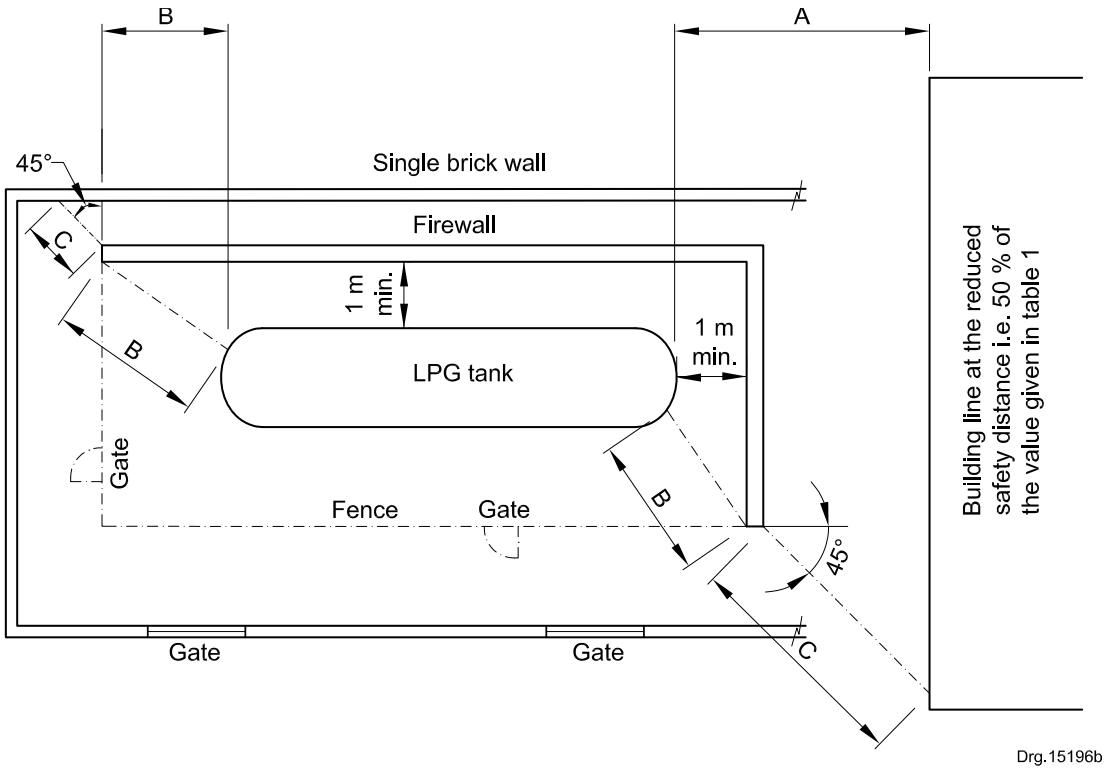
6.3.3.2 Buried or mounded storage vessels shall be located outside of any building. Buildings shall not be constructed over any buried or mounded storage vessels. Sides of adjacent storage vessels shall be separated by not less than 1 m.



NOTE 1 See column 7 of table 1 for information on dimension A.

NOTE 2 See 6.3.2.6 for information on dimension B (with or without a firewall).

Figure 3 — Groups of tanks



Key

A Distance between the tank and the building or boundary when the safety distance is half that indicated in column 3 of table 1

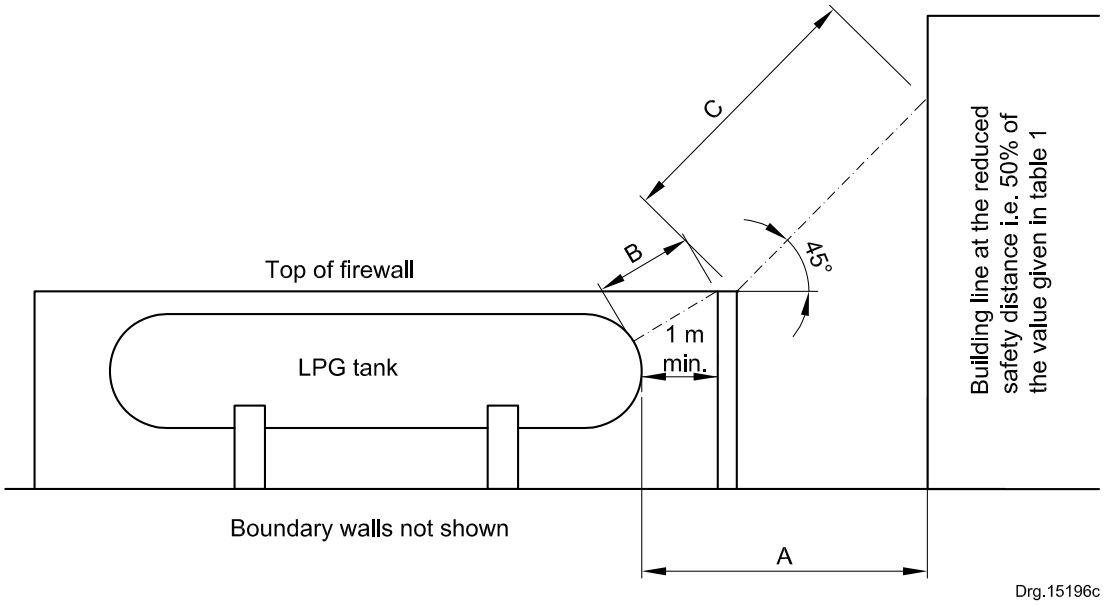
B Shortest distance from the tank to the top of the firewall

C Length of a line taken at 45° from the top of the firewall to the building or boundary

To comply with the requirements of 6.3.2.5, the firewall shall be extended such that the sum of dimensions B and C is not less than the safety distance indicated in column 3 of table 1.

The top of the firewall shall not be lower than the top of the tank.

Figure 4 — Reduced safety distances with firewall — Plan view



Key

A Distance between the tank and the building or boundary when the safety distance is half that indicated in column 3 of table 1

B Shortest distance from the tank to the top of the firewall

C Length of a line taken at 45° from the top of the firewall to the building or boundary

To comply with the requirements of 6.3.2.5, the firewall shall be extended such that the sum of dimensions B and C is not less than the safety distance indicated in column 3 of table 1.

The top of the firewall shall not be lower than the top of the tank.

