

Flat-bottomed, vertical, cylindrical storage tanks for low temperature service —

Part 1: Guide to the general provisions
applying for design, construction,
installation and operation

Committees responsible for this British Standard

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- British Chemical Engineering Contractors' Association
- British Compressed Gases Association
- British Gas plc
- Concrete Society
- Energy Industries Council
- Engineering Equipment and Materials Users' Association
- Institution of Gas Engineers
- Institution of Mechanical Engineers
- Process Plant Association
- Thermal Insulation Contractors' Association
- Welding Institute

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Contents

	Page
Committees responsible	Inside front cover
Foreword	iii
1 Scope	1
2 References	1
2.1 Normative references	1
2.2 Informative references	1
3 Definitions	1
3.1 Types of containment	1
3.2 Other terms	5
4 Design conditions	5
5 Information to be exchanged between the purchaser and the contractor	6
5.1 Information to be supplied by the purchaser	6
5.2 Optional and/or alternative information to be supplied by the purchaser	6
5.3 Information to be agreed between the purchaser and contractor	6
6 Storage concepts	6
6.1 General	6
6.2 Criteria for the selection of storage concept	7
7 Loading cases and design considerations	7
7.1 General	7
7.2 Normal loading cases	7
7.3 Abnormal loading cases	10
8 Pressure relief	11
8.1 General	11
8.2 Primary internal positive and internal negative pressure relief system design	11
8.3 Location of pressure relief valves	11
8.4 Construction of pressure relief valves	11
8.5 Determination of capacity of pressure relief systems	12
9 Commissioning and decommissioning	12
9.1 Commissioning	12
9.2 Decommissioning	13
10 Inspection and tank monitoring	14
10.1 General	14
10.2 Equipment	14
Annex A (informative) Guidance on operation	15
Annex B (informative) Guidance on a method of seismic analysis for refrigerated liquid gas tanks	19
Annex C (informative) Guidance on safety and other aspects	20

	Page
Figure 1 — Examples of single containment tanks	2
Figure 2 — Examples of double containment tanks	3
Figure 3 — Examples of full containment tanks	4
Figure A.1 — Typical example of level alarm	15
Figure A.2 — Typical example of condensation in dome roof for butane gas	16
Figure A.3 — Arrangement of sensors under tank bottom	18
Figure A.4 — Typical heating time recording curve	18
Figure A.5 — Flotation of the inner tank	19
Figure C.1 — Pilot-operated pressure relief valve	22
Figure C.2 — Dead weight type pressure relief valve	22
Figure C.3 — Pilot-operated low-pressure relief valve	23
Figure C.4 — Dead weight type internal negative pressure relief valve	24
Figure C.5 — Arrangement of pressure control valves (PCVs) to flare, and internal positive pressure relief valves to atmosphere, internal negative pressure relief valves, locked block valves and spare positions	25
Table 1 — Loading cases associated with tank types shown in Figure 1 to Figure 3	8
Table B.1 — Component transient loading criteria	20
List of references	Inside back cover

Foreword

This Part of BS 7777 has been prepared under the direction of the Pressure Vessels Standards Policy Committee.

Flat-bottomed, vertical, cylindrical, storage tanks for refrigerated liquefied gases have traditionally been of the single containment design where the liquid is contained in a single shell surrounded by a conventional low bund wall at a considerable distance. Where a double shell construction was used, the outer shell was mainly there to contain the insulation.

These tanks were built in accordance with two British Standards:

BS 4741:1971, *Specification for vertical cylindrical welded steel storage tanks for low temperature service: single wall tanks for temperatures down to -50°C* .

BS 5387:1976, *Specification for vertical cylindrical welded storage tanks for low-temperature service: double-wall tanks for temperatures down to -196°C* .

Until the 1970s it was normal practice to store all refrigerated products in single containment tanks. Since that time it has increasingly become the practice for the inner tank for hydrocarbons or ammonia to be surrounded by an outer tank or wall. It is still the practice to store liquid oxygen, liquid nitrogen or liquid argon in single containment tanks. The outer tank or wall is intended to prevent the release of the liquefied products into the surrounding area in case of leakage from or damage to the inner tank. This philosophy results in increased safety for the surrounding area. Such constructions are known as double containment tanks and full containment tanks.