Figure 5 — Reduced safety distances with firewall — Side view

Dimensions in millimetres

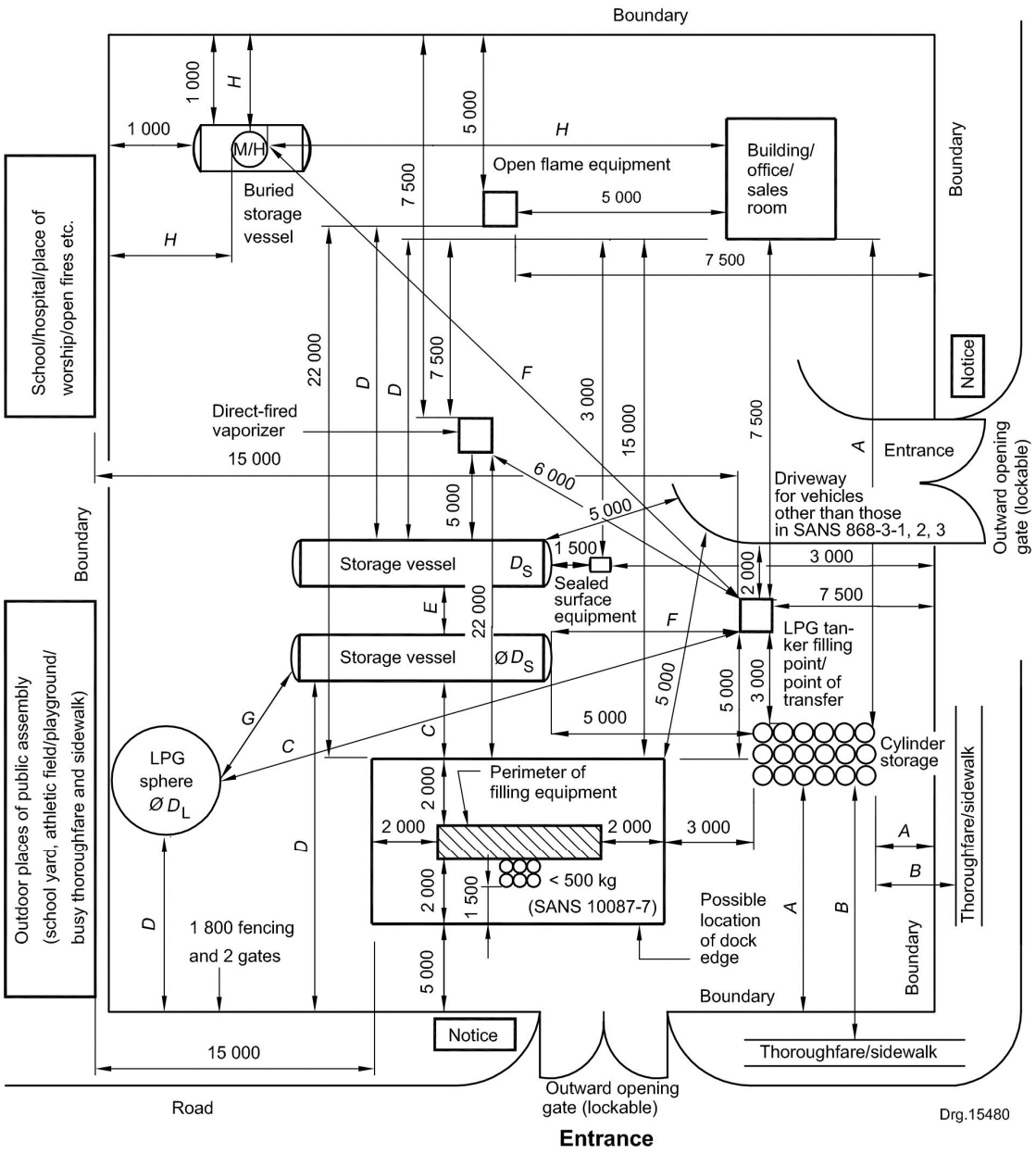


Figure 6 — Safety distances for LPG installations

Dimensions in millimetres

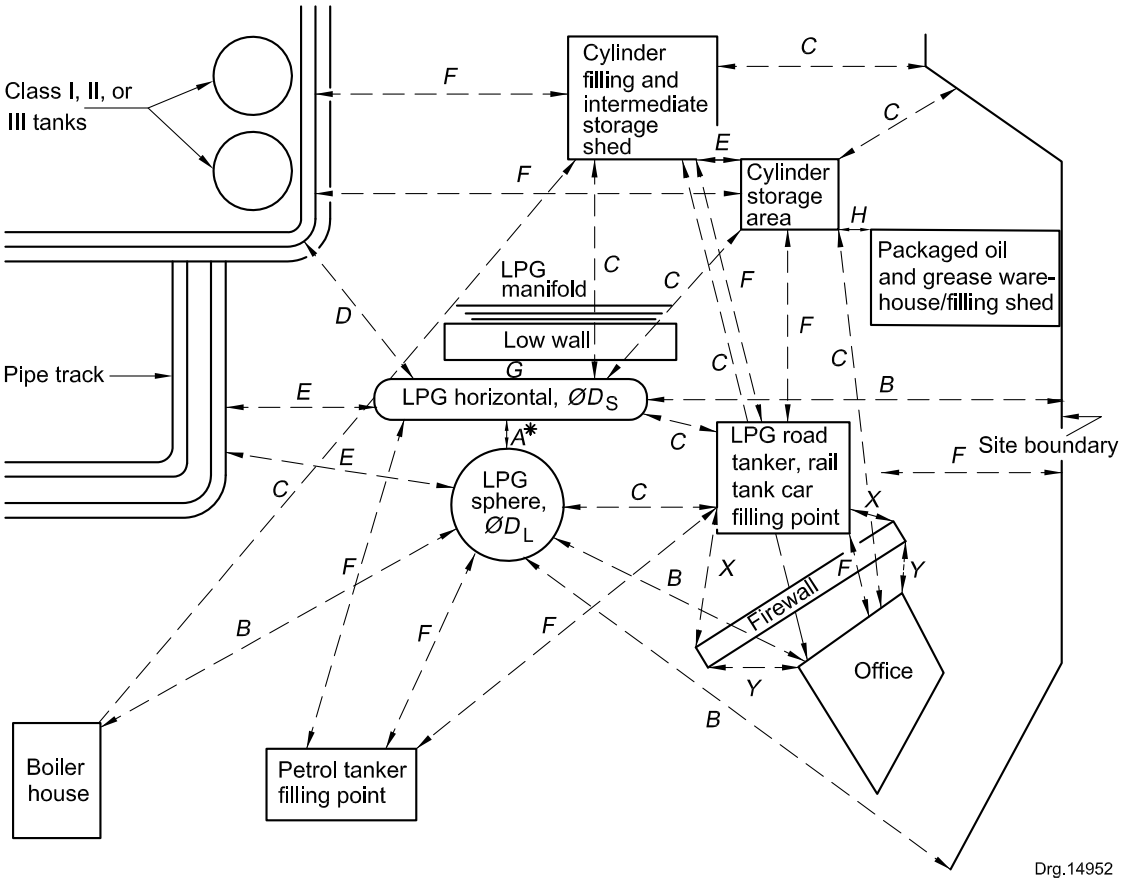
LPG cylinder storage			Above-ground vessels						Buried vessels
Total quantity of stored LPG	Safety distances		Size of vessel	Safety distances					Safety Distance
	A	*B*		*C*	*D*	*E*	*F*	*G*	*H*
kg			Litre water capacity						
501 to 1 000	3 000	5 000	500 to 2 250	5 000	5 000	[a]	0	[a]	
1 001 to 3 000	5 000	5 000	2 251 to 9 000	7 500	7 500		0		5 000
3 001 to 5 000	7 500	7 500	9 001 to 67 500	9 500	9 500		3 000	$\frac{D_L + D_S}{4}$	7 000
5 001 to 20 000	10 000	10 000	67 501 to 135 000	15 000	15 000		6 000		15 000
> 20 001	15 000	15 000	135 001 to 265 000	15 000	22 500		9 000		15 000
			> 265 000	15 000	30 000		9 000	D_L	15 000

[a] ¼ of sum of diameters of adjacent horizontal vessels; ½ of sum of diameters for vertical vessels

Figure 6 — Safety distances for LPG installations *(concluded)*

Table 2 — Separation distances — Liquefied flammable gases, flammable liquids, and oxygen storage

1	2	3	4
Size of storage			**Separation distance**
Liquid oxygen vessel	**LPG vessel**		
	Weight capacity	**Equivalent liquid capacity at 15 °C**	
t	t	m^3	m
Up to 200	0,25 to 1,1	0,5 to 2,2	6
	1,2 to 4,0	2,3 to 7,8	7,5
	4,1 to 60,0	7,9 to 117,0	15
	61,0 to 150,0	118,0 to 300	22,5
	≥ 151,0	≥ 301	30,0
	LPG cylinders and other liquefied flammable gas[a] cylinders above 50 kg total capacity		7,5
The separation distances listed in this table for LPG should be applied to the same stored volumes of other bulk liquefied flammable gases, and bulk flammable liquids, such as acetone, methanol, diesel, and petrol. These distances may be reduced depending on the nature of the flammable liquid and any protective measures, and in such cases an individual assessment of the proposed location shall be carried out.			
[a] Common examples of other liquefied flammable gases supplied in cylinders include ammonia, hydrogen sulphide and ethylene oxide.			



Dimensions in metres

Vessel size or description	Safety distances								
	A[a]	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*X* + *Y*[b]
a) Vessel capacity, L									
500 to 135 000	–	15	15	15	–	15	5	–	≥ *F*
135 001 to 265 000	$\frac{D_L + D_S}{4}$	22,5	15	15	–	15	5	–	≤ *F*
> 265 000	D_L	30	15	15	10	15	5	–	≤ *F*
b) Cylinder filling and storage shed	–	–	15	–	10	15	–	–	≤ *F*
c) Cylinder storage area	–	–	15	–	10	15	–	3	≤ *F*
d) Intermediate LPG vessel filling point	–	–	–	–	–	15	–	–	≤ *F*

[a] May be reduced to 8 m if site boundary is a solid wall.

[b] *X* + *Y* shall not be less than 5 m in any case.

Figure 7 — Safety distances for above-ground combined fuel/LPG facilities

6.4 Enclosure of areas

6.4.1 Storage vessels shall not be installed within bunds. If the ground surface beneath and around storage vessels slopes towards a driveway or an unprotected work area, vapour barriers shall be provided to prevent spillage from reaching those areas.

6.4.2 To minimize trespassing and tampering, any area that contains storage vessels, vaporizers, pumping equipment or facilities for loading, unloading and storage vessel filling shall, unless otherwise protected, be enclosed by an industrial-type fence of height at least 1,8 m. At least two means of gaining access to the area in case of emergency shall be provided (see also figure 2). The site shall, at all times, be secured and unauthorized access shall be prohibited.

6.4.3 Where storage vessels are situated in such a position that they might be subject to vehicle-impact damage, then protection shall be provided (for example, crash barriers, kerbing surrounds or bollards).

When vehicles have access to the vicinity of storage vessels, no vehicles shall

a) For above-ground storage vessels: be allowed closer than 5 m to the storage vessel unless such a vehicle complies with the requirements of SANS 868-3-3. Where this distance cannot be achieved, it may be reduced by using either a vapour barrier, diversion wall or a firewall.

b) For buried storage vessels: be allowed closer than 1,5 m to the footprint of the vessel. This shall be achieved by the installation of crash barriers, kerbing surrounds or bollards. The storage vessel manhole cover and storage vessel fittings shall be protected against tampering.

6.5 Warning notices

At least two warning notices shall be securely attached to the outer side of the fence surrounding the storage area adjacent to the access point (see figure 2). The warnings shall incorporate the pictographs PV 1, PV 2, PV 3 and PV 27 of SANS 1186-1 and shall be of individual size at least 190 mm × 190 mm.

7 Installation (see also annex B)

7.1 General

All materials used in the construction of an LPG installation (including non-metallic parts for valve seals, diaphragms, etc.) shall be resistant to the action of LPG under the service conditions to which they are to be subjected. No piping carrying LPG shall be installed in emergency routes required in accordance with the relevant parts of SANS 10400. Piping installed in normal escape routes shall be approved by the local authority on the fire protection plan of the building. All installations and maintenance shall be carried out by a registered installer, who is registered for the applicable category of installation.

7.2 Risk assessment

7.2.1 If so required by the approving authority or the requirements of this part of SANS 10087, a risk assessment shall be carried out on each installation. The risk assessment shall be carried out in accordance with the appropriate requirements of the Major Hazard Installation Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

NOTE Where other gases in containers of water capacity in excess of 4,5 m^3 are stored in conjunction with LPG, a full risk assessment for safety distances should be carried out in accordance with sound fire protection principles.

7.2.2 In terms of the regulations promulgated under chapter 5 of the National Environmental Management Act, 1998 (Act No. 107 of 1998), the installation of bulk storage vessels shall not commence without environmental authorization from the provincial authority responsible for environmental management. The environmental authorization requires that an environmental impact assessment be undertaken which identifies all the potential environmental implications of construction and operation. The environmental authorization may contain certain specific conditions for the construction of the facility. These conditions may take precedence over the requirements of this part of SANS 10087.

7.3 Installation of storage vessels

7.3.1 Buried storage vessels

Buried storage vessels shall be installed generally in accordance with SANS 10089-3 or SANS 10131 (or both).

Buried and mounded storage vessels shall be protected from loads due to vehicular traffic or other causes, either by erecting a barrier around the area in which the storage vessels are buried or by protecting the storage vessels with reinforced concrete slabs. If the storage vessel area is not barricaded, the storage vessel manhole cover and the storage vessel fittings shall be protected against tampering. Permanent markers shall be provided to indicate the perimeter of the area under which the storage vessels are buried and a permanent warning sign shall be erected.

7.3.2 Mounded storage vessels

Mounded containers shall be installed as follows:

a) Mounding material shall be earth, sand, or other non-combustible, non-corrosive materials and shall provide a minimum thickness of cover for the container of at least 0,3 m.

b) A protective cover shall be provided on top of mounding materials subject to erosion.

c) Storage vessel valves and appurtenances shall be accessible for operation or repair, without disturbing mounding material, as follows:

   1) Where storage vessels are mounded and the bottom of the container is 0,76 m or more above the surrounding grade, access to bottom connections shall be provided by an opening or tunnel with a 1,2 m minimum diameter and a 0,9 m minimum clear area.

   2) Bottom connections that extend beyond the mound shall be part of the storage vessel and shall be designed and installed for the forces that can act on the connections.

d) Mounded storage vessels shall comply with the corrosion-protection requirements of 7.3.5.

7.3.3 Above-ground storage vessels (see figure 1)

For storage vessels of capacity exceeding 9 000 L, the foundations for the tanks shall be designed and approved by a registered professional civil engineer. Differential settlement between the two ends shall not exceed 0,4 % of the length of the storage vessel. The storage vessel shall be placed on a slope of 1,0 % with the drain point at the lower end to facilitate drainage of the vessel.

7.3.4 Storage vessel connections

7.3.4.1 Connections for buried storage vessels shall be on top. Protection against accidental damage for fittings that are at or above ground level shall be provided.

7.3.4.2 Where practical, the connections for mounded storage vessels shall be top mounted with the exception that the discharge, filling and drain lines may be bottom-connected (if the transfer equipment is such that this is possible).

7.3.4.3 Allowance shall be made for any possible future differential settlement between storage vessels and pipework.

7.3.5 Corrosion protection

7.3.5.1 General

Storage vessels and all pipework, including coating materials and their application shall be corrosion protected. If cathodic protection is applied, readings shall be taken and shall be recorded in a pressure storage vessel logbook. These readings shall be reviewed by a competent person and shall be done to the test requirements of Regulation 11 of the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Cathodic corrosion protection and inspection periods shall be in accordance with SANS 15589-1.

7.3.5.2 Buried and mounded storage vessels

Vessels shall be protected from corrosion. Where cathodic protection is not used, then a suitable commercially available coating shall be applied, for example fibre-glass wrapping, bitumen coating, or multi-coat paint systems.

8 Piping

8.1 Pipes for conveying liquid shall be of steel. Pipes for conveying vapour shall be of steel, solid drawn copper, or in the case of buried pipelines, high density polyethylene (HDPE). Buried steel pipelines shall have corrosion protection (see also 7.3.5).

NOTE For low pressure vapour applications, see also SANS 10087-1.

8.2 Steel piping shall be seamless and as follows:

a) Where screwed joints are used, these shall be limited to pipes of nominal bore not exceeding 32 mm. Such pipes shall comply with the requirements of BS 1600 for schedule 80 piping or the requirements of API Spec 5L (or equivalent). Pipe fittings shall be of wrought steel and of a grade at least equal to that of the mating pipes.

b) Pipes of nominal bore larger than 32 mm shall have welded or flanged joints and shall comply with the requirements of BS 1600 for schedule 40 piping or the requirements of API Spec 5L (or equivalent) or the appropriate requirements of ISO 3183.

c) The use of steel pipes in critical locations shall be in accordance with SANS 10087-1.

8.3 Copper piping shall comply with the requirements of SANS 460 for at least class 1 phosphorus de-oxidized copper (Cu-DHP) tubes.

8.4 All pipelines shall be designed to have the flexibility to accommodate any settlement of storage vessels and other equipment, thermal expansion and contraction, and any other stresses that might occur in a pipe system.

8.5 Where it is possible for LPG in the liquid phase to be trapped between two valves, a self-resetting hydrostatic relief valve shall be fitted to relieve the pressure that might build up through thermal expansion of the liquid gas. This shall apply in all circumstances even though the space between the valves might be occupied by a piece of equipment, such as a pump casing or a meter. The discharge from the relief valves shall not be allowed to vent to the atmosphere inside a building or to impinge on other parts, for example storage vessels.

9 Valves and other fittings

9.1 Valves and other fittings shall be of steel with steel trim or of forged brass with brass trim. Cast iron fittings and valves or malleable iron fittings shall not be used, but valves made of nodular iron may be used.

9.2 In the case of commercial butane (liquid or vapour) and propane vapour, flanges and flanged fittings shall comply with the relevant requirements of EN 1759-1 for class 150, and in the case of liquid commercial propane and liquid LPG mixtures (at storage vessel pressure), they shall comply with the relevant requirements of EN 1759-1 (or equivalent API and ISO standards) for class 300.

9.3 The regulating device for the first pressure reduction stage in the vapour discharge line (from the vaporizer) shall be set to reduce the supply pressure to a predetermined lock-up value appropriate to the plant.

WARNING Precautions shall be taken to ensure that the pressure does not increase to a point where the vapour could liquefy.

9.4 Provision shall be made to isolate the vessel, pump and dispenser from each other in the case of fire, or other emergency (i.e. a shut-off valve).

NOTE The actuating method for remote shut off is not specified, but electrical, mechanical, or pneumatic systems may be used.

10 Commissioning and decommissioning of bulk tank installations

10.1 Commissioning and certificate of conformity

All bulk tank installations shall be commissioned in accordance with the requirements of the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993). All installations shall be carried out by a registered installer in accordance with the requirements of the said Pressure Equipment Regulations and a certificate of conformity shall be issued by an authorized person.

10.2 Decommissioning of storage vessels

The following procedure shall be applied before a storage vessel is decommissioned:

a) Remove as much LPG liquid as possible through the storage vessel liquid withdrawal connection.

b) Remove as much of the remaining LPG vapour through the venting connection. Ensure that the vapour is burnt off at a safe location in an approved manner.

c) Purge the storage vessel in accordance with the appropriate requirements given in SANS 10089-1.

d) Ensure that flares are at least 5 m away from the storage vessel being purged (see figure 6).

11 Filling ratios and volumes of storage vessels

11.1 Filling ratios

The safe filling ratio of a storage vessel is a function of ambient temperature and relative density. Table 3 gives the appropriate values of the maximum permissible filling ratios for LPG at corresponding relative density.

Where the density of the product is unknown, use a filling ratio of 0,42 (corresponding to a relative density of 0,495 to 0,499 at 20 °C in the case of a storage vessel of capacity less than 4 500 L).

Table 3 — Filling ratios

1	2	3
Relative density[a] of LPG at 20 °C	**Maximum permissible filling ratio[b]**	
	Storage vessels of capacity less than 4 500 L	**Storage vessels of capacity 4 500 L or more**
0,495 to 0,499	0,42	0,45
0,500 to 0,504	0,43	0,46
0,505 to 0,509	0,43	0,46
0,510 to 0,514	0,44	0,47
0,515 to 0,519	0,44	0,47
0,520 to 0,524	0,45	0,48
0,525 to 0,529	0,46	0,49
0,530 to 0,534	0,46	0,49
0,535 to 0,539	0,47	0,50
0,540 to 0,544	0,47	0,50
0,545 to 0,549	0,48	0,51
0,550 to 0,554	0,49	0,52
0,555 to 0,559	0,49	0,52
0,560 to 0,564	0,50	0,53
0,565 to 0,569	0,50	0,53
0,570 to 0,574	0,51	0,54
0,575 to 0,579	0,52	0,55
0,580 to 0,584	0,52	0,55
0,585 to 0,589	0,52	0,56
0,590 to 0,594	0,53	0,56
0,595 to 0,599	0,54	0,57
0,600 to 0,604	0,55	0,58

[a] For LPG of known and consistent density, the volumetric fill capacity might exceed 85 % when the values in this table and the equation given in 11.2 are applied.

[b] This filling ratio will ensure that a storage vessel is never filled to more than 85 % of its water capacity.

11.2 Filling by volume

11.2.1 Because the contents of a static storage vessel cannot normally be controlled by mass, some means is required for calculating the maximum volume of liquid that may be placed in a storage vessel at any liquid temperature.

11.2.2 When the temperature of the liquid (obtained by measuring the temperature of the LPG by means of a temperature-measuring instrument placed in a pocket installed in the storage vessel (see 5.4.5)) and the filling ratio are known, the maximum volume of liquid that can be placed in the storage vessel can be determined using the following equation:

$$V_T = \frac{D \times 100}{G \times F}$$

where

V_T is the maximum liquid volume (expressed as a percentage of the total storage vessel capacity) that can be placed in a storage vessel when the liquid temperature is T;

T is the temperature of the liquid LPG in the storage vessel, in degrees Celsius (°C);

D is the filling ratio;

G is the relative density of the LPG at 20 °C;

F is the liquid volume correction factor (in accordance with annex C).

11.2.3 The actual maximum quantity, in litres, of LPG that can be placed in a storage vessel is obtained by multiplying the water capacity of the storage vessel by $\frac{V_T}{100}$.

12 Ongoing inspection, testing and certification of vessels

12.1 General

Ongoing inspection, testing and certification of storage vessels shall be carried out in accordance with the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

12.2 Passive fire protection (PFP)

12.2.1 Periodic visual inspection of the condition of the passive fire protection system, where applicable, shall be carried out every three years by a competent person. The inspection results shall be recorded and held with the vessel records.

12.2.2 The inspection shall cover defects in the passive coating and possible resultant corrosion of the vessel (see 14.2.7.5) that could affect the fire protection properties of the system or could result in deterioration of the vessel shell.

12.2.3 Defects in the PFP system shall be corrected by a competent person and a new certificate of compliance shall be issued.

13 Testing for leaks

13.1 After assembly, test all piping systems either pneumatically or hydraulically for leaks at the appropriate of the following pressures:

a) pneumatic testing: 1,1 times the maximum operating pressure; and

b) hydraulic testing: 1,25 times the maximum operating pressure.

13.2 Where pneumatic testing is done, ensure that permission is obtained from the Department of Labour, as required by the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

13.3 After testing, purge-fill all piping systems, thus ensuring that a flammable mixture does not occur in the system on the introduction of LPG.

14 Fire safety

14.1 General

14.1.1 Loose or piled combustible material, plants, weeds and long dry grass shall not be permitted within 3,0 m of any storage vessel.

14.1.2 Access to and around the installation shall be provided for fire-fighting purposes and this area shall be kept free of obstacles at all times.

14.1.3 Since the Fire Control Authority, in whose area LPG storage vessels will be erected, has final jurisdiction regarding the fire hazard involved with such an installation, the relevant Fire Control Authority shall be consulted at an early stage with regard to the placement of storage vessels and any other guidance related to fire-fighting and fire protection facilities.

14.1.4 Such coordination will include the planning for effective measures for control of inadvertent LPG release or fire and the safety of emergency personnel. The provision of acceptable roadways or other means of access for emergency equipment (for example, fire departments) and the effective location and marking of emergency controls shall be considered.

14.1.5 Monthly inspections shall be carried out by the nominated responsible person and corrective action shall be taken to prevent a fire from occurring at or near the installation. In particular, attention shall be given to good housekeeping, reducing ignition sources, reducing fuel loads around the installation, access control to the installation, and to ensuring fire protection measures are in place and in working order.

14.2 Fire suppression systems

14.2.1 Water supply

14.2.1.1 Where required in table 4, there shall be a supply of water for fire protection use in an emergency. Where a sprinkler system is required, an application rate of 10 L/m^2/min over the whole surface of the storage vessel for at least 60 min is required. If water is supplied by means of a recirculation system, the storage reservoir shall hold a 30 min water supply provided that sufficient make-up water can be supplied from the reticulation system. Special consideration shall be given to the possibility that there could be a loss of power on the site and the consequences this would have for the fire protection arrangements provided.

14.2.1.2 On-site hydrants and fixed drench systems shall be so designed that the water flow can be controlled from a safe position beyond the separation distances given in 17.1. Connections to fixed drench systems for fire brigade use shall be provided on the water supply. The connections shall be located in a safe place approved by the fire brigade.

14.2.1.3 There shall be acceptable drainage to deal with water used for fire protection and fire-fighting purposes.

14.2.1.4 A summary of the fire protection requirements are given in table 4. The final system of protection shall be acceptable to the local fire authority.

14.2.2 Fire protection requirements

14.2.2.1 The provision of fire protection at fixed installations shall depend on a number of considerations, including

a) the maximum storage capacity of the installation,

b) individual storage vessel sizes,

c) the number of tanker deliveries, and

d) whether there is an increased risk of fire on site which might affect the storage vessels, for example at LPG cylinder filling areas (see table 4).

14.2.2.2 Higher standards of fire protection might be required by the approving authority where other factors prevail, such as increased off-site risks and hazards, location of the nearest water supply, and the time required for the fire brigade to reach the site.

14.2.2.3 At remote installations where the population near the storage vessels is small (making it easy to evacuate the area), it might be acceptable for the water supply to be more than 100 m from the storage vessels. In such cases, the fire brigade shall be consulted. A comprehensive evacuation plan shall be available and the residents in the vicinity of the installation shall be familiar with it.