Depending on the lowest service temperature, the inner tank may be made from carbon-manganese steel, low nickel steel, 9 % nickel steel, aluminium or stainless steel. The double containment tanks and full containment tanks generally have outer tanks or walls made from prestressed concrete, reinforced concrete with an earth embankment or one of the metals specified for the inner tank. BS 4741 and BS 5387 specified requirements for single containment tanks only and consequently did not include the requirements for material selection, design, construction, loading cases, etc. that are necessary for double containment tanks and full containment tanks.

To redress this situation, the Storage Tank Committee of The Engineering Equipment and Materials Users' Association (EEMUA) published in 1986 *Recommendations for the design and construction of refrigerated liquefied gas storage tanks*, Publication No. 147[1]. The intention of EEMUA was that this document would form the basis of a British Standard to be published a few years later. Together, BS 7777-1 to BS 7777-4 supersede BS 4741:1971 and BS 5387:1976, which are withdrawn.

Although experience has demonstrated that the risk of failure of a single containment tank designed and fabricated in accordance with British Standards is very low, this can be further reduced by more stringent requirements for material selection, design, construction, inspection and testing. For certain stored products, however, the consequences of failure may be considered so great that an outer tank or wall is deemed necessary. Thus a further reduction of risk of failure can be achieved through the use of a double or full containment storage concept. The definitions of single, double and full containment tanks are given in 3.1 of this Part of BS 7777.

The selection of the storage concept should take into account the location, the operational conditions and the environmental conditions. This standard covers only flat-bottomed, cylindrical, stand-alone storage tanks. However, it is not intended to exclude the use of other storage concepts and designs which have been proven in service.

This British Standard comprises four Parts:

- *Part 1: Guide to the general provisions applying for design, construction, installation and operation;*
- *Part 2: Specification for the design and construction of single, double and full containment metal tanks for the storage of liquified gas at temperatures down to -165°C ;*
- *Part 3: Recommendations for the design and construction of prestressed and reinforced concrete tanks and tank foundations, and for the design and installation of tank insulation, tank liners and tank coatings;*
- *Part 4: Specification for the design and construction of single containment tanks for the storage of liquid oxygen, liquid nitrogen or liquid argon.*

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 28, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 7777 provides guidance on design conditions, criteria for the selection of a storage concept, loading cases, internal positive pressure and internal negative pressure relief, testing, commissioning and decommissioning, inspection and monitoring for single, double and full containment tanks for above ground installation at service temperatures down to $-165\text{ }^{\circ}\text{C}$, and for single containment tanks down to $-196\text{ }^{\circ}\text{C}$. Guidance on operation, seismic analysis and safety is given in Annex A to Annex C.

Tanks are intended to contain liquid products to be stored at temperatures equal to or just above their boiling points at atmospheric pressure. The liquids stored in tanks covered by this standard typically include liquid petroleum gas, ethylene, ethane, liquid natural gas and similar hydrocarbons, as well as ammonia, oxygen, nitrogen and argon.

For the purposes of this standard, it is intended that tanks for the storage of hydrocarbons and ammonia are selected from three types (single, double and full containment tanks) taking into account local circumstances and particular needs. For tanks storing liquid oxygen, liquid nitrogen or liquid argon, it is intended that single containment tanks should be used.

This standard does not address the detail design of ancillary equipment such as pump tubes, pumps, valves and instrumentation, but it does refer to these components where there is an effect on mechanical design. Information regarding ancillary equipment is conventionally part of the purchaser specification.

2 References

2.1 Normative references

This Part of BS 7777 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 7777 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 7777 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 7777, the following definitions apply.