14.2.2.4 At large installations where continuous supervision is available, manually operated water sprays can be sufficient. At these installations it might not be necessary to simultaneously drench all the storage vessels and means can be provided to allow drenching of individual storage vessels or groups of storage vessels. A remote manual operating point shall be provided in a safe place.

Table 4 — Summary of fire protection requirements

1	2
Installation of individual capacity or combined capacity L	**Fire protection requirements**
500 to 2 250	Water supply[a] for fire brigade use – within 100 m 2 × 9 kg dry powder extinguishers
2 251 to 9 000	Water supply for fire brigade use – within 100 m 20 mm hose reel 2 × 9 kg dry powder extinguishers
9 001 to 45 000	The risk assessment should give guidance as to whether fixed or portable monitors or fixed sprays (or a combination of these) need to be incorporated in the installation (see 14.2.3). Water supply for fire brigade use – within 100 m 20 mm hose reel 2 × 9 kg dry powder extinguishers
45 001 to 67 500	Fixed or portable monitors or fixed sprays (or a combination of these) Water supply for fire brigade use – within 100 m 20 mm hose reel 2 × 9 kg dry powder extinguishers
> 67 500	Automatic fixed sprays and hydrant and hose Water supply for fire brigade use – within 100 m 20 mm hose reel 2 × 9 kg dry powder extinguishers
Cylinder filling area	20 mm hose reel 2 × 9 kg dry powder extinguishers
Road tanker filling or deliveries – more than twice a week	The risk assessment should give guidance as to whether fixed or portable monitors or fixed sprays (or a combination of these) need to be incorporated in the installation (see 14.2.3). 20 mm hose reel 2 × 9 kg dry powder extinguishers
[a] Water supply shall be sustainable, accessible, and consist of one or more of the following: a) a municipal reticulation system; b) fire hydrants; c) tanks or reservoirs; d) swimming pools; or e) natural sources – rivers, streams, dams, ponds, etc.	

14.2.3 Risk assessment

Table 5 shall be used to determine if the hazard (see 3.15) versus the risk (see 3.21) requires fixed or portable monitors or fixed sprays (or a combination of these). The risk assessment shall be done by a competent person.

Table 5 — Hazards and risks

1	2	3	4
Risk assessment	**Hazard**		
	Low	**Medium**	**High**
Low	No	No	Yes
Medium	No	Yes	Yes
High	Yes	Yes	Yes
If one field is YES then protection required by cooling water should be considered. If more than one field is YES, then the installation shall be protected by means of one of the water application systems. If more than two fields are YES, then the water protection shall be an automatic detection and activation system.			

14.2.4 Precautionary measures

14.2.4.1 Fire protection shall be considered at aerosol filling plants and other LPG filling plants where the storage vessels could be threatened by a fire involving the filling installation or the aerosol store.

14.2.4.2 At installations of fixed storage vessels of individual capacity or combined capacity of 67 500 L or greater, the road tanker bay shall be provided with the same level of fire protection as the fixed storage vessels.

14.2.4.3 At installations where an average of more than two road tanker deliveries a week take place, or where more than two road tankers a week are filled with LPG (based on the consumption over a six-month period, including the winter period), consideration shall be given to the provision of additional fire protection at the tanker bay.

14.2.4.4 Rail loading and unloading gantries shall be provided with fixed water sprays or an equivalent form of fire protection for sites based on the risk assessment in accordance with table 5.

14.2.5 Protection by monitors

If fixed ground or portable monitors are used, they shall be so located and arranged such that all storage vessel surfaces likely to be exposed to fire will be wetted.

14.2.6 Portable fire-fighting equipment

There shall be sufficient, acceptable, portable fire-fighting equipment on the premises (see table 4). This equipment shall be selected and located to enable fires adjacent to the storage vessels to be extinguished and so prevent fire spreading to, or jeopardizing, the LPG installation. Fire extinguishers or hose reels or an equivalent combination of these two types of equipment shall be provided.

14.2.7 Passive fire protection

14.2.7.1 Where fixed sprays or portable monitors or fixed sprays in conjunction with portable monitors are required for fire protection, a system of passive fire protection can be applied as an alternative.

14.2.7.2 Passive fire protection shall be of such quality that, when it is subjected to an acceptable flame impingement for a minimum of 60 min, the shell temperature will not exceed 430 °C. The requirements shall be verified by means of NFPA 58 or an equivalent approved test method.

14.2.7.3 The applicator of the fire protection system shall have a quality control plan detailing the application procedure, and inspection hold points.

14.2.7.4 The vessel shall be suitably prepared with a corrosion protection system compatible with the passive fire protection that will be applied. The design of the anti-corrosion system shall be such that no corrosion of the vessel is expected under the passive protection system for a minimum of 20 years.

14.2.7.5 There shall be a minimum of five inspection ports in the passive fire protection to allow for inspection of the condition of the tank pressure shell. The construction of the ports shall be such that the fire protection integrity of the protection system is not compromised. The inspection ports shall be installed on the top, bottom and dished ends of the vessel and any other potential high corrosion areas on the vessel. A minimum of two of the inspection ports shall be installed on welds.

14.2.7.6 The applicator shall supply a certificate of conformance for the PFP system on completion of the application confirming that the system is compliant with this part of SANS 10087.

14.3 Fire instruction and training

Employees on premises where LPG is stored shall receive instructions and training, as appropriate, to enable them to understand the fire precautions and actions to be taken in the event of fire or leakage of LPG. They shall receive instruction and training appropriate to their responsibilities in the event of an emergency. Those trained to fight LPG fires shall be aware that these fires shall not normally be extinguished unless the source of LPG can be isolated.

At commercial and industrial sites, notices setting out the emergency procedures shall be prominently displayed near the LPG storage area.

14.4 Fire safety documentation and records

Each installation or group of installations on site shall have a comprehensive fire safety file and this file shall be made available to the approving authority on request. Such file shall contain the following:

a) detailed site procedures related to fire emergencies, leaks and external risks;

b) emergency contact numbers: emergency services number of fire and ambulance, gas supplier, site manager, installation company, site safety officer, etc.;

c) all the relevant permits and certificates in accordance with legislative requirements;

d) maintenance schedule and all evidence of inspections, repairs and maintenance that have been carried out;

e) service schedule of all fire equipment and systems, as well as a record of services that have been carried out;

f) record of weekly, monthly, quarterly and yearly inspections that have been carried out; and

g) record of employees trained in accordance with 14.3.

14.5 Rational design

In terms of the National Building Regulations, a gas installation is defined as a building. As such, fire protection can be in terms of a rational design as described in the relevant parts of SANS 10400 prepared by an approved competent person (fire engineering) as defined in SANS 10400-T.

14.6 Protection against static electricity (inductive sparking)

14.6.1 Unless other precautions are taken,

a) an effective earthing connection shall be provided at the discharge point for discharging static electricity from bulk storage vessels; and

b) provision shall be made for effectively bonding each storage vessel and the delivery storage vessel before and during each delivery operation.

14.6.2 The storage vessels shall be so electrically earthed as to provide complete protection against lightning and the accumulation of static electricity.

NOTE A resistance that does not exceed 10 Ω is recommended.

14.6.3 Piping shall be so installed as to ensure electrical continuity, and shall be connected to earth (see also SANS 10089-2). Bonding across flanged joints shall not be required if the measured resistance does not exceed 10 Ω (see also SANS 10142-1).

14.7 Gas detection systems

14.7.1 A combustible gas detection and alarm system shall be installed where unstenched LPG is used at filling and storage sites. Such protection and alarm system shall comply with the requirements of SANS 61779-6.

14.7.2 The gas detection system shall be so installed that the gas supply will be closed in the event of power failure to the plant or gas detection system.

15 Vaporizers

15.1 General

15.1.1 Vaporizers include the following types:

a) ambient,

b) low pressure steam-heated,

c) hot-water-heated,

d) direct gas-fired (direct-fired), and

e) electrically heated.

15.1.2 The capacity of the installed vaporizer(s) shall be large enough to supply the latent heat of vaporization necessary to convert the liquid into vapour at the maximum off-take required from the installation.

15.1.3 Where necessary, accumulation of condensate in the vapour discharge line shall be prevented by lagging of the vapour discharge line or, in cold areas, by the provision of condensate pockets capable of containing the quantity likely to be condensed during a plant shutdown. With steam steam-heated and hot-water-heated vaporizers, care shall be taken to avoid freezing of condensed steam or water.

15.1.4 Care shall be taken to ensure that the LPG pressure does not exceed the safe working pressure of the vaporizer equipment and that the LPG pressure within the storage vessel is not raised above the design pressure.

15.1.5 Vaporizers shall not be fitted with fusible plugs.

15.1.6 Heating or cooling coils shall not be installed inside a storage vessel to act as a vaporizer.

15.1.7 Manually operated valves shall be installed to shut off the liquid or the vapour connections (or both) between the storage vessel(s) and the vaporizer(s).

15.2 Safety distances

15.2.1 Direct-fired vaporizers of any capacity shall be located not closer to the nearest storage vessel, storage vessel shut-off valves, point of transfer, building(s) or property boundary than the relevant distance given in table 5.

Table 5 — Safety distances for direct-fired vaporizers

1	2	3
Minimum safety distance (see also figure 6) m		
To storage vessel	**To point of transfer**	**To building(s) or property boundary**
5	6	7,5

15.2.2 Pressure regulating and reducing equipment shall be protected against radiant heat.

15.2.3 Vaporizers can be installed in buildings used exclusively for gas manufacturing and distributing operations or, in the case of vaporizers of capacity not exceeding 70 L/h (35 kg/h), in buildings other than those referred to above if the room containing the vaporizer is separated from the remainder of the building by a wall that is designed to withstand a static pressure of at least 5 kPa, and that has no opening or pipe or conduit passing through it. All pressure relief devices shall be vented to a safe area outside of the building.

15.2.4 Buildings used to house vaporizers shall be of non-combustible materials, and shall be well ventilated at both floor and roof levels.

15.2.5 The electrical components of electrically heated vaporizers shall be manufactured and installed in accordance with the requirements of clause 17.

15.3 Design and construction

15.3.1 Vaporizers shall be designed, constructed and tested in accordance with an approved standard. All parts of the vaporizers in contact with the liquid LPG shall be of steel or other approved material. The vaporizer storage vessels shall be painted with a corrosion-resistant and light-reflecting paint.

15.3.2 A plate, securely attached in a conspicuous place to the shell of the vaporizer storage vessel, shall be marked (by the manufacturer) with the following information and any other information required by the relevant statutory regulations:

a) the manufacturer's name;

b) the country of origin;

c) the manufacturer’s serial number;

d) the year of construction;

e) the date of initial pressure testing (see 5.7);

f) the design pressure, in kilopascals;

g) the outside surface area, in square metres (when relevant);

h) the inside heat exchange surface area, in square metres (when relevant);

i) the vaporizing capacity, in litres per hour or kilograms per hour;

j) the number and title of the standard in accordance with which the vaporizer was constructed; and

k) the electrical details (when relevant).

15.4 Fittings

15.4.1 Pressure relief devices

15.4.1.1 Vaporizer systems shall have, at or near the point of vapour discharge, at least one pressure relief device. The maximum start-to-discharge pressure of the devices shall be not greater than 110 % of the design pressure of the vaporizer storage vessel.

15.4.1.2 The pressure relief device(s) shall discharge, at a rate of not less than the appropriate rate shown in table A.1, before the vaporizer pressure exceeds 120 % of the start-to-discharge pressure.

15.4.1.3 In the case of a direct-fired vaporizer, the discharge from the safety relief device on the vaporizer shall be piped away from any source of ignition to a safe location.

NOTE 1 In the case of relief devices for vaporizers, the total surface area is the sum of the wetted area of the vaporizer shell and the surface area of the heat exchanger (see table A.1).

NOTE 2 For vaporizers smaller than those given in table A.1, NFPA 58 or API spec 5L or an equivalent approved standard should be used.

15.4.2 Control of liquid carry-over

Vaporizers shall have controls to prevent liquid carry-over.

15.4.3 Heat input control

The heat input shall be so controlled as to prevent the pressure in the vaporizer storage vessel from reaching the start-to-discharge pressure of the pressure relief device(s) in the vaporizer system. The heat input control shall be suitable for the connection system. The vaporizer shall be connected in accordance with the manufacturer's instructions.

16 Periodic inspection, retesting and maintenance

16.1 Pressure equipment

16.1.1 All LPG pressure equipment systems shall be tested and inspected, including periodic inspections and tests, in accordance with

a) the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993);

b) this part of SANS 10087; and

c) the manufacturer’s recommendations.

16.1.2 Any on-site maintenance work carried out on the pressure equipment, including the removal and re-installation of such equipment, shall be done by a registered industrial installer.

16.1.3 Any leakage from plant, pipelines or piping shall be rectified immediately, and the site manager shall be informed.

16.2 Fire equipment

16.2.1 The deluge system, monitoring equipment, fixed ground or portable monitors, hydrants and booster connections shall be inspected, maintained and serviced, including periodic inspections and tests, by a competent person specializing in the inspection and maintenance of such equipment. Maintenance and servicing shall be carried out in accordance with approved standards or, where no such standards exist, in accordance with the manufacturer's specifications, but at least once per year.

16.2.2 Fire extinguishers shall be maintained and serviced in accordance with SANS 1475-1.

16.2.3 Periodic inspections shall be carried out in accordance with the manufacturer’s recommendations.

17 Electrical equipment and other sources of ignition

17.1 The sites of the equipment and operations listed in column 1 of table 6 are classified, in terms of SANS 10108, as hazardous locations of the appropriate zone given in column 3, and the extent of each classified area is defined in column 2. Electrical equipment and wiring sited in these areas shall be limited to the types permissible for use in such areas, in terms of SANS 10108 (or other approved standard), and they shall be installed in accordance with the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

17.2 Except as allowed in clause 15 in respect of direct-fired vaporizers, open flames, cutting and welding operations, portable electric tools, extension lights or any other equipment capable of igniting LPG shall not be permitted within the classified areas specified in column 2 of table 6 unless the LPG facilities have been freed of all liquid and vapour, or special precautions have been taken under carefully controlled conditions.

Table 6 — Extent of hazard zones for certain specified sources of release for heavier-than-air gases or vapours

1	2	3
Installation	**Extent of classified location (excluding areas beyond an unpierced wall, a roof or a solid vapour-tight partition)**	**Zone**
Storage vessels	Within 5 m (in all directions) of connections other than those covered elsewhere in this table	2
Tank vehicle and tank car loading and unloading	Within 2 m (in all directions) of connections regularly made or broken for product transfer	1
	Beyond 2 m from but within 5 m (in all directions) of a point where connections are regularly made or broken and within the cylindrical volume between the horizontal equator of the sphere and ground level as shown in figure 7	2
Gauge vent openings	Within 2 m (in all directions) of the point of discharge	1
	Beyond 2 m from but within 5 m (in all directions) of the point of discharge	2
Pressure relief device discharge point	Within the direct path of discharge	1[a]
	Within 2 m (in all directions) of the point of discharge	1
	Beyond 2 m from but within 5 m (in all directions) of the point of discharge except within the direct path of discharge	2
Pumps, compressors, gas: air mixers, and vaporizers (excluding direct-fired vaporizers): a) indoors without ventilation	Entire room and any adjacent room not separated by a gas-tight partition	1
	Within 5 m of the exterior side of any exterior wall or roof that is not vapour-tight, or within 5 m of any exterior opening	2
b) indoors with adequate ventilation	Entire room and any adjacent room not separated by a gas-tight partition	2
c) outdoors in open air at or above ground level	Within 5 m (in all directions) of the equipment and within the cylindrical volume between the horizontal equator of the sphere and ground level as shown in figure 8	2

[a] Fixed electrical equipment shall not be installed.

[b] Ventilation, either natural or mechanical, is considered adequate when the concentration of the gas in a gas and air mixture does not exceed 25 % of the lower limit of flammability under normal operating conditions.

Table 6 (*concluded*)

1	2	3
Installation	**Extent of classified location (excluding areas beyond an unpierced wall, a roof or a solid vapour-tight partition)**	**Zone**
Pits or trenches that contain or are located beneath gas valves, pumps, compressors, regulators, and similar equipment:		
a) without adequate mechanical ventilation[b]	Entire pit or trench	1
	Entire room and any adjacent room not separated by a gas-tight partition	2
	Within 5 m (in all directions) of a pit or a trench when located outdoors	2
b) with adequate mechanical ventilation[b]	Entire pit or trench	2
	Entire room and any adjacent room not separated by a gas-tight partition	2
	Within 5 m (in all directions) of a pit or a trench when located outdoors	2
Special buildings or rooms for storage of portable containers	Entire area	2
Pipelines and connections that have operational bleeds, drips, vents or drains	Within 2 m (in all directions) of the point of discharge	1
	Beyond 2 m from the point of discharge, the delimitations given under “pumps, compressors, gas-air mixers, and vaporizers (excluding direct-fired vaporizers)” shall be applied	1
Container filling apparatus	Within 2 m (in all directions) of the filling point	1
	Beyond 2 m from but within 5 m (in all directions) of the filling apparatus	2

[a] Fixed electrical equipment shall not be installed.

[b] Ventilation, either natural or mechanical, is considered adequate when the concentration of the gas in a gas and air mixture does not exceed 25 % of the lower limit of flammability under normal operating conditions.

18 Filling point for bulk storage vessels

18.1 The remote filling connection by which a storage vessel is filled, or through which it fills other tanks, shall be at least

a) 5 m away from the cylinder filling area (when applicable),

b) 3 m away from the cylinder storage area (when applicable),

c) 7,5 m away from the boundary of premises, offices and sales rooms, and

d) 15 m away from open fires (excluding direct-fired vaporizers) and from schools, places of worship, hospitals and similar institutions.

For safety distances from the storage vessel itself, see the values for *F* in figure 6.

18.2 The filling operator shall, at all times, be in control of both the tanker and storage vessel control valves.

18.3 If there is a possibility of ignition from a public place, temporary no-smoking signs shall be conspicuously displayed at the public place during discharge operations.

18.4 The storage vessel filling and tanker loading liquid connections of 40 mm or greater nominal bore shall be fitted with either a pull-away coupling or a safety break connection designed to part in the event of a tanker moving off with the hose connected. The coupling shall be designed to part cleanly and seal both ends to prevent loss of contents.

19 Filling of portable containers (up to 120 L water capacity) from a bulk supply

19.1 The filling procedure for portable containers shall be carried out in accordance with SANS 10087-7.

NOTE This is not applicable when filling a container of 500 L water capacity in situ. For information with regard to filling containers of 500 L water capacity in situ, see SANS 10087-1.

19.2 Containers other than those owned by the gas company shall only be filled when permission to fill the portable container has been granted by the owner of the container. This requirement is solely for safety reasons, since the container containment history is an essential reference for correct filling.

19.3 The boundary of the filling site shall be at least

a) 5,0 m away from the boundary of the premises on which it is located,

b) 5,0 m away from driveways within the premises,

c) 3,0 m away from any container storage area,

d) 15,0 m away from outdoor places of public assembly (including school yards, athletic fields and playgrounds, busy thoroughfares and sidewalks),

e) 15 m away from any permanent open fire, for example a boiler room, and

f) the distance given in columns 2 and 3 of table 1 away from the storage vessel.

20 Container storage areas

20.1 The distances between an outside (open-air) storage area for containers (awaiting filling or despatch after filling) and the nearest building, the boundary of the premises, a public thoroughfare or sidewalk, and the line of an adjoining property occupied by a school, place of worship, hospital, athletic field or other point of public gathering shall be not less than the appropriate minimum distances given in table 7.

20.2 The distance between an outside (open-air) storage area for containers (awaiting filling or despatch after filling) and storage vessels shall comply with the requirements of figure 6.

20.3 All containers that are empty (or appear to be empty) shall be handled with the same care as a full container, and the distributing plant operator shall ensure that the valves of all empty containers received for filling are closed properly.

20.4 Containers shall not be stored within 1,5 m of the edge of a platform at which customers or container-distribution vehicles are served.

Table 7 — Minimum safety distances

1	2	3
Total quantity of LPG stored kg	**Minimum distance** m	
	From buildings and boundary of the premises	**From thoroughfares, sidewalks and line of adjoining property of school, places of worship, etc.**
501 to 1 000	3,0	5,0
1 001 to 3 000	5,0	5,0
3 001 to 5 000	7,5	7,5
5 001 to 20 000	10,0	10,0
≥ 20 001	15,0	15,0

21 Filling sheds for portable containers of up to 48 kg

21.1 Buildings used for the filling of portable containers with LPG shall be reserved exclusively for this purpose. Floors in the filling area shall have a non-sparking surface and shall not be below ground level. When a raised platform is used, the space under the platform shall either be filled in completely or left open on all sides (to afford free ventilation). In the latter case, the space under the platform shall not be used for any purpose, and shall be kept free from rubbish. Surface water drains (equipped with a gas-liquid separator) situated outside the building shall be provided.

21.2 Because of the danger of gas accumulations, the formation of pits and similar depressions in the floor shall be avoided. If pits or channels are required for conveyors or other equipment, such pits or channels shall be ventilated by drains that lead to the outside of the building. Such drains shall be so graded as to permit the flow of vapours under gravity, or they shall be connected to forced-ventilation systems.

21.3 Sheds shall preferably be open-sided, but where it is necessary, because of climatic conditions, to give protection to the workers, ventilation shall be provided at both ground and roof levels. The filling of storage containers shall never be carried out in a cellar or in the upper storey of a building.

21.4 An automatic or remotely activated shut-off valve for use in emergency situations (for example, gas leakage or fires) shall be provided on the delivery pipeline on the outside of the filling shed in to the point where the delivery pipeline enters the filling shed. The valve shall fail in the closed position.

21.5 The electrical circuits to the LPG pumps shall be arranged such that, on the operation of an emergency switch, the LPG pumps are electrically isolated. Emergency switches shall be clearly labelled.