3.1 Types of containment

3.1.1

single containment tank

either a single tank or a tank comprising an inner tank and an outer container designed and constructed so that only the inner tank is required to meet the low temperature ductility requirements for storage of the product

the outer container (if any) of a single containment storage tank is primarily for the retention and protection of insulation and to constrain the vapour purge gas pressure, but is not designed to contain refrigerated liquid in the event of leakage from the inner tank

a single containment tank is normally surrounded by a low bund wall (see 3.2.1) to contain any leakage

NOTE Examples of single containment tanks are given in Figure 1.

3.1.2

double containment tank

a double tank designed and constructed so that both the inner tank and the outer tank are capable of independently containing the refrigerated liquid stored. To minimize the pool of escaping liquid, the outer tank or wall is located at a distance not exceeding 6 m from the inner tank

the inner tank contains the refrigerated liquid under normal operating conditions. The outer tank or wall is intended to contain the refrigerated liquid product leakage from the inner tank, but it is not intended to contain any vapour resulting from product leakage from the inner tank

NOTE Examples of double containment tanks are given in Figure 2. Figure 2 does not imply that the outer tank or wall is necessarily as high as the inner tank.

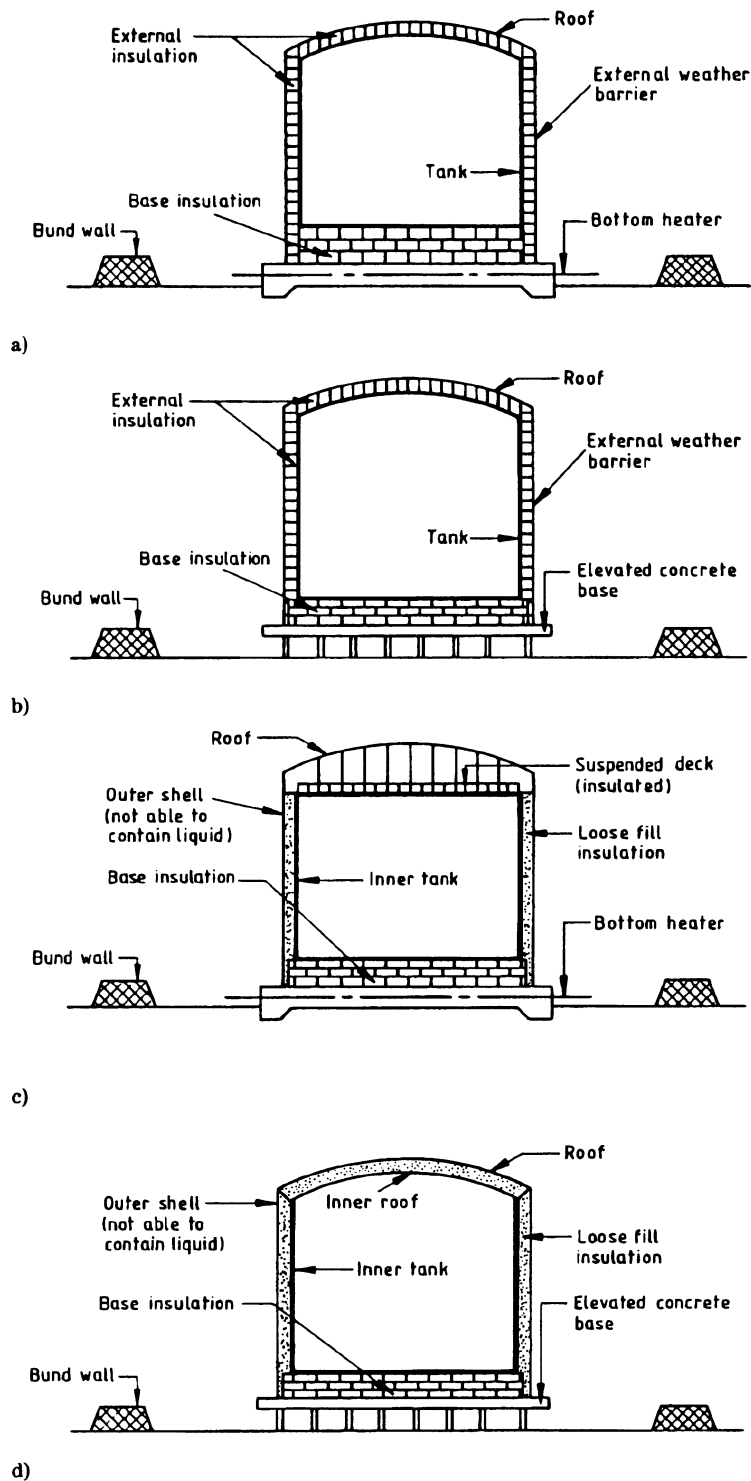
3.1.3

full containment tank

a double tank designed and constructed so that both the inner tank and the outer tank are capable of independently containing the refrigerated liquid stored. The outer tank or wall should be 1 m to 2 m distant from the inner tank

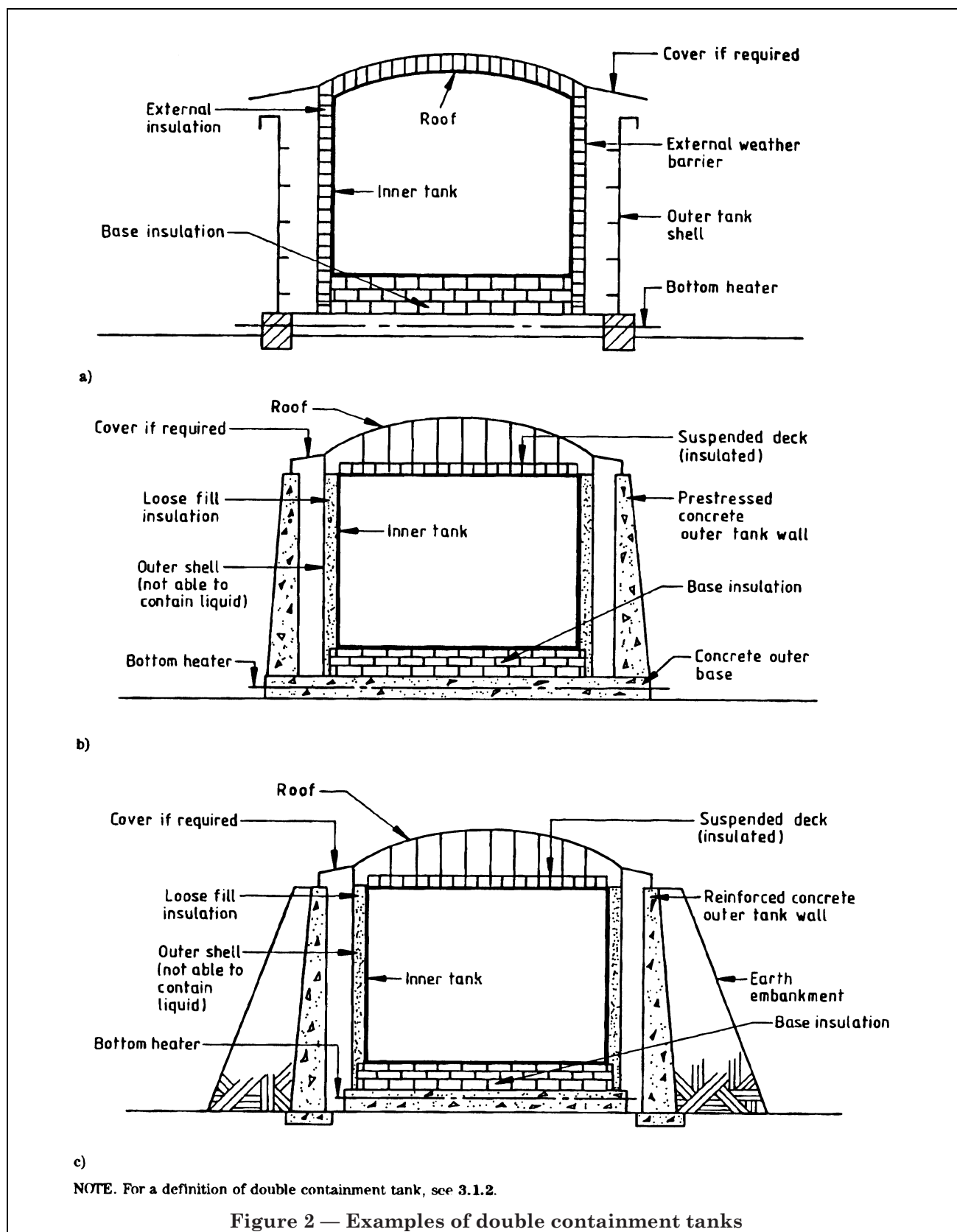
the inner tank contains the refrigerated liquid under normal operating conditions. The outer roof is supported by the outer tank. The outer tank is intended to be capable both of containing the refrigerated liquid and of controlled venting of the vapour resulting from product leakage after a credible event