22 Action in an emergency

22.1 Gas leakage without fire

Unless remedial action, such as closing the valve, can be effected on the spot, a leaking container shall be identified and removed to a safe area.

22.2 Gas leakage with fire

22.2.1 Unless there is a danger that flames might impinge on other containers, no attempt shall be made to extinguish a fire before the source of the leakage has been determined and it is known that the leakage can be stopped after the fire has been extinguished. For example, a fire occurring at the outlet of a container valve can be extinguished by means of a portable extinguisher, provided that the valve is then closed immediately or the container is promptly removed to a place where gas leakage will not result in a subsequent explosion.

22.2.2 Where it is not possible to extinguish the fire and either to stop the leakage or to remove the leaking container promptly, water spray shall be used to keep cool all the containers in the vicinity of the burning fire.

22.3 Containers exposed to fire

22.3.1 If a container that does not incorporate a safety relief device is exposed to severe heat radiation, acceptable volumes of water sprayed onto the container will cool the liquids and will, in all probability, prevent hydraulic rupturing that could result from over-pressurization. Nevertheless, an assessment shall be made of the risks of possible rupture since such rupture occurs with explosive force and can endanger life and property over a considerable area. The impingement of flames on containers shall be regarded as an extremely dangerous condition that necessitates immediate evacuation of the area.

NOTE Evacuation distances will depend on the total volume of gas involved. Evacuation distances of up to 600 m should be considered.

22.3.2 Containers not involved in or affected by the fire shall be removed to a safe area or, alternatively, if this is not possible, such containers shall be kept cool by spraying them gently with acceptable quantities of water. If containers equipped with relief devices are exposed to a severe fire, care shall be taken to avoid jets of gas that escape via these devices (for example, by standing well clear of the containers), since such jets might extend as far as 10 m.

23 Records

Records of inspections, test history and maintenance as required in this part of SANS 10087 shall be available on site (see 5.7, 10.1, 14.4 and clause 16).

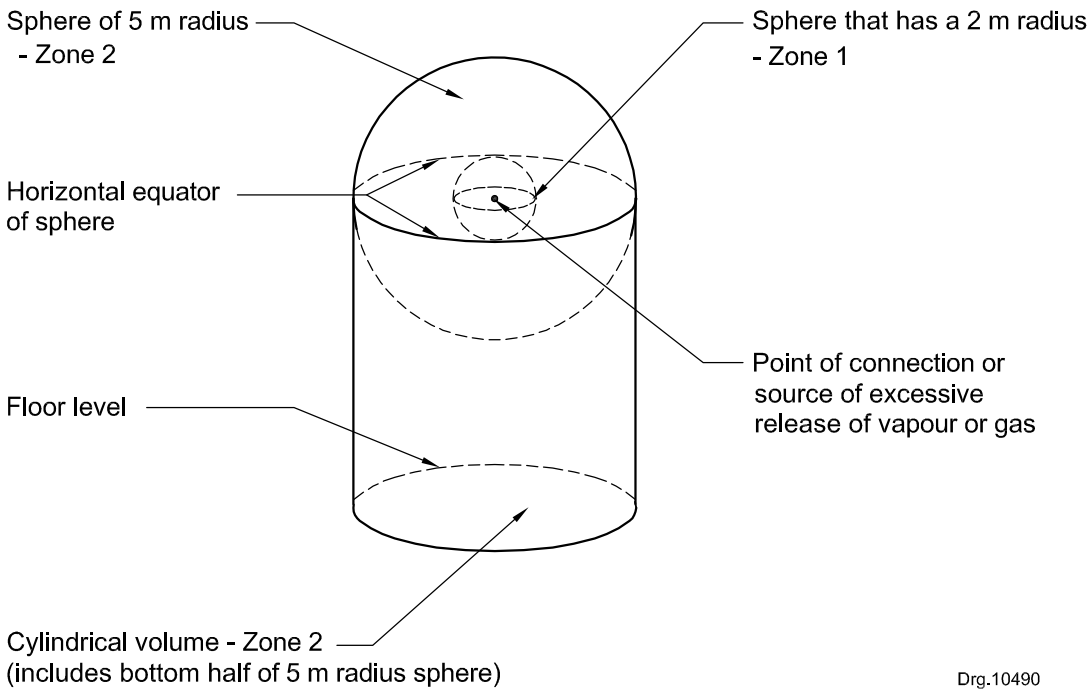


Figure 8 — Identification of zone levels

Annex A
(normative)

Rate of discharge of pressure relief devices

A.1 Surface-mounted storage vessels

The minimum rate of discharge (in cubic metres of air per minute) of pressure relief devices at 120 % of the start-to-discharge pressure is given in table A.1 for storage vessels of surface area up to 200 m^2.

For storage vessels with a total outside surface area greater than 200 m^2, the required flow rate (Q), in cubic metres of air per minute, can be calculated from the following:

$$Q = 10{,}658 \times A^{0{,}82}$$

where

A is the surface area of the storage vessel, in square metres (m^2).

A.2 Buried and mounded storage vessels

The minimum rate of discharge may be reduced to 50 % of the appropriate rates given in A.1.

Table A.1 — Minimum rate of discharge for surface-mounted storage vessels

1	2	1	2	1	2
Surface area of storage vessel m^2	**Flow rate** m^3 of air per min	**Surface area of storage vessel** m^2	**Flow rate** m^3 of air per min	**Surface area of storage vessel** m^2	**Flow rate** m^3 of air per min
1,5	14,9	16,5	106,2	55,0	285,0
2,0	18,8	17,0	108,8	60,0	306,0
2,5	22,6	17,5	111,4	65,0	326,8
3,0	26,2	18,0	114,0	70,0	347,3
3,5	29,8	18,5	116,6	75,0	367,5
4,0	33,2	19,0	119,6	80,0	387,4
4,5	36,6	19,5	121,8	85,0	407,2
5,0	39,9	20,0	124,3	90,0	426,7
5,5	43,1	21,0	129,4	95,0	446,1
6,0	46,3	22,0	134,4	100,0	465,2
6,5	49,5	23,0	139,4	105,0	484,2
7,0	52,6	24,0	144,4	110,0	503,1
7,5	55,6	25,0	149,3	115,0	521,7
8,0	58,6	26,0	154,2	120,0	540,3
8,5	61,7	27,0	159,0	125,0	558,7
9,0	64,6	28,0	163,8	130,0	576,9
9,5	67,5	29,0	168,6	135,0	595,0
10,0	70,4	30,0	173,3	140,0	613,1
10,5	73,3	31,0	178,1	145,0	631,0
11,0	76,1	32,0	182,8	150,0	648,7
11,5	79,0	33,0	187,4	155,0	666,4
12,0	81,8	34,0	192,1	160,0	684,0
12,5	84,6	35,0	197,7	165,0	701,5
13,0	87,3	36,0	201,3	170,0	718,9
13,5	90,1	37,0	205,9	175,0	736,2
14,0	92,8	38,0	210,4	180,0	753,4
14,5	95,5	39,0	215,0	185,0	770,5
15,0	98,2	40,0	219,5	190,0	787,5
15,5	100,9	45,0	241,7	195,0	804,5
16,0	103,5	50,0	263,5	200,0	821,3

Annex B
(normative)

Storage and dispensing of LPG as an automotive fuel at service stations or dedicated automotive fuel LPG dispensing sites

B.1 General

This annex covers the installation and dispensing of LPG at service stations (forecourts). All above-ground storage vessels shall generally be installed in accordance with the requirements of figure 6.

Operating procedures and requirements for the fuelling of fork lift trucks and other LPG operated vehicles shall be in accordance with SANS 10087-8.

Any site shall be under the control of a competent person as defined in the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

B.2 Construction and design

B.2.1 Positioning

The positioning of LPG vessels, especially those above ground, is important especially from a safety point of view. They shall not be positioned under power cables. Distances from the vessel outline shall not be less than 2 m for power cables of less than 1,0 kV, and 10 m for cables of 1,0 kV or above. Access shall be available for both delivery tankers and emergency services.

B.2.2 Vessel protection

B.2.2.1 Firewalls are permitted on no more than two sides of the compound of above-ground vessels and may form part of the site boundary. The installation requirements shall be in accordance with 6.3.2.

B.2.2.2 Storage vessels may also be placed underground in order to improve the level of protection against potential heat gain from fires in the vicinity.

B.2.2.3 For mounded and underground vessels, diversion walls may be incorporated on no more than two sides of the compound.

B.2.3 Safety distances

B.2.3.1 Separation distances (for installations at forecourts)

Separation distances are established to ensure clearance from a vessel or associated equipment (or both) to other pieces of equipment, buildings or potential sources of ignition which, if these caught fire, would pose a risk to the vessel or the associated equipment (or both).

Minimum separation distances between components are given in table B.1.

Table B.1 — Minimum separation distances between components

1	2	3	4	5	6
Components	**Storage vessel**	**Storage vessel filling connection**	**LPG pump**	**LPG dispenser**	**Vehicle being filled**
LPG storage vessel	–	See figure 6 and clause 18	1,5 m[a]	1,5 m	≤ 9 000 L = 3 m > 9 000 L = 7,5 m
Storage vessel filling connection	See figure 6 and clause 18	–	1,5 m	1,5 m	≤ 9 000 L = 3 m > 9 000 L = 7,5 m
LPG pump	1,5 m[a]	1,5 m	–	Nil	Nil
LPG dispenser	1,5 m	1,5 m	Nil	–	Nil
2nd LPG dispenser	1,5 m	1,5 m	Nil	Nil	Nil
Vehicle being filled	≤ 9 000 L = 3 m > 9 000 L = 7,5 m	≤ 9 000 L = 3 m > 9 000 L = 7,5 m	Nil	Nil	–
Underground petrol vessel manhole with filling connection	7,5 m	7,5 m	6 m	6 m	6 m
Above-ground vessel for liquids with < 65 °C flash point	See figure 7				
Remote petrol vessel filling connection	7,5 m	7,5 m	6 m	6 m	6 m
Petrol vessel vents	7,5 m	7,5 m	7,5 m	7,5 m	7,5 m
Petrol dispensers explosion protected	7,5 m	7,5 m	Nil	Nil	Nil
Diesel dispensers explosion protected	3 m	3 m	Nil	Nil	Nil
Parked cars	≤ 9 000 L = 3 m > 9 000 L = 7,5 m	≤ 9 000 L = 3 m > 9 000 L = 7,5 m	Nil	Nil	Nil
Buildings, boundary or fixed source of ignition	As given in figure 6		6 m	6 m	6 m from vehicle fill point

[a] For underground storage vessels, the distance to the LPG pump can be reduced to 0,5 m from the manhole.

B.2.3.2 Installations involving above-ground storage vessels

B.2.3.2.1 Vapour barriers or firewalls, as appropriate, may be used to reduce the distances given in figure 6. However, the presence of vapour barriers and firewalls can create significant hazards, for example pocketing of escaping gas, interference with the application of cooling water by the fire department, redirection of flames against storage vessels, and impeding ingress of personnel in an emergency. Special care shall be taken to ensure that where two walls are joined to form an enclosing corner, the angle shall be not less than 90°.