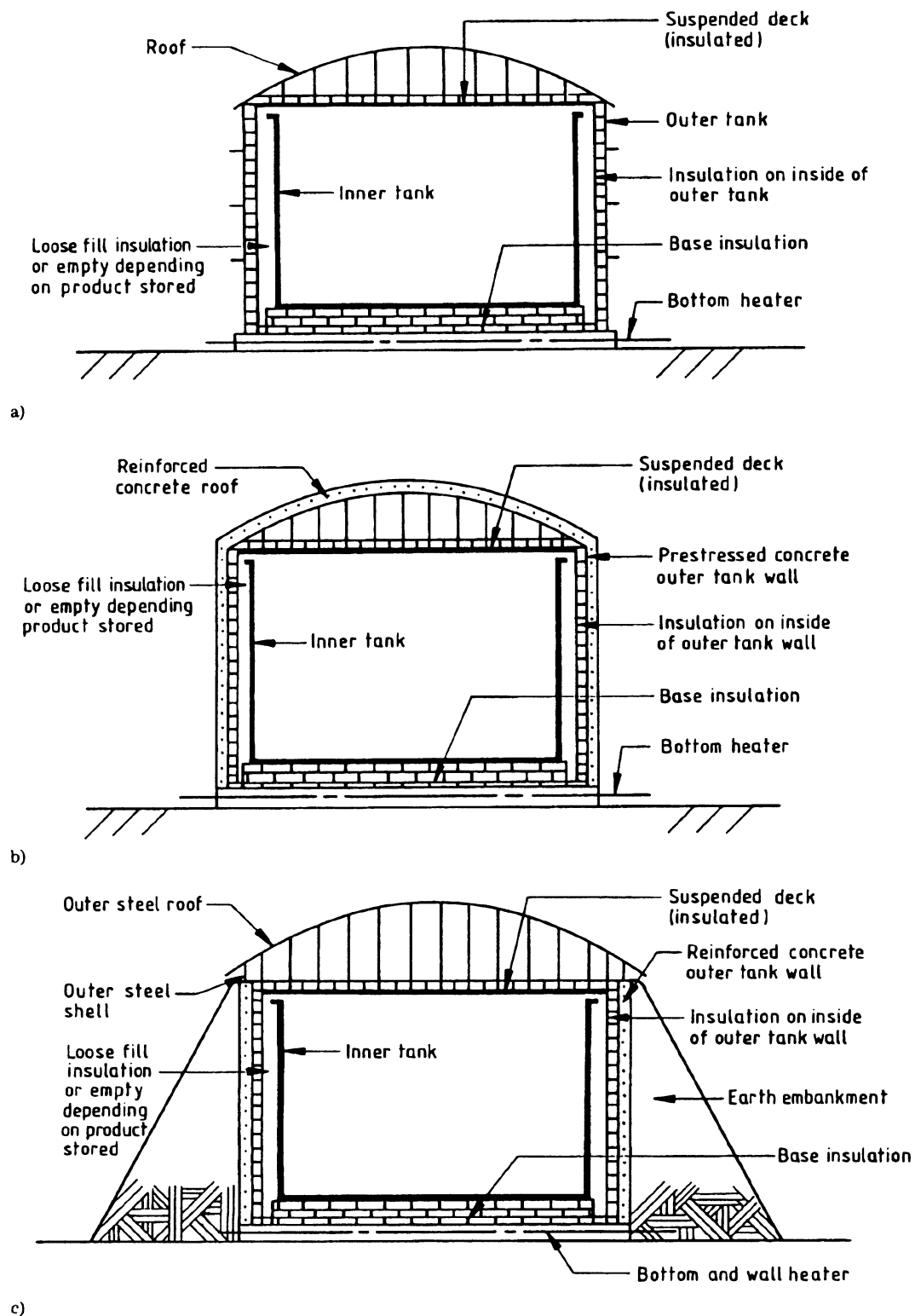
NOTE Examples of full containment tanks are given in Figure 3.



NOTE. For a definition of single containment tank, see 3.1.1

Figure 1 — Examples of single containment tanks





NOTE. For a definition of full containment tank, see 3.1.3.

Figure 3 — Examples of full containment tanks

3.2 Other terms

3.2.1

bund wall

a low construction of earth or concrete surrounding the storage tank, at a considerable distance from the tank, to contain spilled liquid

NOTE Illustration of a bund wall is given in Figure 1.

3.2.2

boil-off

a process of vaporization of very small quantities of refrigerated liquid by heat conducted through the insulation surrounding the storage tank

3.2.3

embankment

a bank of selected earth and other material placed against the outer face of a reinforced concrete wall

3.2.4

roll-over

an uncontrolled mass movement of a stored liquid, correcting an unstable state of stratified liquids of different density

NOTE Roll-over results from differences in temperature or composition throughout the depth of the liquid. It is generally accompanied by a large release of vapour inside the tank.

3.2.5

purchaser

the company or its agent which prepares and agrees a proposal with a contractor (or contractors) for the design, construction, testing and commissioning of a tank for storing refrigerated liquefied gas

NOTE It is not the purpose of this standard to define terms of reference or to allocate responsibilities between contracting parties when the purchaser is not the owner or operator of the storage facility.

3.2.6

contractor

the company with which the purchaser agrees a proposal for the design, construction, testing and commissioning of a tank for storing refrigerated liquefied gas

3.2.7

inner tank

a flat-bottomed, vertical, metallic cylinder, with or without a roof, designed to store liquid during service

3.2.8

outer tank

a flat-bottomed, vertical cylinder designed to contain liquid from the inner tank in the event of leakage

3.2.9

shell

a general term used to describe any metallic vertical cylinder

3.2.10

cover

a device providing weather protection for the annular space of a double containment tank

3.2.11

roof

a member on top of a shell or wall, sealing off the contents from the atmosphere

3.2.12

suspended deck

a structure for supporting the internal insulation under the roof

3.2.13

wall

a general term used to describe any concrete, vertical, cylindrical structure

3.2.14

container

a non-liquid-containing metallic, flat-bottomed cylinder, including the roof, to hold insulation and vapour or purge gas, or the metallic upper part above the concrete wall of a full containment tank

4 Design conditions

Tanks should be designed to suit the pressures that are met in service. The internal positive pressure should be not greater than 140 mbar¹⁾ (gauge), and the internal negative pressure should be not greater than 6 mbar (gauge).

NOTE 1 The internal positive pressure of 140 mbar (gauge) may be exceeded subject to agreement between the purchaser and contractor, but for large diameter tanks the design of the roof to shell joint and anchorage might be limiting (see BS 7777-4).

NOTE 2 For tanks with concrete roofs the internal positive pressure of 140 mbar (gauge) may be exceeded because of increased dead weight.

The lowest service temperature permitted is – 165 °C for tanks conforming to BS 7777-2 and – 196 °C for tanks conforming to BS 7777-4.

¹⁾ 1 mbar = 10⁻³ bar = 100 N/m² = 100 Pa.