B.2.3.2.2 Safety distances shall be measured horizontally and radially from storage vessels except that, if vapour barriers or firewalls are used, the distance shall be measured in a horizontal line around such walls or barriers.

B.2.3.2.3 Storage vessels shall not be installed one above the other.

B.2.3.2.4 The number of storage vessels in any one group shall not exceed six. Unless a firewall is erected between the groups, each storage vessel in one group shall be at least 7,5 m from the nearest storage vessel in another group. When firewalls are used to separate groups of storage vessels, the direct distance from each storage vessel in one group to the nearest storage vessel in another group shall be at least 4 m.

B.2.3.2.5 The minimum horizontal separation distance between above-ground LPG storage vessels and above-ground storage vessels containing liquids that have flash points below 93,4 °C, shall be 6 m. The minimum horizontal separation distance between an underground storage vessel and a second storage vessel, above or below ground, shall be at least 0,5 m.

B.2.3.3 Installations involving buried and mounded storage vessels

B.2.3.3.1 The safety distances applicable to the installation of buried or mounded storage vessels shall be in accordance with the appropriate values given in figure 6. Other parts of the storage vessel shall be no closer than 1 m to a building, boundary or other equipment.

B.2.3.3.2 Buried or mounded storage vessels shall be located outside of any buildings. Buildings shall not be constructed over any buried or mounded storage vessels. Sides of adjacent storage vessels shall be separated by not less than 0,5 m.

B.3 Hazardous area zoning

B.3.1 General

Any equipment that contains a flammable liquid or vapour shall be assessed to determine the potential for forming a flammable atmosphere. This is usually called zoning and the zones (see table 6 and figure 8) are divided into the following:

a) Zone 0: An area in which a flammable gas: air mixture is continuously present or is present for long periods.

b) Zone 1: An area in which a flammable gas: air mixture is likely to occur in normal operations.

c) Zone 2: An area in which a flammable gas: air mixture is not likely to occur in normal operations and if it occurs it will only exist for a short time.

By implication, an area which is not classified as zone 0, 1 or 2 is deemed to be non-hazardous or safe with respect to the selection of electrical apparatus.

The final responsibility for establishing zoned areas is with the end user. It is the responsibility of the designer or installer to provide the relevant information.

B.3.2 Dispenser zone

To be consistent with other fuel dispensers, LPG dispensers shall be considered as petrol dispensers with stage 2 vapour recovery but without the vent air separator.

Manufacturers, importers or anyone putting a dispenser on the market shall provide the unit with a diagram showing the relative zoning areas around the unit. Hazardous zones shall be determined in accordance with SANS 10108, SANS 10089-2 and SANS 10089-3, or other approved sources.

Wiring, junction boxes and glands shall be suitable for the zone in which they are positioned. Installation and testing shall be in accordance with both the relevant standards and the manufacturer's instructions.

B.4 Installation of equipment

B.4.1 Pumps

Pumps shall be for LPG use and installed as close as practical to the vessel but not under the contour of the vessel. Submersible pumps may be used in underground vessels. The pumps shall be designed for the hazardous zone in which they are installed.

B.4.2 Piping

Sealants used on threaded joints and gaskets for flanges shall be designed for use with liquid LPG over the safe operating range. Piping shall be in accordance with clause 8.

B.4.3 Dispensers

Although dispensers may, in general, be considered in the same light as a petrol pump, the following shall be noted:

a) Dispensers may be placed on the island adjacent to a petrol dispenser and shall be protected against impact by the provision of crash barriers or bollards in the immediate vicinity.

b) All dispenser bases shall be securely fixed to a mounting island and fitted with anchored shear valves or similar devices.

c) Each dispenser hose assembly shall be provided either with a pull-away coupling or a safety break connection designed to part at loads of approximately 25 kg to protect the dispenser in the event of vehicle moving off with the hose connected. The coupling shall be designed to part cleanly and seal both ends to prevent loss of contents.

d) The hoses shall be in accordance with EN 1762 or a recognized and approved standard for LPG use.

e) Hose end nozzles shall not allow the flow of product unless connected to a vehicle connection. The hose end nozzle shall be in accordance with SANS 10087-6 or an equivalent approved standard.

f) All dispensers shall be fitted with valves to allow for safe isolation, testing and maintenance. These shall include a return to vessel connection to allow for dispenser testing.

g) All dispensers used for resale purposes shall comply with requirements of the Trade Metrology Act, 1973 (Act No. 77 of 1973).

B.5 Electrical installations

B.5.1 General

In addition to the relevant requirements given in SANS 10089-3, all electrical and electronic installations shall comply with the requirements of the Electrical Installation Regulations or Electrical Machinery Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993), together with SANS 1020, SANS 10086-1, SANS 10108, SANS 10142-1 and SANS 10089-2.

Uncertified electrical equipment or systems shall not be installed in hazardous locations (see also figure 8).

B.5.2 Emergency switches

B.5.2.1 Where the source of supply is in a non-hazardous area, the electrical installation shall have at least an isolation device placed in the non-hazardous area. In the event of excessive distance, the installation shall have an isolation device in an explosion-protected enclosure placed in the hazardous area, to allow rapid isolation. All phases and the neutral shall be isolated, but not the protective conductor. In addition, it shall be possible to de-energize electrical apparatus from any appropriate location if its continued energization would lead to hazards (for example, the spreading of fire). For this emergency switch-off, the operational control unit normally required may be used.

B.5.2.2 Electrical apparatus, which has to continue operation to prevent additional danger, shall not be included in the emergency switch-off circuit, but shall be on a separate circuit.

B.5.2.3 Emergency switches connected to the site's main emergency shutdown system, which will isolate the supply to the fuel and LPG systems, shall be provided as follows:

a) at the control point in the sales building;

b) incorporated at the main exterior emergency switch of the site; and

c) in the LPG vessel compound adjacent to each exit.

B.5.2.4 The electrical circuits to the LPG pump and dispenser shall be arranged such that, on the operation of an emergency switch on the service stations, the LPG pump, dispensers and also the petrol pump and dispensers are all electrically isolated. These shall only be capable of being reset from inside the console area. Emergency switches shall be clearly labelled.

B.6 Prevention and control of fires involving LPG

B.6.1 General

LPG vapours become flammable when mixed with air. Severe fires and explosions can result when such mixtures ignite. The following information is given as a guide to users of LPG:

a) A liquid leak from an LPG container will generate a very large volume of gas vapour. Liquid leaks are therefore a much greater source of hazard than vapour leaks.

b) LPG vapours do not disperse easily and, being heavier than air, will hug ground contours and will tend to flow along natural paths and fill depressions, ditches and pits. In favourable conditions, flammable vapours can travel for long distances from the point of release. They might also enter a building and be contained there, particularly in basements and cellars. Vapour dispersal can be accelerated by water spray or wind.

c) Small fires involving LPG can usually be readily extinguished by dry-chemical-type fire extinguishers. Such extinguishers shall be installed at the filling and storage area.

B.6.2 Vessel installation

The requirements of this part of SANS 10087 and SANS 10087-1 shall be applied for fire prevention and control measures during vessel installation.

B.6.3 Dispenser(s)

One 9 kg multi-purpose dry chemical powder (DCP) fire extinguisher shall be provided per pump island.

B.6.4 Gas leakage

If a leak develops in

a) a filling container: both the local fire authority and the supplier shall be informed immediately and remedial action shall be taken, or

b) the supply line: the supply valve on the container shall be closed and remedial action shall be taken.

B.7 Notices

B.7.1 Notices containing the following warnings shall be displayed at the dispenser:

Liquefied petroleum gas
Extremely flammable
Switch off engine
Apply handbrake
No smoking — No naked lights
Switch off cellular phones

B.7.2 Pictograms shall be used wherever possible. The following additional notice shall be installed at the emergency switch or shall be integrated into the existing emergency switch notice:

Emergency — LPG pump
Switch off here

B.8 Filling operations

The operation of the dispenser shall be in accordance with the manufacturer's instructions.

LPG tanker deliveries shall not be permitted at the same time as a petrol tanker delivery. Only site personnel familiar with operational procedures shall operate the dispenser.

B.9 Training

B.9.1 A written emergency procedure shall be provided at the site and all staff shall be fully trained in the dangers of LPG and on what action to take in the case of an emergency during storage, delivery and dispensing. Staff training records shall be kept on site.

B.9.2 Training shall include how to fill a vehicle and what to do if the following occurs:

a) a customer drives away whilst the hose is still connected;

b) a customer arrives at the unit with a different fill coupling than the nozzle supplied;

c) excess loss of product occurs on disconnection;

d) the dispenser is collided with;

e) a user receives a cold burn; and

f) there is a problem during the tanker delivery.

Some pull-away couplings can be reconnected with the hose still under pressure. The operator should not do this unless trained to do so. Whatever type of pull away/break away is used, the installation, and particularly hoses, should be checked before the system is returned to service.

B.10 Pressure system maintenance

Maintenance shall be carried out on the pressure parts of a dispenser by a registered installer. To comply with the requirements of the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993), a written scheme of examination is required for any part, the failure of which, could lead to danger due to the release of pressure. A written maintenance procedure shall also be required.

A schedule indicating typical equipment that shall be included in a written scheme is given in table B.2.

Table B.2 — Typical equipment and test schedule

1	2	3	4
Typical equipment	**Test schedule**		
	Annual[a]	**Every 5 years**[a]	**Every 10 years**[a]
Base and steelwork	V	–	–
Vessel[b]	V	–	T
Vessel signs[b]	V	R	–
Dispenser Filter Measure Overall	T[c]	T	–
Vessel fittings[b] – fill – liquid out – liquid return – vapour return – relief valve – pressure gauge – drain	 T T T T V V V	T	R
Filter	–	T	R
Pump Internal bypass valve External bypass valve	T T T	R – –	– R R
Hydrostatic relief valve	V	–	R
Test point valves	T	–	R
Hoses[d]	T	R	–
Pull-away coupling	T	–	–
Break-away coupling	V	–	–
Nozzle	T	R	–

NOTE V = Visual inspection

T = the pressure test as given in the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993)

R = Review

[a] Intervals shall be specified by the competent person that draws up the written scheme.

[b] Vessel maintenance is the responsibility of the owner of the vessel.

[c] Procedure for testing the volume measure shall take into account typical volumes dispensed and the flow rate applicable to the installation under normal conditions.

[d] The standard for hoses requires a test at periods that do not exceed 12 months.

Annex C
(informative)

Reduction of volume factors

Table C.1 — Reduction of volume factors

1	2	3	4	5	6	7	8	9	10	11
Observed temperature	**Density at 20 °C**									
	0,500	0,510	0,520	0,530	0,540	0,550	0,560	0,570	0,580	0,590
°C	**Factor for reducing volume to 20 °C**									
0,0	1,058	1,055	1,052	1,049	1,047	1,044	1,042	1,040	1,038	1,036
0,5	1,057	1,054	1,051	1,048	1,046	1,043	1,041	1,039	1,037	1,035
1,0	1,055	1,052	1,050	1,047	1,045	1,042	1,040	1,038	1,036	1,034
1,5	1,054	1,051	1,048	1,046	1,043	1,041	1,039	1,037	1,035	1,033
2,0	1,052	1,050	1,047	1,045	1,042	1,040	1,038	1,036	1,034	1,032
2,5	1,051	1,048	1,046	1,043	1,041	1,039	1,037	1,035	1,033	1,032
3,0	1,050	1,047	1,045	1,042	1,040	1,038	1,036	1,034	1,033	1,031
3,5	1,048	1,045	1,043	1,041	1,039	1,037	1,035	1,033	1,032	1,030
4,0	1,047	1,044	1,042	1,040	1,038	1,036	1,034	1,032	1,031	1,029
4,5	1,045	1,043	1,041	1,039	1,037	1,035	1,033	1,031	1,030	1,028
5,0	1,044	1,042	1,039	1,037	1,035	1,034	1,032	1,030	1,029	1,027
5,5	1,043	1,040	1,038	1,036	1,034	1,032	1,031	1,029	1,028	1,026
6,0	1,041	1,039	1,037	1,035	1,033	1,031	1,030	1,028	1,027	1,025
6,5	1,040	1,037	1,036	1,034	1,032	1,030	1,029	1,026	1,026	1,024
7,0	1,038	1,036	1,034	1,033	1,031	1,029	1,028	1,025	1,025	1,023
7,5	1,037	1,035	1,033	1,031	1,030	1,028	1,027	1,024	1,024	1,022
8,0	1,036	1,034	1,031	1,030	1,028	1,027	1,026	1,023	1,023	1,022
8,5	1,034	1,032	1,031	1,029	1,027	1,026	1,025	1,022	1,022	1,021
9,0	1.033	1,031	1,029	1,028	1,026	1,025	1,023	1,022	1,021	1,020
9,5	1,031	1,030	1,028	1,026	1,025	1,024	1,022	1,021	1,020	1,019
10,0	1,030	1,028	1,027	1,025	1,024	1,023	1,021	1,020	1,019	1,018
10,5	1,028	1,027	1,025	1,024	1,023	1,021	1,020	1,018	1,018	1,017
11,0	1,027	1,025	1,024	1,023	1,021	1,020	1,019	1,018	1,017	1,016
11,5	1,025	1,024	1,023	1,022	1,020	1,019	1,018	1,017	1,016	1,015
12,0	1,024	1,023	1,021	1,020	1,019	1,018	1,017	1,016	1,015	1,015
12,5	1,023	1,021	1,020	1,019	1,018	1,017	1,016	1,015	1,015	1,014
13,0	1,021	1,020	1,019	1,018	1,017	1,016	1,015	1,014	1,014	1,013
13,5	1,020	1,018	1,017	1,017	1,016	1,015	1,014	1,013	1,013	1,012
14,0	1,018	1,017	1,016	1,015	1,014	1,014	1,012	1,012	1,012	1,011
14,5	1,017	1,016	1,015	1,014	1,013	1,013	1,011	1,011	1,011	1,010

Table C.1 *(continued)*

1	2	3	4	5	6	7	8	9	10	11
Observed temperature	**Density at 20 °C**									
	0,500	0,510	0,520	0,530	0,540	0,550	0,560	0,570	0,580	0,590
°C	**Factor for reducing volume to 20 °C**									
15,0	1,015	1,014	1,014	1,013	1,012	1,011	1,011	1,010	1,010	1,009
15,5	1,014	1,013	1,012	1,011	1,011	1,010	1,009	1,009	1,009	1,008
16,0	1,012	1,011	1,011	1,010	1,010	1,009	1,009	1,008	1,008	1,007
16,5	1,011	1,010	1,009	1,009	1,008	1,008	1,007	1,007	1,007	1,006
17,0	1,009	1,009	1,008	1,008	1,007	1,007	1,006	1,006	1,006	1,005
17,5	1,008	1,007	1,006	1,006	1,006	1,006	1,005	1,004	1,005	1,005
18,0	1,006	1,006	1,005	1,005	1,005	1,005	1,004	1,003	1,004	1,004
18,5	1,005	1,004	1,004	1,004	1,004	1,003	1,003	1,002	1,003	1,003
19,0	1,003	1,003	1,003	1,003	1,002	1,002	1,002	1,001	1,002	1,002
19,5	1,002	1,001	1,001	1,001	1,001	1,001	1,001	1,000	1,001	1,001
20,0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
20,5	0,998	0,999	0,999	0,999	0,999	0,998	0,998	0,999	0,999	0,999
21,0	0,997	0,997	0,997	0,997	0,998	0,998	0,998	0,998	0,998	0,998
21,5	0,995	0,996	0,996	0,996	0,996	0,997	0,997	0,997	0,997	0,997
22,0	0,994	0,994	0,995	0,995	0,995	0,995	0,996	0,996	0,996	0,996
22,5	0,992	0,993	0,993	0,994	0,994	0,994	0,995	0,995	0,995	0,995
23,0	0,991	0,991	0,992	0,992	0,993	0,993	0,993	0,994	0,994	0,995
23,5	0,989	0,990	0,990	0,991	0,991	0,992	0,992	0,993	0,993	0,994
24,0	0,988	0,988	0,989	0,990	0,990	0,991	0,991	0,992	0,992	0,993
24,5	0,986	0,987	0,988	0,988	0,989	0,990	0,990	0,991	0,991	0,992
25,0	0,984	0,985	0,986	0,987	0,988	0,988	0,989	0,990	0,990	0,991
25,5	0,983	0,984	0,985	0,986	0,986	0,987	0,988	0,989	0,989	0,990
26,0	0,981	0,982	0,983	0,984	0,985	0,986	0,987	0,987	0,988	0,989
26,5	0,980	0,981	0,982	0,983	0,984	0,985	0,986	0,986	0,987	0,988
27,0	0,978	0,979	0,981	0,982	0,983	0,984	0,985	0,985	0,986	0,987
27,5	0,977	0,978	0,979	0,980	0,982	0,983	0,983	0,984	0,985	0,986
28,0	0,975	0,976	0,978	0,979	0,980	0,981	0,982	0,983	0,984	0,985
28,5	0,973	0,975	0,976	0,978	0,979	0,980	0,981	0,982	0,983	0,984
29,0	0,972	0,973	0,975	0,976	0,978	0,979	0,980	0,981	0,982	0,983
29,5	0,970	0,972	0,973	0,975	0,976	0,978	0,979	0,980	0,981	0,983
30,0	0,968	0,970	0,972	0,974	0,975	0,977	0,978	0,979	0,980	0,982
30,5	0,967	0,969	0,971	0,972	0,974	0,975	0,977	0,978	0,979	0,981
31,0	0,965	0,967	0,969	0,971	0,973	0,974	0,976	0,977	0,978	0,980
31,5	0,964	0,966	0,968	0,970	0,971	0,973	0,974	0,976	0,977	0,979
32,0	0,962	0,964	0,966	0,968	0,970	0,972	0,973	0,975	0,976	0,978

Table C.1 *(concluded)*

1	2	3	4	5	6	7	8	9	10	11
Observed temperature	**Density at 20 °C**									
	0,500	0,510	0,520	0,530	0,540	0,550	0,560	0,570	0,580	0,590
°C	**Factor for reducing volume to 20 °C**									
32,5	0,960	0,963	0,965	0,967	0,969	0,971	0,972	0,974	0,975	0,977
33,0	0,959	0,961	0,964	0,965	0,968	0,969	0,971	0,973	0,974	0,976
33,5	0,957	0,960	0,962	0,964	0,966	0,968	0,970	0,972	0,973	0,975
34,0	0,955	0,958	0,960	0,963	0,965	0,967	0,969	0,970	0,972	0,974
34,5	0,954	0,956	0,959	0,961	0,964	0,966	0,968	0,969	0,971	0,973
35,0	0,952	0,955	0,957	0,960	0,962	0,965	0,966	0,968	0.970	0,972
35,5	0,950	0,953	0,956	0,959	0,961	0,963	0,965	0,967	0.969	0,971
36,0	0,949	0,952	0,955	0,957	0,960	0,962	0,964	0,966	0,968	0,970
36,5	0,947	0,950	0,953	0,956	0,959	0,961	0,963	0,965	0,967	0,970
37,0	0,945	0,949	0,952	0,954	0,957	0,960	0,962	0,964	0,966	0,969
37,5	0,944	0,947	0,950	0,953	0,956	0,959	0,961	0,963	0,965	0,968
38,0	0,942	0,945	0,949	0,952	0,955	0,957	0,960	0,962	0,964	0,967
38,5	0,940	0,944	0,947	0,950	0,953	0,956	0,958	0.961	0,963	0,966
39,0	0,939	0,942	0,946	0,949	0,952	0,955	0,957	0,960	0,962	0,965
39,5	0,937	0,941	0,944	0,947	0,951	0,954	0,956	0,958	0,961	0,964
40,0	0,935	0,939	0,943	0,946	0,949	0,952	0,955	0.957	0,960	0,963
40,5	0,934	0,938	0,941	0,945	0,948	0,951	0,954	0,956	0,959	0,962
41,0	0,932	0,936	0,940	0,943	0,947	0,950	0,953	0,955	0,958	0,961
41,5	0,930	0,934	0,938	0,942	0,946	0,949	0,951	0,954	0,957	0,960
42,0	0,928	0,933	0,937	0,940	0,944	0,947	0,950	0,953	0,956	0,959
42.5	0,927	0,931	0,935	0.939	0,943	0,946	0,949	0,952	0,955	0,958
43,0	0,925	0,929	0,934	0,938	0,942	0,945	0,948	0,951	0,954	0,957
43,5	0,923	0,928	0,932	0,936	0,940	0,944	0,947	0,950	0,953	0,956
44,0	0,921	0,926	0,930	0,935	0,939	0,942	0,946	0,949	0,952	0,955
44,5	0,920	0,925	0,929	0,933	0,938	0,941	0,944	0,947	0,951	0,954
45,0	0,918	0,923	0,927	0,932	0,936	0,940	0,943	0,946	0,950	0,954
45,5	0,916	0,921	0,926	0,930	0,935	0,939	0,942	0,945	0,948	0,953
46,0	0,914	0,920	0,924	0,929	0,934	0,937	0,941	0,944	0,947	0,952
46,5	0,913	0,918	0,923	0,928	0,932	0,936	0,940	0,943	0,946	0,951
47,0	0,911	0,916	0,921	0,926	0,931	0,935	0,938	0,942	0,945	0,950
47,5	0,909	0,915	0,920	0,925	0,930	0,934	0,937	0,941	0,944	0,949
48,0	0,907	0,913	0,918	0,923	0,928	0,932	0,936	0,940	0,943	0,948
48,5	0,906	0,911	0,917	0,922	0,927	0,931	0,935	0,938	0,942	0,947
49,0	0,904	0,910	0,915	0,920	0,926	0,930	0,934	0,937	0,941	0,946
49,5	0,902	0,908	0,913	0,919	0,924	0,929	0,932	0,936	0,940	0,945
50,0	0,900	0,906	0,912	0,917	0,923	0,927	0,931	0,935	0,939	0,944

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